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APPLYING A MARKET SYSTEMS LENS TO TECHNOLOGY SCALE UP

A BRIEF LITERATURE REVIEW

LEO
Leveraging Economic Opportunities

LEO REPORT #13

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ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
AIDED	Assess Innovate Develop Engage Devolve
DFID	UK Department for International Development
E4A	Energy for All project
ICT	Information and communication technology
ICRISAT	International Crops Research Institute for the Semi-Arid-Tropics
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIRR	International Institute of Rural Reconstruction
LEO	Leveraging Economic Opportunity project
M4P	Making Markets Work for the Poor
MEDA	Mennonite Economic Development Associates
MSME	Micro, Small and Medium Enterprises Strengthening project
PROFIT	Production, Finance and Improved Technology project
R&D	Research and development
SDC	Swiss Agency for Development and Cooperation
SMS	Short message service
SRI	System of Rice Intensification
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WHO	World Health Organization
WWF	World Wildlife Fund

I. INTRODUCTION

A. BACKGROUND AND PURPOSE OF THIS PAPER

Technologies have the potential to enable households, communities and firms to improve their yields and income, food security, and participation in the economy. Throughout the literature, there is a clear assumption that technology and development are closely tied. The majority of the world's poor live in rural areas, lack connections to information, and have limited access to many goods and services. In such contexts, small technology improvements can have big impacts and transformative effects. But technology adoption rates among the rural poor are often low. USAID Administrator Shah, in a speech in 2013, highlighted the low rate of agricultural technology adoption in sub-Saharan Africa and many other countries, including very low rates of adoption of improved seeds and fertilizer (Agrilinks, 2014).

In "Learning and Leading for Large Scale Change," Larry Cooley and Richard Kohl contend that "the persistence of poverty and preventable illness in low-income countries after 30 years of development efforts has drawn attention to the relatively poor record of pilot and demonstration projects in successfully stimulating systemic change and reaching large populations" (Cooley and Kohl, 2006).

Similarly, according to Johannes Linn of the Brookings Institute, the limited success of efforts to scale technology adoption is a consequence of the fact that "disconnected, one-off, short-lived, unsustainable initiatives in support of technology adoption have been the rule" (Linn, 2014). Linn asserts that to scale the use of agricultural technologies, governments, aid agencies, foundations, NGOs and the private sector need to focus on *systematic* scaling. Systematic scaling explores potential scaling-up pathways throughout the program cycle that can ensure a successful project is not a one-time event, but is a stepping stone towards wider and sustainable impact. Linn argues that scaling up expands, replicates, adapts, and sustains successful policies, programs, or projects to reach a greater number of people through a non-linear, iterative and interactive cycle (Linn, 2012a).

This call for a more systematic approach to scaling technology adoption resonates with USAID's recent emphasis on strengthening local systems (USAID, 2014). While USAID's rationale for strengthening local systems in general focuses on sustainability, its articulation of market systems development[1] explicitly mentions the potential for scaling: "Achieving sustainable impact at scale is the objective of most USAID projects. Inclusive market system development is increasingly recognized as a potential means for achieving this objective" (Campbell, 2014). Similarly, Peter Beez, in his forward to the SDC- and DFID-funded "Operational Guide for the Making Markets Work for the Poor (M4P) Approach" writes: "Systemic change is the essence of large-scale and lasting development" (The Springfield Centre, 2014). M4P Hub lists the pursuit of large-scale impact as one of the four underlying principles of the M4P market systems development approach.[2]

The goal of this literature review, therefore, is to generate insights into how to use market systems development to improve the scaling up of technologies for the benefit of food security and poverty reduction. The

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[1] Market systems development focuses on "building the capacity and resilience of local systems, leveraging the incentives and resources of the private sector, ensuring the beneficial inclusion of the very poor, and stimulating change and innovation that continues to grow beyond the life of the project" (Campbell, 2014).

[2] http://www.m4phub.org/what-is-m4p/introduction.aspx

review focuses on the agricultural sector and provides a synthesis of the relevant literature, summarizes lessons learned on scaling up technologies, and identifies gaps in research to date.

B. DEFINITIONS

This section will define the use in this paper of the key terms technology, market systems development, and scaling up.

1. TECHNOLOGY

The Merriam-Webster definition of technology is "the use of science in industry, engineering, etc., to invent useful things or to solve problems." This literature review focuses on a wide variety of technologies, all relevant to supporting agricultural market systems in some direct or indirect way. The International Food Policy Research Institute (IFPRI), has identified a number of proven agricultural technologies that are not yet widely used in the developing world. These include no-till farming, integrated soil fertility management, precision agriculture, water harvesting and drip irrigation (Rosegrant et al, 2014)—and, of course, many other technologies are continually being developed for varied purposes.

There appears to be no consistency in how technologies are classified. In much of the literature, technologies are categorized by the *type of function they play*:

- Information and communication technologies (ICT), such as mobile phones;
- Higher, more advanced, technologies, such as production equipment, and irrigation systems;
- Farm management systems, such as no-till methods, terracing, and crop rotation; and
- Improved inputs, such as drought-resistant or disease-resistant seeds, and improved fertilizers and pesticides.

In some of the literature (Jack, 2013), agricultural technologies are categorized by the *impact of their use*:

- Higher yield technologies, such as improved varieties of seeds;
- Lower risk technologies, such as weather insurance, and drought resistant crops;
- Better quality products, such as storage technologies;
- Cost reduction technologies, such as animal-driven ploughing, and nitrogen fixing crops; and
- Reduced externalities, such as no-till agriculture, and terracing.

USAID's Bureau for Food Security and USDA[3] have categorized technologies as follows:

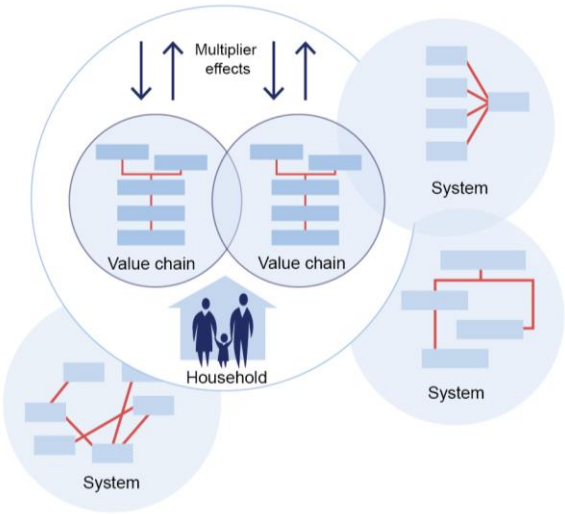
- ICT and insurance
- Post-harvest losses
- Cereals
- Sustainable intensification
- Vegetables, fruits, roots and tubers
- Livestock and aquaculture
- Legumes

[3] http://feedthefuture.gov/article/scalable-agricultural-technologies-inventory

2. MARKET SYSTEMS DEVELOPMENT

USAID, through its Leveraging Economic Opportunities (LEO) project, defines a market system as a "dynamic space […] in which public and private actors collaborate, coordinate and compete for the production, distribution and consumption of goods and services" (Campbell, 2014). The behavior and performance of these market actors are influenced by other market actors, informal and formal rules, financial and non-financial incentives, and the physical environment. In inclusive market systems, more vulnerable market actors (such as poor producers and farmers, ethnic minorities, marginalized women, and other disadvantaged groups) are able to acquire access to the opportunities, skills and resources to make investments in their activities, and reap the benefits that arise from this upgrading process (Campbell, 2014).

Figure 1. Market System – showing interconnected systems[4]



Similarly, SDC and DFID define the market systems development approach as "a set of principles, frameworks and good practices that guide both analyses of market systems and development interventions which bring about pro-poor change within them" (The Springfield Centre, 2014).

The objective of inclusive market systems development is to catalyze a process that results in a competitive, inclusive, and resilient market system (Campbell, 2014). Each of these characteristics is relevant to the scaling of technology adoption among the poor. In *competitive* markets, multiple firms compete with each other to satisfy the demands of a large number of consumers. Competition drives innovation (Brandenburger, 2011), which enables the development of new technologies that meet the needs of consumers. However, innovations will focus on the needs of wealthy customers unless the market system is also *inclusive*, delivering benefits to a range of actors, including the poor and other marginalized groups. Finally, *resilient* markets enable firms to address, absorb and adapt to shocks and stresses in the system. The focus of this literature review is on scaling up the technology adoption process in countries and regions with high rates of poverty. Such areas typically have volatile markets and policy environments, and are experiencing some of the most pronounced consequences of global climate change. The ability to adapt technologies—and the models to promote, sell and service these technologies—in a highly dynamic environment is therefore key.

[4] https://www.microlinks.org/sites/default/files/resource/files/Market_Systems_Framework.pdf

3. SCALING UP

Hartmann and Linn (2008) state that their preferred definition of scaling up is adapted from the one used by the World Bank in connection with the 2004 Shanghai conference on scaling up. It focuses on quality of impact, or "success," and scale and sustainability, and makes clear that scaling up is not only about projects, but also programs and policies: "Scaling up means expanding, adapting and sustaining successful policies, programs or projects in different places and over time to reach a greater number of people."

This contrasts with a widely adopted definition of scaling up proposed by the International Institute of Rural Reconstruction (IIRR, 2000): "Scaling up brings more quality benefits to more people over a wider geographical area, more quickly, more equitably, and more lastingly." This definition emphasizes equity and speed, in addition to the common features of quality, reach and sustainability.

