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Transdisciplinary Sustainability: The Council for Frontiers of Knowledge

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Simon Bell, Fionn Murtagh and Pam Weathers (Editors)

Abstract

This paper introduces the work and diversity of the Council for Frontiers of Knowledge (CFK). In a series of vignettes relating to the intellectual interests of some of the leading academics working with the CFK, both the mission and the trans-disciplinary oversight of the agency are explored.

Introduction

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This paper represents a top slice of the ideas and directions of travel of a number of Directors of the Council for Frontiers of Knowledge. More about this organisation shortly; in this brief introduction I want to set out the scope and vision of this paper. Many agencies exist - charitable, public sector and private - with a mission to improve the flow and uptake of ideas, innovations and useful practice across borders. This journal regularly publishes papers, which describe organisations and agencies that develop themes of knowledge transfer and sustainable intellectual practice. The CFK is one such agency. As will be shown, the CFK is no silver bullet to all the issues that beset the continent, nor is it attempting to confront or engage with the plethora of political and ethical concerns that beset development more widely. CFK is concerned with ideas. This paper contains an overview of the various trans-disciplinary domains of interest to the Directors of the CFK in partnership with some of their African colleagues and an insight into how this work is being applied. In a series of vignettes the key interests of some of the CFK Directors are elaborated and the overall mission of the CFK is revealed. Each article in the collective and synthetic piece can be seen as an observation from a particular edge of human understanding. Together they combine to form a braided strand with common yet distinct threads.

In the introductory piece Atkins Katusabe and Pamela Weathers set out the history of the CFK and place its origin and intention in the contemporary era. Simon Bell and Stephen Morse using the CFK community itself, discuss the potential for participation to be made more inclusive and the outcomes to be evidence-based. Dermot Diamond addresses the twin issues of sensing technologies for health diagnostics and distributed environmental sensing and describes how CFK can foster the inclusion of more African researchers. Jenny Emnéus, Filipo Bosco and Cecilia Agrell discuss a unique programme of mentoring – instigated within the CFK and beginning to show powerful outcomes. Anthony Guiseppi-Elie and Francis Moussy then focus on medical diagnostics and discuss the potential for use in the largely low income countries of Africa. Jim Lynch describes research in technologies for monitoring and assessing de-forestation and, building on this, the current Chair of the CFK Board of Directors, Fionn Murtagh, discusses the role of Information and Communication technologies as both a challenge to, and an indicator of, development in Africa. PK Nair takes up the synthetic theme of this article in his piece which promotes the integrated nature of agro-forestry as key to Africa's productive sustainability. Finally, Pamela Weathers and Alice Amoding consider the value of *Artemisia annua* and the effect of this important medicinal plant in terms of its potential impact on the cultivation of food crops in developing countries that are prone to malaria.

To improve navigation for the reader, we have allocated the papers to sections on Social Sustainability, Technological Sustainability and Agricultural Sustainability.

Introduction to the CFK - Africans Hold the Key to Africa

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Africa is key to the world's next stage of development including opportunities for Science, Technology and Innovation. Africa has many well-educated scientists, engineers, and policy makers who are uniquely placed to identify basic research priorities and application areas that could provide the great impact. Unfortunately, many African universities are unable to offer research opportunities to their faculty, while other research institutions in Africa fail to fulfil their aspirations to build substantive careers as researchers. This truncation of career horizons limits the development of expertise in both depth and breadth and encourages a continued dependence upon externally sourced solutions. The result is not only research and development that is potentially less than desired for local conditions, but a frequent disconnect from local decision making that actually delivers the practical benefits. A more insidious problem is the barrier this creates to Africa playing its full part in the global knowledge pool.

Limited population awareness of scientific agendas is one barrier. Funders in developed countries promote end user participation and public engagement in science; Africa must expect no less for its citizens. The lack of balance between 'home grown' and externally formulated solutions perpetuates established norms that are not going to be remedied unless recognised and challenged from within the continent. A concerted effort by African research and political leaders would help to systemize best practices for research across Africa. Substantial technical progress has been made; R&D budgets have been increased in many African countries, benefiting engineering, agricultural and even basic sciences. The resulting new knowledge base, however, requires one further leap into innovation, which will open new research horizons and economic opportunity, rather than being constrained only by utilitarian research.

