

# The Role of Science Technology and Innovation in Socio-economic Development of Ghana – Linking Research to the private sector at the CSIR-Technology Transfer and Development Centre (TDTC)

Wilhelmina Quaye, George Owusu Essegbey, Edward Decker and Justina A. Onumah

Council for Science and Industrial Research, Accra, Ghana

## Abstract

This paper addresses the issue of linking Research and Development (R&D) to Private Sector's technological needs for business growth and socio-economic development of the Ghanaian economy. Using the concept of transitioning technologies and services from the research laboratories to the marketplace, the Council for Scientific and Industrial Research – Technology Development and Transfer Centre (CSIR-TDTC) has been instituted to strengthen the linkage between Research and the Private Sector. The CSIR-TDTC intervention strategies involve capacity building of researchers to effectively develop and transfer the much needed technologies for private sector growth, creation of platforms for research-industry interactions and development of effective research-industry partnerships among others. Numerous challenges constraining technology transfer to the private sector in Ghana are identified. These challenges are categorized as structural and funding challenges, inefficiencies in the research management systems, challenges on the part of the research scientists as well as challenges relating to policy issues that need to be addressed by the government. Despite these challenges, this paper concludes that industry is looking for much riper technological solutions and therefore research scientists should embark on initiatives to bring promising technologies and innovations to the point that they could be considered for buy-in by industry.

**Keywords:** *technology, development, transfer and industry*

## 1. Introduction

Linking local research to the private sector needs has become crucial for a nation's building and socio-economic development. This has been demonstrated globally where scientific communities create a network of business support providers including incubators, co-working spaces and training centres that reach out to local businesses and share ideas to grow existing businesses as well as create new business opportunities (Dirk 2014, Hall et al 2014, Howard et al 2014, Keith and Toole 2014). For example, Kaufmann and Todtling (2001) observed that crossing the business border to science increases the diversity of firms' innovation partners and respective innovation stimuli which, in turn, improves the capability of firms to introduce more advanced innovations. R&D investments are positively associated with innovation, and eventually innovation into economic growth given the right enablers (Stephen and Rosenberg 1986; Cohen et al 2002; Mowery et al 2003; Bilbao-Osori and Rodriguez-Pose, 2004). There are arguments that the unavailability of the necessary enablers and conditions to strengthen R&D systems cast doubts about the possible returns on R&D investments and that diffusion of technological spillovers particularly to industry take some time. Therefore developing countries need to develop the necessary capabilities and conditions to be able to exploit technology to their own advantage (Fagerberg et al 2010). Effective Technology development and transfer to the private sector is capital intensive and

need to be rooted in market impacts, capacity building and backed by policy (Bozeman 2000).

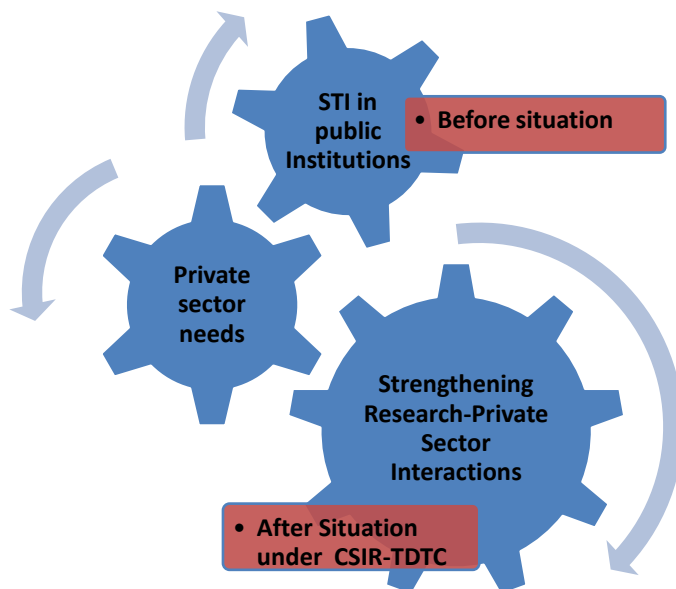
As an emerging economy, Ghana cannot continue to depend on STI outputs from the developed world when the nation can build the capacity of local STI institutions to provide tailor made solutions to its technological needs. It is in the light of this that the Council for Science and Industrial Research (CSIR) has established the Technology Development and Transfer Centre (TDTC) to strengthen the linkage between research and the private sector. Key activities being implemented under the TDTC include (i) establishing a private-sector oriented program based on institutional incentive schemes that encourage scientists to respond effectively to the technology demand from the private sector, (ii) implementing a structured model for engaging the private sector in partnerships for technology development and transfer, (iii) building the capacity of researchers to effectively transfer technology, and (iv) creating a platform for intensive research-industry interaction including organization of technology fairs, business meetings and online discussions via a dedicated website.