DEFINING ADOPTION

There are challenges in defining adoption, since adoption may not be a discrete state, but rather a continuous measure. The definition of adoption often depends on the type of technology under discussion. For example, should farmers be considered to have adopted and even scaled the technology of improved seeds if they recycle improved seeds, or only if they purchase new improved seeds? Some technologies can be partially adopted (such as a farmer growing some improved varieties but also continuing to grow local varieties), whereas some adoption processes are more gradual (such as adopting farm management systems such as conservation agriculture). Defining adoption in a given context will depend on the type of technology being promoted, and how the technology relates to factors such as the variances between management practice and tools, who is adopting, what land size is allocated to the new technology, and past experiences with the technology.

Source: Doss, 2006

The focus on "more quickly" may be misleading, however, since scaling up is often a gradual process. Kohl (Agrilinks, 2014) states that the amount of system building that can be done in the usual one- to three-year period of a project life cycle is limited. He references some of the International Fund for Agricultural Development (IFAD) programs in Africa, which have built agricultural extension and agricultural market systems over two or three project life cycles (over a 10- or 15-year period) rather than through individual shorter-term projects.

Hartmann and Linn's inclusion of policies and programs is reflected in Simmons, Fajans and Ghiron's (2007) publication on scaling up health service delivery, which defines scaling up as: "efforts to increase the impact of innovations successfully tested in pilot or experimental projects so as to benefit more people and to foster policy and programme development on a lasting basis." According to the Global Health University, this definition "highlights the purposeful process of building institutional or environmental capacity that can sustain [technological] innovation" (Global Health University, 2013).

The concept of scaling up in various sectors is described in the literature in the context of systems, environments, policies and institutions, rather than simple "supply driven mass production and distribution" (Global Health University, 2013).

II. A FRAMEWORK FOR SCALING UP

Many of the emerging lessons on technology scale-up can be drawn from insights from sectors outside of agriculture, particularly the health sector. Several frameworks are described below, which have been reorganized and adapted as an organizing framework for this literature review.

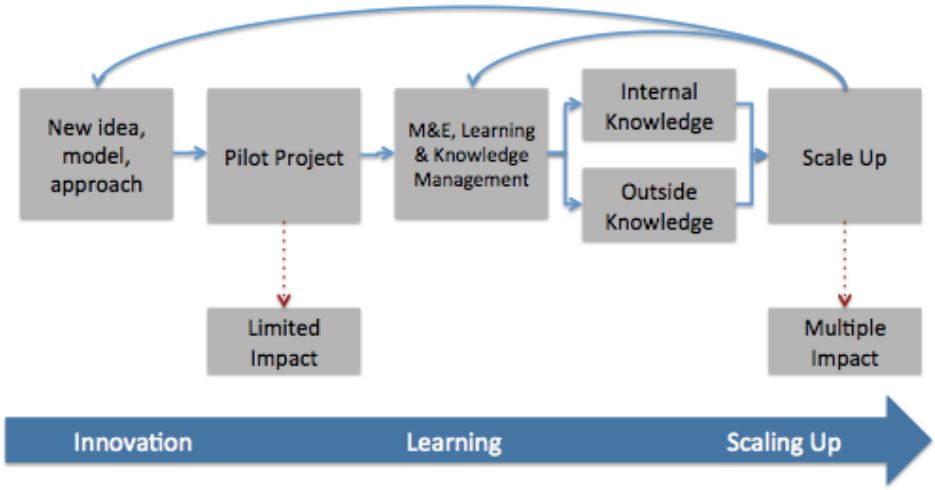
A. MODELS FOR THE SCALING UP PROCESS

1. LINN'S INNOVATION, LEARNING AND SCALING UP PROCESS

Linn describes scaling-up pathways as "the sequence of steps that need to be taken to ensure that a successful pilot or practice is taken from its experimental stage through subsequent stages to the scale ultimately judged to be appropriate" (Linn, 2012a). He refers to an analytical framework for examining scaling up that includes:

1. Pathways to scaling up
2. Understanding who the drivers of the scaling-up process are
3. Spaces for innovation to grow to scale
4. Monitoring and evaluation (M&E) throughout this process

Figure 2. Linn's Innovation, Learning, and Scaling Up as an iterative process[5]



Pathways: There are various pathways for scaling up, including expansion within a geographical area; "horizontal" scaling, or replication from one area to another; "functional" expansion, or a deepening of engagement; and "vertical" scaling, from local to regional or national engagement.

Drivers: Linn refers to the following five drivers of the scaling-up process:

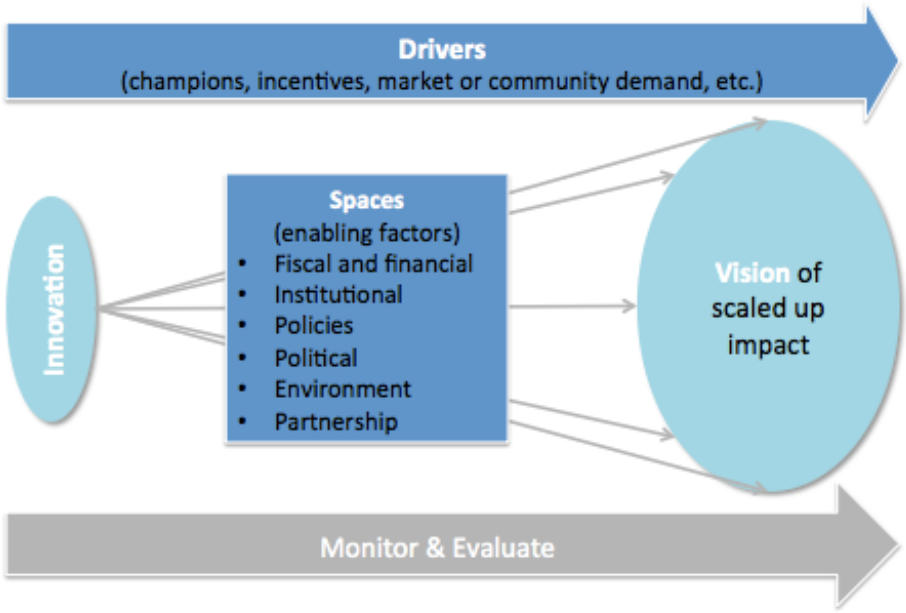
- Champions—leaders who recognize the vision

[5] http://agrilinks.org/sites/default/files/resource/files/Linn.Johannes.USAID%20GLEE%20Presentation%20December%203%202013.pdf

- Technology—ideas and models that have been successful elsewhere
- Demand—by the market or community
- Incentives—e.g., rewards, competition and political pressure
- External catalysts—such as pressure from external actors or political or economic environments

Spaces: Various enabling environments are needed for technologies to reach scale. These include available financial resources, an appropriate legal framework, market demand, institutional capacity, support from decision-makers and key partners, fit with sound environmental practices, and so on.

Figure 3. Linn's Systematic Approach to Scaling Up[6]



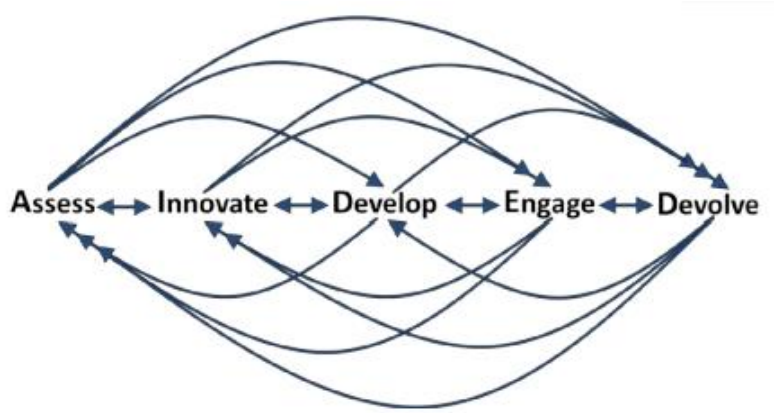
M&E: Linn (2012a, 2012b) points out that there is need for an effective learning process throughout the scaling-up process. This involves systematic monitoring and evaluation focused not only on impact, but also on the effective deployment of the drivers and enabling conditions for the scaling-up process.

2. THE AIDED MODEL FOR DISSEMINATION, DIFFUSION AND SCALE UP

The Yale Global Health Leadership Institute explains the scaling-up process using the AIDED Model, which "can be applied to products, behaviors, organizational forms, and businesses." The model emphasizes the importance of mapping out tailored technology options based on context, supply and demand mechanisms, the networks of institutions in the enabling environment, and the user networks (socio-cultural norms, cooperation and partnerships, information flow to spread innovation message) (Bradley et al, n.d.).

[6] http://agrilinks.org/sites/default/files/resource/files/Linn.Johannes.USAID%20GLEE%20Presentation%20December%203%202013.pdf

Figure 4. The AIDED Model for Dissemination, Diffusion, and Scale Up[7]



The five steps in the AIDED Model are described below:

1. **Assess the landscape**: The first step is assessing user receptivity to the new technology, and enabling environment issues that support or inhibit uptake of the technology. The AIDED Model emphasizes that it is important to distinguish between users' needs in terms of what they perceive as vital for the technology to be able to do, versus their demand in terms of what they prefer between available options. The AIDED Model suggests that assessments could include consideration of:
    - The degree of support in political, regulatory, economic, socio-cultural, technological, and informational environments
    - Users' past experiences with integrating technologies (to assist in avoiding similar challenges or understanding current constraints)

2. **Innovate to fit**: The second step is to tailor technologies to particular users through reiterations, repackaging or improvements to fit with qualities of the user group and environment, making it easy for them to see how it is beneficial to them.

