Technological innovation in the value chain: A case study of soybean processing for food and wealth

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Small-scale food production and processing are the major sources of livelihoods for many rural communities in the developing world, yet the contribution of this sector to economic development of many countries has been ignored. A soybean for food and wealth project was used to demonstrate how the effective harnessing of different disciplines can lead to alleviation of poverty and improved nutritional status in rural communities. This was done by identifying the production and processing constraints of these communities and linking them to research and innovation centres. Their production, processing, and managerial capacities were enhanced through group formation activities, farm and field demonstrations, and facilitation of access to markets. The project demonstrates how food production, processing, and marketing can be improved through linkages between farmers/small-scale enterprises and technology centres. It highlights the need for a synergistic approach to reducing poverty and improving the wealth and health of rural communities.

Keywords: technology, soybeans, innovation, rural enterprises, wealth creation.

SMALL-SCALE ENTERPRISES (SSEs), especially those in food production and processing, form an important sector in most African economies. Studies by the Technology Consultancy Centre in Ghana indicated that over 70 per cent of businesses are in the informal sector (Oti-Boateng, 2009). Agricultural and non-agricultural microenterprises (MEs) and income-generating activities (IGAs) sustain the livelihoods of thousands of households and provide employment for a large proportion of income earners, especially women. However, most of these IGAs barely grow beyond the point of subsistence. Analysis of the problems facing SSEs indicated that most of these enterprises are

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rural or peri-urban, with limited access to farmland and basic infrastructure such as roads, potable water, electricity supplies, sanitation, waste disposal, and telecommunications networks.

Subsistence farmers and processors have limited access to new knowledge to improve productivity...

Over 90 per cent of these MEs are not registered with the government Registrar General's Department or with any trade associations, making it difficult to have any government intervention to improve services, or to form an advocacy group for capacity building. The majority of owners of MEs and IGAs have little or no education, poor techno-managerial capabilities, and poor linkages to financial and technological innovation systems. Subsistence farmers and processors also have limited access to new knowledge to improve productivity, despite much research in the areas of agriculture and manufacturing. The transfer of technology to this sector for the establishment of viable productive enterprises therefore requires a high sense of innovation and tact. This is particularly the case for those enterprises that require the use of intermediate or sophisticated technologies and access to larger markets (Oti-Boateng and Dawoe, 2006).

...there is a missing link with universities, research institutions and other knowledge producers

Upgrading the informal sector to enhance its global economic competitiveness through harnessing the innovative capability and capacity of the formal sector is imperative to Ghana's economic development. But there is a missing link between the informal sector, universities, research institutions and other knowledge producers in technology innovations, advocacy groups, financing agents, and the government. This disconnect has hampered the growth of all enterprises in this sector, from subsistence to SME levels. The deployment of science, technology, and innovation is crucial in realizing the potential of the informal sector to contribute effectively to sustainable national socio-economic development. Opportunities abound for this sector but a model is needed to maximize the effect of all actors.

Background

Recognizing the need to bridge this knowledge gap in order to improve productivity and create wealth, the Government of Ghana initiated the sector-specific Food Crops Development Project (FCDP), financed by an African Development Bank loan of US$13.6 m and a government contribution of $2.07 m for the period 2002–2007. The FCDP sought to improve linkages between research, agricultural extension, farmers, and the informal agricultural sector, and to create the opportunity for transformation of food crop production through harnessing science, technology, and innovation for sustainable development. The aim of the project was to increase the incomes and food security levels of smallholder farmers in eight districts of four regions in Ghana. This would be achieved through increased production and marketing of

cereals and legumes, especially the non-traditional soybean crop, as a source of health and wealth through the adoption of appropriate technologies developed by research. The objectives of the project were to:

- enhance the capacity of agricultural extension agents (AEAs) to train farmers in new technologies;
- enhance the technological capability of farmers through agricultural extension support;
- use group formation to build organizational and management capacity of farmer-based organizations to become cohesive, effective, and sustainable;
- equip farmer-based organizations with the knowledge and skills to access and effectively manage credit;
- build the capacity of farmers to develop strategies for business growth through value chain thinking (including agronomic practices, post-harvest handling, storage, marketing, and processing);
- increase the synergy between research, development, and innovation (through studies, research, and transfer);
- improve effective management, monitoring, and evaluation of AEAs; and
- make recommendations to stakeholders on good practices and opportunities for transforming IGAs into viable and internationally competitive industries.

The main beneficiaries were to be farmers and processors. The partner institutions comprised agricultural extension agents, Ministries of Food and Agriculture, Industry, and Finance, rural banks, research institutions, and the Kwame Nkrumah University of Science and Technology (KNUST). The Technology Consultancy Centre (TCC) of the College of Engineering at KNUST was invited as a partner with the specific role of developing a model for harnessing the potential of all partners, as well as producing prototype machinery for processing soybeans for household utilization and small-scale enterprise development.