Technology transfer which is the process of transitioning technologies and services from the research laboratories to the marketplace is important in facilitating the creation of businesses. The technology transfer process ensures that scientific and technological developments are accessible to a wide range of users including both

the public and private sectors of the economy. The CSIR-TDTC concept presents an interlocking flow of research ideas from Research and Private sector effective interactions as pictured in Figure 1. The CSIR-TDTC envisions becoming a centre of

excellence that uses the transforming power of Science, Technology and Innovation (STI) for wealth creation through effective linkages between Research and the Private Sector.

### Bridging the gap between Research and the Private Sector



**Figure 1: Pictorial Representation of CSIR-TDTC concept**

The CSIR-TDTC bridging the gap between research and private sector concept also promotes research-industry partnerships through a competitive grant scheme. Here some enterprises are identified for technology/innovation transfer through a competitive grant scheme. This helps to solve the problem of the lack of appropriate start-up capital for initiating the process of technology transfer and commercialization particularly dealing with the risk of investing in new technologies and innovations.

Given the above overview of the technology development and transfer to the private sector, this paper attempts to identify the challenges limiting technology transfer to the private sector and draws experiences from the CSIR-TDTC for enhanced technology development and transfer to the private sector that can result into business growth in Ghana.

#### 1.1 Study objectives

The objectives of this paper are as follows:

- To establish the capacity needs of research scientists with respect to technology development and transfer;
- To identify challenges limiting technology transfer to the private sector;

- To establish the institutional level enablers that support technology transfer to the private sector; and
- To make recommendations for enhanced technology development and transfer system.

#### 2. Methodology

Two methodological approaches were used in this study. Firstly, to address the core objectives of this paper a needs assessment survey was conducted. A total of 40 researchers and some key staff of the commercialization divisions of selected CSIR-institutions were purposely selected for capacity needs assessment survey. These CSIR-institutes surveyed include the Animal Research Institute (ARI), Food Research Institute (FRI), Institute of Industrial Research (IIR) and Water Research Institute (WRI) all located in Accra. Others are Forestry Research Institute of Ghana (FORIG), Crops Research Institute (CRI) and Building and Road Research Institute (BRRI) located in Kumasi.

A questionnaire was designed for one-on-one interviews with Research Scientists and selected staff of the commercialization division of the various institutes. Questions asked were both closed and open ended. Themes covered in the structured questionnaire include the following:

- A. Background Profile
- B. Individual Level Capacity Needs Assessment
- C. Institutional level information on technologies developed and transferred
- D. Challenges limiting technology transfer to the private sector

A likert scale (Agree Strongly =1, Agree Moderately =2, Agree Slightly =3, Disagree Slightly = 4 and Disagree = 5) was used to rate respondent knowledge/capacity in the areas including (i) Technology Dissemination and Methodologies (ii) Managing technology transfers to the private sector (iii) Technology Marketing (iv) Technology Partnerships;(v) Collaboration Agreements and Technology licensing; and (vi) Research Proposal development that involves technology transfer to the private sector.

Secondly, participatory observation was done and TDTC project documents were reviewed in order to draw experiences on success and challenges.

