FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

Feed the Future Learning Agenda Literature Review: Improved Agricultural Productivity

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USAID

FROM THE AMERICAN PEOPLE

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TABLE OF CONTENTS

LIST OF ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
BFS	Bureau for Food Security
DFID	Department for International Development
ICT	Information and communications technology
IRDPs	Integrated rural development projects
M&E	Monitoring and evaluation
NGO	Non-governmental organization
NRM	Natural resource management
PES	Payments for environmental services
T&V	Training and visit
TFP	Total factor productivity
U.S.	United States
USAID	United States Agency for International Development
VCF	Value chain financing

MAIN FINDINGS AND CONCLUSIONS

Agricultural productivity growth is essential for improving the competitiveness of farmers in markets, increasing their incomes, reducing poverty, and helping to keep food prices down. Given that most of the land and water that is economically suitable for agriculture is now fully utilized, continued growth in agricultural productivity on existing farm land will also be crucial for meeting the food and energy needs of a growing world population, projected to reach over 9 billion people by 2050. The need to raise agricultural productivity is especially challenging for many African and South Asian countries that face the highest population growth rates and which already have some of the severest per capita land constraints and the highest rates of rural poverty. Not only must agricultural productivity be increased, but it must be done in ways that are environmentally sustainable; contribute to reducing poverty, food insecurity, and malnutrition; create productive employment; and lead to more resilient farm and rural economies.

While large commercial farms will have to play an important role in feeding rapidly urbanizing populations, investing in the productivity of small farms is still vital. One reason is that small farms are home to and feed a large share of the world's poor and hungry. Another is that they make important, sometimes dominant contributions to feeding urban populations, especially in Asia and Africa. There can be no pretence that all of today's small farms (some 500 million less than 2 ha in size) have viable futures in farming, and in many cases the appropriate emphasis should be on providing assistance in diversifying into a nonfarm business or off farm employment, or leaving farming altogether. However, despite the pessimism in recent years about the future of small farms (Collier, 2009), small farms situations are actually very diverse, and there are plenty of viable business opportunities for many to exploit if they receive the rights kinds of assistance (Hazell, 2013b).

The primary driver of productivity growth is new technologies and better ways of doing things and this requires (i) sources of new technologies and improved knowledge, and (ii) their widespread adoption by farmers and rural communities. There are multiple sources of new technologies and knowledge. Indigenous knowledge and farmer experimentation has historically been an important source of technological change, and accounted for slow but steady increases in productivity over generations. But the more dramatic breakthroughs needed to keep pace with rapidly growing and urbanizing populations have come from the application of modern science by agricultural research organizations, both public and private. This has led to a constant stream of new technologies that has enabled sustained and unprecedented rates of growth in agricultural productivity over the past 75 years, though with big regional differences.

This paper takes research and knowledge generation systems for granted, and reviews the evidence base on ways to use new technologies and supporting policies to raise the productivity of smallholders, while making them commercially successful, better environmental managers, more resilient to climate and market risks, and improving their own nutritional well-being. Special attention is given to the challenge of transforming the farms of more women and socially marginalized farmers who are among the poorest small farms.

Promoting technology adoption. The literature on the determinants of technology adoption points to the following constraints that are especially germane to small farm situations, and for poor women and socially marginalized farmers in particular: the inappropriate design of some technologies for small farms; inadequate information about new technologies; poor access to required purchases inputs, credit, and markets; the higher risks and labor requirements of many new technologies; insecure land tenure; low literacy; and difficulties of organizing collective action.

In the past, governments intervened directly through a range of market and nonmarket interventions to help farmers overcome these constraints. The market liberalization reforms of recent years have led to

a greater role for private sector and nongovernmental organization (NGO) players and the emergence of more innovative and diverse types of interventions. This paper focuses on some of the more promising types of new approaches rather than reviewing the efficacy of past government policies.

Participatory research methods and farmer field schools have been developed as ways of engaging small farmers more directly in the design and testing of new technologies so as to better meet their needs, and in providing information and training on an interactive basis. They seem especially promising for meeting the needs of many women and poor farmers. However, questions remain about their costs and whether their impacts can be scaled up beyond the relatively small numbers of farmers directly involved. New developments in decentralizing the management of public extension systems and engaging with new partners from the private and NGO sectors also look promising, but there is still a weak evidence base about their effectiveness, especially in reaching women and poor farmers.

There have been a lot of interesting developments in ways of linking small farms to high value chains, either through contract farming arrangements with agribusiness partners or through membership of a producer group or other intermediary organization. These kinds of linkages show promise for enabling more women and poor farmers to sell into high value markets, although evidence on this is still inadequate. So far, the number of small farms benefiting from these types of linkages remains relatively small, and more work is needed on ways of scaling up from successes.

The reforms of rural financial markets have led to a situation where many small farms are too big to rely on microfinance for their farm credit needs, and too small to be served by commercial lenders. Linking to value chains can be a source of credit as well as a market outlet, but for those who cannot then new innovations like warehouse receipt systems, credit guarantees, and IT banking look more promising. Filling this credit gap for small farms remains an important issue for future research.

A similar gap has arisen in policies for helping small farmers manage risk. Many governments have turned away from direct public interventions like crop insurance and price stabilisation and are looking to market mediated approaches such as weather index insurance and futures markets to help small farmers manage risk. Weather index insurance shows promise but common problems have arisen in pilot programs, such as low farmer demand because of high basis risk and perceived low benefits, and the difficulty and cost of setting up an effective delivery network. These problems are more easily overcome if the insurance is linked to credit and a technology package that offers the farmer a real value-adding proposition that goes beyond simple risk management. Apart from a few export crops, relevant futures markets do not exist for most developing country farmers. Most small farmers need intermediaries to access the futures markets that do exist on their behalf. The few opportunities that arise involve traditional export crops. Given the limited reach of index insurance and futures markets, most small farmers must rely on themselves and their communities to manage risk, and on public relief programs when catastrophic losses arise.

Many small farms and women farmers do not have secure access to their land and this is an impediment to investing in some types of technology. Formal land titling is a more effective approach in Asia than Africa, partly because land rights are already secure at community levels within Africa's customary land tenure systems. The bigger problem in Africa is that the customary tenure systems are biased against women and other socially marginalized groups, so solutions often have to lie in changing cultural norms at community levels through legal and educational means. In all areas of land policy, there is growing evidence to show that transparent and easy access to land records, such as is now possible through digitization and the Internet, can facilitate more secure rights for small farmers, improve the efficiency of land markets, and enhance the value of land for collateral purposes.

Many productivity enhancing investments or technologies must be taken up by groups of farmers or even whole communities (e.g., land terracing, watershed development), and organizing and governing collective action is difficult and costly and subject to elite capture. More research is needed to identify

the conditions under which local organizations emerge and succeed in collective action, and of ways of ensuring that the interests of women and poor farmers are adequately represented.

Much of the literature on adoption treats constraints independently of each other, whereas in reality there may be important linkages amongst subsets of constraints that arise from a common underlying factor. For example, the adoption of many technologies requires a package of complementary inputs (e.g., seeds, fertilizer, pesticides, credit and a market outlet) and farmers may choose not to acquire individual inputs until they can obtain the entire package. These kinds of complementarities are very common for green revolution technologies. On the supply side, specialized suppliers of modern inputs, credit and the like may also be hesitant to supply their input to farmers who do not have access to other complementary inputs. This is known as the coordination problem and is a form of market failure that can lead to suboptimal levels of technology adoption from an aggregate economic perspective. Another type of constraint linkage can arise for farmers who live in remote areas where poor infrastructure and high transport costs may act as a common factor that make it too costly for input suppliers, credit and insurance institutions, market traders, and extension agents to service the area. Women may also face linkages among constraints because of social and other barriers that discriminate against them in the supply of many of the key inputs and services needed for technology adoption.

When linkages arise, policy interventions that remove a common underlying factor might be more effective than interventions that target one constraint at a time. Three promising areas are building rural roads to better connect lagging regions, empowering women farmers, and resolving the coordination problem, though all warrant further study.

While there are many successful examples of project interventions to overcome adoption constraints, much less is known about how to scale these successes up. In fact, the whole methodology of scaling up seems rather fuzzy, with little guidance on the kinds of data and analysis that would be required to enable inferences about scaling up to be made from a pilot project. Rigorous impact evaluations are needed to determine if a pilot is a success, but scaling up also requires attention to the causal factors underlying that success, and an ability to identify, even map, other places where the same conditions for success might exist.

Combining long-term natural resource management (NRM) with increasing productivity and profitability. Environmental problems and the types of improved NRM needed to resolve them differ across farming systems, and particularly between intensive (often irrigated) farming systems and extensive farming systems, often located in low potential areas. Many suitable technologies and improved NRM practices have been developed for both types of farming system, but a compelling observation from a large literature is that few are adopted at sufficient scale to resolve the major environmental problems associated with agriculture.

Most of the constraints considered above as part of the more general technology adoption problem apply to the adoption of improved NRM practices, but the literature highlights the particular importance of their high labor requirements, knowledge intensity, capital requirements, and need for secure long-term property rights and collective action. Even when NRM practices increase productivity or reduce costs and have the potential to be win-win, their adoption can be undermined by perverse policies that make unsustainable practices more profitable than they should be (e.g., subsidies on groundwater pumping and irrigation water), and by the off-site nature of some of the benefits they generate (i.e., externalities), implying that the farmer or community that bears the costs of the improvement does not capture all the benefits. There is widespread evidence that women farmers and poor farmers are less likely to adopt improved NRM practices than other farmers.

Many governments have attempted to resolve these problems by reforming pricing and subsidy policies and devolving more responsibility for NRM back to local communities. This has led to a veritable explosion in the formation of community- and user-based organizations for improved NRM, assisted by

central and local government agencies, environmental and development-oriented NGOs active at grass, roots levels, and donors. Despite a great deal of research, there is still little rigorous evidence on what determines the successful formation of local organizations for NRM. Another literature focuses on the links between community organization for NRM and gender and poverty outcomes. To avoid elite capture and to be able to resolve local disputes, broad representation is needed in their governance, and this is particularly important if the poor and women farmers are to be empowered within such organizations. A number of studies have found that collaboration, solidarity, and conflict resolution increase among all program group members when women are members of groups.

Better management of externalities in agriculture is also a priority issue for NRM that remains largely unresolved. The emergence of markets and programs for payment for environmental services (PES) is a promising development that should be pursued by the international community. More research is needed on the best methods of managing environmental externalities, including evaluative studies of markets and programs for PES. Improved methods and case studies are also needed to better evaluate environmental outcomes so as to better inform environmental policies, and to be able to rank NRM projects against alternative investments that have more measurable impacts.

