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The Nano-Revolution and Economic Development: Is Africa Ready?

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Abstract

Humanity is at the cusp of a technological revolution transitioning from the 'Age of Discovery' to the 'Age of Mastery'. Nanotechnology is central to this revolution. There is an air of realistic optimism about the nanotechnology revolution. Those who missed out on the information technology revolution, resulting in the once yawning 'digital divide', will not miss out this time due to the cost or nature of nanotechnology (Khan, 2006, p.104). Some even argue that such modern technologies should not just be *affordable* but also *extremely affordable* to create 'value for money and for many' (Mashelkar and Borde, 2010). In this paper, the aim is to capitalise on this optimism and it is argued that Africa must renegotiate the governance of nanotechnology to ensure that the social solidarity, inclusionary and redistributive ethos are duly and effectively engaged at the global level. The paper highlights what Africa needs to do on its part besides demanding a renegotiation of the terms of the governance of the technology

Keywords: Nanotech, Digital divide, ICT, Nano-divide, Development

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Introduction

The nanotechnology revolution is set to affect everything from production systems to global power relations, from the way we lead our daily life to a future life without death. Once left to science fiction writers and eccentric futurists, nanotechnology is fast gaining ground as the orthodoxy of present-day science and technology (hereinafter S&T). If we are to follow some predictions, by 2020 most technology will have become nanotechnology or will comprise nanotechnology (Kurzweil, 2003; Davies, 2008). It has already triggered the rejuvenation of S&T with a redrawing of the contours between the various specialisations and their role in the economic development. In this sense, nanotechnology epitomises the whole issue of the governance of S&T proffering a chance to renegotiate the stakes of the developing world.

With the current precariousness of the comparative advantages in natural resources and cheap labour, innovation and S&T turn out to be the only choice for economic development. In the developed world economic reinvigoration and growth is entirely tied to S&T. This front has been neglected and ignored for far too long in the developing world especially in sub-Saharan Africa. Africa missed out previous technological revolutions like the Green and ICT revolutions. It cannot afford to miss out on the nanotech revolution for that would be a final blow hurling its people and economy into a state of irrelevance. The advent of nanotechnology will change this for the better if Africa engages with the phenomenon in a timely fashion.

Nanotechnology — the science of things at the bottom

After more than two decades of active engagement and mammoth investment, there remains a great deal of the disambiguation exercise on the 'ontological status' of nanotechnology. While a consensual definition has yet to be worked out, working definitions are widely adopted by various jurisdictions. Nanotechnology is conventionally defined as science and technology operating at the nanoscale and that scale is confined to the range of 1-100 nanometres. One nanometre (abbreviated as nm) is a billionth of a metre. To help with the imagination of the nanoscale, comparisons with the more familiar length scales are needed. A helpful comparison is made using the human head: one nanometre is to a human head what a human head is to the planet Earth (Gimzweski and Vesna, 2003,

p. 3). A dollar bill is 100, 000 nanometres thick while the human hair is 80,000 nm wide. The smallest of human cells, the red blood cell is 1000 nm wide.

The US National Nanotechnology Initiative (NNI) definition adds one more element on top of the size scale: the creation and use of novel properties and applications at the 1-100nm range. The official NNI definition reads as follows

> Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modelling, and manipulating matter at this length scale (NNI, 2010).

Indeed, the novel property rather than the scale range of 1-100nm tends to be the central defining concept of nanotechnology (Loder, 2005, p.3).

It is the strange properties of matter at the nanoscale and the possible applications thereof that made nanotechnology a subject of enormous interest. At the nanoscale, the classical laws of physics governing the macroworld cease to operate and the laws of quantum physics take over and the strange properties of matter unknown at the macro level begin to dominate. At the nanoscale silver turns into a bioactive antimicrobial substance; gold melts at a much lower temperature than it does at the micro or macroscale; copper strangely becomes a poor conductor; aluminium behaves like chlorine; the soft carbon in the form of graphite becomes a hundred times stronger than steel when manipulated at the nanoscale turning into a much sought-after material with incredibly high strength-to-weight ratio. It is, thus, understandable why the exploitation, actual or potential, real or purported, of these strange properties has become the crucial concept in the definition of nanotechnology.