### 3. Results

This section presents results of the capacity needs assessment survey that address the main

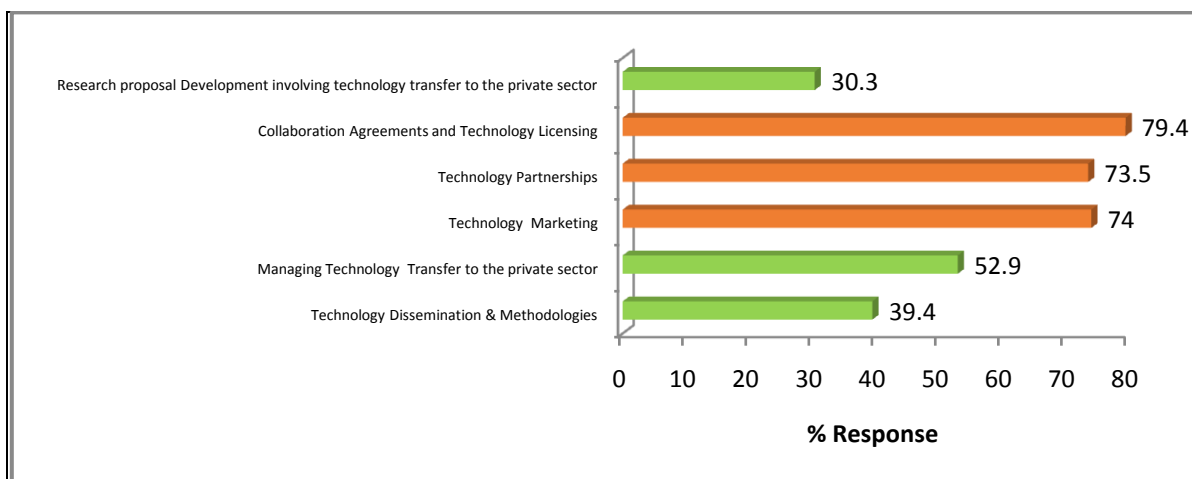
objectives of this paper. In addition some efforts and experiences drawn from the CSIR-TDTC project in bridging the gap between research and industry are shared.

#### 3.1 Capacity needs assessment survey results

Survey findings revealed that majority of researchers in CSIR Institutes interviewed had MPhil/MSc and PhD qualifications in their various field of specialization. This depicts evidence of highly technically qualified staff. Majority of the research scientists had over 10 years' experience in research at the time of the survey. However, the academic training received did not cover topics in technology transfer and marketing skills that specifically address the research-private sector linkages. Using the likert scale rating, Table 1 shows that researchers interviewed moderately agreed that they had acquired substantial formal training in Technology Dissemination & Methodologies and Proposal Writing Skills. Undoubtedly, skills in Technology Marketing, Technology Partnerships, as well as Collaboration Agreements and Technology licensing were lacking. This result also reflected in Figure 2 showing the critical technology transfer capacity needs by the researchers interviewed.

**Table 1: Capacity Needs Assessment of Researchers Interviewed**

Statement	Sample (N)	1=Agree Strongly, 2= Agree Moderately, 3=Agree Slightly, 4 =Disagree Slightly, 5= Disagree		Ranking in descending order of importance
		Mean	Std. Deviation	
You have adequate Knowledge in Technology Dissemination & Methodologies	39	2.18	1.023	1
You have adequate Knowledge in Research proposal Development involving technology transfer to the private sector	38	2.46	1.047	2
You have adequate Knowledge in Managing Technology Transfers	39	2.67	1.108	3
You have adequate knowledge in Technology Marketing	39	2.87	1.080	4
You have adequate Knowledge in Technology Partnerships	39	2.95	1.012	5
You have adequate Knowledge in Collaboration Agreements and Technology Licensing	39	3.46	1.189	6



**Figure 2 Critical capacity need areas of respondents**

Traditionally, researchers interviewed did not perceive technology transfer to the private sector as a core mandate. Capacity and Skills in Technology Marketing, Technology Partnerships, as well as Collaboration Agreements and Technology licensing were lacking. The Needs Assessment Survey therefore concludes that these limiting areas (Marketing, Technology Partnerships, as well as Collaboration Agreements and Technology) need to be strengthened in the capacity building programme under CSIR-TDTC project. Asked to mention other specific training needs that were not covered above, respondents expressed interests in various marketing, negotiation and communication skills required for effective technology transfer to the private sector. Suggested areas of training needs of CSIR Research Scientists enumerated by respondents are listed below:

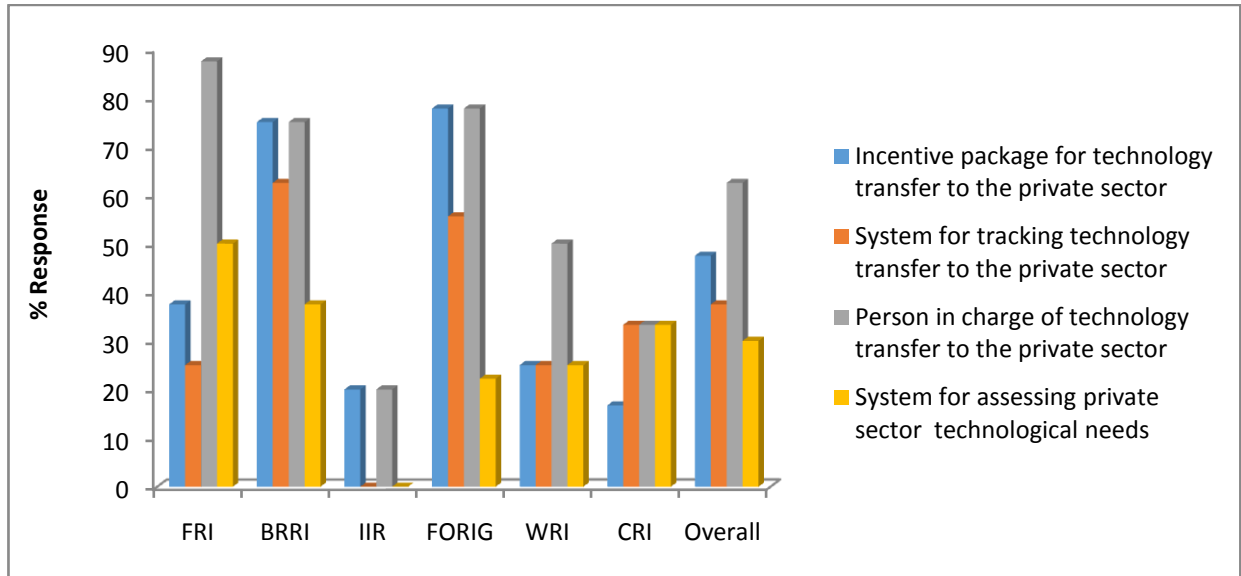
- Comprehensive Technology Evaluation, Profitability Analysis & Other Investment decision tools;
- Techno-Business Spin-Offs and Business Strategies;
- Negotiating, Lobbying & Communication Skills;
- Pricing of Technology;
- Packaging technologies for transfer to the private sector;
- How to investigate the needs of the private sector and identification of marketable technologies;
- Sharing lessons on pilot studies of technology transfer;
- Strategies for Identification of Private Sector Entrepreneurs;
- Forming consortium with the private sector and developing proposals with them;
- Exposure to demand driven research programme; and
- Building business relationships.

### 3.1.1 Institutional level enablers

The survey also sought to establish the existence or otherwise of push factors that incentivize researchers to develop marketable technologies and transfer to the private sector. Platforms for research-private sector interactions were non-existence at the institutional levels except for few CSIR-institutes. For instance CSIR-FORIG and CSIR-BRRI conducted stakeholder workshops that encouraged research-industry engagements. CSIR-FRI also had a strong linkage with the food industry players through analytical service provision.

Respondents were asked whether their various institutes have a system for tracking and evaluating technology transfer and diffusion to the private sector. Again, respondents were asked whether their various institutes have a system for assessing private sector technological needs. Responses to these questions are presented in Figure 3. Survey results revealed weak institutional framework to assess technological needs of the private sector. Tracking of performance of technologies was lacking. Incentive packages for technology transfer to the private sector were not very clear and some researcher could not tell if incentive packages like hunters fee for consultancies were effective.

According to the respondents, the Commercial and Information Divisions of the various institutes have marketing officers but their responsibilities are tied to production and sale of research by-products. Information flow from the Commercialization Divisions of the various CSIR institutes to core research for technology transfer to the private sectors was limited. This was also evidenced in responses to the number of technologies developed at the institutional level. Majority of the respondents felt that information on technologies developed by the institutes could only be obtained from management.



