# Moving Climate Innovation Into the 21st Century: Emerging Lessons from other Sectors and Options for a New Climate Innovation Initiative

**Prepared for the UK Department of International Development and Department of Energy and Climate Change**


**Clean Energy Group**

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## Authors' Note

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## About Clean Energy Group

Clean Energy Group (CEG), a national U.S. nonprofit organization, promotes effective clean energy policies, develops low-carbon technology innovation strategies and works on new financial tools to stabilize greenhouse gas emissions. CEG concentrates on climate and clean energy issues at the state, national and international levels, as it works with diverse stakeholders from governments as well as the private and nonprofit sectors.

CEG assists states to create and implement innovative practices and public funding programs to advance clean energy markets and project deployment; creates networks of U.S. and international policy makers to address climate stabilization; advances effective, 21st century, distributed innovation theories for climate technology; develops new finance and commercialization tools; and works to attract new investors to move clean energy technologies to the market more quickly. CEG's work is designed to greatly accelerate the commercialization of breakthrough low-carbon technologies and to massively scale up existing clean energy technologies as rapidly as possible to strengthen the economy and stabilize climate change emissions. CEG is supported by major foundations, state governments, and federal agencies.

Founded in 1998, CEG is headquartered in Montpelier, Vermont, with staff also based in Washington, D.C. In 2002, CEG created and now manages a separate, national, nonprofit alliance of 20 state-based, U.S. public clean energy funds and programs— the Clean Energy States Alliance or CESA.

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# Moving Climate Innovation into the 21st Century: Emerging Lessons from other Sectors and Options for a New Climate Innovation Initiative

## Executive Summary

The UK Government is committed to achieving an ambitious, effective, and equitable global deal that would limit global temperature rise to 2°C and to helping countries adapt to the inevitable impacts of climate change. Supporting the development and deployment of climate technologies in developing countries is essential to achieving this goal. We need to foster international and local innovation into new, breakthrough technologies and into adapting current technologies to encourage more successful deployment in a broad range of local conditions.

The UK Government commissioned Clean Energy Group (CEG) to research what can be learned from a range of existing international public- and private-sector technology and market development collaborations. The overall purpose of this report is to provide a series of options to structure and implement an international climate technology innovation initiative based on best practices from the agriculture, health, and ICT sectors. The research could also help to inform ongoing international discussions to establish a Technology Mechanism under the UNFCCC, as well as international and bilateral climate programs.

**A Comprehensive Look at Successful Global Technology Innovation**

This report analyses technology innovation models from the agriculture, health and information and telecommunications sectors. Its case studies range from projects like Human Genome Project, to the rise of the mobile phone industry, to why the Global Fund has been so successful and what can be learned from the Consultative Group on International Agricultural Research climate technology. The authors interviewed more than 40 experts from around the globe who created, partnered with or benefited from these initiatives. It explores how these strategies have evolved, especially in developing countries.

This research aims to identify the lessons and best practices from the agriculture, health and ICT sectors that can be applied to the climate technology sector to create a global climate innovation initiative.

The full report can be found at: http://www.cleanegroup.org/Publications/

Based on lessons-learned from nine case studies, this paper presents core principles and three options for a climate technology innovation initiative.

## THE TECHNOLOGY INNOVATION IMPERATIVE

**Climate recovery will require new, much cheaper technologies that serve the needs of the poor.** A solid scientific consensus predicts that billions of people, particularly the world's poorest, face threats of flooding, severe storms, drought and shortages of potable water, food insecurity, and increased risks of disease as a result of climate change.[1] Addressing the impacts of climate change and reducing future climate risks will require new technological solutions for adaptation and mitigation. ***Adaptation needs*** span the whole range of sectors from agriculture to infrastructure, water resource management to public health, many of which require cheaper technology solutions. ***Mitigation technologies*** that reduce greenhouse gas emission in developing countries will also be crucial as emerging economies grow rapidly in the coming decades. These include low-carbon electricity and transport technologies as well as farming and waste management practices. Specifically, many poor countries aim to scale energy access in the near term. Unfortunately today's technologies are not sufficient to meet these growing energy needs while reducing emissions as required.

The only way to rapidly bring down the costs and scale up these necessary climate technologies will be to ***increase innovation all along the technology development value chain***—from lab to product development, to commercialization.

The climate technology innovation needs of developing countries can be summarized into three areas:

- ***Adapt mature technologies*** to local markets
- Create and scale up ***orphaned technologies*** that do not have clear markets in the developed world
- Advance new, ***breakthrough climate technologies***

**From Technology Transfer to Technology Partnerships**
The international community has been—at least in international climate discourse—principally committed to meeting the climate technology needs of developing countries through technology transfer from the North to the South. This conception of technology transfer relies heavily on official development assistance to subsidize expensive OECD technologies for developing countries and posits developing countries as passive recipients—or at best imitators.

Developing countries have consistently emphasized ***affordability, national priority setting,*** and ***national ownership*** for meeting their climate technology needs.

Based on the theory and empirical evidence in this report, it is clear that the conventional notion of technology transfer—from North to South—needs to be challenged, if not turned on its head. The conditions for climate technology innovation in the developing world are, surprisingly, in many cases far more conducive to the invention and scaling of disruptive new technologies than in the OECD.

**Intellectual Property Rights Problems are Not Deal Breakers**

In international climate technology negotiations under the UNFCCC, the issue of protecting intellectual property rights (IPR) has been a major area of controversy between developed and developing countries—and posited as a major obstacle to technology transfer. The over-arching message from experts in the fields of agriculture, health and telecommunications is that "IP is not the most important barrier—in almost every case you can negotiate a solution."

In fact, IPR solutions for joint product development and innovation involve "normal business practices" for companies around the world—including in emerging economies.

This trend means that developing countries are and will continue to be sources of climate technology innovation. Through collaborative RD&D partnerships between Northern and Southern countries and companies, it would be possible to accelerate the process of innovation in developing countries; and also benefit the economies of the developed world in the process.

## Emerging Trends in Innovation Theory and Practice

Over the past twenty years, economic theories of technology innovation have evolved significantly with major implications for climate technology innovation. *There is little evidence to support the view that carbon pricing alone will introduce significant innovation into the climate sector*. All the evidence is to the contrary, that more aggressive interventions are required.

Moreover, from theories of disruptive innovation to new corporate practices of reverse innovation, the North-to-South transfer of technology story does not hold up anymore. There are benefits for the developed world in these trends—through them we gain access to the developing world's culture of frugality.

***Innovation Economics—real world economics that focuses on institutions.*** Innovation economics is a relatively new entrant into the field of innovation theory. It tends to focus on institutions and their capacity to be productive and efficient, so they can drive growth and innovation. Innovation economics argues for a more engaged government role to expressly adopt innovation policies that focus on institutions and the linkages between them. Innovation economics calls for direct public interventions in partnership with the private sector to encourage cost reductions, information sharing, technology transfer and institutional reform, all the elements needed to move climate technology into the commercial marketplace. This is distinctive from neoclassical economic theory, which states that by just setting the price right, through cap and trade for example, will incentivize all the innovation needed to solve climate change.

***Innovation Systems.*** Innovation systems, also called "value chain" analysis or "transition management," is a process that describes a series of sequential activities, where at each step in the process the product passing through this chain of activities gains some value. In this approach, a climate innovation initiative would look at the deficiencies in the value chain of a particular climate technology —from production, to manufacturing, to distribution, to financing—to understand where improvements and public interventions are required to bring about needed innovations to reduce costs and get products to full market deployment.

**Innovation requires independence**

As a general point about the institutional framework for disruptive innovation, to be most effective, independence is critical.

***Disruptive Innovation.*** Distributed innovation theory demonstrates that new technologies are generally introduced into niche markets where a particular customer's needs are satisfied, often at lower levels of performance and cost. At some point, the products move up the value chain, adding more performance and other characteristics through scale and learning. In a recent paper, Harvard Business School Professor Christensen and co-authors apply the theory of disruptive innovation to clean energy.[2] They argue that the first major customers for clean energy should be "*nonconsumers*"—customers in the developing world not currently served by the grid.

***Reverse Innovation.*** Reverse innovation means designing, creating, and manufacturing a product in the developing world, with its demands for lower-cost products as well as products with different performance and other characteristics. Global companies like General Electric (GE) now use this "bottom of the pyramid" market strategy to create products that are later exported to the developed world.

> *The emerging world will undoubtedly make a growing contribution to breakthrough innovations... People who used to think of the emerging world as a source of cheap labour must now recognise that it can be a source of disruptive innovation as well.*
>
> —*The Economist,* "The World Turned Upside Down." April 15, 2010.

The process of reverse innovation up-ends the conventional theory of North to South transfer of technology. *The Economist* highlighted this reverse innovation trend—sometimes called "frugal innovation"—in a summary of new innovation trends for the future.

***Open and Distributed Innovation.*** Open and distributed innovation is essentially a way to tap the "global brain." It refers to the process of linking numerous people with disparate expertise working in different institutions and countries, to accelerate the deployment of a specific technology. At the firm level, "open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas and internal and external paths to market, as the firms look to advance their technology."[3]

Sun Microsystems co-founder, Bill Joy, put the need for open innovation perhaps the most succinctly when he framed it this way—"No matter who you are, most of the smartest people work for someone else."

## CASE STUDIES

The nine case studies presented in this report support the innovation theories described above with empirical evidence. They are based on in-depth literature reviews as well as interviews with over forty experts who work within or closely with the studied organizations. These experts have provided practical lessons on pitfalls and best practices for how to structure a new international climate technology innovation initiative and how to implement a strategy to best accelerate technology innovation and commercialization.

### *Consultative Group on International Agricultural Research*

The Consultative Group on International Agricultural Research (CGIAR) has inspired much interest within the international climate discussions as a model for a global climate innovation initiative. A number of organizations, including the Indian government, the World Bank, and the World Economic Forum, have proposed structuring a network of low-carbon and clean energy innovation centers in the model of the CGIAR—to create a Consultative Group on International Energy Research.[4] Thus it is an important case study for deeper research—and clarification on its effectiveness, its impacts, how it functions, and how it has evolved over its forty-year history.

The conclusion of many of the people we interviewed who have been involved in the CGIAR is that the overarching structure of the organization is not the best model to follow. One reviewer very familiar with CGIAR went so far as to say, "CGIAR is the example *not* to emulate…" However, these same reviewers highlighted the critical importance of the research coming out of particular CG centers, the global benefits of which, over its forty-year span, have exceeded its total cost many times over.

Moreover, the recent CGIAR review and reform process offers a number of important lessons learned for any new global initiative. That is, while the entire organization may be a poor choice to duplicate, some of CGIAR's programs, in particular the successful Challenge Programs, offer operational models that may be extremely effective for climate. Their most compelling element would be an emphasis on collaboration across countries, centers, private and public organizations—a kind of distributed innovation model.

### *Global Fund to Fight Aids, Tuberculosis, and Malaria*

The Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund) is an international public-private nonprofit organization created in 2002. Its programs are widely lauded as exceptionally effective and unique in their emphasis on results and partnerships.

> *"The Global Fund has done an excellent job. It is the institution of choice for health finance. It's having a serious effect in countries—for some countries it represents 90 percent of health budget—it's having a massive effect."*
>
> - Carlton Evans, Global Funds and DFIs Department, UK DFID

Because it does not perform technology innovation itself, the Global Fund may not at first appear to be an obvious case study for global technology collaboration. However, the Fund is an important case study primarily for its unique governance structure, focus on results, and support for innovative programs and financing schemes. Because of perceived failings in existing organizations, the Global Fund's supporters created a new, independent organization and developed a governance structure and procedures unlike any existing international development institution.

In order to create inclusive governance by its constituencies, the Fund is comprised of voting representatives from donors, recipient governments, developing and developed country NGOs, communities affected by the three diseases, and the private sector. The diversity of its Board and its ability to develop creative fundraising has generated a significant amount of global popular appeal for the organization.

### *Mobile Telephone Take-Off in the Developing World*

The uptake of mobile phones around the world represents the "fastest technology adoption in human history," with handset sales volumes reaching over one billion during 2007. By 2008, one in three Africans had access to mobile telephony, and today mobile phones are spreading faster across Africa than anywhere else in the world; there are more phones and related services sold every day in Africa than in all of North America.

The rapid diffusion of mobile phones across the developing world has also radically changed perceptions about doing "good business" in emerging markets. Designing products to meet customer needs, crafting innovative business models from the ground up to achieve effective distribution, and aligning prices with what the poor are willing to pay, are some of the lessons the mobile phone story has to offer.

> *"You don't need a carbon copy of the CGIAR — but you do need to learn the profound lessons from its evolution over the past 4 decades"*
>
> - DFID Senior Agricultural Research Adviser

There has been a huge amount of innovation based on mobile phones coming out of the developing world—like mobile banking; this locally incubated innovation is a main reason why mobile phones have taken off. Contrary to convention, transferring technologies from the West to "the rest" is unlikely to suffice to achieve sustainable market uptake. Technologies that can meet local needs and that create opportunity for enhanced income generation have a greater chance at widespread penetration.

### *Agricultural Value Chains in Sub-Saharan Africa*

The share of the world's agricultural exports from Sub-Saharan Africa (SSA) is roughly 2 percent, declining from 10 percent around four decades ago (FAO 2006). Technological innovation that leads to better post-harvest handling and management practices and improved infrastructure has a high potential of helping SSA achieve these needed productivity gains.

The nonprofit organization Meridian Institute manages the *Innovations for Agricultural Value Chains in Africa* project, funded by the Bill and Melinda Gates Foundation. It was developed to bring together leading scientists (purposely from outside of the agriculture sector) with small producers in the maize, cassava, and dairy value chains in Africa in order to identify innovative "out-of-the-box" post-harvest management and processing technologies—a kind of open innovation process. The multi-disciplinary project team identified key bottlenecks and inefficiencies in the dairy, maize, and cassava value chains that became the focus of their innovation concepts.

The team then developed nearly 200 technology ideas, five of which are currently being developed into commercial products. Meridian Institute has since proposed a "Post-Harvest Commercialization Initiative," which would support the commercialization of these and other post-harvest technologies that could improve smallholder farmer food security and income in SSA.

Perhaps the most significant lesson for the acceleration of climate innovation from the experiences of agricultural innovation is the need to provide targeted support to each stage of the innovation continuum and to find ways to bridge the gaps between the different innovation stages.

### *Public Intellectual Property Resource for Agriculture*

The nonprofit Public Intellectual Property Resource for Agriculture (PIPRA) is an independent organization affiliated with the University of California at Berkeley. It was founded with support from The Rockefeller Foundation in 2003 to address intellectual property rights (IPR) obstacles in the development and distribution of poverty-reducing agricultural biotechnologies for poor countries. The fragmented ownership of IPR in the development of those technologies limited the deployment of new crops for humanitarian purposes.

PIPRA was the first and only entity with a dedicated mission to help developing countries overcome IPR problems to access new technologies. The dedicated nature of an independent organization focused on IPR remains its most critical feature, apart from the progress it has made in the programs it has implemented. Recently, PIPRA has formed a global partnership in the climate and other technology spaces to work on IPR problems. This new initiative, established in 2010, is called "Global Access in Action." The partners to this initiative include World Economic Forum, WIPO (World Intellectual Property Organization), and Global Access for Technology for Development (GATD), among others. Launch of the GAA is anticipated at the WEF in late 2011.

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Some of the key insights coming out of PIPRA case study include:

- IPR is a solvable problem.
- Project-specific IPR solutions may be more effective than global, public patent focused approaches.
- A dedicated IPR organization, with access to technical and legal expertise, may be able to most effectively solve climate technology IPR challenges.

### *Eli Lilly and Open Innovation*

Since the 1990's, the pharmaceutical industry has faced rapidly declining returns on their RD&D investment dollars. Success rates for highly capital-intensive research is on the order of 10 percent. In response, Eli Lilly, the global pharmaceutical company, created three open innovation platforms to improve its R&D productivity and efficiency.

In 2001, Eli Lilly launched InnoCentive, now a private company, as an internet-based platform that connects its clients (seekers) to a global network of registered "solvers." InnoCentive specializes in solving scientific problems for pharmaceutical, biotechnology, consumer goods, and specialty chemical companies. In 2003, Eli Lilly, in partnership with Proctor and Gamble, a consumer goods company, launched YourEncore, which connects companies with retired scientists and engineers to leverage their expertise. In 2009, Lilly launched PD2 (Phenotypic Drug Discovery Initiative), a fully-integrated pharmaceutical network where it shares disease-state assays across an open, collaborative, global team of experts.

These open innovation strategies have played an important role in drug discovery for the company—by expanding the traditional breadth of its in-house corporate R&D and allowing it to access external resources and global talent. While these tools are not a substitute for the traditional, internal models of R&D in the pharmaceutical industry, the open innovation approach has proved to be a successful additional tool for solving particular R&D problems. It has improved a solution rate of difficult technical problems from about 10 percent to about 30-50 percent, a threefold increase in success rate.

Open innovation involves a radical shift in corporate thinking—a movement from a closed internal R&D strategy to an external network of innovators.

Open innovation involves a radical shift in corporate thinking—a movement from a closed, internal R&D strategy to an external network of innovators. This new trend in drug development and open innovation are leading the way in corporate support for open innovation.

### *Product Development Partnerships*

Product Development Partnerships (PDPs) emerged in the 1990's as a collaborative public-private RD&D model to develop new vaccines and medicines for neglected diseases. Because of perceived low-profit opportunities and high risks, private companies were unwilling to invest in developing new products for diseases mainly found in poor countries—without some public support.

Today there are almost 20 PDPs working on neglected diseases from tuberculosis to HIV vaccines to malaria drugs. PDPs have had varying levels of success with the development and marketing of new health technologies—though most are credited with numerous indirect benefits—and most are still at a relatively early stage given that drugs can take decades to develop. Key lessons that come from these experiences include imperatives for funders to be aware of the long timeframes and high risks involved in innovation—and thus take a portfolio approach, taking into account the very different incentive structures of small versus large businesses for participation when developing strategies, and to address the full product development chain as early as possible.

### *The Human Genome Project*

The Human Genome Project (HGP) was established in 1990 in the United States by two federal agencies—to be joined by many others around the globe—to identify and map the 20,000-25,000 genes of the human genome and to determine the sequence of the three billion chemical base pairs in human DNA. In 2003, the complete sequence of the human genome was released, two years ahead of schedule.

The HGP was a unique model. Its commitment from the outset was to create a new scientific standard—not only would it reference an entire human genome—but this sequence would be publically available on an open source platform as soon as the information was developed, often the same day. This public database was intended to be used by the biotech and pharmaceutical industry to launch new research and commercial endeavors in the field of genomics. In fact, it is the private sector that has used the bulk of the HGP data to develop and bring new medicines to market. Also, depositing the data into an open source commons underscored the value of sharing data in a "pre-competitive commons"—where there was value in collaboration rather than commercial competition. The creation of a "pre-commercial commons" for genomic data spawned a new open source business model in commercial biotechnology and inspired subsequent private-sector commons (SNP Consortium).

Importantly, HGP was not set up as a new formal organization; but rather, from its outset, it was established as a consortium of existing national and international research centers, global experts from a variety of disciplines, and private companies. It was a loosely-affiliated network coordinated through the National Institutes of Health (NIH), US Department of Energy (DOE), and the Human Genome Organization (HUGO)—and the largest international science collaboration ever created. HGP successfully engaged multiple entities from many countries, including developing and emerging countries, in an ambitious public project that leveraged public funding worldwide.

### *SEMATECH Semiconductor Alliance*

SEMATECH is a global collaboration of government and semi-conductor manufacturers working together in the "pre-competitive" space to help the industry grow and advance. This industry consortium was started initially to strengthen the US semiconductor industry in the mid-1980's, when the US perceived competitive threats from Japan. Within a few years, the entity was so successful that it ended public support for its operations and became fully funded by its industry members. At the same time, its membership expanded to include non-US manufacturers.

The unique feature of SEMATECH is its ability to bring together companies in a fiercely competitive market and figure out ways to have them work together for their common benefit.

The critical feature of this collaboration is that it focuses chiefly on "pre-competitive" spaces—manufacturing and other product development processes—that benefit all partners, but do not at the same time infringe on their comparative advantage within the industry. It does this by bringing together all players along the semiconductor supply chain, far beyond the initial founding group of manufacturers.

> *Through the SEMATECH alliance, industry participants have learned that pre-competitive collaboration is essential in the quest for technology solutions, best practices, cost effective manufacturing, and optimal use of scarce public and private research dollars.*
>
> - SEMATECH 2009 Annual Report

## PRINCIPLES FOR LOW-CARBON AND ADAPTATION TECHNOLOGY INNOVATION

The following core principles have emerged from the innovation theories and case studies described in this report:

- ***Start by clearly defining the technology barriers and needs with end users to ensure success.***

  **Example**: World Economic Forum's Global Access in Action initiative found "Too often in the past, technology transfer for development has failed because it was supply-driven—without real attention to the technological needs of the poor. Companies, research institutes, and universities need to know specifically what the problems/barriers, how technologies will be used, and what the adoption issues are if they are going to successfully apply their knowledge and technology."

- ***Tap the global brain and bank to link global knowledge and finance with local expertise and experience.***

  **Example:** The successful CGIAR Generation Challenge Program linked experts from over 230 research labs, private companies, national agricultural extension programs, and CG centers, while the key to the successful mobile phones uptake across the developing world was the linking of native entrepreneurs (in almost all cases trained in the West) with international finance. Evolving open and distribution innovation tools (virtual networks, prize competitions, data sharing systems) and practices (multi-disciplinary teams, cross-sectoral learning) can create international networks and tap global expertise.

- ***Look to developing countries as innovators in their own right through "reverse innovation" where developing countries are not just recipients or imitators of developed country technology activities.***

  **Example:** Mobile phone innovations, like mobile banking, demonstrate that future technological innovation is likely to come from developing countries. Similarly, the Global Fund relies on program innovations to evolve from the country organizations it supports.

- ***Focus on market or product development—beyond information sharing and policy.***

  **Example:** The Agricultural Value Chains project focused on developing new products to solve specific challenges in Sub-Saharan Africa—five of the technology concepts are being pursued and one is already being commercialized. The Lighting Africa program has spurred significant poverty alleviation impacts by focusing on product development—off-grid solar lighting—rather than high-level policy changes.

- ***Systems or value chain approaches are critical to steward new technologies to market.***

  **Example:** Innovation Economics emphasizes that successful technology deployment must address all barriers along the technology value chain. The African agricultural innovations case study notes a number of technology projects were unsuccessful because they were introduced to solve a particular problem at one step in the value chain—without considering the full product life-cycle process (i.e., the mechanized cassava peeler).

- ***Build public support including high-level political support.***

  **Example:** One of the keys to the Human Genome Project's success was the high-level support it received from US President Clinton and U.K. Prime Minister Tony Blair. At the same time, HGP was able to articulate the benefits of the project to a broad audience to build congressional support for funding. The Global Fund has also been extremely successful at (and attributes some of its success to) building broad public support for its programs through public events and local support groups.

- ***Involve the private sector early and often.***

  **Example**: The public sector will never have enough money to fund capital-intensive climate technology development alone. All of the case studies have shown that the most effective innovation programs work closely with the private sector to leverage expertise, skills, and funding. In the case of mobile phones' success in Africa, local small businesses and entrepreneurs that were linked with multi-national telecommunications companies were crucial. The Global Fund includes private-sector participants on its board. The success of the SEMATECH consortium, the GSMA mobile phones industry association, and the SNP Biotech Industry Consortium that came out of the HGP demonstrates that a successful international consortium of private companies can be devised to accelerate new technologies. Working closely with the private sector on IP issues will be essential for any climate technology initiative. As PIPRA learned, it is not worth trying to work around the private sector on IP; instead, work with them to find solutions faster and more effectively.

- ***Establish partnerships between public, civil society, and the private sector.***

  **Example:** As noted above, involving the private sector is crucial to successful market creation and commercial technology deployment—getting the policy environment right is equally important. Thus a successful climate technology innovation initiative should be structured as some form of public-private partnership that includes civil society participation. All of the Global Funds programs require participation from all three sectors. GrameenPhone was created out of a joint venture of a multinational for-profit and an indigenous nonprofit, supported with development aid from Norway and George Soros. SEMATECH was established as private company consortium catalyzed by the US federal government. Exactly how the partnership is structured is likely to depend on the technology and market in question, but this should be a central focus in designing a new initiative.

- ***Treat IP as a solvable problem—and support solutions through a dedicated IPR function.***
  **Example**: In most case studies, IPR is increasingly seen as a series of specific legal problems, all solvable within "normal" business practice, rather than intractable political and policy problems that stymie new technology innovation. IPR issues should have dedicated institutional support that is demand driven. This could be incorporated within the organization, or a climate innovation initiative could partner with and support the emerging efforts of the World Intellectual Property Organization's *Global Access in Action,* as described in the PIPRA case study.

- ***Independent organizations are critical for incubating innovation.***
  **Example**: The Global Fund was specifically established as an independent entity, outside of existing organizations such as the World Bank and the UN. Similarly, the CGIAR's Challenge Programs and new Research Programs are expressly established as independent of existing CG center hierarchies.

- ***Operationally lean innovation organizations most often operate with small staff with core expertise—tapping outside, topic-specific expertise as needed.***
  **Example:** The CGIAR's new Climate Change Agriculture and Food Security program is dedicated to staying small with a core staff of 7 people working with researchers in existing institutions around the world—managing its US$70 million annual budget.

- ***A heavily networked entity is one way for an organization to stay lean, by relying on the capacity of existing organizations to the greatest extent possible.***
  **Example:** The Human Genome Project, the GSMA mobile phones industry association and the CGIAR's Challenge Programs are all examples of successful organizations whose success depended on being highly networked and pm leveraging expertise in diverse existing organizations.

- ***Multiple funding sources are critical—public funding should be "seed funding" that leverages additional private-sector and other funding.***
  **Example:** Public funding should be sought from a wide range of governments as well as private foundations and public donations. This has been a key to the success of the Global Fund, which receives funding from almost fifty countries. The Global Fund also receives significant funding from the Gates Foundation, individuals, and creative public-private fundraising programs.

## Illustrative Options For A Climate Technology Innovation Initiative

Based on the analysis of the case studies described above and the forty interviews conducted with experts, we have identified three possible options for a climate technology innovation initiative. It is important to acknowledge that this paper is only designed to provide the intellectual foundation for a much more rigorous, second-phase scoping and design process. Thus the three options described below are notional without the necessary detail to fully support them at this time. The findings of this report (and the resulting options) were explored further at an international workshop on 24th March 2011, with a wide range of interested stakeholders from developed and developing countries including governments, UN agencies, private sector, and academic institutions. This will help further develop options and prepare for the next phase of scoping and design.

## Option 1: Country Specific—Projects Only, No Coordination

This option would consist of a few country-based project initiatives that would not be supported or managed by any global coordinating organization or function. These would be distinct projects that would initiate this effort, with determinations made later about the need for any other supporting entity.

Key design elements:

- Importantly, this option would consist only of implementing projects, without any backup coordinating entity or organization.
- Projects would focus, like Lighting Africa, on climate product development in developing countries in the areas of mitigation and adaptation.
- The projects would use an "innovation systems" or "value chain" approach to identify local institutional barriers to change, and propose solutions to overcome them.

**Pros:** This process would likely be easiest to establish, with simpler institutional problems and smaller amounts of funding.

**Cons**: This approach may not achieve global scale and scope, and limits learning across projects and technologies.

## Option 2: Country Specific Projects with Global Network

This second option would consist of a light, virtual global organization—independent but perhaps linked to some other global body—that would initiate and support a few different technology/market "nodes" in select countries. The theory behind this option is that of a bottom-up, in-country strategy linked to global, open innovation architecture of experts. A combination of in-country capacity building and a dedicated, international, technology innovation support network are the essential elements of this structure. A few early projects would be started in different countries with specific technologies. The other key distinguishing feature would be a virtual team working in a global network—using various open and distributed innovation tools to tap into the "global brain" to solve implementation problems.

Key design elements:

- A Core Team would provide leadership, identify and vet specific technology concepts, strengthen networks, aggregate and share knowledge.
- Project Teams would implement projects in countries where the technologies will be deployed.
- Virtual Resources would efficiently link project teams with various experts, as needed, in the areas of technology design, finance, market analysis, policy, and IP issues.

**Pros:** A global organization, managing multiple projects in different locations and technologies, can allow for faster learning and for greater replication and scale.

**Cons:** This would be more complicated and expensive to execute than Option 1 (though perhaps less expensive than Option 3). In addition, the creation of a virtual network would be a new endeavor that would take some time to structure and put in place.

## Option 3: Central Global Organization with Multiple Projects

This third potential option would be a new centralized division or entity within an existing global organization such as the World Bank/IFC—or under the UNFCCC technology "centre"—that would rely on in-house staff to initiate and manage many technology projects in multiple countries.

Key design elements:

- It would rely on an existing organization to support the project development and implementation.
- It would likely rely on existing expertise to vet projects.
- It would possibly be able to raise funds more quickly given likely relationships with donors.

**Pros**: This option could likely be established most quickly and avoid the challenges of new organizational set up. It would be recognized by existing partners based on past performance. It would also be able to rely on past performance to argue for taking on a new responsibility and new funding.

**Cons:** This option may be less country-led and may not be able to adequately account for individual country priorities. Moreover it is inconsistent with the emerging consensus that independent organizations tend to be more capable of managing innovation.

## Next Steps – A Design Process to Establish the Initiative

Given the many variables and trade-offs involved in consideration of options, we recommend that the next step should be a design process. This could take the form of a "design charette"—a strategic planning exercise where major potential partners, funders, and other organizations are brought together in person for a several-day session to develop a framework for the global technology innovation initiative.

This effort would require new funding. It is important to address this funding question head on in the design process. An in-depth business plan should be developed that could be adopted to "stand up" a pilot as early as the end of 2011. Toward that end, this design process should start as soon as possible. Delaying the start of the design process would likely jeopardize the serious strategic planning needed to develop a collaborative and consensus plan by the end of the year, in time for the 2011 COP in Durban, South Africa.

# I. CLIMATE TECHNOLOGY NEEDS FOR DEVELOPING COUNTRIES

## The Impacts of Climate Change

A solid scientific consensus predicts that billions of people, particularly the world's poorest, face threats of flooding, severe storms, drought and shortages of potable water, food insecurity and increased risks of disease as a result of climate change. These impacts have been well documented by the International Panel on Climate Change (IPCC). These impacts may already be occurring around the world.

The IPCC's predicted climate risks of just a 1-2°C global temperature increase include:

- Reduced crop yields in tropical areas exacerbating hunger and poverty
- Spread of climate sensitive diseases such as malaria
- Increased floods followed by water scarcity for millions of people dependent on rapidly melting Himalayas and the Andes glacier,
- Sea level rise inundating small island states and destroying coastal aquifers
- Extinction of 20 – 30 percent of all plant and animal species[5]

With little historic culpability for global warming, the poor in developing countries are the most vulnerable to these impacts because they have fewer financial and technological resources to mitigate and adapt to severe change.

## Climate Recovery will require New Technologies

Addressing the impacts of climate change and reducing future climate risks will require new technological solutions for adaptation and mitigation. A number of reports and international agreements, including the Bali Action Plan, emphasize the critical importance of technology development and transfer to address climate change. The UNFCCC Expert Group on Technology Transfer has concluded that:

> The importance of technology to address the challenge of climate change cannot be overstated.[6]

In fact, the head of the United Nations announced in late January 2011 that he would no longer focus on emissions reductions strategies to address climate, but rather would work on low-carbon energy technologies and sustainable development as a top UN strategy.[7] In a 2009 *Nature* article, scientists

suggest that the scale of the "technology challenge" to resolve the climate change problem has been "seriously underestimated" by the Intergovernmental Panel on Climate Change."[8]

## Adaptation Technologies

Adaptation needs span the whole range of sectors from agriculture to infrastructure, water resource management to public health. They include hard technologies such as new construction, seawalls, and drip irrigation techniques as well as soft technologies such as planning and forecasting knowledge, and the combination of both. Adaptation technologies can also range from low- to high-tech sectors—from improved irrigation to large-scale computer modeling.

Some examples of adaptation technologies include:

- More effective irrigation methods
- Efficient desalination
- Drought resistant crops
- Improved infrastructure and building technologies to deal with greater threats of flooding and severe storm events such as seawalls and dykes for coping with sea-level rise, floods, and storm surges
- Real time flood forecasting using modeling and computer simulation and advance warning systems[9]

## Mitigation Technologies

One of the most important adaptation strategies in the coming decades will be mitigating the severity of the impacts of climate change. Thus low-carbon technologies are equally important for developing countries to ultimately reduce the severity of climate impacts. Achieving the ambitious target of limiting global warming to 2°C above pre-industrial levels, which the IPCC predicts will still result in the risks described above, will require stopping carbon dioxide ($CO_2$) emissions growth in the next decade and then beginning a rapid emissions decline. These changes are required particularly in the energy generation, buildings, and transportation sectors that are expected to grow rapidly in the coming decades.[10]

Examples of mitigation technologies in these sectors include:

- Improved renewable energy systems such as low-cost solar
- Carbon capture and sequestration for coal
- Green cement that captures carbon dioxide in its production process
- Low-carbon fuels such as direct solar fuels, biofuels from algae, and hydrogen produced from renewable sources
- Electric vehicles and trains
- Improved energy storage
- Superconducting, super efficient electric motors

## Scaling Low-Carbon Energy Access will also be Crucial

Innovations in these types of technologies are needed to replace carbon-intensive energy technologies in the developed world. Meanwhile, developing countries' economies will continue to grow and hopefully pull millions of people out of poverty by providing electricity and basic energy services. Currently, one and a half billion people have no access to electricity. Three billion people rely on traditional biomass and coal for cooking.[11] By 2030, absent significant policy changes, the International Energy Agency (EIA) predicts that at least 1.4 billion people will continue to lack energy services to meet their basic human needs. The problem is most acute in Sub-Saharan Africa, where upwards of 500 million people lack access to modern energy and rural electrification rates are a mere 2 percent.

In September 2010 the United Nations Secretary General, Ban Ki Moon, launched the target of universal energy access by 2030. He described the importance of energy access in poverty reduction and the role of energy services in meeting the Millennium Development Goals (MDGs):

> Universal energy access is a key priority on the global development agenda. It is a foundation for all the MDGs. ...Without energy services, the poor are cut off from basic amenities. They are forced to live and work in unhealthy, polluted conditions. Furthermore, energy poverty directly affects the viability of forests, soils and rangelands. In short, it is an obstacle to the MDGs.

Basic electricity access will assure that poor nations are best situated for sustained and sustainable economic development in the short- and long-term—which will make them more able to cope with climate impacts. Thus supporting energy access is another important adaptation strategy.

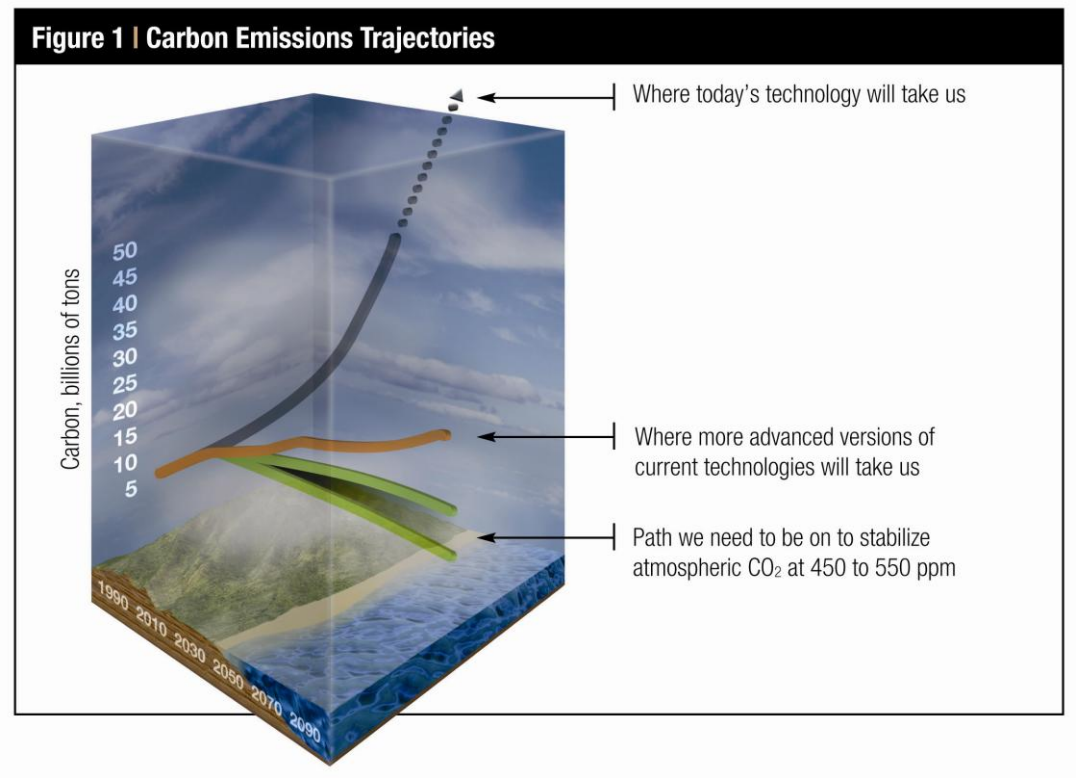
Global energy demand is projected to more than double by 2050 and to more than triple by the end of the century. Almost all of that growth will occur in the developing world.[12]

This is good news in terms of poverty relief but bad news for the planet, if that energy growth is supported by high-carbon fossil fuel energy. The energy technology decisions that developing countries make in the next few decades will have huge implications for the scale and impact of climate change for centuries.

Unfortunately today's technologies are not sufficient to meet these growing energy needs while reducing emissions as required, as Figure 1 below makes clear. Caltech professor Dr. Nathan Lewis writes: **"**Incremental improvements in existing energy networks will not be adequate to supply this demand in a sustainable way."[13]

## All of These Technologies Must Become Cheaper

While a significant number of technically feasible adaptation and mitigation technologies are available, they are not all commercially competitive without government subsidies. Work must be done to bring down those costs. Others that could provide real breakthroughs in cost and performance are still in the lab.[14]




But any drive to make technologies cheaper is not just a technical issue. Certainly, making cost improvements in the hardware through research and development and improved manufacturing efficiencies is critical. Beyond technology-focused cost reductions, creating new business models, new distribution chains, and new infrastructure for delivery of services can be important ways to wring out costs. In addition, financial engineering is essential—new finance tools that smartly use public and private funding can reduce the total cost of capital and be a crucial way to reduce end-use energy costs.

All of these measures in combination—through both "hard" technical breakthroughs and "soft" support tools —will be critical to reduce the costs of mitigation and adaptation technologies in developing countries.

## Innovation Imperative

The only way to rapidly bring down the costs and scale up these necessary climate technologies will be to increase innovation all along the technology-development value chain—from lab to product development, to business and finance models. Innovation is needed at all of these stages to increase performance and decrease costs of technologies.

It is worth noting that innovation does not refer to just early-stage technological breakthroughs in a laboratory. Indeed in the business literature, innovation can encompass the re-packaging or combining of existing technologies, and the development of new uses or business models for products, processes or services. Innovation in this context means creating commercial products that can compete in the marketplace.

## Summary of Climate Technology Priorities in Developing Countries

The climate technology innovation needs of developing countries can be summarized into three areas:

- **Adapt mature technologies** to local markets—with a focus on new business models, deployment, and commercialization strategies to overcome local challenges.
- Create and scale up **orphaned technologies** that do not have clear markets in the developed world, particularly adaptation technologies. Other examples include efficient cook-stoves, small-scale biomass conversion technologies, and off-grid lighting.
- Advance new, **breakthrough mitigation technologies**, particularly clean energy technologies like direct solar fuels, algae biofuels, carbon capture, and cheap energy storage.[15]

While these are some of the technological needs, developing countries' contexts require that they are inexpensive and that poor countries are not simply passive recipients of imported technologies from the rich world. Developing countries' priorities to reach these climate technology goals include:

- **Affordability**—Developing countries have consistently emphasized affordability as their main priority for climate technologies. According to a UN report on climate technology transfer, financial constraints are most often cited as a barrier to adoption of environmental technologies in developing countries—"the biggest obstacle is that **existing technologies are too expensive**, making the resulting services unaffordable for the bulk of the populations of non-Annex I [poor] countries."[16]
- **National priority setting**—The UNFCCC negotiations have demonstrated time and again, that developing countries are very **wary of top-down approaches**.[17]
- **National ownership**—Developing countries want to be partners and owners of new technologies, not just passive recipients. In many cases, this will require financial and technological **capacity building**.

## From North to South Technology Transfer…

The international community has been—at least in international climate discourse and agreements—principally committed to meeting the climate technology needs of developing countries through technology transfer from the North to the South.

The UNFCCC states in Article 4.5 that "[t]he developed country Parties… shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties."

The IPCC has broadly defined technology transfer to include "flows of know-how, experience and equipment" among a large range of stakeholders, without stipulating who transfers and who receives.[18] However, as the UNFCCC article clearly demonstrates, technology transfer is most often conceived as a process whereby the rich world provides expensive technologies invented in the North to the South. This dominant conception of technology transfer assumes the provision of significant subsidies and attention to IPR protection for firms in the North.

For example, one UN report on Climate Change Technology Development and Transfer flatly states:

> *The focus of implementation has generally been on creating conditions in developing countries conducive to foreign investment and building capabilities to absorb and utilize imported technologies.*[19]

Put simply, this conception of technology transfer relies heavily on official development assistance and posits developing countries as passive recipients of technology. Climate technology is then a one-way, conventional development aid strategy.

There are some critics of this approach. Some argue that technology transfer strategies need to shift from a focus on transferring "hardware" (physical equipment) toward transferring "software" to build local "know-how" and "know-why." Many reports have concluded that the existing "tech transfer mechanisms" such as the Clean Development Mechanism and the Global Environment Facility that focus on the transfer of hardware rather than "know how" encourage the consumption of existing technologies, rather than the support of indigenous innovation capacity.[20]

## …To Real Technology Partnerships

This report plainly states that this conventional notion of technology transfer from North to South needs to be challenged, if not turned on its head.