Though scripted in various official documentations across the globe, the US formulation in terms of length scale and novel properties is not meant to serve as the last word; that it is merely 'a working definition' needs to be stressed (Lee, 2010, p.800). Wood *et al* (2007, p.17) rightly suggest a detour in the course of engaging with the phenomenon: 'strict definitions may be irrelevant as perspectives on how it is best pursued and what it can achieve become more important.' They point out that '[r]ather than seeing the issue of the field as a matter of definition or at least as defining it once and for all, it may be more helpful to approach it as a sociological issue' (id, p.12).

Hence, nanotechnology is understood here loosely as 'an umbrella term' for the scientific and technological activities where the conditions in the conventional definition prevail without excluding the features in the more ambitious and perhaps long-term aspects of the technology. The accommodation of the interests of developing countries is dependent on the kind of definition that

will be adopted. The adoption of a broad open-ended definition that would eschew the risk of fragmentation or under-inclusion of certain areas could be of greater crucial importance from developing countries perspective than it is in the developed countries.[1] Accordingly, it is preferred to risk an over-inclusion with such broad understanding than risking under-inclusion and fragmentation (Wood *et al* 2003, pp.26, 29). Thus, no distinction is made here between nanotechnology as material, process, device or system; nor between the modest mid-term 'generations' or the more ambitious long-term generations of nanotechnology.

The Nanotechnology Revolution and the Development Agenda c.2015

The year 2015 is a key date for endeavours both in nanotechnology and economic development. 2015 is the cut-off date for halving extreme global poverty as set out in the UN Millennium Development Goals (MDGs). This is also the year that nanotechnology is set to beat cancer according to the US National Cancer Institute (Cameron, 2007, p.289). In that same year nanotechnology is expected to hit the market to the tune of 1 to 2.9 trillion dollars.[2] If all this comes to pass, the year 2015 will indeed go down in history as a golden year of the 21st century.

While beating cancer and hitting the market to that order are ambitious predictions, halving poverty is not. It is not ambitious not because it is difficult to achieve but because the goals themselves are modest.[3] There is no pretence that poverty will be eradicated; the goal is only to eradicate *extreme* poverty and poverty of other degree is not on the radar. What is more is that it is not the total eradication of extreme poverty that is set as a goal but halving it. Former World Bank President, Paul Wolfowitz, could value the goals as no more than an 'incomplete guide' (Wolfowitz, 2007) concurring with analysts who take the MDGs as 'either an agreed agenda, a minimalistic agenda or an incomplete agenda for human development' (Vandemoortele, 2005, pp. 5–11).

[1] McHale (2009, p.71) discusses the problem of fragmentation in the context of nanomedicine research in the EU. See Niosi and Reid (2007, p.436) discussing the same problem with emerging nations developing nanotechnology.

[2] The US NSF estimate is $ 1 trillion creating 7 million jobs worldwide, IRGC, 2006, p.21. According to Lux Research, nanotechnology will be a $ 2.9 trillion market as early as 2014 and will make up 15% of the global economy. Miller, 2007, p.162; Edwards, 2006, p.38

[3] The Millennium Development Goals (MDGs) are adopted by the UN Millennium Summit in 2000 and are enshrined in its Millennium Declaration. The eight goals are eradicating extreme poverty and hunger, achieving universal primary education, promoting gender equality and empowering women, reducing child mortality, improving maternal health, combating HIV/Aids, malaria and other diseases, ensuring environmental sustainability, and developing a global partnership for development. The progress towards the goals is measured through 21 targets and 60 indicators. UN Department of Economic and Social Affairs, 2010, p.74

Achieving all the goals will be a challenge that would be there well beyond the 2015 rendez-vous. Assessing the pace of progress, former UK Prime Minister Gordon Brown warned that unless 'extraordinary effort' is exerted even some of these minimal targets will not be achieved before the end of the century (Channel 4 News, 2008). UN Secretary General, Ban Ki-moon vented his disappointment at the progress being made which he said is 'unacceptably slow' and facing setbacks due to climate, food and economic crises (UN Department of Economic and Social Affairs, 2010, p.3).