KNUST had a specific role to develop a model for harnessing the potential of all partners

Approaches taken by TCC

TCC has 28 years' experience in research and development, technology transfer, and innovation. It developed a holistic approach that included market research, design, and development of prototype soybean processing machines for small-scale enterprises, capacity building of farmers in soybean processing, and a road map for transfer/adoption of the innovation. The FCDP complemented TCC's efforts through group formation, upgrading of technology in soybean

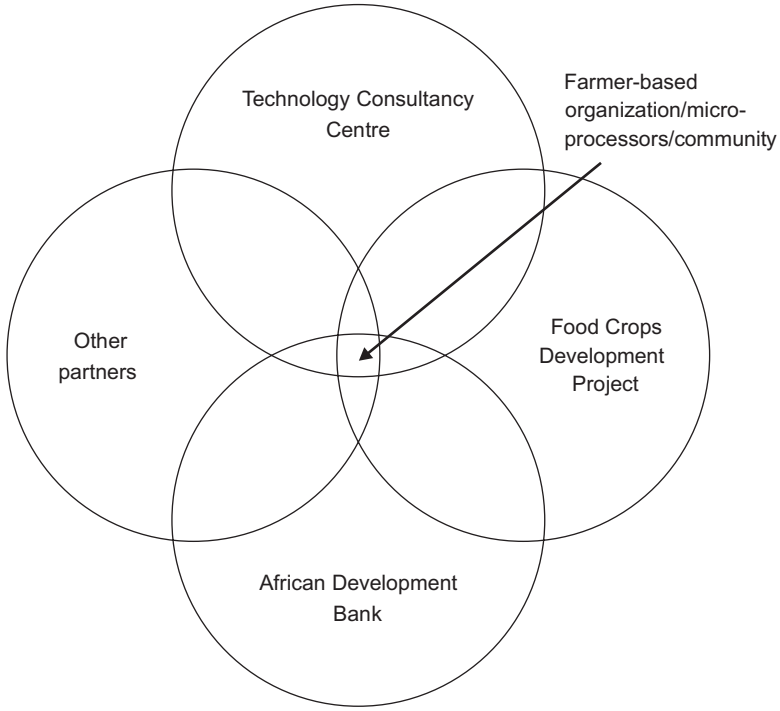

Figure 1. Synergy of partners in the TCC innovation model for soybean for food and wealth

production, training of rural banks in micro-financing, monitoring and evaluation, and ensuring synergy between the partners. These efforts culminated in the development of a model for innovation and transfer of soybean technology to informal communities described in Figure 1.

The TCC model

TCC constituted a multidisciplinary team comprising food technologists, engineers, planners, sociologists, and the community

TCC constituted a multidisciplinary team comprising food technologists, engineers, planners, sociologists, and the community. The TCC team worked in collaboration with all the actors in the project. It conducted a market research study into the feasibility of soybean utilization at household- and small-scale levels to improve food security and income of the informal agricultural sector. Additionally, TCC had the following objectives:

- Analyse the constraints and opportunities in soybean production and processing for sustainable economic development, to enable an informed decision on the effective promotion of this industry in Ghana.

- Design, develop and manufacture prototype processing machinery and equipment for soybean oil and soy flour products for both household and small-scale utilization, by adapting available technology, and working with MEs and SSEs to produce the equipment locally. The equipment development and prototype production first involved design and working drawings for each of the machines. The machines were produced and installed at the TCC Food Processing Unit, and tested for efficiency and performance before being transferred to the pilot community. Feedback from the users, mainly women's groups and small-scale entrepreneurs, was crucial in finalizing the prototype machines. The FCDP management team coordinated most of these activities.

Feedback from women's groups and small-scale entrepreneurs was crucial in finalizing prototype machines

- Formulate value-added soybean products to improve the nutritional status and socio-economic activities of rural households. This was essential for promoting local consumption of this non-traditional crop and reducing post-harvest losses. The work was done in collaboration with the Food Research Institute of the Council for Scientific and Industrial Research, the Nutrition Department of Ghana Health Service, and the Women in Agricultural Development Department of the Ministry of Food and Agriculture.
- Establish pilot processing enterprises for soybean flour, soya oil, and other soy products in three project districts to showcase the feasibility of small-scale processing facilities in soybean producing areas and to promote value-chain thinking. This was also used to evaluate the TCC model. The Agricultural Development Bank and other partners provided an assessment of the feasibility of this innovation.
- Train AEAs, Women in Agricultural Development staff, and farmers in soybean processing technologies. They would ultimately become advocates and transfer the TCC technology innovation to other communities.