While recognizing these major challenges within Africa, a group of young Africans attending a Policy Shaping and Research Development Workshop in 2007 in Kampala, Uganda subsequently formed the Council for Frontiers of Knowledge (CFK) on April 27, 2007. The CFK http://www.thecfkglobal.org was established to form specific contact groups to engage scientists from overseas with local researchers, university leaders and international agencies. Through such direct engagement, CFK was intended to establish research consortia whereby both research and policy competitiveness could be leveraged to enhance science and technology in and for Africa and the world. Since its birth, the CFK has formed an international Board of Directors (http://www.thecfkglobal.org/management.php.html) that has met several times, managed five graduate student Fellowships (http://www.thecfkglobal.org/the-tullow-cfk-partnership.php.html), and convened a major international meeting in Munyonyo, Uganda, November 2012 (http://www.thecfkglobal.org/meetings.php.html). At the November 2012 meeting, more than 29 African countries were represented as were 9 countries from 4 other continents. This convergence of intellectual talent and energy led to new alliances and collaborations that can only enhance and enrich Africans and the broader world community. What follows is a collection of ideas that have emerged from this growing collaborative group via the CFK.

CFK Director Vignettes

Section 1: Social Sustainability

1. Sustainability, Participation and Happiness: Triple Task in Action

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An over-arching requirement of international development is for the continued capacity of groups to work together to common and sustainable ends. It was with this in mind that we originally devised the Triple Task Methodology (TTM) – a means for groups to work together and be understood in how they have achieved what they have achieved. The CFK conference in Munyonyo, Uganda during November 2012 included a session and keynote presentation on the TTM. Our concern here was assessing the levels of participation achieved by a number of groups. The intention of the TTM workshop was to raise awareness of the method and to show how it differs from other participatory methodologies. The pages of this journal are replete with papers on some of the aspects of TTM (please see Bell and Morse, 2013a) and the details do not need to be described here. The interested reader can also refer to Bell and Morse (2012) for an extended description.

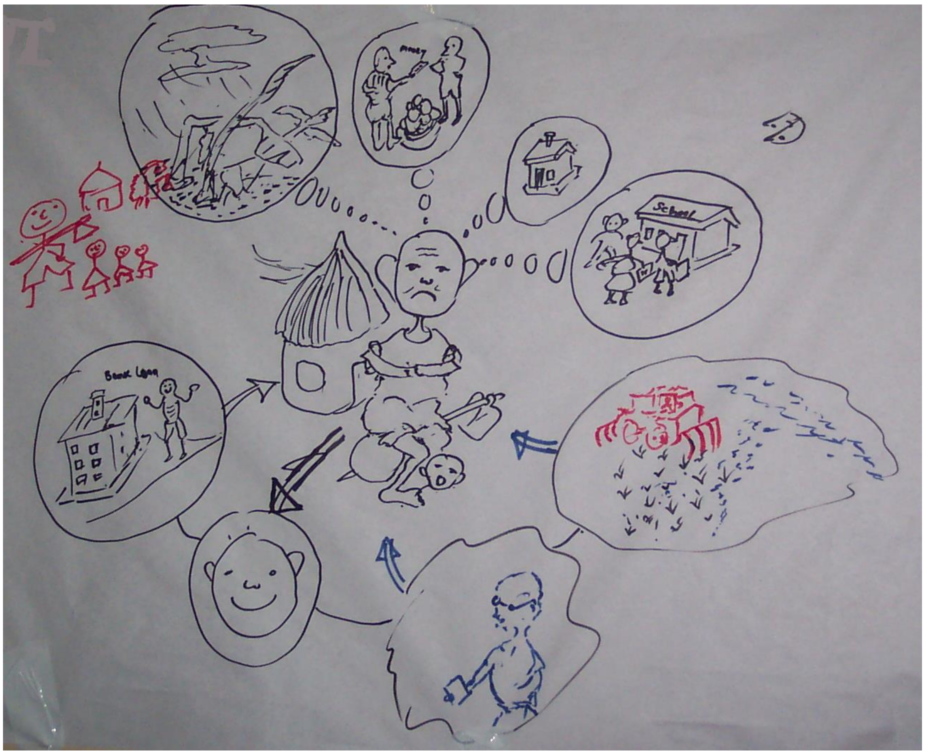
TTM is one approach to taking participation to the "next step". Rather than see participatory methods solely in terms of their "deliverables" – the outputs of the analysis undertaken by those who took part – TTM introduces the notion that how people arrived at those outputs is also important. Hence TTM includes a consideration of group dynamics and the make-up of the groups. It could also include a consideration of factors such as participant experience, age and gender. All of these factors, and others, could potentially have an influence on the journey undertaken by groups during their engagement with an issue. TTM attempts to formalise what facilitators of participatory workshops have instinctively done.