3. **Develop support**: Third, address environmental factors that best support increased use of technology, such as policies, socio-cultural norms and infrastructural components, to increase support and decrease resistance among stakeholders and opinion leaders.

4. **Engage user groups**: Successful scale-up needs integration of new technology into users' practice. This involves contextualizing new technology practices to connect with users' values, typically through opinion leaders, so that the technology becomes integrated into routine practice.

5. **Devolve efforts for spreading the innovation**: The final step is to spread innovation to more user groups through social networks. This includes social network mapping and identifying target user groups to facilitate technology transfer from current to new users.

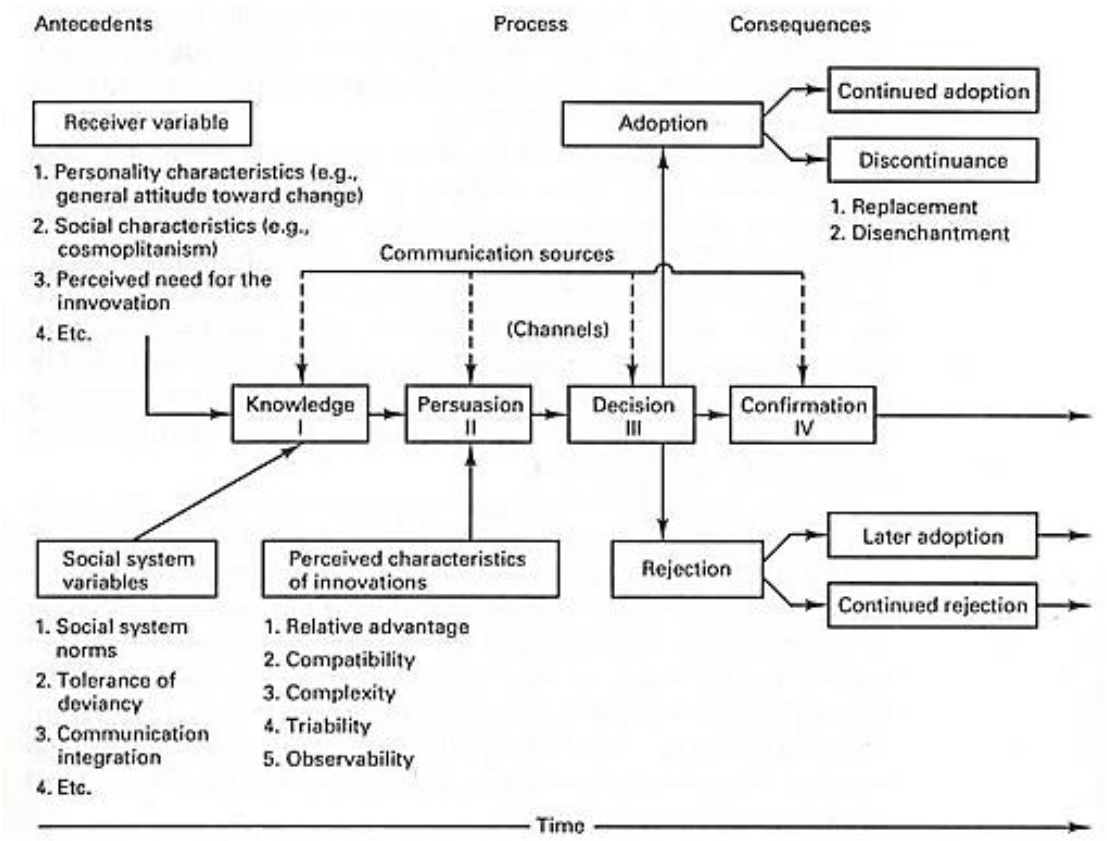
[7] http://www.lmgforhealth.org/sites/default/files/Yale_AIDEDModel_0.pdf

3. ROGERS' DIFFUSION OF INNOVATION THEORY

Everett Rogers explores how innovations are adopted by different groups. He includes technology innovations, although his focus is broader than technologies alone. Rogers identifies five qualities to determine the success of an innovation (Robinson, 2009):

1. **Relative advantage**: "The degree to which an innovation is perceived as better than the idea it supersedes by a particular group of users, measured in terms that matter to those users." The greater the relative advantage, the quicker the adoption rate.
2. **Compatibility with existing values and practices**: "The degree to which an innovation is perceived as being consistent with the values, past experiences, and needs of potential adopters." Those innovations that are incompatible will be adopted more slowly.
3. **Simplicity and ease of use**: The simpler an innovation is, and the easier to use, the quicker its adoption will be.
4. **Trialability**: Those innovations that can be experimented with on a limited basis, or trialed, translate to less uncertainty around the innovation.
5. **Observable results**: "The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it."

Figure 5. Rogers' Diffusion of Innovation Theory[8]



[8] Rogers, E.M. (1995). *Diffusion of innovations (4th edition)*. The Free Press. New York. Retrieved from http://www.ut-wente.nl/cw/theorieenoverzicht/Theory%20Clusters/Communication%20and%20Information%20Technology/Diffusion_of_Innovations_Theory/

4. WHO'S NINE STEPS FOR DEVELOPING A SCALING-UP STRATEGY

The World Health Organization (WHO) describes the scaling-up strategy as "the plans and actions necessary to fully establish the innovation in policies, programmes and service delivery." WHO describes one of the strategic choices in developing a scaling-up strategy as being to decide about the organizational process to scaling up. Examples include: scope of scaling up (extent of geographic expansion; and levels within the system); pace of scaling up (gradual or rapid); number of agencies involved; centralized or decentralized; adaptive or fixed process; and participatory or donor/expert-driven. (WHO, 2010).

The WHO's 'Nine Steps for Developing a Scaling-Up Strategy', (WHO, 2010), discusses the characteristics needed to increase scalability, which include:

- Characteristics of the technology:
  - Credibility (if the innovation has sound evidence or proven advocates)
  - Relevancy (if the innovation adequately addresses problems-at-hand)
  - Advantage (if the innovation is advantageous over other alternatives)
  - Appropriateness (if the innovation fits the needs and context of the user)
- Characteristics of the user organization:
  - Capacity (if the user organization has a perceived need for the technology, the motivation to advocate for its introduction, and has prioritized capacity-building. User demonstrations or pilot testing are helpful in creating this condition.)

The Global Health University attributes failures in scale-up tactics to:

- Inappropriate features of innovation design,
- Preferences of potential users,
- Environments of use (social, economic, or political), and
- Methods of dissemination.

B. ORGANIZING FRAMEWORK

Both WHO's 'Nine Steps for Developing a Scaling-Up Strategy' (WHO, 2010) and Linn (2012a), outline specific strategies for scale up, including vertical scale up ("integration through systematic change" to larger jurisdictions within a geographical area, such as from local to regional to national), horizontal scale up (expansion to new locations or groups), diversification, which Linn refers to as "functional scale up" (adding other functional innovations to address new needs) and spontaneous scale up (unplanned expansion prompted by unexpected needs or circumstances).

- **Vertical scale up (integration through systematic change)**
  In contrast to the vertical linkages typically described in value chain interventions, which are relationships between buyers and suppliers throughout the chain, vertical scale up here refers to systemic change in the market system and enabling environment resulting in environments that are more supportive of integrating new technologies. This includes policy reform and financing mechanisms. The WHO states that "if the government is interested and invested, vertical scale-up is often easier […] With non-governmental organizations or private sector involvement, there may be fewer formalities but other challenges to rapid institutionalization." WHO suggests using strategies that involve "policy briefs, stakeholder meetings, individual activism, political influence, and traction in national policy or budget" to influence vertical scale up.

- **Horizontal scale up (expansion to different locations or groups)**
  In contrast to horizontal linkages typically described in value chain interventions, which are relationships between producers or others at the same level of the chain, horizontal scale up here refers to wide-scale growth or replication of a technology in different locations or by different groups. To be effective, the technology has to be able to adapt to different environments. Successful technology initiatives often work with people who can strategically influence the different opportunities for expansion through participatory communication strategies. Trials or pilots are also used to build an evidence base to advocate for further expansion.

- **Functional scale up (adding other functions to address new needs)**
  Functional scale up is when the technology is intentionally diversified as a result of new needs that emerge. This relates closely to the market systems concept of adaptability, which is essential for competitiveness over time, as well as for resilience to shocks.

- **Spontaneous scale up (unplanned expansion prompted by unexpected needs or circumstances)**
  Spontaneous scale up is the unplanned dissemination of technology prompted by unexpected needs or circumstances. This can be beneficial or present challenges such as the technology being incompletely replicated and not yielding the same results, threatening its credibility.

The various classifications and models discussed above have been combined, reorganized and edited to act as an organizing framework to present the emerging lessons identified through this literature review See Table 1, next page). This framework is predominantly comprised of strategies for scaling up, which are discussed in the context of the development of competitive, inclusive, and resilient market systems.