On-site activities and field days made it easier for farmers and small-scale entrepreneurs to accept the model

Multidisciplinary and participatory approaches were used in the development of the model. Additionally, farm and equipment demonstrations and on-site activities including field days were held, which made it easier for farmers and small-scale entrepreneurs to accept the model.

Constraints of the TCC innovation model

The multidisciplinary team constituted by TCC identified the following constraints:

At national level:

- Although soybean can be grown in many parts of the country, its production is concentrated in three northern regions. An estimate of national production volumes was about 20,000 tons/year, which was insufficient to meet the production demands of local processors. To satisfy their requirements, SMEs often resorted to importation of soybean products from neighbouring countries and from overseas.
- Several macro- and micro-economic policies negatively affect the growth of agriculture enterprises and specifically the soybean industry. These include poor infrastructure, inadequate access to information and communications technologies, limited monetary and fiscal policies that are essential for the growth of micro and small enterprises and microfinance institutions, to name a few.
- Although attempts had been made by the government to increase soybean production and processing in the past, there were no policies to support these MEs and SMEs. Trade liberalization had seen the importation of cheap, low-quality soybean cake and soy products onto the Ghanaian market. This, in effect, caused the collapse of the soybean processing industry in the country.

Importation of cheap, low-quality soy products caused the collapse of soybean processing

At community and enterprise level:

- One of the main challenges was the limited science and technology culture at the community level. This impeded the ability of small-scale equipment producers to read working drawings and produce equipment to specification and, for soybean processors, to produce foods to international standards.
- There was limited availability, choice, and quality of materials for production of prototype machines. These technical and socio-economic constraints delayed the research, transfer, and innovation processes considerably.
- The four major factors hindering soybean production were agronomic, primary post-harvest processing equipment, access to timely credit, and markets. The challenges of equipment manufacturers and processors included availability of good quality raw material in sufficient quantity, access to credit, and obsolete processing equipment.
- Limited knowledge and capacity in the processing of soybean into other value-added products such as flour, oil, composite foods, soaps, etc. Small-scale production of soybean was also identified as a major constraint to the growth of the soybean industry.
- Owing to limited technological capacity and managerial skills, small enterprises were unable to take advantage of emerging global trends in doing business in local and export markets.

Technical and socio-economic constraints delayed the research, transfer and innovation processes considerably

Successes gained by the TCC through its model

Despite the constraints, appreciable successes were gained by the project: new varieties of soybean with the potential to increase yields were released by the Crops Research Institute and the Savanna Agricultural Institute of the Council for Scientific and Industrial Research. The new varieties (CRI-Nangbaar and CRI-Ahoto) have the potential to increase current production by 30 per cent (CRI, 2005) while varieties Jenguma and Quarshie also have the potential to reduce shattering and increase yields by 30 per cent (SARI, 2005) and hence make more raw materials available to processors (AfDB, 2005).

Processing skills enabled rural communities to increase their incomes

The technological capacity of rural communities in the project was enhanced by the processing skills imparted to them, which enabled them to increase their incomes. This supports recommendations made by Zoellick (2010) to invest along the food chain to increase agricultural productivity and production, which not only helps to alleviate hunger, but also contributes to overcoming poverty. New soybean recipes incorporated into local dishes were also introduced to farmers, and this had the potential to improve the nutritional status of farming families.

The most laudable success of the TCC model was the prototype production of 11 pieces of equipment, designed and manufactured for soybean oil or soy flour production at household or small-scale enterprise levels. The equipment was used by the Ministry of Food and Agriculture to establish a small-scale soybean flour and soya oil processing unit, managed by a women's group in a community in northern Ghana. These women were also trained in basic book-keeping, group dynamics, management skills, and conflict resolution. The transfer of knowledge acquired during the development and manufacturing of the prototype machinery also created opportunities for the establishment of small-scale manufacturing industries.

The African Development Bank assessed as very high the impacts of the Bank Group's assistance in the project using five evaluation criteria: relevance and quality at entry; achievement of development objectives and outputs (efficacy); efficiency of allocation and utilization of resources; institutional development impact; and sustainability of benefits and outcomes (AfDB, 2005). The TCC model was adapted in a subsequent Inland Valley Rice Development Project, financed by the African Development Bank in 2005. The major factors contributing to these successes were as follows:

- There was cooperation between the implementing agencies, and the accompanying capacity building through training, demonstrations, seminars, and workshops.
- A baseline survey provided insight into the three different soybean products, oil, flour, and soap, which were identified as

Prototype machines were based on household and small enterprise activities, with inputs from all partners

Soybean recipes were promoted using demonstrations at agricultural shows and publicized on radio and TV

the base products for a number of other secondary products. The development and prototype production of processing machines and equipment were based on the processing activities to make these products at both household and small enterprise levels, with inputs from all partners.

