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BUILDING AN ENABLING ENVIRONMENT FOR AGRICULTURAL TECHNOLOGY COMMERCIALIZATION:

Bridging the Gap Between Innovation and Uptake

Agricultural technologies[1] have the power to drive economic development and improve food security around the globe. Technologies can solve farmers' problems and provide opportunities for productivity growth, improved food safety, and greater farm income. Taking technologies to scale[2] is a complex operation involving diverse actors, contexts, and technologies, and decision-makers at national and international levels recognize that there is considerable room for improvement in scaling efforts. In practice, we see that many technologies are either not useful on-farm or are not reaching nearly enough farmers.[3] Given the high economic potential of leveraging technology for development, there is a sense of urgency underlying the aim for viable agricultural technologies to reach a larger number of users.

The challenges to scaling are rooted in a fragmented commercialization chain - from innovation, through development, to distribution to smallholders. Poorly functioning linkages persist in all three stages of the commercialization chain, and the business enabling environment - the legal, regulatory, policy and institutional framework - often restricts the

[1] In this paper, agricultural technology is considered to be a complex blend of materials, processes, and knowledge. There are two main categories of technology: material technology that takes the form of a physical product (i.e. agricultural tools, improved plant varieties, agrochemicals, etc.), and knowledge-based technology such as technical knowledge, farm management skills, and other processes that assist farmers' production (i.e. soil and water management practices).

[2] Scaling is the process of distribution and transfer of technologies to new beneficiaries in a given space or into larger geographic areas.

[3] Lele, U., J. Pretty, E. Terry, and E. Trigo. Transforming Agricultural Research for Development. Report for the Global Forum for Agricultural Research (GFAR) Global Conference on Agricultural Research (GCARD) (Montpelier: GFAR, March 28–31, 2010). (Finding that agricultural research for development "(AR4D) systems need urgent transformation to better meet the needs of the poor and in particular those of resource-poor farmers and rural communities.").

development and distribution of agricultural technologies within countries and across borders. As a result, smallholders are faced with artificial constraints and higher costs that limit their ability to access and invest in existing, proven agricultural technologies.

Bridging the gap between publicly-funded agricultural research and farmer utilization is a major challenge to commercializing technology, and the central tenet of this policy brief. **To that end, this brief focuses exclusively on the enabling environment for the distribution and utilization of agricultural technologies supported by the public sector in developing countries.**[4] We offer the reader simple guidelines for improving private-sector-led commercialization activities based on existing literature, general consensus, and best practices from around the world.

The content is organized around three distinct yet overlapping stages of the commercialization chain for agricultural technologies: the provision of public funds for basic research, the further development of research into marketable technologies, and the deployment of technology to smallholders. First, effective allocation and provision of publicly-funded agricultural R&D builds up the national research base and contributes to long-term growth in the agricultural sector. Second, improved government engagement with the private sector facilitates a market-oriented commercialization strategy that capitalizes on the potential of innovative institutional arrangements to deliver technologies to smallholders. Third, easing legal and regulatory barriers to private-sector distribution of technology facilitates greater access to livelihood-enhancing agricultural technologies at lower costs, which ease constraints to farmer adoption.

PRINCIPLE I: Governments should improve the quantity and quality of agricultural R&D and extension services.

Basic research in agriculture includes biological pest control, plant breeding, and better soil fertility management strategies, and is typically classified as a public good. Public goods have two features: they are non-excludable, since individuals cannot be effectively excluded from use, and non-rivalrous, where use by one individual does not reduce availability to others. Due to the unique nature of basic research, its funding is predominantly the responsibility of the public sector, as the private sector frequently lacks sufficient incentives to invest in public goods. However, in most developing countries, government funding for research is too low and the quantity and quality of research outputs suffer as a result. Underinvestment persists despite strong evidence suggesting a high rate of return of agricultural research.[5]

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While government funding is essential to R&D, government institutions are not always the most efficient in undertaking the research themselves. Other agents in development, including farmers and their organizations, NGOs, universities, and others also contribute to agricultural innovation. In many developing countries, the research agenda does not always line up with what farmers need on their farms, and the process for granting public funds to researchers often lacks rigor. In these situations, the funding of basic research continues to be based on seniority, continuation of existing programs, and other momentum-based criteria, instead of stakeholder priorities and the potential economic and social impact of the innovations. As such, these processes allocate limited funds inefficiently.