Indeed, the theory and case studies below demonstrate that many breakthrough innovations that the world needs to address climate change may very well come from the South and be transferred to the North. The conditions for climate technology innovation in the developing world are, surprisingly enough, far more conducive to the invention and scaling of new disruptive technologies than the OECD.

To this point, recent analysis out of the Harvard Kennedy School shows that emerging economies are already outspending all of the developed countries on energy innovation. The researchers found that in 2008 China, Brazil, Russia, India, Mexico and South Africa invested $13.8 billion in energy innovation, whereas, more than 24 member-countries in the International Energy Agency, including the United States and United Kingdom, only spent a combined total of $12.7 billion. Together, these six countries also consume more than one-third of the world's energy.[21] And it is not just emerging economies that have innovative capacity to lead the way, as the case study below on mobile phones shows, African and other developing countries are also developing innovations to transfer to the West.

### Intellectual Property Rights Problems are Not Deal Breakers

In international climate technology negotiations, the issue of protecting intellectual property rights (IPR) has been a major area of controversy between developed and developing countries—and posited as a major obstacle to technology transfer. The overarching message we heard from experts in the fields of agriculture, health and telecommunications is that "IP is not the most important barrier—in almost every case you can negotiate a solution."

In fact, IPR solutions for joint product development and innovation involve "normal business practices" for companies around the world— including in emerging economies.

This trend means that developing countries are and will continue to be sources of climate-related innovation. The question is whether the developed world will recognize these trends and become a partner in this new technological revolution. The notion of such a partnership could well change the nature of what is needed to produce effective global cooperation on climate technologies.

Through collaborative RDD partnerships between Northern and Southern countries and companies, it would be possible to speed the process of innovation in developing countries and benefit the environments and economies of the developed world in the process.

## The Role of Intellectual Property Rights

In low-carbon and climate-resilient technologies, the issue of protecting intellectual property rights (IPR) has been a major area of controversy. Some developing countries have advocated that IPR problems are so significant that current IPR regimes may make it impossible to achieve rapid climate technology deployment.[22] Others argue, predominantly in OECD countries, that the impact of IPR barriers in climate technology is far overstated.

In either case, those real or perceived IPR barriers need to be addressed. For this research, we interviewed a number of experts on the topic of how to solve IPR challenges that might arise—and looked to the Public Intellectual Property Rights for Agriculture (PIPRA) (Case Study #5) as a model.

The overarching message we heard from experts in the fields of agriculture, health and telecommunications is that "**IP is not the most important barrier—in almost every case you can negotiate a solution."**[23]

In fact, finding IPR solutions for joint product development and innovation involves "normal business practices" for companies around the world, including in emerging economies. One expert from the World Intellectual Property Organization put it simply this way:

> *Are there IP problems to be solved? Yes.*
> *Are they big? Not at all.*
> *Can they be solved? Absolutely.*
> *Does it take time? Yes.* [24]

Attention to global IPR solutions like public patent pools, experts told us, has proven to be a distraction. A bottom-up, problem-specific approach, rather than a top-down approach in IPR, as in other technology issues, has been the best course of action.

These experiences with IPR in other sectors could provide some guideposts for designing a similar IPR strategy for climate innovation challenges.

# II. EMERGING TRENDS IN INNOVATION THEORY AND PRACTICE

## Defining Innovation

Before moving into a practical discussion of how innovation theory works and could work for international climate technology collaboration, it is important that this description is rooted in what innovation means in the business literature. According a leading innovation expert, "an innovation in the economic sense is accomplished only with the first commercial transaction."[25]

In this paper, climate technology innovation is not meant to be just a lab invention or sharing of a new idea, but rather the *commercial use of that idea as a product in the marketplace*. For purposes of this paper, **innovation means climate technology product development and commercialization.**

## From Pricing to Innovation Economics[26]

It was Lord Maynard Keynes, the economist whose theories were credited with getting the world out of the Great Depression, who said, "…even the most practical man of affairs is usually in the thrall of the ideas of some long-dead economist."[27]

So the question is—what economic theories have in the past promoted and are now driving policy-making in low-carbon and climate-resilient innovation? The answer takes us on an intellectual tour of three economic theories, from "supply-side neoclassical" to "liberal neoclassical" to "innovation economics"—with the latter providing a framework for a new and practical innovation strategy for climate technologies. The first two theories are described as they relate predominantly to low-carbon technologies; however, the thinking that leads to a focus on pricing rather than emphasizing institutional capacity and linkages across organizations is just as relevant to adaptation technologies.

### *Neoclassical Economics—Just Get the Pricing Right*

Neoclassical economic theory suggests that simply setting a price on carbon—and raising the price of fossil fuels—will "let the markets work" by creating a price on pollution that will spur innovation and make clean energy sources more competitive. Under this theory, no further government intervention is needed to spur innovation—with the right prices, the markets will respond accordingly and develop the needed technologies. This doctrine has expressed itself in various policy solutions, from cap and trade to carbon taxes.

The underlying theoretical basis for this doctrine is that economic growth and technological progress depend on maximizing the distribution of resources throughout society. The basic thesis is that the price of goods depends on the consumer's willingness to pay, and that demand will result in the most efficient allocation of resources. In particular, this notion is premised on the belief that an efficient market is based on consumer responsiveness to price signals. So setting a price on carbon will send signals throughout the economy to which consumers will respond—presumably the higher prices on carbon will discourage demand for fossil fuels, and encourage demand for lower carbon-intensive technologies.

This principle holds, in turn, that government policy interferes with the natural allocation of capital, goods, and services throughout the economy. In sum, the proponents of this approach argue that the market will deliver the needed technology innovation with the prices set to reflect pollution externalities. No further government intervention or policy is needed.

There are many critics of this approach who argue that pricing systems alone will not create sufficient incentives for investments in needed innovation and breakthrough technologies. They tend to believe that, at best, pricing might drive limited investment in technical improvements or incremental cost reductions.[28]

### *Keynes and Climate—Pricing plus Some Government Stimulus*

This leads to a second climate innovation theory based on a more liberal "Keynesian" interpretation of neoclassical economics with some, although limited, role for government intervention.

Under this liberal neoclassical theory, markets are prone to more failure than price theorists will admit. These "market failures" justify more government intervention. This theory arguably has a more realistic view that carbon pricing alone is insufficient to rebalance the market equilibrium toward the most efficient allocation of society's resources.

In this approach, markets are quite efficient, but they tend to under produce public goods—whether roads, defense, or environmental protection—that do not respond to individual consumer demand through price incentives. There is no private market for production of these goods, so government must intervene through public funding, policy or other actions to overcome inevitable barriers to efficient markets. Their view is that government investment is crucial to induce more private sector economic growth because it induces more demand for goods and services.

Probably the most famous recent proponent of this approach in climate is Lord Stern in his much cited Stern report done for the UK government. The report strongly supports a regulated cap and trade system for carbon, creating a quasi market for carbon across the world. Under this approach, the "market" is setting the price for carbon, while inducing innovation in technology innovation through higher prices.

But Lord Stern goes further than cap and trade to support government intervention to promote clean energy technologies and related innovation. *The Stern Review on the Economics of Climate Change* agrees that carbon pricing must be complemented by measures to directly develop technologies. Stern writes:

> Governments can help foster change in industry and the research community through a range of instruments:
>
> - Carbon pricing, through carbon taxes, tradable carbon permits, carbon contracts and/or implicitly through regulation will itself directly support the research for new ways to reduce emissions
> - Raising the level of support for R&D and demonstration projects, both in public research institutions and the private sector
> - Support for early stage commercialisation investments in some sectors
> - Such policies should be complemented by tackling institutional and other non-market barriers to the deployment of new technologies[29]

Stern and his colleagues are within the neoclassical economic tradition but recommend government intervention to correct the climate market failures. Their view is that, with carbon pricing and these interventions, sufficient innovation of low-carbon technologies will occur to stabilize emissions over time.

### *Innovation Economics—real world economics that focuses on institutions*

Innovation economics is a relatively new entrant into the field of innovation theory. It suggests that these first two approaches will be insufficient to produce the scale and scope of technology innovation that climate recovery demands. Instead, innovation economics argues for a more engaged government role to expressly adopt innovation policies for more effective economic development.

Innovation economics tends to focus on institutions and their capacity to be productive and efficient, so they can drive growth and innovation. It recommends ways to look at complex institutional systems to better understand what works to shape innovation. Innovation economists suggest that price has much less to do with innovation than factors such as the path dependency of the technologies involved, or government policies in favor of the competition (in this case fossil fuels), or the role of workers and of research institutions.

> The doctrine of 'innovation economics' reformulates the traditional model of economic growth and recognizes knowledge, technology, entrepreneurship, and innovation as primary factors for economic growth rather than as independent forces that are largely irrelevant in the prevailing neoclassical doctrines.[30]

This doctrine grew out of what is called "growth economics" of the 1980s. It is a theory that criticized the limited impact of the first two theories on basic economic growth in modern economies, and offered a countervailing approach to create more innovative economic activity.

This thinking is based on the view that neoclassical innovation theory is just that—too much theory, and not sufficiently based on the real world way in which actors in an economy actually operate. Innovation economics argues that pricing theories fail to appreciate the complexities of the technology innovation process, which has been the realm of business school analysts, private firms, venture capital and other real world players who are not theoretical economists.

Put simply, neoclassical economic doctrines do not directly address innovation as a process to be studied. Rather, they simply assume that pricing will inevitably lead to more technology innovation. Innovation economics is different. It directly focuses on the process of innovation as a field of study. It figures out what works and does not work in the innovation process.

Innovation economists support an active government role to encourage learning, to support new institutions that promote innovation and the linkages between them. They tend to encourage new private and public partnerships.[31] Innovation economics would call for direct climate innovation policies, to encourage cost reductions, information sharing, technology transfer and institutional reform, all the elements needed to move low-carbon technology into the commercial marketplace.

## New Trends in Innovation Practice

Within this historical and theoretical context, there are new practical trends in innovation from companies and business schools. These trends tend to be based more on an innovation economics perspective, with its attention to how institutions do innovation and how they can do it better.

Practitioners have established a discipline of "how" innovation works in practice—establishing the rules of technology innovation for a modern economy. Several of these are relevant to climate technology. In fact, several business scholars have begun to explore how these new innovation strategies could be applied to the issue of commercialization and scale-up of climate technologies in both developed and developing countries.

### *Innovation Systems*

There are three interrelated innovation strategies that focus intensively on the institutional barriers to effective technology innovation. Their basic assumption is that successful innovation depends on a full understanding of all technical, financial, market and institutional elements—and then to target interventions geared to each specific barrier—to bring about successful technology innovation.

They are variously called "innovation systems" or "value chain" or, in the case of more systemic technology change, "transition management" strategies.

As for "innovation systems" strategies, a leading report on the topic identifies it as follows in an agricultural context:

> …the increasingly influential "innovation systems" approach, whereby, innovation—i.e., an idea, practice, or object perceived as new by an individual or other unit of adoption—is viewed as strongly embedded in prevailing social, political, and economic systems, which therefore determine what is learned, where, and by whom. Farmers, households, firms, and organizations are viewed to innovate not in isolation but rather in interaction with one another, within the context of institutions that span public and private spheres.[32]

In a similar approach, a "value chain" analysis is a process that describes a series of sequential activities, where at each step in the process the product passing through this chain of activities gains some value. Generally, the chain of activities gives the products more added value than the sum of the added values

of all activities. In this approach, one would look at the deficiencies in the value chain – from production, to manufacturing, to distribution, to financing—to understand where improvements and interventions are required to bring about needed innovations to get products to market.

A related but more ambitious strategy has been termed "transition management." This approach focuses on what is needed to bring about radical innovation—this means fundamental changes in sectors or entire economies—new regimes "involving wholly new technical functions, new knowledge bases and new organizational forms."[33] Examples of radical innovation include the transition to the information age through the advent of widely available computing power.

Transition management focuses on how to encourage regime changes, what are the different drivers and policy roles to bring about radical innovations. In the case of climate change and regime change,

> The fundamental problem facing innovation policy to prevent dangerous global warming is how to encourage a transition from a fossil-fuel economy to a zero carbon economy… The aim of transition research is to understand how more sustainable regimes might become established over time. This also involves studying how incumbent regimes become unsettled and displaced by alternatives….The governmental…focus should be less in R&D support, and more in system design, where the system is the new technological regime to be developed.[34]

These theorists say that transitions cannot be managed from the top.

> …the model of transition management makes use of 'bottom-up" developments and 'top –down' goals both at the national and local levels…The basic philosophy is goal oriented modulation: the utilization of ongoing developments for societal goals. (In order to achieve these goals), a capacity to coordinate policy intervention must therefore exist…Governments also must have an understanding of innovation dynamics: the barriers to disruptive change, the long-time periods involved…They should create a continuity in support policies. (And) besides missions for particular technologies, we need missions for system innovations…[35]

There are several examples of this transition management approach to low-carbon energy systems by the Dutch, who have created several "transition platforms" for various technologies such the built environment.[36]

### *Disruptive Innovation*[37]

The theory of "disruptive innovation" was popularized by Harvard Business School Professor Clayton Christensen in his book "*The Innovator's Dilemma*" in the mid-1990's. Under his theory, innovative technologies rarely find success by entering directly into mainstream markets or by competing on price or performance. Early success usually occurs in niche markets where the fundamental characteristics of the application are "suited to the merits" of the technology. Niche does not mean small, but refers to suitable. Technologies then often develop from the fringes to overtake the conventional technology.[38]

In disruptive innovation theory, technology innovation follows fairly well defined rules. New technologies generally come into niche markets where the customer needs are satisfied, often at lower levels of performance and cost. At some point, the products move up the value chain adding more

performance and other characteristics through scale and learning. The theory is used to explain the evolution of technologies as diverse as transistor radios, motor scooters, disk drives, and steel manufacturing.

In a recent paper, Christensen and co-authors apply the theory of disruptive innovation to clean energy. They argue that the first major customers for this form of new energy will be "*nonconsumers*"—customers in the developing world not now served by the grid. As they write, using solar as an example,

> Solar energy is both less reliable and more expensive than traditional power generation, despite its desirable environmental impact. Given its limitations, would-be commercializers of solar energy should ask themselves: where are there customers who would value a technology that generates unreliable electricity at the point at which it will be used? The answer: the rural villages of India, Mongolia, Indonesia, Tanzania, and other developing nations. These are the locations where solar energy can be successfully commercialized because it will be competing against non-consumption rather than a reliable, inexpensive power grid.
>
> In contrast to wealthy nations where consumption of electricity and gasoline is ubiquitous, developing nations are an ideal place to commercialize green energy technologies. *In these countries, there is so much non-consumption that green technologies need only be better than the alternative: nothing.* Just as Sony's transistor radio gained acceptance among non-consumers, green technologies such as solar lighting will find enthusiastic receptions in the unconnected villages of the developing world.[39]

Christensen and co-authors reach this conclusion after noting that new energy technologies will have a difficult time competing against commodity grid power for several reasons: technical intractability, system complexity, and difficult head to head competition. They also note, however, that to be successful in developing countries, companies need to create new institutional, business and other infrastructures to succeed in this "non-market" in ways not needed in the developed world. They offer three practical strategies for managers to overcome these unique challenges:

First, localize the business unit in the developing world. Second, perform a full job for customers by tying a technology to an application. Finally, fully integrate across the steps in the value chain necessary to meet the unique needs of the developing world.[40]

## INNOVATION REQUIRES AN INDEPENDENT ORGANIZATIONAL STRUCTURE

As a general point about the institutional *framework* to do disruptive innovation, to be most effective, independence is critical. That is, the institutional structure for innovation should be as independent as possible from existing, traditional institutions. This may be difficult for established and incumbent institutions to accept, but there are clear benefits to such independence. Independence encourages creativity, agility and risk taking- all necessary to encourage innovation.

Professor Clayton Christensen notes that managing for disruptive change usually requires new and independent institutions. He writes that established companies that have tried to develop disruptive innovation capabilities "have a spotty track record…"

> People with new skills can be hired, technology can be licensed, capital can be raised, and product lines, brands and information can be acquired. Too often, however, resources such as these are then plugged into fundamentally unchanged processes — and little change results.... When disruptive change appears on the horizon, managers need … an organization that is geared toward the new challenge before the old one, whose processes are tuned to the existing business model, has reached a crisis that demands fundamental change.[41]

That innovation institutions should be independent entities is an established view in the business literature. One author shares several reasons for this conclusion:

> A firm that invests in augmenting its current capabilities and maintaining its current focus might perform rather poorly in generating ideas that are outside its core capabilities.... To stimulate radical innovations, researchers are often isolated from the influence of the rest of the organization. This has become known as the 'skunk works model' of innovation. The skunk works model was the organizational design followed by IBM to nurture the by then revolutionary PC, and it is employed by many large innovative firms, such as Intel, HP and Apple, to develop potential breakthroughs.... [I]t gives researchers the necessary autonomy, independence and freedom to escape the established lines of thought and produce novel ideas.... [I]t can also help to overcome the resistance that radical innovations meet inside the organization.[42]

### *Reverse Innovation to Create Cheaper Products*

One of the most compelling and surprising new innovation trends is called "reverse innovation." This trend is far removed from purely academic theory. Rather, it is an operating strategy for major global corporations doing business in the developing world, with implications for how climate technology could develop.

Put simply, reverse innovation means designing, creating, and manufacturing a product in a developing country. The product may initially be designed to meet developing world demands for lower cost, but global companies now use this "bottom of the pyramid" market strategy to create products that are later exported to the developed world.

Jeffrey Immelt, the CEO of General Electric, and his co-authors at Tuck Business School at Dartmouth, coined the term "reverse innovation" in a recent issue of *Harvard Business Review*. The article describes two new medical devices—a $1,000 handheld electrocardiogram device and a $15,000 portable ultrasound machine—that were originally developed for markets in rural India and China. These radically cheap devices are now being sold in the US and Europe.

> We call the process used to develop the two machines and take them global *reverse innovation*, because it's the opposite of the ***glocalization*** approach that many industrial-goods manufacturers based in rich countries have employed for decades. With

> glocalization, companies develop great products at home and then distribute them worldwide, with some adaptations to local conditions. It allows multinationals to make the optimal trade-off between the global scale so crucial to minimizing costs and the local customization required to maximize market share. Glocalization worked fine in an era when rich countries accounted for the vast majority of the market and other countries didn't offer much opportunity. But those days are over—thanks to the rapid development of populous countries like China and India and the slowing growth of wealthy nations.
>
> *To put it bluntly: If GE's businesses are to survive and prosper in the next decade, they must become as adept at reverse innovation as they are at glocalization. Success in developing countries is a prerequisite for continued vitality in developed ones*.[43]

*To put it bluntly: If GE's businesses are to survive and prosper in the next decade, they must become as adept at reverse innovation as they are at glocalization. Success in developing countries is a prerequisite for continued vitality in developed ones.*

Reverse innovation up-ends the conventional theory of North to South transfer of technology—that climate technologies will be invented in the North and must be subsidized to make their way into developing country markets. GE argues that reverse innovation will become more and more common and as a consequence, technology transfer increasingly will be South to North.

*The Economist* highlighted this reverse innovation trend - sometimes called "frugal innovation"—in a summary of innovation trends for the future:

> Developing countries are becoming hotbeds of business innovation in much the same way as Japan did from the 1950s onwards. They are coming up with new products and services that are dramatically cheaper than their Western equivalents: $3,000 cars, $300 computers and $30 mobile phones that provide nationwide service for just 2 cents a minute. They are reinventing systems of production and distribution, and they are experimenting with entirely new business models. All the elements of modern business, from supply-chain management to recruitment and retention, are being re-jigged or reinvented in one emerging market or another….
>
> *The emerging world will undoubtedly make a growing contribution to breakthrough innovations... People who used to think of the emerging world as a source of cheap labour must now recognise that it can be a source of disruptive innovation as well*.[44]

*The emerging world will undoubtedly make a growing contribution to breakthrough innovations... People who used to think of the emerging world as a source of cheap labour must now recognise that it can be a source of disruptive innovation as well.*

It is not just new products, but new business models, which will likely come from emerging markets, according to experts writing in a just issued 2011 *Harvard Business Review* article.

> Many companies view emerging markets as one large foothold market, and in this they are right. Classic disruptive innovation theory holds that, ideally, innovations should first be introduced in markets where the alternatives fall short on some dimension (typically price) or are utterly unavailable. Emerging markets fit that bill in spades. They are excellent arenas for trying out product innovations far from competitors' prying

> eyes. *But we are convinced that a much greater opportunity lies in viewing these markets not as one vast lab for product R&D but as unique environments filled with poorly done jobs that could be creatively addressed with business model R&D.*[45]

It seems inevitable that reverse innovation will be applied to low-cost climate technologies. The emergence of China as a preeminent manufacturer and exporter of low-carbon technologies seems just the beginning of this emerging reverse innovation trend throughout the developing world.[46]

***Open and Distributed Innovation***

Distributed and open innovation (DI) is the final trend in innovation theory and practice that merits highlighting. It refers to the process of linking numerous people with disparate expertise working in different institutions and countries, to accelerate the deployment of a specific technology. The business literature defines DI as "the process of managing innovation both within and across networks of organizations that have come together to co-design, co-produce and co-service the needs of customers."[47]

At the firm level, "Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology."[48]

## INNOVATION PRIZES

Innovation prizes are an important tool to tap distributed knowledge and expertise and fit within the open and distributed innovation trend. This area has been widely studied and is the subject of an excellent, new report from DFID.[49]

The idea behind inducement prizes is really simple: incentives matter. The larger the potential reward, the greater the incentive. Inducement prizes do this by offering rewards for pre-specified scientific or technological achievements, such as the solution to a mathematical problem, a device or method to perform a particular function within given parameters, or the completion of a particular task. [50]

Prizes can be an effective complementary tool that could work within the various innovation theories now used in modern product development, and in new strategies in developing countries.

Experts believe that prizes could be useful to promote climate technology innovation.

> *Instead of doling out billions to researchers in the hope they will invent something that will help solve the global warming challenge, the government should offer substantial rewards to* those *who invent or develop technologies that solve particular climate related problems.....Whatever their faults in other contexts, prizes are particularly well suited to the climate policy challenge*.[51]

They also believe that innovation in developing countries may well be suited to artfully crafted prizes. But they should exhibit performance outputs that recognize local conditions, include in country expertise, and are considered as part of a portfolio of investments, not a "silver bullet" that will solve climate problems in poor countries.

In describing this “open innovation” strategy, it is important to avoid some misconceptions. Some have confused “open innovation”—which is essentially a way to “tap the global brain”—with “open source” software or research development. While they share a philosophical approach, they are quite different in practice. Open source typically means communal development of a free good—for example, software that has been placed in the Internet commons for anyone to program and improve. There is no proprietary ownership of the product; anyone can download it and use it for free. In contrast, open innovation is a process of developing products using internal and external sources, but within a proprietary framework—products are still protected through patents or licensing and are not free to the world. It is the process of collaboration that is “open” in both senses, but the products of the process are treated quite differently.

DI has evolved in response to the changing economic and information landscape of the 21st century—knowledge is widely distributed, workers are more mobile, funding can come from venture capitalists outside an organization, and, because of the internet, creativity can be quickly tapped from experts around the planet.

University of California-Berkeley Business School scholar Henry Chesbrough contrasts the old paradigm, which he refers to as “closed innovation,” with the “new era of open innovation.” Open innovation refers to a new model of innovation whereby firms seek ideas from a variety of sources such as product users, universities, startup companies, and so on. In addition, the open innovation paradigm acknowledges that many ideas that originate inside corporate boundaries never commercialize and that firms need to develop more proactive strategies to reap benefits from these hidden assets by licensing to other organizations and finding ways to leverage ideas outside the firm’s boundaries (through corporate entrepreneurship, for example).[52]

Open innovation refers to a new model of innovation whereby firms seek ideas from a variety of sources such as product users, universities, startup companies, and so on.

The central idea behind open innovation is that in this new era companies—and we argue public organizations—cannot afford to rely entirely on their own research or resources.

Sun Microsystems co-founder, Bill Joy, put it perhaps the most succinctly when he framed it this way—"No matter who you are, most of the smartest people work for someone else.”[53]

DI strategies take advantage of the rapid increases and distribution in knowledge and advances in electronic communication that characterize our modern world. Companies use DI strategies to tap knowledge outside their institution and link together innovators, researchers, financiers, and others from around the globe to support the development and deployment of new technologies. They link RD&D to viable commercialization strategies. These are not conventional information sharing networks, but an entirely new approach that goes beyond linking existing institutions; it makes them work in new collaborative ways.

## MATCHMAKING COMPANIES

The use of open innovation has spurned the creation of many private sector companies. They act as "matchmakers," "solution providers" or "innovation intermediaries" to bring entities with problems together with entities that can solve those problems. Matchmaking companies include InnoCentive, YourEncore, NineSigma, Innovation Exchange, Oakland Innovation, Science24Seven and many others. These companies differ widely in their breadth, topical focus, business model and value proposition, a few of them are described in more detail in the Case Study #6 on Eli Lilly Pharmaceuticals.

They connect "seekers" who are encountering specific technology development challenges with "solvers" who can help address these problems. Those posing the development challenges may be, for instance, engineers within small or large technology companies, government researchers or academics. The solution providers might include those same kinds of individuals as well as a range of other scientists and technical experts working at different organizations, including institutions from other sectors. These tools enable potentially tens of thousands of people to review challenges and propose solutions.

DI is a new term in climate but one well known in other private and public sectors, from pharmaceuticals to consumer and agricultural products. In fact, DI strategies have been used to develop products, services, and scientific breakthroughs as diverse as the iPod, the Linux operating system, the Human Genome Project, automobiles, pharmaceuticals and drought-resistant crops in the developing world—as a few of the case studies below will describe in detail.

Some innovation experts have called for use of open innovation to promote low-carbon technologies:

> … progressive climate innovation tends to go beyond the capabilities and capacities of any single company in the industry sector... In order to respond proactively, companies need to embrace Open Innovation practices that link clusters of firms and other institutions (e.g. universities and authorities), within collaborative efforts, designed to create the necessary transformations across industries and along value chains. Those companies that are among the first to manage the integration of sustainable and open innovation strategies stand to acquire the competencies required to render their technologies and business models robust and climate-proof and, hence, to gain substantial first-mover advantage.[54, 55]

As experts in the field have noted, distributed innovation lowers the costs of innovation and often provides better solutions than internal only processes.

> Distributed innovation systems are organized so as to lower the costs of participation for contributors. Reducing or eliminating barriers to entry expands the population that can self-select into the community. …Co-creation not only limits the cost to individuals, but also, because a broader base of knowledge and perspectives is brought to bear in the creation process, tends to produce more robust innovation.[56]

*Those who would adopt or create a distributed innovation system, however, must be prepared to acknowledge the locus of innovation to be outside the boundaries of the focal organization. And this will require a fundamental reorientation of views about incentives, task structure, management, and intellectual property.*

They warn also that

> Those who would adopt or create a distributed innovation system, however, must be prepared to acknowledge the locus of innovation to be outside the boundaries of the focal organization. And this will require a fundamental reorientation of views about incentives, task structure, management and intellectual property.[57]

### VIRTUAL GLOBAL NETWORKS

Sharing information and managing innovation across companies, countries and sectors raises challenging questions—what is the right governance and organizational model? Recently, the answer most often is through virtual networks rather than new bricks-and-mortar institutions.

> An innovative network refers to a number of digitally connected and technologically sophisticated companies, organizations and intermediate agencies ... Usually, a network is dominated by large global corporations and surrounded with its multinational subsidiaries, contractors, strategic and technological partners, suppliers and consumers in its value chain. It also could be a government, university and industry (GUI) alliance.[58]

Many companies and organizations are looking for substitutes to the traditional, structural fix: a centralized organization to manage product development and innovation. In an increasingly global economy, with ever increasing cost pressures, and with the benefit of the latest technology, virtual networks are an attractive if not essential option.

Managing those networks in the corporate sector tends to depend on virtual processes, rather than setting up new divisions or operating arms.

> The emerging forms of technology make certain kinds of personal contacts possible in the virtual networks. Increased dispersions of R&D, design, engineering, and technical support both national and international wide [and] increased global customers…favors global virtual networks… Innovation is no longer an isolated R&D activity.[59]

## INNOVATION LESSONS THAT BRIDGE THE GAP FROM THEORY TO CASE STUDIES

The innovation trends described above are not just theories. They are the way modern corporations practice product development around the globe. They are not necessarily separate and distinct strategies but rather are seen often together as a group of approaches—a combination of disruptive, systems, reverse and open innovation, all working together in a complementary fashion.

There are some basic lessons to be derived from this summary of emerging innovation theory and practice.

- **Direct public interventions—beyond pricing are needed to accelerate climate innovation.** There is little evidence to support the view that pricing alone will introduce significant innovation into the climate sector. Rather, more aggressive innovation interventions are required. The theories of transition or systems innovation suggest that we have a long way to go to create a climate resilient, low-carbon, global economy. Fundamental innovation at all levels of society and throughout technological systems will be needed—to reduce costs, create new products for underserved customers, and to create new business and financial models. Simply subsidizing existing technologies is insufficient to stabilize climate emissions.[60]

- **Climate technology innovations will increasingly originate in the developing world – North-South partnerships should support this trend.** From theories of disruptive innovation to new corporate trends in reverse innovation, the North to South transfer of technology story does not hold up to future product development trends. Increasingly, South to North and South to South climate technology transfer should be part of any technology cooperation regime. Developing countries should be considered partners in climate technology innovation, and indeed, as initiators of innovation and technology development.

- **There are benefits for the rich world in these trends**—through them we gain access to the developing world's culture of frugality. The rich world needs cheaper climate technologies to meet the ambitious targets set by climate science and our governments. New technologies are up against powerful incumbent industries in the rich world—hampering our incentives to develop new technologies and build markets—and economic pressures are limiting the political will to pay for more expensive clean technologies. Many developing countries don't have this industrial/infrastructure legacy. Moreover, as the theory and case studies below show, innovation in the developing world is focused on ultra-low cost "frugal innovation"—this is exactly what the rich world needs for low-carbon technologies to compete and overcome political pressures.[61]

- **Practical innovation tools and strategies are in use in other sectors that could speed collaboration and climate technology innovation**—if put to use in an effective initiative. In fact, innovation practitioners have already begun to apply these strategies to climate.

# Cast Study #1: Consultative Group on International Agricultural Research

## Introduction

The Consultative Group on International Agricultural Research (CGIAR) has inspired much interest within the international climate discussions as a model for a global climate innovation initiative. A number of organizations, including the Indian government, the World Bank, and the World Economic Forum, have proposed structuring a network of low-carbon and clean energy innovation centers in the model of the CGIAR—to create a Consultative Group on International Energy Research.[62] Thus it is an important case study for deeper research—and clarification on its effectiveness, its impacts, how it functions, and how it has evolved over its forty-year history.

Of the people we interviewed who have been involved in the CGIAR, many have concluded that the overarching structure of the organization is not the best model to emulate. One reviewer very familiar with CGIAR went so far as to say, "CGIAR is the example *not* to emulate because it is so incredibly politicized. It is very inefficient. Overhead is half the budget." The reviewer pointed to the historical structure of the centers as a challenge.

However, these same reviewers highlighted the critical importance of the research coming out of particular Consultative Group (CG) centers.

Moreover, the recent CGIAR review and reform process offers a number of important lessons learned for any new global initiative. That is, while the entire organization may be a poor choice to emulate, some of CGIAR's programs, in particular the successful Challenge Programs, offer operational models that may be extremely effective for climate—but of course if not for the network of centers the Challenge Programmes might not have a foundation on which to function. Their most compelling element would be an emphasis on collaboration across countries, centers, private and public organizations— a kind of distributed innovation model. As an agricultural expert from DFID noted:

> You don't need a carbon copy of the CGIAR—but you do need to learn the profound lessons from its evolution over the past four decades.[63]

## History

The Consultative Group for International Agriculture Research has its origins in agricultural research centers established in the 1950's through funding by the Rockefeller and Ford Foundations. CGIAR was established in 1971 as a loose network of four agricultural research centers in developing countries. The concept was for donors, private and public, to more effectively coordinate their support for agricultural research in the developing world and for the various centers that were evolving to share resources and experiences. By 2000, the CGIAR network evolved into a coalition of fifteen autonomous, legally independent research centers—loosely guided by a partnership of 64 members that include 21 developing and 26 developed countries, four co-sponsors, as well as 13 other international organizations.[64]

The mission of the CGIAR is to "to achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, forestry, fisheries, policy, and environment."

Until 2010, the CGIAR was not a legal entity. The World Bank hosted the secretariat for this informal partnership among governments, private foundations, and international organizations and provided a series of 'virtual' offices services for the centers which took advantage of these to varying degrees. At this time CGIAR funding and research was not centralized. The donors gave money to each center independently, and the CGIAR budget was the aggregation of these bilateral donations.

Today, the CGIAR is in the midst of a dramatic reform process. After a multi-year review and stakeholder consultation process in 2010, the CGIAR totally restructured itself from the center-driven informal partnership to become a two-pillar organization: a Consortium of CGIAR Centres that is now a legal international entity, and the CGIAR Fund, which is held in trust by the World Bank.

## The CGIAR's Historical Impacts

A 2008 independent review of the CGIAR concluded that the CG centers' "research has produced high returns since its inception, with overall benefits far exceeding costs... Even under the most conservative assumptions, they far outweigh total research expenditures of $7.1 billion since 1960 (expressed in 1990 dollars)."[65] But the same review noted that the CGIAR "suffers signs of age."[66]

The CG system was very successful early on in developing specific improvements in important crops—initially sorghum, rice, and wheat. These programs were very successful; the varieties developed at CGIAR reached penetration levels of more than 50 percent in Asia and Latin America.[67] CGIAR system became less successful when it moved away from a crop development focus to address broader agriculture related issues such as gender and poverty.

The reforms since 2000 are in many ways a direct response to this mission creep, to move the organization back towards more concrete product development goals. Despite its early success, CGIAR's accomplishments have slowed in the past few decades because of "increasingly fragmented and restricted project and Center based programming and funding."[68] The traditional loosely networked

"centers of excellence" approach was not capable of solving the complex agricultural challenges facing the developing world today.

***A Much Needed Reform***

The CGIAR has undergone two major reform processes. These reforms were instigated for a number of reasons, most importantly because donors felt the returns on their investments were declining—CGIAR research wasn't achieving high impacts or efficiencies. To address donor concerns, the reforms sought to create simple and effective investment mechanisms that required less direct oversight. Many donor countries, like the UK, have less staff to manage more funding—they can't micromanage projects. Instead, they needed effective investment mechanisms. That is why they wanted to create a centralized fund that was independently managed.[69] Thus the reforms were enacted because:

- ***Donors wanted more coordination and a greater results focus*.** Every review of the CGIAR in the past decade has recommended stronger central coordination of funding and a tighter link between priorities, performance, and fund allocation. As one expert from DFID noted that donors were not working together. They were funding individual projects and centers. And for this reason they were not able to achieve a collective efficiency. There was no emphasis on a results-focus for the research. There was mission creep. CG centers were lacking real alignment in terms of priorities. Moreover, many Centers lacked transparency in their accounting systems—donors could not see the results of their funding. According to one comment, "*There were over 60 donors and 15 centers working more or less independently with hundreds of stand-alone research projects."*[70]

- ***The CG Centers need to shift from a focus on institutions to issues.*** Some centers were becoming more focused on institutional survival than results with global relevance**.** This perspective from experts inside the CG system was frequently repeated: "The system has become way too insular and institution-focused."[71]

  > The reform is about getting away from the institutions, from each center doing its own thing, to focusing on the issues… because at the end of the day who really cares about the institutions. It should really be about the research work and the issues.[72]

- ***The research landscape has changed significantly since 1971***. In the almost forty years since the CGIAR was established, many national research centers in developing countries had gotten much stronger. At the same time the world has become more "networked." Today, it is much easier to rapidly tap information and skills around the globe. The independent review noted that the world is made up of increasingly complex systems and interdependent institutions. Science depends on uptake by a wide variety of partners.[73] For these reasons, there is now a need for CG centers to work closely with these national centers and international experts.

  > It's a very different world from when the CG started – the model of the CG was created in the 60 and 70s when you probably couldn't even make an international phone call from some of the centers. So everyone needed their

> own complement of specialists, it needed to be duplicated everywhere, because you couldn't send samples around—but now the way the world is changing there are companies in China that could probably do that much cheaper than having your own staff. **You don't need your own bricks and mortar lab in every region in the 21st century**.[74]

- More over there was ***a need to encourage more cross-cutting partnerships and collaborations.*** "The priority challenges are becoming more transnational in scope, putting a premium on regional and global collective action and on the development of international public goods."[75] "All this heightens the need for coordinated efforts across sectors and institutions."[76]

The first reform period attempted to centralize some back office services for CG centers in the CGIAR Secretariat at the World Bank and led to the creation of the Challenge Programs in 2001, described in more detail below. However, the CG donors determined that this early reform didn't go far enough, so in December 2008, the CGIAR decided to significantly change its governance structure in order to establish a results-oriented research agenda, clarify accountability across the system, and streamline governance and programs for greater efficiency.

The reform process, however, has not been easy. CG Centers are reluctant to give up their special status and funding. There is a lot of institutional inertia and historical baggage. But by establishing incentives that reward working as a cohesive system over centre-centric behaviors, these will eventually become a thing of the past.

## New Structure

Since the earlier reforms did not produce the desired results, the CGIAR has been changed again, now divided into two separate entities: the CGIAR Center Consortium and the CGIAR Fund. The reform has also established an Independent Science and Partnership Council to review and evaluate programs and a Strategic Results Framework upon which the work programs will be based. This new organizational model will take a **more programmatic approach**—initiating large research programs that will "bring CGIAR scientists and partners together to address critical issues and deliver international public goods that advance global development objectives."[77]

- The **CGIAR Center Consortium office** will be based in Montpellier, France and taken out of the World Bank. As the review recommended, "the World Bank needs to disengage from operational management of the CGIAR network of Centers."[78] The consortium secretariat will analyze the centers' administrative needs and attempt to centralized back office services for the centers to improve efficiency. The Consortium will allow for the CG centers to coordinate their research priorities and speak with one voice to the donors.
- The **CGIAR Fund Council** is a representative body of all the public and private foundation funders. It is chaired by a Vice President of the World Bank and comprises eight representatives of donor countries, eight representatives of developing countries and regional organizations and six representatives of multilateral and global organizations and foundations. Before the reform, all 64 members of the CGIAR needed to reach consensus. Donors noted that this was a very

cumbersome process, though it was more representative. The Fund Council is informed by the Funders forum, in which every donor is able to participate. But ultimate funding decisions are left up to the Fund Council.

- An **Independent Science and Partnership Council** (ISPC) consists of a group of nine leading global scientists who are appointed by the Fund. This ISPC plays a key role in the programming and strategic process, as well as in quality awareness and control. It makes sure that the research programmes are aligned with the strategic research framework of CGIAR. It is based in Rome.
- A **Strategic Results Framework** was developed in consultation with hundreds of governments and civil society groups, which identified eight major areas for the CGIAR Fund to focus their funding.
- **CG Research Programs.** The main channel of donor funding will be through ten to fifteen major global programs. The focus of these programs comes directly out of the Strategic Results Framework. Based on these defined areas, the CGIAR Consortium will put forward Research Programs that define a lead center but incorporate research from other centers and partnerships from organizations outside the centers. The rule of thumb is for 30 percent of funding to flow to partners. The CGIAR Fund will then review the proposals, with the advice of the ISPC and develop a performance contract based on delivery of results for the CGIAR Consortium. The first CG Research programs were approved and initiated in late 2010—one on improving rice crops and the other on climate change, agriculture, and food security (CCAFS). As an example of the scale of these programs, the Rice program will receive US$120 million per year for 20 years. Over 400 partners are included. By comparison, the annual budget of the lead center is around US$30 million per year. CCAFS is a strategic partnership between CGIAR and the Earth System Science Partnership (ESSP). Main staff is located in Columbia and Copenhagen. CCAFS has an annual budget of US$70 million for ten years, with only seven full-time staff to coordinate and direct the funding. Most of the funding will go directly to programs and research and 35 percent is intended for partners outside of the CGIAR.[79]

## Generation Challenge Program

The CG Research Programs are in many ways an expansion of the successful CGIAR Challenge Programs that were initiated during the earlier CGIAR reform. These were initiated to encourage cross-cutting partnerships among CG centers and other partners and to emphasize concrete results. They addressed "the need for the System as a whole to take on global challenges in cooperation with a wider range of partners."[80]

> A Challenge Program is a **time-bound program** of high-impact research that falls within the scope of the CGIAR mission, seeks to resolve complex issues of overwhelming global and/or regional significance (and, if the latter, with global impact), and **requires partnerships** among a wide range of institutions **to develop and deliver its products**.[81]

The Generation Challenge Program (GCP) was established in 2003 as a ten-year program with the objective to produce better crop varieties for poor farmers, making use of innovations in plant genetic diversity, advanced genomic science, and comparative biology.[82] The GCP does its work by tapping into the diversity of gene banks in the CG centers and partner organizations across 18 crops. Before the GCP, there was very little synergy and learning across differing varieties of crops as the CG centers were established to address specific crops. The GCP consortium, made up of 18 members—seven CG centers along with 11 universities—and national agriculture programs in the developing and developed world totaling 230 institutions, has contributed to strengthening agricultural research efforts. It is funded by national governments, multilateral institutions, and private foundations.[83]

### *A Distributed Innovation Approach*

The GCP exemplifies the application of a collaborative, distributed innovation approach for a global public good.

***Product Focus**:* The GCP was created to better link "upstream," research activities with "downstream" activities (product development, testing and deployment). The GCP is designed to drive research from the laboratory to the market- to develop tools and technologies that help plant breeders in the developing world produce better crop varieties for resource-poor farmers.

> Each GCP project is designed with embedded product Delivery Plans and clear impact indicators. The project impact pathway is thus identified and articulated at project inception. These plans are jointly conceived with product users, taking into account local priorities. Product design and development are thus driven by relevance to, and feedback from, users … developing country institutes, universities and small and medium enterprises.[84]

***Partnerships across the value chain and around the globe:*** GCP has built partnerships that link discovery science with applied research through a broad network of plant scientists from diverse backgrounds, working in international and national agricultural research—at CGIAR Centres, in academia, and in regional and national research programmes.[85] The management team for GCP was also distributed around the globe, with some managers working half-time with their home institutions.

