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INDIA'S POTENTIAL BEST PRACTICES FOR FOOD AND NUTRITION SECURITY

FOOD, AGRICULTURE AND RURAL MARKETS SYSTEMS (FARMS) PROJECT

September 2011

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PREFACE

The Governments of India and the United States have formed a strategic partnership, as part of which they are sponsoring the Food, Agriculture, and Rural Markets Systems (FARMS) project. The objectives of FARMS are to:

- Reduce poverty, hunger, and undernutrition in targeted parts of India; and
- Develop knowledge useful to targeted parts of India and other countries, especially those in Africa.

The knowledge sought is about what works ("best practices") and what does not work in agriculture, nutrition, and agricultural adaptation to climate change. FARMS seeks this knowledge in India because India is recognized as a leading country with very substantial experience in testing and improving approaches to enhancing food and nutritional security and to alleviating poverty.

This document is an important starting point for FARMS' work planning process. The steps in this process are the following.

- Gather and analyze information on potential best practices
- Vet FARMS team analysis of best practices with knowledgeable stakeholders and experts
- Develop implementation plan
- Carry out best practice pilot activities and conduct rigorous evaluation (or sometimes only evaluation) to determine effectiveness (and learn about scalability and transferability)
- Share widely knowledge of what worked, what did not work, and why
- Promote improvement, adoption and/or scale-up of best practices in India and other countries, including in Africa

This document presents the FARMS team's research thus far on the first step. The assessments in this document constitute the team's initial appraisal of the potential best practices, not a final determination. This is a "living document," so it may be updated periodically when appropriate.

ACRONYMS AND ABBREVIATIONS

AAS	Agromet Advisory Services
AG	Anaerobic Germination
AI	Aritificial Insemination
AIC	Agriculture Insurance Company of India Limited
APHA	American Public Health Association
APMC	Agriculture Produce Market Committee
ARD	Agriculture and Rural Development - Department for International Development
ARG	Automatic Rain Gauge
ASAT	*Anchal Se Angan Tak*
ASC	Agricultural Science Centers (In Hindi, *Krishi Vigyan Kendra*, KVK)
ASI	Agribusiness Systems International
ATMA	Agriculture Technology Management Agency
ATP	Agribusiness and Trade Promotion
AVRDC	The World Vegetable Center, previously known as the Asian Vegetable Research and Development Center
AWC	*Anganwadi* Centre
AWD	Alternate Wet(ing) and Dry(ing)
AWS	Automatic Weather Station
AWW	*Anganwadi* Worker
BAIF	Bharatiya Agro Industries Development Research Foundation
BASIS	Program at University of Wisconsin, formerly a program funded solely by USAID
BCC	Behavior Change Communication
BDS	Business Development Services
BI	Bioversity International
BMGF	Bill & Melinda Gates Foundation
BO	Butter Oil
BP	Best Practice
BPL	Below Poverty Line
BPO	Business Processing Operations
CA	Conservation Agriculture

CAADP	Comprehensive Africa Agriculture Development Program
CABI	Centre for Agricultural Bioscience International, formerly, Commonwealth Agricultural Bureaux International
CARE	Cooperative for Assistance and Relief Everywhere
CAT	Centre for Advanced Technology, Indore
CDM	Clean Development Mechanism
CER	Certified Energy Reduction
CGIAR	Consultative Group on International Agricultural Research
CIAE	Central Institute for Agricultural Engineering
CIF	Climate Investment Fund
CII	Confederation of Indian Industry
CIMMYT	International Maize and Wheat Improvement Center (Spanish acronym CIMMYT is for *Centro Internacional de Mejoramiento de Maíz y Trigo*)
CINI	Child In Need Institute
CIP	International Potato Center (Spanish acronym CIP is for *Centro Internacional de la Papa*)
CIPMC	Central Integrated Pest Management Centres
CIRM	Centre for Risk Management
CMSA	Community Managed Sustainable Agriculture
CNFA	Citizens Network for Foreign Affairs
COCO	Connect Online Connect Offline
CPRI	Central Potato Research Institute
CRIDA	Central Research Institute on Dryland Agriculture
CRRI	Central Rice Research Institute
CRSP	Collaborative Research Support Program
CS	*Chaupal Saagar*
CSISA	Cereal System Initiative South Asia
CSSRI	Central Soil Salinity Research Institute
CT	Conservation Tillage
CTF	Clean Technology Fund
DAP	Diammonium phosphate
DFID	Department for International Development
DMMTT	District Mobile Monitoring Training Team
DNA	Designated National Authority
DNE	Dairy Network Enterprise
DPIP	District Poverty Initiatives Project

DRCSC	Development Research Communication and Services Centre
DSCL	DCM Shriram Consolidated Limited
DST	District Support Team
ENA	Essential Nutrition Actions
ES	Executive Summary
ESADA	East and Southern Africa Dairy Association
FAI	Financial Access Initiative
FAO	Food and Agriculture Organization of the United Nations
FARMS	Food Agriculture and Rural Market Systems
FCI	Food Corporation of India
FCS	Food Consumption Score
FDI	Foreign Direct Investment
FDP	Fertilizer Deep Placement
FFV	Fruit and Fresh Vegetables
FIRB	Furrow Irrigated Raised Bed
FMCG	Fast Moving Consumer Goods
FPO	Field Process Outsourcing
FRB	Federal Reserve Bank of New York
FUE	Fertilizer Use Efficiency
GAIN	Global Alliance for Improved Nutrition
GCCA	Global Cold Chain Alliance
GDP	Gross Domestic Product
GEAG	Gorakhpur Environmental Action Group
GEDA	Gujarat Energy Development Agency
GEF	Global Environment Facility
GHG	Greenhouse Gas
GMO	Genetically Modified Organism
GOI	Government of India
GRFMA	Gujarat Roller Flour Mills Association
GSS	*Gram Sampark Samooh*
HAFED	Haryana State Cooperative Supply and Marketing Federation
HDFC	Housing Development Finance Corporation
HFP	Homestead Food Production
HKB	*Hariyali Kisan Bazaar*
HKI	Helen Keller International

HP	horsepower
ICAR	Indian Council of Agricultural Research
ICDS	Integrated Child Development Services
ICICI	formerly, Industrial Credit and Investment Corporation of India
ICMR	Indian Council of Medical Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communications Technology
IDD	Iodine Deficiency Disorders
IEG	Impact Evaluation Group
IFA	Iron & Folic Acid
IFAD	International Fund for Agricultural Development
IFFCO	Indian Farmers Fertiliser Cooperative Limited
IFMR	Institute for Financial Management and Research
IFPRI	International Food Policy Research Institute
IIT	Indian Institute of Technology
IKP	*Indira Kranti Pratham*
IKSL	IFFCO *Kisan Sanchar* Limited
ILO	International Labor Organization
ILRI	International Livestock Research Institute
IMD	India Meteorological Department
INM	Integrated Nutrient Management
IOCL	Indian Oil Corporation Ltd
IPA	Innovations for Poverty Action
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IR	Intermediate Result
IRDA	Insurance Regulatory and Development Authority
IRRI	International Rice Research Institute
ITC	formerly, Indian Tobacco Company
ITGI	IFFCO Tokio Group Insurance
JPAL	Abdul Latif Jameel Poverty Action Lab
KAP	Knowledge, Attitude and Practices
KARI	Kenya Agricultural Research Institute
KCC	Kisan Credit Card
KGFS	*Kshetriya Grameen Financial Services*