**Figure 3: Enabling systems for research-private sector linkages at the institutional level**

### 3.1.2 Perceptions

The survey also sought to elicit ideas and perceptions about research-private sector linkages among Researcher Scientists. Research Scientists interviewed perceived investment in R&D as the responsibility of the central government. However, given the dwindling funding trend for R&D activities, researchers are being challenged to push R&D outputs to the marketplace. Again, the private sector entrepreneurs are usually unable to afford the cost of technologies that could enhance their businesses. Successful public-private partnerships require clear mechanisms for the allocation of costs and benefits among actors. Specific perceptions among respondents are listed below:

- R&D investment is the responsibility of Ghana Government;
- The CSIR mandate does not encourage research-private sector partnerships for profits;
- Contract farming is not encouraged in Ghana;
- The private sector cannot pay for the actual cost of research;
- Existing Commercialization strategies only encourages production of research by-products;
- Some CSIR institutes are closely linked to the private due to the nature of their activities;
- Crops Research Institute conducts research on public goods. Donor funded projects cannot be commercialized if not enshrined in the contract terms; and
- Technology transfer to the private sector is not valued much as compared to publications in the CSIR promotional criteria.

### 3.1.3 Challenges limiting technology transfer to the private sector

There are numerous challenges constraining technology transfer to the private sector in Ghana. The challenges can be categorized as structural and funding challenges, inefficiencies in the management systems, challenges on the part of the research scientists as well as challenges relating to policy issues that need to be addressed by the government. Some of these challenges mentioned by respondents are listed below.

#### Structural and Funding Challenges

- Weak R&D infrastructure and inadequate facilities;
- CSIR-Institutes lack the infrastructural capacity to compete with foreign institutions in developing and transferring technologies to the private sector;
- Lack of the state of the art equipment that will leverage research into areas of key interest to the private sector;
- Lack of funds for developing technologies tailored to the private sector;
- Lack of platforms for research-private sector interactions; and
- The private sector has inadequate incentives to invest in research.

#### Challenges with the Research Management System

- Lack of motivation for technology transfer to the private sector;
- Lack of institutional system to track technological needs of the private sector;
- Lack of personal and logistics for technology marketing;



- Technically half-baked technologies which are not fully ready for entrepreneurial purchase;
- Unwillingness on the part of the private sector to pay for cost of R&D activities
- Lack of information and knowledge on the capability of CSIR-Institutes

#### Challenges linked to Researchers

- Inadequate techno-commercial evaluation of technologies developed;
- Lack of training by research scientists in communication skills especially to effectively transfer technologies to the private sector;
- Researchers do not have time to play marketing roles;
- Lack of awareness creation of technologies developed;
- Difficulty in developing marketable technologies;
- Lack of marketing capacity on the side of researchers;
- Limited scale of production making technologies too costly;
- Competition from foreign technologies and other service providers; and
- Lack of human capacity that understand the need for technological upgrade and willingness to pay for such technologies;

### **3.2 Capacity building of research scientists**

Based on findings from the Capacity Needs Assessment Survey, research scientists were trained to build their capacities in technology marketing and technology partnerships, collaboration agreements and technology licensing as well as managing technology transfers. Under the CSIR-TDTC project, over 60 research scientists from CSIR Institutes have been trained. Research scientists were drawn from CSIR Institutes including Animal Research Institute (ARI), Food Research Institute (FRI), Institute of Industrial Research (IIR), Water Research Institute (WRI), Forestry Research Institute of Ghana (FORIG), Crops Research Institute (CRI), Science and Technology Policy Research Institute (STEPRI) and Building and Road Research Institute (BRRI). Resource Persons with adequate experience in the subjects of technology marketing and technology partnerships, collaboration agreements and technology licensing were used as course instructors for the training workshops. The research scientists had opportunity of hands-on-practical demonstrations using the well-designed training

modules for applications on technology transfer strategies.

### **3.3 Business seminars and technology fairs**

The CSIR-TDTC bridging the gap between research and private sector concept creates technology and innovation sharing platforms for research-industry/private sector interactions. This ensures responsive research, improved knowledge transfer, and increased private sector in R&D investments. Business Seminars are organised to stimulate interests of entrepreneurs in the innovations developed by the CSIR-Institutes and some concrete follow up actions agreed to by the researchers and the entrepreneurs. In such business seminars, entrepreneurs are also sensitized on the value and applicability of CSIR technologies and their knowledge enhanced on the technology and innovation opportunities available in the research system. The business seminars are enriched with the participation and presentations by financial operators such as the Venture Capital Fund as well as institutions interested in scaling up of local businesses. In one of the business Seminars, representatives from Stanford University were invited to share their experiences with scaling up businesses through the innovation systems.