[4] This report highlights good practices solely for R&D provision by national governments and encourages amplified government support for agricultural research. Although we also recognize the importance of private-sector funded R&D, due to its distinct nature it is not covered here. We do, however, discuss the necessity of private sector engagement during the R&D phase so that the research agenda addresses underlying demand. See Principle 1 for further discussion of this dynamic.

[5] Alston, J., C. Chan-Kang, M. Marra, P. Pardey, and T.J. Wyatt. A Meta-analysis of Rates of Return to Agricultural R&D: Ex Pede Herculem? IFPRI Research Report No. 113. (Washington, DC: International Food Policy Research Institute (IFPRI), 2000).

ENSURE EFFECTIVE PUBLIC-SECTOR INVESTMENT IN BASIC RESEARCH.

The public sector is the dominant funder and executor of agricultural R&D.[6] However, under-investment by national governments, such as in their National Agricultural Research Systems (NARS), limits the volume of basic research carried out in a majority of developing countries. Spending in sub-Saharan Africa is especially acute, where most countries spend less that 1 percent of their agricultural GDP on agricultural R&D. Zambia, for example, spent .3 percent in 2010. National R&D programs with sufficient budget allocation and a long-term commitment to R&D, such as those in Brazil or China, improve the effectiveness of the system and reduce national dependency on short-term, ad hoc donor funds.[7] Alternative sources of funding and collaboration can improve budgetary constraints. Evidence from Colombia shows that co-funding of research by farmer organizations or private companies can relieve financial constraints and support mutual goals. In this way, Cenicafé[8] and the government in Colombia address the recent, grim outbreak of coffee leaf rust affecting Colombia and other Latin American and African states.

The lack of institutional capacity in many developing country public research institutes constrains the quality of R&D. This is often an outcome of limited budgets, which must cover basic operating costs as well as competitive salaries to attract quality staff and the expenses of research and extension. In Bangladesh, the Bangladesh Rice Research Institute and Bangladesh Agricultural Research Institute have faced challenges due to under-qualified researchers in the area of seed management with respect to research, extension, production, and marketing.[9] These government organizations supply 84 percent of quality rice seed yet supply meets only 40 percent of total farmer demand.[10] Here, weak institutional capacity limits the availability of proven technology to the detriment of farmers and agricultural production. Regional and sub-regional cooperation agreements to combine capacities and carve out specializations can help improve research quality. For example, Tanzania belongs to the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), an intergovernmental association for agricultural research and extension in the sub-region that complements the activities of national, African, and international research institutions. They have seen better utilization of high-value non-staple crop technologies and knowledge due to strengthened R&D implementation capacity through working with National Agricultural Research Institutes (NARIs) and instilling better information and knowledge management between partners.[11]

ALIGN NATIONAL PRIORITIES WITH A DEMAND-LED RESEARCH AGENDA.

All too often, well-intentioned developing country governments set research agendas that are not receptive or responsive to the needs of farmers. When this occurs, the value of public investments diminishes as research is misaligned with farmers' problems. National and regional research priorities set by government leadership must be aligned with the demands of stakeholders so that innovative technologies can be economically profitable and technically sound. Institutionalizing research priorities ensures that farmers' problems are not sacrificed by researchers who pursue their own academic interests. Restrictive incentives and culture within most developing country public offices, including research

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[6] Beintema, N., G-J. Stads, K. Fuglie and P. Heisey. ASTI Global Assessment of Agricultural R&D Spending: Developing Countries Accelerate Investment (Washington DC: IFPRI, 2012).

[7] Ibid.

[8] Cenicafé is the National Center for the Investigation of Coffee under the Colombian Coffee Growers' Federation (FNC), a farmer cooperative.

[9] Shaheen Akter and W. M. H. Jaim, Seed, Fertilizer and Innovation in Bangladesh: Industry and Policy Issues for the Future (Washington DC: IFPRI, 2012).

[10] The International Rice Research Institute (IRRI), a member of the CGIAR Consortium, has been associated with the development of almost all high-yielding rice varieties in Bangladesh since the release of IRRI-developed IR8 in 1962.