KGVK	*Krishi Gram Vikas Kendra*
KSK	*Kisan Seva Kendra*
KSNDMC	Karnataka State Natural Disaster Monitoring Centre
KVK	*Krishi Vigyan Kendra*
KVV	*Krishi Vigyan Vahan*
LSA	Livestock-insurance Agent
MART	Marketing Assistance for Rural Territories
MAS	Marker Aided Selection
MCX	Multi Commodity Exchange of India Limited
MFI	Microfinance Institutions
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MI	Micro-insurance
MIE	Multilateral Implementing Entities
MILMA	Kerala Co-operative Milk Marketing Federation
MIS	Management Information System
MMTC	Minerals and Metals Trading Corporation of India
MNO	Mobile Network Operators
MOA	Ministry of Agriculture
MPUAT	Maharana Pratap University of Agriculture and Technology
MRJ	Mela Ram Jaggi & Sons
MRV	monitoring, reporting and verification
MSAMB	Maharashtra State Agriculture Marketing Board
MSSD	Market and Structural Studies Division
MSWC	Maharashtra State Warehousing Corporation
MT	Metric Ton
MTID	Markets, Trade, and Institutions Division
NABARD	National Bank for Agriculture and Rural Development
NAFED	National Agricultural Cooperative Marketing Federation of India Limited
NAIS	National Agricultural Insurance Scheme
NAPCC	National Action Plan on Climate Change
NBS	Nutrient Based Subsidy
NCDEX	National Commodity and Derivatives Exchange of India
NCIPM	National Centre for Integrated Pest Management
NCMSL	National Collateral Management Services Limited
NDCC	Nutrition and Day Care Centers

NDDB	National Dairy Development Board
NERIST	North Eastern Regional Institute of Science & Technology
NHB	National Horticulture Board
NFHS	National Family Health Survey
NHM	National Horticulture Mission
NICRA	National Initiative on Climate Resilient Agriculture
NIE	National Implementing Entity
NJAS	Wageningen Journal of Life Sciences
NMCE	National Multi-Commodity Exchange of India Limited
NPK	Nitrogen, Phosphorous, and Potassium
NPM	Non-Pesticide Management
NRLM	National Rural Livelihoods Mission
NRM	National Resource Management
NRMD	Natural Resource Management Division, ICAR
NS	Natural Service insemination methods
NSC	National Seed Company
NSPOT	NCDEX Spot Exchange
NSS	National Soil Survey
ODA	Official Development Aid
OECD	Organization for Economic Cooperation and Development
OMFED	Orissa State Cooperative Milk Producers' Federation Limited
OMSS	Open Market Sale Scheme
OP	Open Pollinated
OUAT	Orissa University of Agriculture and Technology
PAN	Pesticide Action Network
PATH	Program for Appropriate Technology in Health
PAU	Punjab Agricultural University
PC	Producer Companies
PD	Positive Deviance
PDS	Public Distribution System
PEC	Formerly, Projects and Equipment Corporation of India Limited
PHH	Post-harvest handling
PIKA	Partnerships for Innovation and Knowledge
PMIS	Pest Management Information System
PPPP	Public Private Panchayat Partnership

PRA	Participatory Rural Appraisal
PRADAN	(PRADAN) Professional Assistance for Development Action
QTL	Quantitative Trait Loci
RBH	Rural business hub
RCM	Regional Climate Models
RCS	Registrar of Cooperative Societies
RCT	Randomized controlled trial
RDA	Recommended Dietary Allowance
RFID	Radio-frequency identification
RMSI	Risk Management Solutions India
SAFANSI	South Asia Food and Nutrition Security Initiative
SAU	State Agricultural University
SD	Secure Digital
SERP	Society for Elimination of Rural Poverty
SEWA	Self Employed Women's Association
SF	Stagnant Flood
SHG	Self-help group
SIG	Special Interest Group
SKS	SKS Microfinance
SLE	SLE-Berlin
SMP	Skim Milk Powder
SMS	Short Message Service
SPV	Solar Photovoltaic
SRI	System of Rice Intensification
SRTT	Sri Ratan Tata Trust
SSC	State Seed Companies
STC	State Trading Corporation of India Limited
SUN	Scaling Up Nutrition
TANU	Tamil Nadu Agricultural University
TBD	To Be Determined
TMC	Terminal Market Complex
TNAU	Tamil Nadu Agricultural University
TPS	True Potato Seed
UDP	Urea Deep Placement
UNFCCC	United Nations Framework Convention on Climate Change

UP	Uttar Pradesh
VCS	Verified Climate Standard
VER	Verified Emission Reduction
VMF	Village Model Farms
WARDA	West Africa Rice Development Association
WASH	Water, Sanitation and Hygiene
WBCI	Weather Index-Based Crop Insurance
WBCIS	Weather Index Based Crop Insurance Scheme
WFLO	World Food Logistics Organization
WFP	World Food Program
WWF	World Wildlife Fund
XIMB	Xavier Institute of Management, Bhubaneswar
ZMQ	a software development company
ZT	Zero tillage

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EXECUTIVE SUMMARY

USAID/India's Food Agriculture and Rural Markets Systems (FARMS) project is part of the US Government's contribution to its strategic partnership with the Government of India's Evergreen Revolution, which has the objective of spreading more of the benefits of the earlier Green Revolution to states not yet well reached, while also promoting a sustainable and equitable agricultural system that meets its population's requirements in terms of income generation, nutrition and environmental sustainability.

The project expects to achieve the following Intermediate Results:

1. Increased agricultural productivity and output to increase farmers' income;
2. Expanded use of knowledge, innovations and research by farmers and agribusinesses;
3. Farmers linked to markets and expanded trade and investment;
4. Improved household nutritional status, particularly of women and of adolescent girls; and
5. Improved natural resource management practices and agricultural systems adapted to projected climate changes.

FARMS is different from most foreign assistance projects in that it was created to be a development laboratory for fostering innovation and testing best practices, rather than a project focused on accomplishing one narrow purpose. Thus FARMS sets out to develop an inventory of best practices (BP) from all over India that have the prospect of alleviating all or part of the recognized constraints to greater food security and nutritional adequacy in India and in other developing countries. These best practices will undergo pilot testing and/or rigorous evaluations and then dissemination to target zones.