Through these partnerships, GCP "brings together different partners who collectively achieve far more than any single institute working on its own." According to a 2008 review, GCP's emphasis on partnership has nurtured a "spirit of community and cross-fertilisation of diverse ideas."

> Perhaps the most important value of the GCP thus far is the opportunities it has provided for people of diverse backgrounds to think collectively about solutions to complex problems and in the process to learn from one another.[86]

> When new partnerships form, new paradigms, and even science, emerge that could never have been achieved by the individuals alone. It is trans-disciplinary; much more than simply having people of different disciplines working together. Completely unexpected information and understanding have emerged when diverse CP participants meet, leaving behind their preconceived disciplinary or institutional notions, biases and knowledge. *—A CP project leader.* [87]

***Competitive and commissioned research:*** The CGP has used both competitive and commissioned research. About 30 percent of CGP funding has been through competitive grants. A 2008 review concluded that competitive grant projects have been successful in expanding partners and establishing linkages among partners. They are particularly useful during the early research stages to identify partners and research outside of known circles. However, they did find some drawbacks to competitive bidding- particularly because of a lack of flexibility in procurement rules—and recommended that later in the CP program it would be useful to shift to more commissioned research for continuity.

### *Outcomes*

The GCP is on track to shut down operations in 2013, having "contributed considerable scientific information on genetic diversity" for important crops for poor farmers.[88] GCP's 1st External Programme and Management Review, however, concluded that "Perhaps the most important value of the GCP thus far is the opportunities it has provided for people of diverse backgrounds to think collectively about solutions to complex problems and in the process to learn from one another." The same review recommended that in the last five years of the program, GCP should take an even more end-product oriented approach in order to achieve more concrete product results from the program by 2013.

### *Challenges within GCP*

The 2008 review also recommended some **governance** reforms, concluding that the GCP needed a more independent board. Originally, the board was made up of representatives from the 18 members, which created resulted in several challenges.

First it was difficult to have a constructive, efficient discussion with so many agendas and vested interests at the table. But more importantly these initial partners wanted to keep control of the money—"they were just dividing the pie among the centers again."[89] For these reasons, the GCP shifted to an independent executive board made up of seven members who were not involved in any research or CGIAR business for at least five years.

Second, the GCP also came up against bureaucracies—internally, overtime the programs needed more staff than originally intended. But more importantly, it was beholden to the World Bank's procurement rules, which didn't afford enough flexibility, for example, to adapt competitive grants. One manager noted that "it became very tiring, lots of admin and little science."[90]

Third, the GCP also did not work as effectively with the private sector as expected. On the positive side, formal agreements have been passed with marker service laboratories (KBioscience, DNA LandMarks) to develop suitable markers for large-scale genotyping, in particular for less-studied crops such as legumes, and attractive prices have been negotiated for GCP partners as the Programme is promoting the outsourcing of routine genotyping for all its projects. Despite that effort and even though representatives from several multinational seed companies are members of the different GCP scientific and advisory committees, collaboration with these large companies and the ability of the GCP to access technologies, tools, or germplasm remained extremely limited. The main reasons for that are 1) research collaborations with the private sector works better on a bilateral basis, and the GCP represents

a broad consortium of partners with diverse interests; 2) the GCP IP policy does not allow exclusivity rights; and 3) the capacity building mission of the GCP and its objective to support active partnership are not always optimal conditions to tap efficiently into private sector resources and services. Therefore, for specific research projects, the GCP spent much more for research that could have done more efficiently and cost-effectively by private companies.

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

All of the lessons detailed below have important implications for any effort to structure a climate technology innovation initiative. One clear message from a review of the CGIAR is to avoid a simplistic view of the organization—a more nuanced approach is needed to assess the complexity of the organization, its history, and its results. Each Center was designed and implemented differently; each takes a different approach to its job. However there are number of consistent messages about the CGIAR, the GCP, and the reform process that come out of hours of interviews and hundreds of pages of reviews.

**Importantly, the reasons for reform in the CG systems are just as relevant for climate technologies as for agricultural research**. As the first sections of this report highlight, today there is more capacity in developing countries, we live in a more networked world with more complex challenges, and there is a more important role of the private sector in these technologies. All this heightens the need for coordinated efforts across sectors and institutions.

- **Need for central coordination of funding and research.** Every review of the CGIAR in the past decade has recommended stronger central coordination of funding and a tighter link between priorities, performance, and fund allocation. This is needed to reduce inefficiencies; however, there seems to be an intrinsic tension between country priorities and centralized global coordination of efforts. A key lesson that will be applicable to climate is the need for some kind of strong, central coordination of research efforts—whether working with new or existing organizations.

- **Need for results oriented research and funding.** Many reviews and interviewees emphasized that research should be output oriented. Donors should "buy" research products. They need a competitive market for research. This is a very different approach from just giving money to an institution. The experience of the Challenge Programs has shown that the impacts have been strongest for those Challenge Programs (CPs) with discrete and concrete product development goals- like the Generation Challenge Program and Harvest Plus. They have found less impressive results from the CPs that addressed broader more flexible goals—like the regional Sub-Saharan Africa Challenge Program. In order to monitor for results, agencies need proper management systems such as accounting, digital, or online systems. This came up as a frequent problem and a cause of inefficiencies and exasperation by some interviewees from the CG centers.

  But there are some voices critical of this kind of results-oriented funding. One academic fears that "A new generation of private donors and foundations with funding allocations restricted to

their own priorities and with research compliance cemented by performance-related contracts narrows the scope for free and collective searches for innovative technology."[91] Reviews of the CPs recommended having flexibility in the design and outputs of projects as learning happens throughout the network.

- **Beware of creating special centers with special rights.** The CGIAR system has struggled to take on broader global challenges that require coordination between and outside of CG Centers. Donors have also struggled to bring in a more competitive approach to improve performance or to achieve efficiencies across the centers. The CGIAR Centers have resisted these changes because they are ultimately autonomous legal entities, focused on keeping themselves functioning and their researchers paid. At the same time, the CG Centers rely almost completely on CGIAR donor funds—comprising about 70 percent of Center budgets. The reviews repeatedly report that Centers don't want to compete with research centers outside the CGIAR. They see this money as theirs. Interviews consistently supported the view that CG centers became much more focused on their own survival rather than results.

> There's a huge amount of energy that goes into promoting each individual center. This also leads to a lot of the squabbling over the funds.[92]

Unfortunately for the CGIAR, it faces a legacy problem, such that CG centers have resisted the reforms necessary to succeed in this changing world. But one interviewee noted that in the case of climate technologies, "you have a better starting point, you don't have to create centers with a special relationship to a fund."[93]

- **Work with existing institutions when possible; build capacity as needed through a possible accreditation system.** A number of interviewees recommended that a new climate initiative should work with existing institutions. But make sure they have multiple funding streams so that they don't become dependent on one funding source—and so that you can encourage competition. The individual work of the CG Centers has been essential—and indeed there may be gaps in climate technology innovation capacity in particular countries that will require the set up of new centers. But where existing institutions cannot be strengthened, new centers should be set up in a competitive environment and have multiple funding streams.

However, one of the benefits of the CG Centers is that donors know easily who to fund—out of a pool of hundreds of possible awardees—they have some kind of assurance of quality. One interviewee suggested that in order to "separate the wheat from the chaff," an accreditation system could be established. This could be used to both build capacity for existing institutions and create a number of quality assured institutions.

> Forty years ago there was a dearth of scientific capability in developing countries around the world – the CGIAR filled that crucial gap – if you were starting with a blank page today there would be no need to go around building research Centres from scratch – with bricks and mortar.[94]

In fact, bricks and mortar centers may actually be more important in the agricultural space where plants need to be tested in the field or in a controlled environment; this may be less important for most climate technologies—where labs may already exist for testing.

> I think the more spread out, the more open access system is the way to go.[95]

- **Include downstream deployment and product development in projects.** Many reviews of CGIAR emphasized that research funding should be explicitly linked to product deployment. CG centers focus on the early-stage research rather than deployment—they leave that stage up to national extension agencies, with mixed results. Some interviewees saw this as a weakness of the system. The successful Challenge Programs explicitly included an emphasis on downstream product development in their program design. But it must be noted that this later stage work can be expensive and requires a long-term commitment from donors to see results; in some cases, they will not be evident for 10-15 years. Any climate initiative should focus on the whole technology value chain, including business models for deployment, to get needed technologies into the market.

- **Structure funding and governance to incentivize collaboration.** As the experience of the GCP has shown, governance structures matter. Incentives for boards and grant applications must be neutral, otherwise institutions will be more focused on self-survival. Under the former funding structure, CG centers had no incentive to collaborate among themselves or with outside groups. The key recommendation from the review of the Challenge Programs was that any conflict of interest should be avoided by having governance invested in a Board of independent individuals.[96]

- **Today's complex, global challenges require more strategic partnerships**. One of the key findings of the CGIAR independent review was that the CGIAR system needs to take a more strategic approach to partnership to become more cross-sectoral and global. Climate technology innovation similarly will require significant partnerships across countries, sectors, and along the value chain. Any climate technology initiative should look to experiences from the CGIAR Challenge Programs on how to structure those partnerships effectively and dedicate adequate time to building networks, relationships, and effective communication systems.

  The CGIAR review documents contain a gold mine of useful, detailed information on how to structure effective partnerships. These should be considered thoroughly when scoping any international climate technology initiative. A few key lessons on partnerships come out of the Challenge Programs:

  - Allow a significant amount of time on process and team building to develop social capital in partnerships. This time spent should be considered an investment in more effective science and not a transaction cost.[97]
  - "Partnerships are difficult to cultivate but there are so many things good about them. Partnerships within the Challenge Program have remarkably brought capacity building in a most effective manner"—A CP Project Leader[98]

- Effective communication systems are essential for dispersed multi-disciplinary teams. The CP networks have been made to work via virtual communication; however, personal face-to-face contact remains vital. “We have also found that issues are resolved best in more formal decisions among partner institutions when it is built on plenty of informal communication among individual researchers and managers.”[99]

- **Work with private sector.** One key strategic partner should be the private sector. In the case of CGIAR, private labs and agricultural companies invested hundreds of times more money into relevant research than the public sector could ever invest. Interviewees recommended that public centers should avoid doing what the private sector does best, for example: use private labs that can do analysis cheaper and better and faster.

# Case Study #2: Global Fund to Fight Aids, Tuberculosis, and Malaria

## Introduction

The Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund) is an international public-private nonprofit organization. It was created in 2002 to coordinate and increase funding for the treatment and prevention of these three diseases in developing countries. At the time, there was a growing global consensus that existing organizations within the UN system, and organizations like the World Bank, were not able to effectively manage a large, new influx of public funding on these diseases. The belief was that there was a need for an independent organization to manage significant new funds for these diseases and that the existing institutions were not appropriately structured.

Since its creation, the Global Fund has established itself as the pre-eminent international health-financing organization. Its programs are widely lauded as exceptionally effective and unique in their emphasis on results and partnerships.

> The Global Fund has done an excellent job. It is the institution of choice for health finance. It's having a serious effect in countries—for some countries it represents 90 percent of health budget—it's having a massive effect.[100]

Its programs have resulted in new partnerships between the public and private sector, governments and civil society in the developed and developing world. The Global Fund has also pioneered implementation of performance-based development aid, lessons from which it has shared with the broader development community. And finally, the Global Fund has been a model of transparency—all information on its grants is available in almost real time on its user-friendly website.

This extraordinary success has not come about by accident but by design. The Global Fund was established as a financing mechanism rather than an implementing agency. It was designed to function like a private foundation that determines programmatic priorities and monitors the results of its grants but does not implement or design the proposals of its grantees.

Thus, it may not at first appear to be an obvious case study for global technology collaboration. However, the Fund is an important case study primarily for its unique governance structure, focus on results and support for innovative programs and financing schemes, as well as its institutional history.

For these reasons, it provides important lessons for how to create a governance structure for any new initiative designed to accelerate global climate technology innovation.

## History: Creation of a New, Independent Organization

The Global Fund was born out of discussions at the July 2000 G8 Summit that recognized the need for significant additional resources to combat AIDS, malaria and tuberculosis. UN Secretary General Kofi Annan further supported its creation at the African leaders summit in 2001 when he called for a "global fund to channel additional resources" towards these diseases.

Naturally, there were significant disputes about the management of this new fund among national governments and existing global organizations, particularly the World Bank. An independent review describes the history this way:

> While some AIDS experts and donors considered the creation of a totally new institution of this kind a great mistake, the prevailing political judgment was that existing agencies needed a jolt from new competition…The Global Fund's advocates also believed that a new, unbureaucratic and lean financing agency was needed to tap the additional funds expected from donors.[101]

Because of these perceived shortcomings of existing institutions, and to attract new funding, the Global Fund's supporters created a new, independent organization and developed a governance structure and procedures unlike any existing international financial or development institution.

## Unique Governance Structure

The Global Fund was incorporated as a nonprofit Foundation under Swiss law in 2002, with headquarters based in Geneva. In order to allow the Fund to start operations quickly, an agreement was reached with the World Health Organization (WHO) to provide administrative services to the secretariat. The agreement with WHO was always intended to be temporary. In fact, as of January 1, 2009, the Global Fund became an administratively autonomous organization.

The World Bank was assigned to operate only as the Global Fund's Trustee to manage the organization's money. But it has had no operational control over the program funding decisions of the Fund. It has been responsible only for ensuring the integrity and transparency of the financial controls of the Fund's operations.

### *Inclusive Board*

The Board of the Global Fund also is unusual for an international institution. In order to create inclusive governance by its constituencies, it is comprised of voting representatives from donors, recipient governments, developing and developed country NGOs, communities affected by the three diseases, and the private sector.

> Board membership is simply much more democratic and inclusive than in other international organizations where governments are major shareholders.[102]

Inclusiveness has strengths and weaknesses: it means that voices from civil society and recipient countries—not often heard on the boards of multilateral development banks—are heeded and have just as much sway as the US government, for example. However, gaining and balancing all of these different points of view and reaching consensus takes time, and special interests can stymie progress. One interviewee described the decision-making process as "cumbersome" and "effective but not efficient."

### *Small Secretariat*

Another unique characteristic of the organization's governance—at least in the beginning—was its very small, lean secretariat. Initially, the designers apparently were thinking of having about a staff of only 15 people.[103] But they soon realized this unrealistic—the number of staff increased from an early aim of keeping it under 100, but then it grew to 150 in 2005 and to almost 600 in 2010.[104]

The original designers believed that a small, grant-making secretariat would avoid the slow-moving, bureaucratic pitfalls of large institutions like the World Bank and UN. With an agile secretariat, the Global Fund would be able to move quickly, acting as a funder (similar to a private foundation model) with implementation handled by in-country consortiums of existing organizations.[105]

However, as the Global Fund's program grew (from under US$1 billion per year in 2005 to US$2.75 billion per year in 2010) difficulties in implementation of projects arose and the Board added more and more responsibilities to the secretariat. These included, for example, efforts to mainstream gender, account for sexual orientation, and analyze market dynamics. Meeting these mandates requires money and people. Moreover, there was significant turnover due to staff burn-out from overloaded work schedules.[106] All of these factors pushed the Global Fund to increase staff capacity.

While the size of the Secretariat has grown, its operating costs are quite small. The small secretariat of the Global Fund was designed to maximize effective use of donations. At present, the operational cost of the Secretariat is on the order of US$280milion, 5 percent of the total annual expenditures, an extremely cost effective overhead and administration cost.[107] Even more compelling, according to the Global Fund, almost all of these operating expenses are covered by the interest earned on the Trustee account at the World Bank. The funding entities, therefore, see virtually all of their funds go directly into programs, not overhead expenses.

## Impact

Since it was established, the Global Fund has disbursed almost US$11 billion for HIV/AIDS, malaria and tuberculosis and the board has approved US$19.3 billion in grants to poor and middle-income countries (from 2002-2010).[108]

The Global Fund has supported programs that have produced many practical and positive results. It estimates that, by the end of 2009, 4.9 million lives have been saved due to its work. [109] In regards to HIV and AIDS, 2.3 million people received antiretroviral treatment, including 930,000 HIV-positive pregnant women, reducing mother-to-child transmission, and 4.9 million AIDS orphans who were provided with basic care.[110]

Many attribute the Global Fund's impressive results to its dedication to "performance-based funding," as described below.

## Performance-based Funding

In perhaps what is its most important contribution to innovative program financing at the international development level, the Global Fund has been a pioneer in implementing "performance-based funding."[111] Performance-based funding ensures that funding decisions are based on a transparent assessment of results against time-bound targets.[112] This is a different paradigm from traditional development aid that focuses on recording how money is spent, rather than on what targets have been achieved.

At the Global Fund, all initial grants are made for two years, after which there is an intensive review process. The grant performance is graded, where high performing grants can be extended for 5 years, followed by an additional 5 years if the project continues to produce results. Money from under-performing grants is reallocated to better-performing grants where results are achieved.

This model has been recognized by independent evaluations as unique in terms of the scale at which it has been implemented.

> A great asset of the Global Fund is its commitment to measure – and document – results, and to make them available for all to see on its very informative website.[113]

The Global Fund's objective to provide funding to countries on the basis of proven performance has its critics—according to one interviewee, only 12 countries receive 45 percent of the Fund's support. Ironically, "failure to meet targets could indicate the need for greater support to weak health systems rather than withholding of funds."[114] Some countries do not have the capacity to monitor and quantify these results. In response, the Global Fund established an Early Alert and Response System (EARS) group to work with countries to improve their performance. However, the Global Fund claims that low-performing grants are equally distributed across low-, middle- and high-income countries—and thus conclude that low- capacity countries are not disadvantaged.

## Innovative Financing for Global Public Goods

The Global Fund, because of its unique structure as a public-private partnership and its inclusive board, has been able to access a wide range of innovative funding sources. Almost fifty countries have pledged money to the fund. Most of these countries are wealthy OECD and Middle-Eastern countries, but poor countries have also pledged, including India, Namibia, Malaysia, Thailand, Uganda, and Burkina Faso.

One innovative source of public funding for the Global Fund is its **Debt2Health** initiative. Through this program, bilateral debt in a poor country can be cancelled if the country agrees to re-allocate the money saved into health program investments in partnership with the Global Fund. Four (4) debt swaps have been agreed to so far with the German government forgiving debts in Indonesia, Pakistan, and Cote d'Ivoire, and between Australia and Indonesia. The Global Fund negotiates the agreement and monitors the country's investment.[115]

The Global Fund is also supported by private foundations like the Bill & Melinda Gates Foundation, and private companies like the Chevron Corporation, as well as private sector partnerships.

The creative funding arrangements and the private-sector partnerships deserve special mention. A few are described below—such as a Real Madrid Soccer Match held in 2002. Individuals can also donate to the Fund.

- **Dow Jones Exchange Traded Fund**: In December 2010, the Global Fund with the Dow Jones Indexes launched an exchange-traded fund—based on an index of firms investing in health and development—aimed at both traditional investors and "socially responsible" ones. While this is a new mechanism that has yet to show results, presumably the Global Fund will receive some kind of percentage in compensation from the fund.

- **Product (RED):** This private-sector partnership was launched by singer and international celebrity, Bono, in 2006 with the Global Fund. This initiative invites companies to develop (RED) branded products, with a percentage of the profits from sales directed to the Global Fund for African AIDS programs. As of December 2010, (RED) partnerships with companies like American Express, Apple, Dell, Gap, Emporio Armani, Starbucks, and Nike, and (RED) concerts have generated more than **US$150 million** for the Global Fund. There has been some controversy over the program: complaints at the high-cost of advertising for the program, and the small amount of profit dedicated to the Global Fund from the products.[116]

## Public Support and Awareness Raising

The diversity of the Global Fund's Board and recipients, and its ability to develop creative fundraising, has generated a significant amount of popular global appeal for the organization. Through its unique fundraising efforts and partnerships the Global Fund has been very effective in raising public awareness around the world about the severity of the AIDS crisis. There are many **Global Fund support groups** in countries—something that is unheard of in the case of the World Bank.[117]

This aspect of the Fund's public support is worth underscoring. There are no similar public-support funding and support mechanisms for climate technology. The unique nature of the Fund's structure, partners, and members provides a new platform for raising awareness and support to address these critical health problems in the developing world.

## Transparency

Another unique strength of the Global Fund is its commitment to transparency. As a supporter of the Fund has noted:

> There is widespread agreement that a key strength of the Global Fund is its transparency, openness and capacity for self-criticism. The Global Fund's very user-friendly website is full of valuable information on virtually every aspect of the Global Fund's work. This easy access provides interested parties ample opportunity to follow developments at the Board as well as in individual projects and to have a very good

> picture of results achieved. Another feature is the on-line Partnership Forum, which permits a broad range of stakeholders to offer their views on the Global Fund's performance. This degree of transparency is remarkable and a model that facilitates accountability in ways other agencies, including the World Bank, would do well to emulate.[118]

## A Learning Organization

Since it was established, the Global Fund has sought to be a nimble, adaptable organization that learns through its operations, partnerships and evaluations. The Fund's internal evaluations have emphasized the importance of learning through partnerships.[119] The organization has demonstrated this ability through a number of innovative programs it has developed in response to criticisms such as dual-track financing, which allows the Fund to grant money to both government and civil society in parallel in a country, and the creation of a voluntary pooled-procurement program.[120] The Global Fund is also developing an internal knowledge hub for rapid and easy access to the latest information for staff.

## Challenges

While the Fund has had numerous successes, it is inevitable that, with the enormous problems it seeks to solve, the Global Fund has faced a number of challenges. These include:

- **Financing vs. Implementing.** Since, its creation there has been growing tension for the Global Fund to become more involved in building capacity in recipient countries, and supporting development and implementation of the best practices that it is discovering through its performance monitoring.

  > Where the line should be drawn between adhering firmly to the approach of a lean financing entity on the one hand, and advising recipients on their proposals and implementation on the other, is a difficult philosophical and practical matter for the Global Fund, and is a central unresolved issue of policy for the Global Fund Board and its main stakeholders. [121]

- **Staff size.** Because of the pressure to undertake more direct project management and capacity building, the secretariat has grown rapidly. Despite its designers' early intentions, the Secretariat has grow rapidly, particularly over the last few years. With a staff of 600, it is now far from the lean, nimble 15-person secretariat initially imagined. How to keep this organization nimble and quickly reactive with such a large staff remains an issue to be resolved. Also, moving in this direction expands the nature of the Fund from a purely financing entity to one that also has implementation and operating responsibilities.

- **Slow speed of getting funding to recipients.** The Global Fund was able to act quickly at first, approving its first batch of proposals within the first few months of the Global Fund's existence. But this timeframe has slowed considerably. Now, getting the money out the door takes much longer—about 18 months after the launch of a call for proposals. This slow time frame is mostly attributed to the rigorous monitoring and review process of the funding to ensure it is properly managed. But despite the reasons, this slow disbursement of funds is particularly a problem in countries that don't have the staff, health

system capacity, or bureaucratic structures to absorb and effectively distribute large grants.

- **Onerous reporting and proposal process**. Because of its rigorous monitoring and evaluation for results, one interviewee noted that the burden of proposal writing and reporting placed on recipient countries—many of whom have minimal administrative and accounting capacity—is onerous. This process is often expensive and time consuming, and countries often ask other third-party organizations like WHO or UN agencies to assist in this process. These organizations don't feel they share in the credit with the Global Fund and this has led to some alienation of these organizations.

> Country health administrations shut down for 3 months to develop the proposal.[122]

- **A few more capable countries consistently receive funding.** One interviewee pointed out that the same countries that have figured out the proposal process receive funding regularly, while others are left out, "A lot of countries are consistently rejected."[123]
- **Difficulty securing consistent funding.** In 2010, the Global Fund requested US$13 billion as the "lowest funding level' needed to effectively succeed. However, governments only dedicated $11.7 billion over three years much lower than the $20 billion 'ideal' level.[124] The Global Fund's dependence on unreliable pledges from large donors trickles down to its grant making process—such that it cannot make long term grant commitments without guaranteed long term funding.
- **Recent Concerns over monitoring corruption.** At the end of 2010 and into 2011, concerns were raised by some funders of the Fund that it had not properly monitored fraud committed by some of its grantees. The Associated Press had reported that it had learned that up to two-thirds of certain project's funds were misspent in Mauritania, Mali, Zambia and Djibouti. The Fund defended its operations and suspended funding to those countries.[125] One interviewee, however, defended the Fund by noting that the information on fraud was from the Global Fund's own press release and demonstrates the Fund's commitment to transparency.[126] All monitoring and evaluation reports are rapidly placed on the website.

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

- **Independence allows for more innovation and flexibility.** A number of the experts interviewed recommended that any new international organization trying to be innovative and respond rapidly should be independent of existing large bureaucracies. The Global Fund was able to develop an innovative board structure that included public, private, and civil society and new partnerships and procedures because it was established as a nonprofit organization outside of existing organizations, freed from historical organizational cultures and constraints. However, one interviewee noted that it is also important for existing organizations to feel some kinship with the new entity, rather than competition. She also noted that the downside of not being

associated with an established organization is that it takes more time to establish partnerships and engage all stakeholders.[127]

> It's a challenge to be autonomous and independent but I would recommend the same path.[128]

- **Leveraging existing organizations can help to quickly start operations.** The Global Fund was able to begin grant making within months of its incorporation because it worked with existing organizations to support the entity. The WHO provided administrative assistance, the World Bank acted as the Funds Trustee, and the Fund worked with existing organizations in countries to develop and implement proposals. However, one interviewee warned that while it had allowed the Global Fund to start up immediately, working with the WHO did slow down and encumber procurement and HR processes later on, and in fact she would recommend that in the future it might be better to start completely independent of existing bureaucracies.[129]

- **To the greatest extent possible, include representatives from all stakeholders—donors, recipient countries, civil society, and the private sector—in decision making.** One interviewee noted that what makes the Global Fund so unique is that there is equal participation of all the stakeholders, and the decision-making process includes the beneficiaries and the implementers of programs. Unlike many other international organizations, "Who runs the show doesn't depend on who gives the money."[130] These kinds of partnerships provide excellent opportunities for learning and for public support and buy-in, but the trade-off can be seen in lost efficiency and speed. The Global Fund's focus on developing a very inclusive board, has allowed for important learning across the organizations and sector. It has also helped to build public support for the organization. However, "you pay the price of inefficiency."[131] Similarly, it is admirable to try to use country systems, but again, there are challenges in terms of effectiveness and efficiency for less-developed countries.

- **Include private-sector participation.** There are two reasons why the Fund stressed the inclusion of the private sector. The first is that it can encourage more funding from the private and foundation sectors. Second, it brings a sound economic perspective that public sector participants may lack.

> They know how to run a business. It's a good thing to have this expertise for an organization with a US$200 million running cost. They teach about how to be good board members and tend to behave better than others.[132]

- **Focus on performance by linking resources to the achievement of clear, measurable, and sustainable results.** As noted above, the Global Fund has had impressive, measurable results on public health and has been called a model health organization. Any climate initiative would do well to take a similar approach to be able to base its programmatic and policy decisions on empirical evidence, rather than subsidy and economic theory.

- **Learn by doing and share the lessons.** The Global Fund began operations quickly, providing grants just months after it was established; it was able to do this without having any major failures because it took a careful, performance-based approach that staged funding according to results—which also allowed for course corrections during the grant term. This reporting and monitoring process also culled out important lessons that could be shared across countries. Of course, the latest evidence of some corruption among grantees simply underscores the challenges of any development aid to countries and grantees with a history of poor governance and financial controls.

- **Be aware of trade-offs and inherent risks of innovation.** The trade-off to rigorous results monitoring is that the reporting and monitoring required can be cumbersome and time consuming and can leave out under-performing countries. These are challenges the Global Fund continues to address. Moreover, monitoring results in the context of innovation may be much more challenging than in the case of programs that the Global Fund supports. Technology innovation support is by nature high-risk and often requires longer-term commitments. These realities must be incorporated into any monitoring and results framework for an innovation facility.

- **Build public support and awareness.** The Fund's creative use of outreach, financing, and private sector partnerships holds promise for how a similar set of mechanisms could be developed to build public support for low-carbon and climate-resilient technologies.

- **Staying small and nimble is hard, but important.** As one interviewee advised, "Be careful what you wish for." The very success of the Global Fund to attract very large financial pledges, to achieve real results, and to include many voices has led to significant pressure on the organization to grow its activities, to include more issues such as gender mainstreaming, capacity building, and vaccine procurement improvements. All of these mandates require more people and time, forcing the organization to grow to the point where some believe there may be "a law of diminishing returns for internal management." This is an unresolved tension for the Global Fund. It is currently in a process of reviewing how to improve internal efficiencies, learning, and management.

# Case Study #3: Mobile Telephone Takeoff in the Developing World

## Introduction

The rapid diffusion of mobile phones across the developing world offers important lessons to policy-makers trying to facilitate successful climate technology innovation. Designing products to meet customer needs, crafting innovative business models from the ground up to achieve effective distribution, linking international finance and technology with local knowledge, and aligning prices with what the poor are willing to pay are some of the lessons the mobile phone story has to offer.

The success of mobile phones across the developing world has fundamentally challenged conventional notions about economic development. Once perceived as a non-market comprised of 3 billion disparate people living on less than US$2 per day, the "base of the pyramid" (BoP) has proven it represents a huge unmet business opportunity ripe for anyone willing to meet consumer demand with a supply of the right mix of technological innovation, pricing structures, and effective business models tailored to established distribution systems.

The case of mobile phone takeoff in the developing world suggests that technologies which offer additional benefits and opportunities for enhanced income generation have a good chance at widespread penetration. Unique partnerships such as joint ventures between profits and nonprofits, the crucial role of local capacity building resulting from those educated afar and returning to their homelands to invest in the local economy, and the bridging of local entrepreneurs and foreign investors are some of the key takeaways from the story of mobile phone adoption in the developing world.

The need to develop and support institutions that work to accelerate the market and shoulder the risk for the common good of the target industry is also a key lesson learned. The development of customized business models and needs-oriented mobile communications services were facilitated by organizations like the Global System of Mobile Communication Association (GSMA), a neutral inter-national organization that serves as the global mobile phones industry group representing and addressing common industry constraints. This type of organization can play a key role in linking the public and private sector in new product commercialization by overcoming the "valley of death" between research/proof of concept and late stage deployment by providing a bridge between government-supported research and private sector investment. [133]

## The Age of Mobile Telecom in the Developing World

In light of the recent global economic downturn, the global mobile telephony market has come out remarkably unscathed. Contrary to the world economy's slow creep out of recession, mobile phone markets continue to demonstrate unprecedented growth rates, which are projected to continue in a steep upward trajectory for decades to come. The uptake of mobile phones around the world represents the "fastest technology adoption in human history," with handset sales volumes reaching over one billion during 2007, the equivalent of ten times the number of personal computers sold that year (1 new phone for every six people on earth).[134] Today penetration rates have exceeded 100 percent of the population in many developing countries.[135]

In 1993, there were 141 million fixed telephone lines and only 3 million mobile phones in the developing world.[136] By 2002, the Global System for Mobile Communications (GSM) had overtaken fixed lines in both the developed and developing world, and in 2003 witnessed a market penetration of 608 million mobile phones while fixed lines trailed at 546 million.[137] Four years later, the number of mobiles worldwide had doubled that of fixed line connections at 2.6 billion.[138] Today mobile phones are widely available across the developing world, even to the low-income population at the BoP: "among the least developed countries (LCDs), [by 2008] mobile subscribers outnumbered fixed lines by seven to one."[139]

While Africa remains the world's poorest and most underdeveloped continent, with 315 million people (one in every two people in Sub Saharan Africa) surviving on less than one dollar per day, Africa is not at the periphery of the global mobile phone boom. GSM started to become available towards the second half of the 1990's in Africa, and by the year 2000, one in fifty Africans had access to mobile phones.[140] Growth took a sharp upturn in the first few years of the century and the mobile subscriptions market grew by nearly 90 percent, from less than 1 million to 47 million in the six year period between 1996 and 2002.[141] By 2008, one in three Africans had access to mobile telephony and today mobile phones are spreading faster across Africa than anywhere else in the world.[142] There are more phones and related services sold every day in Africa than in all of North America, totaling a whopping 547,584,543 connections.[143]

The impact of mobile phones on everyday life in the developing world has been perhaps more astonishing than the unparalleled growth rates. "People who until a few years ago had never used a phone or bank are now transferring money by phone."[144] In countries where phones and electricity have long been "mere figments of imagination," the introduction of cellular towers in people's backyards has transformed the way people live.[145] In addition to a phone, mobile technology has increasingly become a bank, a credit card, and a mini-computer, providing an instant connection to the world for people who never before had access to any of these services.

## A Closer look at the Mobile Phone Boom Explosion in the Developing World

### The Rise of GrameenPhone in Bangladesh

A joint venture between a multinational for-profit and an indigenous nonprofit, GrameenPhone offered the world a new perspective on doing business in the developing world. In 1993, New York venture capitalist Iqbal Quadir's computer's internet connection crashed. In his resulting frustration at being disconnected from the basis of his entire business world, he realized that "connectivity was productivity" in the developed world and developing world alike. With a vision of bringing the same kind of internet connectivity found in Manhattan to the rice paddies of his native country of Bangladesh, Quadir quit his job and set out to establish mobile communications services in a country where there was at that time one phone for every 500 people.[146]

Quadir's business model built upon the successful microfinance model engineered by Grameen Bank founder Muhammad Yunus. Asking, "Why can't a cell phone be like a cow?"[147] Quadir's business model was based on the successful Grameen concept of the women micro-entrepreneurs that sold milk from the cows they bought with Grameen Bank microloans. From this idea birthed the concept of "phone ladies"—women with good credit histories that could take out loans to buy cell phones and then pay back loans with money earned from selling air time to villagers.

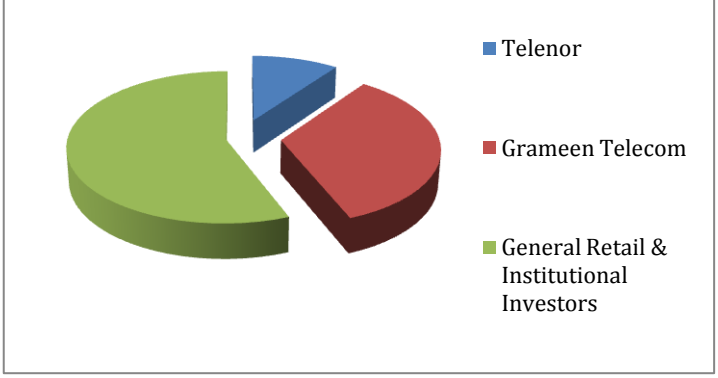
After a difficult and slow start involving a multi-year bidding battle to acquire a GSM license from the government, Grameen phone was one of the winners. Once the network was erected, 250,000 village phones owned and operated by "phone ladies" and financed through microloans from Grameen Bank were connected. The result was that one-hundred million people instantly gained access to telephony and a new class of micro-entrepreneurs was born, making twice the annual income of an average Bangladeshi.[148] In 2005, a million new subscribers signed up in a six-week period in Bangladesh (stemming from competition from Egypt's Osracom sparking price wars) and another 2 million in the second quarter of 2007, at which point six competing mobile operators had come online.[149]

GrameenPhone's take-off was unbridled. By 2007, ten years after it started offering mobile service in Bangladesh, it had acquired more than 10 million subscribers with total revenues pushing $1 billion and annual profits exceeding US$200 million.[150] Total foreign investment in Bangladesh from Grameen-Phone and other players in the telecom sector amounted to more than $2 billion dollars by this time.[151] In contrast, Bangladesh received $268 million in total foreign investment in 2003.[152]

### GrameenPhone: Ownership Structure

GrameenPhone joined Norway's Telenor AS with Bangladesh's Grameen Bank in a unique multinational for-profit (Telenor) and indigenous nonprofit (Grameen Telecom) partnership. Today, Telenor holds 55.8 percent of GrameenPhone, with Grameen Telecom Corporation owning the remaining 34.2 percent, and general retail and institutional investors holding the remaining shares (Figure 2).[153]

Figure 2 | GrameenPhone Ownership Structure



The joint venture has been extremely successful in bringing mobile communications to Bangladesh. Grameen Telecom Corporation—as a not-for-profit company that works in close collaboration with the "internationally reputed bank for the poor"—Grameen Bank—brings the "most extensive rural banking network and expertise in microfinance" to the table.[154] Today Grameen Bank reaches more than 67,000 villages which are serviced by 2,121 bank branches spreading across the rural countryside.[155] As of May 2006, the bank had 6.33 million borrowers, 97 percent of whom were women.[156] Telenor AS—as the largest telecommunications service provider in Norway with mobile phone operations spanning 12 other countries (for-profit corporation)—brings extensive technological know-how and managerial expertise, both of which have been "instrumental in setting up such an international standard mobile phone operation in Bangladesh."[157] As "one of the pioneers in developing the GSM service in Europe," Telenor has also played an instrumental role in helping to transfer its expertise and knowledge to the local Bangladeshi mobile communications workforce.[158]

As noted on GrameenPhone's website:

> The international shareholder [Telenor] brings technological and business management expertise while the local shareholder [Grameen Telecom] provides a presence through-out Bangladesh and a deep understanding of its economy. Both are dedicated to Bangladesh and its struggle for economic progress and have a deep commitment to GrameenPhone and its mission to provide affordable telephony to the entire population of Bangladesh."[159]

In addition to the for-profit/non-profit partnership between Telenor and Grameen Telecom, GrameenPhone was set up from the beginning to be inclusive, with a goal of allowing the public to gain a stake in the company. The initial public offering was important for raising additional capital, increasing public awareness of the company, and ensuring accountability, integrity, and transparency.

> Being a public limited company, the Board of Directors of GrameenPhone have a pivotal role to play in meeting all stakeholders' interests. The Board of Directors and the Management Team of GrameenPhone are committed to maintaining effective Corporate Governance through a culture of accountability, transparency, well-understood policies and procedures.[160]

### Mobile Phones Take Foothold in Africa

Within a year of GrameenPhone's launch in Bangladesh, cell phones began to gain traction in Africa. By 2000, the industry was booming and people were injuring themselves climbing trees to get reception from nearby cellular towers. M-Net (today's MTN) was one of the first companies to launch the fight for a cellular license, starting in South Africa around the mid-1990's, leading the continent in what would become a major cellular phone economy in the years to follow.

Like in Bangladesh, strong initial government opposition and politics made acquiring a service license a difficult first step—a lesson worth noting for other technology entrants trying to overcome unfavorable (and often deeply embedded) policy and regulatory structures. This story played out in South Africa for telecom startup MTN, as well as in Zimbabwe.[161] In both cases, enthusiastic entrepreneurs (trained in the West) had to battle entrenched public monopolies to gain licenses—and in both cases as soon as

they had legal access their businesses took off, far surpassing their public rivals. In the first week Zimbabwe's Econet gained 10,000 subscribers, within two months gained 45 percent market share, and by 2000 it was operating in eight countries, with revenues of US$300 million.[162]

The early successes of these private cellular investors and the opportunity to attract foreign investment started a flood of deregulation of government telecom markets. Companies like MTN were then able to offer services in other countries such as Uganda, Rwanda, and Swaziland and competition drove the rampant spread of cellular phone technology.

Big investors like Dr. Mohamed Ibrahim ("Mo"), a Sudanese native bringing a wealth of experience and financial backing back home (he was the former technical Director of British Telecom's Cellnet), played a critical role in driving the cellular boom. With a desire to reinvest in his homeland, Mo created MSI, what became a US$1 billion annual revenue operation to fill technical knowledge gaps in mobile network system design. He pioneered a software package, *Planet,* for new license winners to help them optimize their network design and build out. Soon MSI had equity shares in emerging cell companies all over the world and was the first to invest in the "risky markets" of sub-Saharan Africa. MSI-Cellular Investments (now Celtel International BV) began offering services in Sub-Saharan Africa by 2000. Raising more than US$1 billion in debt and equity, Celtel rapidly took hold of the market, acquiring licenses in Malawi, Zambia, Sierra Leone, Republic of Congo, Gabon, Chad, DRC, Guinea, Burkina Faso, Niger, Sudan, and Tanzania.

The year 2000 was the beginning of a massive communication revolution across the developing world. Governments started issuing license tenders after they saw the huge payouts from foreign investors, which invited operator competition that drove market development. By 2001, fixed-line phones had been substantially overtaken by cellular phones across developing world and subscriber numbers were doubling every year. [163] By 2002, roughly 70 licensed mobile networks were operating in Africa. From 8 million mobile phones in 1998, 2007 witnessed the adoption of more than 120 million phones in Africa—estimated to have reached as many as 480 million people due to phone sharing. [164]

### Three Forces of Innovation: Native Entrepreneurs, Foreign Investors, and Locally Adapted Technologies

In his book, "You Can Hear Me Now," Nicholas Sullivan argues that "three forces for external combustion"—information technology, imported by native entrepreneurs, and backed by foreign investors—provided what economists call an "exogenous shock" needed to push countries on a path away from under-development.

The dominant economic paradigm believes that this shock would be the result of regulatory or aid reform. However, the story of mobile phone uptake in BoP economies challenges this notion and suggests that it is private enterprise and investment in technology innovation and dissemination that creates new wealth and provides a better chance at improving a country's GDP.

The model looks like this: private investment generates profits that are reinvested to generate further profits→ spin-off businesses are created and competition drives the market and forces government

reform→ capital markets deepen→ new liberalized policies and regulations support further investment and the country begins to operate from its own technology, entrepreneurs, and capital.

**Native entrepreneurs and foreign investors** were significant causes of the mobile boom. Entrepreneurs like Quadir of GrameenPhone, trained in the West then returned with foreign capital to soak up business opportunities from market failures. Foreign investors gained confidence in the market opportunity because of the native entrepreneur's implicit comprehension of local markets (such as the role of the informal economy and complex local supply and distribution chains) and the regulatory environment (particularly in order to overcome price buildups associated with high import tax rates and connection fees for handsets).

Foreign investors were critical to the development of the mobile telephony industry. Behind Grameen-Phone's success was George Soros, who provided Grameen Bank with a low-interest loan, and Norway's Telenor AS, which likely wouldn't have joined Grameen Bank without angel investor Joshua Mailman from New York.[165] Similarly, Celtel International relied on US$1billion in Western debt and equity to finance its launch across Sub-Saharan Africa.[166] With insufficient capital markets, dependence on foreign investors is the only way to push innovation to maturity in the developing world. Today, companies like MTN, Orange, and Zain are driving sector development and relying on investments from Ericsson, Nokia, and others.