The TTM at the CFK conference involved a total of 7 groups, each comprising 5 to 7 members. The group members were asked to explore what sustainable development meant to them in Uganda. The participants were mostly students from Makerere

University in Kampala, along with lecturers and researchers. The outputs were rich, Figure 1 being an example of just one output from one group. The picture may not at first glance appear to contain all that much but in fact has a rich set of interacting considerations comprising education, livelihood, climate change, credit and markets. It also includes an important factor (highlighted in the bottom-centre) of emerging and significant importance – happiness. Sustainability is almost defined by the group that drew the picture as "promoting happiness of the current generation without compromising the ability of future generations to also be happy." Thus development is not just about continuing to be able to make a living in an important but one-dimensional sense but also continuing to be able to enjoy life. These are not, of course, unrelated as Figure 1 points out, but those that see their engagement in researching, teaching or "doing" sustainable development as a "job" can all too easily forget the importance of happiness. This finding, maybe an often held view of groups across the world, but rarely seen or noticed by many conventional methods is, we argue, an emergent and valuable contribution derived from the use of TTM.

Given the failings of Rio+20 in 2012 and gloom that has spread amongst the sustainable development community following that conference – George Monbiot writing in the Guardian newspaper (UK) called it "perhaps, the greatest failure of collective leadership since the first world war" – it was certainly refreshing to hear some new and positive ideas in Kampala, even if a framing of sustainability using happiness also has its limits. After all, people are resilient and can be happy even if they are living in a society that has much poverty, inequality or lacks certain freedoms. Inter-governmental meetings may be failing the world but at least some amongst the younger generation can see the bigger – and richer – picture.

Figure 1 Rich picture produced by a Triple Task group during the CFK conference.



2. Empowering Young Researchers through eMentoring

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The word Mentor roots back to Greek mythology when Odysseus left for the Trojan War, entrusting his friend Mentor to raise his son Telemachos, with the mission to promote the boy's development in his absence. In modern society, mentoring programs are perceived as important and efficient tools for many organisations to vitalize their leadership and development programs; the mentor serves as a contact builder, coach, conversation partner and inspirer. It is unarguable that the combination of long experience and fresh ideas creates a more innovative and satisfactory work climate, thus leading to a win-win situation for both the organisation and the individuals in it. Already in 1979, a study from the Harvard

Business Review showed that mentored managers earned more money at a younger age, were better educated, were more likely to follow initial career goals, and had greater career satisfaction.

The CFK is establishing an eMentoring program, which is essentially the same as a normal "face-to-face" mentoring program, with the exception that the main communication is performed electronically. Since transnational collaboration, development and communication are central to CFK's activities, the eMentoring program will, on the one hand, help empower young African and Western researchers within the CFK, and on the other hand, help to establish new networks and communication platforms. These will be of paramount importance for an African-Western scientific communication interface. To our knowledge this type of activity has never before been pursued between African and Western scientists.

The main purpose of the CFK eMentoring program is to empower young researchers (mentees) within the CFK with knowledge, skills and self-confidence so that her/his possibilities to succeed as a researcher increase. The mentee will have the opportunity to develop in a tutored relationship with a senior researcher (the mentor) mainly through electronic communication via a secure web platform; however, initial and final face-to-face meetings will be an essential part of the experience. eMentoring is a flexible and relatively cost effective way to convey knowledge, and could overcome infrastructure issues in dispersed international collaborations or networks such as the CFK. In the future it could enable a larger group of people to participate who otherwise are alienated from traditional mentoring programs due to time, distance, social, and/or financial problems.

To establish the CFK eMentoring program, a first inventory will be made to establish which African and Western Universities/organisations can benefit and are willing to participate in the program. We begin with a 12 month pilot program in 2014 with a trial group of 15 mentees and mentors. Mentees will be selected through an application process and thereafter paired with a suitable mentor, recruited with the help of senior scientists participating in the CFK.

The program will kick-start with a 10-day training workshop in Africa with the participation of all mentees and mentors. Thereafter communication between mentees and mentors will take place through the web-based CFK eMentoring platform. The program will end with a face-to-face meeting between mentor and mentee, either in the form of a joint final workshop with all mentor and mentee pairs, or single meetings at a place selected by the mentee-mentor pair. Face-to-face meetings during the electronic communication period are obviously possible, but will not be an official or financed part of the program.