Table 1. Organizing Framework Drawing on Multiple Scaling-up Frameworks and Theories

Type of Scale Up	Intervention Areas	Emerging Market Systems Strategies
Vertical	Business enabling environment and policy reform	• Facilitate policies that drive behavior changes needed for technology adoption • Facilitate policies that spur demand- and supply-side scaling of agricultural technologies
	Support markets development	• Facilitate financial service provision, including by technology providers, to incentivize adoption and scaling • Strengthen markets for the servicing and repair of technologies • Work with R&D systems to stimulate local, market-driven processes
	Stakeholder engagement and information flow	• Facilitate information flows within market systems that drive technology scaling • Align market actors' incentives to encourage scaling
Horizontal	Commercial distribution and promotion	• Focus on the business model as much as on the technology • Buy down the risk of market actors taking on new behaviors to catalyze technology uptake • Employ demand- and supply-side strategies for effective scale up
	Leveraging champions and networks	• Encourage market actors to target "early adopters" to drive adoption and technology improvements • Support clear visions for scaling • Ensure local opinion leaders are adequately informed about technologies • Support market actors in using social networks that engender trust and facilitate information dissemination • Promote professional networks and linkages to diverse market actors
	Strategic partnerships	• Promote the inclusion of the local private sector in partnerships for scaling up • Strengthen the capacity of national and local institutions responsible for coordination • Bring partners together to strengthen the service offerings of entrepreneurs

	Appropriate and relevant technology	• Build the capacity of technology distributors to understand features that act as drivers for scaling • Facilitate market actor adaptation and localization strategies • Use piloting and local testing to confirm the potential of a new technology and build local experience and capacity • Use smart subsidies to buy down initial investments in new technologies or technology adaptation
	Extension services and behavior change strategies	• Support extension service delivery through various market system actors • Target underlying behaviors and attitudes that eventually lead to technology adoption
Functional	New emerging needs	• Strengthen feedback mechanisms to address emerging needs and spur scale up

III. EMERGING LESSONS

The literature does not appear to have directly explored technology scaling in the context of market systems development. There are, however, many lessons that can be drawn from technology scale-up initiatives that can provide insights into how market systems development strategies can be used to further the scaling up of agricultural technologies.

A. VERTICAL SCALE-UP STRATEGIES

1. BUSINESS ENABLING ENVIRONMENT AND POLICY REFORM

Political conditions often change over time, impacting business enabling environment and policy reform interventions' support of technology scaling. For example, there may be initial political buy-in from the government, but changes in leadership can often take place before technology adoption reaches scale, which can have implications that affect whether or not the scaling-up process is sustained. Emerging lessons suggest the following market systems development strategies:

- Facilitate policies that drive behavior changes needed for technology adoption
- Facilitate policies that spur demand- and supply-side scaling of agricultural technologies

FACILITATE POLICIES THAT DRIVE BEHAVIOR CHANGES NEEDED FOR TECHNOLOGY ADOPTION

Examples from the literature demonstrate how market systems development initiatives can facilitate national and local government structures to implement appropriate policies which drive the behavior changes within the market system that are needed for adoption of technologies.

The Loess Plateau Watershed Rehabilitation Project in China, funded by the World Bank, is frequently cited as a successful case of technology adoption and scale up. The project was successful in transforming a barren area into a thriving agricultural region, improving the livelihoods of three million farmers and their families. The vision for the project was very ambitious, requiring a complete transformation of ingrained agricultural practices and the introduction of new technologies, including new crops and agricultural practices. Part of the project's success is attributed to the government of China implementing a grazing ban in the region. To combat soil erosion, livestock were no longer allowed to graze freely but needed to be kept in fenced-off areas. This forced farmers to take up new farming practices and making associated technology investments, such as constructing animal sheds and pens, procuring fodder-processing equipment, and purchasing animals more suitable for pen feeding. This was necessary to allow for changes in agricultural practices without severe interruption of the farmers' economic livelihoods. The government also created land-leasing options for farmers. This incentivized farmers to invest in upgrading strategies through technology adoption, as they were able to benefit from the output of their fields and orchards. (Mackedon, 2012)

FACILITATE POLICIES THAT SPUR DEMAND- AND SUPPLY-SIDE SCALING OF AGRICULTURAL TECHNOLOGIES

Market systems development initiatives can facilitate scaling through a variety of interventions, including facilitating government to put in place appropriate policies that stimulate the demand/supply and hence scaling of agricultural technologies. The literature points to a variety of policies that have supported both demand- and supply-side technology scaling. These include policies that relate to rural finance and tax incentives, through to import, credit, and interest rate policies.

For example, in recent years, Brazil has instituted rural finance, tax, import, and interest rate policies to make it easier for farmers to access agricultural technologies, such as machinery. As a result, smallholder farmers have adopted mechanized farming techniques and animal traction technologies (including tractors and combine harvesters), agricultural production has risen sharply, and the machinery industry has developed from being a net importer to a world–class exporter (de Assis de Carvalho Pinto, Marcal de Queiroz, and Capucio de Resende, 2013).

2. SUPPORT MARKETS DEVELOPMENT

Effective scaling of technologies requires strong support market systems, including financial systems that provide widespread access to savings mechanisms, credit and insurance; market systems to support the distribution, servicing and repair of technologies; and research and development (R&D) systems. The literature explores examples that can guide market facilitation strategies in supporting both financial and non-financial market system development, with emerging lessons suggesting the following market systems development strategies:

- Facilitate financial service provision, including by technology providers, to incentivize adoption and scaling
- Strengthen markets for the servicing and repair of technologies
- Work with R&D systems to stimulate local, market-driven processes

FACILITATE FINANCIAL SERVICE PROVISION, INCLUDING BY TECHNOLOGY PROVIDERS, TO INCENTIVIZE ADOPTION AND SCALING

The literature demonstrates how financial service offerings, through technology manufacturers and distributors, can incentivize demand-side adoption and expansion of agricultural technologies. Market systems development strategies can facilitate the provision of financial products and services by technology manufacturers and distributors, to incentivize and support early adoption and scaling. These can include financial services such as leasing arrangements, and new payment plans and methods.

As an example, conservation farming technology in Brazil was incentivized through reducing the upfront machinery investment burden through leasing arrangements by equipment providers (Fredrich, 2013). Equipment providers recognized that by offering access to machinery through leases, allowing for lower payments over time, farmers were willing to take on the risk of adopting the new technology.

In another example, a mobile-technology firm, M-KOPA, in Kenya, has developed an innovative mobile technology platform to support asset financing in emerging markets, often in rural, agricultural sectors. M-KOPA Solar offers solar electricity products under an affordable payment plan using cell phone technologies. The innovation lies in the M-KOPA platform, which embeds accounting, customer relationship management, mobile payments, and inventory tracking in one system. M-KOPA was started up by one of the founders of M-PESA. M-KOPA uses the M-PESA platform to process the payment component of its system. Under the payment plan, clients make a down-payment and then daily installments until the product is paid off. The electricity stops working when payments have defaulted and starts up again when new payments have been made (McGregor, 2012). M-KOPA is achieving scale by reaching over 50,000 clients in less than three years.

Similarly, Sygenta's Kilimo Salama pilot in Kenya bundles m-enabled services with agricultural inputs to incentivize the adoption and scaling of agricultural technologies. Kilimo Salama sells affordable agricultural inputs (such as seeds, chemicals and fertilizer) bundled with weather index-based insurance against drought and excess rain at a cost of 5 percent of the inputs purchased. The service also provides three SMSs per season

offering the customer agricultural tips and farming advice. (Kubzansky, 2013) The insurance is distributed to farmers via a mobile application through local agrodealers, which according to the firm, is an innovative distribution channel for agricultural micro-insurance (Kilimo Salama, 2010).

STRENGTHEN MARKETS FOR THE SERVICING AND REPAIR OF TECHNOLOGIES

A support system for the servicing and repair of technologies is essential to the long-term sustainability of technology adoption at scale. Although there have been some improvements in tools and implements over time, the literature claims that a continuing major constraint to poor, small-scale farmers adopting mechanized agriculture is difficulty in getting spare parts, as well as the lack of training on good maintenance of machinery and inadequate facilities for servicing and repair. Long and Brindley (2013c) explain that it is important to ensure that there is skilled labor available locally in order to service technologies. Shrestha (2012) found that in Nepal, where animal and human power represent over 70 percent of the total farm power available, agricultural mechanization policy needs to focus on improved access to related institutions such as distribution networks for spare parts and service centers for repairs and breakdowns in order to increase the percentage of Nepalese farmers using mechanical power. Currently, the cost of spare parts for equipment used, even when available, is too high, and most tractor dealers focus on tractor sales and not on related services.

WORK WITH R&D SYSTEMS TO STIMULATE LOCAL, MARKET-DRIVEN PROCESSES

Goldstein, Hazy, and Silberstang (2010) describe the Social Entrepreneurship and Economic Development project that was established in the village of Cisondari near Jakarta, Indonesia. Local townspeople set up a group in 2008 in collaboration with the Bandung Institute of Technology, the Singapore Management University, and the Asia Research Centre of the International Management Division of the University of St. Gallen, Switzerland, to generate innovation for the benefit of local economic development. In this model, uneducated farmers joined with research professors; economic development specialists worked with nutritional experts; and poor villagers developed objectives with much wealthier funders to create a systems thinking approach to testing innovation, experimentation and scaling. The authors argue that this close collaboration between academics and community members is the reason that innovations were accepted and utilized by the entire town and throughout the region.