Despite the modest ambitions and with only less than a third of the time left, achieving the MDGs as planned is proving less and less certain. And for this the niggardliness of the rich is to blame.[4] On the contrary, technology is taking the credit for the achievements so far attained as is evident from mobile phone penetration which is well ahead of schedule.[5] One of the targets through which progress towards the eight goals is measured is the provision of the benefits of new technologies especially ICTs. Nanotechnology is held to be a potential catalyst in achieving the goals and is directly correlated to seven of the eight goals (Salamanca-Buentello, 2005; UN Millennium Project, 2005).

Beyond the 2015 rendezvous, there are other less publicized yet crucial dates. Eventually, by the end of the century, the wealth that our technologies will enable us to create will be worth $1000 trillion according to the predictions of Bill Joy — a man rather known for his dystopian views on technological progress. Former US House Speaker Newt Gingrich (2001, p.25) helps us translate this figure in a more intelligible way using a familiar benchmark — the US economy: it is like adding 100 US economies. This in turn means that by the end of the century, everyone on the planet will be enjoying the same or higher living standard as contemporary US citizens.

These generous predictions do not go unchallenged though. A back-of-the-envelope calculation has it that in order for everyone to attain the living standards of US citizens, the resources of two other planets are required (Spohrer and Engelbart, 2004, p. 67). A rather sober calculation by the World Wildlife Fund (WWF) sets the figure at *four planets* (in Barry, 2007, p.233). Whereas 'terraforming' and the colonisation of space is humanity's dream being pursued with ongoing endeavours in space exploration — and it is made an even more serious proposition with nanotechnology and the space

[4] Some figures shade light on this state of affairs: According to the 2006 WTO World Trade Report 21 developed countries spent almost $250 billion on subsidies close to 1.4 % of their GDP. This is double the percentage GDP that Blair's Commission for Africa recommended as necessary for Africa to achieve the MDGs. *South Bulletin*, 2006, p.430. It has also come to light that Americans favour the elimination of all kinds of foreign aid. See Avi-Yonah, 2004, p.372.

[5] Uniquely among the MDGs, the target to enable 50% of the world population to have access to phone services by 2015 has already been met as 80% are now within the reach of a mobile telephone service. Bishop, bbb2005. See also UN Department of Economic and Social Affairs, 2010, p.4

elevator project (O'Mathuna, 2009, pp.25, 164) — the full subscription of the resources of two other planets at least in this century is utterly unrealistic.

The role of technology in economic development has always been a defining issue of the whole debate on development and underdevelopment. The debate dwells on the issue of technological resources more than it dwells on natural resources. Ever since its inauguration on the world stage as a component of the Truman Doctrine, development has been but a highly contested concept. The deplorable situation the vast majority of humanity finds itself after half a century of development thinking and practice has failed to provide a solution to the enigma of development. As Wolfowitz (2007) said 'there is still a lot that we don't understand about what makes development work'. As a result, there has been fatigue and resignation on the part of a significant section of the development scholarship which has evolved into the 'post-development' school that, on the whole, rejects the various incarnations of the concept of development (Pieterse, 2010, p 110). Other schools of thought added to the various nuances of development ranging from those that enhance the dominant neoliberal paradigm to those that claim to present viable alternatives to it.

While the development discourse has been dominated by growth, reflections on 'limits to growth' and on sustainability made it abundantly clear that unfettered growth is not after all a good idea. Economic growth in pursuit of development needed to be recast as 'sustainable development' in view of the ecological crisis humanity is facing. After much reflection on what will happen if current practices of economic growth are maintained for the coming decades and centuries, 'development' was re-authored as 'sustainable development' in the landmark UN document, *Our Common Future*, alias, the *Brundtland Report* (Escobar, 1995, pp.196- 7).

The launching of 'sustainable development' as a way of addressing the ecological crisis has not introduced much that is seen to be working. Growth remains the bottom line while environmental quality and social equity — that are supposed to be amending the unwanted consequences of unfettered growth — are continually deferred. The problem with sustainable development is that it is enceinte with incompatible ideas in a bid to reconcile profit-mongering as driver of growth with ascetic thrift for the sake of environmental preservation.

Now, with nanotechnology and the requisite global regulatory regime in place, it may be possible for the first time to contemporaneously pursue the dissonant sustainability trio, *viz*, economic prosperity, environmental quality and social equity. As changes in science and technology unravel new opportunities and challenges, the debate on development continues with new and broader dimensions. Nanotechnology is opening up a whole new avenue by which the renaissance of the

'development' concept in ways agreeable to both its critics and proponents alike may become far from tenuous.