The monumental impact of the partnership between local entrepreneurs and foreign investors in facilitating the mobile phone boom in the developing world cannot be overstated.

It offers a key lesson for accelerating other technology innovation sectors; the partnership between OECD or wealthy-country investors and local entrepreneurs was essential to provide the necessary capital and local know-how to launch mobile technology into the marketplace, and then to support its commercialization.

### GSMA: Demonstrating the potential of an International Collaborative Organization to accelerate Market Development

The Global System for Mobile Communication Association (GSMA) represents the interests of the worldwide mobile communications industry. Spanning 219 countries, the GSMA unites nearly 800 of the world's mobile operators, as well as more than 200 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers, Internet companies, and media and entertainment organizations. The GSMA is focused on innovating, incubating and creating new opportunities for its membership, all with the end goal of driving the growth of the mobile communications industry on behalf of the whole industry. The GSMA's mission is to create value for operators and the mobile industry in the provision of services for the benefit of end users, so that those users can readily and affordably connect to and use the services they desire, anywhere, anytime.[167] The association is funded primarily by membership dues from its operators and vendors, and from returns it receives from producing premier industry events.

The Groupe Speciale Mobile (GSM) (later to become Global System for Mobile Communication), was originally formed by a mandate by the Confederation of European Posts and Telecommunications (CEPT)

to bridge the communications divide by designing a pan-European mobile technology.[168] Unlocking communications between continents meant setting international standards and synchronizing communication devises to be able to send and receive communications across multiple networks.

The GSM standard became the internationally accepted digital cellular telephony standard. This foundation helped GSMA earn street credit by the industry as a trusted and unbiased industry ally. Overtime, the Association's focus shifted away from standard-setting to market facilitation activities. Evolving with changing market conditions, the GSMA's main activities grew by identifying market gaps it could fill.

> The GSMA works where there is opportunity to be capitalized and the market needs a nudge. The role is reduced when the market matures. GSMA works in markets that need a catalyst.[169]

> Once an activity becomes business as usual, the organization abandons it and moves on to fill other voids.[170]

One way GSMA supports market acceleration is to reduce risk costs for the industry by piloting new ideas and technologies ahead of the market, and then sharing successes and failures with the industry. An association like the GSMA is an appropriate entity to shoulder risk for the industry. Putting capital towards testing and piloting innovations on behalf of the industry can help reduce market failures. GSMA's role as a market catalyst works in part because the industry values the common benefits of open innovation and public knowledge-sharing above the benefits of keeping information private.

> The industry feels comfortable sharing information with us (GSMA) because we have been able to create a relationship of trust. The industry views us as a friend and therefore shares information that it might not otherwise because it knows we are working for them. They see that we're not trying to sell a product, just move a market along.[171]

> Regular working groups support the development of a "mobile ecosystem and knowledge system, providing the industry with a forum for exchange and a knowledge management hub to bring ideas together.[172]

An international organization like the GSMA can act as a neutral broker to reduce the gap between technology supply and consumer demand. This type of organization may play a key role by providing a neutral bridge between government-supported research and private-sector development—linking innovation actors, joining the public and private sectors in product innovation and deployment, and by overcoming the "valley of death" between research/proof of concept and late-stage development.[173]

## GSMA'S EMERGING HANDSET PROGRAM

The need for a more affordable handset that could meet the purchasing power of the poor, prompted the GSMA to establish its Emerging Market Handset Program. Representing operators in Asia, the Middle East, Africa, and Turkey, GSMA ran a competition to design a low-cost handset, which was won by Motorola. The handset cost less than US$30—a drastic reduction from Grameen-Phone's first handset that cost around $400, including duty and taxes.[174] In 2007, the GSMA claimed that the Motorola handset was selling at a rate of 31,000 per day, amounting to more than 11 million per year.[175]

This and other market developments played a key role in supporting handset vendors to add a range of low-cost phones aimed at BoP consumers to their inventory. Major handset manufacturers have been able to develop and introduce ultra-low-cost products specifically for the African market, priced between US$25-$45 each.

# Technological innovation and collaboration lessons-learned from the rapid adoption of mobile phones in the Developing World

The mobile phone takeoff in the developing world has many lessons to offer other sectors looking for clues about how to jump start new product markets or accelerate existing ones. It also provides architecture for facilitating international collaboration around new technology innovation and deployment by offering insights into the conditions that contribute to successful market uptake in the developing world.

- **New technology innovations have the opportunity to tap huge undeveloped markets and take advantage of sizable business opportunities in the developing world.**

Mobile phone diffusion in the developing world challenged the then conventional viewpoint that claimed that "the poor" do not constitute a market and certainly offer little in the way of a business opportunity case. To the contrary, the widespread uptake of the mobile phone by all economic classes in society reinforced C.K Prahalad's novel idea that in fact there may be "Fortune at the Bottom of the Pyramid"—that in aggregate the poor are wealthy and that the base-of-the-pyramid can represent a huge unmet business opportunity for entrepreneurs willing to take the risk to tap it: "by virtue of their numbers, the poor represent a significant latent purchasing power that must be unlocked."[176]

Vodacom's Clive Wilson supported this point when he claimed:

> We can't put these things up fast enough. People here may not spend much but there are so many of them that it makes these areas more than viable — they are very profitable.[177]

The realization that there were huge business opportunities for new technologies in the developing world—perhaps more than the developed world where new technologies compete with entrenched legacy technologies and established sector monopolies—triggered the industry confidence needed to invest in this new innovation space. Changing ideologies of what constitutes a lucrative market may also

have played a role in challenging conventional paradigms of best practices for conducting business in emerging economies. This new recognition of the BoP, for example, may have started the deterioration of the longstanding notion (still somewhat persistent today) that "the only way that companies can prosper in these markets is to cut costs relentlessly and accept profit margins close to zero."[178]

The nature of mobile technology innovation also supported widespread dispersion of mobile telephony to the masses. By design, GSM is an "open system" such that components are designed to be compatible across different manufacturers. This early design insight allowed for vendor competition and dramatic price reductions necessary to meet consumer demand and support new market development.

The mobile phone boom was also supported by the fact that the incumbent technology (fixed lines) was too expensive and too limited to achieve economies of scale. Therefore, when GSM arrived, mobile phones were both *pulled* into the market by demand as well as *pushed* into the market by advances in phone technology, supported by the fact that there was little competition from legacy technology.

Mobile phones have been spreading rampantly over the last decade and market penetration rates in Africa have reached an all-time high of over 56 percent (as of end of Q4 2010).[179] However, penetration rates vary, with countries like Namibia and Seychelles achieving penetrations rates of 99 percent (2,091,632 connections) and 111 percent (87,366 connections) and others like Eritrea and Ethiopia at a mere 4 percent (210,489 connections) and 6 percent (5,365,210 connections), respectively.[180]

The fact that some African countries still face remarkably low rates of penetration indicates that the future remains ripe for tapping unmet market potential, both for existing companies looking to expand business and for new companies looking to enter the market. And manufacturers that have "already carved out a strong, early foothold in the African market, can certainly look forward to attractive growth prospects over the next decade."[181]

- **Disruptive Technologies may be more successful at penetrating markets in emerging markets**

As noted in Section 2 of this report, disruptive technology most often begin in niche market segments ignored by larger firms (which typically concentrate on adding extra functions to high-profit products). The technology then improves, expands, and displaces well-established incumbent (legacy) technologies.[182]

Mobile phones were able to overtake fixed lines because they introduced superior features at lower prices and thus opened new markets. Further, the social and economic impact of mobile phones was much more disruptive in the developing world because this was the majority of people's first experience with telephony access, not to mention additional features introducing them to banking, the internet and digital messaging (SMS). This impact and the fact that the developing world represents the majority of the users has led some to claim that the mobile phone is actually more of a developing world technology than a developed world technology.[183]

- **Some of the greatest innovations in mobile phone business models and services are stemming from developing world users. These innovations are now being transferred to the rich world.**

The theory of "reverse innovation" suggests that a growing number of the world's business innovations will in the future come not from the "West" but from the "rest." Advanced mobile cell phone technology in the developing world has enabled people to use their phones for everything from accessing the internet, making financial transactions and money transfers to searching for and advertising jobs and sending medical advice and prescriptions.

With the capacity to reach 2 billion subscribers in 80 countries, Texteagle, a mobile service that offers small jobs via text messaging in return for small payments has created a new way for anyone with access to a phone to generate income. Based on the idea of "crowdsourcing" (breaking down jobs into small tasks and sending them to lots of individuals), Texteagle is supplying jobs—everything from checking what a street signs say in rural Sudan for a satellite-navigation service to translating words into a Kenyan dialect for companies trying to spread their marketing.

The take-off of novel services like mobile banking and mobile work in the developing world suggests that the developing world may have something to teach the rest of us. The ability of cell phones to become "your wallet" and "your job" are concepts that are likely to "first take root in poor countries and then migrate to rich ones."[184] The world's creative energy appears to be shifting to developing world consumers, who are becoming innovators in their own right, rather than just talented imitators and receptors of imported innovation.

## M-PESA — "MOBILE-MONEY"

Today there are nearly 12 million M-PESA subscribers in Kenya; roughly 54 percent of the population has mobile banking accounts[185] and, as of June 2010, *The Economist* reported M-PESA customers could conduct transactions at some 17,900 retail outlets, more than half of which are found in rural areas.[186]

The ability to transfer money is still a new phenomenon in Kenya. A little over three years ago, many people did not have access to banking services and money transfer was expensive and complicated. Vodafone solved this issue by creating a low-cost mobile money transfer service. Operated by Safaricom, Kenya's leading mobile network, M-PESA customers register for free with any number of M-PESA Agents (including gas stations, local food markets, and multiple other shops in addition to the local Safaricom dealer). M-PESA customers can instantly deposit and withdraw money at any of the agents or transfer money electronically via their handset to any mobile user (even if they are not a Safaricom subscriber). They can purchase air-time for themselves or others and send remittances, check their balance, pay bills, complete business-to-customer transactions such as paychecks and microfinance loan disbursements and even deliver humanitarian aid and initiate international money transfers.[187]

The **M-PESA** model has made it possible for Coca-Cola distributors in Zambia to text payments to truck drivers; for local craftspeople without electricity or telephone lines in Rwanda, to accept mobile credit card payments; for people in the Philippines to buy soap and pizza by phone; and for Indian villagers to receive remittances from overseas through their handsets.[188]

- **Aspiration value may be a key indication of the market opportunity potential.**

Beyond their stated features, mobile phones became heavily tied with societal image as a "cultural icon," implying values like "importance, social situation, style, and trendiness."[189] For the poor who were used to limited opportunity for improvement, the introduction of mobile phones represented "a sense of aspiration" and new found opportunity.[190]

The mobile trader, for example, is immediately catapulted up the social ladder because the phone becomes an opportunity and an occupation. "Although the trader cannot afford to buy an expensive phone, his job enables him to use and be seen with the best phones around" which "contributes to his reputation as a trader and raises interest in his goods in general."[191]

Mobile phones represented "a sense of aspiration" for poor people who had little opportunity.[192]

- **New technology innovations that offer additional features and operational attributes (often unrelated to the primary technology service) hold promise for rapid uptake—filling multiple services needs via one device.**

Technological solutions aimed at the developing world are often "passé" products of the West. They are pushed into foreign economies in large volumes with the intention to overcome the small profit margins expected from their uptake. By providing stripped-down versions of higher-end products available in the developed world, they try to create sufficient demand where it hasn't existed before.[193]

But this conventional technology transfer approach has proven unsuccessful across a number of technology areas. As a recent *Harvard Business Review* article noted, "a far more robust approach to creating an affordable emerging market offering is to trade off expensive features and functions that people don't need for less-expensive ones that they do need."[194] After overcoming its reputation as an amenity of the wealthy, filled with fancy functionality "that poor people would never use," GSM offered a better and cheaper alternative *in addition* to a whole suite of new features designed to fill other market gaps such as access to banking and internet services.[195]

The M-PESA model, for example, offers an important lesson for those involved in technology design for emerging economies. Rather than push large volumes of down-graded products from the West into Kenya to try and offset slim profit margins, Vodafone identified the need for banking services and was able to offer a superior customer value proposition to complement voice communications. This filled a gaping hole in the economy (universal access to banking services) and supported the transition from an informal cash economy towards a formal credit-and-debt culture.

What was once a lower end product offering evolved into a higher-end, better performing product for the consumers in the developing countries, offering more and better functions than any transferred technology developed in and sold from the West.

- **To be successful, business models must be customized to local markets rather than imported from the West.**

A recent *Harvard Business Review* article suggests that the difficulties Western companies have had tapping emerging economies isn't because they can't create viable technology or hardware offerings. Instead they get their business models wrong.[196]

The establishment of mobile phone markets in the developing world proves the point. Overcoming technical and policy issues was not enough—"new approaches to commercialization [were required] as well."[197] Applying business models from the West to emerging markets, by keeping fundamental profit formulas and operating models unchanged and selling to the highest income tiers, has proven to be the wrong approach to generate sufficient returns in the developing world.

Instead, a more successful approach is to target consumers that sit at a midway point between low- and high-end products and service markets. Those customers represent a strong business opportunity because their needs are being met very poorly by existing low-end solutions, and they can't afford even the cheapest of the high-end alternatives.[198]

Another approach, as demonstrated by mobile phone development, is to avoid or reduce upfront cost barriers by pioneering new business models. The following business model innovations undoubtedly played a significant role in the effective distribution and uptake of mobile telephony in the developing world:

- **Access to Multiple service providers.** After the transition to digital systems in the 1990's, the introduction of Subscriber Information Management (SIM) cards enabled the division of the operator and handset manufacturer. This meant that users were not "locked in" to one operator's network. This was particularly useful in the developing world because cash-constrained users could swap between different SIM cards and service providers depending on where they can find the best connection or cheapest rates.
- **Shared phones.** A research study conducted in Kibera, a massive Nairobi slum, found that on average each phone owned was shared by 4 people.[199] Thus, "while few people in rural areas can afford to splash out US$30 for a handset, they may be willing to spend a dollar or two to make important calls on a shared cell phone."[200] The ability of GSM to support multiple users through the ability to swap out SIM cards, lease-out devices, and top-up air time on an incremental basis enabled GSM to significantly reduce capital outlays and likely reach much greater numbers than if a sharing model was not technically feasible.
- **Prepaid Subscriptions.** "Pre-paid subscriptions are perhaps one of the keys to understanding the broad adoption of mobile communication."[201] Deemed as "the most significant innovation since the development of the cellular concept and its initial implementation," some argue that two-thirds of today's subscribers may not have gotten access to service without this feature.[202] The ability to purchase air time before paying the full cost of ownership through low denomination scratch cards also enabled mobile communications to assimilate into the established informal distribution system of fast moving consumer goods.[203] Like Coca-Cola, cigarettes, and chewing gum, operators found a way to add "minutes" to the list and tap a highly effective distribution

network. Most operators sell airtime in tiny denominations (starting at $0.25) for people who can't afford to buy in large quantities and tie up cash.

- **Integrating Local Distribution Channels—"Telephone Ladies."** The concept of "telephone ladies" in Bangladesh or "umbrella ladies" in Ghana (women who run small independently owned mobile phone-based telephone services) also created a highly effective early distribution model. Low-income people could lease a phone and purchase air time as their finances could allow, and instantly receive an information channel to the outside world. "Just a lawn chair, an umbrella, and some minutes to sell"— informal and alternative business models played a significant role in achieving market penetration by relying on existing models of distribution and exchange and offering a high demand service for lease and at low-cost, thus providing an affordable alternative to individual ownership (which is now starting overtake the lease-based system). [204]

➢ **Technology solutions that offer end-users opportunities for new income streams are likely to achieve widespread adoption in the developing world.**

Margaret Chinhete, a Zimbabwean woman says she spends about US$13/month on her new phone, but easily covers this cost with the extra cash she makes from selling more crafts now that she can contact customers by phone. "*When I bought this I had never made a phone call. Now I use it to call business contacts. It saves me from walking kilometers every day and I have doubled my monthly earnings.*"[205]

Similarly in Kiptsuri, Kenya, Sara Ruto's first cell phone represents a "lifeline for receiving small money transfers, contacting relatives in the city, or checking chicken prices at the nearest market.[206]

The literature provides ample evidence that the growth of the mobile telecoms market has brought significant benefits for wider economic development. Research shows that adding ten mobile phones per 100 people in a typical developing country may boost growth in GDP per person by 0.8 percentage points.[207] "From the phone ladies in Bangladesh to the sari sari shop keepers and resellers in the Philippines to the phone *top-up* shops in Africa, the cell phone explosion in poor countries has already created more than 1 million (and counting) new income opportunities."[208]

Some of the opportunities for social and economic advancement arise from the mobile phone's ability to gather and exchange information about pricing and market information (e.g., farmers no longer need to walk to market to determine product pricing); improve transport efficiency and distribute economic development; reduce isolation between rural and urban areas and increase security; and facilitate international economic linkages.[209] As a result of the mobile phone's ability to transform societies and improve lives, today Africa has "less walk" and "more talk" as phones continue to make daily social and business routines more efficient.[210]

Perhaps one of the most significant lessons of the mobile experience that can be applied to other sectors is that the technology was able to **empower people** to generate new income streams *in addition* to basic phone service. Part of the reason cellular telecom was easily embraced in the local economy is

attributed to the fact that it not only saves money and time, it ***creates money and time***; it is an income generation tool. Some call this an "enabling technology" such that it stimulates innovation in other areas (e.g., mobile banking).[211] Yet others refer to this kind of innovation as "inclusive capitalism," or capitalism that "spreads wealth as it creates wealth, which empowers the poor as it generates return for investors, a win-win capitalism."[212] Connection to the mobile communications network instantaneously produced hundreds of millions of new income opportunities.

# LESSONS FOR CLIMATE TECHNOLOGY INNOVATION

The mobile phone case study offers many lessons for the development and commercialization of climate technologies in the developing world. In particular, the mobile phone expansion in the developing world makes a strong case that technological solutions that fill unmet needs, are superior and more affordable than the alternatives, and are supported by innovative business models can achieve success in emerging markets once thought too difficult to penetrate.

Moreover, contrary to convention, transferring technologies from the West to "the rest" is unlikely to suffice to achieve sustainable market uptake. Technologies and business models targeting developing world populations, especially aimed at BoP markets, will need to adapt to the local business environment and informal economy system. New technologies will likely require whole new business models and new service options to fill unmet needs.

The story of telecom expansion, and particularly GSMA's role, point to some ways that an international innovation initiative could support both upstream product development and reduce downstream market bottlenecks.

The most notable lessons that can be applied to support the acceleration of climate innovation from the mobile phone revolution include the following:

- **Nurture local "talent" and build incentives**. Find and bring native entrepreneurs that have been trained in the West back to their countries to grow the local economy and increase local fields of knowledge; support policies and structures that reduce the "brain drain" effect where local intellect is permanently lost to the West.

- **Define the business case.** Support the development of market research and other market analytics across a level playing field to evaluate the business opportunity. Share the results with the industry to build early confidence in the market opportunity.

- **Invest in innovative ways to support and connect native entrepreneurs with foreign investors.** Organizations like GSMA have been successful at playing this convening role by connecting operators, investors and the mobile industry and by providing both virtual networks and annual conferences.

- **It is very important to support the private sector and to overcome the institutional inertia** of existing (often public) entities that may have unfavorable policy and regulatory systems that limit or block new

entrant technologies from gaining market share. Support policies that endorse market liberalization, which should open markets to private sector competition needed for rapid market development.

- **Evaluate the "disruptive" potential of the technology**. Does it introduce new functionality or face immediate direct competition from established technologies? Will it occupy an unoccupied niche market territory or have to compete with legacy technologies? Does it offer something that is better, more affordable, simpler, easier to use/access, or higher-performing than what exists now? Does it provide greater value than established products, in services, time and functions? In the case of mobile phones, the fact that it was a radical innovation and did not face immediate threat from fixed lines certainly helped it gain traction in emerging market economies. Overcoming well entrenched and often subsidized legacy technologies will be more challenging than entering less competitive markets with radical innovations that can fill unmet needs or launch into alternative market niches.

- **Look for ways to design products to support the cultural aspiration value** of the technology or service offering.

- **Support the R&D of technology solutions** that can both fill the first need (the main service the technology provides) and then look for ways to hybridize the technology by offering additional features to fill subsequent (often unrelated) needs may provide a successful design model. The design of new Solar LED lamps that offer additional, built-in, charging capacity for mobile phones and have multiple adaptors for other technology inputs is a case in point.

- **Support the customization of business models to local market architecture** rather than recycling Western models. For example, analyze informal economies and local distribution channels and build partnerships with established suppliers and non-profit/community groups that have achieved significant reach into the rural areas.

- **Evaluate new technologies for their ability to provide additional income generation** from the services the technology supplies. The opportunity to create additional income streams from the technology is likely to stimulate additional consumer demand and willingness to pay for the technology.

- **Create an international organization or entity working on behalf of the industry** that can act as a neutral broker supporting both supply push and demand pull and can have a significant impact on developing and accelerating new technology innovation markets.

- **Support joint product innovation** to facilitate alignment of technology with the needs and purchasing power of low-income consumers.

# Case Study #4: Agricultural Value Chains in Sub-Saharan Africa

## Introduction

The share of the world's agricultural exports from Sub-Saharan Africa (SSA) is roughly 2 percent, falling from 10 percent around four decades ago.[213] This is strikingly low when considering that SSA possesses 12 percent of the world's arable land, 65 percent of the population lives in rural areas and 75 percent of the SSA labor force works in agriculture.[214]

Imports face an opposite parallel—"Sub-Saharan Africa is the only developing region that has seen its share of world agricultural imports increase rather than decrease."[215]

SSA's difficulty in competing in global international agricultural export markets is not due to lack of participation in the sector. The convergence of falling exports and rising imports masks the fact that the continent's farmers and traders are investing heavily in the sector, albeit often at levels inadequate to generate sustained growth in productivity and income.[216] SSA's insufficient agricultural output is hampered by its diversified farming economy, undeveloped market structure, lack of access to finance and credit, and inadequate information and transportation infrastructure.[217] These and other factors render agricultural production in Africa risky and costly and limit the effective deployment of new and improved agricultural technologies.

Post-harvest losses of crops and livestock products are also a persistent problem in SSA that contributes to food insecurity and lost income for smallholder farmers. Estimates suggest that as much as 15-30 percent of maize, 25 percent of milk, and 50 percent of bananas and plantains never make it to market.[218] Improved post-harvest handling and management practices remain a critical challenge that will need to be overcome for SSA to boost production to the point where it can compete in global food markets and better meet its own food needs.

According to a recent World Bank report, the lack of ability to gain a competitive advantage in global export markets poses a substantial threat that SSA will become "trapped into producing low-skill, low-value products and service, struggling to obtain a significant value-added share in global trade."[219] It follows, the report adds, "that raising the productivity and increasing the efficiency of agricultural value chains are basic to the success of SSA rural economies and to the growth of incomes of their rural populations."[220]

Technological innovations that lead to better post-harvest management practices and infrastructure improvements have a high potential of helping SSA achieve these needed productivity gains. Direct and immediate benefits of these improvements will accrue to smallholder farmers, who will profit from enhanced income opportunities. Women, who play important (yet often overlooked) post-harvest processing, value addition, and handling roles in getting produce to market will also be direct beneficiaries of these improvements.[221] Improved post-harvest handling technologies would enable women to divert time and labor towards revenue-generating activities.[222] Improvements in gender equality for women may therefore be an additional co-benefit of improving value-chain operations.

## Meridian Institute Project – Technology Innovations and Commercialization for Agricultural Value Chains in Africa

With funding from the Bill & Melinda Gates Foundation, Meridian Institute, a nonprofit organization, directed the *Innovations for Agricultural Value Chains in Africa* project, using a process of open and distributed innovation to develop and accelerate the commercialization of new agricultural technologies to improve post-harvest management and enhance value chains in Africa.

The project brought together leading scientists and innovators with small producers in maize, cassava, and dairy value chains in Africa to identify innovative "out-of-the-box" post-harvest management and processing technologies that could add significant value for smallholder farmers[223] by reducing value chain inefficiencies.

The project commenced in the spring of 2009, followed by a field trip in August involving interactions among leading scientists and innovators, African farmers and processors, agricultural experts, businesses, and government agencies, and culminated in the end of 2010. Through multiple in-field visits with local stakeholders along the value chain continuum and smallholder farmers themselves, the project identified key bottlenecks and inefficiencies impeding the ability of smallholder farmers to increase their incomes in the dairy, maize, and cassava value chains. The project team's goal was to identify technology concepts that could reduce these impediments.

These field visits resulted in the development of nearly 200 technology ideas, 22 of which demonstrated potential to reduce value chain inefficiencies and were thus developed into concepts. These concepts were presented to the Bill & Melinda Gates Foundation in November of 2009. Concepts included: Modified Plastic Tank with Dryer Options; Milk Container with Anti-Microbial Properties; Cassava Tuberator; Universal Power; Milk Safety Diagnostics; Reproductive Health Diagnostics; and Vector-Borne Disease Diagnostics.

Concept briefs and implementation strategies have been developed for the most promising technology solutions. Five have been completed and will be evaluated for commercialization potential. A follow on-effort has been conceptualized that could support potential technology commercialization of some of the promising ideas that came out of the *Agricultural Value Chains in Africa* project as well as a broad range of other ideas outside of the project that demonstrate promise to improve smallholder farmer food security and income opportunities in SSA. The concept, called the "*Post-Harvest Commercialization Initiative*," draws key lessons from the agricultural value chains project and in-depth analysis of

commercialization pathways by Meridian and their partners. Based on the analysis of the commercialization pathways, the initiative seeks to present opportunities to systematically improve the efficiency and success of post-harvest technology commercialization and adoption, and offers a structure (e.g. organizational & financial model) and strategy to do so.

## Project Approach: An exercise in "Open Innovation"

The innovative product concepts developed through the *Agricultural Value Chains in Africa* project are the results of a novel collaborative project approach designed by the Meridian team. It has relevance for advancing other technology sectors.

The project design was characterized by an unconventional process "involving internationally distributed expertise from non-agricultural disciplines—a form of "open innovation"—to analyze problems from fresh perspectives."[224] The interdisciplinary group included scientists and innovators at the cutting edge of their fields but specifically fields outside of agriculture, to tap "diverse bodies of knowledge to try and come up with concept solutions for longstanding and somewhat intractable problems in the agricultural sector in Africa."[225] The goal was thus to "apply ideas from emerging areas of science and technology to enhance African agricultural innovations" by producing actual concepts and deployment strategies rather than simply add to scientific research.[226]

This international team of interdisciplinary scientists and innovators met with African farmers and processors, agricultural experts, businesses, and government agencies. Direct engagement with local partner institutions through a two-week field trip in East and West Africa helped the project team to best identify the most pressing constraints in the maize, dairy, and cassava value chains that were in need of technically, socially, and economically feasible solutions.[227]

### *The Multi-perspective Project Team*

To this end, four teams worked together to meet the project objectives. The teams included:

- An *international science team* comprised of twelve people at the leading edge of their disciplines
- Four *value chain partners* that were singled out for their "deep expertise and experience working within a specific value chain"—Food Research Institute of Ghana (Cassava Value Chain partner); International Livestock Research Institute of Kenya (Dairy Value Chain Partner); East Africa Dairy Development Project of Kenya (Dairy Value Chain Partner); East Africa Grain Council of Kenya (Maize Value Chain Partner)[228]
- Additional *value chain experts and participants* engaged for their deep understanding of local agricultural value chains and ability to provide insight regarding specific value chain constraints, feedback on product ideas and tools, support business plan development and other commercialization activities. This group included the International Institute of Tropical Agriculture (IITA), Nigeria; Natural Resources Institute (NRI), UK; International Center for the Improvement of Maize and Wheat (CIMMYT), Mexico; and *icipe* —African Insect Science for Food and Health, Kenya[229]
- Additional *consultants*, including New Growth International to develop a lessons learned report; Arthur D. Little to assist in the development of business plans for the three most promising

technology concept outputs; Women Organizing for Change in Agriculture and NRM (WOCAN) to ensure gender issues were integrated throughout the process; and Public Intellectual Property Resource for Agriculture (PIPRA) to support the development of a global access strategy. Finally, Conrod Associates Communications L.L.C. was contracted to produce video overviews of each value chain and brief highlights of key value chain constraints.[230]

Careful attention was also paid to ensuring that solutions complemented existing value-chain improvement efforts and considered the policy, legal, institutional, market, and socio-economic conditions.

As one project team member notes:

> The project approach is based on being process experts not substantive experts, for example looking at the political context, cultural context, power dynamics, and other factors around the issue. This ability to look at issues from different lenses and provide multiple solution sets supports a kind of triangulation where intrinsic biases or issues that arise from a single perspective and problem solving approach can be overcome.[231]

In support, another project team member offers:

> Successful technology adoption is not just about the technology. Many technologies aren't being used, or are broken or not adopted for various reasons. The key is to looking at how to position for rapid adoption, through a full spectrum lens, looking at economic issues, local entrepreneurship, and the policy environment.[232]

### *The Post-Harvest Commercialization Initiative—from concept to commercialization*

As noted above, a number of extremely promising technology concepts resulted from the multi-perspective team collaboration. However, the Meridian Institute team discovered a number of barriers to commercialization as they sought to push the most promising products into the SSA market. The Meridian Institute's "*Post-Harvest Commercialization Initiative*" was conceived to overcome a common disconnect in the innovation system that often occurs in the development stages between early technology concepts and later stage commercialization. The Initiative's aim is "to accelerate commercialization and increase successful adoption of post-harvest technologies that can help smallholder farmers increase their incomes by facilitating progress at key steps along the commercialization pathway."[233]

The commercialization initiative was conceived through support of a steering committee retained to "help guide the process of developing recommendations and analyzing potential models and approaches for agriculture technology commercialization."[234] Subsequent national and international meetings and consultations were held with members of the development community, the private sector, stakeholders and other experts to vet and further develop the proposed initiative. Following a meeting in New York City and additional stakeholder consultations, Meridian presented the Initiative to potential partners at the African Green Revolution Forum in Accra, Ghana, on 2 September 2010.[235] Presently, the concept is still seeking both feedback and funding to begin implementation.

The initiative focuses on reducing the following common constraints to agricultural technology commercialization in SSA:[236]

- *High transaction costs of finding the right partners* – technology developers, funders/financiers, commercial implementers, and other partners needed to successfully commercialize technologies
- *End users' needs are not incorporated in product design* (i.e., acceptability, accessibility, affordability, adoptability)
- *Lack of access to appropriate financing* to support and limited planning for market development and scaling up of technology
- *Lack of information/knowledge sharing*
- *Poor alignment of objectives and incentives among partners*, including incentives for private sector engagement and investment.

To reduce these constraints, the Post-Harvest Commercialization Initiative proposes to implement two broad measures: 1) Catalyze relevant technology design and commercialization processes and 2) Strengthen and scale up successful design and commercialization processes.

The first measure proposes to build strong ties among organizations that can supply information on technology and innovation needs for smallholder farmers (e.g., farmers' organizations, NGOs, and private sector associations). Additionally, it proposes to form relationships with the wide array of institutions and individuals that demonstrate potential to devise technology concepts (e.g., universities and polytechnics, companies, international agricultural research centers, government agencies) and to support processes that generate new technology concepts, on an as needed basis, to complement existing technologies. Finally, it proposes to develop a product selection process to identify and pre-select an array of diverse technology concepts likely to spawn investor interest.

To strengthen and scale up successful design and commercialization processes, the initiative proposes to establish partnerships with end users, "Champions,"[237] financial institutions, and technology developers. Once these partnerships are developed, the initiative proposes to identify resources and service providers that can channel support to the partner institutions to fill gaps in the commercialization process (e.g., regulatory and policy support, market analysis needs, and analysis of adoption requirements). It will also facilitate knowledge sharing by documenting lessons learned and best practices, thereby serving to "deepen and broaden knowledge about successful design and commercialization processes."[238] For example, it proposes to "create strong links to practitioners and theorists to identify, share, and enhance successful design practices and commercialization approaches as well as share lessons learned from failed technology introductions."[239]

## Innovation Lessons from Agriculture in Africa

- **International collaboration—via strategic cross-sector partnerships—supports successful innovation and technology adoption.**

The Meridian project offers a key lesson for the successful adoption of new technologies in other sectors. Namely, that "interactions among public, private, and collective initiatives" are "crucial to sustainable processes of agricultural innovation and diffusion."[240] Interactions between the four groups of partners—the international science team, local value chain partner institutions, value chain experts and participants, consultants, and others (in this case in R&D stages)—were critical to ensure that the key players were invested in the solutions generated and that the whole range of institutions and individuals needed to move the ideas from the conception stage towards later development stages were engaged from the onset.

Of the hundreds of innovative ideas generated through the *Innovations for Agricultural Value Chains*, 22 were identified for further development and five are being refined for potential commercialization. One promising example, the "Cassava Tuberator" micro-dryer, dramatically decreases the drying time for cassava chips through a forced-hot-air technology that also reduces reliance on expensive fuels used in conventional drying machines. Another concept, a modified plastic tank designed to enhance maize storage time, is being prototyped by a company in Kenya.

These ideas and others that came out of the Meridian project would not have been generated without a coordinated approach that linked interdisciplinary expertise with the direct beneficiaries of the proposed technologies, in partnership with the local institutions already working to advance agricultural value chain efficiency.

As noted by one of the local engineers on the project team:

> The idea to really sit down with people from all over and try to find a collaborative solution was excellent. The truth and reality is that Africans have not found these solutions by themselves. The result has been no solutions and the predicament we are in. We need to think outside the box. Increased stores of knowledge can facilitate this.[241]

The importance of developing and nurturing cross-sector partnerships is well documented in the literature as contributing to the success of new technology development and deployment in the developing world.

## KENYA'S BANANA TISSUE CULTURE PROGRAM

In 1996-97, the public Kenya Agricultural Research Institution (KARI) launched an international collaborative biotechnology project. The International Service for Acquisition of Agri-biotech Applications (ISAAA) facilitated the project, funded by the Rockefeller Foundation and the International Development Research Center. The project used tissue culture (TC) laboratory techniques to supply pathogen-free planting material to 150 smallholder farmers in four major banana growing areas of Kenya.

The following organizations provided cross-sector support roles to roll out the program: ISAA undertook initial technology brokering from South Africa; KARI performed on-station and on-farm technology trials and adaptations. KARI also worked with the public extension service and a number of NGOs in an aggressive extension and publicity campaign aimed at farmers. A private company, Genetic Technology Laboratory (GTL), handled production of the initial tissue culture banana plantlets. The Institute of Tropical and Sub-tropical Crops (ITSC), a public research institute in of South Africa where the use of in vitro banana plantlets was already being implemented, offered technical backstopping services.[242] Local private entrepreneurs and pre-selected farmers were also brought into the process to serve as the tissue culture plantlet distributors in exchange for credit.

The banana tissue culture project demonstrates that these partnerships were essential for successfully testing and distributing the banana-tissue innovations. The banana tissue culture project supports farmers to improve yields through the use of disease-free and insect-free planting materials, which has contributed to considerable improvement in the Kenyan banana sector. It is estimated that tissue culture technology in Africa has increased banana productivity from 20-45 tons per hectare and supported more than 500,000 resource-poor farmers from tissue culture transfer. For the typical family, which can average up to 10 individuals, increased production can support an increase in household income from US$1-3 /day.[243]

The success of the banana tissue culture program in Kenya also provides validation of the critical role of a thorough needs-assessment process and pre-concept development is attributed to the fact that "the laboratory-based R&D had been *firmly tied to the needs identified through participatory on-farm research*, ensuring that priorities had correctly been identified and the technology accurately targeted."[244]

- **A thorough assessment of end-user needs is essential for successful technology uptake**

As noted by one of the Meridian project team coordinators:

> To bring an intimate knowledge of the issues, several local partners were brought in that had worked extensively on the agriculture value chains and thus could identify the key constraints and provide context on technologies and other interventions that had been tried (especially those that were unsuccessful) in the past.[245]

To identify gain first-hand knowledge of the challenges faced by smallholder farmers, the Meridian project team spent two weeks in the field (at sites in east and west Africa) visiting smallholder farmers, engaging with local entrepreneurs, value-chain specialists and other stakeholders that are most deeply involved in the specifics of post-harvest value chains. This careful needs-assessment was crucial to

ensure that the ideas generated were targeting actual post-harvest issues and reducing tangible value-chain constraints.

Improved (TMS) cassava varieties, the mechanized cassava grater in West Africa, improved maize varieties and the hammer mill in Eastern and Southern Africa, and the oil-press machine (*mafuta mali*) in East Africa are other examples in the literature of agricultural value chain interventions whose innovation success can be attributed to their ability to successfully identify and address actual end-user needs.[246]

- **Local involvement in the innovation process is needed to ensure solution adoption**

Although many partnerships are needed to support successful technology realization, the role of local involvement throughout the innovation process cannot be over stated. Local partners—especially the beneficiaries of innovation and those needed to support commercialization—were needed to ensure that the ideas generated by the project team would be adoptable, scalable, appropriate, affordable, and able to feasibly reduce the value chain constraint they were designed to overcome.

As one Meridian team member noted:

> The addition of local partner agencies/consulting groups representing small holder farmer interests and already working in this space to the group of scientists (2 were from Africa) provided good representation of the needed stakeholders and African interests. Having both internal and external eyes work on the problems in Africa is very important. Poverty has many dimensions. Someone on the team must be from Africa so they can look at problems with the understanding of what it means to be poor.[247]

A primary operating principal of Meridian Institute is designing "collaborative approaches that bring together people who understand the issues and have a stake in their resolution."[248] One of the Meridian Institute implementers of the agricultural value chain project validates this point, claiming that "affected populations are always involved with helping shape the outcome and Meridian is careful to make sure stakeholders are engaged in an appropriate way."[249]

The key lesson drawn is that it is imperative to ensure that innovations are operationally relevant to the circumstances of intended users.

A focus on local involvement in technology solution generation is starting to appear in the national restructuring of public innovation institutions and policies in Africa. For example, Ethiopia's National Agricultural Extension Program is based on a decentralized "package approach" envisioning a high level of institutionalized farmer involvement in technology development and diffusion in a "Participatory Demonstration and Training Extension System."

- **Innovation models that nurture the private sector as the primary driver of innovation, but are backed by public intervention, facilitate successful technology development and commercialization.**

In the past, traditional approaches to agricultural technology development and diffusion in Africa were based on "one-way flows of information (knowledge) *from* the public sector *to* farmers and traders.

Private (market-based) and localized, collective initiatives were either ignored altogether or viewed as passive recipients of publicly-generated and disseminated knowledge."[250]

However, today the private sector "has rightly come to be considered a major source of innovation and communication" and "interactions among public, private, and collective initiatives are now viewed as crucial to sustainable processes of agricultural innovation and diffusion."[251]

One of the concepts that arose from the Meridian project work is a modified plastic tank for maize storage. One of the project team members, who was instrumental in developing the concept, returned to Kenya to meet with maize equipment firms to share the concept. A firm has since taken on the potential commercialization of the concept, beginning with supplying funding for product prototyping. This transfer of technology to the private sector is a critical junction needed to move technologies towards commercialization and bridge the "valley of death" that often occurs between research concepts and full-scale product development.

## THE MECHANIZED CASSAVA GRATER IN NIGERIA:

### the Crucial Role of the Private Sector

Introduced in the 1930's, the mechanized cassava grater initially had limited uptake. By 1969, only 25 percent of the cassava producing villages in Nigeria had access to the technology.[252]

Today, a range of cassava graters, from the most basic models to those that are highly advanced, have gained widespread adoption and are found in virtually all major cassava producing villages in West African countries where cassava is processed into *gari* (e.g., Nigeria, Ghana, Cote d'Ivoire, Benin, Guinea, among others).[253] Moreover, total consumption on of cassava in Africa has also doubled from about 24 million tons per year in the early 1960's to about 58 million tons in early 2000's, in part due to farmers' ability to successfully process an abundant supply of cassava into gari at affordable costs and with limited labor costs.[254]

Although Government R&D agencies were involved, the cassava graters they developed are thought to have "achieved limited adoption because they were expensive and inconvenient compared to graters developed by village artisans."[255] Village smiths, welders, mechanics, and other private-sector players are attributed with the successful adoption of graters because they were able to develop affordable products and business models that met local needs (i.e., village entrepreneurs provided grating services to smallholder farmers for a fee based on the quantity grated, and roadside mechanics and welders offered maintenance services).

- **Adequate time and resources for field testing of new technologies with end-users is crucial.**

The field testing and demonstration stage was identified as a key challenge arising from the Meridian project design. Before the concepts were presented for further implementation, the project team acknowledged that they needed more time to bring the ideas back to the field for testing.

> Once we had solution concepts, there wasn't enough time to bring them back to the end-users (not an intermediary institution but the small holder farmers themselves) to

> see if they would actually work before prototyping. Performance feedback at every step [from innovation to commercialization] is critical for any new technology.[256]

They also noted:

> The largest barriers preventing new technologies from being successful in the market are cost and inappropriateness [of design]. Too often technologies perform wonderfully in laboratory conditions and may be good for developed world markets but ineffective and inappropriate for developing countries.[257]

## INVESTING IN PROTOTYPING AND DEMONSTRATION

The failure of the PRODA Cassava Peeler provides a supporting example of the need to make investments in the prototyping and demonstration stage.

In 1984, the Product Development Agency (PRODA), a government research and development agency in Nigeria, led an initiative to improve cassava value chains in West Africa, which resulted in the invention of a prototype cassava peeling machine. However, a crucial innovation step in the R&D process was overlooked: the field testing and modification stage by end users. The technology was launched directly from the laboratory to market but failed to be adopted.

This failure provided an "important lesson for future introduction of technologies in commodity value chains in sub-Saharan Africa, that is, existence of an urgent constraint (need) within a value chain does not imply that any innovation aimed at redressing the constraint would succeed. A successful innovation should be aimed at redressing the constraints while fitting into the production circumstances of the actors."[258]

- **An institution or group of institutions is needed to own the process of stewarding technology concepts into the market- particularly to overcome common bottlenecks in the development process that often impede technologies from maturing to the point of commercialization**

The follow-on effort to the *Innovations for Agricultural Value Chains in Africa* project—the *Post-Harvest Commercialization Initiative*—was envisioned to provide targeted interventions to help promising technology concepts move towards commercialization.