3. STAKEHOLDER ENGAGEMENT AND INFORMATION FLOW

Due to the extended timeframe of most scaling-up processes, it is critical to have buy-in from multiple actors over the long term. The literature describes relevant stakeholders to include governments, civil society, the private sector, donors and beneficiaries. Through its own institutional review, IFAD found that local government ownership, engagement, support and capacity of key functional ministries are key to scaling up (Hartmann et al, 2013). In addition to general support for stakeholder engagement, emerging lessons suggest the following market systems development strategies:

- Facilitate information flows within market systems that drive technology scaling
- Align market actors' incentives to encourage scaling

FACILITATE INFORMATION FLOWS WITHIN MARKET SYSTEMS THAT DRIVE TECHNOLOGY SCALING

Market facilitators can support the development of information flows among market actors that drive the adoption, adaptation, and scaling of technologies. Oxfam's rice intensification program in Vietnam, for exam-

ple, worked to make the System of Rice Intensification (SRI) available at scale in northern Vietnam to smallholder farmers.[9] The program found that "Farmers' own findings and their messages are powerful in vertical scaling and leveraging political support" (Castillo, Le, and Pfeifer, 2012). The first stage of the program involved local testing, through Farmer Field Schools with over 1,000 farmers, to confirm the potential of SRI in northern Vietnam and to build the local experience of extension agents, technicians, and farmers. Farmers reported increased yields by 9 to 15 percent while at the same time decreasing their inputs, which has resulted in an average increase in income of US$95–$260 per hectare per crop season, and positive changes in the health and the farmers and their environment (Castillo, Le, and Pfeifer, 2012). As a result, the Minister of Agriculture "officially acknowledged SRI as a technical advancement and paved the way for broader local-level application of SRI, with provincial governments able to access central government funding to support SRI extension" (Africare, Oxfam America, WWF-ICRISAT Project, 2010).

ALIGN MARKET ACTORS' INCENTIVES TO ENCOURAGE SCALING

Facilitating the alignment of market-based incentives across market actors can support the sustainable adoption of technologies at scale. Kohl (Agrilinks, 2014) discusses incentives as one of the major challenges in scaling. He suggests considering:

- Who is going to do this?
- What is the political interest of the various stakeholders and why would they get on board?
- If we are working with a value chain, what is the business case for the private sector to get involved?
- Are they going to make money?
- Is this their target market?
- What is the risk?

Kohl emphasizes that if incentives are not aligned among the public and private sector, and the beneficiaries or participants themselves, a breakdown in the scaling-up process can occur. In the context of technologies specifically, he emphasizes the need to align incentives among market actors such as the interface between frontline service delivery, people providing agricultural machinery services, people selling seeds, those providing agricultural extension, farmers themselves, and wholesalers and retailers who are buying from farmers (Agrilinks, 2014).

B. HORIZONTAL SCALE-UP STRATEGIES

1. COMMERCIAL DISTRIBUTION AND PROMOTION

Technology access is often based on models that rely on subsidies, which limits the potential for scaling. Similarly, models relying on collective ownership of assets often face problems with sustainability. For example, Manje and Snelgrove (n.d.) comment on irrigation equipment provided by a project in Zambia: "Acquisition did not include access to spare parts and after-sale service support, as they were received for free, farmers did not appear to care about continued functionality." In addition, "failed irrigation schemes owing to challenges of collective ownership and management" created more challenges for sustaining scale up

[9] SRI differs from conventional rice planting techniques, as it "encourages farmers to optimize the performance of the individual rice plant rather than maximize inputs" (Castillo, Le, and Pfeifer, 2012).

(Manje and Snelgrove, n.d.). The authors provide a comparison between technology uptake and scaling through a commercial model versus a more traditional funding model (see table 2).

Table 2: Comparisons between technology adoption and scaling in a commercial model and subsidized handout model

Lens	Commercial Model of Technology Adoption & Scaling	Subsidized Handout Model of Technology Adoption & Scaling
Product demonstration	Product demonstration is conducted by technology suppliers; good start of supplier-buyer interactions	Product demonstration is usually provided by the NGO
Access	Provide equal and wide access to farmers who would like to acquire the technologies	Access limited to the provider's target group, normally selected by an NGO
Ownership	Promotes individual ownership and responsibility	Technologies mainly provided under collective ownership and hence do not promote individual ownership and responsibility
Promoting economic choice	Farmers are able to select technology based on needs and preferences	NGO selects technology and provides to farmers
Entrepreneurial spirit	Strengthens entrepreneurial spirit among technology buyers	Does not promote entrepreneurial spirit as there is no financial commitment on the part of the technology recipients
After-sales service support and access to spare parts	Farmers more concerned about after-sales service support and availability of spare parts	Farmers usually do not know where they can obtain after-sales support or purchase spare parts as acquisition is not directly through the technology supplier or dealer
Supplier-buyer linkage	Good prospects of ongoing interactions between suppliers and farmers	Farmers normally have no direct linkage to suppliers
Supply chain development	Good prospects of developing a sustainable supply chain	Model is often disruptive to efforts to build a commercial supply chain

Although the table above highlights that commercial strategies can be more effective strategies for sustainable scale-up, Kohl (Agrilinks, 2014) provides the perspective that even existing commercial channels may not be adequate to achieve scale, but rather that entirely new models may be needed. Kohl explains that there is a tendency for technology to be distributed via traditional service delivery channels, such as existing private-sector providers of inputs, buyers of outputs upstream or downstream from farmers, government agricultural extension systems, or NGOs that are providing technical assistance. He points out that existing service delivery channels tend to be "biased to replicating the inequities in access that already exist in service delivery."

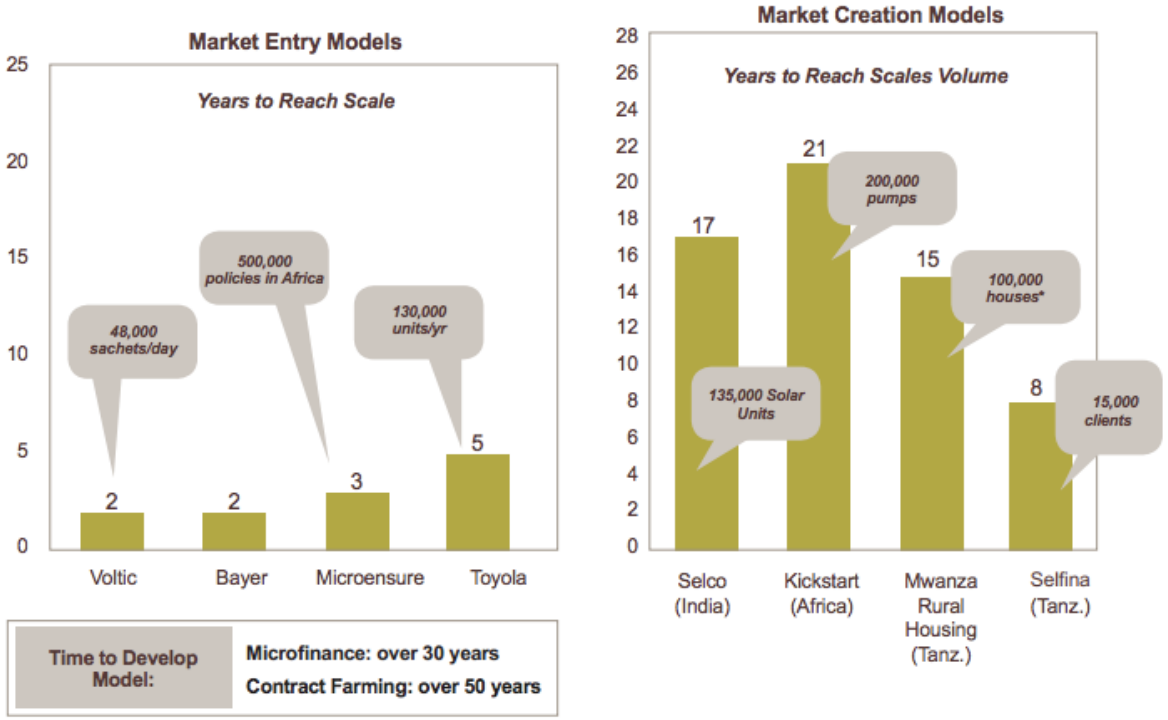
The literature related to commercial models for the distribution and promotion of technologies includes emerging lessons suggesting the following market systems development strategies:

- Focus on the business model as much as on the technology
- Buy down the risk of market actors taking on new behaviors to catalyze technology uptake
- Employ demand- and supply-side strategies for effective scale up

FOCUS ON THE BUSINESS MODEL AS MUCH AS ON THE TECHNOLOGY

Kubzansky (2012) points out that in private sector-led development, business models often matter far more than the underlying product technologies. Low-income markets (markets with low purchasing power and variable cash flows) require different business models to middle-income markets. Kubzansky describes *market entry business models* as targeting markets where low-income consumers are already accustomed to paying for a good or service, even if "informally, expensively and sometimes for life-endangering quality." Examples include money transfers, where M-PESA substituted for already existing expensive and insecure transfers of cash; and cookstove technologies, where many consumers already pay for both cookstoves and sometimes fuel. The underlying demand makes it faster to achieve large-scale reach, because the task and cost of creating demand is far lower (see figure 6).