Beyond efforts aimed at reconciling, or rather balancing, opposing pursuits, a new approach to address the quest of development is required. The development discourse needs to aggressively engage with the governance of the phenomenon of nanotechnology. Such engagement is not an absent activity as can be seen from efforts to correlate what is largely thought to be 'blue skies' nanotechnology research to the here and now of the poverty alleviation effort as expressed in the MDGs.

The consensus on the MDGs, and through them on sustainable development, seems to offer a way out of the enigma of development. The MDGs are 'the standard reference' to 'development' that momentarily put off the erudite wrangling on the essence of the entire project of 'development' (Pieterse, 2010). From the unusually overwhelming assent to the MDGs, it seems the world has reached a working consensus over the notion of development. By the time the MDGs were adopted, poverty has become too real to be a subject of further global deliberation. In terms of having a set of common goals and priorities, the MDGs present a definitive agenda that would certainly serve well beyond their use-by date.

No half measures: Nano-applications vs. Nano-proper

The momentous speech by Richard Feynman, the speech that is widely held to have started all the bustle about nanotechnology today, reserved a clause on developing countries.[6] However, the more influential work that championed the particular issue on the nanotechnology and development interface has been that of Salamanca-Buentello *et al* (2005). Credit is attributed to this work for having ignited 'a lively debate' on the issue of nano and development (Schummer, 2007, p.291). The debate was indeed lively with the authors being subjected to some of the most unforgiving critiques on many levels as their work continues to influence legislatures in some developing countries into committing significant funds for nanotechnology initiatives.[7] Among the charges they still have to answer is their sweeping deduction in assuming the voices of a handful of experts to be coterminous with the voices of the people in developing countries (Invernizzi and Foladori, 2005, p.300).

[6] Feynman's (1960) illustration on the advantages of miniaturisation cites the Brazil of the 1950's and 1960's just as a representative developing country to whose needs nanotechnology can be deployed.

[7] Lawmakers in the Argentinean Congress seem to have been influenced by these scholars when they decided to fund nanotechnology research. Malsch, 2008

The other major yet less direct critique is their piecemeal approach. Salamanca-Buentello *et al* (2005) came up with a list of top ten applications of nanotechnology in areas of energy storage, production and conversion; enhancement of agricultural productivity; water treatment and remediation of disease, drug delivery systems, food processing and storage, air pollution and remediation, construction, health monitoring and vector and pest detection and control.

Their failure to emphasise the generic feature of nanotechnology coupled with their preoccupation with various applications relevant for achieving the MDGs was at best an incomplete account of the potential of nanotechnology. The debate having degenerated into a debate on particular artefacts and applications, their detractors did not lose time to add nanotechnology in the list of technologies that were supposed to benefit the poor but were never seen to have done so (Hunt and Mehta, 2006, p.279). The lack of emphasis on the generic nature of nanotechnology and on its core ideas was such a grave oversight that even their subscribers were misled to limit their recommendations to the applications rather than nanotechnology proper — the generic enabling technology: Schummer (2007, p. 294) who credits the work for stirring up debate advises that developing countries should invest in selected applications rather than on 'such vague projects as nanotechnology overall'.

The matching of nanotech applications and development goals is a nice dive yet misses the pool — the potential of nanotechnology and its comprehensiveness. The correlation of certain nano-applications to certain problems offers only a partial glimpse of the potential of nanotechnology in the way towards 'the final mastery over nature'.[8] Countries engaging in nano-initiatives allured by specific applications should not lose sight of the big picture. This overarching promise of nanotechnology should be the major interest in any nano-policy.

It is not the passive role of consumers that these countries need to play in the innovation process. The days of the transfer of black-boxed technology widely practiced under the aegis of liberal free trade regimes did little by way of facilitating technological learning in developing countries (UNCTAD, 2007, p.2). Avoiding a slide towards 'dependency on ongoing technological charity' by foreign nations and firms is what developing countries should be aiming at (Miller and Scrinis, 2010, p.120). African scholars are warning that Africa should not fall prey to the marketing ploys of technology developers pointing out that 'there is no developer of a new technology that will readily transfer his technology but every technology developer provides literature on his technology for market growth' (Durojaiye, 2011). At any rate, even to use the technology as consumers, which may itself require a great deal of

[8] On the 'notion of finality' see Berne, 2006, p.215; also Fogelberg and Glimmel, 2003, p.3.

innovation, developing countries need to develop their research infrastructure just like the developed nations are doing with theirs.