The literature review and interviews with key stakeholders that has comprised the work of the best practices inventory has been invaluable in guiding FARMS towards a truly viable and meaningful set of activities. Taking the time to search for the existence, or lack thereof, of hard evidence that has measured and documented in a scientific way the success of any one best practice is the first step in fulfilling the FARMS mandate to use empirical evidence to inform public debate about best practices that lead to greater food security. Through this work, the FARMS team has made significant progress towards revealing the key questions related to certain best practices and identifying the people, organizations and literature that represent the best bodies of knowledge with regard to these best practices.

The best practice assessments are divided into the following sections: Description of best practice, Innovative feature, Technical area (with designations of one primary area and any number of secondary areas), Constraint(s) addressed, Applicable landscape/agro-ecology, Resource organizations and individuals, Assessment criteria, and Possible activity(s) for FARMS.

The assessment criteria employed are: effectiveness, scalability, transferability, relevance, and sustainability.

The following table summarizes the nature of each best practice reviewed and its scores on each of the five criteria. Scores on the five criteria were assigned to each best practice as follows:

Green Meets criterion fully
Yellow Meets criterion partially
Red Meets criterion very little
NA = Not applicable.

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
IR 1 - Increased Agricultural Productivity and Output to Increase Farmers' Incomes					
Improving Fertilizer Use Efficiency Using Soil Testing and ICT	Fertilizer use efficiency (FUE) is a primary goal of the GOI, as there is a noted imbalance of fertilizer application on the national scale indicating significant waste. Information and Communications Technology (ICT), combined with a low-cost, accessible soil testing technique, has the potential to address this issue in a very cost effective way. Ekgaon has developed an ICT-based farmer service delivery mechanism using ICT that focuses on the issue of FUE. FARMS will explore the possibility of improving upon this model by pairing this technology with low-cost soil test kits.				
	Yellow	**Green**	**Yellow**	**Green**	**Yellow**
Urea Deep Placement	Urea Deep Placement (UDP) is a method of fertilizer modification and application that consists of pressing fertilizer into pellets (super granules) and placing them underground near the root zone of plants. It is thus far used exclusively in rice cultivation. UDP increases FUE by creating a low-cost, slow-release fertilizer. This is an effective technology that is sometimes constrained in its adoption, since the placing of the pellets is labor-intensive. FARMS may work to develop mechanized placement and test the degree to which offering a mechanized placement method increases adoption of UDP.				
	Green	**Yellow**	**Yellow**	**Green**	**Green**
Artificial Insemination	Artificial Insemination (AI), if practiced correctly, can create efficiencies in livestock herd management, especially when the goal is to alter the genetic composition of the herd for increased productivity or to introduce special adaptive traits. The effectiveness of AI in India is relatively low due to its technical complexity and the lack of skilled inseminators. Given these considerations, FARMS views AI as potential best practice, but one that will require significant modification if piloted. FARMS believes that the AI program of BAIF offers some valuable lessons for improving AI as it is practiced with smallholder farmers in developing countries.				
	Yellow	**Red**	**Red**	**Green**	**Yellow**
Integrated Pest Management	Integrated Pest Management (IPM) is a systems approach to reducing damage caused by pests to an acceptable level without harming the environment. Many Indian farmers and stakeholders in agriculture consider the development of IPM a laudable goal. There are several institutions in India that have a competency and interest in IPM and FARMS can work to develop a community of practice amongst them. Bringing in international expertise through the IPM CRSP (Cooperative Research Systems Project), FARMS can also build capacity, systematize approaches and work towards specific solutions to key problems. Through its work with IPM, FARMS will always assure the use of state of the art IPM practices; including the use of sterile male techniques and pheromone traps. Ultimately, FARMS may work towards the establishment an IPM center of excellence.				
	Yellow	**Red**	**Yellow**	**Green**	**Green**

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
Small Ruminant Introduction Program	Small ruminants represent a great opportunity to generate income and increase the availability of animal products to improve nutrition, especially in environmentally marginal geographies. Small ruminant programs seek to improve the genetics, care and feeding of goats and sheep in village clusters. FARMS sees an opportunity to include small ruminants as an element in a food-based nutrition activity in India.				
	Yellow	Yellow	Green	Green	Green
Tools for Women	Central Institute for Agricultural Research (CIAE) has developed several tools for women that are designed to reduce the drudgery of tasks that women undertake in agriculture. FARMS could work with Digital Green to increase the adoption of the most promising tools and generate empirical evidence on the current constraints to adoption and their impact on households.				
	Yellow	Yellow	Yellow	Green	Green
India's Potato Production System	The Indian potato industry is a success in many ways. Through advanced varietal development and an ever evolving seed production system, India has become one of the world's leaders in potato production. FARMS views India's potato industry, taken as a whole, as a model of collaboration between state and private sector interests and one that has successfully created a viable, profitable and self-contained domestic industry. Malawi and other countries may have something to gain by being exposed to the details of this model, and Indian potato researchers have expressed an interest in sharing some of their lessons learned.				
	Yellow	Yellow	Green	Green	Green
IR 2 - Expanded Use of Knowledge, Innovations and Research by Farmers and Agribusinesses					
Digital Green	Digital Green is an extension and educational tool using short, low-cost videos to introduce new concepts, knowledge or technologies to rural populations. FARMS may work with Digital Green to develop a training center that can expand the use of this effective extension model to NGOs and other development practitioners in India and in other countries.				
	Green	Green	Green	Green	Yellow
ICT in Agriculture	Information and Communications Technology (ICT) is considered a mechanism for the delivery of best practices, but not a best practice in itself. ICT will increasingly play a greater role in the development of smallholder agriculture. FARMS plans to initially conduct a sector-wide assessment of ICT in agriculture with the view of setting up a pilot program to test a few of the most innovative and potentially successful models.				
	NA	NA	NA	NA	NA
IR 3 - Farmers Linked to Markets and Expanded Trade and Investment					
Kisan Credit Card	Kisan Credit Card (KCC) provides short-term credit to all farmers, small and large, as a revolving fund based on the land area a farmer wants to mortgage and the specific crop grown. FARMS could conduct a pilot to generate more awareness about the cash credit facility benefit of KCC and/or FARMS could work with Reserve Bank of India-approved Business Correspondents to implement KCC and assess if this approach increases the number of transactions and uptake of KCC.				
	Yellow	Green	Red	Green	Yellow