Figure 6: Time to Scale Up of Different Business Models[10]



Note: The different industries for the companies listed above include Voltic, drinking water in Ghana; Bayer, chemical crop protection in Kenya; Microensure, bundled credit life coverage via microfinance institutions; Toyola, clean cookstoves in Ghana; Selco, solar home systems in India; Kickstart, irrigation pumps in East Africa; Mwanza, rural housing Tanzania; and Selfina, microleasing in Tanzania.

[10] http://www.brookings.edu/~/media/research/files/reports/2012/10/blum%20roundtable/10%20business%20models%20kubzansky.pdf

Kubzansky describes *market creation business models* as attempting to create markets among the bottom of the pyramid for "socially beneficial goods and services that are not usually paid for by low-income households, require significant amount of trust, and often entail behavioral change and related communications." Investments in behavioral change, for instance, in irrigation, do not benefit only the first private company to invest in this area, but the whole category of private players involved in supplying irrigation technology. "Such investment is a public good, but the cost can render a given business model unviable if left to one enterprise to cover." Market creation business models involve finding a business model that works, requiring experimentation and failure. Kubzansky also explains that *mature models* scale faster than *less proven models*, as there is more of a challenge in covering fixed costs and piloting cost. Many private sector firms and impact investors tend to focus on later stage, less risky, easier-to-reach segments and markets, which require less business model adjustment and cost.

In Timor Leste, where over 80 percent of the population survive on agriculture, Mercy Corps, through the European Commission-funded Energy for All (E4A) program, is supporting the development of commercial markets to provide access to clean, reliable and affordable forms of energy. In urban areas, where consumers are willing to pay for fuel, clean cooking stove uptake is significantly faster than in rural areas where (free) collection of fuel is prevalent. (Mercy Corps, project info, 2014).

BUY DOWN RISK OF MARKET ACTORS TAKING ON NEW BEHAVIORS TO CATALYZE TECHNOLOGY UPTAKE

Suppliers and buyers in weak markets are not likely to respond to new market opportunities independently. Mechanisms, such as vouchers subsidized through development funds, can be used as a short-term strategy to catalyze the market while complementary, longer-term solutions—such as access to financing—are being developed. Subsidized vouchers can act as an incentive for private sector firms to start providing certain technologies or promoting those technologies to new target audiences. For example, MEDA's project in Zambia accelerated supply and demand for water technologies (treadle pumps, hip pumps and drip irrigation systems) to underserved rural populations. MEDA implemented a successful, commercially-driven model using a discount promotion strategy (via vouchers) through technology suppliers. Discount vouchers served as an incentive to reduce risk aversion among farmers, and technology demonstrations led to increased sales as farmers saw firsthand the environmental and financial benefits of owing these technologies. The vouchers also served as an incentive to draw irrigation suppliers into the rural areas (Manje and Snelgrove, n.d.).

SLOW PRIVATE SECTOR UPTAKE

"MEDA's program design required private sector water technology suppliers to be proactive in direct marketing and selling of the water technologies. This entailed investments in technology promotions, marketing campaigns and retail networks closer to farmers. After the first year, it was clear that water technology suppliers needed to invest in dynamic retail networks that reach farmers even in the remote rural areas. Since most of the suppliers were used to NGO sales which did not require them to directly interact with farmers, jumping at this opportunity and innovatively implementing marketing and sales strategies was challenging. For this reason, water technology sales were low in the first year; only 500 water technologies were sold directly to farmers under the discount voucher promotion. However, with additional coaching and by seeing the ability of farmers to purchase technologies, suppliers eventually started investing in marketing and by the second year over 1,300 sales had been made."

Source: Manje and Snelgrove, n.d.

EMPLOY DEMAND- AND SUPPLY-SIDE STRATEGIES FOR EFFECTIVE SCALE UP

To strengthen a market system that can support sustained scale-up strategies, both demand- and supply-side strategies can be leveraged. As an example, based on a market facilitation strategy, ACDI/VOCA employed a model in Kenya that included both supply- and demand-side interventions to promote improved crop protection products and services at scale (reaching 370,000 smallholder farmers). These interventions included encouraging input suppliers to package branded products in small quantities to encourage experimentation, sponsorship by commercial firms of on-farm demonstration plots, and supporting the development of input supplier agent networks. (ACDI/VOCA, 2010).

2. LEVERAGING CHAMPIONS AND NETWORKS

Linn (2014) speaks about leaders of the microfinance giants BRAC and Grameen Bank in Bangladesh as examples of institutional champions who have been responsible for significant scaling of a variety of technologies, ranging from new agricultural practices to mobile phone applications. Technology providers or development practitioners can work with proven technology providers to lend credibility and support scaling of new technologies. M-PESA is a well-cited example of successful scaling due to the trusted, well-known Safaricom brand acting as a proven advocate for any of Safaricom's new technology platforms or functions (infoDev, 2013; Morawczynski, 2010; Ngugi, Pelowski and Ogembo, 2010).

But potential champions for driving or supporting scaling up extend beyond established lead firms, and may include community leaders, early adopters, and visionaries. These champions may also have networks that can be leveraged to further drive scaling up. The literature related to the leveraging of champions and networks includes emerging lessons suggesting the following market systems development strategies:

- Encourage market actors to target "early adopters" to drive adoption and technology improvements
- Support clear visions for scaling
- Ensure local opinion leaders are adequately informed about technologies
- Support market actors in using social networks that engender trust and facilitate information dissemination
- Promote professional networks and linkages to diverse market actors

ENCOURAGE MARKET ACTORS TO TARGET 'EARLY ADOPTERS' TO DRIVE ADOPTION AND TECHNOLOGY IMPROVEMENTS

Robinson (2009) discusses Everett Rogers' *Diffusion of Innovations* (2003, 5th edition) in which a population can be divided into five segments: innovators (representing 2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%).

According to Robinson (2009), Rogers argues that in general, what *early adopters* say about an innovation determines its success. Depending on the type of technology in discussion, the literature defines early adopters as lead farmers, innovators and visionaries. Ngugi, Pelowski, and Ogembo (2010) describe early adopters as those who "are willing to risk the costs of a new technology if there is compelling evidence that the new technology can help achieve business or personal goals." Early adopters need no incentive for adoption other than the technology itself, although direct interventions such as subsidies or discounts can act as incentives to spur uptake by early adopters (Magnan et al, 2013).

The literature explains that as with other behaviors, people adopt technologies more readily when they are aware of peers who have served as early adopters, proving the value of the technology and therefore reducing the risk of adoption for others. As an example, Magnan et al (2013) say that having an early adopter in a farmer network increases other farmers' perceived value of the technology. The authors share examples of

exposing farmers to early adopters of a particular technology through field visits to the early adopters' fields. They note that their study suggests that, "seeing results is essential; the diffusion of knowledge about the technology via farmer-to-farmer contacts is conditionally dependent on direct observation by the farmer" (Magnan et al, 2013).

Early adopters can be used not only to spur uptake by peers, but also to provide feedback on the need for improvements in the technology (Fredrich, 2013; Robinson, 2009).

SUPPORT CLEAR VISIONS FOR SCALING

Management Systems International (MSI) stresses that it is important to have a visionary behind a project or company, to take the vision to scale. Technology providers or project implementers do well to define, in their initial stages, a clear vision of what scale looks like and the path to reach it, in order to realistically determine how to approach the scale-up process (MSI, 2012a). As examples, key visionaries were behind the success of the Olyset mosquito net, and the Microfinance International Corporation which provides remittance and other services to bottom of the pyramid clients (Kato and Hosono, 2013).

Visionaries typically also need to be able to relate directly to the target market to more effectively drive strategies to scale. D'Andrea et al (2011) describe how almost all successful Latin American retailers targeting emerging consumers "started as humble, small-scale projects by low-income entrepreneurs. The active presence of founders who rose from poverty and understand customers' needs from their own personal experience provides inspiration and meaning to the purchasing process."

ENSURE LOCAL OPINION LEADERS ARE ADEQUATELY INFORMED ABOUT TECHNOLOGIES

Bello and Obinne (2012) found that interpersonal channels, such as between local opinion leaders and farmers, are useful sources of information for rural farmers; however, there is a need to address the quality of information that comes through these channels. They explain that information dissemination to rural farmers needs to be tailored to real problems, real applications and real situations around technology use. Although they find that this can be delivered through local opinion leaders, they reinforce that local opinion leaders do, however, need to have enough training to be able to process mass media information to ensure that quality information is transferred. At the same time, they need to have enough of a connection with rural farmers to be able to understand and articulate their needs well.

Within agriculture, successful farmers are often local opinion leaders. Fredrich (2013) discusses the importance of progressive farmers in the uptake of conservation agriculture technology. He explains that because conservation agriculture is a knowledge-intensive concept, adoption must take advantage of experienced practitioners who can mentor newcomers.

SUPPORT MARKET ACTORS IN USING SOCIAL NETWORKS THAT ENGENDER TRUST AND FACILITATE INFORMATION DISSEMINATION

Magnan et al (2013) describe how farmers in India often rely on social networks as their most trusted source of information. The authors advocate that these networks should be tapped into to provide exposure to new technologies, and therefore to influence behavior change and technology uptake. The authors maintain that there are usually higher levels of trust through communication within the same social classes. For example, when selecting lead farmers as demonstrators of a new technology, it works well to include poor farmers within the group of lead farmers, since the strongest relationships are peer-to-peer relationships among poor farmers.