Impact of agricultural value chain interventions on employment. Agricultural growth, especially high value agriculture, can generate significant additional employment in farming and along commodity value chains in a myriad of production, trading, processing, storing, wholesaling, and retailing functions. Also, productivity increases that raise farm incomes lead to additional employment in the rural nonfarm services and informal manufacturing sectors that cater to local consumer demands. Overall, each dollar of additional income generated in agriculture has a multiplier effect on nonfarm income, generating an additional $0.40 to $0.50 of income for rural regions, and $0.75 to $1.00 for national economies. Employment multipliers are much harder to estimate because lots of rural nonfarm employment is seasonal and part time and is not reported in census data, but appear to be large because of the employment-intensive nature of the service and informal manufacturing sectors. These are also sectors in which women and poor people play important roles.

Given the increasingly integrated nature of many value chains, more research is needed to determine the implications for employment. If, as Reardon and colleagues have recently found (Reardon, Chen, Minten, & Adriano, 2012), small scale traders and processors using low-tech facilities are being squeezed out of value chains for food staples by larger and more modernized firms, then research is needed to determine the net impact on employment and on the employment opportunities for the poor. Similarly, given the preference of many agribusinesses to source from large farms, important questions arise about how much employment large farms create. Some studies have shown that the employment effects may be quite favourable in the case of some high value crops, but this is still a hotly disputed issue.

Impact of agricultural productivity interventions on resilience. Some interventions that raise agricultural productivity also reduce downside risks and hence contribute to greater resilience. These include (i) breeding new crops and livestock that are tolerant or resistant to drought and other stresses, (ii) building irrigation systems, (iii) investing in water harvesting, (iv) conservation farming, and (v) building rural roads. Resilience can also be strengthened by interventions that help farmers cope with losses when they occur. These include credit and insurance, early warning systems and safety net programs. Mechanisms that help farmers cope with losses can also have an indirect impact on average productivity. This arises because once farmers know they can rely on such assistance they may be willing to increase their risk exposure by investing in technologies and land improvements that raise average levels of productivity, even when these are more risky. However, difficulties can arise when risk coping interventions are heavily subsidized because farmers may be encouraged to take on too much risk, inadvertently increasing their dependence on future government assistance. For example, compensation for crop or livestock losses in flood prone areas may lead to an expansion of livestock and cropping in

those areas, with the potential for even greater losses during future floods. Subsidies need to be used smartly to avoid these kinds of problems, and that is something that still needs further research.

While it is relatively straightforward to evaluate the average productivity impacts of interventions that also improve resilience, evaluating their impact on resilience depends on observing outcomes in extreme years, and this may require collection of panel data over long periods of time at carefully chosen benchmark sites.

Inclusion of nutrition education in agricultural extension programs. It is now reasonably well established that if nutrition education is incorporated into nutrition-oriented agricultural interventions then this increases the likelihood that programs will have a positive impact on dietary diversity and nutrition. What is less clear is how nutrition education works, and further research is needed on this issue if better guidance is to be provided on the best types of nutrition education to provide, and how to link this education with other complementary activities such as health care initiatives, women's empowerment training, women's control of income, and/or women's land rights.

Who should provide nutrition education also remains an important question. A recent study of agricultural extension programs around the world found that many farm extension agents are already providing advice and training at community and farmer levels on ways to increase the physical availability of nutritious food, including growing nutrition-rich crops, linking farmers to markets to sell and buy nutritious foods, and better use of grown and purchased foods (Fanzo et al., 2013). Many extension agents have also received training for these purposes. With that said, the scale of the nutrition advice and training being provided by agricultural extension agents is still small. Nor does an increased availability of nutritious foods necessarily translate into greater nutritional well-being. It also depends on access, diet choice, and intra-household distribution issues that affect food intake; health issues that impact on the effective conversion of food into nutritional outcomes; and agricultural extension agents who are not much involved in providing training and advice on these issues. Nor apparently are the issues widely covered by health extension agents; so there is an important gap that may require specially trained nutritional workers to fill.

Further research is needed at the national level to better understand which agencies or sectors are currently providing nutrition education and the extent to which multisectoral collaboration can improve the efficiency and cost-effectiveness of service delivery. In many countries, the Ministry of Health provides nutrition education but is not well-coordinated with the Ministry of Agriculture, and nutrition professionals and agricultural extension workers are not delivering a coordinated message.

Small farm diversity. A noticeable shortcoming of much of the literature reviewed for this paper is that insufficient consideration is given to the diversity of small farm situations when drawing conclusions about appropriate interventions for raising agricultural productivity. Distinctions are frequently made between small and nonsmall farms, between men and women farmers, and between poor and nonpoor farms, but without recognizing that for targeting purposes there may be more relevant variation within these groupings than between them. Particularly relevant here is a growing literature showing that farms are becoming more widely differentiated by size and livelihood strategy, and by market forces and locational factors that have an important bearing on their prospects as farmers, and hence the kinds of support they need. Recent trends have been towards an ever greater number of small farms, while on average their holding size has shrunk and they have become more diversified into off-farm sources of income. There has also been a widening gap between farming opportunities in dynamic regions and more stagnant or lagging regions. This has created a more diverse and polarized set of smallholder farming situations that needs to be considered when targeting agricultural investments. This is especially important when the objective (as with Feed the Future) is to help more small farms become successful and profitable farm businesses.

Typologies for small farms based on location and market orientation have been developed and these could aid in designing agricultural interventions. Further research is needed to develop and test the relevance of smallholder typologies, and to assess the most effective forms of agricultural interventions for each type of smallholder. This should also include analysis of the best ways to integrate agricultural interventions with complementary policies and investments, such as safety nets and assistance with migration and off-farm diversification. Another challenge is developing practical ways of identifying the different groups on the ground.

I. ABOUT THE LEARNING AGENDA

*The objective of this paper is to summarize available evidence on key questions for the Feed the Future Learning Agend*a theme on nutrition and diet quality, and document expert opinion on gaps in the scientific literature for this theme that are in most urgent need of attention.

Feed the Future is an initiative of the U.S. Government, undertaken in response to the commitment of global leaders at the G8 Summit in L'Aquila, Italy in July 2009, to "act with the scale and urgency needed to achieve sustainable global food security." Feed the Future aims to tackle the root causes of global hunger and poverty through inclusive agriculture sector growth and improved nutritional status, especially of women and children. Feed the Future aims to achieve these objectives through several intermediate results detailed in the Feed the Future Results Framework: sustainably increasing agricultural productivity, expanding markets and trade, promoting increased public and private investment in agriculture and nutrition, supporting vulnerable communities and households to increase resilience, increasing access to diverse and quality foods, promoting improved nutrition-related behaviors, and improving use of maternal and child health and nutrition services. The Feed the Future approach focuses on smallholder farmers, especially women.

An important objective of the Feed the Future monitoring and evaluation (M&E) component is to generate evidence to address unanswered questions in the development literature pertaining to the causal linkages in the Feed the Future Results Framework. In line with the United States Agency for International Development's (USAID's) new Evaluation Policy launched in January 2011, Feed the Future's M&E approach emphasizes generating, learning from, and sharing evidence and results that can inform future programming and investments, increasing the chance that future investments will yield even more results than previous investments.

To organize this work, USAID's the Bureau for Food Security (BFS) led the development of a Feed the Future Learning Agenda in the first half of 2011 (USAID, 2011), made up of a set of key evaluation questions related to the causal linkages in the Feed the Future Results Framework. These questions were designed to be answered using evidence-based hypothesis-testing, primarily through impact evaluations but also through performance evaluations, economic analysis, and policy analysis. In June 2011, a meeting was held with key experts from implementing partners and other stakeholders (U.S. Government agencies, universities, research centers, NGOs, think tanks, the private sector, and others) to review and validate the key questions and the thematic groupings into which they had been organized to form the Feed the Future Learning Agenda. These stakeholders also provided preliminary design ideas for impact evaluations to be conducted to address these questions.

To ensure that Feed the Future impact evaluations were well-conceived, build on existing evidence, and fill critical evidence gaps, BFS is providing resources for a comprehensive assessment of existing evidence and gaps in knowledge within the framework of the Feed the Future FEEDBACK project. This assessment includes development of annotated bibliographies and literature review papers organized around the six themes of the Learning Agenda:

1. Improved Agricultural Productivity;
2. Improved Research and Development;
3. Expanded Markets, Value Chains and Increased Investment;
4. Improved Nutrition and Dietary Quality;
5. Improved Gender Integration and Women's Empowerment; and
6. Improved Resilience of Vulnerable Populations.

Annotated bibliographies for each of the Learning Agenda themes have already been prepared. Literature review papers for each theme, including this one, present expert analyses of the current state of the scientific evidence for the key questions related to each theme and offer additional guidance on the gaps remaining to be filled by the impact evaluations. At a later stage, the assessment will also include activities aimed at articulating and demonstrating how new evaluations and studies conducted under the auspices of the Feed the Future M&E program contribute to filling the gaps in the body of evidence identified in this and the other five expert papers on the Learning Agenda themes.

II. ABOUT THE THEME: IMPROVED AGRICULTURAL PRODUCTIVITY

Productivity is a measure of economic efficiency, or the returns to the inputs used in agriculture. Although useful, partial measures of productivity like labor and land productivity are not reliable measures of economic efficiency because they do not take account of the use of other inputs or their costs. A better measure of economic efficiency is total factor productivity (TFP), sometimes referred to as multifactor productivity. This is calculated as the ratio of total output to total input, and measures the average productivity of all the inputs used.

Agricultural productivity growth is essential for improving the competitiveness of farmers in markets, increasing their incomes, reducing poverty, and helping to keep food prices down. Increases in agricultural productivity reflect upward shifts in the production function due to new technologies or management practices, and these shifts increase the returns to inputs. Without these shifts, diminishing returns set in when additional land, labor, and other inputs are used to increase production. Diminishing returns imply that the cost of producing a unit of output (e.g., a kilo of rice) increases, making agricultural products, including food, more expensive to produce.

The primary driver of productivity growth is new technologies and better ways of doing things and this requires i) sources of new technologies and improved knowledge, and ii) their widespread adoption by farmers and rural communities. There are multiple sources of new technologies and knowledge. Indigenous knowledge and farmer experimentation has historically been an important source of technological change, and accounted for slow but steady increases in productivity over generations. But the more dramatic breakthroughs needed to keep pace with rapidly growing and urbanizing populations have come from applying modern science by agricultural research organizations, both public and private. This has led to a constant stream of new technologies that has enabled sustained and unprecedented

rates of growth in agricultural productivity over the past 75 years, though with big regional differences. For example, global agricultural TFP grew by about 1 percent per annum between 1961 and 2007, but by only 0.6 percent per annum in Sub-Saharan Africa (Fuglie, 2010).