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
Rural Business Hubs	Rural business hubs (RBHs) are a "one-stop shop" for farmers that provide key farm inputs and services, and in some cases output buy-back, credit services, and other retail products. To some degree, RBHs have been a success in India, but it is clear too that many factors must come together for their success and the investment requires patient capital. Therefore, the immediate scalability of RBHs by the private sector may be constrained. FARMS will therefore consider working with Hariyali Kisan Bazaar and other RBHs to determine the critical factors for success and seek to improve their financial viability as means to make scaling up more attractive to the private sector.				
	Yellow	**Red**	**Yellow**	**Green**	**Yellow**
Linking Smallholder Farmers To Commercial Value Chains	To increase the food security of the Indian smallholder, there is a need to increase incomes from farm and non-farm activities. Improving market infrastructure, market operations and diversification into higher-value products will play a significant role. FARMS will work to identify the key elements of successfully linking smallholders to commercial value chains so that diversification into higher-value products is seen as an attractive option for farmers and so that agribusiness entities will have the tools and the understanding of how to link their supply chains to smallholders.				
	Yellow	**Green**	**Green**	**Green**	**Green**
CoolBot and Other Low-Cost Post-Harvest Handling Methods	Reducing post-harvest losses is a great, and often overlooked, opportunity to increase the food supply. Most post-harvest technologies are capital-intensive, but FARMS has identified a few low-cost possibilities for reducing losses and improving product quality. The CoolBot, a low-cost, mini cold storage unit, is a good example. FARMS understands, however, that these technologies are only effective in value chains that offer a premium for properly handled product. If FARMS sees an opportunity to develop value chains and integrate the use of the currently available technologies, it will establish a pilot activity along those lines and as a means to promote the use of these value-adding, loss-reducing technologies.				
	Yellow	**Yellow**	**Yellow**	**Green**	**Yellow**
Producer Companies	The Companies Act of India was modified to designate a new type of entity, Producer Company. The Act was designed to create an option for smallholder farmers to work collectively, while avoiding the common pitfalls of working within cooperatives as they exist in India. Traditional cooperatives in India are laden with GOI involvement and mostly serve the best interest of a few members. The concept of Producer Companies is borrowed from the concept of cooperatives as they exist outside of India and thus cannot really be seen as an innovation of India. However, Indian producer companies have devised some innovative models for effective management of farmer aggregation systems and provide sound examples of the cluster approach to development. FARMS will seek ways to work with the Small Farmers Agribusiness Consortium to develop evidence of the potency of this approach and to inform policies that further encourage the trend towards farmer cooperation and linkage to commercial, higher-value markets.				
	Yellow	**Green**	**Green**	**Green**	**Green**

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
IR 4 - Improved Household Nutritional Status, Particularly of Women and Adolescent Girls					
Home Gardens	A homestead garden is a garden near a home that is designed to provide vegetables and/or income to the family throughout the year. Some homestead garden interventions integrate poultry or small ruminants, and a nutrition education component to improve their viability. FARMS has identified several potential partners to implement a homestead gardens pilot and may seek to rigorously evaluate their efficacy in improving household nutritional status both with and without the inclusion of animal sources of food. This work will provide more clear answers to some of the important questions regarding food-based solutions to nutrition.				
	Yellow	**Yellow**	**Green**	**Green**	**Green**
Multi-Sectoral Nutrition Education	*Anchal se Angan Tak*, Positive Deviance, and Dular are three innovative nutrition education pilots being implemented as overlays to the Integrated Child Development Scheme. In addition, IKP is implementing innovative fee-based nutrition-cum-day-care-centers (NDCC) in Andhra Pradesh. An interesting possibility for FARMS could be to expand Positive Deviance and NDCC to new areas and assess the cost-effectiveness and efficacy of these programs.				
	Yellow	**Green**	**Yellow**	**Green**	**Red**
Micronutrient Fortification in Staples	Fortification of staple foods at the industrial level has sometimes been very successful whereas in small, local mills it has not. India's Public Distribution System has started distributing fortified wheat flour instead of wheat grain in some states. Ultra Rice is a micronutrient-dense look-alike grain (of pasta) that is mixed into whole-grain rice. Among several possible activities for FARMS, the most likely seem to be pilot testing or scaling up Ultra Rice, evaluation of a state-level program to improve implementation, and evaluation of a flour fortification program at small scale.				
	Yellow	**Green**	**Green**	**Green**	**Green**
IR 5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes					
Conservation Agriculture	Conservation agriculture (CA) is a combination of agronomic practices that seeks to maximize the efficiency of input usage and conserve natural resources. Soil conservation through minimal soil disturbance (no-till) is a major tenet of CA. India is pioneering an effort to adopt and adapt conservation agricultural practices in the Indo-Gangetic Plains. In partnership with the Cereal Systems Initiative in South Asia (CSISA) program, FARMS may conduct rigorous evaluations that determine the economic viability of these practices for the farmers that adopt them and measure their actual effectiveness in conserving agricultural resources.				
	Green	**Yellow**	**Green**	**Green**	**Yellow**
Laser Land Leveling	Laser-assisted precision land leveling was originally practiced in countries that have large fields and mechanized cereal production, but through the work of CSISA, farmers in India have reduced the cost of laser land leveling and made it accessible to smallholder farmers. A level farm field improves water use efficiency, reduces irrigation time, reduces soil erosion, eliminates puddle formation, promotes even crop height, decreases weed burden and encourages the even maturing of crops. Laser land leveling is nearly a transfer-ready best practice that could have implications for several African regions. FARMS may seek private sector mechanisms for the transfer this technology to Africa.				
	Green	**Yellow**	**Green**	**Green**	**Yellow**