Without such a program or entity to carry the promising concepts forward, there is a substantial threat that these ideas will become "orphaned" from further development and trapped in the "valley of death." Despite increasing efforts and investments to improve management processes to reduce post-harvest losses, the majority of the technology projects introduced in the past have not gained traction among smallholder farmers or other stakeholders along the value chain. The proposal of this initiative offers a key lesson about the need for an institutional entity or cluster of entities to provide coordinated product development support at each and every stage of the technology innovation continuum, from early R&D stages through commercialization. In lieu of this entity, many good ideas may be just that—good ideas—that unfortunately never achieve realization.

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

The successes and failures of technology projects to improve agricultural commodity value chains in Sub-Saharan Africa offer key insights that can be applied to the acceleration and adoption of technology innovations for climate change mitigation and adaptation in the developing world.

Of the many lessons offered, the following have the most relevance for advancing climate innovation:

- **An institution(s) that can facilitate a coordinated and "distributed innovation" approach to product development may have a high success rate for generating workable solutions.**

The Meridian project demonstrates how an internationally coordinated collaborative approach can produce concrete results in industries requiring accelerated product development in geographic areas that are difficult to reach. The process of bringing together global experts from diverse disciplines to provide fresh perspectives to longstanding problems has direct relevance for climate innovation development.

As noted by one of the project implementers:

> [Lessons from these sectors are] highly applicable and relevant to climate change solution generation. Clean technology is more capital intensive and needs to overcome regulatory and other issues but the core elements of value chain project could be applied to the energy and climate space. There is tremendous value in bringing different landscapes and fields of knowledge to look at problems from different angles. It is not cheap or quick but can lead to significant technology innovation breakthroughs.[259]

- **Climate innovation can benefit from the "innovation systems" approach employed by the Meridian project**

Just as the agricultural innovation process was envisioned as embedded in prevailing social, political, and economic systems, effective climate innovations must be designed and deployed within the intricate systems in which they operate and span both public and private spheres. A key principal of the Meridian project was to be mindful of the contribution by others already invested in improving value chain operations by supporting improved markets, infrastructure, and policy and institutional frameworks to better link smallholder farmers to markets. The project's focus on **inclusive** research, product, and market development proved to be a successful approach to technology innovation that has clear implication for the climate space.

- **Successful uptake of new technologies depends on nurturing the whole innovation system, from research and development through commercialization.**

Perhaps the most significant lesson for the acceleration of climate technology innovation from the experiences of agricultural innovation is the need to provide targeted support at each stage of the innovation continuum and to find ways to bridge the gaps between the different innovation stages. he

examples presented here demonstrate that successful technology uptake requires needs-based *research* (e.g., Meridian Institute end-user consultations), *development* that involves careful *prototyping* and *demonstration* with end-user and private sector implementer's endorsement (PRODA cassava peeler example), and the articulation of clear pathways for *commercialization* (banana tissue culture example).

The Meridian project was successful in generating technology concepts at the research and development stage, but the project timeline and financing were finite, leaving the majority of the promising ideas stranded in the concept phase. As a result, Meridian Institute has proposed a "Post-Harvest Commercialization Initiative," as described above in detail, to improve, support, and accelerate the commercialization of post-harvest technologies in Sub-Saharan Africa (potentially including some of the innovations developed by participants in the Meridian project as well as other promising technologies).

While this project was designed to tap collective, scientific knowledge to identify new technology concepts and was thus specifically aimed to facilitate ideas that didn't require extensive investments in upstream research or scientific "breakthroughs," the scenario of promising concepts becoming "orphaned" from further development is representative of common bottlenecks in the larger innovation framework. In order to support the successful acceleration of climate innovation it will be critical for a program or institution to bridge the gap or "valley of death" between research and late-stage development.

This means an overhaul to the current approach to most technology adoption. "Supply-side efforts that consist of under-funded research with an occasional tax incentive or regulatory incentive thrown in" will simply not be adequate to support the introduction of new climate technologies and achieve scale needed to make a meaningful impact.[260]

- **Rather than acting as disconnected entities, R&D institutions could better support the commercialization process by being open to collaborating with others early on to prepare products for successful launch down the commercialization pathway.**

A key challenge in Africa's agricultural sectors is the inability to scale up and scale out local successes in innovation. Thus, "scaling plans should be developed and budgeted for up-front" and strategic partnerships established early on, long before the technology is ready for demonstration.[261] A small independent entity, for example, that can support the progression of products from R&D towards potential commercialization pathways, by proactively linking R&D institutions with subsequent players down the innovation chain could increase the success rate of product commercialization.

- **End-users and other implementation stakeholders must be involved throughout the innovation process, starting with needs assessment in early R&D stages, through prototyping and demonstration and commercialization.**

The *Post-Harvest Commercialization Initiative* lays out a structure to support the commercialization of the concepts generated in the value-chain project in addition to other promising ideas that may require commercialization support. Among other points, the initiative recognizes that it is critically important that technology commercialization projects are needs-driven. Thus the concept note proposes that "the initiative should be structured to engage beneficiaries early and throughout the process to identify

(evolving) technology needs and requirements and evaluate opportunities that could have a positive impact."[262] As the examples above demonstrated (PRODA cassava peeler example; mechanized cassava peeler example) the adoption potential of new technologies is low if they are launched directly into the market without end-user participation and buy-in through a careful needs assessment; limited end user engagement in product development is a key impediment to successful technology development. Participation is needed to validate the usability of new concepts as well as to provide feedback at the prototyping, demonstration, and later stages regarding adoptability and affordability.

Climate technology innovations will need to engage end-users and other affected stakeholders throughout the innovation process to reduce the potential for market failure. Engagement of local end-user perspectives will be especially important in early R&D stages to identify key needs and, later, to validate the concept's applicability and adaptability to address local challenges and to help identify appropriate distribution models and delivery networks.

- **Both the Private and Public Sectors are needed to accelerate technology development and deployment.**

The success of the mechanized grater in Nigeria and the maize container concept conceived in the Meridian agricultural value-chain gaps project provides useful lessons for facilitating new technology adoption in other sectors. Namely, that new technology innovation processes should seek to establish strong *private-sector partners***.** Private sector buy-in to validate early concepts will be important and commercialization cannot occur without private sector uptake of innovations. The mechanized grater example also suggests an additional point- the significance of coordinated public sector support underlying private sector efforts and the promise of public-private partnerships in spawning and commercializing technology innovations.

In the agricultural sector in Africa, it has been found that private firms often under-invest because they are not able to fully recoup investment costs or make enough profit from agricultural goods, despite the fact that they provide high social returns.[263] "Unless appropriate private incentives exist (for example, conducive intellectual property rights regimes), markets for agricultural R&D products and services fail. Public roles in agricultural innovation systems therefore rest on providing such incentives for welfare-enhancing private investment, and, where necessary, public provision to fill key gaps left by market failure."[264]

Akin to the agricultural sector, accelerating climate innovations in the developing world will also require a mixture of private- and public-sector interventions. Demand pull will need to be supported to drive markets, and supply push from government-supported R&D investment will be needed to jump-start innovation and support existing concepts that demonstrate promise. Climate technologies that can gain early private-sector interest and investment from local entrepreneurs, SMEs, and MNCs will have a better chance at commercialization. At the same time, public support will be needed to bring external knowledge and expertise to the innovation process, to help provide finance for R&D, and to help proven technologies that need funding support to achieve scale.

The public sector must also create an enabling policy environment. As evidenced in the agricultural sector literature in Africa, "innovations preceded by strengthening of the enabling policy environment have often succeeded (e.g., sorghum processing in Nigeria and smallholder dairy in Kenya). Those introduced without a review of supportive policies have often failed (e.g., the food-grade, aluminum milk cans in East Africa, and the community-based animal health workers across Africa)."[265] The Post-Harvest Commercialization's commitment to engaging in policy and public sector operations is indicative of a needed public role to support the development of enabling policy.

- **There is a strong need for a neutral institutional entity that can collect and share information and capture best practices and lessons learned.**

As the *Innovations in Agricultural Value-Chain Gaps* project and the banana tissue culture program allude, it will be vitally important in the climate technology innovation sector to appropriately assess end-user needs and preferences to design solutions that are adoptable and adaptable to the local landscape and are affordable (access to finance will be especially instrumental for supporting the progression of highly capital intensive innovations).

Information generation and sharing will also be essential to help the private sector understand and gain confidence in the market opportunity and for consumers to understand the benefits of new technology alternatives over legacy technologies. Protecting intellectual property will also require attention from an institutional entity that can both protect the rights of technology developers and disseminators and reward innovative activities; such protection has enabled success of the seed industry across Africa (through enforcement of breeders' rights) and the export flower industry in Kenya (through strict patent laws)."[266]

# Case Study #5:
# Public Intellectual Property Resource for Agriculture or PIPRA – A Model for Dedicated IPR Support Services

## Introduction

The nonprofit Public Intellectual Property Resource for Agriculture (PIPRA, www.pipra.org) is an independent organization affiliated with the University of California at Berkeley. It was founded with support from The Rockefeller Foundation in 2003 to address intellectual property rights (IPR) obstacles in the development and distribution of poverty-reducing, agricultural biotechnologies for poor countries. The fragmented ownership of the intellectual property rights (IPR) in the development of those technologies limited the deployment of new crops for humanitarian purposes.

PIPRA was the first and only entity with a dedicated mission to help developing countries overcome IPR problems to access new technologies; the dedicated nature of an independent organization focused on IPR remains its most critical feature, apart from the progress it has made in the programs it has implemented.

PIPRA's founding mission was to focus on IPR issues, particularly patents, in plant biotechnology for crops in developing countries. In particular, the focus was on public patents that were typically housed in universities funded by federal research support. The initial goal was to find ways to accelerate the use of those publicly-patented technologies in the marketplace to improve agricultural productivity in developing countries, and to serve as a clearinghouse for those patents to better develop agricultural products for the poor.

But, over time, it was concluded that this sole focus on public patenting, without a similar focus on the role of private patents in the agricultural space, was not working as effectively as planned. Therefore, the organization expanded their mission to provide more consultant services in the IPR space for both the public and the private sector, and did not focus exclusively on public patents. At the same time, it expanded its mission beyond agriculture to work on IPR issues in energy, health and water.

Most recently, PIPRA has formed a global partnership in the climate and other technology spaces to work on IPR problems for the poor. This new initiative, established in 2010, is called "Global Access in Action." [267] The partners to this initiative include World Economic Forum, WIPO (World Intellectual Property Organization), and Global Access to Technology for Development (GATD). [268] Among its core

beliefs is that licensing IP for applications to benefit the poor can be achieved without compromising core commercial markets of IP owners. Efforts are now underway to raise funds and establish the operating partnership.

There is an emerging view from the work of PIPRA in developing country IPR issues that challenges a prevailing notion that IPR, under current IPR regimes, is an insurmountable global problem to providing technology to the poor. Those who hold this belief argue for a global solution to climate technology IPR. But, according to a program manager of the Gates Foundation who has worked with PIPRA, in most developing-country technology issues, "IPR is not the most important barrier—in almost every case you can negotiate a solution. "[269] Moreover, through the hands-on work of PIPRA, he has come to the conclusion that global solutions to IPR such as broad-scale patent pools are not the answer. Instead, he said, "We are now less ambitious—rather than a global solution to IPR problems, we are more interested in solving specific problems."[270]

## Establishment and Operation of PIPRA

According to its managing director, PIPRA's mission is quite ambitious.

> PIPRA provides intellectual property rights and commercialization strategy services to increase the impact of innovation, particularly for developing countries and specialty markets.
>
> PIPRA also helps innovators working to create new applications for agricultural, health, water, and energy technologies in developing countries and helps public sector organizations get their technologies out of the lab and into use. We do this by improving innovators' ability to navigate IPR issues and think strategically about commercialization.[271]

However, it is important to stress the early direction of the organization. PIPRA's founding mandate was targeted on public patent problems for crops in developing countries. The premise for the initial strategy was to overcome barriers to the humanitarian licensing of biotechnologies. The partners involved generally were research universities and public-sector institutions. The notion was that greater coordination and publication of public patents would result in greater commercialization of products for the poor.

> The early model of PIPRA was a clearinghouse – patent information from major public sector organizations (mostly US universities) would be gathered, licensing information would be collected. By providing accessible and searchable data on public sector patenting, PIPRA would increase transparency and lower transaction costs – supporting better commercialization of agricultural biotechnology innovations from the public sector. Complementary to the clearinghouse structure, PIPRA also promoted better management of IP among public sector organizations, including education and outreach on humanitarian use licensing and a range of other topics. [272]

Fairly early on, it became clear that this public focus was too narrow. Putting patents online through a clearinghouse was a popular solution to the IPR problems a decade ago. It was based on the idea that all patents were "blocks" to innovation, and that disclosure of publicly patented material would somehow resolve these patent blocks and thickets.

That solution proved too simplistic, and many similar IPR clearinghouses folded during that time. What became clear is that the problem of how patents were used and licensed was much more complicated than originally thought. Part of that new appreciation was the need to work with private-sector patent holders, rather than around them, if there was any hope of using patents for commercial product development. Dealing only with public sector patents addressed only part of the problem.

In the beginning, PIPRA tried to solve agricultural biotech challenges for the poor without private-sector involvement, just using publicly licensed IPR material. They found it did not work in the plant research area for two reasons. First, PIPRA found that university tech-transfer offices did not have a clear incentive to focus on licensing for poor and developing countries, instead tech transfer offices were looking for financial returns. Second, PIPRA discovered that too many important patents were held by private companies who, it turned out, weren't opposed to humanitarian licensing.

As the managing director described it,

> The beginning assumption of PIPRA was to ask whether, across technology fields, it was possible to work only with public-sector patents to improve technologies for the developing country's poor. The solutions tried were common licensing, patent pools, tied together in one standardized creative commons approach to patents. The answer was that it did not work. [273]

This failure taught the founders an important lesson in IPR:

> Just knowledge-based models in aggregate do not work in the patent space for developing countries, and is not likely to work to make an impact in other areas. We need to address specific incentives and how to engage public and private participants to make a difference. Organizations must deal with many transaction costs in any such effort. [274]

In response, PIPRA evolved from a patent clearinghouse to an IPR service provider. This evolution has been quite dramatic, according to its managing director.

> Much has changed over the decade since PIPRA was first conceived. While perspectives on the use of IPR remain wide-ranging, especially where public sector and developing country interests are at stake, there has been a general movement toward viewing IPR less as a block to innovation and more as a high, but surmountable, transaction cost. Importantly, IPR-related transaction costs have been put into perspective amidst other costs of developing genetically modified crops (including regulatory, technical, marketing, and political issues).[275]

As the organization now notes, "Our services are now focus on: research and analysis; agreement negotiation and drafting; lab services; and international workshops." [276]

In general, PIPRA's staff engages in three types of activities. First, they apply an in-depth understanding of IPR law and science to address innovation problems in a practical setting. Second, they offer project-specific services, such as analyzing the IPR issues around a specific technology, advising whether there are alternative technical strategies that could avoid IPR hurdles, discussing the costs and benefits of patenting/licensing the invention, and exploring which companies are likely to be interested in product development and deployment. And third, they support the negotiation and drafting of agreements necessary to move technologies from the lab into the marketplace.

In particular, PIPRA's core activities include the following:

- IP analysis—either broad landscapes or focused on particular technologies
- Biotechnology resources, e.g., the PIPRA vector
- Drafting and negotiating agreements, with the support of a pro bono attorney network
- Research consortia support, including public-private partnerships
- IP management workshops at public institutions
- Regional IP Resources, mainly in Latin America and Southeast Asia
- Commercialization strategy to improve technology delivery
- IP handbook
- IP policy analysis

These services have proved useful to public-sector institutions, consortia and public-private partnerships in developing and implementing IPR management strategies in agriculture.

PIPRA operates as a membership organization. It is open to any university, public agency, or non-profit research institution actively engaged in research. It also works in collaboration with the private sector, law firms, and other organizations.

PIPRA also provides IP evaluations for specific projects such as Gates Foundation-funded projects. The basic service they provide for a funder on projects is to assess the patent status of a proposed grantee, and then identify the problems that the grantee might have to bring a product to market. Armed with that information, the funder can then intelligently work with the grantee to overcome the specific patent problems as a condition of funding a project.

In the end, all these PIPRA IPR services go to address one core problem – risk reduction.

> The purpose of all this work is "to reduce public risk." That is, government support (and foundation support for projects), as it moves down the line toward product development, inevitably involves IPR. So these funders must act like private investors early on and assess the IPR implications of their public investments. They need advice on strategic IPR issues up front. This is also done to avoid any liability to investors and participants in the projects.[277]

## Assessment of PIPRA's Performance

The organization that probably has worked most closely with PIPRA from a funding and accountability perspective is the Gates Foundation. An interview with a key program officer there offered several insights into the operation of the organization, including a strong endorsement of their mission and activities. He has had dealings with PIPRA for over seven years, including four years at the Foundation, using PIPRA on a CG Challenge Program grant.

Here are some major conclusions he has reached about PIPRA:

- Their basic strength is their provision of services to clients. He has used PIPRA as a consultancy to evaluate project proposals, and then has used them to identify and help straighten out patent challenges.
- His assessment is that PIPRA is "great" at the job they do in the IPR area and reasonably priced. "No one else comes close in understanding the issues as deeply as they do," he notes.
- He noted that as compared to the CGIAR's internal IPR program, which provides general insights on relevant international agreements, PIPRA was able to provide a roadmap and a pro-bono lawyer for negotiating IP hurdles. [278]

In general, the experts we interviewed concluded that global solutions, like patent pools to overcome IPR issues in the agricultural area, did not work as well as hoped. They take too much time and money to organize and in many cases private companies are reluctant to hand over control of their patents to an outside entity. Their reluctance is not for fear of lost profit (as they understand the humanitarian use of the crops); instead companies are afraid of being held liable for problems, health or otherwise, resulting from crops developed from their patents—from research over which they did not have any oversight. In these cases, companies want specific legal agreements and continued monitoring to be assured they will not be held liable—then they are happy to grant humanitarian licenses. "Give a few lawyers a few months and they'll come up with a solution."[279]

Instead of global solutions, the Gates Foundation expert has concluded that specific IPR problems for specific projects can be readily solved with good legal and technical expertise. According to him, "IP is not the most important barrier—in almost every case you can negotiate a solution… IPR is not a deal killer."[280] In the case of agriculture in Africa, for example, getting the science to work and the regulatory and political environments are much more difficult problems to address than IPR issues.

The work with PIPRA and other groups in IPR has convinced the Gates Foundation not to pursue global solutions to IPR problems. Rather, it would use PIPRA to identify case-specific IPR obstacles that can be solved through dedicated application of legal talent and technical expertise.

## Global Access in Action—A New Global Initiative on IPR

Based on the work of PIPRA, there is a new effort to replicate and expand its approach globally to many technology areas, including climate.

In 2010, several organizations came together with PIPRA to explore creation of a new global initiative to focus on IPR in developing countries. It is called Global Access in Action or GAA. The current partners include the World Economic Forum, WIPO and a host of other partners.

According to its mission statement,

> Global Access in Action believes that licensing IP for applications to benefit the poor can be achieved without compromising core commercial markets of IP owners. More companies, research institutes, and universities will engage in technology transfer benefitting the poor if we can reduce transaction costs and mitigate risks (e.g., liability

> risks). Global Access in Action does this by raising awareness, advocating global best practices, and supporting programs with a practical approach. At the heart of this approach is the recognition that 'Bottom of the Pyramid' humanitarian uses of IP do not compromise core markets.[281]
>
> Access in Action was founded in 2010 with a mandate to promote technology transfer for the benefit of the world's poor and under-served. Incubated by the World Economic Forum Global Agenda Council on IP, this alliance of companies, research institutes, and universities aims to assist owners of knowledge assets as they demonstrate their global responsibility, without compromising their global competitiveness. Global Access in Action raises awareness, advocates, and mobilizes resources to ensure that the international technology transfer community is increasingly able to strike the right balance between preserving commercial markets and creating access to technology for the poor.

GAA intends to accomplish these goals through two complementary platforms: 1) a Global Responsibility Licensing Platform and 2) a Partnership Services Platform.

***Global Responsibility Licensing Platform***

Through the licensing platform, the group plans to provide free online access to practical legal knowledge resources and patent information, as well as support the development of continuing-legal-education resources. As part of this work, GAA will create an online database to gather together, and make publicly available, information about the patents within members' portfolios—providing a resource for identifying technologies with potential humanitarian uses. It also will create legal tools to cover, piece by piece, the anatomy of licenses and partnership agreements. Each section will include critical considerations specific to development and deployment of technologies for the poor, practical analysis, and examples of language and redacted agreements that have been used in the past. Finally, it "will develop educational materials, courses, and workshops to improve the skills of practitioners engaged in drafting and negotiating agreements related to technology transfer for development." According to GAA, the "courses will set the standard for sharing practical legal know-how. They will target practitioners from developed and developing countries with the goal of lowering transaction costs over time and improving the quality of agreements in this field by building human capacity."[282]

***Partnership Services Platform***

Through the partnership services platform, GAA will provide "project-specific services for 1) needs identification, 2) practical agreement support, and 3) review of commercialization strategies with a focus on due diligence & aligning research, development, and deployment to impact the poor." The underlying theory behind these approaches is what GAA terms Demand-Driven Innovation Needs Identification.

> Too often in the past, technology transfer for development has failed because it was supply-driven – without real attention to the technological needs of the poor. Companies, research institutes, and universities need to know specifically what the problems, how technologies will be used, and what the adoption issues are if they are going to successful apply their knowledge and technology.

> Projects designed to apply technology to the needs of the poor have often lacked rudimentary due diligence and consideration of strategies for development and deployment. Without integrating downstream issues strategically into a project, donors and partners engaged in the project have increased risks of delays, reduced impact, or even failure. [283]

GAA says that their approach would consist of the following elements, which distinguishes them from prior top down IPR efforts:

- Practical approach
- Independent
- Resources to Reduce Transaction Costs
- Private Sector Engagement
- Global Engagement
- Demand Driven

The structure of GAA is designed to operate under a board of trustees drawn from developed and developing countries. It will have a Secretariat responsible to the board, supported by a small team of experts.

GAA is now in a start-up phase. Launch of the GAA is anticipated at the WEF in late 2011.

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

PIPRA's experiences suggest a number of important lessons for resolving IPR issues in the climate technology area:

- **IPR is a solvable problem.** In many case of agricultural cases, a host of other regulatory, scientific, and financial problems were actually greater barriers to the commercial deployment of improved crops for the poor. The IPR problems can be solved with sufficient expertise and dedicated attention.

- **Project specific IPR solutions may be more effective than global, public patent focused approaches.** The PIPRA experience suggests that IPR issues are difficult to resolve with global solutions. Rather, IPR obstacles in most cases are technology or product specific and require unique solutions and legal agreements between private and public entities that depend on particular markets. PIPRA's success suggests that a more practical approach than global patent agreements or public patent pools would be to create an institutional process to address the specific IPR challenges that will arise for particular technologies in particular countries.

- **A dedicated IPR organization, with access to technical and legal expertise, may be able to most effectively solve climate technology IPR challenges.** An institution dedicated to IPR can be a source of expertise, transfer of knowledge and problem solving. Most important, it can identify real problems in a particular technology area, bypassing much of the rhetoric surrounding IPR issues in the climate debate. The emerging collaborations with PIPRA through the now forming Global Access in Action project may provide a promising institutional framework to resolve climate related IPR problems through a "case specific" approach.

Therefore, an institutional ad-hoc response may be the most effective strategy at this time. A new institution would have the in-house capacity to systematically incorporate an "IPR strategy" function to determine (1) where specific IPR problems exist that prevent climate technology innovation and diffusion and, (2) where they do exist, how to creatively address and overcome them.

- **Technology development must be user needs driven—rather than supply driven.** A related lesson from PIPRA, which the GAA's Partnership Service Platform responds to, is that climate technologies must come directly out of an assessment of the demands of the poor. This is another reason why IPR solutions should be project specific rather than preemptively dedicating significant resources to creating solutions (public patent pools) that may not in the end be relevant to the emerging needs of the poor.

# Case Study #6:
# Eli Lilly and Open Innovation

## Introduction

Since the 1990's, the pharmaceutical industry has faced rapidly declining returns on their RD&D investment dollars. Success rates for highly capital-intensive research was on the order of 10 percent.

In response, Eli Lilly, the global pharmaceutical company, created three open innovation platforms to improve its R&D productivity and efficiency. In 2001, Eli Lilly launched InnoCentive, now a private company, as an internet-based platform that connects its clients (seekers) to a global network of registered "solvers." InnoCentive specializes in solving scientific problems for pharmaceutical, bio-technology, consumer goods, and specialty chemicals companies. In 2003, Eli Lilly, in partnership with Proctor and Gamble, a consumer goods company, launched YourEncore, which connects companies with retired scientists and engineers to leverage their expertise. In 2009, Lilly launched PD2 (Phenotypic Drug Discovery Initiative), a fully-integrated pharmaceutical network where it shares disease-state assays across an open, collaborative, global team of experts.

These open innovation strategies have played an important role in drug discovery for the company—by expanding the traditional breadth of its in-house corporate R&D and allowing it to access external resources and global talent.

While open innovation tools are not a substitute for the traditional, internal models of R&D in the pharmaceutical industry, the open innovation approach has proved to be a successful additional tool for solving particular R&D problems. It has improved a solution rate of difficult technical problems from about 10 percent to 30-50 percent—a threefold increase in success rate.[284]

InnoCentive, YourEncore, and PD2 adopt slightly different open innovation models. InnoCentive's and YourEncore solvers neither work in collaboration nor share their solutions with one another. Solutions are discovered in isolation. On the other hand, PD2 encourages networking among its solution providers.

All of these companies have now expanded their offerings to sectors outside of pharmaceuticals to include transport, consumer products, and engineering. The key to success for all of these companies is that they apply global collaboration and tap experts from outside their sector.[285]

## Big Pharma Looks for New Business Models…

A 2010 Morgan Stanley analysis revealed that less than ten percent of pharma's R&D investments are likely to reach the market as new drugs.[286] Dr. Francis Collins, director of the National Institutes of Health, has stated that pharma's research productivity has been in decline for fifteen years despite increasing levels of investment. The pharmaceutical industry spent US$45.8 billion in research in 2009[287] up from $30 billion in 2004.[288] This high level of investment is not very effective at producing results. The industry estimates that bringing a single drug to market can exceed $1 billion.[289]

The industry's "closed" R&D model—where all research and development is done inside a company—was proving to be financially unsustainable.

As one reviewer noted about the challenges in the closed R&D model:

> It is surprising…to realize how little focus we have had on the failure of our business model. It seems like the industry has spent a lot of energy finding explanations to its problems rather than to fundamentally rethink the way we discover, develop, and market our products…[290]

Eli Lilly, the 10th largest pharmaceutical company in the world, is one pharma company that when faced with these facts began to look for new business models for drug research and discovery. From its founding in 1876, Lilly's internal R&D program was the primary driver of new drugs until the early 1990's when senior management decided to develop an Office of Alliance Management with a commitment to cultural change within the organization. The office was empowered directly by the CEO and was assigned responsibility for forging and overseeing partnerships.

Since the mid-1990s, six new drugs have been developed out of these partnerships. The Office of Alliance Management ultimately led to a culture ready to embrace open innovation; in the late 1990s, Lilly developed the Technology Scouting Network—an online tool allowing Lilly researchers to search outside the company for assistance on specific technical problems. Anyone in the online network could respond and receive a cash award if his solution were accepted.

Lilly executives recognized that someone outside their company may have vital knowledge, ideas and expertise with the potential to address specific problems.

## …And discovers Open Innovation

In 2001, Eli Lilly took an even more unconventional approach to boost its innovation capacity. Eli Lilly's top executives empowered a small team of scientists and managers to come up with new business models taking advantage of the power of the internet from R&D and Sales Marketing perspectives. A new division with Eli Lilly was created and called eLilly.

To help incubate the new initiative, Lilly moved the team out of Eli Lilly's premises. This relocation removed team staff from the predominating corporate culture of hierarchical and internally focused R&D. An offsite, special facility housed the 16 employees with expertise in research, science, and marketing. This team reported directly to Eli Lilly's CEO. All this happened very quickly—this new

initiative was staffed in January of 2001 with sufficient financial resources; by February, it had moved to its new facility; by the end of June, one team had launched one of its first, new, business-model solutions: InnoCentive. More ideas and models would follow to include Chorus and Maguzzi.

This early Eli Lilly online tool was to become InnoCentive, which, today, is a stand-alone internet-based service that acts as an innovation intermediary, assisting companies, scientists, academics, and entrepreneurs.

InnoCentive aims to find solutions at a fraction of the cost of internal R&D—what some have dubbed "reinventing the wheel."[291] Since the initial integration of open innovation tools at Lilly, the company has developed and supported two other collaborative, open innovation programs: YourEncore and the Phenotypic Drug Discovery Initiative.

Open innovation (OI) involves a radical shift in corporate thinking—a movement from a closed, internal R&D strategy to an external network of innovators. Expanding beyond the traditional confines of R&D enables information sharing across sectors into vast networks of expertise. The resulting open innovation network can more efficiently develop new opportunities on which pharmaceuticals can capitalize. Furthermore, the OI model was attractive to Eli Lilly because:

- It reduces the cost of failure by sharing the risk,
- It leverages unused IP, and
- It increases access to networks of information.

Dr. Alan Palkowitz, VP of Discovery Chemistry Research and Technologies at Eli Lilly, described the move to open innovation this way:

> The heart of this open approach is really finding the independent centers of creativity, diverse thought and scientific perspective that can then complement what we have internally. That really takes drug discovery to a higher plain.[292]

## Eli Lilly's Open Innovation Models

Some open innovation models (e.g., InnoCentive) use an "awards" incentive to attract solvers—effectively, an award is paid for a solution to a posted problem. Others provide biotechnology tools within their drug discovery networks for free (e.g., Eli Lilly's PD2); if anyone within the network discovers a finding worthy of pursuit, then Lilly has first negotiation rights. YourEncore links companies to retired experts who then contract for specific projects. NineSigma uses yet another business model—as an intermediary, it helps companies establish criteria for soliciting high quality responses to high value challenges—the "solver" then works with the "seeker" company to resolve licensing agreements and IP issues. *See box below for more examples.*

The success of these OI initiatives relies not only on a facilitated exchange of information, but also on a corporate culture that embraces the sharing of information.

### *InnoCentive*

InnoCentive was one of the first internet-based, open innovation companies. It was created as an online

market place between corporations with R&D challenges (narrowly defined, discrete scientific problems) and external scientists (Solvers), who could approach problems from many different angles. Using broadcast search techniques, InnoCentive posts scientific problems from its clients to a global network of over 120,000 registered solvers. The seeker firm provides prize money to the solver and acquires all the rights to any IPR.

In the beginning, InnoCentive was focused only on solving Lilly's most difficult organic chemistry problems. But the company quickly expanded to post problems from other companies and industries. As of July 2010, 1044 challenges had been posted, 19,346 solutions had been submitted, and 685 awards distributed for $5.3 million.[293] InnoCentive's solution rate was very high for pharma—30 percent compared to a 10 percent solution rate in the lab—a figure made more impressive if one considers that these were problems Lilly's R&D could not solve.

Firms can post discrete scientific problems together with a cash prize for an acceptable solution. Problem posters and prospective solvers typically remain anonymous to one another throughout the process. Such an innovative approach gave top scientists around the world the opportunity to solve the problem of their choice (self select) and earn financial rewards. InnoCentive's business model is a "hub-and-spoke" model. The scientific problems are broadcast to the large global community of solvers. However, the solvers work independently and do not share their knowledge and solutions with each other. Anonymity reduces barriers to participation[294] and allows companies to post their problems without revealing their specific weaknesses or research focus.[295] From the beginning, InnoCentive crafted a carefully defined governance structure that protected IPR from the solver and seeker perspectives.

InnoCentive is now an independent company, which has expanded from its initial client base to a variety of industries including consumer products and petrochemicals. Currently, InnoCentive accepts problems from a wide variety of companies and industries. Nonprofit organizations also are making use of Inno-Centive directly or through an InnoCentive partnership with the Rockefeller Foundation.

The Rockefeller Foundation provides funding support to enable non-profits to post their technical or scientific challenges; the funding provides the solver with the financial reward. Since 2006, ten challenges have been posted by developing country non-profits with an 80 percent solution rate. The most successful of these challenges was posted by SunNight Solar in conjunction with the non-profit Global Giving, seeking a solution to improve the design of dual-purpose solar lights that could be used as interior lighting. The challenge was solved by an engineer in New Zealand who proposed a solar flashlight that is now in use across Africa, Gaza, and other areas with limited access to electricity.

Solutions can and do arrive from unexpected sources. Harvard Business School professor, Dr. Karim Lakhani, in collaboration with Lars Bo Jeppsen (Copenhagen School of Business and Dr. Jill Panetta (former CSO of InnoCentive), has studied InnoCentive's OI model and has concluded that the further the problem is from a solver's expertise, the more likely the solver is to solve it, often using specialized knowledge or equipment from another industry or sector.[296] One such example comes from the Ocean Spill Recovery Institute, which sought a way to separate frozen oil from water in oil recovery barges. The challenge was solved by a chemist from the concrete business who had no experience in the oil

industry. His solution adapted a tool from the cement industry designed to vibrate cement and keep it in its liquid form.[297] In another example, a seeker firm's R&D laboratory was having severe difficulties with a toxicology study. Their problem was solved by a PhD in protein crystallography using methods common in her field. She was able to transpose her crystallography knowledge to the toxicology problem.[298]

### *YourEncore*

In 2003, Lilly expanded the InnoCentive model and was the first client, along with Boeing, of YourEncore, which was founded in partnership with Proctor and Gamble (P&G) to tap the expertise of their retirees. YourEncore helps companies accelerate innovation by connecting then with a network of retired scientists and engineers. It has built a network of over 4000 retired scientists and engineers from over 150 companies who solve problems across the value chain from building prototypes to implementing new designs.

Unlike InnoCentive, YourEncore connects the scientists through a collaborative web platform, moving away from the InnoCentive "hub-and-spoke" model to an interactive open community model. To facilitate open innovation, YourEncore controls collaboration using measures that keep IP secure. YourEncore facilitators develop potential IP and work with clients to secure IP when providing information to external experts; ultimately, answers to problems posted by a client are the property of the client.

Examples of YourEncore's successful solutions include a retired PhD Kodak chemist who was able to solve a consumer products company color stability challenge in a new hair dye product. In another case, a retired rocket scientist with expertise in avalanche predictions found a way to stop powdered detergent from caking.[299]

### *Phenotypic Drug Discovery Initiative (PD2)*

Based upon the successes of InnoCentive and YourEncore, Lilly launched PD2 in 2009 as the next evolution of its open innovation model. PD2 shifted Lilly's OI model from a focus on bilateral linking between itself and external companies to a collaborative network among hundreds of companies. The network shares technologies not only with Lilly, but also with each other, creating a strong, dynamic system of collaboration. This is a move away from the traditional "hub-and-spoke" model with Lilly as the central coordinating unit, to a "network" model with decentralized governance.

According to founder Dr. Palkowitz,

> Our aim is not just to create value for Lilly, but to create unique value for those with whom we are interacting.[300]

PD2 uses disease-state assays and a web portal to evaluate the therapeutic potential of compounds synthesized in biotech labs. PD2 allows Lilly to access top global-research talents, new therapeutic processes, and rich chemical compounds. If an entity within the network discovers an interesting molecule, Lilly has the first right of negotiated access.[301] Lilly taps into the ideas and compounds of the greater scientific community and reserves the right to collaborate on licensing agreements. If no agreement is reached, the researcher is granted no-strings ownership over the data report.[302]

To encourage participation and grow the network, Lilly had to come to the table with money and with enabling technologies[303]. Many of the smaller firms within the network did not have access to reliable biological assays systems or the resources to evaluate biological compounds.

Daphne Zohar, founder of PureTech Ventures, sees great need for the PD2 initiative as a bridge between academia and industry and at a time when the old pharma innovation infrastructure is suffering financially.[304] With PD2, Lilly closed the information gap by providing key assays through a web portal for free.

Open collaboration is aided by PD2's clear IP agreements. Under the conditions of a Materials Transfer Agreement (MTA), all IPR remains with the investigator company. Collaboration agreements may be established; if there is no resulting agreement, the investigator may publish the assay data under the terms of their MTA with the company.

PD2 has 109 affiliations across 17 countries, all which are submitting compounds they've discovered. Its early successes include connecting two European companies who used Lilly's network to build an integrated solution for a chemical, manufacturing, and controls service.

## Open Innovation Evolution

InnoCentive, YourEncore, and PD2 provide a history of the evolution of open innovation within Eli Lilly. Rather than acting as a collaborative network, InnoCentive works as an intermediary, connecting problem solvers to seekers by providing a cash award to the solver. Solutions that are not selected are not released back to the public domain**.** In addition, solvers do not know if their solution was ever used by the seeker or how it was used. In contrast, PD2 provides full transparency between solvers and seekers and rather than creating a "hub and spoke" model of which InnoCentive is the center, PD2 creates a dynamic network. This range of open innovation business models has been followed by a number of different open innovation companies.

Most global companies today, from P&G to General Motors (GM), from consumer products to large industrial products, are using open innovation strategies to achieve a better return on their research and development dollars. They are working with companies like the following:

**NineSigma—http://www.ninesigma.com**

NineSigma is the first open innovation company to work as an intermediary between seekers and providers. The two companies are brought together to decide on a licensing agreement, IPRs, financial terms, etc. NineSigma does not pre-prescribe price or IP rights, so that large firms can work cooperatively with the provider company. NineSigma's role is to identify experts for any specific challenge, relying on cross-industry seeding, and ultimately, finding a co-development partner for the seeker. NineSigma undertakes a fresh search of solution providers for each challenge. By working with the seeker firm to develop and define the challenge, NineSigma helps the company establish criteria for high quality responses.

Like InnoCentive, NineSigma does not facilitate the collaboration of solutions, but it does allow collaboration on solutions which may need input from various sectors. NineSigma provides the seeker

firm with a set of proposals and recommendations, and works with the firm to craft an agreement. NineSigma has seen a huge growth in the number and types of firms using its OI services. It receives seeker proposals from large companies like British Petroleum, GM, and Kraft, but it also receives proposals from the public sector (e.g., US DOE, state economic development agencies, armed forces). GM has submitted nearly 300 problems.

NineSigma serves as a broker in the business of sourcing ideas. NineSigma posts request for proposals (RFP) to a community of solvers worldwide. Anyone can submit a non-confidential proposal back to NineSigma. The idea is not to get back specific solutions for a discrete scientific problem, but to identify people most likely to be able to provide solutions on a contract basis. NineSigma will connect the company and the solution provider to discuss and negotiate next steps.

**Oakland Innovation—http://www.oakland.co.uk**
Oakland is a specialist research consultancy that helps organizations tap into external networks to speed up the innovation process, access new competences, manage/share risk, and benchmark business processes. Oakland has built a global network of associates and partners and experts from industry and academia with expertise that spans markets, continents and cultures. In the Science & Technology arena Oakland creates value for clients through the identification and evaluation of enabler and competitive technology for product and process innovations.

**Innovation Exchange (IX)—http://www.innovationexchange.com**
Innovation Exchange is one of the newest entrants into the Open Innovation arena. The IX web-based community works on a pay-for-performance model. Diversity and collaboration are two hallmarks of the Innovation Exchange open innovation marketplace. The IX belief is that a diversified team of innovators who are collaborating will deliver more innovation than an individual contributor working alone. This is distinctly different from the hub-and-spoke model of the InnoCentive global platform. Similar to the other innovation tools, problem definition is a critical core competency that is needed to use this platform. Currently IX tackles a different class of innovation challenges than other distributed innovation providers: business rather than science.

**Other Corporate Open Innovation Examples**
GlaxoSmithKline recently announced that it was embracing an open innovation strategy to develop new drugs for the developing world. Its first step is to release data on over 13,000 compounds free of charge on a web-based open platform. It is working in partnership with the US National Library of Medicine and the European Bioinformatics Institute, but it has invested US$48 million of its own money to build an "open" research facility in Spain.

## Challenges

There are many challenges to embracing open innovation within pharma and in other sectors. Below is a list of more challenges the industry faces in embracing open innovation models:

- *Award Incentive*. In the case of InnoCentive, which uses an awards-based incentive, there is not enough data to determine if a $10,000 prize can really create a $1 billion drug. What is the incentive

for a small, start-up biopharma firm to post solutions for a $10,000 prize when its discovery could potentially lead to a billion dollar drug? How do you tap solutions that are worth more than the prize money? The cost to play (use of the platform) can be considered cost-prohibitive and be a barrier to entry for a small, start-up company or nonprofit organization.

- *Cracking corporate culture*. How difficult is it for senior management with a hierarchical R&D culture to embrace a radically different way of operating? Can corporate culture assume that not all the best minds work for "us"?

- *"You don't know what you don't know*." In addition to changing the corporate senior-management culture, open innovation models face the challenge of getting internal experts to participate. Scientists at Lilly were reluctant to support InnoCentive because they were afraid to show their failings. Similarly, Lilly scientists were afraid of becoming obsolete once PD2 started. In addition, scientists are figuring out that there's a lot to learn from experts in non-related fields. Also, internal scientists' reward structures must be clarified so that they won't be punished for not knowing an answer, but they will be rewarded for tapping into the wisdom of the crowd and using all the tools available for getting to an answer quickly.

- *The bottom line*. Lilly was able to provide start-up funds for both InnoCentive and Eli Lilly. Inno-Centive constantly seeks new problems and broadens it seeker base to be able to fund its work. In addition, pricing models change all the time as companies try to make a profit doing OI. Developing world institutions cannot afford to pay the cash award to the problem solver; thus, they are excluded from participation.

- *Negotiating IPR*. The pharmaceutical industry has a strong proprietary, IPR-dependent culture. The IP framework has allowed businesses to profit from years of market exclusivity. Changing this IP mentality is critical to OI's success.

- *Measuring success.* InnoCentive has broadened the scope of its work outside of the pharmaceutical industry to meet its bottom line. Solution rates do not tell us whether solutions were adopted by the seeker company. It is not known if any substantive work is coming out of their broader OI initiatives. Retention of clients is another measure of success and adoption.