Given that most of the land and water that is economically suitable for agriculture is now fully utilized, continued growth in agricultural productivity rather than land expansion will be key to meeting the food and energy needs of a growing world population, projected to reach over 9 billion people by 2050 (Conway, 2012). The need to raise agricultural productivity is especially challenging for many African and South Asian countries that face the highest population growth rates and which already have some of the severest per capita land constraints and the highest rates of rural poverty. The pressure on agricultural systems is also increasing because of rapid urbanization and changing diets, particularly the shift toward greater consumption of livestock products; increasing demands for industrial and energy crops; growing competition for water between agriculture, industry, household, and environmental uses; and climate change (Conway, 2012).

Not only must agricultural productivity be increased, but it must be done in ways that reverse much of the environmental degradation that has occurred in the past. In irrigated and high potential rainfed farming systems, this includes problems with pollution of waterways from fertilizer runoff; pesticides that kill beneficial insects and other wildlife and harm people; irrigation practices that lead to salt build up and eventual abandonment of some of the best farming lands; increasing water scarcities in major river basins; retreating groundwater levels in areas where more water is being pumped than can be replenished; loss of agricultural biodiversity; and high greenhouse gas emissions. In lower-potential rainfed farming systems, the main environmental problems have been crop area expansion through reductions in the length of fallows and by encroachment into forests and fragile lands (e.g., steep hillsides and watershed protection areas), resulting in land erosion, declining soil fertility, and loss of biodiversity (Conway, 2012; Hazell & Wood, 2008).

Smallholder farms provide for the food security and nutritional well-being of huge numbers of rural poor. But many small farms are net buyers of food and they generate relatively little of the food required to feed large and growing urban populations. Urban populations are projected to grow strongly across the developing world (United Nations, 2011), and feeding these populations will require rapid growth in marketed food supplies. For most foods, these supplies will need to come from commercially oriented farms that can generate net surpluses. It follows that a food security agenda needs to walk on two legs. One leg is to provide support to the many food insecure smallholders who farm to cover part of their own household consumption requirements and supply small amounts of cash income. The other leg is to invest in commercially oriented farms, including commercially viable smallholders, which can produce marketed surpluses. The second leg will become increasingly important as urbanization proceeds and a growing share of the poor and malnourished become urban based and detached from the land.

There can be no pretence that all of today's small farms (some 500 million less than 2 ha in size) have viable futures in farming, and in many cases the appropriate emphasis should be on providing assistance in diversifying into a nonfarm business or off-farm employment, or even leaving farming altogether. There has been much pessimism in recent years about the future of small farms (Collier, 2009; Collier & Dercon, 2009), but this paper builds on the recognition that small farms are very diverse, and there are plenty of viable farm business opportunities for them to exploit if they receive the rights kinds of assistance.

This paper takes research and knowledge-generation systems for granted, and reviews the evidence base on ways to use new technologies and supporting policies to raise the productivity of smallholders, while making them commercially successful, better environmental managers, more resilient to climate and market risks, and improving their own nutritional well-being. Special attention is given to the challenge

of transforming the farms of more women and socially marginalized farmers who are among the poorest small farms.

III. KEY QUESTIONS FOR THE THEME

1. Promoting Technology Adoption

What are characteristics of effective, efficient, and sustainable vehicles for promoting adoption of innovation (technology, practices, behaviors) and diffusion of products and new technologies among the poor, women, and socially marginalized? What are the most binding constraints in promoting technology adoption and the most effective interventions for dealing with these constraints?

Evidence

Introduction

There is a large literature on the determinants of technology adoption amongst farming populations (Feder, Just, & Zilberman, 1985; Lipton, 1989; Doss, 2006; Jack, 2013). The standard approach used by many economists is to estimate econometric relationships between determining factors and adoption rates for a farming population, and to control for subgroups like gender and farm size by adding identifier variables (dummy variables). Additionally, there is a literature arising from more qualitative and multidisciplinary research on the social and economic problems of the poor and women farmers that provides additional insights within specific socioeconomic contexts (Meinzen-Dick et al., 2011; Adato & Meinzen-Dick, 2007). Based on combining these different sources of evidence, the following constraints emerge as important to the adoption decisions of small farms and for poor, women, and socially marginalized farmers in particular:

- Appropriateness of new technologies in terms of their fit with a farm's resource endowments and own consumption requirements (e.g., the storability, cooking, and taste traits of new crop varieties) (Meinzen-Dick et al., 2011).
- Lack of knowledge due to poor access to trusted sources of information, and neglect by extension agents (Peterman, Behrman, & Quisumbing, 2010).
- Limited access to market opportunities (Peterman et al., 2010).
- Poor access to needed inputs like seeds, fertilizers, and pesticides in terms of their accessibility and affordability (Peterman et al., 2010).
- Insufficient financial assets, such as own savings and access to credit, to finance new investments or purchase inputs (Peterman et al., 2010). This can be particularly important for lumpy investments where a threshold level of capital is required.
- Production and market risks that discourage the use of untried technologies, particularly if needed inputs have to be purchased with credit (Adato & Meinzen-Dick, 2007). For longer term investments in trees and other improvements in the sustainable management of natural resources, there are additional risks such as the loss of land rights; loss of assets

due to theft, civil strife or natural catastrophes; changes in health; and changes in government policies.

- Seasonal labor bottlenecks that arise from higher labor requirements that new technologies or crops often introduce, such as additional weeding or manual harvesting associated with the use of higher yielding crop varieties and fertilizer. Women and poor farmers are less likely to have access to hired labor or mechanization, and competition with household work can be severe (Peterman, Behrman, & Quisumbing, 2010; Meinzen-Dick et al., 2011).

- Limited access to land and insecure property rights which undermine incentives to make investments that improve the long-term productivity of natural resources (Adato & Meinzen-Dick, 2007).

- The poor education and literacy levels of many women and heads of poor households.

- Poor people are more likely to suffer from poor health and this can contribute to low adoption rates for agricultural technologies. Jack (2013) claims there is substantial evidence pointing to a relationship between labor productivity and nutrition and health, which may directly affect adoption decisions. Gender-based differences in task allocation within wage labor systems may also result in differential health impacts on men and women (Meinzen-Dick et al., 2011).

- Poor, women and socially marginalized farmers often are less able to participate in the kinds of collective action needed when productivity enhancing investments or technologies must be taken up by groups of farmers or even whole communities (e.g., land terracing, water capture, integrated pest management, and the improvement of communal forests and grazing areas) (Meinzen-Dick et al., 2011).

Best practice interventions

Many constraints to technology adoption reflect underlying market failures that lead to suboptimal levels of technology uptake and productivity growth from an aggregate economic perspective (Jack 2013). They also make it harder for many poor farmers and women farmers to adopt, constraining the potential of agricultural research and development (R&D) investments to contribute to social and environmental goals (like reducing poverty and land degradation). For these reasons, most countries have long intervened to promote the development and adoption of productivity enhancing technologies in agriculture.

Many early attempts to promote technology uptake and productivity growth involved direct government support to small farms, including the public provision of agricultural research and extension; shoring up farm credit systems; subsidizing key inputs (especially fertilizer, power, and water); and intervening in markets to ensure farmers received adequate prices each year to make new technologies profitable. Research by Dorward and others (Dorward, Kydd, Morrison, & Poulton, 2005; Dorward, Kydd, Poulton, & Bezemer, 2009) have shown that these kinds of interventions can be quite effective at early stages of agrarian development when value chains are still poorly developed, and the demand for key inputs like improved seeds and fertilizers is still too low and spatially thin for private delivery systems to work adequately. But as value chains develop, these kinds of interventions can quickly become costly, inefficient, and crowd out the private sector. Many countries cut back or phased out these policies after the mid-1980s as part of market liberalization programs. This has led to a greater role for private sector

and NGO players and the emergence of more innovative and diverse types of interventions. New approaches being tried fall into the following broad categories:

- Developing and disseminating appropriate technologies;
- Access to markets and inputs;
- Access to credit;
- Risk management;
- Secure access to land; and
- Collective action.

It is not possible to fully review the literature on these experiences in the space permitted here, but some of the more recent interventions are reviewed below, especially those focused on assisting poor, women, and socially marginalized farmers. In evaluating alternatives for overcoming adoption constraints, consideration should be given to their cost-effectiveness in assisting target groups, their realism in terms of existing cultural norms and institutional capacities, and the scope for scaling up.

Developing and disseminating appropriate technologies. To facilitate the development and spread of appropriate technologies that better meet the needs of small farms, participatory research methods have been developed and tested that involve farmers in setting research objectives and selecting research outputs for trials in their own fields. Farmer field schools (FFS) have also been developed as a way of engaging farmers in interactive and experimental group learning experiences about new technologies. These methods show particular promise for addressing the needs of specific target groups like women farmers (Quisumbing & Pandolfelli, 2010). For example, in a rigorous impact evaluation of FFS projects in East Africa, Davis et al. (2010) found that women were just as likely to participate as men farmers, and they gained more than men from the training in terms of their subsequent farm productivity and income. The FFS approach also successfully reached households with low levels of education, but the farmers who gained the most in terms of subsequent productivity had medium rather than small-sized holdings.

In recent years, extension systems have changed in other important ways that may have improved their ability to target the needs of poor, women and socially marginalized farmers. Advances in information and communications technology (ICT) have offered new ways of overcoming distance and cost constraints and scaling up the reach of extension services (Aker, 2011), though there is some evidence that women may have less access to ICT than men (Huyer, Hafkin, Ertl, & Drybaugh, 2005). There have also been attempts to decentralize the management of extension systems to involve local governments and farmer organizations, and to bring in new partners from the private sector and NGOs (Swanson, 2008; Davis, 2008). There has also been some progress in bringing in more women scientists and extension agents, who are needed to overcome the gender barriers found in some cultures (Meinzen-Dick et al., 2011).

There is an emerging but so far inconclusive evidence base on what works best and under what circumstances and whether these new approaches are successful in helping poor, women, and socially marginalized farmers. For example, fee-for-service arrangements for extension services show promise for making service providers more accountable to farmers (Anderson & Feder, 2007), but as Jack (2013) observes, if the poor are less willing or able to pay, they may be excluded. One approach to ensure coverage of the poor is to issue targeted extension vouchers, though experiences to date have met with little success (Rivera & Zijp, 2002).