Valuable discussion on the general concept of nanotechnology, and its impact on 'the broader socio-economic structures', was missed due to the excessive attention on specific applications (Miller and Scrinis, 2010, p.120). Nanotechnology is more than (the sum of) its applications. There is more to it as an idea, a blueprint, and information than particular applications. History of technology teaches that this is the point that needs to be emphasised: Blueprints and ideas and not the stuff or applications are the essence of technology. Jeffrey Sachs (2006, p.41) argues that 'the essence of the Industrial Revolution was not coal; it was (the idea) how to use the coal.' Similarly, the assembly line that is associated with Fordism is mistakenly perceived as the key to mass production. It was the idea that 'the complete and consistent interchangeability of parts and the simplicity of attaching them to each other' that made the assembly line possible (Womack, 1990, p.26). Likewise it is the idea that individual atoms instead of crude chunks of matter can be used as interchangeable building blocks and not the black-boxed finished products that come as nano-applications that make nanotechnology truly revolutionary. It is a meta-blueprint calling for a full distinct treatment in its own right irrespective of the various applications.

Such was the treatment nanotechnology is accorded in the report of the UN Millennium Project Task Force, *Innovation: Applying Knowledge in Development*, that carefully avoided generalisation from various applications. The report's conclusion on the relevance of nanotechnology was based not on a casuistic correlation of problems to their nano-solutions but on the general features of nanotechnology and its promises.

> Nanotechnology is likely to be particularly important in the developing world, because it involves little labor[sic], land, or maintenance; it is highly productive and inexpensive; and it requires only modest amounts of materials and energy. Nanotechnology products will be extremely productive, as energy producers, as materials collectors, and as manufacturing equipment (UN Millenium Project, 2005, p.70).

Considering the more common discussion of specific applications, the relative generality of the above statement is unquestionable. However, an even more radical claim can be and should be made as Fogelberg and Glimmel reason out:

> It [the vision captured in the concept of nanotechnology] also promises the long awaited answers to a burdensome set of urgent questions or needs in the world, thus addressing

> global problems persistently plaguing mankind such as pollution, physical disease, and material poverty. From an engineering meta-perspective it has been argued that the roots of those mega-problems are in fact one and the same: *the poor control of the structure of matter*. (Fogelberg and Glimmel, 2003, p.11)

While the discussion of various applications may serve as a necessary antidote to the generality of the claims that are being made on behalf of nanotechnology, it only gives an incomplete and misleading picture of the potential of the technology. Nanotechnology offers the opportunity for a total control of nature — deciphering her code, and emulating and outpacing her performance. Nanotechnology converging with other technologies marks the transition from the 'Age of Discovery' to the 'Age of Mastery' whereby humans will be graduating into the '*active choreographers of Nature*' (Kaku, 1998, p.5). Those who lay hands on this technology will certainly be in control of nature not only in terms of harnessing it to their advantage but also in terms of totally reconstructing it.

'Ready or Not!'— What Africa needs to do

Preparedness is a priority theme in the nanotechnology policy of the advanced countries. US law has provided for the establishment of the American Nanotechnology Preparedness Centre right at the outset while non-governmental organisations like Drexler's Foresight Institute have as their mission educating society on preparing for the nanotech era. (Schummer, 2006, p.425) A report for the UK government has called for preparatory measures to be put in place before society is overwhelmed by the breathtaking advance of nanotechnology that is catalysing advances in S&T in general (BBC News, 2006).