- Development of the selected equipment focused on new and/or modified equipment to suit the objectives and performance requirements of the project. A systematic approach was taken to bringing the equipment to the required standards before manufacture. This involved: 1) developing the methods for production; 2) determining the requirements of the equipment; 3) determining the specifications of materials and inputs to be purchased; and 4) deciding job requirements of workers.
- About 20 soybean recipes were formulated for household use to improve the nutritional status of vulnerable groups such as children, HIV/AIDS patients, and the elderly. These were promoted through exhibitions and demonstrations at national, regional, and community agricultural shows, and publicized through radio and TV talks.
- Government policies and initiatives in food production, processing, and marketing have been successful in linking all sectors of research and scientific and technological outputs. The pragmatic approach developed by the agricultural sector was useful in the success of the model for harnessing knowledge, whether it was generated through research or acquired through learning, and applied for production of goods, processes, or services.
- Regular monitoring and evaluation of the innovation process at each stage of development and implementation provided an opportunity to review the progress of activities and assess the impact of the model. It also offered TCC the opportunity to develop a model in terms of technology applications, applied research and transfer, and to identify and strengthen the means to address them. TCC benefited enormously from this synergy and partnership.

A summary of the prerequisites for a successful transfer of soybean technology for food, health, and wealth is therefore as follows:

A situational analysis or market research is needed to: 1) identify the constraints of farmers and communities; 2) identify constraints that hinder the growth of ventures and identify mechanisms that exist for acquisition of technological upgrading; 3) identify policies, practices, and strategies that can facilitate growth of these enterprises; and 4) identify possible partners to assist in making a difference.

This type of analysis not only serves to ascertain the feasibility of a technology, but it also serves as a baseline for monitoring and evaluating the progress and impact of the model. The second

prerequisite is the availability of strong, knowledge-based institutions that have experience in research, technology innovation, development, and transfer. These institutions must have entrepreneurship attributes and they must have the ability to take advantage of global economic trends. The third prerequisite is the availability of credit facilities, which are essential for production, processing, and marketing of products. Above all there is the need for a cohesive community-based group that shares the same aspirations and goals.

Conclusion

The TCC model has clearly demonstrated the importance of knowledge sharing and transfer through capacity building in both technical and managerial skills development for reducing poverty. Technology empowers people by allowing them to expand the choices in their daily lives. A spillover effect is harnessing those technologies to upgrade subsistence livelihoods to generate income and improve the prospects of innovation and prosperity. This can also accelerate a community's ability to harness for its own use and welfare, simple and common technologies that are not available locally. These can be adopted and adapted from elsewhere to improve the quality of life and also to create wealth through establishment of viable enterprises (Oti-Boateng, 2009).

Technology empowers people by allowing them to expand the choices in their daily lives

The importance of science, engineering, and technology in transforming economies is evident in both the developed and emerging economies, especially in food production and processing. For Africa to be competitive, it has to harness its human and natural resources and invest significantly in science and technology for food security. This requires innovation at all levels of the economy.

The transformation of subsistence microenterprises to small- and medium-scale enterprises requires strategic planning and implementation at macro, financial, and community levels, with the ultimate goal of enhancing technological and economic growth and development. Technological capability and capacity building should make more efficient use of available resources. It should create improved product quality and allow value addition and access to international competitive markets, and result in improved lifestyles of producers. These benefits can only be feasible if policies on transforming the informal sector have well-defined objectives with the required human and capital resources. The operational and technological capability of micro- and small-scale enterprises should be improved through training and technology acquisition or upgrading. Indicators for success should include development of new or improved products and processes, adding value to people's lives and income generation for wealth creation.

Growth requires an injection of new technological capability built on existing indigenous technology and knowledge

The acquisition of improved technology must make an impact on the level of production and operation of enterprises, by enabling them to grow from subsistence level to small- or medium-scale ventures. This requires an injection of new technological capability built on existing indigenous technology and knowledge, while allowing for innovation and modernization. The era of globalization also provides opportunities for wider markets for high-quality and competitive products at international, regional, and national levels. Micro-financing should not only bring about socio-economic changes through improvement in living standards, but it should also bring about ripple effects for sustainable job and wealth creation.

For micro-finance to be effective in transforming subsistence living to small- and medium-scale enterprises, there is a need for human and institutional capacity building, and clear policy changes and guidelines, with well-defined objectives and strategies at enterprise, institutional, national, regional, and international levels.

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