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

When companies are convinced to try open innovation techniques, they consistently find that they access creative, useful solutions to their (often intractable) problems. Because they hold such promise, OI tools should be applied to climate technology innovation. There are some key lessons to be learned from the experience of Eli Lilly and these spin-off companies.

- **Strong senior management support is key.** Open innovation models need a champion, preferably senior management, to be successful within a corporate culture that relies on hierarchical internal R&D. For a climate innovation initiative, this could mean creating a high-level Open Innovation position right from the start of the organization. OI initiatives also need adequate financial

support—at least at the seed state. Both InnoCentive and PD2 received sufficient financial support from Eli Lilly.

- **Independence helps cultivate innovation.** To encourage outside-the-box thinking, Eli Lilly's management placed the InnoCentive team "outside the company" in their own office space that allowed the team to escape from the business-as-usual culture. InnoCentive co-founder noted that this was a key ingredient in allowing the team to develop the OI tools.

- **Skillful problem definition is critical.** The open innovation experts we interviewed emphasized that problem definition is at least 50 percent of the solution.[305] Defining the problem well also takes time, expertise and input from a variety of stakeholders, most especially end users. An OI intermediary company such as NineSigma provides clients with guidance by accurately and clearly defining the problem and the need for a solution.

- **Incentive structures must be properly crafted to engage the right "solver."** Different incentives motivate different participants. Financial incentives or awards attract "solvers"—usually individuals, not organisations or large firms. InnoCentive's financial incentive attracted Russian scientists, but it was largely the scientific challenge that attracted EU and US scientists who were largely compelled by the pure challenge and the scientific recognition.[306] In the case of NineSigma, the reward is usually a jointly-developed product or initiative—this incentive attracts entrepreneurs and small companies that highly value their solution.

- **Need to craft IPR that suits both seeker and solver.** In the same vein as designing the incentive structure, the IPR agreement can be crucial—and will engage different kinds of solutions and solvers. With InnoCentive, for example, solvers give away all IP rights to the seeker when they receive their cash prize. Other OI companies, like NineSigma, allow for a more nuanced IP negotiation where the solver can retain some IP rights.

- **Need to involve a diversity of solvers or participants in network.** Innovation is increased through the collaboration of many different skill sets across different industries and when applied along the entire R&D value chain. All of the OI companies described above dedicate significant resources to cultivating their "solver" networks, reaching out to scientific communities, entrepreneurial groups and universities. A climate technology initiative should tap a broad spectrum of solvers, including people outside the climate technology field.

- **A climate technology initiative could use an existing open innovation platform such as InnoCentive or NineSigma rather than creating a new platform and solver community from scratch.**

# Case Study #7: Product Development Partnerships

## Introduction

Product Development Partnerships (PDPs), originally called Public-Private Partnerships, emerged in the 1990's as a collaborative RD&D model to develop new vaccines and medicines for neglected diseases. Because of perceived low-profit opportunities and high risks, private companies were unwilling to invest in developing new products for diseases mainly found in poor countries. At the same time, governments were unable, because of limits of funding and expertise, to develop and distribute new products alone. PDPs were developed as an innovative model to collaboratively engage the expertise, finance and knowledge of private companies, academics, NGOs and the public sector to develop new health products for the poor. A recent DFID review concluded,

> Evidence has been emerging that these partnerships result in quicker, less costly development of the technologies with superior public health benefits relative to existing technologies. They also improve the overall enabling environment for other actors to do the same.[307]

## How PDPs work

Today there are almost 20 PDPs working on neglected diseases from tuberculosis to HIV vaccines to malaria drugs.[308] Each PDP focuses on a specific health product goal (e.g., drugs, vaccines, diagnostics), and many PDPs limit themselves to a specific disease area. PDPs apply an industry-based model, researching a portfolio of solutions in the early stage of development to prioritize the best candidates for the later, much more expensive stages of testing and clinical trials.

Many PDPs have staff that come from the private pharmaceutical industry and have experience bringing health technologies to market. PDPs have independent science boards, to protect governments from picking winners and losers—"placing that responsibility with those who have better information and expertise with which to make those decisions."[309]

PDPs have been established under very different structures with varying degrees of in-house research versus providing funding to academics or private companies. "The majority of PDPs work as virtual non-profit R&D organizations, whereby activities are outsourced to academic or private sector partners, with the PDP linking together expertise, and providing public funding, technical oversight and portfolio management."

The Medicines for Malaria Venture (MMV), which was highlighted by interviewees as a strong model, has been able to successfully leverage private labs and research from pharmaceutical companies. MMV does not do very much in-house research but instead funds companies to do research with well-defined agreements on pricing and IP.

The management of IP also varies among PDPs, because where the IP comes from varies widely—whether from small biotech companies, large pharmaceuticals, or academic researchers. MMV has signaled its commitment to open source IP management when, in 2010, it contributed intellectual property to the Pool for Open Innovation against Neglected Diseases.[310]

PDPs work on the full product development chain, from research through testing, manufacture and deployment. Thus they work with a large range of actors, from academics to manufacturers in India and China to health regulators and clinics in least developed countries.

> Early on, PDPs factor in total delivery costs and ease of technology delivery into their 'target product profiles' and these form part of the basis of project selection. As the R&D pipelines for PDPs mature, they have become increasingly involved in developing 'access' strategies. In this transition, the scope of their partners has widened to encompass not only partners needed to develop the product, but also those responsible for financing and delivering the product.[311]

### *Successes*

Drug and vaccine development can take 10-20 years from research through deployment, and PDPs are fairly recent developments; thus few health products have yet to be deployed from PDPs efforts. However, the DFID report concluded that "PDPs are achieving tangible results–notably rich pipelines of technologies in development and ten product launches since their start."[312] One interviewee also highlighted the important "side effects" that PDPs are having from focusing donor funding and private attention on neglected diseases and building regulatory and health capacity in developing countries. PDPs have also inspired a new public discussion around "translational research," which emphasizes delivery of products and service, shifting public money downstream to product development.

PDPs have also been successful at linking together the many different actors in the health-product development chain from academics, biotech firms, developing country regulators, and health clinics. "PDP management knits together all these different partners towards a common objective."[313]

### *Weaknesses*

PDPs are expensive, with long time horizons for success. As noted, to date there are few concrete health outcomes resulting from PDPs, while some products have been developed and approved, they have yet to be fully distributed and used in affected communities. Thus they required "patient" funding, which can be challenging for public officials to support with tax payer dollars.

## Applicability to Climate Technology Innovation

The applicability of PDP's for climate technology innovation will depend very much on the type of technology in question. An interviewee noted that the key thing is to think carefully about the

characteristics of the development profile of the technology, when are costs and risks highest? Who are the key players and how well capitalized are they? Who do you want to incentivize in the project? Who has the innovation? Who will take the technology to scale?

For example, the Pneumococcal vaccine efforts decided to use an Advanced Market Commitment model—which requires private companies to invest their own capital upfront for the prize of later market rewards—because experts believed that big pharmaceuticals were the key actors with the necessary innovation. These large companies can bear the high research costs. Alternatively, small or medium-sized biotech firms need financial support earlier on for cash flow support. So a key question is whether the lead developers are big companies or small start-ups.

Another interviewee noted that PDPs are best used for real technology breakthroughs rather than incremental innovations. He wondered whether low-carbon energy technologies would not be the best choice for the PDP model because they are too capital intensive and have a profit opportunity. But adaptation and orphaned climate technologies may be well suited to this kind of an approach.

The recent DFID report notes the following characteristics of technologies that may be suitable for PDPs:

- The costs and/or risks of technology development are high in relation to the anticipated market return for the private sector.
- The new technology would result in significant public goods that a private company cannot capitalize on—e.g., pollution control.
- Existing technologies are sub-optimal, i.e., on the grounds of cost effectiveness; the new technology is a substantial improvement upon existing technologies in terms of quality, safety, effectiveness, etc., allowing higher uptake at lower cost.
- PDPs seem to work best to address a specific technological goal or gap. Other models may be considered if the goal is to support for technological innovation more broadly in a particular field.
- Push funding, including via PDPs, may be well suited to situations where the desired innovation is likely to come from smaller or capital constrained firms.[314]

With these characteristics in mind, PDPs could be suitable to most climate technologies.

The DFID report also notes, “PDPs may be more suited to situations where pockets of expertise are relatively concentrated and easy to identify” as opposed to pull mechanisms like Advanced Market Commitments, which can tap into a diffuse group of actors. However, PDPs could use open and distributed innovation strategies, in fact pioneered by the pharmaceutical industry, to a tap into distributed knowledge and expertise, while also pushing new products to market.

# LESSONS FOR CLIMATE TECHNOLOGY INNOVATION

- **Diversify funding to manage high costs, long time frames and high risk.** By their nature, health PDPs have long-term time frames and are high risk. Drug and vaccine development may take up to 20 years and private companies estimate that only 10 percent of research results in new products. "Vaccine development costs are estimated to range between several hundred million dollars and US$1.5 billion. Similarly, the cost to develop a drug new chemical entity is estimated to be between US$600 million to US$800 million, including out-of-pocket costs, costs of failure and costs of capital."[315]

  For these reasons, PDP design should establish periodic milestones and measures of success beyond final product deployment. Funders must also be aware of the risks when they enter into PDPs. For these reasons, one research group "highlighted the need to diversify [PDPs'] funding sources."[316]

- **Be aware of the different incentive structures of large and small/medium size companies.** A comprehensive report out of the Wellcome Trust and the London School of Economics on PDPs noted the different roles and incentive structures that SMEs versus large pharmaceuticals play in health PDPs.[317] With these insights in mind and with consideration of policymakers' objectives around the role of various actors, PDPs should be designed to engage the right stakeholders.

- **"Focus on one thing."** One interviewee noted that the most successful PDPs focus on one thing. For example, Medicines for Malaria Venture focuses on a cure for malaria rather than a range of activities like bed-nets, drugs, etc.

- **Outsource research.** He also noted that the best (and less expensive in many cases) models outsource their research and development and act more as fund and portfolio managers. MMV does not have labs but instead "buys" these services from the best private or academic groups who are already established to do this work.

- **Address the full product development chain as early as possible.** PDPs are successful because they address the full product-development chain from discovery, clinical trials, and manufacturing to regulation and delivery. Toward this end, PDPs address delivery strategies and IP agreements right up front, when initial product analysis is done.

The initial scope of this research work did not include an analysis of PDPs as a model for climate innovation. The topic arose through interviews and research in other areas. Thus this case study does not provide an exhaustive analysis of the strength and weaknesses of specific design elements of PDPs. In the next design phase of this work program, it would be worth developing a deeper analysis of successful PDP governance and implementation approaches in order to clarify more specific factors for success and determine which model might be most appropriate for climate technologies—i.e., in-house vs. outsource, IP management structures, and incentive structures for SMEs vs. large companies.

# Case Study #8:
# The Human Genome Project

## Introduction

The Human Genome Project (HGP) was established in 1990 in the United States by two federal agencies —to be joined by many others around the globe—to identify and map the 20,000-25,000 genes of the human genome and to determine the sequence of the three billion chemical base pairs. In 2003, the complete draft of the human genome was released, two years ahead of schedule; and in 2006, the last chromosome sequence was published. The data have been used to accelerate the search for genes that influence diabetes, cancer, childhood eczema, and more. The HGP achieved its goal two years earlier than expected—due to a variety of factors such as international cooperation, advances in genomics, competition from the private sector, and advances in computing technologies.

The HGP was a unique model. Its commitment from the outset was to create a new scientific standard—not only would it reference an entire human genome, but this sequence would be publically available on an open-source platform as soon as the information was developed, often the same day. This public database was intended to be used by the biotech and pharmaceutical industry to launch new research and commercial endeavors in the field of genomics. In fact, it is the private sector that has used the bulk of the HGP data to develop and bring new medicines to market. The government's dedication to transferring new technologies created by the data analysis to the private sector eventually catalyzed a multibillion-dollar US biotechnology industry. The information and technologies generated by the HGP revolutionized biological research across the life sciences.

One of the successes of the HGP is that it has spawned a new, open-source business model in commercial biotechnology. The HGP has changed the licensing culture in large-scale genomics. After the HGP demonstrated the enormous benefits to private companies of sharing early data in a kind of "pre-competitive commons," there was increased motivation for private sector and academic scientists to generate basic resources together.[318] Private laboratories developed tools to facilitate the exchange of new data. In turn, it has led to a corporate revolution in the biology field with a proliferation of researchers and new companies now using similar open source techniques to solve research problems and create new products. Large public-private collaborations sprung out of the HGP. Examples include the SNP Consortium, the Mouse Sequencing Consortium, and the International Genomics Consortium.[319]

## The HGP's History

After the development and deployment of the atomic bomb during the Second World War, Congress charged the US Department of Energy (DOE) and its predecessor agencies to study the effects of radiation and energy on genetic material to determine and understand any related health effects. Prior to the formation of the HGP, the DOE Office of Science conducted workshops and initiatives to understand the human genome.[320]

As the DOE developed new technologies for working with DNA in the 1980's, the idea to sequence the entire human genome arose. Not only had the DOE already developed specialized tools and equipment but also could facilitate cross-discipline scientific collaboration. Furthermore, its demonstrated expertise in handling projects of this size and scope solidified the agency's role in the HGP. Thus, DOE initiatives led to the formal foundation of the HGP in 1990.

The DOE's Office of Science began a collaboration with the US National Institutes of Health National Human Genome Research Institute through a Memorandum of Understanding in 1998 to coordinate activities and leverage their assets.[321] At an early stage, NIH was established as the lead agency.[322]

The related goals of the project included storing the human genome sequence in publicly-accessible databases, transferring technologies to the private sector, and addressing ethical, legal, and social issues associated with genomic research and discovery. Its international research centers deposited all human genomic DNA sequence information into the public domain where it is available for free to encourage further research.

### *Changes within the HGP—a competitive boost from the private sector*

HGP's first task was to construct maps of the human chromosomes, postponing the actual genomic sequencing until new technologies could make the process faster and cheaper. Thus, the HGP first began analyzing the genome of simple model organisms like the fruit fly or roundworm—an extraordinary investment that taught scientists how to sequence on simple organisms. The process, however, was lengthy. Critics who felt that the technology was already good enough and fast enough to sequence the human genome began their own private sequencing companies, while the HGP continued to debate how much time and funding should be allocated to building tools like maps and sequencing machines, rather than on sequencing.[323]

In May 1998, the private firm Celera Genomics announced its intention to sequence the entire human genome within three years, using a "whole-genome shotgun" strategy—a strategy fundamentally different from the public approach and one that potentially could present significant sequencing gaps.[324] Craig Venter, founder of Celera, boasted that Celera could sequence genomes faster than the HGP and at a fraction of the cost.

In direct response to Celera's declaration, the Wellcome Trust, DOE, and NIH increased their support for the HGP and set a new goal for completing sequencing by 2003. Initially, the public sector welcomed the privately-funded competition, believing that the additional data would be merged with the public data set, providing greater coverage of the sequence and accelerating the public availability of the sequence. While the NIH and DOE hesitated to see the private genome sequencing effort as a race, and

while they welcomed the private sector's approach, they chose to continue providing high-quality human DNA sequencing using their original methodology.[325]

It was thought that HGP's policy of open data release facilitated the research of others, regardless of whether they were in the private or non-profit sector. However, once Celera revealed its plans to make its sequencing data publically available only every quarter, the public agencies balked at any chance of joint publication or cooperation.

> Taking an unprecedented step in the disclosure of research findings, HGP policy stated that sequencing data should be released into pubic databases within 24 hours of generation.[326]

A working draft of the human genome was release in 2000 with 97 percent completion and 85 percent accuracy. The early release of the draft data resulted from Celera's announcement that it too was near completion of the preliminary genomic sequence. The early release of the draft sequence led to a program of cooperation between Celera and the HGP with both ventures publishing the genomic data simultaneously.

Despite parallel efforts in the private sector to map the human genome, the HGP decided to continue its efforts based on a few factors: 1) It was unknown whether the private venture would be able to sequence the human genome on newly developed machines; 2) Since Celera was using a "whole-genome shotgun" approach, it would be employing genomic fragments; this approach would yield highly useful data, but would also contain thousands of gaps; and 3) Celera planned to release sequence data quarterly. The HGP released data daily and feared that any delay in releasing data would result in delayed access.[327]

***International Public and Private Funding***

The HGP was one of the largest publically-funded international scientific research projects; the issue of funding the HGP was considered both controversial and extravagant. The initial estimates for the cost of the HGP were about US$3 billion for a fifteen year period (1990-2005) and included the sequencing of the human genome, the study of human diseases, the sequencing of experimental organisms, the development of new biomedical research tools and computational methods, and consideration of ethical and legal issues.

The Human Genome Project (HGP) was funded primarily by the US government, but other governments, private foundations and research centers also contributed financial support.[328] The US Congress initially funded the NIH with $17.3 million and the DOE with US$11.8 million for the first year.[329] Funding was increased through each subsequent year of the project up to US$200million per year; because of its demonstrated success, it eventually became a multi-billion dollar project.[330]

The total cost of the Project to US taxpayers was roughly US$2.7 billion,[331] though only a fraction of the total was spent on deciphering the genome. The majority of the funding was spent on basic research and the development of analytical and technical tools. In addition to Project-specific funding, both the NIH and the DOE set aside 3-5 percent of their annual budget for addressing ethical, legal, and political issues associated with the HGP.

Several sequencing centers participated in the HGP with their own funds. The U.K.'s Wellcome Trust was a major funder of the Sanger Center (one of the HGP's major sequencing centers), contributing US$77 million in 2000 alone and overall providing one-third of the HGP's budget.[332] The Japanese government funded several sequencing centers with a total of nearly US$16 million over five years.[333]

Government sponsored sequencing also occurred in France, Germany, China, and India; as the Project grew, the breadth of partners included globally dispersed laboratories within 18 countries. China was the only developing-country member to join the HGP, assuming responsibility for one percent of the total genome sequencing.[334] Emerging economies such as Brazil and Mexico contributed molecular biology techniques and studied model organisms of particular interest to their region.[335]

In addition, private sector involvement in the HGP was encouraged through sophisticated contractual frameworks from the Project's inception; private companies provided lab equipment and made use of HGP's data. Technologies were licensed to private companies, and grant monies were available for private companies engaged in innovative research.

## Structure: A decentralized, virtual consortium of existing organizations

Importantly, HGP was not set up as a new formal organization, but rather from its outset, it was established as a consortium of existing national and international research centers, global experts from a variety of disciplines, and private companies. It was a loosely-affiliated network coordinated through the NIH, DOE, and the Human Genome Organisation (HUGO), the largest international science collaboration ever created.

The NIH (primarily) and the DOE provided grants to participating research centers. Research centers were given much leeway in their approaches to sequencing the human genome as long as they contributed to the Project's goals.[336]

Each laboratory or research center worked independently on parallel sequencing for selected organisms such as mouse, human, and *E.coli*. However, through the funding decisions, the joint effort of these entities was closely coordinated, and largely funded, by the DOE and NIH; both agencies had grant-making authority, co-developed 5-year plans, and drafted guidelines on sharing data and resources.[337]

The sequencing centers helped to map and sequence not only the human genome, but also the genomes of smaller organisms. HUGO, an international organization, coordinated the efforts of these sequencing centers for the HGP and provided an interface between the HGP and the many organizations involved in the HGP initiative. Established in 1989, HUGO's mission is to coordinate research on the human genome and foster collaboration between scientists and facilitate the exchange of data relevant to human genome research.[338]

Once Celera entered the Genome race, this competition forced the HGP to reorganize with more efficient, compact organizational structure. Under pressure from private-sector rivalry, the HGP tightened control over its research centers. First, it concentrated its research efforts at five sequencing centers: Whitehead, Washington University, Baylor, Sanger, and DOE's Joint Genome Institute.[339] HGP

increased its sequencing pace, reoriented its schedule, and announced new goals such as the completion of a rough draft covering 90 percent of the genome by 2001.[340] Furthermore, the HGP expanded its contracts with private firms to develop higher-speed sequencing machines. In fact, in 1999, HGP purchased sequencing machines from the same company that supplied Venter's Celera.[341]

## Open Source Approach

The Human Genome Project catalyzed open innovation and open source practices in biotechnology and bioinformatics.[342] That is, it used the open source model by making data freely available to the public-without private patents. It also spawned private sector use of the open innovation model with new companies using various Internet-based tools to solve problems and create new commercial products through collaborative, product development partnerships around the globe.

The HGP coordinated independent research centers to allow for data sharing in a timely and consistent manner. **Data were rapidly deposited into the public domain (prior to publication in scientific journals)** so that research could be accessed, read, and built upon. Only research centers who agreed to make their data available to all participants were able to participate; furthermore, data had to be made publically available within the first 24 hours (to ensure that data remained in public domain). Most public funders made it a condition of grants that results would have to be freely and publically available immediately. HGP's open source approach enabled researchers and research centers to share information, but more importantly, its open source approach allowed anyone to access and use the raw sequencing data. Placing data in open access databases ensures that all data is available to downstream researchers. Accessible genomic data in the public domain allows researchers to discover potential cures for neglected diseases.

Each independent laboratory associated with the HGP had its own methods and systems for conducting research and recording data. From the beginning, it was clear that data sets were not transferable amongst institutions. Thus, standards, platforms, and tools were needed to be able to share and access information. To increase collaboration amongst the HGP-affiliated research centers, labs, and universities, a congruent system or repository was needed. Open innovation in bioinformatics propelled the creation of software code and databases, traded and pooled on a mutual basis, and facilitated the sharing of data.[343] For example, BioPerl is an open source software tool that facilitated the interchange of data amongst the global laboratories (who mostly kept their data in dissimilar formats).[344] Additional databases at University of California-Santa Cruz and Ensembl provided data in addition to tools for searching and using sequence data. The Wellcome Trust funded the Ensembl project to store genomic data from the Sanger Centre.

While the Project's mechanism for collecting data used open source techniques, it did so in a restricted manner by only involving certain academic and research institutions to participate in research. The HGP used a more "top-down" approach than other open source models. However, raw data, once deposited into the public domain, were available to anyone through traditional open source channels.

The HGP data currently is stored in GenBank, a free, accessible database which facilitates innovation in a variety of biotechnology fields.

Since the completion of the HGP, the open source model has emerged in the biopharmaceutical industry. HGP's open source model opened the door to many future private and public endeavors. It was widely recognized that public investment in the HGP did spin off a great deal of further pharmaceutical innovation and promoted start-up ventures, many of which in turn used open source methods to develop techniques and tools for genomic mapping and product development. (In fact, Celera Genomics, HGP's main private venture competitor, used HGP's sequencing machines and research results, enabling it to enter into the competition riding on HGP's back.)

For example, the SNP Consortium (single nucleotide polymorphism) was established in 1999 as a public-private collaboration to discover 300,000 SNPs in two years and release the findings into the public domain by 2001. By 2001, the Consortium had identified and mapped more than 1.5 million SNPs. The goal of the SNP consortium included producing a publically-available map using SNPs as markers throughout the human genome, primarily by coordinating all SNP data and serving as the primary database for publicly released SNPs. (The software is compatible with and consists of Perl scripts.)[345] The Consortium was funded by private companies as the data would be a powerful tool to enhance the discovery and development of therapeutic tools and more effective medicines.[346] In 2001, it contracted with Celera Genomics to provide data for genome-wide SNP-based linkage maps for genetic analysis.[347]

With the completion of the discovery phase of the SNP initiative, research focus has shifted towards mapping genetic variants and how they are distributed among people and among populations. The HapMap Project formed as an international collaboration of scientists and public agencies to develop an open source resource for finding genetic variations that relate to diseases. The open source access helps biomedical researchers find genes (through haplotype identification) involved in disease; once the variants have been discovered, researchers can uncover the origins of illnesses.

Other private companies are using the HGP data and associated technologies to create new medicines and new products within the public sphere. In 2007, the pharmaceutical company Novartis released information about which genes are likely to be associated with diabetes and made the data available for free.[348]

They are not alone in experimenting with an open source model—the last decade has seen much experimentation with alternative R&D such as the public-private partnership models described above. A critical mass of information is needed before private companies and researchers can develop new therapeutic tools. And if the cost of bringing a new drug to market exceeds US$1 billion, pharmaceuticals could benefit from public-private partnerships, open source, and federal research projects.[349]

### *Challenges*

The HGP faced several challenges over its thirteen year period, including competition from the private sector, referenced above. In addition, challenges included:

- *Funding a US$3 billion initiative*. Despite the initial enthusiasm for funding the HGP at US$200 million per year, once private companies entered into the race to sequence the human genome, the public began to raise the question of why the federal government should be funding this kind of research when it was clear that the private sector was willing to bear the cost of research. The NIH,

DOE, and to some extent, the President, convinced Congress that the human genome needed to remain in the public domain and should thus be funded by the public.

- *Proceeding at slow pace seen as inefficient*. The HGP had adopted a fairly conservative, cautious, methodical approach to sequencing relatively small chunks of DNA, eventually reassembling the pieces. By contrast, Celera was shredding the entire genome and was using a computer to re-assemble the sequenced pieces. HGP finally shifted gears after Celera announced its intentions to sequence the entire human genome in three years.[350]

- *A loosely affiliated Consortium.* Prior to Celera's entry into the genomic field, the HGP was seen by some as moderately inefficient and too decentralized. Competition from the private sector encouraged and hastened the final stages of the Project. Celera challenged the HGP, suggesting that it could sequence the human genome faster and cheaper than the public sector effort and insinuating that Congress was wasting tax-payer funds on the HGP. These insinuations caused the HGP to quickly restructure into a more centralized and compact organization exerting more control over the global research centers involved in the project.

## LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

The HGP provides a wealth of important lessons for a global climate technology initiative:

- **Well-defined goal with a timeframe is key to success.** The HGP had a clear mission: map the entire human genome in 15 years.

- **Build public support by clearly articulating the benefits of the project.** HGP's success also lies in its well articulated compelling potential benefits—mapping the human genome was seen as the fundamental milestone in the development of science, and the ramifications of unraveling our genetic code included understanding and, ultimately, treating a huge number of diseases.[351] These huge potential benefits were made clear to public funders and the public to keep support high.

- **High-level policy support is extremely important.** US President Clinton and UK Prime Minister Tony Blair announced their agreement on a statement of principle, which applauded researchers who had made their data freely available and ensured that the human genomic sequence could not be patented, thereby assuring that all data resulting from sequencing the human genome be publicly available.[352]

- **Allocate sufficient resources.** Once the HGP was well underway and Celera's private initiative entered into the picture, both the Wellcome Trust and the US agencies increased their funding to accelerate the genomic sequencing.[353] Intensifying efforts at the HGP were crucial for maintaining congressional support and funding.

- **Engage the Private Sector**. From the outset, HGP anticipated and promoted the private sector's participation in developing and commercializing genomic resources and applications. It strived to establish infrastructure and funding models for future technology development to give rise to

commercially viable products within the private sector. The potential for commercial development of genomics research and DNA-based products within the US was expected to exceed $45 billion by 2009.[354] Moreover, HGP engaged with the private sector—using Celera's competition as an incentive to boost its efforts.

- **Working with existing agencies and labs allowed the program to start up quickly and decrease costs.** HGP coordinated the research of existing agencies and labs. This enabled the HGP to start research quickly, not create a new bureaucratic agency. It used funding to create, initially, a decentralized global project. Then, with pressure from the private sector, it tightened control and mandated more coordination among researchers through funding strictures and with the help of HUGO. This central coordination ultimately hastened the success of the project and led to greater progress within a shorter period of time. This shift emphasizes the importance of having a central organization orchestrating research of distributed centers.

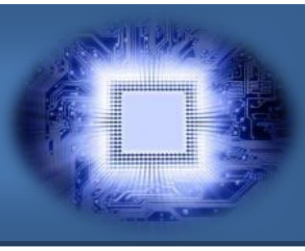
- **Global Partnership.** The project figured out how to involve multiple entities from many countries, including developing and emerging countries, in an ambitious public project, leveraging public dollars worldwide. This global partnership allowed HGP to tap more resources both financially and intellectually.

- **Depositing the data into an open-source commons allowed the private sector to innovate on top of the "pre-commercial commons"—and showed where there was value in collaboration rather than commercial competition.** This may be the best example of a pure "open source" data driven process, where there are no patent protections or liability issues, but where pure data can serve and advance a broader industry-wide goal in a space where there are no commercial conflicts (except of course, where there might be a Celera-type competitor trying to convert the space into a commercial one).

- **The creation of a "pre-commercial commons" for genomic data allowed private companies to use the data and created subsequent private-public spin-offs (SNP Consortium) and successful business development (Celera).** Private sector participation accelerated further public and private investment in genomic research efforts around the globe. Through this open access, the field of genomics was born; researchers can develop new therapies based on gene sequencing data to target locale-specific diseases. Over 1000 genetic tests have been developed to diagnose disease and 350 biotechnology-based products are being tested in clinical trials.[355] Included in ongoing research is the identification of genetic variants that can increase susceptibility to infectious diseases such as malaria and TB, which represent a significant portion of loss of life in the developing world.[356]

- **This pure data driven public collaboration produced significant, follow-on commercial activity, a possible model for some forms of climate innovation.** A compelling factor for funding the new initiative was the long-term implications that the research would have on the biotechnology and pharmaceutical industries.

# Case Study #9: Semiconductor Manufacturing Technology — SEMATECH



## Introduction

SEMATECH is a unique global collaboration of semiconductor manufacturers who work together in what is termed the "pre-competitive" commercial space, to help the industry grow and advance. It is one of the most unique and successful examples of industry and government collaboration.

This industry consortium was started initially to strengthen the US semiconductor industry in the mid-1980's, when the US perceived competitive threats from Japan. At that time, fourteen manufacturers and the US government came together to solve common manufacturing problems and to collectively share risks associated with new industry processes. Funding was shared by the private sector and the federal government. It was essentially an effort solely focused on building up the manufacturing infrastructure for the domestic US industry. Initial government funding for the effort came from the Defense Department, as it was considered a matter of national security. [357]

Within a few years, the entity was so successful that the private sector financed it completely through membership fees, ending public support for its operations. At the same time, its membership expanded globally to include non-US manufacturers.

As part of its international expansion, it created a subsidiary to focus in the mid-1990s on certain tools and standards for one type of chip assembly. The success of that work led it to create International SEMATECH as a dedicated international subsidiary that now works with members from the US, Europe, and Asia. At the same time, this effort started to focus on state and regional players in the industry by launching an "International SEMATECH Manufacturing Initiative" or "ISMI" that is focused on reducing the cost per wafer of semiconductors. It also created an "Advanced Technology Development Facility" in collaboration with several US universities as a for-profit research facility. During this time, International SEMATECH changed its name back to SEMATECH to cover all these entities. [358]

In its latest venture, the Advanced Technology Development Facility (ATDF) merged with the Silicon Valley Technology Center (SVTC). SVTC operates what it calls an "open access facility" where various techniques can be tested to accelerate commercialization of the lab to facility processes for computer chips.

The organization credits its success to a basic strategy—pre-competitive collaboration. Perhaps more than in any other industry, semiconductor manufacturers must constantly evolve to thrive in a fiercely competitive business, pursuing new technologies and practices that drive ongoing reductions in the cost per function, but developing new manufacturing processes is extremely capital intensive and risky. Through the SEMATECH alliance, *industry participants have learned that pre-competitive collaboration is essential in the quest for technology solutions, best practices, cost effective manufacturing, and optimal use of scarce public and private research dollars.*[359]

## History of the Organization

By the mid-1980's, government and private businesses coveted microchips not only for their vast technological potential but also for the immense economic benefits inherent to their manufacture. Despite early US dominance in semiconductor innovation, Japan surged ahead in manufacturing the technology, a terrifying prospect for US companies who sensed the market for semiconductors would only become more profitable. President Reagan's Defense Department was also concerned about the military implications of a dependency on imported semiconductors, used widely in Cold-War era weapons programs.

Thus, in 1987, 14 highly competitive domestic semiconductor manufacturers joined with the federal government to form a consortium called SEMATECH. The new partnership was conceived as an experimental effort to regain US share of the global microchip market and increase domestic semiconductor manufacturing expertise.

The effort fostered an unprecedented degree of collaboration among highly competitive US firms. The industry consortium model worked. SEMATECH was successful in devising cost-cutting manufacturing technologies and processes which led the US to regain control of global semiconductor production from the Japanese.

By 1992, the semiconductor disaster was thought to have been averted and the United States was regaining its place in the global market for microchips. With that success, near the end of 1994, SEMATECH announced its plans to relinquish federal funding.[360] Following this success, the organization went global. Since that time, it spun off the many nonprofit and for-profit initiatives, global ventures and partnerships, already described. The organization now represents more than half the world's production of semiconductors, with a sizeable number of all members of the industry's supply chain.

## How SEMATECH Functions

Probably the best summary of the general functions of the organization come from a US National Academy of Sciences report on SEMATECH:

> How does SEMATECH function? Under its by-laws, SEMATECH is prohibited from engaging in the sale of semiconductor products. SEMATECH also does not design semiconductors, nor does it restrict member firms' R&D spending outside the consortium. SEMATECH members contribute financial resources and personnel to

> the consortium. They are required to contribute 1 percent of their semiconductor sales revenue, with a minimum contribution of $1 million and a maximum of $15 million. Of the 400 technical staff of SEMATECH, about 220 are assignees from member firms who stay at SEMATECH's facility in Austin, Texas, from 6 to 30 months. Because the objective has been to bolster the domestic semiconductor industry, membership has been limited to US-owned semiconductor firms. US affiliates of foreign firms are not allowed to enter (a bid by the US subsidiary of Hitachi was turned down in 1988). However, no restrictions are placed on joint ventures between SEMATECH members and foreign partners.
>
> The SEMATECH consortium focuses on generic process R&D (as opposed to product R&D). At its inception, SEMATECH purchased and experimented with semiconductor manufacturing equipment and transferred the technological knowledge to its member companies.
>
> Since 1990, SEMATECH's direction has shifted toward "subcontracted R&D" in the form of grants to semiconductor equipment manufacturers to develop better equipment. This new approach aims to support the domestic supplier base and strengthen the links between equipment and semiconductor manufacturers. By improving the technology of semiconductor equipment manufacturers, SEMATECH has arguably increased the spill-overs it generates for nonmembers. ..These spillovers may be international in scope; SEMATECH members may enter joint ventures with foreign partners, and equipment manufacturers may sell to foreign firms.[361]

As a matter of organization, more than 20 percent of SEMATECH's staff consists of temporary assignments from member organizations.

## What SEMATECH Does – A Unique Collaboration among Competitors

It goes without saying that the unique feature of SEMATECH is its ability to bring together companies in a fiercely competitive market and figure out ways to have them work together for their common benefit. The way SEMATECH does this, in some detail, is critical to understand its success and its possible replication in other industry sectors such as clean energy.

Probably the critical feature of the scope of this collaboration is that it focuses chiefly on "pre-competitive" spaces—manufacturing and other product development processes that benefit all partners, but do not at the same time infringe on their comparative advantage within the industry. It does this by bringing together all players along the semiconductor supply chain, far beyond the initial founding group of manufacturers.

As the managers of this program explain,

> Design enablement companies, equipment and materials suppliers, fabless, fab-lite, and assembly and packaging companies must join with vertically integrated chipmakers to develop system-wide solutions. We need to redouble our efforts to extend the lifecycle of our mature fabs by realizing further productivity gains and streamlining the insertion of new manufacturing applications. Gaps and duplication in global R&D must be identified and closed. Rising regional interests across the globe should be engaged more effectively.

> And all of this must be done in a business environment constrained by consolidation and affordability considerations.
>
> We bring together manufacturers, suppliers, industry alliances, and government partners to pursue shared technical goals with minimized risk. We cooperatively explore new ideas, reducing the cost of blind alleys and finding the most workable options. SEMATECH has been performing this way for more than 20 years, and today stands as the world's most reliable bridge between semiconductor R&D and volume manufacturing.[362]

As another manger put it, "collaborative innovation centered on core competence – that is the formula that SEMATECH is using."[363]

SEMATECH at the domestic level does this collaborative work across an extremely broad range of industry practices. It works on:

- Integration of technologies
- Cost reduction
- Productivity of manufacturing processes
- Green manufacturing
- New technology breakthroughs
- Raising collaborative funding for research centers
- Developing technology infrastructure for transitions to new processes
- International symposia and conferences and sponsors research papers
- Research into next generation commercialization strategies
- Managing real facilities to test new products

Through its international initiative ISMI, SEMATECH is engaged in numerous activities.

- It has worked on improving productivity across all chip fab facilities by sharing best practices.
- It has shared benchmarking of metrics and evaluation of facility operation.
- It has worked on reducing greenhouse gas emissions from facilities through efficiency and other measures.
- It works on supplier and equipment readiness.

It works on providing demonstration of new tools for the industry.

Probably one of its most innovative collaborations is with the Silicon Valley Technology Center (SVTC). SVTC is a technology services company that serves as a bridge between the lab and fab. It enables customers to bring novel silicon technologies and products to market. It provides, what they say is a "cost-competitive process development infrastructure in a manufacturing-like fab environment, enabling the accelerated commercialization of proof of concepts into real, manufacturing-ready technology solutions."[364]

SVTC offers access to two real world fabricating facilities where customers and others can work on various silicon problems in a fabrication plant. Probably its most important customers are companies

working on novel technologies that need a space where they can develop their new products. In addition to operational capacity, the facilities offer IPR protection so that the experimental work can remain confidential. As their materials suggest, having this form of "independence" is key to the success of the collaboration.[365]

Importantly, in addition to technical support, SVTC offers commercialization services to new companies with new products. It also offers partnerships and financing opportunities to these new companies.

Finally, in June 2008, SVTC launched its SVTC Solar business unit, attempting to apply its business model for the semiconductor industry for the development of photovoltaic (i.e., solar cell) products.[366] It is not clear from the public record whether this initiative has succeeded.

## Impact and Value of the SEMATECH Model

According to assessment of value to its members, the consortium has delivered significant benefits.

> The General Accounting Office Survey indicated that the SEMATECH research most useful to members includes methods of improving and evaluating equipment performance, fabrication factory design and construction activities, and defect control. Several executives maintained that SEMATECH technology had been disseminated most easily through ''people-to people interaction…[367]

However, there has been criticism of the consortium, ranging from the initial exclusion of small companies, to high membership fees. Some researchers have said that the company contributions to joint research has resulted in a reduction of the research and development budgets of the individual members, an overall reduction in R&D investment. [368]

But overall, the program has generally been seen as a success under most criteria.

> SEMATECH managed to overcome obstacles to cooperation and create a viable organization that enabled US manufacturers to resume world leadership in the semiconductor market. Avoiding the mistake of explaining SEMATECH's success by reference to a single causal factor, the authors present three different perspectives for analyzing the consortium's achievements:
>
> 1. Horizontal collaboration between chip manufacturers, vertical partnerships with their equipment suppliers, and collaboration with academic and national laboratories created a viable, cooperative consortium of organizations that had previously been competitors.
>
> 2. The consortium built a close relation with the government by gaining assurance of antitrust exception, securing support from the Department of Defense, and heading off excessive government control of SEMATECH's operational activities.
>
> 3. SEMATECH successfully carried out its technological strategy of producing increasingly miniaturized silicon chips and improving its equipment and manufacturing processes.[369]

Finally, the main lesson from this group is that it cannot be automatically duplicated in other industries. A specific evaluation of the transferability from one to another sector is critical. As a Harvard Business Review article noted in reviewing a book on SEMATECH,

> Clearly, an understanding of the consortium's success is relevant to any national industry whose survival is threatened by increasing global competition. But (the authors) conclude that SEMATECH provides no blueprint for the recovery of critical industries. Rather, "the most valuable lesson of all is that the consortium's experience offers insights into the process of how competitors learned to co-operate, rather than a specific formula of success for others to follow". (The authors) are right to emphasize the particular characteristics of the SEMATECH experience. [370]

# LESSONS FOR A CLIMATE TECHNOLOGY INITIATIVE

There are several key lessons from the SEMATECH experience for any climate innovation effort:

- A successful international consortium of private companies can be devised if the focus is on "generic" or "pre-competitive" areas of cooperation and collaboration. There is no proof that further commercialization activities cannot be coordinated, but this consortium is supportive of more "generic" industry collaboration.
- It is probably important for initial public funding to create such a consortium using a form of cost sharing to ensure buy in of the respective industries.
- It is possible to move from a smaller, domestic entity to a global organization, with evidence of success at the smaller scale efforts.
- It is possible to move away from public funding to private funding with sufficient proof of a consortium's success.
- Once a consortium has success with "pre-commercial" non-competitive activities, it is possible to collaborate with other ventures that focus on commercialization activities, like incubators, financial support, management assistance and partnership development.
- All in all, automatic transferability of the model should not be assumed, without a clear analysis of the issues to be addressed and how the model can be adapted to solve the problems identified.

# III. INTERNATIONAL CLIMATE INNOVATION INITIATIVE: PRINCIPLES, OPTIONS AND NEXT STEPS

This report, so far, has identified emerging technology innovation theories and empirical insights from case studies in agriculture, health, and telecommunications sectors.

Based on that material, this section:

- Addresses the question of *transferability* of insights from the agriculture, health and ICT sectors are to climate technology.
- Identifies *overarching principles* that should be considered to establish the strategies and structure of a global climate technology innovation initiative.
- Provides *illustrative options* of how international climate innovation based on global collaboration could be managed and implemented.
- Provides a series of *decision points* and pros and cons for consideration of options.
- Finally, it proposes a *design process* using this work as the basis, to design more detailed options.

## Transferability of Case Studies to Climate Innovation

An obvious question that may arise from the case studies and the innovation principles is: how transferable are insights from the agriculture, health, and telecommunications industries to the low-carbon and climate-resilient technology sectors?

There is no simple answer to this question. The climate technology space is so broad—from low-tech consumer products, to capital-intensive infrastructure scale investments, from drought resistant crops to nanotech solar panels. Nonetheless, while there will be differences in the strategy and structure of an initiative or program based on the target technology or market need, the evidence suggests that the key innovation theories and principles below can be—and are being—applied consistently across all areas of innovation.

In other words, there is *nothing inherently unique* in these principles and industry practices that would prevent transferability to the climate space. In fact, the contrary may be true—there are elements of the low-carbon technology sector in developing countries, which make them uniquely amenable to application of these new innovation strategies.