Access to markets and inputs. Market liberalisation policies and the rapid growth of high value markets have enabled the private sector to take a more prominent role in providing farm inputs, technologies and marketing services (McCullough, Pingali, & Stamoulis, 2008). Agricultural marketing chains are also changing and farmers are increasingly being asked to compete in markets that are more demanding in terms of quality and food safety, more concentrated and integrated by large agribusinesses, and much more open to international competition (McCullough et al., 2008). Supermarkets, for example, are playing an increasingly dominant role in controlling access to urban retail markets, and direct links to private exporters are often essential for accessing high-value export markets. Large farms are often the preferred suppliers in these integrated market chains, and many small farms struggle to diversify into higher-value products (Reardon, Timmer, & Berdegue, 2004). In Africa, many smallholders are not only missing out on new high value chains, but with the withdrawal of the state from most marketing functions, they have also lost access to modern inputs, credit and market outlets even for their traditional food staples (Djurfeldt, Aryeetey, & Isinika, 2011).

Within this changing economic landscape, the hunt is on to find policy interventions that can help more smallholders and women farmers successfully link to modern value chains. A lot of recent attention has focused on ways of linking small farms to large agribusiness partners, usually through contract farming arrangements. These may involve direct contract farming arrangements between individual farmers and agribusinesses, or more often membership of a producer organization that enters into marketing arrangements on behalf of its members. Wiggins and Keats (2013) provide a useful review of different approaches and provide many illustrative case studies.

Based on a careful meta-narrative of five contract farming case studies, Barrett et al. (2012) conclude that the private sector is more receptive to smallholders when they are located in the right places in terms of the crops and ecologies they want to work with, and the location of their processing facilities and markets. Farmers in remote areas are least likely to be of interest. Surprisingly, initial farm size and wealth turn out not to be that important, as also observed by Swinnen and Maertens (2007). Barrett et al. (2012) also find that agribusiness partners prefer to work with organized farmer groups that can enter into contractual arrangements, and the involvement of NGOs that catalyze and support such organization is attractive. Also exploring the value of NGO intermediaries, Ashraf, Gine, and Karlan (2009) used a randomized trial to evaluate the impact of one NGO project (DrumNet, a project of Pride America) in helping organize and link groups of smallholders to an exporter of green beans and sweet corn. They find that the program was effective in enabling more small farmers to participate in the market, but the main beneficiaries were middle income farmers rather than high or low income farmers. While the project significantly raised the incomes of new entrant farmers, it had little impact on the incomes of farmers who already produced and sold these crops[1].

Public policy can play supporting roles in facilitating small farm access to markets and inputs. There is much interest today in the design of "smart" subsidies that can help kick-start fertilizer use and private distribution systems, and speed up adoption of complementary technologies like improved seeds. To keep the costs of a fertilizer subsidy down, the subsidy rate should be targeted to avoid displacing existing commercial sales, and have a definite sunset clause. At this stage vouchers look most promising as an effective delivery mechanism for a subsidy, and if they are redeemed through private agro-dealers they can also help build up a fully privatized procurement and distribution system (Minot & Benson, 2009). They may also be relatively easy to target and phase out. But they do have some problems and their use still needs rigorous evaluation in a variety of settings. Recent research using randomized trials also shows that the timing of subsidy payments within the agricultural calendar can also make a critical difference to farmers' purchasing decisions, and hence to the effectiveness of targeted interventions

[1] Unfortunately, the viability of the whole project was undermined by the introduction of the EU production requirements for export crops, since none of the farm groups were certified and the costs of doing so was excessive in relation to the profitability of the crops they produced.

(Duflo, Kremer, & Robinson, 2011). Another way of facilitating greater use of fertilizer inputs by women and poor farmers is to offer greater choice of bag sizes, as standard 50-kilo bags may be beyond their means or needs (Quisumbing & Pandolfelli, 2009).

Evidence on impact of value chain linkages for poor, women, and socially marginalized farmers is limited; in a companion review Campbell (2013) concludes that "Studies of value chain projects are few in number, produce results that can rarely be aggregated, typically lack rigor, and generally fail to measure impacts on poverty. However, the limited data that are available suggest that value chain interventions can significantly contribute to poverty reduction by increasing the competitiveness of specific value chains and their service markets."

Access to credit. Since the demise of the agricultural development banks, there has been considerable progress in developing market-facilitated approaches to rural finance. Emergence of informal and semi-formal credit institutions (including village banking schemes, savings, and credit cooperatives and microfinance) and increased lending by commercial banks are examples. In many respects these new approaches have been successful, increasing the range of financial services available in rural areas and for poor people. Nevertheless, they have encountered problems in reaching emerging smallholders who are too large for microfinance but at the same time remain outside the formal financial intermediation, and in making sufficient financing available along value chains to meet the needs of small- and medium-sized agribusinesses (Rahman & Smolak, 2013).

A promising approach to solving these problems is value chain financing (VCF), made possible by new opportunities for interlinking markets for inputs, outputs and credit in today's more integrated value chains. In practice, VCF can be as simple as a trader providing a cash advance and accepting payment in kind at harvest time, or it can be a highly sophisticated configuration of farmers, traders, and agribusinesses that leverages formal financial flows. VCF requires an enabling business environment for domestic and international investors. Experience to date suggests that VCF works better for high value chains than food staples (Rahman & Smolak, 2013).

Warehouse receipt systems have also emerged as another way to increase agricultural lending to emerging small farms. This approach requires the public sector to devise an appropriate institutional framework, legislation to recognise a receipt as legal tender, licensing and inspection of warehouses, performance oversight, and collaboration with the private sector to establish commodity quality standards (Adesina et al., 2013).

Poor farmers rely more on informal sources of lending and microfinance. Their credit worthiness can be improved through new forms of collateral made possible by ICT such as credit reports that condition future loan opportunities on past performance and fingerprinting for tracking borrower repayment records (Jack, 2013).

Risk management. Many governments have used crop insurance programs and price stabilization schemes to help farmers manage production and market risks, often with the aim of encouraging greater uptake of more profitable crops and technologies. Both proved expensive and not very effective, and interest today lies with market-mediated approaches such as weather index insurance and futures markets (Hazell, 2011).

Weather index insurance (WII) looks promising, but is still being tested through small-scale pilot programs. The evidence from a recent review of some 40 pilot programs from around the world found common problems in insuring small farmers, such as low demand because of high basis risk and perceived low benefits, and the difficulty and cost of setting up an effective delivery network (Hazell et al., 2010). These problems can be overcome if the insurance is linked to credit and a technology package that offers the farmer a real value-adding proposition that goes beyond simple risk management. Governments can also help by creating more enabling conditions for WII. Particular attention is needed

to the regulatory environment for insurance, creating a sufficiently dense network of weather stations to reduce basis risk, and provision of a first line of reinsurance during the inception years. So far there has been limited spontaneous development of WII by the private sector, and governments, research institutions or international agencies like the World Bank and the International Fund for Agricultural Development (IFAD) have had to initiate activities (Hazell et al., 2010).

Apart from a few export crops, relevant futures markets do not exist for most developing country farmers. Most farmers need intermediaries to access the futures markets that do exist on their behalf. The few opportunities that arise involve traditional export crops and contract farming, where farmers can be offered a forward price by a marketing association or private agribusiness firm that can then sell the risk in the futures market (Hazell, 2011; Larson, Anderson, & Varangis, 2004).

Public sector credit guarantees are showing some promise as a way of leveraging more bank credit into agricultural value chains, and this may help offset some of the constraints faced by farmers and small and medium sized agribusiness firms arising from risk. For example, USAID has been providing credit guarantees for more than a decade to selected agricultural banks in transition and developing countries, and impact evaluations using mixed methods show these have been effective in enabling lenders to reach out to new types of borrowers in the agricultural sector, and that many of these borrowers have been able to graduate to commercial loans without guarantees (http://www.usaid.gov/dca/dca-evaluations).

Secure access to land. Many governments have attempted to improve property rights for farmers through land registration and titling programmes, and evaluations of some of these programs typically show positive impacts on investment, access to credit, and land productivity in Asia and Latin America, but with less encouraging results for Sub-Saharan Africa (Feder & Nishio, 1999; Deininger, 2013). Part of the problem in Sub-Saharan Africa is that farmers have often shown little demand for land titles and have been unwilling to incur the costs of keeping their titles up to date when, for example, land is partitioned, sold, or bequeathed. This is widely attributed to existing low levels of commercialization of farming, sometimes abundant land, a lack of effective institutions for enforcing property rights, and because land rights are often anyway secure within the existing customary land tenure systems (Deininger & Feder, 2009; Migot-Adholla, Hazell, Blarel, & Place, 1991).

While there are circumstances where land titling is justified, more cost-effective and politically feasible alternatives may exist. Improvements to land rental and sales markets can be helpful, and measures such as reforming rental laws, and streamlined procedures for registering and enforcing contracts and resolving disputes may be helpful. Where customary land rights already exist, as in most of Sub-Saharan Africa, it may be better to strengthen and build on the customary systems rather than replace them. A promising approach is the titling of lands at community rather than individual farm levels, thereby protecting the rights of the community against outsiders while leaving the community empowered to manage its own land rights arrangements. A number of African governments have initiated land policy and legislative reforms based on these principles although their effectiveness is not yet known (Deininger, 2013).

Securing land rights for women can be even more challenging. In much of Sub-Saharan Africa, there is no concept of co-ownership of property by husband and wife under customary law, so formalizing customary arrangements without first changing women's inheritance and ownership rights can easily lead to catastrophic outcomes for women (Joireman, 2007). Although many African countries now give attention to gender equality in national legislation, implementation remains constrained by deeply rooted cultural norms, compounded by women's lack of access to legal institutions, especially in rural areas. Creating law regarding co-ownership without effective enforcement of that law will not improve the current situation (Joireman, 2007; Meinzen-Dick & Mwangi, 2008). Also needed is the education of legal and traditional authorities and men and women in areas where customary law might conflict with new statutes.

In all areas of land policy, there is growing evidence to show that transparent and easy access to land records, such as is now possible through digitization and the internet, can facilitate more secure rights for small farmers, improve the efficiency of land markets and enhance the value of land for collateral purposes (Deininger, 2013).

Collective action. Many productivity enhancing investments or technologies must be taken up by groups of farmers or even whole communities (e.g., land terracing, water capture, integrated pest management, and the improvement of communal forests and grazing areas). To be effective, community organizations need to involve all the key stakeholders. In some cases this may need to involve only a group of farmers within the community, as for example in contouring part of the landscape. In other cases it may need to involve the whole village, as in watershed development projects. In some cases it will be necessary to embrace several villages, as in the management of open rangelands which may be shared by a number of local communities or even distant tribes. We consider some of the evidence on ways of promoting and strengthening community organization for collective action in our answer to question two on natural resource management (NRM).