[11] Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), "High Value and Non-Staple Crops Programme", accessed February 11, 2014, {http://www.hvns.asareca.org}.

institutes, constrain their participation in agricultural innovation networks.[12] Convening diverse stakeholders can build consensus around pragmatic policy recommendations and R&D priorities in line with legislative mandates, national priorities, and commercial feasibility. Building capacity for intermediation is pivotal to successful research relationships. In many countries, agricultural research, extension, and education are in two or three different ministries and there are significant barriers to collaboration. A well-designed, neutral, trustworthy agency or broker fuels progress by working with a wide range of stakeholders, including government ministries, development partners, civil society, and private sector representatives (i.e. farmers, technology firms, NGOs, foundations) to encourage collaboration and linkage without creating dependencies. The point is function rather than form. Effective reform means moving toward more effective governance with appropriate capacity to manage deal-making, a clear operational plan to support its mandate, and the aptitude to facilitate long-term relationships.

CONSIDER ALTERNATIVE MECHANISMS FOR AGRICULTURAL RESEARCH.

There is an important distinction between long-term and short-term research goals and the type of funding mechanism appropriate for each type. Long-term research activities and research with the potential to produce transformational discoveries requires continuity, integrated research programs, and research infrastructure, which are best funded through sustained support from the national budget. Research for incremental change with shorter time horizons is best achieved through general competitive funds. For both types of research, a greater emphasis on performance-oriented impact is needed that shifts research from a NARI-centric perspective to a more pluralistic system. Government institutions often lack incentives to innovate most efficiently, creating an uncompetitive environment likely to produce low-quality results. For example, the Indonesian agricultural technology development and dissemination system lacks scientific rigor and high-quality research due to a lack of external reviews and linkages and non-competitive funding.[13] Incentivizing potential research providers (i.e. universities, technology businesses, cooperatives, etc.) using policy tools can take the form of public investment in upstream or basic research, public research grants, public subsidies on R&D input costs, tax reductions and exemptions for R&D inputs and capital equipment, or programs designed to lower the costs of meeting regulatory requirements. Competitive grants funds (CGF) have become popular over the years as an effective part of a portfolio of mechanisms to fund agricultural research. CGFs typically entail nationwide contests to submit proposals for technical review, fostering a diversification of research suppliers, and most focusing primarily on financing short-term agricultural research activities. Chile's Technological Development and Innovation Program, for instance, used CGFs strategically to capitalize on private sector scientific and technological capabilities. These CGFs led to world class research results benefiting Chilean industry, especially in the biotechnology space, in part because Chile's program requires applicants for its CGFs to form consortia with companies willing to market the resulting innovations so as to embolden scientists to see the commercial potential of their work.[14]

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PRINCIPLE 2: Incentivize the private sector to transform research into marketable technologies.

Applied research leading to technology of direct utility to farmers depends on the availability of results from basic research. Some degree of development and adaptation is required to transition publicly-funded basic research, which may have limited impact, into practical agricultural technologies ready for use by smallholders. The resulting marketable

[12] World Bank, Agricultural Innovation Systems: An Investment Sourcebook, "Module 1: Thematic Note 2: How to Build Innovation Network", accessed February 10, 2014, {http://go.worldbank.org/NGYKG2VNA0}.
[13] World Bank, Project Information Document: Appraisal Stage, for the Sustainable Management of Agricultural Research and Technology Dissemination Project (Washington DC: World Bank, 2011).
[14] IDB America Magazine, "From the laboratory to the investment fund" (Washington DC: Inter-American Development Bank (IDB), 2005) {http://www.iadb.org/idbamerica/index.cfm?thisid=3181}.

technologies are characteristic of a private good and subject to market and competitive pressures best handled by the private sector. Private-sector engagement drives competitive and responsive marketing systems with the potential to bring more accessible and affordable technology to market.

The diffusion of technologies requires more than delivering ready-to-use technology to farmers; it requires building absorptive capacity and improving the ability of the public and private sectors to identify, adapt, and implement the most appropriate technologies.[15] Different business models are needed to transfer diverse types of research and technology to end users. Therefore, various enabling environment considerations must be addressed, such as how to incentivize and engage the private sector in further development and distribution of agricultural technology and how to determine the best type of institutional arrangement and enabling environment to move technology along the commercialization chain. Government facilitation, not intervention, is crucial.

INCREASE ACCESS TO FOREIGN AND DOMESTIC RESEARCH RESULTS.
To complement national investments in R&D, countries should pursue the acquisition of existing technologies from other countries, especially in sectors where local industry is far from the technology frontier. Solutions for many developing country farmers' issues already exist. Pest management practices and irrigation technologies, among others, have been created and are appropriate or adaptable to local conditions. Thus there is a need for greater private-sector access to both indigenous and foreign research results. Legal and institutional barriers often exist that prevent local adaptation of foreign research. Regulatory and administrative reforms can lift these barriers to allow improved access to interested parties, such as training programs to facilitate the evaluation and adoption of technologies, mechanisms for sharing ideas within and across borders, and government-funded technology inventories that are searchable.