Whereas the preparedness in the developed countries is essentially aimed at managing the changes brought about by the technology in the rich world environment, 'preparedness' for Africa could mean a totally different issue of survival. A more compelling reason for emphasising the need for Africa's readiness for the nano-revolution is the devastating effect it may have on Africa. Africa would not have the luxury of a choice of interested investors that will be willing to exploit its people and resources. Africa may find itself yearning for the good old days of arm-twisting by multi-nationals like the diamond giant DeBeers whose interest in Africa's diamond and cheap labour is set to diminish. African diamond that DeBeers has been marketing for more than a century is certainly to lose the market as purer yet cheaper diamonds 'cultured' in backyard garage workshops take over the market. (Maney, 2005). Africa cannot rely on mining its diamonds or on creating the market for 'organic diamonds'. The impact of the nano-revolution on Africa is in no way limited to the loss of markets for

certain commodities. The renowned neuroscientist Baroness Greenfield explains the dire consequences of falling behind the technological wave in terms familiar in African history.

> [The Vast Majority outside of the first world — of which Africa is the bottom] are n danger of not only of being disenfranchised from a vastly more comfortable way of life but also of being exploited and abused in ways more sinister, pervasive and cruel than even that witnessed by the worst excesses of the colonial past.(Greenfield, 2003, p.268)

The comforting proviso is that the Baroness has not dismissed the possibility of an alternative scenario whereby the capabilities developed by the new technologies can be deployed to bring an end to the binary world of the haves and have-nots (Id).

Measures to avoid such horrid eventualities need to be radical given the prevailing development practices. Summarising the development thinking and practice of the post-War decades, Juma highlights how technological innovation was kept strictly on the sidelines:

> One of the most damaging legacies of [the divergence in developed countries own innovation policy and development cooperation programmes] was the consistent downplaying of technological innovation as a force in economic development. In fact many development agencies exhibited outright hostility to proposals that sought to integrate innovation in development cooperation strategies (Juma, 2010, p. xiv).

The World Bank, until the recent swing, consistently failed to promote S&T in its development policies.[9] Critics both without and within the Bank exposed the Bank's insincerity in helping developing countries build S&T infrastructures. A recent UNCTAD report revealed that this sustained neglect is still unceasing even in the latest projects of the Bank (UNCTAD, 2007, p.13). Current practices at the Bank like strategies embodied in Poverty Reduction Strategy Papers (PRSPs) hardly contain references to S&T (id).

What is more the bank's policies were even inimical to S&T endeavours by developing countries. Far from being encouraged to invest in research activities, their obligations to service their debts were the priority that they were constantly reminded of. Accordingly, in order to perform their debtor obligation, they were compelled to squeeze and slate the meagre and the less politically sensitive budget they allocate to S&T research (Dickson, 2003).

[9] Over a 25-year period (1980-2004), only 3.9 % of total World Bank lending has on average gone to strictly defined S&T projects. Crawford *et al*, 2006, p.33

The emphasis of development policy at the World Bank has been on the exploitation of natural resources and cheap labour. This was in contrast to the prescription for developed countries whose development is entirely tied to science, technology and innovation (UNCTAD, 2007, p.13). A more pertinent illustration of the importance of S&T for development is the experience of the newly developed countries that owe their lift-off from poverty to S&T (UN Millennium Project, 2005, p.xiv). The example of South Korea and Ireland is cited as particularly instructive and a question is posed as to why governments in least developed countries should not follow the same route (UNCTAD, 2007, p.14).

Despite the self-evident relevance of S&T and the official reiterations that S&T is the defining element of development, the belated awakening that developing countries should raise their research capabilities took place only recently (Juma, 2010, p.xiv) One of the changes in policy direction brought forward by the Wolfowitz presidency of the World Bank is the affirmation that developing countries will have to develop their own S&T base. As can be seen from some activities being undertaken by the bank, this change in policy direction is probably there to stay and unlikely to be as short-lived as the Wolfowitz presidency.[10]

Developing countries are now being told that investing in S&T is a make-or-break decision if they are to remain relevant to the global economy (Wolfowitz, 2007). More than 50 years of development practice has yielded little for the majority of the globe's population. Neither the invisible hand of the market nor the visible hand of state planning as practiced in communist states brought acceptable results. The hope now rests on the 'invisible leg' of technology (*The Economist*, 2006).