There are three reasons for this conclusion:

- First, there are a number of prominent scholars of innovation who have written about how these innovation principles could and should be applied to low-carbon technologies—from

Professor Clayton Christensen of Harvard Business School to Dr. Rene Kamp of Maastricht University to Richard Lester of the Massachusetts Institute of Technology.

- Second, and perhaps most important, many of these principles are already being put into practice with significant success by the Lighting Africa Project managed by the International Finance Corporation in collaboration with a host of public and private sector partners (*see box below).*
- Third, the applicability of these principles and case studies will depend greatly on the problems to be solved. Many of the innovation principles and case studies are derived from what might be considered consumer products. So, to the extent that the mitigation and adaptation challenges involve lower-cost products, like US$30 solar lanterns or US$80 solar panels, the innovation principles studied are directly on point.

It is in the area of larger-scale, more capital-intensive energy or adaptation systems where the challenges of transferability are greater. If the problems to be solved are in the area of marine technologies, or carbon capture and storage, or offshore wind, the principles have simply not yet been applied. There is no reason to believe that they are not applicable. In fact, the whole concept of "innovation systems" in the literature is typically contained in descriptions of what is needed to change wholesale, networked, and embedded technological systems—precisely the kind of systems that characterize the energy system.

## LIGHTING AFRICA

The Lighting Africa (LA) program, a joint International Finance Corporation (IFC)-World Bank (WB) initiative, demonstrates the successful application of new innovation systems approaches to one of the most persistent energy access issues in the developing-world: off-grid lighting. LA identified a series of market gaps for off-grid lighting products that the private sector was unable to overcome:

- Lack of market information and consumer knowledge of products
- Low quality products spoiling the market
- Lack of low cost consumer and business finance
- Policy and regulatory constraints

To overcome these barriers, LA supports private sector innovation by providing detailed market analysis, product testing and certification, access to finance through local banks, and an online virtual network to link manufacturers and distributors. Through these interventions, Lighting Africa acts as "bridge" or "matchmaker" for entrepreneurs and local and international businesses along the supply chain.

**Early results** indicate that markets for modern, off-grid lighting in Sub-Saharan Africa are accelerating rapidly since the launch of the program. With current growth rates, portable solar lighting costs are projected to continue to decline by 40 percent per year. With this rapid progress, reaching Lighting Africa's initial goal of providing 2.5 million people with access to cleaner lighting by December 2012 is on track.

In 2010, over 134,000 solar portable lamps which had passed Lighting Africa quality tests were sold in Africa, providing more than 672,000 people with cleaner, safer, better lighting. Eight products have so far passed Lighting Africa quality tests and are available in the African market, retailing between US$22 and US$97. Since February 2011, the first testing lab in East Africa is offering testing of off-grid lighting products as a commercial service to manufacturers and distributors. The lab, at the University of Nairobi, uses Lighting Africa's low-cost initial screening method.

After the program's early success piloting its approach in Kenya and Ghana, Lighting Africa has expanded to eight additional countries in Sub-Saharan Africa and India. LA's quality assurance approach is already being implemented internationally.

**Replication.** Lighting Africa is now spinning out some of its work to a newly formed independent organization—the *Global Off-Grid Lighting Stakeholder's Association*. The Association represents a unified industry voice dedicated to the development of clean off-grid lighting solutions. It will seek to enable economic, ecological, and social benefits for all stakeholders.

The association will also support the expansion of off-grid lighting markets in developing countries outside of Africa. The association is an important first step in moving the Lighting Africa program towards a self-sustaining operation, and provides an "exit strategy" for the World Bank Group, which has served to jumpstart the off-grid lighting industry.

The Lighting Africa example demonstrates that individual firms cannot and should not "go it alone" to commercialize climate technologies in developing countries. The program underscores the need for an international public partnership to serve as a neutral broker to identify and fill gaps across the value chain, share international knowledge, enable relationship building, and respond to evolving market needs—actions that individual countries and private sector developers cannot do on their own.

# PRINCIPLES FOR CLIMATE TECHNOLOGY INNOVATION: STRATEGY AND STRUCTURE

The following core principles have emerged from the innovation theories and case studies described in this report.

## Strategy to Guide the Innovation Programs

**Clearly define the technology barriers and needs with end users**. This is the key to success. The open innovation experts we interviewed emphasized that problem definition is at least 50 percent of the solution.[371] The successes and failures described in the agricultural value chains case study also highlight the critical role of precise problem identification in close cooperation with end users. The project team concluded that technology commercialization projects must be needs driven. The recent successful distributed innovation trend of "consumer-driven innovation" is closely linked with this principle- global companies such P&G and IBM have dedicated initiatives to tap consumers insights.

As the PIPRA case study showed, WIPO and World Economic Forum's Global Access in Action initiative is also founded on Demand-Driven Innovation Needs Identification. The GAA recognizes that, "Too often in the past, technology transfer for development has failed because it was supply-driven – without real attention to the technological needs of the poor. Companies, research institutes, and universities need to know specifically what the problems, how technologies will be used, and what the adoption issues are if they are going to successfully apply their knowledge and technology."

- **Set a concrete, time-bounded goal and focus on results—but allow for learning**. The case study programs that had discrete, measurable goals had more consistent results. For example, according to reviews and the experts we interviewed, two of the four CGIAR Challenge Programs were more successful than the others—those involved with the programs attributed this to these programs focus on a few concrete, time-bounded goals whereas the other programs aimed for broader, less discreet objectives.

  Similarly, programs must be defined by clearly prescribed performance standards. The Global Fund's success is a case in point. Reviews and experts consistently attributed the Global Fund's impressive results to its dedication to "performance-based funding."

  Any goals must allow for learning along the way. **Knowledge generation, documentation, and learning are critical.** These processes must be incorporated in programs to ensure that best practices are captured and broadly disseminated and implemented. Successful programs experiment with models, and then improve upon and respond to monitored results and empirical evidence, which requires regular review and evaluation processes. The Global Fund

is a model organization in this respect with frequent and regular external reviews of programs, out of which they adapt or develop new program models and approaches.

- **Tap the global brain and bank.** This principle was consistently support across the case studies. Programs that link global knowledge and finance with local expertise and experience are consistently the most successful.
    - The successful CGIAR Generation Challenge Program linked experts from over 230 research labs, private companies, national agricultural extension programs and CG centers.
    - The Meridian Institute's innovative approach (agricultural value chains case study) gathered a multidisciplinary group of international science experts, specifically not from agricultural fields, with local farmers and experts. The broad range of perspectives and experience inspired "outside the box" thinking that resulted in simple, creative technology solutions- some that are now being commercialized.
    - The Human Genome Program linked experts from across the globe and across sectors with financial support from multiple national governments, these coordinated efforts led to a solution (mapping the human genome) a full two years ahead of schedule.
    - By using an open innovation approach, Eli Lilly pharmaceuticals was able to increase its solution rate to 30 percent compared to 10 percent using only in-house research—a figure made more impressive if one considers that these were problems Lilly's R&D could not solve.
    - The key to the successful mobile phones uptake across the developing world was the linking of native entrepreneurs (in almost all cases trained in the West) with international finance. George Soros provided GrameenPhone with a low-interest loan and Norway's Telenor AS partnered in a joint venture.372 Similarly, Celtel International relied on the local expertise of Mohamed Ibrahim (a Sudanese native and the former technical Director of British Telecom's Cellnet) and $1billion in Western debt and equity to finance its launch across sub Saharan Africa.[373]

  Mitigation and adaptation solutions must be structured to solve local problems but they can be supported by international experiences and multi-sector expertise. A climate innovation initiative should use evolving open and distribution innovation tools (virtual networks, prize competitions, data sharing systems) and practices (multi-disciplinary teams, cross-sectoral learning) to create international networks and tap global expertise.

- **Look to developing countries as innovators in their own right.** Developing countries are not just recipients or imitators of developed country technology activities, as the recent trend in reverse innovation has demonstrated**.** The mobile phone case study, in particular, demonstrates that future technological innovation is likely to come from developing countries. Similarly, the Global Fund relies on program innovations to evolve from the country organizations it supports. It is critical for any climate innovation initiative to think beyond North to South technology transfer to technology partnerships.

- **Focus on market or product development to have huge impacts on poverty reduction and economic development.** Development programs that focus on technology or market creation to serve local communities have had significant success spurring economic development in the poor world. These are projects that go beyond policy best practices and information sharing. The mobile phones case is the most dramatic example. GrameenPhone was created out of a joint venture of a multinational for-profit and an indigenous nonprofit, supported with development aid from Norway and George Soros. The project did not attempt to change policy, instead it was trying to get mobile phones to poor people in Bangladesh—but it ended up changing the policy environment dramatically in Bangladesh- and set off a cascade of similar programs across Sub-Saharan Africa that led to similar policy changes. The model looks like this: market specific public interventions and partnerships spur private investment which generates profits for businesses and income for end users that are reinvested to generate further profits→ spin-off businesses are created and competition drives the market and forces government reform→ capital markets deepen→ new liberalized policies and regulations support further investment and the country begins to operate from its own technology, entrepreneurs, and capital.[374] The Lighting Africa program described above saw similar poverty alleviation impacts by focusing on product development- off-grid solar lighting- rather than high level policy changes.

- **Systems or value chain approaches are critical to steward new technologies to market.** Innovation Economics described in chapter two, particularly innovation systems, emphasizes that successful technology deployment must address all barriers along the technology value chain. Empirical evidence from the case studies supports this, particularly experiences in African agricultural value chains. As the case study notes a number of technology projects were unsuccessful because they were introduced to solve a particular problem at one step in the value chain- without considering the full product life-cycle process (e.g., the mechanized cassava peeler). The Lighting Africa program has also been so successful because it has addressed market and technology barriers at all points on the product development chain.

- **Build public support including high-level political support.** One of the keys to the Human Genome Project's success was the high-level support it received from US President Clinton and UK Prime Minister Tony Blair. At the same time, HGP was able to articulate the benefits of the project to a broad audience to build congressional support for funding. The Global Fund has also been extremely successful at (and attributes some of its success to) building broad public support for its programs through concerts, benefits, and local support groups. Public support can be built by clearly articulating the benefits of the program. Benefits can include not just solving a particular problem—like mapping the Human Genome to find cures for diseases—but these kinds of effective public technology investments can spur a huge number spin-off companies and in some cases the creation of entire industries. Public investments in the Human Genome Project led to the creation billions of dollars of private companies. Public investments in GrameenPhone in Bangladesh led to the creation of the mobile phone industry and entirely new income streams for the poor.

- **Involve the private sector.** The public sector will never have enough money to fund capital-intensive climate technology development. All of the case studies have shown that the most effective innovation programs work closely with the private sector to leverage expertise, skills, and funding. Indeed, successful public technology innovation programs should eventually be crowded out by the private sector—as was the case for SEMATECH, the semi-conductor research alliance that was initially funded jointly by government and industry, but within a few years, public funded ended and member dues fully supported the program. Similarly, Lighting Africa is shifting many of its activities to an independent industry consortium, the Offgrid Lighting Stakeholders Association. This hand off to the private sector provides an exit strategy for public funding—though timing will be crucial.

  The private sector can be engaged in a number of ways, but should be included early and often.

  - The Global Fund includes private sector participants from the pharmaceuticals industry on its board. A number of interviewees emphasized the important role that private sector participation played on the Board. They felt that the private-sector participants brought an important perspective, a high level of efficiency, and effective decision making.
  - In the case of mobile phones success, local small businesses and entrepreneurs, linked with multinational telecommunications companies, were crucial in the success of publically supported programs.
  - The success of the SEMATECH consortium, the GSMA mobile phones industry association, and the SNP Biotech Industry Consortium that came out of the Human Genome Project demonstrated that a successful international consortium of private companies can be devised to accelerate new technologies if the focus is on "generic" or "pre-competitive" areas of collaboration.
  - Finally, working closely with the private sector on IP issues will be essential for any climate technology initiative. As PIPRA learned, along with other in agriculture, it is not worth trying to work around the private sector on IP, instead work with them to find solutions faster and more effectively.

- **Treat IP as a solvable problem**. IPR is increasingly seen as a series of solvable specific legal problems, all well within "normal" business practice, rather than intractable political and policy problems that stymie new technology innovation. Experts interviewed for the PIPRA case study emphasized this point: "IPR is not a deal breaker." In the case of commercial products, international companies manage joint ventures and licensing all the time. "Just get some lawyers involved and give them a few months to agree on the details." In the case of humanitarian products, like drought resistant crops in Africa, experts at PIPRA and the Gates Foundation noted that companies in almost all cases are more than willing to provide free humanitarian licensing for these kinds of uses. Their biggest concern is around liability for regulatory, health, or environmental problems that might result. In these cases, again it is a question of structuring the right legal agreement that focuses on liability protection and safeguards for companies. These experts noted that trying to work around the private sector

through public patenting or establishing broad solutions like patent pools did not work well. Developing country researchers and entrepreneurs should, however, be supported to manage IPR thickets through some kind of dedicated IPR assistance - like the PIPRA model.

## Structure to Guide the Strategy

- **Independent.** Independent organizations are critical for incubating innovation. The theory and case studies above consistently emphasize the importance of independent organizations that are not encumbered by hierarchies, and of bureaucratic cultures that encourage innovation. As the theory in Section Two of this report has shown, the first recommendation for encouraging disruptive innovation is to create independence for an innovation focused team—most radical innovation comes from groups outside of established company hierarchies. The empirical evidence from the case studies supports the theory. The Global Fund was specifically established as an independent entity outside of existing organizations such as the World Bank and the UN. The experts we interviewed credited the Global Fund's creative programs and effectiveness to its independent structure. Similarly, the CGIAR's Challenge Programs and new Research Programs are expressly established independent of existing CG center hierarchies. And the CGIAR's new Consortium is based in France, not the World Bank, to overcome the challenges that come with being stuck in a large bureaucracy. Finally, the concept for InnoCentive, the extremely successful OI company, was inspired by a group of Eli Lilly executives who were expressly sent to a separate building to be able to think outside the box – or the bureaucracy.

- **Operationally lean**. Successful, innovation organizations most often operate with small staff with core expertise—tapping outside, topic-specific expertise as needed. The intent is to create stability and continuity while maintaining flexibility to respond to changing project specific requirements. There is no "one size fits all" approach to technology innovation in developing countries; it is critical to address very different needs of different technologies. As one expert in this space noted:

> Technologies are country and sector specific. There is no 'silver bullet' technology nor do 'one size fits all' measures work for all countries. Flexibility in its design and operation… would prevent [the climate technology mechanism] from becoming yet another redundant 'top-down' international bureaucracy. [375]

Staying small and flexible can be challenging. The Global Fund, while still small by comparison for the level of funding it manages, originally was designed to have ten to fifteen employees—it now employs over 600 in the secretariat. There are a few best practices to retain "leanness" and avoid institutional ossification (when organizations often become more focused on institutional survival than mission). Whenever possible, orchestrate and manage activities through virtual governance networks with a small facilitating group or hub of employees that links with existing organizations, rather than a large, new, central management group. Through this process, it is possible to run activities with a small group linking activity around the world instead of setting up bricks and mortars offices in all countries of interest across the world. The Global Fund has

taken this approach by decidedly not setting up in-country offices. Instead the Fund relies on existing organizations, national and international, to manage, monitor and implement programs. The CGIAR's new Climate Change Agriculture and Food Security program is dedicated to staying small with a core staff of seven people working with researchers in existing institutions around the world, managing its US$70 million annual budget.

- **Heavily networked**. One way for an organization to stay lean is to rely on the capacity of existing organizations to the greatest extent possible. A heavily networked organization can also better tap distributed knowledge and expertise. The Human Genome Project, the GSM mobile phones industry association, and the CGIAR's Challenge Programs are two examples of successful networked organizations. The Global Fund is also a relatively lean organization that relies on dispersed experts and organizations to develop, implement, and monitor the programs it funds.

- **Multiple funding sources.** Public funding should be "seed funding" that leverages additional private-sector and other funding; securing private-sector financing is the only sure route to durable market creation. Public funding should be sought from a wide range of governments as well as private foundations and public donations. This has been a key to the success of the Global Fund, which receives funding from almost fifty countries. Most of these countries are wealthy OECD and middle-eastern countries, but poor countries have also pledged, including India, Namibia, Malaysia, Thailand, Uganda, and Burkina Faso. The Global Fund also receives significant funding from the Gates Foundation among others. Individuals can donate, and it has developed creative public-private fundraising approaches like benefit concerts, Product (RED) and a Dow Jones Exchange Traded Fund.

- **Public Private Partnerships.** As noted above, involving the private sector is crucial to successful market creation and commercial technology deployment. A successful climate technology innovation initiative should be structured as some form of public-private partnership. The case studies provide a range of structures: a consortium model like SEMATECH, a neutral "market maker" model like Lighting Africa, among others. Exactly how the partnership is structured is likely to depend on the technology and market in question but this should be a central focus in designing a new initiative.

- **Geographically relevant**. It is important to connect to partners with strong community connections, and to global resources for technology knowledge support and finance mechanisms. You need to involve local end-users and businesses, as emphasized by the experiences in agricultural value chains.

- **IPR Function.** Rather than viewing IPR as a problem to be solved some time later in the process or by broad political agreements, IPR issues should have dedicated institutional support that is demand driven. This could be incorporated within the organization, or a climate innovation initiative could partner with and support the emerging efforts of the Global Access in Action as described in the PIPRA case study.

- **Engage Policy.** Following all these principles will be insufficient unless policy issues affecting the enabling environment are addressed in parallel. As evidenced in the agricultural sector literature in Africa, "innovations preceded by strengthening of the enabling policy environment have often succeeded (e.g., sorghum processing in Nigeria and smallholder dairy in Kenya). Those introduced without a review of supportive policies have often failed (e.g., the food-grade aluminum milk cans in East Africa, and the community based animal health workers across Africa)."[376]

  In particular, a strong business policy environment is critical for success, in some cases deregulation is needed to encourage greater economic competition. This was certainly the case for mobile phones in Bangladesh and through Sub-Saharan Africa, where liberalizing telecommunications policies unleashed a flood of private-sector investment and innovation.

# Illustrative Options For A Climate Technology Initiative

Based on the analysis of the case studies described above and the forty interviews conducted with experts, we have identified three possible options for a climate technology innovation initiative. It is important to acknowledge that this paper is only designed to provide the intellectual foundation for a much more rigorous, second phase scoping and design process. Thus the three options described below are notional without the necessary detail to fully support them at this time.

## OPTION 1: COUNTRY SPECIFIC—PROJECTS ONLY, NO COORDINATION

This option would consist of a few country-based project initiatives that would not be supported or managed by any global coordinating organization or function. These would be distinct projects that would initiate this effort, with determinations made later about the need for any other supporting entity.

Key design elements:

- Importantly, this option would consist only of implementing projects, without any backup coordinating entity or organization.
- Projects would focus, like Lighting Africa, on climate product development in developing countries in the areas of mitigation and adaptation.
- The projects would use an "innovation systems" or "value chain" approach to identify local institutional barriers to change, and propose solutions to overcome them.

**Pros:** This process would likely be easiest to establish, with simpler institutional problems and smaller amounts of funding.

**Cons**: This approach may not achieve global scale and scope, and limits learning across projects and technologies.

## OPTION 2: COUNTRY SPECIFIC WITH GLOBAL NETWORK

This second option would consist of a light, virtual global organization—independent but perhaps linked to some other global body—that would initiate and support a few different technology/market "nodes" in select countries. The theory behind this option is that of a bottom-up, in-country strategy linked to global, open innovation architecture of experts. A combination of in-country capacity building and a dedicated, international, technology innovation support network are the essential elements of this structure. A few early projects would be started in different countries with specific technologies. The other key distinguishing feature would be a virtual team working in a global network—using various open and distributed innovation tools to tap into the "global brain" to solve implementation problems.

Key design elements:

- A Core Team would provide leadership, identify and vet specific technology concepts, strengthen networks, aggregate and share knowledge.
- Project Teams would implement projects in countries where the technologies will be deployed.
- Virtual Resources would efficiently link project teams with various experts, as needed, in the areas of technology design, finance, market analysis, policy, and IP issues.

**Pros:** A global organization, managing multiple projects in different locations and technologies, can allow for faster learning and for greater replication and scale.

**Cons:** This would be more complicated and expensive to execute than Option 1 (though perhaps less expensive than Option 3). In addition, the creation of a virtual network would be a new endeavor that would take some time to structure and put in place.

## OPTION 3: CENTRAL GLOBAL ORGANIZATION WITH MULTIPLE PROJECTS

This third potential option would be a new centralized division or entity within an existing global organization such as the World Bank/IFC—or under the UNFCCC technology "centre"—that would rely on in-house staff to initiate and manage many technology projects in multiple countries.

Key design elements:

- It would rely on an existing organization to support the project development and implementation.
- It would likely rely on existing expertise to vet projects.
- It would possibly be able to raise funds more quickly given likely relationships with donors.

**Pros**: This option could likely be established most quickly and avoid the challenges of new organizational set up. It would be recognized by existing partners based on past performance. It would also be able to rely on past performance to argue for taking on a new responsibility and new funding.

**Cons:** This option may be less country-led and may not be able to adequately account for individual country priorities. Moreover it is inconsistent with the emerging consensus that independent organizations tend to be more capable of managing innovation.

# KEY DECISIONS POINTS FOR CONSIDERATION OF OPTIONS

To assess these options, stakeholders should consider a series of decision points, in somewhat descending orders of specificity. In the end, all of these decisions are interdependent and likely cannot be answered alone, since decisions on function and form will necessarily impact each other.

## Strategy Related Considerations

1. **Clarify the target technologies and markets.** The first and most important decision to guide the operational strategy will be – which technology needs are to be addressed? The technologies under discussion, whether for mitigation or adaptation, stand at varied levels of commercial development. At the same time, each technology will face different consumer demands in distinct policy environments. Each of these challenges requires different roles for the public and private sector. If the need is to create low-cost solar and lighting products for the rural poor, the public sector may not need to subsidize new technologies but instead identify market needs, and support entrepreneurship skills and financial capacity. For capital-intensive emerging technologies like offshore wind, marine energy, central solar plants, or major adaptation projects, more sophisticated policy tools will be needed to create demand and more public finance will be needed initially to leverage private capital.

   There will be very different institutional, technical, and other dynamics for mitigation vs. adaptation, high vs. low capital, and mature vs. breakthrough technologies. Each will require different solutions—this decision should be the foundation of the rest of the scoping work. There are many great analysis tools and databases out of the UNFCCC process and others that can be relied on here.

   A basic, related question is whether specific technology areas should be selected or whether the program should address a particular market need from a technology neutral approach—for example, to structure a program around cheap, small-scale biomass gasifiers or scoping a program more broadly around any mini-grid renewable power solutions. The lead of IFC's Lighting Africa program has highlighted the program's initial technology-neutral approach as a key principle to its success.

2. **Geography.** Once the general objectives are identified and technologies selected, the next obvious question is where the most optimal conditions exist to pursue the various technology innovation projects. Should the effort have a global scope, or be confined to a few countries, at least in the start up phase? These decisions can be based on several factors, including whether the technologies selected could be commercialized in a single country market, or whether a more global approach is needed to reach commercialization. This, in turn, may depend on factors such as the initial capital costs and market structures for commercialization.

For example, a US$25 or US$50 solar LED lighting product (as in Lighting Africa) could possibly be commercialized in one country, as they have in Kenya. However, attempts to commercialize more capital-intensive marine wave or tidal projects might well require a multi-country market. Each, in turn, will depend on the enabling environment in country and on political barriers to project viability.

3. **Amount of funding available and willingness of funders to fund.** This is closely related to the technology questions above. The amount of funding available will determine which kinds of technologies can be addressed and the costs of the projects. Also, the experience of international donors making pledges for various causes (whether the Global Fund or CGIAR), and sometimes not following through on paying those pledges, must be taken into account in any funding decisions regarding this initiative. Thus a safer bet may be to address less capital-intensive technologies that are closer to market deployment and where more private capital may be leveraged.

4. **Interests of the private sector and their willingness to participate.** As noted, success will be dependent on the participation of the private sector. Focusing on projects where the private sector can participate and leverage their resources should be a critical path to early selection of projects. Thus the initiative may want to focus on markets where there is a latent opportunity for the private sector and the underlying economics provide a profit margin. In this regard, it is important to look at the first mover costs—and be sure that these can be addressed—to know how and why they are doing to go down, not just betting on learning curves.

5. **Timeframe for success.** It is important to determine how long funders and other partners are willing to support the initiative without concrete results. The answer to this question may also determine which technologies to target. It may be important for a technology initiative to focus on some technologies that are later-stage and ready for deployment in the near term.

6. **Implementation Strategy.** Should the initiative start off the bat with a global initiative or should it have a staged roll out with pilot programs before a full international facility is set up?

## Structure-Related Considerations

1. **Should the facilitating hub be virtual or co-located?** Should the Core Team/Secretariat be set up as co-located with some physical entity or should it be virtual?

2. **Location.** In a related question, if there is a core team collocated, where should the Core Team be located? Should it be based in a developing country in order to be a credible "developing-world" initiative or should it be located in the North, in the USA or Europe, to be closer to sources of possible funding?

3. **Should the core team/secretariat be set up as an independent and/or nonprofit organization?** Most of the core innovation principles suggest any effective innovation entity be housed in an entity independent of existing organizations to encourage creativity, nimbleness and

unconventional problem solving skills. At the same time, there is a trend to house these independent organizations within a nonprofit structure to avoid any commercial interests from influencing the operation of the organization.

4. **Skills and Size of Core Team/Secretariat**
   - How could the Initiative best organize a Core Team/Secretariat of individuals with strong business acumen, financial skills, and the ability to take technologies through a rigorous product development and commercialization process?
   - What size of the core team/secretariat seems appropriate for the tasks at hand?
   - What are the appropriate models to emulate to create the optimal team and Secretariat?
   - What are the functions of the team with respect to project implementation in country?
   - What the separate but related global functions of the core team/Secretariat regarding project coordination and facilitation?
   - What are the appropriate incentives (financial and otherwise) for members of the small Core Team? Should they have "skin in the game" (i.e., benefit personally or institutionally from successful commercialization of specific technology concepts)? Or, does that create perverse incentives (i.e., commercialize products that bring them the greatest financial return, and not the largest benefit to the larger group of smallholder farmers)?

5. **Partners.** Which organizations have strong relevant experience and expertise and could be part of an Initiative?

6. **Financial Model**
   - What would it cost to set up and operate the Core Team and a typical Project Team?
   - Who would fund the process?
   - How would funds leverage other funding?
   - How likely is it that the Core Team can eventually be supported in part or completely through revenue from commercializing technologies (i.e., generate revenues by charging fees for its services and/or create modest revenue streams from successful projects)? Would this jeopardize the Core Team's independence?
   - If the Core Team will require on-going funding from donors, how will this be received by donors?
   - If the Initiative can demonstrate it is leveraging other resources, will that justify on- going investment by donors?
   - Who would serve as trustee for the funds to assure accountability?

7. **Timeframe**
   - Is this a time-bound effort that would be set up for a limited time or an unlimited time based on performance and outputs?
   - Is a minimum time frame of commitment required to assure success and the credibility of the operation?

- Could the Initiative fade out over time as capacity, processes, and systems to support technology commercialization and innovation in climate technologies become more robust?

8. **Links to Existing Climate Institutions**
   - How will it link to new UNFCCC technology "centre" and network?
   - Can this effort be stood up before UNFCCC resolves issues regarding centre and network under Cancun agreement?
   - Can parallel processes work and how would that be handled?

# Design Process for Consideration of Options and Scoping

Given the many variables and trade-offs involved in consideration of options, it is recommended that the next step should be a design process. This could take the form of what is called a “design charette” —a strategic planning exercise where major potential partners, funders and other organizations are brought together in person for a several day session to develop a design framework for the global technology innovation initiative. The purpose of the charette would be to consider this paper and the various options contained in it.

Apart from strategic and structural considerations, one other important feature of any new initiative would be a decision about how to fund it. The case studies outlined here detail numerous challenges to fund continuing global efforts such as the Global Fund and CGIAR. This effort would require new funding in difficult economic times for many developed countries. So it is important to address this funding question head on in the design process.

An in-depth implementation and operational plan should be developed that could be adopted to launch a pilot as early as the end of 2011. Toward that end, the design process should start as soon as possible. Delaying the start of the design process would likely jeopardize the strategic planning needed to develop a collaborative and consensus plan by the end of the year, in time for the 2011 COP in Durban, South Africa.

# CONCLUSION

This paper describes promising new innovation theories and practices used in many non-climate sectors by public agencies and major global corporations. These new strategies drive technology development and collaboration in both developed and developing countries. In many cases, they are the cutting edge approaches by which corporations do product development in poor countries, and export those products back to the developed world. These new directions represent where 21st century technology innovation is now heading.

Based on these strategies and case studies, the paper makes many specific recommendations for how these innovation approaches could be applied to accelerate climate mitigation and adaptation technologies.

Using these strategies to structure and implement a global climate initiative could produce many benefits. They could make developing countries partners in the process of creating new technology products. They could result in cheaper climate technologies. They could lead to wealth-creating markets for these technologies in poor countries. They could result in a global effort where cost reductions, rather than subsidies, are the drivers behind the expansion of clean energy. They could turn the traditional strategies of technology transfer from only the North to South on its head—to create a new direction of technology transfer from the poor to the West. And at the same time, they could provide cheaper low-carbon and adaptation technologies to the developed world.

Because of the promise of these new innovation practices, the paper proposes that the next step in this investigation should be a design and strategy process. It would be used to create a new climate innovation initiative based on these new emerging practices. This process should begin immediately so that any new initiative would have the next few months to develop a collaborative design in time to announce at the Durban, South African COP in December, 2011.

We trust that these recommendations start a new direction for global climate innovation—to address the twin challenges of mitigation and adaptation in ways that comport with the most creative and leading theories and practices that drive innovation in fields outside of climate. It is time for climate innovation to follow these 21st century principles to solve the most pressing technology, financial, and institutional challenges facing the planet.

# ENDNOTES

[1] UNFCCC, "Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries (2007). Available at http://unfccc.int/resource/docs/publications/impacts.pdf.

[2] Shuman Talukdar, Michael B. Horn, Rich Alton, and Clayton M. Christensen, "Winning and Losing Bets on Green Technologies" (April 28, 2010). Available at SSRN: http://ssrn.com/abstract=1597315.

[3] H.W Chesbrough, *Open Innovation: The new imperative for creating and profiting from technology* (Boston: Harvard Business School Press, 2003) p xxiv.

[4] Delhi High Level Conference on "Climate Change: Technology Development and Transfer," Chair's summary (October, 2009). p7 paragraphs 9 and 10. Available at http://moef.nic.in/ downloads/public-information/Chair percent27s percent20summary-FINAL.pdf.

See also: World Bank, "World Development Report 2010: Development and climate change" (Washington, D.C.: International Bank for Reconstruction and Development/The World Bank, 2009) p306. Available at http://go.worldbank.org/FTD88BBDV0.

See also: Carlos M. Correa "Fostering the Development and Diffusion of Technologies for Climate Change: Lessons from the CGIAR Model," Programme on IPRs and Sustainable Development (ICTSD: December 2009). Available at http://ictsd.org/i/publications/66697/.

[5] UNFCCC, "Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries (2007). Available at http://unfccc.int/resource/docs/publications/impacts.pdf.

[6] UNFCCC, "Report on options to facilitate collaborative technology research and development," note by the Chair of the Expert Group on Technology Transfer Subsidiary Body for Scientific and Technological Advice, Thirty-third session, Cancun, 30 November to 4 December 2010.

[7] Goldenberg, "Ban Ki-moon ends hands-on involvement in climate change talks, UN secretary general will redirect efforts to making more immediate gains in clean energy and sustainable development," *The Guardian*, January 27, 2011. Available at http://www.guardian.co.uk/environment/2011/jan/27/ban-ki-moon-un-climate-change-talks.

[8] Pielke, et al., "Dangerous Assumptions," *Nature* 452, 531-532 (3 April 2008).

[9] A table of adaptation technologies can be found in the United Nations Department of Economic and Social Affairs, "Climate Change: Technology Development and Technology Transfer," p17. Available at

http://www.un.org/esa/dsd/resources/res_pdfs/publications/sdt_tec/tec_technology_dev.pdf.

[10] International Panel on Climate Change, "Climate Change 2007: Synthesis Report Summary for Policymaker," p5. Available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.

[11] Practical Action, "Poor People's Energy Outlook 2010." Available at http://www.lightingafrica.org/files/Practical percent20Action percent202010 percent20-percent20Poor percent20Peoples percent20Energy percent20Outlook_0.pdf .

[12] Nathan S. Lewis, et al., "Basic Research Needs for Solar Energy Utilization: Report of the Basic Energy Sciences Workshop on Solar Energy Utilization" (Argonne, IL: Argonne National Laboratory, September 2005). Available at http://www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf.

[13] Ibid, p ix.

[14] United Nations Department of Economic and Social Affairs, "Climate Change: Technology Development and Technology Transfer."

[15] These technology needs are adapted from the UNFCCC Expert Group on Technology Transfer, "Report on options to facilitate collaborative technology research and development," note by the Chair of the Expert Group on Technology Transfer Subsidiary Body for Scientific and Technological Advice Thirty-third session Cancun, 30 November to 4 December 2010, pp13- 14.

[16] UNFCCC Subsidiary Body for Scientific and Technological Advice, "Synthesis Report on Technology Needs Identified by Parties not Included in Annex I to the Convention" (New York: United Nations, 2006) p viii. Available at http://www.un.org/esa/dsd/resources/res_pdfs/publications/sdt_tec/tec_technology_dev.pdf.

[17] Interview with Ahmed Abdel Latif, Programme Manager for Intellectual Property and Technology at the International Centre for Trade and Sustainable Development (ICTSD).

[18] The Intergovernmental Panel on Climate Change (IPCC), "Methodological and Technological Issues in Technology Transfer" (IPCC, 2000). Available at http://www.ipcc.ch/ipccreports/sres/tectran/index.htm.

[19] United Nations Department of Economic and Social Affairs, "Climate Change: Technology Development and Technology Transfer," p vi. http://www.un.org/esa/dsd/resources/res_pdfs/publications/sdt_tec/tec_technology_dev.pdf.

[20] David Ockwell, et al, "Enhancing Developing Country Access to Eco-Innovation: The Case of Technology Transfer and Climate Change in a Post-2012 Policy Framework," (OECD: 2010).

See also United Nations Department of Economic and Social Affairs, "Climate Change: Technology Development and Technology Transfer." Technology transfer involves more than hardware supply; it can involve the complex processes of sharing knowledge and adapting technology to meeting local conditions. Domestic technical and managerial capacities, institutions and investments in technological learning all influence the effectiveness with which technology can be absorbed and adapted.

[21] Ruud Kempener, Laura D. Anadon, and Jose Condor, "Governmental Energy Innovation Investments, Policies, and Institutions in the Major Emerging Economies: Brazil, Russia, India, Mexico, China, and South Africa,." Discussion Paper #2010-16. Energy Technology Innovation Policy Discussion Paper Series (Harvard Kennedy School, November 2010). Available at http://www.eenews.net/assets/2010/12/17/document_cw_01.pdf.

[22] Britt Childs and Casey Freeman, "Tick Tech Tick Tech: Coming to Agreement on Technology in the Countdown to Copenhagen," World Resources Institute (June 2009).

[23] Lawrence Kent (Agriculture Program Officer with the Gates Foundation). Personal communication. January 27, 2011.

[24] Anatole Kratiger (WIPO formerly involved in PIPRA and CGIAR). Personal communication. 2010.

[25] Joel West, Presentation to the University of California, Haas School of Business (September 24, 2009) citing other sources available at http://openinnovation.haas.berkeley.edu/speaker_series/OISS_Sep_14_2009.pdf.

[26] Much of the analysis in this section on economic theories of innovation is based on an excellent paper by the US based Information Technology and Innovation Foundation by Atkinson and Hackler, "Economic Doctrines and Approaches to Climate Change Policy," (ITIF October 2010) available at http://www.itif.org/publications/economic-doctrines-and-approaches-climate-change-policy.pdf.

[27] Tim Worstall. "In Thrall to Some Long Dead Economist," (Oct 2008). http://www.adamsmith.org/blog/misc/in-thrall-to-some-long-dead-economist/.

[28] For example see:

- Global Climate Network, "Breaking Through on Climate: Overcoming the Barriers to the Development and Wide Deployment of Low-Carbon Technology" (July 2009). Available at http://www.globalclimatenetwork.info/publicationsandreports/publication.asp?id=680.
- Deutsche Bank Advisors, "Investing in Climate Change 2009: Necessity and Opportunity in Turbulent Times" (October 2008). Available at http://www.dbadvisors.com/deam/dyn/globalResearch/1113_index.jsp.

[29] Nicholas Stern, et al, "Stern review report on the economics of climate change," (HM Treasury, London UK: 2006), p393.

[30] Robert Atkinson and Darrene Hackler, "Economic Doctrines and Approaches to Climate Change Policy," (The Information Technology and Innovation Foundation: 2010), p7.

[31] Ibid, p8.

[32] New Growth International, "Science and Innovation for African Agricultural Value Chains: Lessons learned in transfer of technologies to smallholder farmers in sub-Saharan Africa," draft report prepared for Meridian Institute (July 2009), p. 3. Available at http://www.merid.org/value-chain-innovations/docs/Value_Chain_Innovations_-_Lessons_learned_091007.pdf.

[33] Rene Kemp, et al, "Analysis of Innovation Drivers and Barriers in Support of Better Policies: Economic and Market Intelligence on innovation," Innogrips (2011): at p87. Available at http://www.merit.unu.edu/archive/docs/hl/201104_INNOGRIP2_Report_v29B.pdf.

[34] Ibid, p98.

[35] Ibid.

[36]Rene Kemp, "The Dutch Energy Transition Approach," *International Economic Policy* (2010) 7:291-316.

[37] For more information on disruptive innovation see:

- Clayton Christensen, Heiner Baumann, Rudy Ruggles and Thomas Sadtler, "Disruptive Innovation for Social Change," *Harvard Business Review* (2006): 94-101.
- Website of Professor Christensen available at http://www.claytonchristensen.com/books.html.

[38] Clayton Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (New York: Harvard Business Review, 1997).

[39] Shuman Talukdar, Michael B. Horn, Rich Alton, and Clayton M. Christensen, "Winning and Losing Bets on Green Technologies" (April 28, 2010). Available at SSRN: http://ssrn.com/abstract=1597315.

[40] Ibid., p. 8.

[41] Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, p. 174-175.

[42] Andrea Fosfuri and Thomas Ronde, "Leveraging Resistance to Change and the Skunk Works Model of Innovation," Center for Industrial Economics Discussion Papers (Copenhagen, Denmark: University of Copenhagen, 2007) 10:9, 11.

[43]Jeffrey R. Immelt, Vijay Govindarajan, and Chris Trimble, "How GE is Disrupting Itself," *Harvard Business Review* (October, 2009).

[44] *The Economist*, "The World Turned Upside Down," (April 15, 2010). http://www.economist.com/node/15879369.

[45] Matthew J. Eyring, Mark W. Johnson, and Hari Nair, "New Business Models in Emerging Markets," *Harvard Business Review* (January – February 2011).

[46] Pew Charitable Trusts, "Who's Winning the Clean Energy Race," A G-20 Fact Sheet on Clean Energy Investment (2010). Available at http://www.pewglobalwarming.org/cleanenergyeconomy/pdf/PewG-20Report.pdf.

[47] Lewis Milford, et al. Accelerated Climate Technology Innovation Initiative (ACT II): A New Distributed Strategy to Reform the U.S. Energy Innovation System." Clean Energy Group and Meridian Institute. November 2009. Available at http://www.cleanegroup.org/assets/Uploads/2011-Files/Reports/ACTIIReportFinalNovember2009.pdf

[48] Chesbrough, *Open Innovation: The new imperative for creating and profiting from technology*, p xxiv.

[49] "Literature Review of Innovation Prizes and Their use for Social/Development Objectives." Enquiry No. A0396 (DEW Point, 2010).

[50] Ibid, at 2.

[51] Ibid, citing Adler, "Eyes on a Climate Prize: Rewarding Energy Innovation to Achieve Climate Stabilization," *Harvard Environmental Law review* (2010).

[52] Heike Mayer, "Catching Up, The Role of State Science and Technology Policy in Open Innovation," *Economic Development Quarterly* (2010) 24(3) 195–209.

[53] K.R. Lakhani and J.A. Panetta, "The Principles of Distributed Innovation" (MIT Press, 2007), p2.

[54] Christensen and Lundsten, "Saving the Climate is Saving the Business – Aligning Sustainable and Open Innovation," *Innovation Management* (April 7, 2010). Available at http://www.innovationmanagement.se/2010/04/12/saving-the-climate-is-saving-the-business-aligning-sustainable-and-open-innovation/.

[55] For more information on open and distributed innovation see:

- Thomas Malone and Mark Klein, "Harnessing Collective Intelligence to Address Climate Change," *Innovations* vol. 2, no. 3 (2007), p15-26.
- Diego Rodriguez and Doug Solomon, "Leadership and Innovation in a Networked World," *Innovations* vol. 2, no. 3 (2007), p3-13.
- Philip Evans and Bob Wolf, "Collaboration Rules," *Harvard Business Review* vol. 83, no. 7 (2005), p96-104.

- Alan MacCormack, Theodore Forbath, Peter Brooks and Patrick Kalaher, "Innovation through Global Collaboration: A New Source of Competitive Advantage," *Harvard Business Review* (2007).
- Steven Eppinger, "Innovation at the Speed of Information," *Harvard Business Review* vol. 79, no. 1 (2001), p149-158.
- Larry Huston and Nabil Sakkab, "Connect and Develop: Inside Proctor and Gamble's New Model for Innovation," *Harvard Business Review* vol. 83, no. 3 (2006), p53-66.
- William Taylor, "Here's an Idea: Let Everyone Have Ideas," *New York Times* (March 26, 2006).

For more information on how open and distributed innovation could be used to accelerate clean energy commercialization, see:

- Clean Energy Group and Meridian Institute, "Accelerated Climate Technology Innovation Initiative (ACT II): A New Distributed Strategy to Reform the US Energy Innovation System" (November 2009). Available at http://www.cleanegroup.org/Reports/ACTII_Report_Final_November2009.pdf.
- Hakkim and Heidrick, "Open Innovation in the Energy Sector," PICMET 2008 Proceedings, 27-31 (July 2008, Cape Town, South Africa), p565-571.