Successful innovation in industrialized and more advanced developing countries are often the result of intensive cooperation and feedback loops between firms and supporting institutions, including universities and research centers. Yet in many developing countries, such as those in sub-Saharan Africa, little progress has been made in developing such linkages. Awareness about potential market opportunities for a technology incentivizes companies to commercialize technology. For example, creating a 'needs inventory' with up-to-date information on farmers' needs informs interested parties. Implementing a plan for commercializing new research and technology through private channels makes government more commercially minded and fuels private-sector entrepreneurship. For example, the Government of India's Department of Science and Technology (DST) established the National Science & Technology Entrepreneurship Development Board (NSTEDB) as an institutional mechanism that promotes knowledge-driven and technology-intensive enterprises. NSTECB has entered into an agreement with Glow BioTech Ltd., a company that develops and commercializes new technologies related to natural, agricultural, and veterinary products, and Thapar University for production and promotion of bio-fertilizers. The collaboration led to a 50 percent increase in Glow BioTech's sales.[16]

HARMONIZE LOCAL, NATIONAL, AND REGIONAL AGRICULTURAL POLICIES.
Fragmented agricultural policy in many developing countries disrupts the flow of technology within a country and across borders. For example, with variation in regulatory systems for agricultural inputs from country to country, the importation process becomes

PHOTO BY FINTRAC INC.

[15] World Bank, 2010 World Bank World Development Report: Development and Climate Change, Chapter 7 – Accelerating Innovation and Technology Diffusion (Washington DC: World Bank, 2009).
[16] National Science & Technology Entrepreneurship Development Board (NSTEDB), "First Report on Technology Business Incubation 2009" (India: Department of Science and Technology, 2009) {http://www.nstedb.com/fsr-tbi09/Images/chapter5.pdf}.

more difficult, less timely, and more expensive. Thus regional harmonization of trade agreements is vital to functioning input and output markets. Currently, the Economic Community of Central African States (CEEAC) is implementing a common agricultural policy across its members.[17] Successful implementation will be crucial to their effectiveness at expanding agricultural trade within the region. As developing countries are becoming more integrated in the global trading system, uncertainty about the regulations governing the entry and use of new technologies can constrain technology transfer and the private sector's incentives to develop and commercialize new technology in larger markets. Border regulations should be as unobtrusive as possible to minimize delays and associated transaction costs, while recognizing that too little regulation can mean opportunities for corruption (e.g. government's granting of patents, certification of product quality, and import licensing of technology products). Adequate consumer protection is needed to protect the buyers of agricultural technologies (e.g. pesticide labeling, seed quality control, and fertilizer quality testing). Strong organizational structures for national agricultural control systems are needed to avoid problems such as duplication of regulatory activity among different agencies, increased bureaucracy and a lack of coordination between the different bodies involved in food policy, monitoring, and control of food safety. Similar policy harmonization principles also apply at a subnational level. The coordination of clear and transparent policies across local governments and between local and national levels creates a more consistent legal and regulatory environment that encourages the transfer and expansion of technologies with greater predictability and fewer adaptation requirements.

PROTECT INTELLECTUAL PROPERTY RIGHTS (IPR).

Intellectual property rights (IPR) are awards to inventors and institutions of certain exclusive rights to produce, copy, distribute, and license goods and technologies.[18] Furthermore, IPR gives innovators personal property ownership rights and a means to prevent unauthorized use of their work (e.g. patents, copyrights, and trademarks). IPR systems must balance public interest in accessible, affordable, livelihood-enhancing technologies, with the reality that some market power may stimulate innovation by facilitating the recovery of related expenses and financial risk management. It follows that the policy implications should be guided along the lines of a country's level of development and its level of imitative or innovative capacity. Practice shows that a wide range of national policy approaches have been used by developing countries to address IP ownership. Legal mechanisms include plant variety protection, trademarks, trade secrecy rights, and plant breeders' rights. Other approaches involve labor law, government procurement or contract law, and laws governing national R&D or innovation systems.[19] Effective public-sector IPR enforcement is crucial to spurring innovation and encouraging the innovator to transfer their technology to domestic and foreign markets. Yet not all developing countries have proper IPR systems in place, or the means to enforce them. Myanmar, for example, has a relatively undeveloped IPR system. The country is not yet a member of The International Union for the protection of New Varieties of Plants (UPOV) and is in the process of drafting a Plant Variety Protection (PVP) law. Strengthening IPR in Myanmar has the potential to spur foreign direct investment, greater domestic innovation, and increased technology diffusion. In drafting new legislation, balance must be struck between the