### **3.4 Technology profiling and competitive grant scheme**

All marketable technologies developed by the participating CSIR Institutes in the TDTC project have been screened and profiled. The Technology Profiling activity is to support the promotion and transfer of already developed marketable technologies with substantial benefits to the private sector as well as catalyze the development of demand driven research that ultimately results into commercial products and services. Technology Profiling covers a detailed description of each marketable technology that has been developed by CSIR Institutes participating in the CSIR-TDTC project. The detailed technology description consists of innovation characteristics, how the technology works, resources required for the adoption and utilization of the innovation, dissemination strategies, end-users or targeted clients. Table 2 presents an overview of some technologies developed by the CSIR-Institutes surveyed, their clients or target markets and type of information package available to influence decisions by private sector on investment in R&D outputs.

**Table 2: Overview of some marketable technologies, type of information available for decision making on technology adoption**

Institute	Technologies	Clients	Type of Information given to entrepreneurs
CSIR-Industrial Research Institute	Biogas technology Single/Twin hybrid energy saving stoves Integrated cassava processing plants Extraction of 5-Hydroxytryptophan (5-HTP) from Griffonia simplicifolia seeds Mechanised palm kernel shell separator	Bioresources International Ankaful Maximum Security Prisons Jonny's Food and Meat Complex Slaughter House East Gonja District Assembly Other District Assemblies Pusiga Weavers Association	Performance Indicators Technical and Financial Feasibility Technical and Commercial information Information on possible local raw materials, production process and product characterization
CSIR-Food Research Institute	High Quality Cassava Flour (HQCF) processing Choco-Peanut processing High Quality Yam Flour (HQYF) Rice based products for diabetics Mushroom Production Development of different substrate from Agricultural Waste	Bakers Group-Hohoe Suhum Bakers Association Francis Farm-Accra Goshenland Entreprises Kharis Foods Company Limited ELSA Foods Ebenuts Limited Dodo Foods BAMAF Industries Neat Foods Ghana Samba Foods Limited	User friendly information Demonstrations Technical Information Training and backstopping Information on nutritional and medicinal benefits Set-up cost Pricing Profitability Analysis
CSIR-Water Research Institute	Fish feed formulation Brood stock production & management Fingerling production Diagnostic markers for infectious diseases Production of Tilapia in small cages/Cage farming Polyculture Integrated aquaculture agriculture Rainwater harvesting Investigations into groundwater contamination with petroleum products	West Africa Fisheries Tropo Farms Crystal lake Gynae farms Kuma Farms MOH GHS EPA WRC	Benefits of the technology Cost effectiveness Ease of use of technology Climate Change adaptation
CSIR-Building and Road Research Institute	Pozzolana mix Anti-Termite Treatment Extract from local plants Fast-Track Construction Techniques Fired clay Products Mosquito-Control Fired Clay Soak-away Stones Construction Cost Indices Building Codes for Ghana Bamboo as Trusses	Pozzolana Ghana Limited Mining Companies (AGC) Municipal and District Assemblies Ministries Building and Road Contractors Institute of Surveyors Ghana High Way Authority WANCHIN Infrastructural Engineering Association of small scale contractors	Complete investment package (Profitability Analysis, Availability of raw materials, Market Research Information) TV Documentary Radio Discussions Business Seminars Flyers Manuals Brochures
CSIR-Forestry Research Institute of Ghana	Techniques for the production of improved seeds and seedlings Mixed plantation strategies to reduce pest outbreak in plantations Customized wood identification system for submerged timber trees Techniques for processing and utilization of lesser-used timber species Certification for treated electricity poles Techniques for bamboo and rattan Identification and cultivation Cassava Flour as plywood adhesive mix extender Production of prekese syrup Mushroom cultivation In-situ treatment of utility poles to extend service life Rural-based non-pressure wood/ bamboo preservation technology	Forestry Commission Mining Sector Timber Industry Private Plantation Developers International Tropical Timber Organisation Mushroom farmer DUPAUL Busi Stevensons	Advert/Promotions Flyers Radio Announcement Stakeholder Meetings Fact Sheet/Handouts Farmer fields demonstrations Contract Data Specifications
CSIR-Crops Research Institute	Improved cowpea varieties Improved soyabean varieties Improved maize varieties Improved rice varieties Improved agronomic techniques for plantain Improved pepper varieties Organic and inorganic fertilizer rates for citrus Improved varieties of groundnuts	Farmers and Farmer Groups Seed Dealers (Antika Seed, Agri-Commercial Services, M&B Seeds, Mabert Seed Company, Heritage Seeds, Premium Foods and Meridian Seeds) Rural Innovation Consult Guinness Ghana Limited Ayensu Starch Caltech NGOs (ADRA, World Vision, TechnoServe) Rice Mills Wienco YARA (Fertilizer formulations) MIDA Consultancies	Field Demonstrations Yield Potential of improved varieties Nutritional Benefits Presentations Evaluation Reports Inputs Requirements