Linkages among constraints

Much of the literature treats each constraint to adoption independently, whereas there may be important linkages amongst subsets of constraints that arise from a common underlying factor. For example, the adoption of many technologies requires a package of complementary inputs (e.g., seeds, fertilizer, pesticides, credit and a market outlet) and farmers may choose not to acquire individual inputs until they can obtain the entire package. These kinds of complementarities are very common for green revolution technologies where improved seeds or fertilizer or even irrigation have relatively modest productivity impacts on their own, but when packaged together lead to powerful synergies in their combined impact (Hazell, 2009). On the supply side, specialized suppliers of modern inputs, credit and the like may also be hesitant to supply their input to farmers who do not have access to other complementary inputs. This is known as the coordination problem and is a form of market failure that leads to suboptimal levels of technology adoption from an aggregate economic perspective (Poulton & Lynne, 2009). Economists differ in the extent to which they believe the coordination problem undermines the development of private service suppliers. Conventional liberalization policy does not recognize this as a problem, but others (Dorward et al., 2005 & 2009; Djurfeldt, Holmen, Jirstrom, & Larsson, 2005) argue that it is an important factor underlying the slow growth of food staples production in many African countries.

For farmers who live in remote areas with poor infrastructure, high transport costs may act as a common factor that make it too costly for input suppliers, credit and insurance institutions, market traders, and extension agents to service the area.

Women may face linkages among constraints because of social and other barriers that discriminate against them in the supply of many of the key inputs and services needed for technology adoption (Meinzen-Dick et al., 2011). Based on a review of 67 quantitative studies published since 1999 (75 percent from Sub-Saharan Africa), Peterman et al. (2010) find that many women farmers face unequal access to a range of inputs and services, but after controlling for access, women are just as likely to adopt as male farmers. Unfortunately, although strongly suggestive of strong links between constraints, neither the authors nor the studies on which they base their review appear to formally test for correlations in access to different inputs and services for the same households.

When linkages arise among constraints, policy interventions that remove a common underlying factor might be more effective than interventions that target one constraint at a time. A key challenge is then

for policymakers to find efficient ways of overcoming linkages among constraints. Three promising areas are building rural roads, empowering women, and resolving the coordination problem.

Rural roads. Several studies show favourable growth and poverty impacts from investments in rural roads. The primary impact pathways are through improved market access and lower transport costs, which help enable farmers to overcome access constraints to several required inputs and markets for technology adoption. Econometric studies using pooled time series and cross-sectional data at regional levels are often criticized because of the quality of available data and statistical estimation challenges (especially endogeneity problems). They have the advantage, however, that they can capture benefit spillovers across sectors and space, take account of the impact of the cumulative value (or stock) of road investments, and the long lead times before full impacts are realized. These studies show that public investments in rural roads can have significant productivity impacts, and in the case of work by Fan and colleagues in several African and Asian countries, that road investments lead to more favourable benefit /cost ratios and poverty reduction than many other types of public investment (Fan & Rao, 2008; Binswanger, Khandker, & Rosenzweig, 1993). Van de Walle (2013) reviewed the small number of rigorous impact evaluation studies that have been undertaken of rural feeder road projects, and showed that while results vary, the preponderant body of evidence shows favourable impacts on agricultural productivity, employment and poverty reduction (van de Walle, 2013). In some studies, the benefits to the poor are muted by low levels of illiteracy.

Women's empowerment. Interventions targeted at specific gender constraints (such as discussed in Quisumbing & Pandolfelli (2010)) have merit but may have modest impact on their own because other complementary inputs may still not be available to women farmers. The underlying problem is often a general pattern of discrimination against women that affects their access to land, technology, knowledge, inputs, credit and markets (Meinzen-Dick et al., 2011). Finding ways to empower[2] women that overcome this discrimination would level the playing field and might be far more effective than addressing each constraint on its own. Studies show that given equal access to knowledge and inputs, the productivity of women farmers in Africa would increase (Quisumbing, 1995); Udry, Hoddinott, Alderman, and Haddad (1995) estimate that the amount of this increase could be between 10 and 20 percent. But as Peterman et al. (2010) observe, this is not just a legal, political, or economic issue, but requires changing gender relations, views, and social institutions in many settings.

Resolving the coordination problem. During the green revolution era, governments addressed coordination problems by stepping in and providing most key inputs and services themselves, essentially integrating the value chains for food staples. The approach led to mixed results, showing some big successes in launching the green revolution in many Asian countries, but failing in much of Africa and becoming increasingly redundant in Asia as the green revolution matured (Fan, Gulati, & Thorat, 2008; Rosegrant & Hazell, 2000). Most countries have since scaled back or removed these types of interventions and shifted to market liberalization policies and greater reliance on the private sector. While there have been sizeable efficiency gains from this change in policy, remaining coordination problems, especially in Africa, have left many small farms at a disadvantage. For example, based on farm surveys in several African countries, Djurfeldt et al. (2011) found that while the private sector does a reasonable job in servicing large farms growing food staples in areas with good market access, many smallholders, especially in more remote areas, remain underserved.

[2] Meinzen-Dick et al. (2011, p.10) usefully define female empowerment as leading to increases in opportunities for women in contexts ranging from access to or ownership of valuable assets to increases in mobility and personal decision making, in which gender norms had previously limited or prevented their participation. Definitions of women's empowerment are discussed in more detail in a companion review paper on *Improved Gender Integration and Women's Empowerment* (Spring, 2013).

A key challenge is how to fix coordination problems without introducing new types of public sector mechanisms that might be more costly and inefficient than the market failure problems they are trying to solve. The problem is more easily resolved in high value chains where large agribusiness players often step in and "integrate" the value chain, but remains a challenge for many food staple chains.

One approach is to set up a high level committee or trade association comprising public and private sector representatives to coordinate activities along a value chain. Using value chain analysis, such committees or trade associations could in principle identify bottlenecks, propose solutions and then oversee their implementation. The Presidential Initiatives for selected commodities in Ghana and Nigeria played this role, though the results have been mixed (Sanogo & Adetunji, 2008).

Evidence Gaps

An important evidence gap arises from insufficient attention to the linkages between adoption constraints. While it is clearly easier to structure projects, research, and rigorous impact evaluations around single issues, this may lead to disappointing outcomes and miss out on opportunities for leveraging much larger impacts by overcoming a whole cluster of interlinked constraints at the same time. The poor, women and socially marginalized farmers seem most likely to be held back by linked constraints, though this is something that still needs to be researched. Of the three types of linkages reviewed in this paper, the coordination problem seems in most need of additional research, particularly within the context of food staples in Africa. The literature on this issue remains quite divisive and unresolved (Hazell, 2013a).

While there are many successful examples of project interventions to overcome particular adoption constraints, such as linking small farms to high value markets, providing insurance or credit, or securing land rights, much less is known about how to scale up these successes. In fact, the whole methodology of scaling up seems rather fuzzy, with little guidance on the kinds of data and analysis that would be required to enable scaling up inferences to be made from a pilot project. Rigorous impact evaluations are needed to determine if a pilot is a success, but scaling up also requires attention to the causal factors underlying that success, and an ability to identify, even map, other places where the same conditions for success might exist.

Among single issues, additional research is needed on ways to link more small farms to high value markets, including the role that intermediaries like NGOs can usefully play in setting up the initial arrangements between small farm organizations and large agribusiness firms. A key issue is the sustainability of these linkages after the intermediary has completed its work.

Participatory research methods warrant further evaluation. They are resource intensive, particularly of scientific expertise, and there is insufficient evidence to show under what conditions they lead to wide-scale adoption rather than leading to "boutique" research outputs that fill narrow niches at high cost. There are also unresolved questions about the cost and sustainability of farmer field schools, and whether their impacts can be scaled up beyond the relatively small numbers that can be reached directly (Anderson & Feder, 2007).

Credit guarantees look promising but so far there do not seem to have been any rigorous evaluations of their effectiveness in expanding private lending to small farms and small and medium sized enterprises along value chains.

Early studies indicate that digitization and online posting of land records has a positive impact on security or land rights for small farmers, efficiency of land markets, and use of land as collateral. This seems like a promising area for further research and exploration.

2. Approaches That Combine Long-Term Natural Resource Management (NRM) with Increasing Productivity and Profitability

What are approaches that successfully address long-term natural resources management objectives while effectively increasing productivity and profitability?

Evidence

Introduction

A compelling observation from a large literature on the sustainable management of natural resources is that despite the widespread development of many improved (NRM practices, few are adopted at sufficient scale to resolve the major environmental problems associated with agriculture. Most of the constraints considered for Question 1 apply to the adoption of improved NRM practices, but the literature highlights the particular importance of their high labor requirements, knowledge intensity, capital requirements, and need for secure long-term property rights and collective action (Shiferaw, Okello, & Reddy, 2009; Tripp, 2006; Meinzen-Dick, Knox, Place, & Swallow, 2002; Lee & Barrett, 2001; Barrett, Place, & Aboud, 2002; World Bank, 2007). Many NRM practices also yield low or risky returns that are not attractive to farmers (Pender, Place, & Ehui, 2006). Even when NRM practices increase productivity or reduce costs and have the potential to be win-win, their adoption can be undermined by perverse policies that make unsustainable practices more profitable than they should be (e.g., subsidies on groundwater pumping and irrigation water), and by the off-site nature of some of the benefits they generate (i.e. externalities), implying that the farmer or community that bears the costs of the improvement does not capture all the benefits. There is widespread evidence that women farmers and poor farmers are less likely to adopt than other farmers (Place, Swallow, Wangila, & Barrett, 2002a; Peterman et al., 2010).

NRM for different farming systems

The types of improved NRM needed vary across farming systems. As noted earlier, in intensive (often irrigated) farming systems the main environmental problems are surface water and aquifer depletion, water logging and salinization of soils, chemical pollution, and biodiversity loss. In extensive farming systems, often located in low potential areas, the main problems are expansion of the agricultural area into remaining forest, habitat and biodiversity loss, decreasing carbon sequestration capacity, soil erosion, soil fertility depletion, and degradation of watersheds (Hazell & Wood, 2008). Poverty and population growth are typically more prevalent drivers of degradation in extensive than intensive farming systems.

A priority for irrigated farming must be to improve water use efficiency while substantially reducing total water use, water pollution, land degradation, and the unsustainable mining of groundwater. Suitable technologies are already available, such as improved fertilizer management (involving better choices about fertilizer types and application rates and timings to better match the changing nutrient needs of plants over their growing season), ecological approaches to pest management (IPM), and improved water management practices (World Bank, 2007). These can be win-win strategies for yield as well as improved environmental outcomes, but their uptake has been patchy despite intensive efforts to promote them (Pingali, Hossain, & Gerpacio, 1997; Lee & Barrett, 2001). Water charges based on full

cost recovery, greater devolution of water management decisions to local user groups, and more effective regulation of externalities are three key changes that are needed, but have proven politically difficult to implement in most countries (World Bank, 2007).