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[17] Meeting of the Committee of Experts of the Sixth Joint Annual Meetings of the Economic Commission for Africa Conference of African Ministers of Finance, Planning and Economic Development and African Union Conference of Ministers of Economy and Finance, "Assessment of progress on regional integration in Africa" (Abidjan, Cote d'Ivoire: United Nations Economic and Social Council, Economic Commission for Africa and African Union Commission, March 21-24, 2013).

[18] World Bank, "Intellectual Property and Development, Lessons from Recent Economic Research" (Washington DC: World Bank and Oxford University Press, 2005).

[19] G. D. Graff, Echoes of Bayh-Dole? A Survey of IP and Technology Transfer Policies in Emerging and Developing Economies (Berkeley, California: University of Berkeley, 2007).

Interests of technology-intensive multinationals interested in investing in and transferring technology to Myanmar and striving to develop its own viable and innovative technological base.[20]

ALLEVIATE CONSTRAINTS TO BUSINESS ENTRY.

A strong national competition policy alleviates barriers to business entry and encourages competition in the technology space. Laws restricting competition in certain technology or activity areas should be reconsidered as protected industries tend to be inefficient. In Nepal, the National Fertilizer Company Limited (NFCL) became the sole importer and distributor of subsidized fertilizer in 2009, which led to a large mismatch between the estimated fertilizer demand of 585,000 tons annually and the supply by NFCL of 100,000 in 2009-2010 and 180,000 in 2010-2011.[21] A more competitive Nepalese fertilizer sector coupled with effective regulation and enforcement of quality control could address under-supply problems and has the potential to improve agricultural productivity. According to Nepal's current policy, legal limitations on who can sell fertilizers have resulted in limited geographic coverage: farmers from areas with no sellers are either unable to access the subsidized fertilizer or are forced to spend great amounts of time, money, and effort to get to the nearest location to buy the fertilizers.[22] Other policy measures that support business entry include easing business registration and the acquisition of licenses. These reforms typically have a favorable impact on the business enabling environment by saving firms substantial amounts of time and money.[23] Permitting and officially recognizing a range of legal forms (e.g. limited liability company, limited partnership, general partnership, cooperative, etc.) also enables businesses to leverage diverse resources for a common cause and reduce individual risk, making finance options more obtainable and investments more reasonable. In the Sahel, for example, the International Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP) linked capital-poor farmers with local banks by aggregating borrowers into farmer associations able to handle default risk in a way similar to the small group-lending strategies of micro-credit schemes. Due to bank recognition of their new organizational form, established farmers' associations have been able to access bank loans.[24]

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SELECT PRIVATE-SECTOR PARTNERS THROUGH A PROCESS THAT CONSIDERS BUSINESS MODEL DESIGN.

Getting technology from industry to farmer demands an innovative business model at least as much as it requires an innovative technology. In many developing countries, public-private partnership (PPP) agreements are a valuable policy tool to bring the public and private sectors together to commercialize technology. Adoption of disease-resistant, early-maturing soybean has the potential to bring significant increases in yields to farmers, yet PPPs are needed to increase seed availability to more farmers. In Uganda, for example, adoption of these soybeans has led to yield increases of 200 percent.[25] Building successful partnerships entails recognition of the incentives various partners bring to the negotiating table, thoughtful preparation (i.e. proper partner selection, complementary partnership capacities, sufficient funding of the project development phase, and a general budget that meets partnership and project needs), and effective governance of the relationship (i.e. presence of an operating committee, monitoring and evaluation, etc.). PPPs must be based on well-defined roles, mutual goals, and clear technology ownership arrangements. Part of

Getting technology from industry to farmer demands an innovative business model at least as much as it requires an innovative technology.

[20] Joel Ankar and Chris O'Hara, "Strengthening Intellectual Property Rights in Burma", accessed February 11, 2014, {http://www.irrawaddy.org/contributor/strengthening-intellectual-property-rights-in-burma.html}.

[21] K. D. Joshi, C. Conroy and J. R. Witcombe, Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future (Washington DC: IFPRI, 2012).