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
Climate Analogues	Climate Analogues are derived from a web-based tool that facilitates the comparison between agro-ecological zones along a set of climate-based parameters. They are particularly useful for comparing geographic areas with respect to the cropping systems they can support both in the present and in the future by taking into account predicted changes in the climatic parameters according the various models of climate change already developed. Climate Analogues synthesizes vast, complex and disparate data to offer decision-makers a quick, low-cost and user-friendly means of visualizing and analyzing those data for planning and decision-making purposes. Though it is particularly robust in its coverage of India, the tool is global in coverage. It can be used for activities in the Indian states targeted by FARMS. It may also be useful for comparing conditions in these states with those prevailing or anticipated in African countries in the context of FARMS' technology transfer activities and climate change adaptation strategies.				
	Yellow	**Green**	**Green**	**Green**	**Green**
Carbon Finance for Adaptation	The overlap between the climate adaptation and mitigation benefits of certain agricultural practices suggests potential for carbon markets to help finance and promote climate-smart agriculture on a large scale going forward. Based on its past success in shaping and harnessing carbon finance, India is well positioned to be a trailblazer in the demonstration and mainstreaming of land-based agricultural carbon. FARMS could make a variety of contributions to GOI-funded initiatives working in this direction. For instance, it could support the identification, field testing and evaluation of dual benefit agricultural practices, and support the development of related greenhouse gas accounting principles, protocols and management tools.				
	Yellow	**Green**	**Green**	**Green**	**Green**
National Initiative on Climate Resilient Agriculture	NICRA is a GOI initiative that aims to enhance the resilience of India's agricultural sector in the face of climate change, focusing on applied research, technology demonstration, and scientific capacity building. FARMS, with its similar mandate, could support NICRA in field testing and evaluating technology packages in vulnerable districts, identifying strategies for promoting the adoption of climate change adaptation practices that may also have the benefit of reducing greenhouse gas emissions or sequestering carbon. FARMS can help NICRA in developing protocols and tools to track the adoption climate adaptation practices and also, if needed, account for carbon sequestered by these same practices.				
	Yellow	**Green**	**Green**	**Green**	**Green**
Stress-Tolerant Varieties of Cereals for Climate-Resilient Agriculture	In South and Southeast Asia, IRRI, through its Stress Tolerant Varieties of Rice for Africa and South Asia (STRASA) program, has had excellent success in improving the most popular rice varieties through marker-aided selection, a modified traditional breeding technique. This has improved greatly the plight of farmers who regularly suffer crop losses due to flooding, saline encroachment and variable rainfall. FARMS proposes to work with STRASA to improve the part of their program that makes linkages with farmers by understanding the best mechanism for introducing and disseminating these new varieties and in possibly developing a model for village-level seed production.				
	Green	**Yellow**	**Yellow**	**Green**	**Green**
System of Rice Intensification	The System of Rice Intensification (SRI) is a package of rice production practices that has been demonstrated to reduce the required amounts of seed and water required to produce a given quantity of rice. FARMS may assess the variability and degree to which SRI saves water in on-farm applications in various Indian rice production settings. Also, FARMS feels that more information is needed on SRI's impact on women's labor demands compared to traditional rice production systems.				
	Yellow	**Yellow**	**Green**	**Green**	**Green**

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
Weather-index Based Crop Insurance	Weather-index based Crop Insurance (WBCI) uses insurance payouts linked to weather data, whether temperature, rainfall or moisture, which results in significant reductions in the transactions costs of processing claims, and also reduces the extent of moral hazard. A possible next step for FARMS could be to work with several organizations in India that are developing innovative indexed insurance products. FARMS can work with these organizations to implement pilots and to evaluate the efficacy of these innovative products.				
	Yellow	**Green**	**Green**	**Green**	**Green**
Ridge to Valley Integrated Watershed Management	This best practice in India is a system of participatory activity design and implementation by clusters of local villages. It improves their watersheds by sustainably maximizing water flows to farmers and villagers. FARMS may expand this practice by integrating sustainable agroforestry management practices and test it in vulnerable districts in FARMS' target areas.				
	Yellow	**Green**	**Green**	**Green**	**Green**
Livestock Insurance	Livestock insurance covers death of the animal and is best provided as part of bundled financial services. FARMS could evaluate the impact of these financial products on household incomes by collaborating with Institute for Institute for Financial Management and Research (IFMR) Trust and expand the scope of their ongoing evaluation of integrated financial services.				
	Yellow	**Yellow**	**Green**	**Green**	**Yellow**

1. INTRODUCTION

USAID/India's Food Agriculture and Rural Markets Systems (FARMS) project is part of the US Government's contribution to its strategic partnership with the Government of India's Evergreen Revolution, which has the objective of spreading more of the benefits of the earlier Green Revolution to states not yet well reached, while also promoting a sustainable and equitable agricultural system that meets its population's requirements in terms of income generation, nutrition and environmental sustainability.

The project expects to achieve the following Intermediate Results (IRs):

1. Increased agricultural productivity and output to increase farmers' income;
2. Expanded use of knowledge, innovations and research by farmers and agribusinesses;
3. Farmers linked to markets and expanded trade and investment;
4. Improved household nutritional status, particularly of women and of adolescent girls; and
5. Improved natural resource management practices and agricultural systems adapted to projected climate changes.

FARMS will accomplish these results through the following operational steps:

1. Gather and analyze information on potential best practices
2. Vet FARMS team analysis of best practices with knowledgeable stakeholders and experts
3. Develop an implementation plan
4. Carry out best practice pilot activities and conduct rigorous evaluation (or sometimes only evaluation) to determine effectiveness (and learn about scalability and transferability)
5. Share widely knowledge of what worked, what did not work, and why
6. Promote improvement, adoption and/or scale-up of best practices in India and other countries, including in Africa

As indicated in this operational framework, FARMS will be different from most foreign assistance projects. It has been created to be a laboratory for innovation and testing, rather than a project focused on accomplishing one narrow purpose. This document is the culmination of the first operational step; developing an inventory of best practices (BP) from all over India that have the prospect of alleviating all or part of the recognized constraints to greater food security in India and in other developing countries.

The literature review and interviews with key stakeholders that has comprised the work of the best practices inventory has been invaluable in guiding FARMS towards a truly viable and meaningful set of pilot activities. Through this work, the FARMS team has made significant progress towards revealing the key questions related to certain best practices and identifying the people, organizations and literature that represent the best bodies of knowledge with regard to these best practices.

Taking the time to search for the existence, or lack thereof, of hard evidence that has measured and documented in a scientific way the success of any one best practice is the first step in fulfilling the FARMS mandate to use empirical evidence to inform public debate about best practices that lead to greater food security. The next step in the process is to vet the analysis with field-level implementers

and other stakeholders and develop a plan for the execution of pilot activities. The reason for the pilots, aside from having tangible impact in the ground, will be to generate evidence about best practices that work well and how they might work better. Remaining true to the call for more rigorous evaluations and the use of evidence-based decision making in USAID programming, FARMS will use scientifically controlled designs in its pilots to generate evidence-based knowledge for a range of best practices that improve food and nutrition security for those living under $1.25/day.

FARMS is also meant to work in concert with the Indian government to assist it as it positions itself as a global donor and a source of science, innovation, technology and development approaches for those countries that are positioned to benefit from achievements made in India. FARMS' pilots and evaluations will generate evidence-based knowledge that will comprise a portion of India's development offerings, but FARMS will add further value by working towards the creation of mechanisms for sharing knowledge and transferring technologies through both the Indian public and private sectors. FARMS will draw inspiration from India's commitment to working with African countries, by focusing its efforts at transfer on three specific African countries: Kenya, Liberia and Malawi.

Through its initial work in developing the best practice inventory and the subsequent analysis, FARMS has developed and/or reinforced certain number of concepts that will guide its implementation.

- Achieving food security through enhancing agricultural production has been the major focus in most developing countries. Several countries have succeeded, to a significant extent, in achieving this objective. However, nutritional adequacy has not been addressed effectively. In India, an emphasis on initiatives to improve agricultural productivity alone, while improving farmer incomes, has failed to address India's malnutrition crisis.