In extensive farming systems, one promising technology that has already had far ranging impacts in many hillside and agropastoral areas is agroforestry (Place et al., 2002b). Conservation farming has been successfully adapted to a wide range of conditions in Latin America, Asia, and Africa (World Bank, 2007; Haggblade et al., 2010). In the Sahelian countries, simple and low-cost bunding techniques and tree planting retain soil nutrients and reduce erosion, leading to higher and more stable yields and incomes (Haggblade et al., 2010; Reij, Tappen, & Smale, 2009).

Small-scale, farmer-controlled irrigation developments that use simple and low-cost technologies like river diversion, lifting with small (hand or rope) pumps from shallow groundwater or rivers, or seasonal flooding enjoy localized successes in Africa, especially when used to grow high value horticulture crops (World Bank, 2007). Beyond poverty reduction, small-scale irrigation can increase incomes from women's agricultural activities and improve the diversity of families' nutrition. Small-scale watershed development projects have also increased farm incomes and reduced soil erosion, as in some of the lower rainfall areas of India and Ethiopia (Pender et al., 2006; Kerr, Pangare, & Vasudha, 2002; Joshi, Jha, Wani, & Shiyani, 2005).

Community-based approaches to NRM

Community-based approaches are considered important for providing the secure property rights and collective action needed for improving NRM. They might also serve as an important vehicle for managing local externalities and as an intermediary between local people and the project activities of governments, donors, and NGOs, helping to inform and adapt investments and policies to local needs and conditions and representing local interests (Baland & Platteau, 1996; Uphoff, 2001; Meinzen-Dick et al., 2002). On the other hand, attempts by governments to manage collective action themselves by nationalizing forests and rangelands, and through top-down watershed development programs and irrigation management, have been met with limited success, and the more recent trend has been back towards greater devolution of the management (if not the ownership) of common properties resources to local communities and user groups, and the empowerment of local institutions to manage them.

This has led to a veritable explosion in the formation of community and user-based organizations in recent years for improved NRM, assisted by central and local government agencies, environmental and development-oriented NGOs active at grassroots levels, and donors. Although much has been written about the determinants of successful collective action (Ostrom, 1994), and there have been many case studies of local organizations and collective action for NRM, rigorous evidence on what determines their formation remains weak (Pender & Scherr, 2002). There has been recent work using randomized trials and other rigorous impact evaluation methods to study user groups for managing single resources like fisheries and irrigation water, but these may have limited relevance for more complex NRM problems defined at landscape levels and involving multiple resources and multiple stakeholder groups.

In a rare quantitative study, Pender and Scherr (2002) analysed the determinants of local organizations and their impact on NRM using survey data from 48 villages in the central hillsides of Honduras, a region of limited agricultural potential facing serious problems of poverty and resource degradation. At the time of the surveys (late 1990s) there were on average 15 organizations active per community, of which seven were locally governed (i.e. within the village) and the rest were externally governed (e.g., government agencies and external NGOs). About 40 percent were concerned to some degree with NRM. The authors found that the density of local organizations was positively associated (at the 10 percent level) with the presence of external organizations (a possible catalytic effect), population density

(an induced innovation effect), distance from an urban market, and adult literacy, and negatively associated with rapid population growth (greater scope for conflict), the percentage of the community born locally (less new ideas), and the importance of basic grains and forestry in village livelihoods. One reason external organizations might be helpful is that they can provide technical training and leadership support during the start-up and early development stages of local organizations. The same study also finds some positive associations between the density of local organizations involved in NRM with both collective and private (farmer) investments in improved NRM, although results vary by type of investment.

Another literature review focuses on the links between community organization for NRM and gender and poverty outcomes. To avoid elite capture and to be able to resolve local disputes, broad representation is needed in their governance (Uphoff, 2001). This is particularly important if the poor and women farmers are to be empowered within such organizations (Meinzen-Dick et al., 2011). Westermann, Ashby, and Pretty (2005), in their study of the natural resource management outcomes of 33 rural programs in 20 countries in Africa, Asia, and Latin America, found that collaboration, solidarity, and conflict resolution increase among all program group members when women are members of groups.

Management of externalities

Another widespread problem holding back the uptake of improved NRM practices is the offsite (or externality) nature of many environmental problems, meaning that the farmers who cause an environmental problem do not bear the full consequences of the damage. With water pollution, for example, it is the people who live downstream of the offending farmers who suffer the consequences. Again, farmers who mine groundwater impact on all users in a watershed. In these kinds of cases, the standard policy approach is to regulate and penalise the farmers causing the problem, but this requires more effective public institutions and enforcement systems than exist in many developing countries. Sometimes solutions can be found in local organizations that bring key stakeholders together (e.g., river basin management authorities provide a forum for linking upstream and downstream users), but too often there are no easy solutions to these kinds of externality problems.

Not all externalities are costs. Some externalities lead to benefits, such as the provision of important environmental services like watershed and habitat protection, and carbon sequestration. These can be of considerable benefit to societies at large, but the farmers and communities who provide these services are not rewarded for their efforts in the market. The result is that they engage in farming practices which, even if sustainable, do not provide sufficient environmental services. In these cases there may be need for some form of financial compensation, and the emergence of market based schemes for paying for environmental services (PES) is a promising development (World Bank, 2007). Emerging carbon payment markets are a good example, and under some circumstances can be used to pay farmers for sequestering carbon in their landscapes. So far there is limited experience in using PES in agriculture; however, there are many interesting pilot schemes underway.

Evidence Gaps

Given the importance of the costs of collective action and externalities in constraining the uptake of many improved NRM practices, both warrant further research. In particular, more empirical research is needed to understand the factors leading to the formation of successful community organizations for NRM, and which serve the interests of women and poor farmers and not just the better off farmers. Additional evaluative studies of markets and programs for PES are also needed.

The high labor requirements of many improved NRM practices are often blamed for making them unattractive to farmers, yet there is surprisingly little data about their seasonal and total labor requirements and how this matches with the labor profiles of the small farms who are supposed to adopt (Tripp, 2006).

Although there are many studies that evaluate the productivity impacts of improved NRM and the constraints to their adoption, very few have attempted to evaluate environmental impacts other than in broad qualitative terms (Barrett et al., 2002; Waibel & Zilberman, 2007). Improved methods and case studies are needed to better inform environmental policies, and to be able to rank NRM projects against alternative investments that have more measurable impacts.

3. Impact of Agricultural Value Chain Interventions on Employment

To what extent do agricultural productivity interventions in the staple and non-staple crop value chains lead to the generation or improvement of on-farm and off-farm employment?

Evidence

Introduction

Agricultural growth, especially when focused on small farms, can generate significant amounts of agricultural employment. In Asia, the green revolution in food staples created huge amounts of employment, particularly in irrigated areas (Lipton, 2005). But increased labor demand put pressure on wages that stimulated widespread mechanization, leading to an eventual reduction in labor per hectare (Otsuka, 2007). In India, this has contributed to a sharp decline over time in the employment intensity of agricultural growth (Bhalla & Hazell, 2003).

Additionally, agricultural growth generates employment along commodity value chains in a myriad of trading, processing, storing, wholesaling, and retailing functions. These functions have typically been undertaken by a host of small-scale traders and processors using low-tech facilities, but this appears to be changing. In a recent study of the value chains for rice and potatoes in Bangladesh, China, and India, Reardon and colleagues found that traditional traders and processors are diminishing in importance while large shares of total output are now marketed, stored, processed, and distributed by medium- to large-scale intermediaries using modern technologies and facilities (Reardon et al., 2012). While employment amongst traditional traders and processors may be declining, higher value jobs are being created along value chains, and labor costs now account for a quarter to one-third of total value-chain costs. These kinds of employment opportunities are likely to grow with urbanization and rising per capita incomes.

Employment opportunities in high value agriculture (HVA)

While there are still opportunities for creating agricultural employment in food staples, especially in Africa, the better opportunities today lie with high value agriculture (horticulture, intensive livestock, and aquaculture). The demand for high value agriculture (HVA) has grown rapidly over the past two decades, and HVA has high on-farm labor requirements. Vegetables, for example, generate up to five times more employment per hectare than cereals (World Bank, 2007). Additional jobs are also created along value chains in processing, storage, transporting, marketing and supplying needed inputs. Women

make up a substantial share of employment in these industries, especially vegetables and livestock, and in on-farm processing (Ali & Abedullah, 2002).

Employment multipliers in nonfarm economy

In addition to employment creation in farming and along agricultural value chains, agricultural productivity growth can leverage powerful indirect employment multipliers in the nonfarm economy. A good example is the green revolution in Asia which generated significant employment and income growth in the rural towns and rural nonfarm economy within adopting regions, as well as more broadly. Numerous studies have attempted to quantify these growth linkage effects using a variety of analytical approaches, from simple linear, fixed price input-output and semi-input-output multiplier models to more recent econometric estimates and simulations with computable general equilibrium (CGE) models. Haggblade, Hazell, and Dorosh (2007, Table 7.3) compare multiplier estimates (measures of the total income generated per dollar of additional income in agriculture) from a variety of empirical studies using different methods. Averaged over all the studies, the income multipliers estimated with econometric and CGE models are similar, falling in the range 1.4 to 1.5 for rural regions, and 1.75 to 2.00 for national economies. Semi-input output multipliers are about 20 percent larger, and standard input-output model multipliers are about 20 percent as large again. There are also regional differences, the multipliers lie in the range 1.6 to 1.8 in Asia, and 1.3 to 1.5 in Africa and Latin America.

Decompositions of the income multipliers show that how rural households spend additional income (consumption linkages) is far more important than the production linkages arising from the extra amounts farmers spend on farm inputs and marketing services in raising productivity (Haggblade et al., 2007). Moreover, the consumption induced multipliers arise primarily within the service and informal manufacturing sectors.

Employment multipliers are much harder to estimate, not least because much rural nonfarm employment is part time and seasonal and not adequately captured in census data. However, given the dominance of the consumption linkages and the known employment intensity of many of the service and informal manufacturing activities that supply local consumer demand, then the employment multipliers can be expected to be large. These are also activities in which women and poor people play important roles, so they can also gain from the income and employment multipliers (Haggblade et al., 2007; Hazell & Haggblade, 1993).

Another implication of the predominance of consumption linkages is that it is the amount of agricultural income that is generated that really matters for employment creation. As such, high value commodities offer more scope than food staples for raising incomes, though their relatively small base means that they have to grow much faster to achieve the same impact as a more modest growth in food staples (Diao et al., 2007).