[22] Ram Krishna Shrestha, "Fertilizer Policy Development in Nepal", Journal of Agriculture and the Environment, Vol. 11 (2010).

[23] Recent work on this topic has been undertaken by USAID and Fintrac, including their 2013 AgCLIR assessments in Myanmar and Benin by the Enabling Agricultural Trade (EAT) project (www.eatproject.org).

[24] Dr. John Sanders, Professor, Department of Agricultural Economics, Purdue University. via phone and email correspondence in October, 2013.

[25] United States Agency for International Development (USAID), Scalable Agricultural Technologies: Legumes, Legumes Technology Inventory, accessed February 11, 2014, {http://agrilinks.org/sites/default/files/resource/files/Technology%20Inventory%20-%20Legumes%2020May13.pdf}.

an innovative business model is its approach to dealing with unique market, legal, and regulatory systems over time. The form a partnership may take is diverse, as well as the type of partners engaged (e.g. farmers organizations, private industry, non-profits, etc.). The involvement of experts in feasibility and adoption studies at the outset, and incorporating creative financing, pre-sale training, and post-sale maintenance into a business model can help ensure commercial viability. In West and Central Africa, the Purdue Improved Crop Storage (PICS) technology faced weak legal enforcement systems that hampered their ability to commercialize their technology and found that wholesale-retail trust relationships were vital to the input supply chain for grain storage materials. Increases in scaling occurred once Purdue University integrated a business model that included vendor meetings and similar trust building exercises into their commercialization strategy.

PRINCIPLE 3: The legal and regulatory framework should facilitate the adoption of agricultural technologies by smallholders.

The adoption of agricultural technologies at scale is essential for transforming agriculture, improving food security, and raising farmer income. Farmer adoption decisions are highly complex and only a select subset of these considerations is put forth in this section. Yet regardless of how one focuses the analysis, the main determinant of technology adoption is the same: meeting the expected value condition of the end-user. A technology's value (perceived and actual) is strongly influenced by the enabling environment, making legal, regulatory, policy, and institutional considerations important in any strategy to encourage technology adoption. The government's role is that of a facilitator whose objectives are to improve market information systems through extension services, alleviate financial market constraints to technology adoption, and make targeted investments in infrastructure that ease the costs of moving technology to farmers.

ALLEVIATE KNOWLEDGE INFRASTRUCTURE CONSTRAINTS AFFECTING ADOPTION.

Providing information about the payoffs of a technology has been shown to increase adoption.[26] However information dissemination and access remain a significant constraint to adoption in many developing countries. Information services of a public-good nature are typically delivered by the public sector, either through its institutions, like national extension services, or through funding to extension partners, including NGOs, women's groups, and farmer associations. Connections with local partners during technology development or implementation, and working with local commercial partners when doing field tests improve the likelihood of adoption. This connection is also important because distribution and scaling of technology requires local implementation and knowledge of the local commercialization channels. Dissemination strategies vary according to technology and context, making government-funded information management systems such as a computerized database on agro-ecological zones, climate, temperature, and rainfall of the country important for technology transfer activities. Effective provision of these services depends on the strength of the extension system. Transfer is often limited by broken extension systems that suffer from weak funding, poor expertise, and an administrative structure where extension is disconnected from agricultural education and research. For example, substantial research (both public and NGO-based) on neem oil in India has proven that it can be an effective insecticide. One constraint to commercialization has been inadequate information provided to farmers on seed harvesting and processing and tree management techniques by extension agencies that lack both appropriately trained staff and the facilities to demonstrate neem's efficacy.[27] Improved governance of agricultural knowledge systems can be attained through providing regional extension hubs or NGOs up-to-date information on outcomes. Targeted investments can improve farmer

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[26] R. Jensen, "The (perceived) returns to education and the demand for schooling", Quarterly Journal of Economics, 125(2) (2010), 515-548.