We anticipate that mentees and mentors taking part in the CFK eMentoring program will gain personally and professionally, i.e., integration of long experience with new ideas combined with establishment of new international and national contacts will together generate a creative and progressive climate, across borders of different cultural, religious, and scientific backgrounds.

3. Low Cost Diagnostics for Low and Middle Income Countries (LMICS)

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The healthcare outcome for many in low- and middle-income countries is decidedly linked to early diagnosis and requires development and delivery of low cost diagnostic tools and technologies for resource challenged regions (Burgess et al., 2007) There is an innovation gap (a disparity in capacity to realise the benefits of innovative thinking) that favours advancements in the diagnosis and treatment of diseases in developed world markets over those in the developing world. These global health disparities, the "10/90" gap, (http://www.globalforumhealth.org/about/1090-gap/ 2012) are of concern for both infectious diseases and non-communicable diseases. An emerging incentive is being found in the nexus of three non–obvious benefits: i) The potential for the development of novel diagnostic modalities, tools and techniques, that address the resource challenges of developing countries, ii) simultaneously addressing the continually rising cost of health care in the developed world, and iii) accessing the potentially large, hitherto under-served markets of developing countries.

Within low-and-middle-income countries, three infectious diseases, HIV/AIDS, malaria and tuberculosis, are among the top ten causes of death, cumulatively accounting for ~3.5 million deaths per year according to the World Health Organization (WHO). Non-communicable diseases (NCD) are the leading cause of mortality worldwide and attributable to 36 million deaths per year according to WHO. Of these NCD-related deaths, approximately 80% occur in low-and-middle-income countries. Design criteria, in the form of standards for diagnostics, must be ASSURED (Affordable, Sensitive, Specific, User-friendly, Rapid and robust, Equipment-free and Deliverable) to end-users. This methodology is applicable to both infectious diseases and non-communicable diseases. Appropriate and ASSURED (Peeling et al., 2006) diagnostics for low and middle-income countries will, in addition to saving millions of lives locally, yield significant global benefits (Burgess et al., 2007). Scientists, engineers, technologists, investors and their diagnostic companies are working to accelerate the development and delivery of new diagnostic solutions. For example, paper-based diagnostics are being developed to take advantage of the lightweight, control of chemical composition, compatibility with biological samples, chemically modifiability, high color contrast, flammability, flexibility and pore size control of this inexpensive and ubiquitous resource – paper (Martinez et al., 2010). The Cambridge (USA)-based point of care diagnostics company, Diagnostics For All (http://www.dfa.org/index.php 2012), is developing paper-based diagnostics to address the pressing need for routine and continual monitoring of liver function for persons on antiviral, malaria and tuberculosis therapies. Another example is a novel microfabricated bioelectronics biochip that counts CD4+ T lymphocytes from leukocytes. The goal is to produce devices called micro-Total Analytical Systems (µTAS) with high accuracy, low coefficient of variation and applicability to resource-challenged regions. The Daktari CD4, developed by Daktari Diagnostics, Inc. (http://www.daktaridx.com), is based on the forgoing technology. Recently completed trials in Botswana (Rodriguez et al., 2005) and

Tanzania (Moon et al., 2011) confirm the viability of portable diagnostic platforms for field use in resource challenged regions.

One method to encourage the access of quality medical devices in low-and-middle-income countries is through the WHO Diagnostic Prequalification Programme, which produces a list of appropriate quality diagnostics for use in low-and-middle-income countries to encourage procurement of quality products. Using both WHO specialists as well as external experts, WHO validates both the device and its manufacturer. Implementation strategies require integration of new diagnostic technologies into national health care frameworks. WHO also provides information about the needs as well as tools to facilitate the development of diagnostics such as Preferred Product Profiles and specimen/strain banks to facilitate testing of prototypes. A remaining challenge for the diagnostic developers is often to have appropriate field access for evaluation of their tests. The CFK maintains a strategic thrust in diagnostics.