#### 4. Discussion and conclusions

From the literature, institutional partnerships for public–private research collaboration are growing in the United States and other developed countries (Keith and Toole 2014). But the same cannot be said about developing countries. Developing countries need to develop the necessary capabilities and conditions to be able to exploit technology to their own advantage (Fagerberg et al 2010). There seems to be a capacity gap in transforming research results into forms that can be easily adopted by industry. Given the fact that research and development outputs or technologies developed by R&D institutions must address private sector needs and challenges and ultimately enhance productivity, Capacity Needs Assessment Survey was conducted in this research and findings used to develop training modules for capacity building activities under the CSIR-TDTC project. The Technology Development and Transfer training package focused on creating improved and upgrading competences in Technology Marketing, Technology Partnerships, as well as Collaboration Agreements and Technology licensing. From the Capacity need Assessment Survey, other areas that need attention include Technology Packaging, Pricing, Negotiation and Communication Skills required for effective technology transfer to the private sector.

A close examination of the challenges limiting technology development and transfer identified in this research suggests that building the capacities of researchers alone is not adequate. To effectively transfer technologies to the private sector, structural and funding challenges, inefficiencies in research management, and challenges relating to policy need to be addressed. According to Henry and Loet (2000), the Triple Helix of University/Research-Industry – Government relations will be needed to handle challenges limiting technology development and transfer to the private sector. Effective Technology development and transfer to the private sector is capital intensive and need to be rooted in market impacts, capacity building and backed by policy (Bozeman 2000). This also implies that the technology needs of the private sector have to be regularly assessed in order to inform researchers as well as policy decisions by government. Both researchers and policy makers need to have in-depth knowledge about the industry level of technology and innovative readiness as done in developed economies.

Under the CSIR-TDTC project, technologies developed by participating CSIR institutes have been profiled, R&D Strategic Plan developed, a Competitive Grant Scheme launched and a website ([www.csir-tdtc.org](http://www.csir-tdtc.org)) created for research–industry interactions. To ensure effective tracking of project performance, the CSIR-TDTC has a strong Monitoring and Evaluation component with clearly

spelt out indicators at output, immediate and intermediate outcome levels, as well as ultimate outcomes that impact on the project beneficiaries. Project sustainability is ensured through institutionalization of incentives for outreach to the private sector and increasing revenues derived from contract work for external clients. Technology Development and Transfer to the private sector efforts need the cooperation of all relevant stakeholders, including local governments, institutions and development partners, NGOs, community organisations, commercial organisations and private entrepreneurs as well as the general public that constitute the bulk of the target market.

##### 4.1 Lessons learnt

- Industry is looking for much riper technologies that solve difficult to solve challenges and therefore research should embark on initiatives to bring promising technologies/innovations to the point that they could be considered for buy-in by industry.
- Researchers should collaborate with industries that are built around academic discoveries. Researcher must receive adequate education on business and entrepreneurship and technology marketing.
- There is the need to start bridging the research-industry gap with great science and great scientists who have good ideas, who can assess and evaluate economic impacts of transferring a particular technology to the industry. Select the right partner and firm up on contract terms that respect the integrity and commitment of all parties.
- Business Unusual – Researchers need to conduct research differently from the traditional thinking by not just doing things that are nice to do but rather things that must be done, look for not only good technology/innovation, but also the right scientists with business mind-sets. We should start thinking of researchers attached to industry to facilitate technology/innovation transfer to the industry.
- The scientist/researcher need to be extremely articulate about very technically detailed information, need to write in a way that can help the non-scientist understand what is being done, be persuasive to generate the much needed buy-in from industry and demonstrate good leadership skills.



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