[27] FJ Childs, JR Chamberlain, EA Antwi, J Daniel, and PJC Harris, Improvement of Neem and its Potential Benefits to Poor Farmer (United Kingdom, Ghana, and India: Department for International Development, 2001).

adoption, such as investments in farmer education programs (e.g. local trainings on the technological solutions available and how to use them correctly) and information systems that facilitate trade (e.g. mobile and high-speed internet that reaches rural areas) and focus on delivery of credible and accurate information to farmers. In Zambia, no public market information system exists, so farmers rely on information from other farmers and local brokers, who often manipulate the information they give to suit their own needs. In response to this problem, the government and the Zambia National Farmer Union (ZNFU) have partnered to provide an SMS-based market information system. More information has led to stronger links to larger markets, increased competition among traders and processors, and better prices received for the product traders and farmers sell or produce. Commodities covered in the system include maize, beans, groundnuts, cassava, pigs, goats, and others. So far, over 1,000 hits per week have been recorded on the system.[28]

BROADEN AND DEEPEN RURAL FINANCIAL MARKETS.

Inadequate rural financial markets often prevent farmers from borrowing funds to invest in a technology and from insuring against the risk associated with experimenting with a new technology. Meeting the need for financial services for smallholders is a well-documented problem, and too little progress has been made in the development of financial services specific to their agricultural activities.[29] Capital-poor farmers require non-traditional bank loans, credit offerings, and collateral systems. As farmer wealth grows, the options for financial service providers for smallholders expand from microfinance institutions (MFIs) or savings and loan groups promoted by nonprofits to agricultural banks, credit unions, and input providers.[30] Financial providers and policymakers must translate demand-side needs into new general and agriculture-specific product and policy approaches that include more smallholders in local financial systems. Government offerings of lines of credit, guarantees, and financial education and trainings can help financial providers operate in rural settings. Legal recognition of institutions offering value-transfer and lending functions and granting the permission to lend to non-traditional providers, such as mobile banking companies, can increase the availability of financial services. Developing policies to enable MFIs to accept savings in countries where they are restricted due to legal statutes also improves farmers' financial situation. Lastly, a legal framework that encourages business model innovation can lead to more customers reached. See side bar for an example.

BUILD MARKET INFRASTRUCTURE TO LOWER THE COST OF TECHNOLOGY DISTRIBUTION.

Inadequate infrastructure characterizes most developing countries and contributes to higher price tags for agricultural technology. Rural contexts that are otherwise favorable for technology adoption are often hampered by geographically driven transaction costs (e.g. low population densities, weaker competition, and remote locations) that restrict proper functioning of agricultural input and output markets. In turn, market access and the profitability of technology adoption by farmers are reduced. Infrastructure supports on-farm production (e.g. irrigation, power, electricity, and storage), adds value to the domestic economy and enables goods to move efficiently from farmer to buyer. One key benefit of better infrastructure is a reduction in the costs of commercializing technology and the price paid by farmers. Market-oriented development is facilitated through investment in farm-to-market roads and traceability systems. For example, the Kenyan government facilitated the development and privatization of the Kenya Tea Development Agency Holdings Ltd. (KTDA) by addressing key barriers to scale, such as poor feeder road networks for factories limiting access to markets. To address this constraint, it built

M-PESA IN KENYA

Currently, 15 million Kenyans use M-PESA, an innovative, mobile phone-based financial service. The statistics on financial access before the launch of M-PESA in Kenya show that the formal financial system was serving 26.4 percent of Kenya's adult population, and Kenya had fewer than two bank branches per 100,000 people. Today M-PESA has over 35,000 agents countrywide and handles roughly 70 percent of financial transactions.

Source: Peter Gakure Mwangi, "How M-PESA is Transforming Kenya's Economy", accessed February 11, 2014, {http://www.thinkm-pesa.com/2012/03/how-m-pesa-is-transforming-kenyas.html}.

[28] IFAD, Rural Poverty Portal, accessed February 11, 2014, {http://www.ruralpovertyportal.org/country/voice/tags/zambia/shemp}.

[29] Christen, Robert Peck, and Jamie Anderson, "Segmentation of Smallholder Households: Meeting the Range of Financial Needs in Agricultural Families", Focus Note 85 (Washington, DC: CGAP, April 2013). (Finding that "different kinds of households have different kinds of financial needs, and that this variety in demand cannot be met by the same suite of financial products, terms of service, or even formal financial service providers.").

[30] Ibid.