While the emphasis on building research infrastructures in developing countries relates to S&T in general, the focus has been mainly on agriculture and only in certain selected countries (UNCTAD, 2007, p.13). References to other emerging technologies let alone nanotechnology are rare and there are even suggestions that developing countries need not engage new technologies like nanotechnology as there are widely available technologies not yet used by developing countries. The current enthusiasm on policy changes in respect of technology and development is of limited relevance to emerging technologies in general and nanotechnology in particular as it insists on making

[10] At the World Bank level, the launch of the 'Science, Technology and Innovation Global Forum' is indicative of a sustained policy change on the subject. See the 'STI Global Forum' website at http://go.worldbank.org/DWODQ7E3EO. There is also a major rethink among donor countries emphasising science in development assistance. *The Economist*, 2004

an exception for high-tech in favour of mature technologies apparently because the patents on them have expired.[11]

The usefulness of these mature technologies for developing countries is undeniable. It is however, limited for at least two major reasons: For one thing if developing countries are ultimately expected to integrate into the competitive global market, their failure is a preordained reality. They cannot rely on outdated technologies that patent-holders would have long made obsolete in expectation of the expiry of their patents. Such obsolescence naturally follows disruptive technologies like nanotechnology. By definition, a disruptive technology is one that 'renders the basic skills associated with the old technology useless and makes its infrastructure obsolete' (Romig *et al* 2007, p.1637). Moreover, the idea of a 'second rate technology' is implicit in the preference for mature technologies just as was the case with 'intermediate technologies' tried earlier (Edgerton, 2006, p.191).

For the poor countries (excluding the newly rich developing countries) acquiring nanotechnology capability is still expensive, but so is maintaining the pre-nano status quo. A Nigerian government minister spelled out what choice developing countries can afford to have:

> developing countries will not catch up with developed countries by investing in existing technologies alone. [In order] to compete successfully in global science today, a portion of the science and technology budget of every country must focus on cutting-edge science and technologies (Wood *et al*, 2007, p.15).

Secondly, the need for new technologies arises because there is some drawback of a prior technology. The ecological cost of the majority of the crude pre-nano technologies is one of the most compelling reasons for an accelerated drive towards adopting nanotechnology. The advice encouraging the use of mature technologies sidelines the issue of sustainability. The core idea of nanotechnology and in particular the biomimcry that it heavily employs as its mode of operation aligns with the prevailing sustainability ethos.

The scepticism that nanotechnology is not for developing countries is grounded on the appreciation that the present level of research capacity and funding in these countries is not conducive for nanotechnology initiatives to be effectively implemented. The message is that these countries should

[11] Juma (2007) explicitly excludes nanotechnology. See also the reference to cutting-edge technologies in UN Millennium Project, 2005, p.33. The UN Task Force recommends a S&T and innovation policy favouring mature technologies rather than 'cutting-edge technologies' but later the danger of 'path dependence' is raised and it all becomes an issue of directing policy at 'the right level'.(pp.32, 40)

utilise their resources in areas where their relative strength lies with the implicit intention to maintain the global division of labour in which developing countries would continue as 'banana-exporting republics'.

It should be kept in mind that countries, rich and poor, are pursuing nanotechnology not for the purpose of tackling some pressing exigencies but mainly for the purpose of avoiding a deficit in the 'competency legacy that might well form the basis for the next Kondratieff or Schumpeterian economic long wave' (Romig, *et al*, 2007, p.1639). The comparative advantage that developing countries were to cash in as a result of the global division of labour and their natural endowments no longer exists and it is unlikely to revive in the technology-led future of the global economy (Pieterse, 2010, p.49). In the rapidly changing global economy, the idea of focussing on a static comparative advantage is not a saleable advice.

Regarding their research capacity, it is noted that it is not a divine rule that these countries cannot develop this capacity. Opportunities for developing countries to build their research infrastructures for nanotechnology and S&T in general exist in a manner never experienced before. Thus far, the flight of their educated population to the core countries, the so-called 'brain drain', has been a major cause of the stagnation and deterioration of their research infrastructures. There is now a way to look at the 'brain drain' in a positive way. While some countries like India are able to halt and reverse the process, others are finding ways to make the most out of it (Bound, 2007, p.9).