4. Public/Private Sector Initiatives in Ecosystems Management: Introducing the inFORm Consortium

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Half the land surface of the Earth lies within the tropics and it is within this vast area that the world's governments wish to reduce and preferably stop deforestation to reduce the impact of climate change (Freer-Smith et al., 2007). Gross tropical deforestation has been estimated to emit circa 2.9 PgC yr^{-1} (petagrams Carbon per year) that, after compensation for the carbon sink from tropical forest regrowth of circa 1.6 PgC yr^{-1}, amounts to a net contribution of circa 1.3 PgC yr-1 to the atmosphere (Pan, 2011). If deforestation ceased completely in 2013, this could save 2 PgC yr^{-1} currently emitted by deforestation, and associated changes in land use. This would by the end of the century avoid 175 PgC entering the atmosphere and preventing about 0.5°C of global average warming. The proposed guideline by the IPCCC to reduce deforestation is REDD+ (Reducing Emissions from Deforestation and Forest Degradation, and the Role of Conservation, Sustainable Management of Forests, and Enhancement of Forest Carbon Stocks). An interdisciplinary approach is needed to approach the issue and countries, FAO and the World Bank have indicated their willingness to deploy substantive funds to achieve the objective.

In order to achieve the REDD+ objectives, DMC International Imaging where I am Director of Forestry has formed the inFORm consortium for international forest management. The members are Astrium, Helveta, the World Resources Institute, Y-Zen, Quarry One Eleven, University of Leicester and University of Surrey; they are supported by a team of distinguished consultants and an International Advisory Board. The wide range of expertise covers policy development, technologies, training, market development, forestry services, social and environmental issues, financial aspects of forestry management, and effective management and leadership. Earth observation (Lynch, 2012; Lynch et al., 2013) can contribute two aspects of the forest monitoring problem: the location of all trees, and the number of trees. Satellite wide area view enables a highly-accurate census to be made. Then the imagery can be processed to make biomass estimates and gain a measurement of the carbon stocks bound up within them. This will allow us to see the carbon for the trees, and then just as importantly, to estimate how the carbon stock tropical forests of the sub-Saharan CFK countries is changing over time.

It is important to fit forestation in relation to the establishment of country tools for land use monitoring and large scale agriculture, and to build an understanding and commitment to forest protection. That will facilitate the implementation of successful systems for land management, including the development of alternative land user scenarios and incorporation of approaches to best practices. This will include analysis of the impact on environments and local peoples and the introduction of financial payment systems for carbon. Wood tracking systems will be used; this will generate a timber government administered legality assurance system and the development of regulatory frameworks by governments for land ownership.

Monitoring, Reporting and Verification (MRV) is at the heart of the REDD+ approach and the Global Observation of Forest and Land Cover Dynamics have published a REDD Sourcebook under the GOFC-GOLD (www.fao.org/gtos/gofc-gold/) programme, but the methods can only be approved by the Intergovernmental Panel on Climate Change. UNFCC requirements Policy-makers need to recognise and adopt the full potential of satellites in the ability to monitor nationally the world's forests, particularly in the tropical forests of Africa.

Section 2. Technical Sustainability

5. Low-Cost Distributed Sensing Platforms for Environment and Health Monitoring

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There is a well-known truism, often ascribed to Sir William Thompson (Lord Kelvin), "It is not possible to evaluate improvements if one cannot measure the original and final situations", in other words, "If you can't measure it, you can't improve it". Globally, there is a realisation that societal health is closely correlated with the quality of the environment, and therefore improving the general quality of life of society will require integration of environmental and health related measurements, including water/air quality and health diagnostics (Diamond, 2004). The challenge therefore is to deliver ways to enable these measurements to be performed at point-of-need, as often as required, and at an acceptable cost. For African countries, this challenge is particularly difficult, given the greater health and environmental issues, and lower available resource base for implementing infrastructural initiatives. However, there are also considerable grounds for optimism, particularly if the creativeness of the people can be mobilised, and government policies that are designed to develop an increasing level of self-reliance and sustainability are implemented. The following factors could contribute to a rapid improvement in the quality of life of people:

- Many African countries have considerable wealth in terms of mineral resources, and there are very positive indications of large-scale hydrocarbon deposits that are increasingly raising Africa's position as a major player in global energy markets. Whilst it is recognised that hydrocarbon availability does not translate directly into improved living standards, financial measures derived from policy can help to ensure that resulting prosperity can be shared.
- Many African countries are already investing this new wealth in education and research programmes. This investment could be further leveraged through exchange programmes designed to develop strong international linkages, through for example, aligning priorities with the EC Horizon 2020 programme (see http://ec.europa.eu/research/horizon2020/index_en.cfm last checked 2013.01.21), and developing regional/national initiatives similar to the Brazilian "Science Without Borders" Programme (see http://www.cienciasemfronteiras.gov.br/web/csf-eng/faq last checked 2013.01.21).
- Africa has a rapidly developing wireless communications infrastructure that provides a low cost basis for harvesting and sharing data generated from distributed monitoring of health and the environment.
- The technical skills and know-how developed by young researchers working on these topics are directly relevant to key emerging technologies that will shape our future world, such as Cloud Computing, data analytics and visualisation, and internet-scale sensing and control. Young African scientists and engineers will therefore provide a resource to attract and embed multinationals active in these areas of significant future high-value employment, creating conditions that will underpin future sustainable wealth beyond the exploitation of natural resources.

The key requirement now is to develop sensing technologies for health diagnostics and distributed environmental sensing at a cost basis that is orders of magnitude lower than is currently available (Murray, 2010). African researchers can make a significant contribution to progress in this area, by targeting these key global research challenges that are directly relevant to improving the status of African society (Byrne et al., 2010).

6. From Shared and Collaborative Technologies to Common Ideals and Aspirations

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If technologies are changing, and social organisation and activities correspondingly, then it is important that there be groups like CFK to help with roll-out and take-up. This is with the aim of reaping the benefits both widely and deeply. Just a few current technology trends are reviewed in the following, all of them related to new developments in research, education and society generally. My aim is to point to areas of the world, including Uganda, where leadership of global research and education initiatives can and should arise.

Technology comprises the relationships between human individuals and human society in combination with the world around us; technology goes hand in hand with new perspectives and new practices that are driven by research.

One potential beneficial outcome of the economic downturn in parts of the world at present is a turn towards new goals and new aspirations in the way society operates. This is very central in regard to power, energy and fuel. An insightful view in favour of a turn towards self-sustaining and scalable power, for example scalable to the global domestic requirements of the more than seven billion people on Earth, is presented by Datta (2011). Micro-generation of energy leads to autonomy, and is very much self-sustaining. Areas of direct use are domestic appliances, transport, lighting, heating and cooling. For a form of pervasive and ubiquitous energy micro-generation, Datta (2011) points to butanol and related liquid fuels. He also points to how intellectual property rights must not impede the full flowering of what he terms as the ambition of an eAGE, energy-agnostic global economy.

Telecoms are a good barometer of societal development. In ITU (2013) graphical presentations of the data available show the surge in fixed (wired) broadband subscriptions from 2009 onwards in Uganda, and the major increase in fixed-telephone subscriptions, and in mobile-cellular telephones since the middle of the last decade. Even if there is still a long way to go, for developing countries in Africa and elsewhere, the data speak clearly; growth is being driven by developing countries that accounts for more than 80% of new mobile-cellular subscriptions added in 2011. The total mobile -cellular subscriptions reached almost 6 billion globally by end of 2011 (ITU, 2013), being approximately 1.5 billion in the developed world, and 4.5 billion in the developing world.

Out of about 200 countries the ICT Development Index, IDI, has values for Uganda of 1.53 in 2010 and 1.67 in 2011 corresponding to a world ranking of 136 and 132, in 2010 and 2011, respectively. For comparison from East Africa, Kenya is at rank 114 in both years. While in the lower end of the development scale as measured by this ICT Development Index, I will turn next to one area where technical advance in East Africa could well be strong in the future.

Diversity presents enormous advantage, in individual and social contexts, if it is permitted and facilitated. Take language for example. With more than 1000 languages spoken in Africa, Uganda has its fair share (at least 32, according to Encyclopaedia Britannica). This points to the need for voice recognition telecommunication technologies, both to support all languages (and, potentially too, dialect and other expressions of language) not just in functional terms but for the capability to be there to transmit outwards and onwards the encapsulated wisdom that is the sinew of any such structured form of expression. In the education setting, this is a point that Lord David Puttnam makes very well (see e.g. Shaw, 2012), viz., that voice expression represents a great continent that is ripe for exploration by our communications and information technologies.

Uganda and Africa have the wherewithal to achieve planetary thought leadership on many levels. In personal terms, I find the attractiveness of working in the CFK context to be highly correlated with what we, in our Western countries and societies, can learn from East Africa and elsewhere in the region.