Robinson (2009) draws an important insight from Rogers' Diffusion of Innovations, stating that "impersonal marketing methods like advertising and media stories may spread information about new innovations, but it's conversations that spread adoption." For this reason, Rogers emphasizes peer-to-peer conversations and peer networks. Over time, adoption due to mass media becomes less influential, whereas adoption due to interpersonal communication becomes more influential (Robinson, 2009).

PROMOTE PROFESSIONAL NETWORKS AND LINKAGES TO DIVERSE MARKET ACTORS

Research on networks of influence and patterns of interactions look at how information about technology and innovation is diffused through networks of friends and neighbors, extension agents, NGOs, input suppliers, and other actors. Network members may explicitly influence farmers' decisions to adopt innovation (through technology transfer, technical advice, and joint learning) or implicitly influence these decisions (by providing opinions and information). For example, research from Bolivia (Monge, Hartwich, and Halgin, 2008) showed that adopters of technology and practices in quinoa production had links with farmers' associations and NGOs as well as with other quinoa producers, whilst non-adopters of technology only had links with other farmers. In peanut production, adopters of technology also had linkages with multiple market actors, maintaining effective interactions not only with NGOs and farmers' associations but also with product buyers and input suppliers.

3. STRATEGIC PARTNERSHIPS

Successful scaling of technologies requires building strategic cooperation and partnerships at multiple levels: global, national, and local. MSI (2012a) notes the importance of partnerships, stating that "partnerships between institutions with complementary resources and strengths can be a synergistic way to provide the resources needed for the scaling up process." Expansion to different locations or to different groups is supported through the formation of appropriate, strategic partnerships. As an example, the scaling of long-lasting insecticide-treated mosquito nets in Africa was made possible through a consortium that included the company behind the technology (Sumitomo Chemical), the largest bed net manufacturer in Africa, international organizations, the private sector, and NGOs. This consortium facilitated cost efficiencies and wider distribution across the continent (Kato and Hosono, 2013).

The literature related to partnerships for scaling up includes emerging lessons suggesting the following market systems development strategies:

- Promote the inclusion of the local private sector in partnerships for scaling up
- Strengthen the capacity of national and local institutions responsible for coordination
- Bring partners together to strengthen the service offerings of entrepreneurs

PROMOTE THE INCLUSION OF THE LOCAL PRIVATE SECTOR IN PARTNERSHIPS FOR SCALING UP

At the global level, an example of a key strategic partnership to support scaling of technologies is the Alliance for a Green Revolution in Africa (AGRA). AGRA has effectively released and disseminated over 150 new seed varieties across sub-Saharan Africa through its Program on African Seed Systems (Pingali, 2012). During this process, it became very clear that more proactive steps had to be made to strengthen and include the private sector at the local level. This led to the creation of the Agro-Dealer Development Program, which expects to provide training, capital and credit to establish 9,000 certified agro-dealers. AGRA describes a strong agro-dealer system as "crucial to farmers' success because these local retailers serve as the primary conduits of farm inputs such as seeds and soil nutrients, and knowledge about their safe and efficient use" (AGRA website).

STRENGTHEN THE CAPACITY OF NATIONAL AND LOCAL INSTITUTIONS RESPONSIBLE FOR COORDINATION

In Ethiopia, multiple donors, including USAID, Feed the Future, UNDP, World Bank, and Rockefeller Foundation, are supporting the government's strategy to increase smallholder productivity through support to the Agricultural Transformation Agency, which "has been instrumental in bringing about improved coordination not just among the national agencies involved in agricultural development but also across the multitude of bilateral and multilateral agencies supporting Ethiopia's development" (Pingali, 2012). But Pingali also notes that the ability to successfully partner with national and local institutions is constrained by their technical, policy, and management capacity, since institutions that are strong in these areas are often flooded with donor requests.

BRING PARTNERS TOGETHER TO STRENGTHEN THE SERVICE OFFERINGS OF ENTREPRENEURS

Entrepreneurs, including agro-dealers, often need to be able to offer multiple services and/or products to smooth income and remain profitable in low population density areas (Fowler and White, 2015).

To distribute wireless telephone networks, TechUniv set up an operating infrastructure of phone and internet kiosks in villages run by entrepreneurs. The kiosk served as a focal point to aggregate all kinds of demand for services, such as those related to education, healthcare and finance. The kiosk entrepreneurs helped to disseminate new services and ventures as additional entrepreneurs were drawn into the network. This included the installation of a low-cost weather monitoring kit in each village to enable agricultural weather-based insurance companies to obtain accurate data (Surie, 2011).

4. APPROPRIATE & RELEVANT TECHNOLOGY

When promoting technology adoption at scale, sophisticated technologies are not always the most appropriate. For example, the literature shows that radio is in many cases still a preferred technology to other forms of ICT, and mobile phones with basic functionality are often preferred over more sophisticated models, as simple processes are more easily remembered by the less literate (Long and Brindley, 2013b).

An FAO report (2010) describes how even in countries that are rapidly urbanizing—such as India, Mexico, Brazil, and South Africa—animal power remains important and highly persistent in rural areas. While large-scale farms use tractors, many small-scale farmers continue to use animal power because of the various benefits: it is a renewable energy source; the animal contributes to food production through milk, meat, manure and offspring; and maintenance is relatively easy compared to engine maintenance, which requires access to spare parts and mechanics.

The literature related to ensuring the appropriateness of technologies includes emerging lessons suggesting the following market systems development strategies:

- Build the capacity of technology distributors to understand features that act as drivers for scaling
- Facilitate market actor adaptation and localization strategies
- Use piloting and local testing to confirm the potential of a new technology and build local experience and capacity
- Use smart subsidies to buy down initial investments in new technologies or technology adaptation

BUILD THE CAPACITY OF TECHNOLOGY DISTRIBUTORS TO UNDERSTAND FEATURES THAT ACT AS DRIVERS FOR SCALING

The literature highlights several inherent characteristics of a technology as key drivers. Low capital requirements, enhanced by the ability to share technologies among users, and ease of use, all act as drivers to the uptake and scaling of agricultural machinery (Hatibu, 2013). These factors have been found to support the adoption of a human-powered irrigation pump, the MoneyMaker, designed and sold by KickStart International (Sijali and Mwago, 2011). The MoneyMaker pump requires a comparatively low capital outlay compared to similar irrigation systems, is often shared among users (studies showing that 33% of the pumps get lent out to neighbors), and is easy to use by both men and women.

Technologies that allow users to improve access to new markets incentivize scaling. The literature discusses how people, even those at the bottom of the pyramid, are willing to pay for technologies that guarantee market access. Sauerhaft and Hope-Johnstone (2012) cite the example of PepsiCo introducing drip irrigation to potato farmers in India. In this case, farmers were willing to adopt this technology because it ensured a guaranteed market for their potatoes through PepsiCo. Similarly, Hatibu (2013) describes the improved adoption of mechanization for cotton production on state farms in Tanzania, Uganda and Ethiopia, as it guaranteed a market for the cotton.

In contrast, a lack of market access has been cited as a reason for the failure of scaling technology in the past. For example, improved seeds for maize production were introduced in Ethiopia, and although farmers saw increased yields, they were never scaled because there was a lack of buyers for the resulting crops (IFPRI, 2014).

FACILITATE MARKET ACTOR ADAPTATION AND LOCALIZATION STRATEGIES

Adaptation and localization strategies are central to expanding to new markets and bringing technology to scale. A lesson highlighted throughout the literature is that if a model works in one context, there is no guarantee that it will be adopted and scaled elsewhere. As an example, the mobile money platform in Kenya, M-PESA, has not been nearly as successful in Tanzania (Morawczynski, 2010; Ngugi et al, 2010). M-PESA has successfully scaled vertically and functionally, but less so horizontally outside of Kenya. One explanation for the lack of horizontal scaling in Tanzania is that Safaricom has almost an 80% market share in Kenya, whereas Vodafone's market share in Tanzania is half as large, at around 40% (Rasmussen, 2009, as cited in Ngugi, Pelowski, and Ogembo, 2010). Another explanation is that Kenyans adopted M-PESA because it was a technology created by Kenyans, whereas Tanzanians viewed it as a foreign technology (Ngugi, Pelowski, and Ogembo, 2010).

A technology may work as it was intended in a new location but might not be suited to the local preferences in the region and, therefore, will not be adopted or scaled. For example, an improved seed variety for a crop cultivated for home consumption may be imported from another region and grow well in the new location. But the variety is unlikely to be adopted if it makes preparation and cooking more difficult, or if the household does not like the flavor or texture (Adesina and Akinwumi, 1993 and Gafsi and Roe, 1979, as cited in Jack, 2013).

In Brazil, the manufacturing industry for tractors and combines for smallholder farmers is dominated by multinational companies. Brazilian companies have however been developing and delivering technological (niche) equipment for tropical crops; for example, for mechanization of the production of beans, sugar cane and coffee. In this way the country has developed a domestic industry for niche machines alongside promotion of imported machinery (de Assis de Carvalho Pinto, Marcal de Queiroz, and Capucio de Resende, 2010).