- The FARMS team believes that nutrition considerations must be addressed by multiple stakeholders complementing each other. Access to, and availability of, adequate calories and protein is but the beginning; there is a need for access to a variety of foods as part of a balanced diet and sufficient knowledge of holistic nutrition considerations that change behavior and attitudes sufficiently to act on this knowledge. A diverse diet should provide the essential micronutrient complement required, including bioavailable iron, vitamin A and zinc.

- With increasing political awareness of these issues, now is an opportune time to facilitate convergence at the policy and action levels to comprehensively address both food and nutrition security, giving nutrition its due emphasis.

- FARMS has also internalized the notion that agricultural productivity gains without embedded sustainability and resilience in the face of climate change are not gains at all. Therefore the strategy and programming of India's Evergreen Revolution, a revolution that seeks sustainable and equitable growth in agriculture, will play a central role in its selection of best practices and the programmatic activities of FARMS.

- The piloting and scale-up of activities will be reinforced through emphasis on gender and equity; partnership with private sector, other USAID projects, CGIAR institutes and other related national and international projects; ICT and knowledge management; monitoring, evaluation and implementation (governance); and education.

The set of best practices in the body and annex of this inventory was compiled from literature reviews, interviews and site visits during the various phases of work both before and under the Task Order, including the proposal phase, the pre-inventory phase, and the inventory phase. As work continued from one phase to the next, the process of finding and assessing best practices for their potential became more objective and less opportunistic. FARMS remains open, however, to considering new opportunities to address key food security constraints, no matter when or how they may present themselves. The list presented here is thought to be a good representation of high-potential best practices that will address food security via the five intermediate results of the project, but the list will not be considered closed or complete at any point throughout the life of the project.

The best practice assessments that follow have this outline:

- Description of best practice
- Innovative feature
- Technical area, with designations of one primary area and any number of secondary areas from among the five IRs
- Constraint(s) addressed
- Applicable landscape/agro-ecology
- Resource organizations and individuals
- Assessment criteria: effectiveness, scalability, transferability, relevance, and sustainability
- Possible activity(s) for FARMS

Most of these designations are self-evident. The criteria deserve some explanation.

1.1 CRITERIA FOR ASSESSING BEST PRACTICES

Through the development of the inventory, the FARMS team has deepened its understanding of each best practice. Based on the information acquired, FARMS has made a qualitative assessment of each potential best practice using five criteria developed by the FARMS team. The best practice assessments form the body of this inventory. The criteria correlate well with those proposed by the Development Assistance Committee at the OECD for evaluating development cooperation (OECD DAC Network on Development Evaluation, 2010).

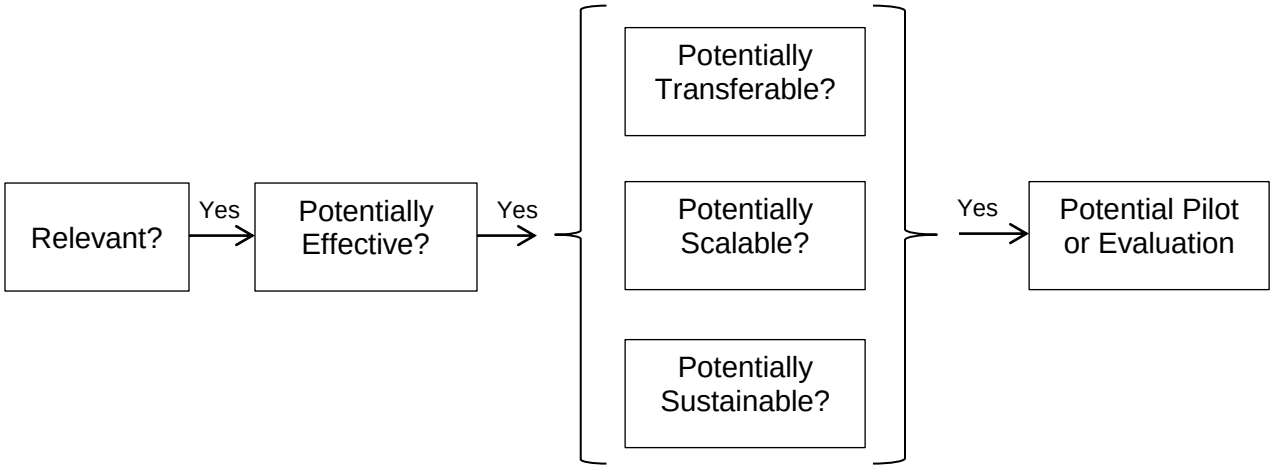
There can be perceived overlap in the definitions of certain criteria, and some of them have a more logical 'fit' with certain best practices or certain target populations than others. There are also sub-criteria within each criterion, so one is tempted to multiply the number of criteria substantially. In this context, the FARMS team strove to make the criteria as comprehensive as possible, while also trying to limit their number. The resulting set of criteria stem from a high degree of reflection and debate among those who developed them. The FARMS team believes that they provide the best framework possible for assessing potential best practices for inclusion in the FARMS program. The team also believes that these criteria will have broader applicability as an assessment tool for donors who are assessing development programs, for technology incubators, and for central planning units within governments.

Several indicative questions or bullet points are included with each criterion to help delineate its nature and scope. It should be noted that not every question or point pertains directly or in the same way to each best practice, so the best practice assessments do not follow a strict list of questions.

It should also be noted that these criteria serve two purposes: they support the assessment of potential best practices before they are pilot-tested under FARMS, and they are also part of the analytical framework that will guide our evaluations of those best practices that are implemented as pilot activities.

One can use the assessment criteria individually or as part of a decision tree that assists in the determination of whether to proceed to a field test of the BP. The conceptual underpinnings of such a decision tree are shown in Figure 1.

FIGURE 1: DECISION TREE CONCEPT FOR APPLYING BEST PRACTICE ASSESSMENT CRITERIA



If a BP is not relevant to FARMS, then no further attention is given to it. If the BP is judged potentially (or actually) effective, then consideration moves to the remaining three criteria. If the BP "passes" on all three of these, then it will be in consideration for implementation as a pilot and/or evaluation. It should be noted, however, that the definition of "relevance" in use in these assessments, which includes whether FARMS can add value through implementation or evaluation, requires consideration of transferability, scalability, and sustainability. Thus there is in fact a feedback loop from these three criteria back to relevance that is not shown in Figure 1 in order to present the main flow of the decision-making process.

Each of the criteria against which the best practices were assessed is described and defined as follows.

1.1.1 EFFECTIVENESS

Is there is evidence of effectiveness or potential effectiveness of the best practice? Is the best practice cost-effective?