Section 3. Agricultural Sustainability

7. Agroforestry for Food Security and Environmental Sustainability in Africa

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Most criteria and indicators of food production, food security, and other quality-of-life parameters are alarmingly low across the African continent, and the health and productivity of the fragile ecosystems have been severely compromised by unsustainable management under changing climate and increasing human and animal populations (Brown, 2012). Input-intensive agricultural technologies that have proven successful in some regions of the world (Evenson and Gollin, 2003) have turned out to be unsuitable for Africa's infertile soils, unforgiving climate, weak infrastructure, and socio-cultural traditions (Beddington et al., 2011).

A consensus has now emerged that the key to tackling hunger in Africa is revitalizing its soils; but there is no agreement on how to accomplish that (Gilbert, 2012). Many argue that large doses of chemical fertilizers are the most expedient solution; others argue for "greener" and cheaper solutions. High fertilizer prices and poor infrastructure are often quoted as the main impediments to large-scale fertilizer use in Africa (Beddington et al., 2011); but a more insurmountable problem is ecology: the inherent inability of tropical soils to sustain heavy application of chemicals and machinery has been well demonstrated. On the other hand, adopting time-tested practices such as agroforestry that rely on conservation farming and fertilizer trees have shown to improve soil health and raise and sustain crop yields (Fischer, 2011).

During the past thirty-five years, research and development efforts have widely demonstrated the positive role of integrated agroforestry systems in addressing some of the major problems such as food and nutritional insecurity, soil degradation, desertification, and climate change. The role of trees on farms in providing ecosystem services such as soil improvement, climate change mitigation, water quality enhancement, and biodiversity conservation has now been recognized. Exploiting nitrogen fixation by tropical legumes, enhancing the efficiency of nutrient cycling, and benefitting from the deep-capture of nutrients are the primary bases of the soil sustainability advantages of such systems (Herrero et al., 2010; Nair and Garrity, 2012).

These time-tested systems and their social values (Summers et al., 2012) have been ignored in our modern agricultural development efforts. We treat agriculture and forestry separately although these sectors are often interwoven on the landscape and share many common goals. We also have not given adequate attention to using modern scientific techniques for enhancing and exploiting the potential of indigenous plants that provide multiple products and ecosystem services and incorporating them into widely adoptable land-use systems (Nair and Garrity, 2012). A middle ground that ensures a judicious combination of moderate fertilizer use in conjunction with green technologies, rather than a rigid either/or choice, seems to be the prudent approach to improving soil fertility and maintaining environmental sustainability in Africa. Science has a major role to play in this transformation. Modern scientific techniques should be used to enhance and exploit the potential of indigenous plants that provide multiple products and ecosystem services and incorporate them into widely adoptable land-use systems.

8. Sustainable Whole Plant Antimalarials to Improve Health and Wealth

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The scourge of malaria mainly hits the poor who also are often subsistence farmers. For 2010, WHO estimated 216 million cases of malaria with ~655,000 deaths. Over 2,000 years ago, the Chinese brewed a tea infusion mainly containing the plant, *Artemisia annua* to treat “fever”, which was very likely malaria (Dalrymple, 2012). In the 20th century modern medicine replaced many ethnobotanical treatments for disease including malaria. Quinine is an example of a pure compound used for decades, but then due to emergence of drug resistance in the parasite, had to be replaced with newer pure compounds like artemisinin. Currently the most effective antimalarial therapeutic is artemisinin and its derivatives delivered as Artemisinin-based Combination Therapies (ACTs) where artemisinin is combined with a long half-life partner drug, such as mefloquine (ASMQ) or lumefantrine (Coartem). Artemisinin and its derivatives are also proving effective *in vitro* against some viruses, and many other neglected tropical diseases including schistosomiasis, leishmaniasis, trypanosomiasis and even some livestock diseases (Dalrymple, 2012). Although availability has recently increased, the drug is still in short supply for treating malaria and, thus, unavailable for many of the other artemisinin susceptible diseases. Use of transgenics and new chemical syntheses will likely increase the drug’s availability, but current production is based on extraction and purification from cultivated *A. annua,* which is relatively easy to grow. Unfortunately, parasite resistance to the drug is emerging (Phyo et al., 2012). Loss of the artemisinins in the frontline fight against malaria would be devastating.