Steven Fondriest, COR
USAID
+1.202.712.0314
stfondriest@usaid.gov

Nate Kline, EAT Chief of Party
Fintrac Inc.
+1.202.621.7349
nkline@fintrac.com

Dr. James Lowenberg-DeBoer
Associate Dean and Director IPIA
Professor, Dept of Ag Econ
Purdue University
+1.765.494.6876
lowenbej@purdue.edu

www.eatproject.org

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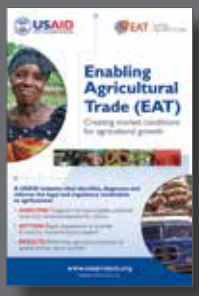

ABOUT THE EAT PROJECT

The Enabling Agricultural Trade (EAT) project, funded by the United States Agency for International Development (USAID), is USAID's primary agricultural policy and enabling environment project – and promotes inclusive agricultural sector growth - a critical component of Feed the Future - by creating enabling environments that increase private sector investment and promote food security. EAT offers a suite of targeted and customizable tools to identify, diagnose, and address key policy and institutional constraints to inclusive agricultural sector growth.

and upgraded feeder road networks around tea factories.[31] Improved market infrastructure coupled with wide-ranging facilitation in other areas, such as a liberalized market structure for tea and the lack of distortions due to domestic policies, extension services to smallholders to improve their competitiveness, and targeted R&D to improve tea cultivation practices has enabled the KTDA to reap benefits such as increased competitiveness and improved productivity, income, and output for the nearly 600,000 smallholder growers that own it.[32] Furthermore, direct government investment or funding for private-sector infrastructure development should target building on-farm and pooled storage capacity where need exists. Crop protectants, storage containers, metallic silos, and warehouse receipt systems (WRS) improve trade infrastructure, reduce post-harvest risks faced by producers, and help increase access to finance.

PROMOTE INTEGRITY IN AGRICULTURAL TECHNOLOGY.

Fraud in agricultural technology occurs through the unauthorized use of IP technology and the sale of fraudulent products such as fake seeds, counterfeit fertilizer and pesticides, and diluted chemicals. The government has the task of reducing fraud by enforcing the laws and regulations it puts in place. Without government enforcement of the rights of technology companies, incentives for the private sector to invest and commercialize technology are reduced. A government strategy of ongoing market monitoring for fraud and an effective enforcement strategy deters fraudulent actions without creating a chilling effect on legal uses for technology. In practice, however, good court systems are rare. Courts frequently suffer from large delays due to an overburdened docket, corrupt judges or court staff, difficulty enforcing judgments, and insufficient IT infrastructure for efficient case management. While tackling the root causes of fraud opportunities remains a necessary government function, innovative private-sector solutions are also applauded and encouraged. In some contexts, the private sector has played an important role in consumer confidence and technology commercialization where government enforcement is weak. For example in Uganda, the agencies responsible for oversight, inspection, and enforcement of agricultural inputs lack the knowledge or manpower to effectively enforce government regulations nationwide. This shortfall has created an enabling environment for illegal trafficking of agricultural inputs. New specially marked packages (SMPs) have been piloted by private seed companies that allow farmers to send the package code via SMS to the company for verification of the package's authenticity. The seed brands sold using SMPs have seen their market shares double, despite the higher price of their seed versus non-verified brands.[33]

CONCLUSION

Wide-ranging country experience indicates that bridging the gap between publicly-funded agricultural R&D and its utilization on-farm is a major challenge. Taking actions that target key challenges faced along the commercialization chain - from innovation, through development, to distribution to smallholders - sets government on course to successfully connect agricultural research and farmer adoption of agricultural technologies. Reforms of the enabling environment are necessary to attain agricultural transformation through technology-enhanced farming with the potential to raise farm incomes at scale. Institutional and administrative constraints to effective agricultural R&D, restrictions to private-sector distribution and marketing of agricultural technologies, and legal and regulatory barriers to technology adoption must be addressed. In doing so, governments and other stakeholders will be able to drive market-oriented agricultural development and facilitate greater access to agricultural technologies at a lower cost to farmers.

[31] Monitor Deloitte, PowerPoint presentation at USAID's MPEP Seminar Series titled, "Overcoming Barriers to Scale to Reach the Poor" (Washington DC: USAID Microlinks, 2014).

[32] Food and Agriculture Organization of the United Nations (FAO), "Making Kenya's efficient tea markets more inclusive" Monitoring African Food and Agricultural Policies (MAFAP) Policy Brief #5, (FAO, 2013) {http://www.fao.org/docrep/018/aq657e/aq657e.pdf}.

[33] International Fertilizer Development Center (IFDC), Fighting Counterfeit CPPs in Uganda, Report Volume 38, No. 1 (Alabama, USA: IFDC, 2013), {http://www.ifdc.org/Nations/Uganda/Articles/Fighting-Counterfeit-CPPs-in-Uganda/}.