First and foremost, any best practice that involves a hard technology such as a seed variety, a farm implement, or an agricultural technique, there should be established evidence of the technology's efficacy under research station conditions. If this evidence is missing for any best practices involving a hard technology then it will not be considered by FARMS because the technology is likely in very nascent stages of development.

For all best practices, the evidence on effectiveness should come from applications of best practice in real-world situations, where households may face constraints in adopting the best practice, and socio-

economic conditions could limit or enhance the impact of the technology on the household. A best practice is considered effective if first, there is evidence that the best practice leads to its intended outcome (e.g. greater fertilizer use) and second, there is evidence that the intended outcome has a positive impact on households (e.g. impact on yield and incomes). Some best practices may have defensible evidence on both elements, or there may not be evidence on either of the elements, or in some instances there may be evidence on only one of the elements. If there is already established evidence on the second element through previous evaluations, then the evaluation may only focus on whether the best practice leads to its intended outcome. For example, consider a best practice that uses an innovative approach to promote fertilizer use among farmers. If it has been already established that fertilizer use leads to greater farm yields and incomes, then the effectiveness of the best practice can be evaluated by assessing the extent to which fertilizer is adopted by farmers.

However, if the evidence on the best practice's impact on the household is not compelling, or not available for the specific context or geography, then it needs to be generated through an evaluation. The overall impact of a best practice on a household comprises two elements: (i) the extent to which it is adopted, or the extent to which the program reaches the population it intended to reach, and (ii) the extent to which it impacted the households that adopted it, or the households that were reached. This measure should be comprehensive in that it also takes into account the unintended consequences whether positive or negative on the beneficiaries, such as the financial costs or the additional labor burden that a best practice places on a household in relation to its benefits. The product of these two elements is the impact of the best practice on the target population. As an example, consider a best practice that involves an innovative approach to provide information on appropriate fertilizer application based on soil testing. The impact of the best practice depends on the extent of adoption of appropriate fertilizer usage by farmers, and the impact appropriate fertilizer use had incomes of the farming households, where the latter depends on the increase in yields, and other factors that affect returns such as access to input and output markets.

The most ideal evidence is a rigorous evaluation that clearly attributes the impact to the best practice by estimating a counterfactual, that is, what would have happened if the program had not taken place. Rigorous evaluations generate the counterfactual by randomly selecting control households from the same population as the program households, or use quasi-experimental approach to create a control group that is similar to the treatment group in every other way except that it received the program. The definition of a clear counterfactual is particularly important when the intent is to attribute the program's impact on household income or anthropometric outcomes since other factors influence household incomes and anthropometric outcomes.

If the best practice has not been evaluated rigorously for its overall effectiveness, FARMS will assess the best practice against a series of criteria to determine if it is potentially effective, namely:

- Did other, less rigorous evaluations conclude that the best practice is effective?
- Do experts in the area agree that the best practice is a success?
- Are government programs actively promoting the best practice?
- Is the best practice a common model used by several implementing organizations?
- Has the best practice been readily adopted?

Cost-effectiveness is the second component of this criterion. A best practice may have been determined to be effective in achieving the desired outcome, but if the cost is prohibitively high, then the cost may outweigh the benefits. Cost-benefit or cost-effectiveness evaluations assess program costs (monetary or nonmonetary), in particular their relation to alternative uses of the same resources and to the benefits being produced by the program. Cost-effectiveness is the financial cost to achieve a particular outcome

for a particular target beneficiary or group of beneficiaries. A related concept is return on investment, which compares benefits to costs. Both concepts can be useful to governments and donor agencies considering funding implementation of a particular best practice. Cost-effectiveness can be calculated for one activity within an evaluation or as part of a comparison between different approaches to achieving the same outcome.

For many best practices there may be little data available on cost effectiveness, cost-benefit or the return on investment that could inform the assessment in this inventory. In certain pilots, however, FARMS will be positioned to make better estimates of the cost-benefit ratio as it will be able to monitor all costs, while also measuring the benefits, at least over the time scale of the project itself. In some instances, FARMS may assess cost-effectiveness within the evaluations. Long-term costs and benefits will still have to be an extrapolation from the current data. FARMS will try to account for the following benefits when applicable:

- The long-term benefits of introducing a farming technique that is propagated with little or no cost to other beneficiaries
- The benefits of building long-lived infrastructure
- The long-term effects that good nutrition, especially during early childhood, can have on lifelong revenue generation potential
- The effects that risk mitigation can have on the livelihood strategy and the long-term financial viability of a household or individual

1.1.2 SCALABILITY

Could this best practice be implemented successfully at a greater scale?

The primary condition of scalability is that the best practice is applicable to a broad section of the population or our target set of beneficiaries. For any project, it is important to define the set of beneficiaries to understand measures of scalability. For the FARMS project, this target group is the rural poor earning less than $1.25/day in India and an equivalent set of rural poor in USAID Feed the Future focus countries. Innovations in niche products that are not applicable widely throughout these populations, therefore, will score low. Beekeeping or the commercial cultivation of aloe vera are examples of such niche products. A small subset of the FARMS' target population is engaged, or even has the potential to be engaged, in these activities and therefore innovations in these, even if they are applicable to 95% of the persons participating in these trades, would score low on scalability.

There are other important characteristics of best practices that may impede their scalability, which include the following:

- Dissemination has thus far relied on the sphere of influence of particular NGOs;
- The best practice relies on the existence of scarce resources such as: a particular micro-climate, dynamic leadership or a rare natural resource like a mineral deposit or natural spring.
- Requires a high level of cooperation among various stakeholders
- Has a highly complex implementation strategy
- Requires the flow of complex information

1.1.3 TRANSFERABILITY

Do the necessary conditions for transfer exist in Africa and India?

FARMS will conduct evaluations, or, if available, use evidence from existing evaluations to identify the key determinants of success of the best practice in India. For example, these evaluations will assess whether certain socioeconomic characteristics of the region or of the households were critical for

success, or if certain external factors outside the influence of the best practice (e.g., conducive policy environment, high literacy levels, or good road infrastructure) were critical for success. The best practices selected for transfer should be those for which these key conditions for success are not a constraint in the regions selected for transfer. Alternatively, a best practice may need to be tailored by combining other best practices that address the binding constraints.

The FARMS team will assess the relevance of the best practices against the context of the target environment to identify the potential barriers to adoption, which in turn will help refine and tailor best practices for the target environment in India or Africa.

To effectively assess a best practice according to this criterion, FARMS will have to consider where the best practice might be transferred. The seven targeted states in India and the three countries in Africa are not uniform, and even within these countries and states there exists considerable regional variability that could make a best practice transferable to one region but not to the adjoining region. This could be due to many factors, such as the agro-climatic zone, local infrastructure, or the policy environment. For the initial ranking, FARMS will look at the general transferability of a best practice within the broad zone that defines the project, i.e., the Indian states of Uttar Pradesh, Bihar, Orissa, and West Bengal, and parts of Utterakhand, Assam and Rajasthan, while also including Kenya, Liberia and Malawi. Ultimately, consultations with experts on the target populations may be needed to complete this step to assess the environment targeted for the transfer of a best practice.