Because the plant contains a complex mixture of other lower potency antimalarial compounds like flavonoids (Liu et al., 1992), use of the whole plant may offer a possibly permanent solution to this recurring problem of drug resistance. Indeed recent studies show that in animal models consumption of the dried leaves of the plant is more effective than the pure drug in reducing parasitemia (Elfawal et al., 2012). Likewise prophylactic use of an *A. annua* tea infusion in Uganda showed an 80% reduction in malaria cases (Ogwang et al., 2012), and some preliminary human trials in Africa of oral consumption of dried *A. annua* leaves showed excellent reduction in parasitemia (see review by Weathers et al., 2014). Local cultivation and production of dried leaves from high quality *A. annua* cultivars would provide Africans with an opportunity to establish small enterprises resulting in jobs, which would also allow people to become more self-sufficient and less reliant on the West for their healthcare needs (Weathers et al. 2011).

A. annua also has significant allelopathic properties both on itself, microbes, and other plants including weed seeds. Microbial soil populations also may be significantly altered after being exposed either to *A. annua* leaf debris or artemisinin leached from leaves and roots (Herrmann et al., 2013). Currently the plant is grown mainly on large plantations. If small stakeholder farmers begin to grow *A. annua* in rotation or intercropped with other produce, then overall food crop productivity could be affected. It is well established that small-scale farmers in developing countries like those in Africa need better tools and opportunities to boost food crop productivity, increase income, and build better lives. This challenge is best met using environmentally sustainable and economically affordable solutions. Considering *A. annua* is grown round the world including in at least 21 countries in Africa, the effect of this important medicinal plant should be investigated for its impact on the cultivation of food crops in developing countries where malaria is endemic. The CFK has been instrumental in connecting African and Western investigators like us to plan and implement studies for sustainable solutions linking medicine and agriculture.

Conclusions

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The perspectives and the expertise represented by the authors of this article span many fields: biology and biotechnology, agriculture, environmental science, computer science and technology, sensor technologies including biosensors, and nanotechnology, social science and international development. As authors, we represent frontline research and R&D. Coming together in the cross-disciplinary and oriented plaform that is the CFK certainly has enormous potential. However, the important question that follows is: will CFK be more than the sum of its parts, and can we as the CFK go even further and shape a new model of collaborative and collective action?

Being fearless and self-confident in realizing a CFK vision is a small part of the answer. A far more central part of the CFK model is that an orientation and alignment with entrepreneurship and industry goes hand in hand with academe and scholarship. That is a combination that has been rendered necessary only in recent times, with quite major transformation of university systems, of research production, scholarship output, and new forms of teaching that should result in better quality educational outcomes.

Motive forces for this have included demographics, such as the massive increase in research funding and output in emerging economies including, for example, those of China, India and Brazil. A constraining motive force is the banking and economic crises in some Western countries that limit direct funding. When research funding is available, it is often targeted towards a limited number of large groups, passing over investigators at smaller or poorer institutions. The latter group, however, shoulders much of the responsibility of encouraging the younger generation to move into the STEM fields (science, technology, engineering, and mathematics). If the mentors do not have the resources or are themselves stymied in their research efforts, it is discouraging and potentially counterproductive, dragging down the overall effort to improve research and education. New models are therefore needed.

The CFK is working towards the realization of the full potential of Africa's education and research, with all the social consequences that implies. In CFK we also have, increasingly over time, the capability to represent Africa's education and research to the more developed world. An example of that ability at work, and CFK's access to all levels in African education and research, was provided by the session at the CFK Conference held in November 2012, entitled "Vice Chancellors and Donors Forum", which had a debate between representatives, including Presidents or Vice Chancellors, from 67 universities in Uganda, Kenya, Somalia, Tanzania, Nigeria, South Africa, Zimbabwe, Rwanda, Burundi, Botswana, Sudan, Senegal, Mozambique, Ethiopia, Ghana, Zambia, Democratic Republic of Congo, Benin, Southern Sudan, Malawi, Burkina Faso, Cameroon, Sierra Leon, Lesotho, Morocco, Ivory Coast, Gabon, Tunisia, Benin, and Angola .

We would hope that besides sharing in the development of new technologies there would also be some broad policy implications that emerge. These generally could include the following:

- CFK provides evidence that multi-lateral intellectual and academic collaboration can provide African scholars with access to sources of funding and international assistance and so
- the challenge is presented to other scholars and academic institutions to explore similar and collaborative ventures and thus,
- this form of non-governmental scholarly philanthropy should and can be expanded.

Such is the new model that we are pioneering, a new model of transdisciplinary sustainability that is the CFK wherein international partnerships engage in empowering our colleagues in less developed countries, like those in Africa, to achieve transformational sustainability.

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