As noted above, the estimated growth linkages are typically lower for Africa than Asia. This is partly because of weak production linkages due to limited development of agricultural processing and other value adding activities in Africa, and the low use of modern inputs in farming. Also, lower per capita rural incomes and less developed rural towns mean that the consumption linkages are weaker (Dorosh & Thurlow, 2013).

Evidence Gaps

Given the increasingly integrated nature of many value chains, more research is needed to determine the implications for employment. If, as Reardon and colleagues have found (Reardon et al., 2012), small-scale traders and processors using low-tech facilities are being squeezed out of value chains by larger

and more modernized firms, then what is the net impact on employment and on the employment opportunities for the poor? Also, given the preference for many agribusinesses to source from large farms, important questions arise about how much employment large farms create and whether it is enough to offset the employment losses incurred when production (sometimes even land) is transferred from the smallholder sector. Some studies have shown that the employment effects may be quite favourable in the case of some high value crops (e.g., Maertens, Colen, & Swinnen, 2011; Maertens, Minten, & Swinnen, 2012), but this is still a hotly disputed issue.

4. Impact of Agricultural Productivity Interventions on Resilience

Which agricultural productivity interventions have had the greatest impact on resilience of households and individuals to recover from (regain consumption levels and rebuild assets) or withstand (maintain consumption levels and protect assets) common and extreme shocks?

Evidence

Introduction

Resilience can be strengthened in different ways. Some agricultural investments that raise average productivity also improve resilience by reducing downside risks. These include (i) breeding new crops and livestock that are tolerant or resistant to drought or flood, (ii) building irrigation systems, (iii) improved water harvesting, and (iv) conservation farming. Resilience can also be strengthened by non-agricultural interventions that contribute to improved ways of managing and coping with losses when they occur. Examples include (i) investing in roads that improve market access, (ii) improving farmers' access to credit and insurance, and (iii) establishing early warning systems and effective safety net programs. A full review of the literature on resilience interventions and their impact on poverty reduction and improvement in nutritional status is presented in the companion paper *Improving Resilience of Vulnerable Populations* (Frankenberger, 2013). Here we consider only those interventions that are expected to generate increased resilience by improving agricultural productivity.

Varietal improvements

Over recent decades, plant breeders have developed strategies for ensuring that the crop varieties grown by farmers can withstand climatic and biotic stresses. Before releasing new varieties to farmers, they test them in different environments and under induced stresses (Smale, Hazell, Hodgkin, & Fowler, 2009; Anderson, Hazell, & Evans, 1987). The robustness of new varieties has been improved by breeding for tolerance to specific risks such as drought, flood and disease. This ability has increased with advances in the biosciences, as has the speed with which breeders can respond to new risks such as evolving pest or climate risks. In many cases, resilience has been improved with little or no sacrifice in average yield, leading to win-win outcomes.

Soil and water management

Irrigation investments should in principle reduce risk while increasing average productivity, but results have been mixed. Much depends on the reliability of the water source and the efficiency of water

management. Kerr et al. (2002) found that watershed development projects improved resilience as well as productivity. Improved soil management practices like conservation farming also raise average yields whilst reducing drought risk (Haggblade et al., 2010; Reij et al., 2009).

Nonagricultural interventions as trigger

Rural roads contribute directly to raising productivity but also by expanding markets they facilitate risk pooling and have a stabilizing influence on food prices. The flow of food from surplus to deficit regions can be an extremely important price buffer in drought years.

Insurance, credit, and safety net programs can all help reduce risk exposure by providing assistance in the event of losses. Some programs, such as food for work and relief employment, have also proven useful in building infrastructure that helps raise agricultural productivity (Hoddinott, 2008; Bezu & Holden, 2008). Additionally, interventions that offset losses may be sufficient to induce households to take on more risk and make investments of their own that lead to future gains in productivity. For example, many conventional agricultural insurance programs were successful in inducing farmers to expand the area of more profitable crops grown in insured areas and to use more intensive farming methods (Hazell, Pomareda, & Valdés, 1986). Feed subsidy policies in drought years in the Western Asia North Africa (WANA) region not only helped protect flock sizes in drought years, but also over time led to a steady increase in rangeland stocking rates (Hazell, Oram, & Chaherli, 2003).

A difficulty with these kinds of win-win outcomes is that when heavily subsidized, they may inadvertently worsen future problems by encouraging people to increase their exposure to potential losses and become increasingly dependent on government assistance. For example, compensation for crop or livestock losses in drought-prone areas may encourage farmers to grow more of the compensated crops or livestock even when they are more vulnerable to drought than alternative land uses (Hazell, 2011). Subsidies on any input (e.g., fertilizer) can encourage overuse of that input in terms of the balance between the economic value of the additional production and the cost to the tax payer (Siamwalla & Valdés, 1986). In this case the "overuse of the input" is excessive adoption of farming practices and livelihood strategies that lead to a growing dependence on government assistance. A better option is the promotion of market-assisted and unsubsidized risk management aids such as weather index insurance provided by private insurers. As discussed earlier, there has been limited success so far in insuring large numbers of smallholders against weather risks, and even more so in the absence of subsidies (Hazell, 2011).

Evidence Gaps

While it is relatively straightforward to evaluate the average productivity impacts of interventions that also improve resilience, evaluating their impact on resilience depends on observing outcomes in extreme years, and that is not easily arranged within the time frame of a typical program intervention or research project. The problem is compounded by climate change, which may affect the frequency and severity of extreme events in unknown ways. One solution to this problem is to rely on farmer estimates of what they think the resilience benefits are (as, for example, through experimental trials with insurance products), but this approach may not be reliable when introducing new technologies or when climate is changing and farmers face considerable ambiguity about future outcomes. Another approach is to collect panel data over longish periods of time at carefully chosen benchmark sites, something that may become especially important for measuring the impacts of climate change on farming systems.

More research is needed on smart ways of subsidizing risk-reducing interventions like weather insurance and relief programs for poor smallholders so as not to inadvertently increase their future dependence on subsidized programs by encouraging them to take on too much risk.

5. Impact of Including Nutrition Education in Agricultural Extension Programs

Does including nutrition education (social and behavior change communication) in agriculture extension services lead to reductions or elimination of household hunger and improved dietary diversity?

Evidence

Introduction

In recent years, there has been increased recognition of the important role that agriculture can play in addressing the world's nutritional needs, including not only the quantity of calories consumed but dietary quality (Fan & Pandya-Lorch, 2012; Burchi, Fanzo, & Frison, 2011; Webb & Kennedy, 2012). This increased emphasis on the synergy between agriculture and nutrition has led to the implementation of diverse and at times complex agricultural programs with nutritional objectives, many of which have been put in place by a range of actors other than national extension agencies.

Value of nutrition education

Several reviews, some systematic, of agriculture and nutrition programs have been published in recent years, and a common theme that emerges from these reviews is that including nutrition education along with agricultural interventions increases the likelihood of success. For example, in a review of food-based strategies for addressing vitamin A and iron deficiencies Ruel (2001) summarized the evolution of programs that encouraged the production of micronutrient-rich foods. Until the 1990s, these programs rarely included nutrition education components and generally did not demonstrate dietary or nutritional impacts. The author cites several studies that compared groups that had received nutrition education to groups that had not, all of which found that the groups with access to this educational component showed more favorable results. Ruel concludes the following: "A key to success appears to be the inclusion of a strong nutrition education and behavior change intervention. For example, strategies to promote increased production of micronutrient-rich foods are more effective when combined with a nutrition education intervention, which ensures that increased household food supply and income translates into improved dietary quality" (Ruel, 2001). Reviews of other types of agricultural programs with nutrition goals, such as food gardens and animal production, draw similar conclusion about the importance of nutrition education (Berti, Krasevec, & FitzGerald, 2004; Leroy & Frongillo, 2007; Arimond et al., 2011; Gibson & Anderson, 2009; Webb & Kennedy, 2012).

While these reviews present a common message that nutrition education is important in agriculture and nutrition programs, many do not include clear evidence for how this conclusion was reached other than to say that nutrition education is a common feature of successful programs. In order to better understand what is known about the role of nutrition education in agricultural programs, two types of programs commonly cited in the literature are examined below: homestead food production (HFP) and biofortification.

Impact of nutrition education in homestead food production programs

Interventions to promote HFP began in Bangladesh by Helen Keller International in the late 1980s, and have since spread to South Asia, Southeast Asia and the Pacific, and Sub-Saharan Africa. These programs typically consist of combinations of home gardening, animal production, and nutrition education, and are often implemented with local NGOs and include a strong emphasis on the role of women (Iannotti, Cunningham, & Ruel, 2009). Program evaluations have shown that HFP programs have successfully increased intake of targeted foods, but have not shown strong evidence of improved nutritional status (Olney, Rawat, & Ruel, 2012; Ruel & Alderman, 2013).

Several scholars suggest that nutrition education is an important component of HFP programs. For example, Meinzen-Dick, Behrman, Menon, and Quisumbing (2012) argue that the success of HFP programs is due in part to the inclusion of nutrition education, particularly that which is gender-sensitive. Iannotti et al. (2009) also emphasize the role of nutrition education in HFP and suggest that this should "take the form of dialogue and negotiation with caregivers, households, and communities—rather than lectures and top-down knowledge transfer—to overcome barriers and maximize opportunities for behavior change." However, Olney, Talukder, Iannotti, Ruel, and Quinn (2009) argue for the need to use a program theory framework to better understand how HFP programs work and state the following, "Further understanding of the relationships between homestead food production program inputs (including nutrition education) and changes in child feeding, care, and health-seeking behaviors, child food and nutrient intake, and health and nutrition outcomes could provide critical insight to help refine and enhance the program design for optimal impacts." Olney et al. (2012) argue that the nutrition education component of HFP programs is in need of improvement and that more careful analysis of the impact pathways through which HFP affects consumption of micronutrient-rich foods and nutritional status is necessary.

Impact of nutrition education in biofortification programs

Biofortification refers to the scientific process of increasing the nutrient profile of staple foods using conventional or transgenetic plant breeding. The hope is that micronutrient deficiencies can be addressed in part by increasing the nutritional levels of foods that are already widely consumed by the poor (Bouis & Islam, 2012). Interventions involving the dissemination of orange-fleshed sweet potatoes (OFSP) have shown promising results. For example, Low et al. (2007), Hotz et al. (2011), and Hotz et al. (2012) report on projects in Sub-Saharan Africa that combine an agricultural extension component including the distribution of vines, a demand creation component including nutrition education, and marketing information. Each of these projects demonstrated increased consumption of vitamin A-rich foods in the intervention group relative to the control, and two (Low et al., 2007; Hotz et al., 2012) also demonstrated increased serum retinol (the indicator of vitamin A levels in the blood).