USE PILOTING AND LOCAL TESTING TO CONFIRM THE POTENTIAL OF A NEW TECHNOLOGY AND BUILD LOCAL EXPERIENCE AND CAPACITY

Oxfam's work in Vietnam to scale SRI encouraged local testing across a wide range of local contexts. This built "an evidence base confirming the potential of SRI and ...local experience in extension approaches that [enabled] farmers and local technicians to adapt SRI principles and learn how to maximize benefits for themselves." Farmers tested SRI to "assess crop performance, profitability, and scope for local adaptation" (Castillo, Le, and Pfeifer, 2012). As SRI gained greater support, there was a risk that proponents would lapse into presenting it as a quick set of prescriptive steps: fixed seedling age, fixed spacing, fixed fertilizer regimes, and fixed water regimes. While this approach will give some positive outcomes, it generally limits farmers' own learning and the program's long-term goals. The program has therefore worked hard to ensure that SRI remains principle based rather than prescriptive. It emphasizes farmer experimentation, which takes more time and requires genuine investments in building the capacity of farmers and the ability of extension service providers to keep pace with the plans of individual farmers.

USE SMART SUBSIDIES TO BUY DOWN INITIAL INVESTMENTS IN NEW TECHNOLOGIES OR TECHNOLOGY ADAPTATION

Market systems development initiatives could strategically subsidize initial technology adaptation and adoption, as high upfront costs to introduce new technologies and build a critical mass of users can lead to much lower-cost replication to other areas later.

For example, bio-fortification of staple food crops can be a sustainable way to deliver nutrients to the poor. The first bio-fortified crop to be released was the orange sweet potato, which is rich in vitamin A, and has been distributed in areas of Africa where there are vitamin A deficiencies and where the white or yellow sweet potato varieties (which have little or no vitamin A) are traditionally consumed. In order for bio-fortification technology to be successfully scaled, the cost of delivering the nutrients through food crops must be lower than the cost of other interventions such as vitamin A supplementation. According to Bouis, Howdy and Yassir Islam (2012), "once a critical mass of orange sweet potato adopters and producers were established in a region (at a relatively high cost per household), complementary activities encourage diffusion of orange sweet potato at a lower cost to neighboring villages."

5. EXTENSION SERVICES AND BEHAVIOR CHANGE STRATEGIES

Technology adoption is often promoted through extension agents and mass media campaigns. Hanyani-Mlambo (2002) describes several categories of extension agents, ranging from public agricultural extension service providers and public research organizations, through to NGOs and donor-supported rural development programs. The author describes typical weakness in extension services in Zimbabwe as including lagging technical knowledge, outdated communication methods, weak in-service training, limited on-the-ground coverage, and poor availability of logistical support, such as having no transport or equipment. Ozowa (1997) similarly notes the high ratio of farmers to extension workers in Nigeria (one extension worker to 1,500 to 3,000 farmers in parts of the country) as inadequate for effective agricultural information diffusion. The problem is compounded by the scarcity of women in extension, especially in a society where cultural taboos make it difficult for male extension workers to reach women farmers.

Mass media channels can be useful sources of information for rural farmers (Bello and Obinne, 2012). However, one of the key limitations is that messages are not tailored to the information needs of rural populations. In addition, broadcast media may be restricted by poor reception in some areas and the inappropriate timing of broadcasts; and printed material developed to disseminate technical information about complex farming practices or products is often incomprehensible to farmers (Ozowa, 1997).

The literature suggests the following market systems development strategies:

- Support extension service delivery through various market system actors
- Target underlying behaviors and attitudes that eventually lead to technology adoption

SUPPORT EXTENSION SERVICE DELIVERY THROUGH VARIOUS MARKET SYSTEM ACTORS

The lack of technical knowledge of many extension workers in developing economies is well documented. Adebayo (2004) suggests that private-sector involvement in the design and delivery of extension services is key to addressing this weakness. The author notes, "Credibility comes through as an important consideration from the point of view of clients. The fact that extension services are provided by the private sector, even when it is funded by government, is a positive feature." However, Mbowa, Shinyekwa, and Lwanga (2012) provide a cautionary tale in the privatization of veterinary extension services delivery in Uganda, which led to the market being flooded with untested and substandard inputs, contributing to non-adoption of essential inputs by small-scale dairy farmers.

Market development initiatives can therefore play a role in supporting the emergence of accredited agents. Fowler and White (2015) highlight a number of market development projects that successfully established or supported networks of private sector agents that provides inputs, services and extension advice. These include the PROFIT project in Zambia, which reached 180,000 farmers through its input sales agent network; the MSME project in Cambodia, which supported 3,849 smallholder-operated enterprises to deliver vaccines in the swine value chain; and the Sunhara project in India, which used private-sector franchisees to reach over 10,000 potato producers. Schwartz (1994) notes the complementarity of public- and private-sector extension and the growing prevalence of blended approaches to service delivery.

TARGET UNDERLYING BEHAVIORS AND ATTITUDES THAT EVENTUALLY LEAD TO TECHNOLOGY ADOPTION

Technology adoption may be limited by a lack of information, knowledge or skills, as well as by low tolerance for risk. For example, in Gujarat, India, research by Gaurav, Cole, and Tobacman (2011) showed that financial education had a positive and significant effect on rainfall insurance adoption, increasing uptake from 8% to 16%. A money-back guarantee (a full refund if the policy did not make any payouts) also had a consistent and large effect on farmers' purchase decisions.

But risk and knowledge may not be the only factors influencing how decisions regarding technology adoption are made by the rural poor. Underlying attitudes and behaviors that constrain adoption need to be identified and changed before wide-scale adoption is likely to take place. In many public-sector agricultural extension programs agents deliver technical information on agricultural technologies but do not address underlying attitudes, and thus neither sustain the farmers' interest nor effect the desired attitudinal change (Ozowa, 1997). Similarly, Castillo, Le, and Pfeifer (2012) criticize extension services that overlook farmers' needs and "rely on prescriptive, top-down approaches that have failed to invest in their ongoing adaptive capacity."

Market facilitators therefore need to identify underlying behaviors and encourage farmer experimentation and learning. Farmer participation in design and delivery of the Oxfam's rice intensification program in Vietnam "fostered buy-in, helped to garner support for horizontal scaling, and facilitated functional expansion and longer-term systemic changes." The extension services work in a more "participatory manner and are increasingly able to integrate farmers' challenges and demands." (Castillo, Le, and Pfeifer, 2012).

Ragasa (2012) draws on the literature and 35 case studies to identify a broad range of gender norms and practices that limit women's uptake of technology. She concludes that efforts to scale-up technology adoption should include "championing the cause of gender equality and women's empowerment."

C. FUNCTIONAL SCALE-UP STRATEGIES

1. NEW, EMERGING NEEDS

Agricultural technologies must be adapted to local agro-climatic conditions; they may need to be altered to respond to shifts in market demand; and may be able to be repurposed to take advantage of new opportunities. The literature suggests that feedback mechanisms from the users to the producers and distributors of technologies are essential for functional scaling up.

STRENGTHEN FEEDBACK MECHANISMS TO ADDRESS EMERGING NEEDS AND SPUR SCALE UP

As an example, the M-PESA mobile money system in Kenya has scaled up functionally by recognizing a new need among the user base: the ability to save money, not simply transfer funds. M-PESA has therefore added mobile savings accounts to their technology platform, which has supported scale up. (Vaughan, Fengler, and Joseph, 2013).

Sijali and Mwago (2011) provide the example of KickStart's irrigation pump, the MoneyMaker, which has evolved based on users' expressed needs. For example, the original MoneyMaker could only pump water 7 meters deep into the ground. Based on feedback, it was adapted to be able to push water through sprinklers and hosepipes, facilitating much larger uptake by rural farmers.

IV. GAPS IN KNOWLEDGE

Despite the important lessons that have been drawn from the literature around scaling technologies, there remain gaps in knowledge and research.

1. LACK OF DATA ON TECHNOLOGY SCALING

Some of the literature notes the challenge of discussing scaling up technologies when there is a lack of current or comparative data on technology uptake. For example, Ragasa et al (2013) note that the last official nation-wide maize technology adoption impact study in Ghana was in 1997, making it difficult to have evidence-based discussions about the adoption process.

2. LACK OF SCALING STRATEGIES FOR TECHNOLOGIES THAT DO NOT HAVE IMMEDIATE BENEFIT

Little information is available about how to scale technologies that do not result in quick returns on investment. In such cases, scalability is challenged as the demonstration effect and resulting investment take much longer to occur.

Another area where there is a lack of information is how to scale technologies that are necessary to address future challenges, such as climate change, but might not affect the short-term growing season. A recent IFPRI publication provides useful examples. Rosegrant et al (2014) discuss four technologies that research has shown will have significant positive effects on yields by 2050, taking into account externalities such as climate change. One of these technologies is no-till farm management. This type of technology takes time, often several growing cycles, to begin to show results, thus requiring significant trust and investment on the part of farmers. The adoption of no-till farm management requires farmers to think about the future health of the soil, which can be difficult for subsistence farmers who need good shorter-term yields. The authors admit that further research needs to be done on the best methods of scaling this type of technology.

3. LIMITED PUBLISHED RESEARCH ON LEARNING FROM PRACTICAL IMPLEMENTATION

Many of the examples being presented at conferences or spoken about within informal learning networks appear to be unpublished. This limits the conclusions that can be drawn within a literature review. Interviews or review of internal project documents may be a good source for obtaining this type of data.

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