The exodus of scientists to countries where their potential can be realised to the full is not an unjustifiable move unless one looks forward to their potential being wasted on sub-optimal performances. Rather than those brains being drained, they were being 'banked' overseas where they have the chance for further enrichment (id, p.8). The 'brain drain' is indeed a positive phenomenon and as Juma likes to recast it, it should be understood as 'global knowledge flow' (Juma, 2007). With the ICT revolution reaching the four corners of the globe the repatriation of knowledge has never been easier. It is characteristic of our time that it offers 'an unprecedented opportunity to develop, disseminate and share the benefits of technical innovation to more users more rapidly.' (UNEP, 2007, p.69) That is one reason for optimism about the possibility of a research infrastructure capable of handling nanotechnology in developing countries.

Africa needs to be ready for the long haul in pursuing nanotechnology. In this sense, readiness for the nano-revolution involves a double effort on Africa's part: designing and implementing nano-initiatives to harness the technology for development and, on the other hand, negotiating and securing safety-net mechanisms until such time that it scores a level of technological progress that places it on a par

with the advanced regions. This double-pronged action fissures into several lines of action that need to be taken both by African governments individually and at the regional level collectively. It involves seemingly discrete yet closely related measures ranging from readjusting citizenship and immigration laws to reverse or otherwise exploit the 'brain drain' to budgetary and tax laws to source nano-initiatives.

The other less recognised yet vital measure is filling the post of a 'concept champion' in Africa. The post should be held *ex officio* by the highest echelons of political power. That was the role taken in the US by Bill Clinton referred to as the 'father of nanotechnology' (Jones, 2004) while in office. In Russia, it is held by Vladimir Putin throughout his presidency and premiership. Considering the shadow it will cast over the entire nano-engagement process, filling the post of the 'concept champion' should be an immediate preoccupation. Ugandan President Yoweri Musevini has inadvertently acknowledged that taking up this responsibility is long overdue when he called for a more proactive science communication in respect of nanotechnology (Wamboga-Mugirya 2008). Likewise, what Ethiopian Prime Minister Meles Zenawi has to say in relation to ICT is true of nanotechnology and alludes to the call for leadership in the S&T effort as a whole: 'Because we are poor, we can't afford not to use ICT.' (quoted in Firth, 2005). While the political will to give due attention to the role of S&T in African development in general is in greater supply, the emphasis on nanotechnology in particular is not at the level required by the exigency the technology is triggering.

The time has come for Africa to aggressively engage with the governance of the phenomenon of nanotechnology. Such engagement is not an absent activity. Yet, the need to spur the momentum cannot be overstated. Africa is waking up to a world of opportunities that could enable it play catch-up which, given Africa's economic and technological predicament, could only mean 'leapfrogging'. A long overdue re-examination of the role of S&T in development is underway and is galvanising major policy changes within the multilateral development agencies and among donor countries. The UN declaration on the MDGs and the efforts to correlate nanotechnology research to poverty alleviation endeavours by the UN are proof of the changing emphasis on the technology-development nexus. Africa, on its part, is laying the ground for action. *The Addis Ababa Declaration on Science, Technology and Scientific Research for Development* (Assembly/AU/Decl.5 (VIII), January, 2007) is among the most recent expressions of renewed commitment in this direction. Beyond such broad and undifferentiated moves, Africa needs to further demonstrate its readiness to have a slice of the value chain that the nanotech revolution will create by specifically targeting nanotechnology on its own.

Conclusion

Referring to the biotechnology debate, Yoweri Mussevini said the debate has 'gone on for a very long time while other parts of the world have moved to other technologies like nanotechnology' (Wamboga-Mugirya 2008). The debate is still stuck with what are soon to become technologies of yesteryears. It is not nanotechnology but ICT and biotechnology that are high on the agenda of the political leadership in Africa. Meles Zenawi was not speaking of nanotechnology when he said that '[t]he first mental block that we had to cross was the view that ICT is for the rich' (quoted in Firth, 2005). However, his statement is not without relevance for nanotechnology engagement. While, half a decade later, the 'mental block' about ICT may have been crossed, another mental block that nanotechnology is not for Africa has yet to be tackled. There should be no second thoughts on the need to have Africa on board the nanotech bandwagon. Africa needs to avoid the eventuality where it finds itself on the side of the nano-divide that is so reminiscent of the digital divide but with far more sinister consequences — potentially more sinister than was witnessed under slavery and colonialism according to Baroness Greenfield (2003).

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