In an early feasibility study on OFSP in Kenya, Hagenimana et al. (1999) tested the importance of including nutrition education in the overall intervention and found that the nutrition education and food processing activities were critical to the success of the intervention, particularly in areas where vitamin A status was low. However, de Brauw, Eozenou, Gilligan, Kumar, and Meenakshi (2013) reached an opposite conclusion after conducting a causal mediation analysis to identify the impact pathways that led to adoption of OFSP and improved vitamin A status in Uganda and Mozambique.

Inclusion of nutrition education in agricultural extension

Based on a qualitative review of agricultural extension programs around the world, Fanzo et al. (2013) find many farm extension agents are already providing advice and training at community and farmer levels on ways to increase the physical availability of nutritious food, including growing nutrition-rich crops, linking farmers to markets to sell and buy nutritious foods, and better utilization of foods grown and purchased. Many extension agents have also received training for these purposes. That said, the scale of the nutrition advice and training being provided by agricultural extension agents is still small. Nor does an increased availability of nutritious foods necessarily translate into greater nutritional wellbeing. It also depends on access, diet choice, and intrahousehold distribution issues that affect food intake, and health issues that impact on the effective conversion of food into nutritional outcomes, and agricultural extension agents are not much involved in providing training and advice on these issues. Nor apparently are they widely covered by health extension agents, so there is an important gap that may require specially trained nutrition workers to fill.

Evidence Gaps

Other than to present results demonstrating that nutrition education is commonly present in successful agriculture or integrated agriculture and nutrition programs, most studies that cover this topic do not examine why this is so. To better understand the extent to which including nutrition education in agricultural extension programs reduces hunger, increases dietary diversity, and ultimately improves nutritional indicators, more research is needed. Causal mediation analysis and impact pathway analysis using a program theory framework, such as described in de Brauw et al. (2013) and Olney et al. (2009) respectively, are examples of the types of research that are needed to analyze the contribution of nutrition education to program outcomes. Careful analysis of this sort can be particularly valuable for programs that have the potential to be scaled up for large-scale impact and where cost-effectiveness is critical to sustainability.

In addition to analyzing the role of nutrition education in and of itself, further research is necessary to identify what inputs are needed to complement nutrition education programs in agricultural extension such as women's empowerment programs and/or health care initiatives. In other words, it is important to consider what combination or package of program components must come together in order to reduce hunger, increase dietary diversity, and improve nutritional indicators. As we have seen, there is a dearth of studies that carefully examine the role of nutrition education in agricultural programs, and studies that further analyze the combination of nutrition education and other programmatic components in agricultural extension are largely absent.

How agricultural extension systems can contribute to meeting nutrition education is also an important topic requiring further study. In their review of the existing nutrition work of agricultural extension systems, Fanzo et al. (2013) conclude that these activities should be expanded and they provide a range of recommendations on how this might best be done. However, these recommendations are not underpinned by any rigorous assessments of the impact of the ongoing nutrition activities of agricultural extension workers, or their cost in terms of the resources needed or the opportunity costs incurred given nutrition work must compete with other demands on agricultural extension agents. Important questions also remain about the best ways of providing nutrition extension, such as whether it is more effective to target men, women, or both, and whether to work at household or community levels. Existing studies demonstrate the importance of including health care initiatives alongside nutrition interventions, but more research is needed on how best to combine health and nutrition programming.

Finally, further research is needed at the national level to better understand which agencies or sectors are currently providing nutrition education and the extent to which multisectoral collaboration can improve the efficiency and cost-effectiveness of service delivery. In many countries, the Ministry of Health provides nutrition education but is not well-coordinated with the Ministry of Agriculture, and nutrition professionals and agricultural extension workers are not delivering a coordinated message. Efforts have been made in some countries to prioritize and coordinate nutrition activities across sectors (see for example International Food Policy Research Institute (2012) regarding Malawi, and Levitt, Pelletier, Dufour, & Pell (2011) regarding Afghanistan).

IV. BROADER QUESTIONS FOR THE THEME

A noticeable shortcoming of much of the literature reviewed for this paper is that insufficient consideration is given to the diversity of small farm situations when drawing conclusions about appropriate interventions for raising agricultural productivity. Distinctions are frequently made between small and nonsmall farms, between men and women farmers, and between poor and nonpoor farms, but without recognizing that for targeting purposes there may be more relevant variation within these groupings than between them. Particularly relevant here is a growing literature showing that farms are becoming more widely differentiated by size and livelihood strategy, and by market forces and locational factors that have an important bearing on their prospects as farmers, and hence the kinds of support they need. Recent trends have been towards an ever greater number of small farms, while on average their holding size has shrunk and they have become more diversified into off-farm sources of income (Master et al., 2013). There has also been a widening gap between farming opportunities in dynamic regions and more stagnant or lagging regions (Ghani, 2010; Masters et al., 2013). This has created a more diverse and polarized set of smallholder farming situations which needs to be considered when targeting agricultural investments. This is especially important when the objective (as with Feed the Future) is to help more small farms become successful and profitable farm businesses.

A number of farm typologies have been offered in the literature to help manage this diversity. Vorley (2002) distinguishes between farmers operating in three rural worlds. In rural world 1, commercial farmers are globally competitive, linked to export markets, and use modern technologies; in rural world 2, farmers sell primarily in local, regional and national markets and use intermediate technologies; in rural world 3, farmers are subsistence-oriented and use traditional technologies. The World Bank (2007) identifies five smallholder groups: market-oriented, subsistence-oriented, off-farm labor-oriented, migration-oriented, and diversified households that combine multiple income sources. Berdegué and Escobar (2002) identify three groups of family farms based on regional context and household assets. The first category comprises family farms with good assets (land, labor, and/or access to capital) and who are located in places with good agricultural potential and access to markets. These farmers are usually fully integrated in a market economy and make a substantial contribution to the production of food for domestic and international markets. The second category comprises family farms that have reasonable assets and agricultural potential but are constrained by being located in slow- moving regional economies with limited market access. The third category comprises resource-poor farmers located in places where conditions are adverse not only for agriculture, but often for nonfarm activities. The majority of smallholders in this group are poor, subsistence oriented and may be diversified into low productivity nonfarm sources of income. Fan, Brzeska, Keyzer, and Halsema (2013) differentiate small farms according to their profitability within the agricultural sector (subsistence farmers without profit potential, subsistence farmers with profit potential, and commercial smallholder farmers), and the different stages of economic transformation (agriculture based, transforming, and transformed economies).

Most of these ideas can be captured for present purposes in the 2×2 typology in Table 1 (Hazell, 2013b). Here two types of regional context are defined: favored regions that have good agricultural production potential and/or good market access, and less-favored regions with poor agricultural production potential and/or poor market access. Favoured regions provide many more business opportunities for small farms, particularly in today's world of rapid urbanization, changing diets, and globalization of agricultural value chains. The opportunities for shifting into higher value agriculture for urban and export markets can be particularly attractive as, for example, in some of the rural hinterlands around large cities in India, China, and Mexico, or the opportunities for producing fresh horticultural products for export in Kenya and Central America. Dynamic rural regions also generate plenty of nonfarm business and employment opportunities. In less-favoured regions, market opportunities for most small farms are much more constrained, and crop yields can be expected to be lower. These regions tend to be much less competitive, more risky, and oriented to production of staple foods, largely for local consumption. As stagnant regions, there is typically also little growth in nonfarm business and employment opportunities.

Table 1. A simple typology of small farms

	Market-oriented small farms	**Subsistence- and transition-oriented small farms**
Favored regions with good agricultural production potential and/or market access	A	C
Less-favored regions with poor agricultural production potential and/or market access	B	D

Table 1 also differentiates small farms into two groups. Market-oriented small farms are those who are already successfully linked to value chains, or who could link if given a little help. Market-oriented small farms may be full- or part-time farmers. The second group consists of small farms that are primarily subsistence-oriented. This group includes small farm households that are heavily diversified into off-farm sources of income and who are at various stages of transition out of farming. Very high shares of small farms fall into this category throughout the developing world today, many of them headed by women. This group also includes households that are marginalized for a variety of reasons that are hard to change, such as ethnic or gender discrimination, affliction with HIV/AIDS, or being located in remote areas with limited agricultural potential. Many of the same factors also prevent them from becoming transition farmers. Subsistence-oriented farms frequently sell small amounts of produce at harvest to obtain cash income, but they are typically net buyers of food over the entire year.

The relative importance of these two small farm groups varies widely from region to region. In a less-favoured region in a slow-growing country – the worst of all possible worlds, and a situation all too prevalent in Africa – the number of market-oriented farms is low and there are numerous subsistence-oriented small farms trying to get out while lack of off-farm opportunities prevents them from doing so, leaving many trapped in low productivity farming. At the other extreme, in a dynamic region in a dynamic country – such as some of the coastal areas in China – there are a large number of market-oriented small farms producing lots of high value products for the cities. There are also many other small farmers being pulled out of agriculture into much better-paid opportunities in the industrial areas and in their local nonfarm business economy; and only a very small group of subsistence farmers – often the elderly or the infirm. There are lots of other regions, of course, that fall somewhere between these two extremes.

Table 1 provides a basis for targeting different types of small farm development strategies. In cells A and B, the focus should be on supporting small farms on a business basis in exploiting available commercial farming opportunities, especially high value agriculture. In cells C and D, it may be more relevant to focus on raising the productivity and nutritional content of foods for own consumption, and developing off-farm employment and nonfarm business opportunities. The challenges in B and D will be greater than in A and C because of the more limited farm and nonfarm opportunities available. At a higher level, policymakers should also consider what kinds of public investments (e.g., roads, irrigation structures) could transform more less-favored regions into favoured regions (e.g., the transformation of the Brazilian Ceradó) and how investments in human capital might transform more subsistence- and transition-oriented farmers into successful entrepreneurs.

Further research is needed to develop and test the relevance of smallholder typologies, and to assess the most effective forms of agricultural interventions for each type of smallholder. This should also include analysis of the best ways to integrate agricultural interventions with complementary policies and investments, such as safety nets and assistance with migration and off-farm diversification. Another challenge is developing practical ways of identifying the different groups on the ground. There has been enough recent work using GIS and spatial analysis methods to identify target areas for rural development purposes. Most of this work focuses on mapping different regions in terms of their agro-ecology, market access, and rural population density (see, for example Omamo et al., 2006), but so far there has been limited work on disaggregating further according to differences in farmer endowments, market orientation, and gender.

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