[56] Lakhani and Panetta, "The Principles of Distributed Innovation."

[57] Ibid, p15.

[58] Dr. Elias G. Carayannis and Vivienne W.L. Wang, "Innovation Networks and Clusters as Tech Transfer Catalysts and Accelerators," The George Washington University School of Business and Public Management, Department of Management Sciences (January 2004). Available at http://www.iamot.org/conference/index.php/ocs/4/paper/viewFile/570/85%20Pg%203

[59] Ibid, p5.

[60] For more information on the need for technology innovation that goes beyond reliance only on existing technologies, see a paper from Clean Energy Group and various citations that support the proposition. Clean Energy Group, "Crash Course for Copenhagen" (Dec. 2009). Available at http://www.cleanegroup.org/Reports/CEG_Climate_Course_Copenhagen_Dec2009.pdf.

[61] See *The Economist*, "First Break all the rules: The charms of frugal innovation," April 2010. http://www.economist.com/node/15879359 and *The Economist*, "Life should be cheap," January 2011. http://www.economist.com/node/17961922?story_id=17961922.

[62] CGIAR has been referenced as a model for climate technology centers by a number of individuals and organizations, for example:

- Delhi High Level Conference on "Climate Change: Technology Development and Transfer," Chair's summary (October, 2009). P 7 paragraphs 9 and 10.

Available at http://moef.nic.in/ downloads/public-information/Chair percent27s percent20summary-FINAL.pdf.

- World Bank, "World Development Report 2010: Development and climate change" (Washington, D.C.: International Bank for Reconstruction and Development/The World Bank, 2009) p306. Available at http://go.worldbank.org/FTD88BBDV0.
- Carlos M Correa, "Fostering the Development and Diffusion of Technologies for Climate Change: Lessons from the CGIAR Model," Programme on IPRs and Sustainable Development (ICTSD: December 2009). Available at http://ictsd.org/i/publications/66697/.

[63] Jonathan Wadsworth, (Senior Agricultural Research Adviser DFID). Personal communication. 2010.

[64] The 2008 Independent Review of the CGIAR System Synthesis Report provides an excellent overview of the CGIAR history at page 23. CGIAR Independent Review Panel. "Bringing Together the Best of Science and the Best of Development. Independent Review of the CGIAR System. Report to the Executive Council" (Washington, DC, 2008).

[65] See CGIAR website on impact, available at http://www.cgiar.org/impact/index.html and www.cgiar.org/pdf/pub_cg_corp_folder_inserts_IMPACT_10_09.pdf.

[66] CGIAR Independent Review Panel. "Bringing Together the Best of Science and the Best of Development. Independent Review of the CGIAR System. Report to the Executive Council; Synthesis Report" (Washington, DC, 2008), p1.

[67] CGIAR Independent Review Panel. "Bringing Together the Best of Science and the Best of Development. Independent Review of the CGIAR System. Report to the Executive Council; Technical Review" (Washington, DC, 2008). Available at http://www.cgiar.org/pdf/agm08/agm08_CGIAR-technical-report.pdf.

[68] CGIAR Change Steering Committee, "A revitalized CGIAR – a new way forward: the integrated reform proposal" (2008), p4. Available at http://www.cgiar.org/pdf/agm08/agm08_reform_proposal.pdf.

[69] This also addresses calls for donor harmonization in the Paris Declaration and Accra Agenda for Action.

[70] Wadsworth, (Senior Agricultural Research Adviser DFID). Personal communication. 2010.

[71] Todd Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[72] Laura Ivers, (Communications Director, CGIAR Secretariat). Personal communication. 2010.

[73] CGIAR Independent Review Panel, "Technical Report," p329.

[74] Wadsworth, (Senior Agricultural Research Adviser DFID). Personal communication. 2010.

[75] CGIAR Independent Review Panel, "Technical Report," p20.

[76] Ibid, p. 25.

[77] CGIAR Change Management Initiative at http://www.cgiar.org/pdf/pub_cg_corp_folder_inserts_change_10_09.pdf.

[78] CGIAR Independent Review Panel, "Technical Report," p184.

[79] Direct communication with Bruce Campbell, Executive Director of CCAFS. See also http://www.ccafs.cgiar.org/about.

[80] CGIAR Independent Review Panel, "Technical Report," p187.

[81] CGIAR Science Council Secretariat, "Report of the First External Review of the Generation Challenge Program," (2008), p. 5. Available at http://www.generationcp.org/UserFiles/File/Report-of-the-EPMR-to-the-GCP_March08.pdf.

[82] Ibid.

[83] The largest donors of the Challenge Programs have consistently included: the UK government, the USA, European Community, and the World Bank, all of which would also most likely be key funders for a climate change technology innovation initiative. From the program's inception in 2003 until 2007, the GCP has raised a total of more than US$67 Million from a diverse group of donors. The largest donor, the EC, has donated a total of US$29.5 Million (43.8 percent of the total), DFID has contributed US$18.9 Million (28.1 percent) and the World Bank has provided 11.8 Million US$ (17.5 percent). The remaining GCP donors are the Bill and Melinda Gates Foundation, the Rockefeller Foundation, the Swiss Government, SIDA, the Pioneer Fund, the Austrian Government and the Syngenta Foundation. From CGIAR Science Council Secretariat, "Report of the First External Review of the Generation Challenge Program" (March 2008).

[84] CGIAR, "MTP Overview," p14. http://cgmap.cgiar.org/docsRepository/documents/MTPProjects/2011-2013/GCP_2011-2013_OVERVIEW.PDF.

[85] A list of current GCP partners (over 200) is available at http://www.generationcp.org/gcppartners.php?da=0646141#nars.

[86] CGIAR Science Council Secretariat, "Report of the First External Review of the Generation Challenge Program" (March 2008), p35.

[87] Jonathan Woolley, (CPWF), Jean-Marcel Ribaut (GCP), Howarth Bouis (HarvestPlus) and Adewale Adekunle (SSA-CP), "The CGIAR's Challenge Program Experiences: A Critical Analysis," (6 February 2009), p6. This document has been prepared by staff of the four Challenge Programs (CPs) established by the CGIAR in 2002-2004 as a

contribution to the first meeting of the Consortium Planning Team (CPT) with the Alliance Executive and Deputy Executive (17-20 February 2009).

[88] CGIAR Science Council Secretariat, "Report of the First External Review of the Generation Challenge Program" (March 2008), p A-1.

[89] TheoVan Hintum, (Former Interim Director of the Generation Challenge Program.) Personal communication. 2010.

[90] Ibid.

[91] Barbara Harris, (University of Oxford.) Personal communication. 2010.

[92] Ivers, (Communications Director, CGIAR Secretariat). Personal communication. 2010.

[93] Ibid.

[94] Wadsworth, (Senior Agricultural Research Adviser DFID). Personal communication. 2010.

[95] Ibid.

[96] M.A. Palenberg, "Cross-cutting Observations based on the Review of Three CGIAR Challenge Programs." Munich, April 2008. (Munich, Germany: Institute for Development Strategy, 2008).

[97] Ibid.

[98] Jonathan Woolley, (CPWF), Jean-Marcel Ribaut (GCP), Howarth Bouis (HarvestPlus) and Adewale Adekunle (SSA-CP), "The CGIAR's Challenge Program Experiences: A Critical Analysis," (6 February 2009), p6.

[99] Ibid, p6.

[100] Carlton Evans, (Policy and Programme Manager Global Funds and DFIs Department, UK DFID.) Personal communication. 2010.

[101] Andrew Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study," (January 2006), p18. Available at http://siteresources.worldbank.org/INTHIVAIDS/Resources/375798-1103037153392/GFWBReportFinalVersion.pdf.

[102] Keith Bezanson, "Replenishing the Global Fund: An Independent Assessment," (Global Fund: 2005), p10. Available at http://www.theglobalfund.org/documents/publications/replenishment/assessment_report_en.pdf

[103] Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study," p. 20.

[104] The ratios of staff to resources managed still compare favorably to other development financing institutions see Bezanson, Keith, "Replenishing the Global Fund: An

Independent Assessment," (Global Fund: 2005), p23. Available at http://www.theglobalfund.org/documents/replenishment/2010/Agenda_More_Efficient_and_Effective_Global_Fund_en.pdf.

[105] The Global Fund closely monitors and evaluates the impacts of its grants, however, the programs are developed and implemented by in-country groups, called Country Coordinating Mechanisms, which are made up of government agencies, Non-Governmental Organizations, local community organizations, and the private sector.

[106] Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study," p 22.

[107] See AVERT.org at http://www.avert.org/global-fund.htm.

[108] The Global Fund. "Global Fund Grants - Summary Report" (April 2010). Available at http://web.theglobalfund.org/TGFWebReports3/ReportOutput.jsp?chartId=SummaryReport.

[109] The Global Fund, "Innovation and Impact 2010," (2010). Available at http://www.theglobalfund.org/documents/replenishment/2010/Global_Fund_2010_Innovation_and_Impact_en.pdf.

[110] Global Fund Press Release, "2.8 million people on AIDS treatment through Global Fund investments" (2010, 8th June). Available at http://www.theglobalfund.org/en/pressreleases/?pr=pr_100608.

[111] See http://www.theglobalfund.org/en/performancebasedfunding/.

[112] Global Fund Performance Based Funding Brochure http://www.theglobalfund.org/documents/performance/Performance-based_Funding_brochure.pdf.

[113] Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study," p23.

[114] R. Brugha, and G. Walt, "A global health fund: a leap of faith?" *BMJ* (Published 21 July 2001) 323:152-154.

[115] See Global AIDS Alliance website http://www.globalaidsalliance.org/index.php/29.

[116] Other AIDS related organizations have also developed innovative financing programs, such as UNITAIDs funding from air traffic charges and GAVI Alliance's (a public-private partnership that funnels money towards vaccines for neglected diseases in the poor world) which has raised more than $1 billion in short-term financing by issuing bonds backed by sovereign pledges of aid money in future years.

[117] Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study."

[118] Ibid, p. 19.

[119] The Global Fund, "Innovation and Impact 2010," (2010), p. 5.

[120] See Global Fund website http://www.theglobalfund.org/en/procurement/vpp/.

[121] Shakow, "Global Fund - World Bank HIV/AIDS Programs Comparative Advantage Study," p. 22.

[122] C. Evans, (Policy and Programme Manager Global Funds and DFIs Department, UK DFID.) Personal communication. 2010.

[123] Ibid.

[124] Andrew Jack, "Global disease fund fails to hit target." *Financial Times* (October 5, 2010).

[125] Talea Miller, "Global Fund Defends Corruption Practices," PBS Reports (January 27, 2011). Available at http://www.pbs.org/newshour/rundown/2011/01/global-fund-responds-to-corruption-reports.html.

[126] Helen Evans, (GAVI Alliance formerly Deputy Executive Director of the Global Fund). Personal communication. 2010.

[127] Ibid.

[128] Enrico Mollica, (Global Fund Executive Office). Personal communication. 2010.

[129] H. Evans, (GAVI Alliance formerly Deputy Executive Director of the Global Fund). Personal communication. 2010.

[130] Mollica, (Global Fund Executive Office). Personal communication. 2010.

[131]C. Evans, (Policy and Programme Manager Global Funds and DFIs Department, UK DFID.) Personal communication. 2010.

[132] Ibid.

[133] Charles Weiss, William B. Bonvillian, *Structuring an Energy Technology Revolution* (Cambridge: MIT Press, 2009). p34.

[134] Ekine, *SMS Uprising: Mobile Activism in Africa*, (Oxford: Pambazuka Press, 2010), p2.

[135] Rates exceeding 100 percent of the population implies that in some countries in the developing world some people have multiple phones. Source: Sokari Ekine. *SMS Uprising: Mobile Activism in Africa* (Oxford: Pambazuka Press, 2010). p2.

[136] James E. Katz, *Handbook of Mobile Communication Studies* (Cambridge: MIT Press, 2008). p22.

[137] Ibid.

[138] Ibid. p16.

[139] Ibid. p23.

[140] de Bruijn, Nyamnjoh, and Brinkman, *Mobile Phones: The New Talking Drums of Everyday Africa*, p11.

[141] Lighting Africa, "Solar Lighting for the Base of the Pyramid- Overview of an Emerging Market (Washington: International Finance Corporation, 2010). p58.

[142] de Bruijn, Nyamnjoh, and Brinkman, *Mobile Phones: The New Talking Drums of Everyday Africa*. p11.

[143] Mobile phone market penetration in Africa (total/by country), accessed 3/21/2011 from the Wireless Intelligence Database; retrieved by GSMA for the purpose of this report

[144] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy* , p xix.

[145] Ibid.

[146] Ibid, p xviii.

[147] Ibid.

[148] Ibid.

[149] Ibid, p. xxiv.

[150] Ibid, p. xvii.

[151] Ibid.

[152] Ibid, p. xxxv .

[153] Grameen Phone Ownership Structure, available at www.grameenphone.com/about-us/corporate-information/ownership-structure (Feb 2011).

[154] Ibid.

[155] Ibid.

[156] Ibid.

[157] Ibid.

[158] Ibid.

[159] Ibid.

[160] Grameen Phone Corporate Information/ Corporate Governance Structure, available at www.grameenphone.com/about-us/corporate-information/corporate-governance.

[161] As early as 1991, MTN proposed to state-owned Telkom that they jointly develop GSM service for South Africa but their offer was immediately refused. A year later, a group commissioned by the Department of Posts and Telecommunications recommended that the government issue 2 licenses, starting with Telkom. Again M-Net approached Telkom with an offer to collaborate but Telkom wanted to retain control over the telecom sector and thus claimed it was already working on rolling out a national GSM network (albeit very slowly). With the change in balance of power after Nelson Mandela's release, Nthato Motlana, the chairman of NAIL (New Africa Investments Limited) lobbied the African National Congress (ANC) for 9 months until he won the battle for the second license tender. MTN won the license and became the first private company to sell mobile communications service in South Africa. After building out their communications network, MTN started offering its first service to South Africans in 1994. Within 6 months MTN had matched and then surpassed Vodacom's subscribers (Telkom's cellular subsidiary). MTN's subscriber rates took off after that, taking advantage of "first-mover" opportunity entering new regions and quickly securing 80 percent of subscribers.

Another "communications for the masses" visionary and engineer by western training, native Strive Masiyiwa proposed a joint public – private cellular venture to state owned Posts and Telecommunications Corporation (similar to MTN's proposal to Telkom.) Also like MTN he was flatly rejected. Masiyiwa took PTC to the Supreme Court and won, resulting in the first tender for a private cellular license in Zimbabwe. Also like in South Africa, state-owned PTC had started service through its company – NetOne – but market penetration was extremely low. The private company Telcel won the first license in Zimbabwe but violated tender specifications so was revoked and the license granted to Masiyiwa who started the venture Econet. Source: Sullivan, Nicholas P. *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy* (San Francisco: John Wiley & Sons, 2007).

[162] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy*, p113

[163] Ibid, p123.

[164] Ibid, p xxiv

[165] Ibid, p xxvi

[166] Ibid.

[167] GSM Association home page— organization description, available at www.gsmworld.com/about-us/index.htm.

[168] GSM Association About Us- Organizational History, available at http://www.gsmworld.com/about-us/history.htm.

[169] Jesse Moore, (Former GSMA employee). Personal communication. 2010.

[170] David Taverner, (GSMA). Personal communication, 2010.

[171] Ibid.

[172] Ibid.

[173] Weiss and Bonvillan, *Structuring an Energy Technology Revolution* (Cambridge: MIT Press, 2009). p34.

[174] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy*. p xxxiv.

[175] Ibid, p162.

[176] C.K. Prahalad. *The Fortune at the Bottom of the Pyramid: Eradicating poverty through profits* (Upper Saddle River, NJ: Wharton School of Publishing, 2005). p xlviii.

[177] Reuters. "Cell Phone Boom in Rural Africa: Companies adapt to emerging market — sell short airtime, shared phones."

[178] Erying, Johnson, and Nair, "New Business Models in Emerging Markets," *Harvard Business Review* (January 2011- February 2011).

[179] Mobile phone market penetration in Africa (total/by country), accessed 3/21/2011 from the Wireless Intelligence Database; retrieved by GSMA for the purpose of this report.

[180] Ibid.

[181] International Telecommunications Union (ITU), *No end in Sight for Africa's mobile telephone boom.* Available at http://www.itu.int/en/pages/default.aspx.

[182] Charles Weiss, William B. Bonvillan, *Structuring an Energy Technology Revolution* (Cambridge: MIT Press, 2009). p221.

[183] Sokari Ekine, *SMS Uprising: Mobile Activism in Africa*, p2.

[184] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy*, p. 127.

[185] M-PESA market penetration data accessed 3/21/2011 from the GSMA MMU (Mobile Money for the Unbanked) program; retrieved by GSMA for the purpose of this report.

[186] Erying, Johnson, and Nair, "New Business Models in Emerging Markets."

[187] Ibid.

[188] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy*. p125.

[189] de Bruijn, Nyamnjoh, and Brinkman. *Mobile Phones: The New Talking Drums of Everyday Africa*, p147.

[190] Russell Southward, *Less Walk More Talk: How Celtel and the Mobile Phone Changed Africa* (West Sussex, UK: John Wiley & Sons, 2008). p40.

[191] de Bruijn, Nyamnjoh, and Brinkman. *Mobile Phones: The New Talking Drums of Everyday Africa,* p147.

[192] Southward, *Less Walk More Talk: How Celtel and the Mobile Phone Changed Africa,* p40.

[193] Erying, Johnson, and Nair, "New Business Models in Emerging Markets."

[194] Ibid.

[195] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy,* p56.

[196] Erying, Johnson, and Nair, "New Business Models in Emerging Markets."

[197] Ling, Rich, Jonathan Donner. *Mobile Communication: Digital Media and Society Series* (Cambridge: Polity Press, 2010). p45.

[198] Erying, Johnson and Nair, "New Business Models in Emerging Markets.

[199] Southward, *Less Walk More Talk: How Celtel and the Mobile Phone Changed Africa,* p 43.

[200] Reuters, "Cell Phone Boom in Rural Africa: Companies adapt to emerging market — sell short airtime, shared phones."

[201]Ling and Donner, *Mobile Communication: Digital Media and Society Series,* p45.

[202] Ibid.

[203] Southward, *Less Walk More Talk: How Celtel and the Mobile Phone Changed Africa,* p42.

[204] Ling and Donner, *Mobile Communication: Digital Media and Society Series,* p xi.

[205] Reuters, "Cell Phone Boom in Rural Africa: Companies adapt to emerging market — sell short airtime, shared phones."

[206] Elizabeth Rosenthal, "African Huts Far From the Grid Glow With Renewable Power," *New York Times,* December 24, 2010, available at http://www.nytimes.com/2010/12/25/science/earth/25fossil.html.

[207] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy,* p. xxxiv.

[208] Ibid, p xxxii.

[209] Ling and Donner, *Mobile Communication: Digital Media and Society Series*, p.66-70.

[210] Southward, *Less Walk More Talk: How Celtel and the Mobile Phone Changed Africa*, p. xv.

[211] Weiss, Charles, William B. Bonvillan, W. *Structuring an Energy Technology Revolution* (Cambridge: MIT Press, 2009). p14.

[212] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy,* p.145.

[213] C. Martin Webber and Patrick Labaste, "Building Competitiveness in Africa's Agriculture: A Guide to Value Chain Concepts and Applications, (Washington DC: The World Bank, 2010).

[214] Ibid.

[215] Ibid.

[216] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009) available at http://sites.merid.org/value-chain-innovations/docs/Value_Chain_Innovations_-_Lessons_learned_091007.pdf .

[217] Ibid.

[218] Meridian Institute, "Post-Harvest Technology Commercialization Initiative-Innovations for Agricultural Value Chains in Africa," (Concept Note, 2010). Available at http://sites.merid.org/value-chain-innovations/docs/PH_Commercialization_Initiative_-_Concept_Note.pdf.

[219] Webber and Labaste, "Building Competitiveness in Africa's Agriculture: A Guide to Value Chain Concepts and Applications."

[220] A "value chain" describes the full range of value-adding activities required to bring a product or service through the different phases of production, including procurement of raw materials and other inputs, assembly, physical transformation, acquisition of required services such as transport or cooling, and ultimately response to consumer demand. (Source: C. Martin Webber and Patrick Labaste, "Building Competitiveness in Africa's Agriculture: A Guide to Value Chain Concepts and Applications, (Washington DC: The World Bank, 2010).

[221] Meridian Institute, "Post-Harvest Technology Commercialization Initiative-Innovations for Agricultural Value Chains in Africa," (Concept Note, 2010)

[222] Ibid.

[223] Specifically targeting farmers that earn $1-2 dollars per day.

[224] Jessica Morey, "Linking International Experts Solves Local Agriculture Challenges-Collaborative project focuses on removing market barriers in Africa." (Washington: Bureau of International Information Programs, U.S. Department of State, 2010). Available at http://www.america.gov/st/energy-english/2010/August/20100823155626aynos0.3994563.html.

[225] Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[226] Meridian Institute, "Innovations for Agricultural Value Chains in Africa: Applying Science and Technology to Enhance Cassava, Dairy, and Maize Value Chains," (project description). Available at http://sites.merid.org/value-chain-innovations/project.html.

[227] Ibid.

[228] Meridian Institute, "Innovations for Agricultural Value Chains in Africa: Applying Science and Technology to Enhance Cassava, Dairy, and Maize Value Chains."

[229] Ibid.

[230] Ibid.

[231] Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[232] Robert Adams, (Agricultural Value Chain Project Participant). Personal communication. 2010.

[233] Meridian Institute, "Post-Harvest Technology Commercialization Initiative- Innovations for Agricultural Value Chains in Africa."

[234] Meridian Institute, "Innovations for Agricultural Value Chains in Africa: Applying Science and Technology to Enhance Cassava, Dairy, and Maize Value Chains."

[235] Ibid.

[236] Meridian Institute, "Post-Harvest Technology Commercialization Initiative- Innovations for Agricultural Value Chains in Africa."

[237] "The 'champion' is linked to a specific technology that is being commercialized. In the case of our diagnostic tools, for example, the champion would be Diagnostics for All and Iddex. For the maize container, it would be Kentainers (the private company that would commercialize the product). The entity (independent or housed elsewhere) plays the early stage role of maturing the concept (if the concept is in its early stages); this may include identification of a champion if that wasn't clear from the outset" (Todd Barker, Meridian Institute).

[238] Meridian Institute, "Post-Harvest Technology Commercialization Initiative- Innovations for Agricultural Value Chains in Africa."

[239] Ibid.

[240] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[241] Dr. Moses Kizza Musaazi, (Agricultural Value Chain Project Participant). 2010.

[242] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[243]"African Biotechnology Stakeholders Forum." Available at www.absfafrica.org/index.php?option=com_content&view=article&id=11:capacitytcbanana&catid=1:capbuld&Itemid=3.

[244] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa."

[245] Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[246] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa."

[247] Musaazi, (Agricultural Value Chain Project Participant). 2010.

[248] Meridian Institute, "About Us" (Organization description). Available at www.merid.org/About.aspx.

[249] Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[250] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa."

[251] Ibid.

[252] Ibid.

[253] *Gari* is a granulated cassava product. It is the most widely processed product due to ease of transport and storability (long shelf-life). It is processed through peeling, grating, water expressing, and toasting of freshly harvested cassava.

[254] The replacement of hand grating with the mechanized grater is thought to have halved the cost of *gari* production, from 51 days of labor to prepare a ton of *gar*i to 24 days. (Source: New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[255] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[256] Musaazi, (Agricultural Value Chain Project Participant). 2010.

[257] Ibid.

[258] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[259] Barker, (Partner, Meridian Institute, facilitated Generation Challenge Program). Personal communication. 2010.

[260] Weiss, Charles and William B. Bonvillan, W. *Structuring an Energy Technology Revolution* (Cambridge: MIT Press, 2009). p1.

[261] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[262] Meridian Institute, "Post-Harvest Technology Commercialization Initiative - Innovations for Agricultural Value Chains in Africa," (Concept Note, 2010).

[263] New Growth International, "Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa," (Draft Report Prepared for Meridian Institute, 2009).

[264] Ibid.

[265] Ibid.

[266] Ibid.

[267] "Global Access in Action." Available at http://globalaccessinaction.org/.

[268] "Global Access to Technology for Development," Available at http://www.gatd.org/.

[269] Lawrence Kent, (agriculture program officer with the Gates Foundation). Personal communication. January 27, 2011.

[270] Ibid.

[271] Dr. Sara Boettinger, (Managing Director of PIPRA). Personal communication. October 19, 2010.

[272] "PIPRA," Available at www.pipra.org.

[273] Ibid.

[274] Ibid.

[275] Ibid.

[276] Ibid.

[277] Ibid.

[278] Kent, (agriculture program officer with the Gates Foundation). Personal communication. January 27, 2011.

[279] Ibid.

[280] Ibid.

[281] Mission statement of "Global Access in Action." Available at http://globalaccessinaction.org/.

[282] Ibid.

[283] Ibid, 4.

[284] Jill Panetta, Ph.D., (Consultant). Personal Communication, November 2010. InnoCentive boasted a 30 percent solution rate when initially focused on chemistry problems; this figure is quite high compared to a 10 percent lab solution rate. The InnoCentive website currently posts a 50 percent solution rate, but there is no research into the effectiveness of the solutions.

[285] Ibid. Whereas InnoCentive applies a broad diversity of disciplines to each problem, PD2 only involves exerts from within a range of scientific disciplines, i.e. chemistry, biotech, engineering, etc.

[286] "Morgan Stanley Analysts Review Drug Stocks, Upgrading AstraZeneca." (January 2010). Available at http://www.thepharmaletter.com/file/22189/morgan-stanley-analysts-review-drug-stocks-upgrading-astrazeneca.html.

[287] Gardiner Harris, "Federal Research Center Will Help Develop Medicines." *New York Times*, January 22, 2011.

[288] George Michael, *Fast Innovation* (McGraw Hill, 2005).

[289] Harris, "Federal Research Center Will Help Develop Medicines."

[290] Thomas Senderovitz, "How Open Innovation Could Reinvigorate the Pharmaceutical Industry with Fresh R&D Opportunities." *Expert Rev. Clin. Pharmacol.* 2 (6) (2009): 585-587.

[291] Michael, *Fast Innovation*.

[292] "Interview with Dr. Alan D. Palkowitz.," Available at http://www.innovate1st-str.com/newsletter/january2010/AlanPalkowitz.pdf (January 2010).

[293] "InnoCentive Facts and Stats." Available at https://www.innocentive.com/about-innocentive/facts-stats (2011).

[294] Panetta, (Consultant). Personal Communication, November 2010. It was thought that a large firm would not be likely to accept a worthy solution if the solution were submitted by, for example, an undergraduate student.

[295] "Innovation Inside Out." Available at http://www.computerworld.com/s/article/print/95854/Innovation_inside_out (September 2004).

[296] Cornelia Dean, "If You Have a Problem, Ask Everyone." *New York Times*, January 22, 2008.

[297] Clean Energy Group and Meridian Institute, "Accelerated Climate Technology Initiative (ACT II): A New Distributed Strategy to Reform the U.S. Energy Innovation System" (2009).

[298] Panetta, (Consultant). Personal Communication, 2008.

[299] Ibid.

[300] Conversations on the Cutting Edge, Interview with Dr. Alan D. Palkowitz. Available at www.innovate1st.com.

[301] Ibid.

[302] Lilly tests each submitted compound and prepares a data report with a complete biological profile of the compound.

[303] Conversations on the Cutting Edge, Interview with Dr. Alan D. Palkowitz. Available at www.innovate1st.com.

[304] "Lilly Offers "Free" Assays." Available at http://www.the-scientist.com/blog/display/55763/ (June 2009).

[305] Panetta, (Consultant). Personal Communication, November 2010.

[306] Ibid.

[307] Cheri Grace, "Product Development Partnerships (PDPs): Lessons from PDPs established to develop new health technologies for neglected diseases," DFID Human Development Resource Centre (June 2010), p. 2. Available at http://www.dfid.gov.uk/Documents/publications1/hdrc/lssns-pdps-estb-dev-new-hlth-tech-negl-diseases.pdf.

[308] M. Moran, et al, "The Role of Product Development Partnerships in research and development for neglected diseases," *International Health*, Volume 2, Issue 2, Pgs.114-122 (June 2010).

[309] Grace, "Product Development Partnerships (PDPs): Lessons from PDPs established to develop new health technologies for neglected diseases," p. 3.

[310] http://www.bvgh.org/News/BVGH-News/Press-Releases/Article-16-August-2010.aspx

[311] Grace, "Product Development Partnerships (PDPs): Lessons from PDPs established to develop new health technologies for neglected diseases," DFID Human Development Resource Centre (June 2010), p.6.

[312] Ibid, p. 6.

[313] Ibid, p. 5.

[314] Ibid, pgs. 7-8.

[315] Ibid, p. 4.

[316] Moran, et al, "The Role of Product Development Partnerships in research and development for neglected diseases."

[317] M. Moran et al. "The New Landscape of Neglected Disease Drug Development" Pharmacetical R&D Policy Project, Wellcome Trust, London School of Economics (2005). Available at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_publishing_group/documents/web_document/wtx026592.pdf.

[318] Kathy Hudson, "Biotech in Northeast Ohio Conference: The Human Genome Project: A Public Good," *Health Matrix* 12 (367) (2002).

[319] The SNP Consortium is an international collaboration of pharmaceutical companies and the UK's Wellcome Trust. Research occurs at public laboratories like Stanford University and the Sanger Centre. The Mouse Sequencing Consortium is a public-private-government-academic consortium. The International Genomics Consortium is another private-public partnership focused on obtaining gene expression data on cancer samples.

[320] The DOE (and its predecessor agencies) were charged with studying the effects of radiation and energy production on genes after the atomic bomb was developed and deployed. The DOE was interested in developing methods to detect changes to genetic material and in the 1980s, the idea to sequence the human genome to serve as a reference point was developed. Available at http://www.ornl.gov/sci/techresources/Human_Genome/publicat/judges/drell.html

[321] Ari Patrinos and Daniel W. Drell, "Introducing the Human Genome Project: Its Relevance, Triumphs, and Challenges," *ABA Judges' Journal* 36 (3) (1997).

[322] "Exuberant Innovation: The Human Genome Project." Available at http://arxiv.org/ftp/arxiv/papers/1003/1003.2882.pdf (March 2010). Ari Patrinos directed research at the DOE's Human Genome Program, while Francis Collins directed the NIH's National Human Genome Research Institute.

[323]Leslie Roberts, "Controversial From the Start," *Science* 291 (5507) (2001): 1182-1188.

[324] Whole-genome shotgun sequencing entails sequencing small segments of DNA and then assembling the small segments into a continuous sequence. The technology allows many sequences to be read in a short amount of time, but since the sequences are spliced together, accuracy is usually lower than sequencing long strands.

[325] "Testimony on the Human Genome Project: How Private Sector Developments Affect the Government Program." (June 1998). Available at http://www.hhs.gov/asl/testify/t980617a.html

[326] Francis Collins and others, "New Goals for the U.S. Human Genome Project: 1998-2003," *Science* 282 (5389) (1998): 682-689.

[327]"Testimony on the Human Genome Project: How Private Sector Developments Affect the Government Program."

[328] "Human Genome Research Sites." Available at http://www.ornl.gov/sci/techresources/Human_Genome/research/centers.shtml and "International Human Genome Sequencing Consortium," available at http://www.genome.gov/11006939. Research centers include the U.S. DOE, U.S. NIH, and the Wellcome Trust.

[329] "The Department of Energy and the Human Genome Project Fact Sheet." Available at http://www.ornl.gov/sci/techresources/Human_Genome/project/whydoe.shtml#whydoe. The DOE is charged with studying and analyzing genome structure – specifically genetic damage and the consequences of genetic mutations, especially those caused by radiation and chemical by-products of energy production. The DOE felt that a reference sequence was the best way to analyze these effects.

[330] "Human Genome Project Budget." Available at http://www.ornl.gov/sci/techresources/Human_Genome/project/budget.shtml.The HGP cost approximately $3 billion over a 13-year period and included a variety of scientific activities related to genomics such as the development of new technologies for biomedical research, computational methods, and human genome sequencing.

[331] "The Human Genome Project Completion: Frequently Asked Questions." Available at http://www.genome.gov/11006943. This figure only represents U.S. investment into the HGP; it does not account for funds contributed by the Wellcome Center or other research centers.

[332] Wellcome Trust Sanger Institute, "Celebrating a Decade of Discovery Since the Human Genome Project".

[333] Leslie Roberts and others, "A History of the Human Genome Project." *Science* 291 (5507) (2001): 1195.

[334] "Leading Scientist Searches for New Frontiers." Available at http://www.china.org.cn/english/scitech/140631.htm.

[335] Volker Lehmann and Antje Lorch, "The Race for the Human Genome," *Biotechnology and Development Monitor* N 40 (1999): 6-9.

[336] Eight years into the project, the NIH and DOE recognized that their Project's organizational structure was not the most efficient. Research centers were setting their own priorities, working on different organisms, and recording data in dissimilar formats. They quickly restructured once Celera announced its intention to sequence the human genome faster and more efficiently than the HGP.

[337] Roberts and others, "A History of the Human Genome Project."

[338] "The History of Hugo: The Human Genome Organisation." Available at http://www.hugo-international.org/abt_history.php.

[339] Roberts and others, "A History of the Human Genome Project."

[340] "Exuberant Innovation: The Human Genome Project."

[341] Ibid.

[342] Minna Allarakhia, "Open Source Biopharmaceutical Innovation: A Mode of Entry for Firms in Emerging Markets," *Journal of Business Chemistry* 6 (1) (2009): 11-30.

[343] Ibid.

[344] For example, BioPerl is an open source software tool that facilitated the interchange of data amongst the global laboratories (who mostly kept their data in dissimilar formats). BioPerl existed prior to the HGP, but it provided crucial support to the HGP when it provided computer support and databasing services to all the affiliated laboratories and created a software system to be used by the entire genome community.

[345] Gudmundur A. Thorisson and Lincoln D. Stein, "The SNP Consortium Website: Past, Present and Future," *Nucleic Acid Research* 31 (1) (2003): 124-127.

[346]Ten pharmaceutical companies were involved including AstraZeneca, Aventis Pharma, Bayer AG, Bristol-Myers Squibb Company, Roche, Novartis, and Pfizer.

[347] "The SNP Consortium Reaches Agreement with Celera Genomics and Applied Biosystems to Construct Genome-Wide SNP Linkage Map." Available at http://cmbi.bjmu.edu.cn/news/0108/316.htm.

[348] Matthew Herper and Robert Langreth, "Biology Goes Open Source," *Forbes*, February 12, 2007.

[349] Gardiner Harris, "Federal Research Center Will Help Develop Medicines," *The New York Times*, January 22, 2011.

[350] Leslie Roberts, "Controversial from the Start," *Science*, February 16, 2001. Vol. 291 no. 5507 pp. 1182-1188.

[351] "Testimony on the Human Genome Project: How Private Sector Developments Affect the Government Program." For example, the isolation of a gene for Parkinson's disease showed that changes in DNA can cause Parkinson's in some families.

[352] To clarify, raw data is to be kept publically available, but patents on gene sequences are acceptable.

[353] "The Human Genome Project: A Decade of Accomplishments: 1993-2003." Available at http://www.libraryindex.com/pages/2256/Human-Genome-Project-DECADE-ACCOMPLISHMENTS-1993-2003.html.

[354] "The Department of Energy and the Human Genome Project Fact Sheet." Available at http://www.ornl.gov/sci/techresources/Human_Genome/project/whydoe.shtml.

[355] "NIH Fact Sheet: Human Genome Project," available at http://www.nih.gov/about/researchresultsforthepublic/HumanGenomeProject.pdf .

[356]"Study Reveals Genetic Link To Infectious Disease Susceptibility." Available at http://www.eurekalert.org/pub_releases/2010-05/wt-srg051810.php (May 2010).

[357] "Sematech Facing Cut." *The New York Times*. February 20. Available at http://www.nytimes.com/1988/02/20/business/SEMATECH-facing-cut.html?src=pm.

[358] SEMATECH. Available at http://www.SEMATECH.org/.

[359] SEMATECH. "Annual Report." 2009.Albany, NY. Available at http://www.SEMATECH.org/corporate/annual/annual09.pdf.

[360] Jesse Jenkins, Devon Swezey, and Yael Borofsky, "Where Good Technologies Come From: Case Studies in American Innovation.," Oakland: Breakthrough Institute. 2010.

[361] Douglas A. Irwin and Peter J. Klenow, "Sematech: Purpose and Performance," 1996. Available at http://www.pnas.org/content/93/23/12739.full.

[362] SEMATECH, "Annual Report."

[363] Ibid.

[364]Silicon Valley Technology Center. Available at http://www.svtc.com/.

[365] "Fact Sheet," Silicon Valley Technology Center. Available at http://www.svtc.com/about-svtc/fact-sheet.

[366] Ibid.

[367] Douglas A. Irwin and Peter J. Klenow, "Sematech: Purpose and Performance."

[368] Ibid.

[369] Larry D. Browning and Judy C. Shelter, "Sematech: Saving the U.S. Semiconductor Industry." (College Station: Texas A&M University Press, 2000). Available at http://www.hbs.edu/bhr/archives/bookreviews/76/2002springadavies.pdf.

[370] Ibid.

[371] Panetta, (Consultant). Personal Communication, November 2010.

[372] Sullivan, *You Can Hear Me Now: How Microloans and Cell Phones are Connecting the World's Poor to the Global Economy, p.* xxvi.

[373] Ibid.

[374] Ibid. p. xxi.

[375] Ahmed Abdel Latif, (Programme Manager for Intellectual Property and Technology at the International Centre for Trade and Sustainable Development, or ICTSD). Available at http://ictsd.org/i/trade-and-sustainable-development-agenda/98857/.

[376] New Growth International, "*Science and Innovation for African Agricultural Value Chains- Lessons learned in transfer of technologies to smallholder farmers in Sub-Saharan Africa*," Draft Report Prepared for Meridian Institute (2009).

# APPENDIX 1

**International Climate Innovation Initiative**
**Interviews List**
2/3/2011

**Technology and Innovation Experts:**

- Shane Tomlinson -- E3G's Director of Development
- Cath Bremner- COO Australian Carbon Trust, formerly of the UK Carbon Trust
- Andrew Higham, UNFCCC Secretariat leading the technology workstream.
- Prof Ambuj Sagar - Indian Institute of Technology, Delhi
- Anthony Lambkin- Infodev Climate Innovation Centers
- Patrick Avato, IFC lead of Lighting Africa program
- Drew Nelson, US Lead Negotiator on Climate Technology Mechanism
- Ajay Mathur, India Lead Negotiator on Climate Technology
- Kunihiko Shimada, Japanese Lead Negotiator on Climate Technology
- Matthew Kennedy, Ireland Lead Negotiator on Climate Technology
- Jim Watson, Director SPRU
- Dr. Rene Kemp- Professorial fellow at UNU-MERIT and Professor of Innovation and Sustainable Development at ICIS, Maastricht University
- Rich Alton - General Management Fellow at the Harvard Business School Forum for Growth and Innovation
- Chris Trimble, Adjunct Associate Professor of Business Administration, Tuck Executive Education at Dartmouth
- Nambi Arivudai, Project Director [Climate Change], M.S. Swaminathan Research Foundation, India
- Henry Chesbrough- Berkeley University Business School author of "Open Innovation" – requested
- Ahmed Abdel Latif- International Centre for Trade and Sustainable Development, Egypt

**CGIAR**

- Professor Barbara Harris, University of Oxford
- Laura Ivers, Communications Team Leader, CGIAR secretariat
- Jonathan Wadsworth, DFID
- Todd Barker, Meridian Institute, managed GCP program
- Theo Van Hintum, Program Manager Generation Challenge Program
- Jean-Marcel Ribaut, Director of the Generation Challenge Programme
- Bruce Campbell, Director Climate Change, Agriculture and Food Security CG Research Program

**Global Fund**

- Carlton P Evans, Global Funds and DFIs Department, DFID
- Helen Evans, GAVI Alliance formerly Deputy Executive Director of the Global Fund
- Jacqueline Wittebrood, Communications Focal Point, Developed Country NGO Delegation to the Global Fund Board
- Enrico Mollica, Global Fund Executive Office

**Mobile Phones**

- Dave Taverner, GSMA. Senior Programme Manager for the Green Power for Mobile (GPM) programme.
- Chris Locke, Managing Director of the Development Fund at GSMA.
- Jesse Moore, formerly with GSMA, now collaborating with M-PESA.
- Arata Onoguchi, IFC- ICT industry specialist- leading the Green Power for Mobile (GPM) project with GSMA on behalf of the ICT dept. TBD

**Innovation in Agricultural Value Chains**

- Robert (Bob Adams), Principal, Robert Adams Consulting, USA
- Dr. Moses Kizza Musaazi, Consultant to the project; Team Leader Technology for Tomorrow (T4T); Team Leader & Coordinator PISAT; Senior Lecturer Makerere University
- Todd Barker, Meridian Institute, Project Lead

**PIPRA**

- Dr. Sara Boettiger, Director of Strategic Planning and Development at PIPRA
- Anatole Krattiger, WIPO formerly involved in PIPRA and CGIAR
- Lawrence Kent, Gates Foundation, Agricultural Development
- J. Tohme client of PIPRA's, CIAT - requested

**Eli Lilly and InnoCentive**

- Dr. Jill Panetta—Co-founder and former Chief Science Officer of InnoCentive; Distributed Innovation Consultant
- Dr. Alan Palkowitz, Vice President, Discovery Chemistry Research & Technologies, Eli Lilly & Company.
- Denys Resnick, Director of Strategic Programs, Nine Sigma

**Human Genome Project**

- Dr. Ari Patrinos—formerly with DOE Human Genome Project
- Prof. John Sulston- formerly with the Sanger Institute, which worked on HGP
- Dr. Ronald Davis—director of the Stanford Human Genome Center
- Dr. David Lipman, Director, National Center for Biotechnology Information at the NIH

**CAMBIA**

- Richard Jefferson—Cambia CEO

**Product Development Partnerships**

- Saul Walker, DFID