Another way to consider the conditions critical for success is that if they are missing, there is a barrier to implementation. There are several known barriers to the transfer and adoption of new technologies and best practices that may exist to some degree in the target environments. The following list provides a summary of the different types of barriers. In order to provide a more refined assessment of the transferability of a best practice, FARMS will look at each of these types of barriers in the targeted environments to determine: 1) If the barrier exists in that environment to a degree that might negatively prejudice successful transfer in a significant way and 2) If so, is this best practice particularly susceptible to that type of barrier. The types of barriers include:

- Poor policy environment
- Poor access to markets
- Limited flow of information
- Limited access to finance
- Few existing risk transfer mechanisms, e.g., insurance

Finally to assess the transferability, we will consider existence of the following factors that might positively facilitate the transferability:

- There is a mechanism to send from India
- There is a mechanism to receive the best practice in Africa
- There is a champion in India
- There is a champion in Africa
- There is synergy with existing programs, grass-roots movements, and/or it addresses clearly acknowledged and recognized needs

1.1.4 RELEVANCE

Is the best practice, its pilot and/or evaluation relevant to FARMS' stated objectives?

The best practice, its pilot and/or its evaluation must fit within the objectives of the FARMS project, be feasible with the time and financial resources available to FARMS, and provide an opportunity for FARMS to add value.

This document addresses the first point by specifying the IRs to which each BP contributes in each assessment.

As part of assessing feasibility, the team would, for example, see if the success of the BP requires a change in policy that it cannot effect. If this were not feasible, then the BP would not be considered relevant for FARMS. It might also be the case that a pilot or an evaluation of the best practice were not feasible due to practical constraints, e.g., an evaluation would need to cover seven years to produce credible results.

Finally, the assessment will consider the value that could be added by FARMS. All things considered, is there an opportunity to implement and/or evaluate the best practice in India? If there were a case where a BP were already known to be effective and were already being scaled up, then there might not be much for FARMS to add. Thus the FARMS team will assess the potential for the project to affect the best practice, the way the best practice is implemented, or the expected outcomes of the best practice within the scope of the project.

It is also important to know whether the work that the FARMS project could do on the best practice would add value to the existing body of knowledge. If evidence of the success of the best practice in promoting food security is rigorous, consistent and overwhelming, then it may be that a pilot activity or further study is not warranted.

In selecting a set of best practice pilots or evaluations, FARMs will strive to ensure that the best practices taken collectively respond favorably to the following questions:

a. Do the set of best practices selected address the key program elements in the proportion assigned in the FARMS budget?
b. Do the set of best practices ensure that FARMS' resources are well distributed across the targeted geographies in India and in the targeted African countries?
c. Is there an opportunity to implement and/or evaluate a pilot program of this best practice in India?

1.1.5 SUSTAINABILITY

Will this best practice need to rely on donor support, subsidies or the like for its success?

In looking at the sustainability of a best practice, we will ask the following questions:

- Are incentives aligned in such a way that the best practice and/or its implementation and dissemination are likely to be undertaken by the private sector?
- Is there a significant potential for spontaneous, low-cost adoption to continue to take place beyond the life of the project?
- Are there stable, public institutions that are well positioned or mandated to sustain the roll-out and implementation of the best practice?

- Is the best practice environmentally sustainable, i.e., there are no long-term, negative effects on the environment, or these costs do not justify the benefits?
- Does a conducive policy environment exist?

1.2 OTHER CONSIDERATIONS

There are often other reasons why a best practice is relevant to the FARMS program, e.g., a political/diplomatic motivation, the existence of a viable partner with a ready-made pilot or evaluation that saves the project time and/or money, or an explicit demand from Africa or another target region for this best practice. FARMS will thus remain alert to particular opportunities on which it can capitalize.

2. SUMMARY OF THE ASSESSMENTS

This chapter presents the individual assessments of potential best practices, preceded by a brief summary.

This document assesses 27 potential best practices, out of 56 that were initially considered by the FARMS team. Given the large size of the task of assessing so many best practices, it necessarily resulted that some of these assessments are more complete than others. Where the FARMS team has been able to collect and analyze a reasonable amount of descriptive and evaluative material, the resulting best practice assessment is included in the body of this inventory. Where this was not possible for a potential best practice, that practice is listed in the annex with a brief discussion of work to date and the BP's potential.

Table 1 shows all the assessed best practices and the primary and secondary FARMS Intermediate Result (IR) to which they contribute. Best practices might contribute to more than one IR. This is accommodated by designating one IR as the primary intended result and others (as appropriate) as secondary. Each best practice is listed in Table 1 under the IR group that FARMS has determined is the primary result to which that best practice will contribute.

Table 2 summarizes the insights gained by assessing each of the best practices against each of the five criteria described above. The FARMS team has assigned a score for each best practice against each criterion. The narrative assessment of each best practice in this document provides the facts and reasoning behind the score. Table 2 also highlights the key points from those narratives that relate to each score.

Scores on the five criteria were assigned to each best practice as follows:

Green	Meets criterion fully
Yellow	Meets criterion partially
Red	Meets criterion very little

No overall score is provided for each best practice. The FARMS team feels that there are too many problems with constructing such a score, so it would be more misleading than useful. In particular, there is no inherently correct set of weights to use in combining the scores on different criteria.

Indeed at this point in the FARMS work program, scoring best practices on individual criteria is imperfect and somewhat subjective, yet useful in several ways. It is primarily useful for summarizing all the qualitative data collected in the best practice inventory. It will be helpful when making decisions about the allocation of resources within the project. The color-coded scoring system allows the reader to visually construct his or her own average score for each best practice and to search within criteria for those best practices that best meet that criterion.

This assessment and scoring exercise is meant to guide the FARMS team in developing its implementation plan, but is not meant to be the final determination of whether a best practice is included in the FARMS programs' evaluations and/or pilot activities. Before those decisions are made, considerable vetting with knowledgeable experts and stakeholders will be undertaken.

TABLE 1: BEST PRACTICES AND THE INTERMEDIATE RESULTS TO WHICH THEY CONTRIBUTE

Best Practice	IR 1 Increased Agricultural Productivity and Output to Increase Farmers' Incomes	IR 2 Expanded Use of Knowledge, Innovations and Research by Farmers and Agribusinesses	IR 3 Farmers Linked to Markets and Expanded Trade and Investment	IR 4 Improved Household Nutritional Status, Particularly of Women and Adolescent Girls	IR 5 Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes
Improving Fertilizer Use Efficiency (Soil Testing, ICT)	Primary	Secondary			Secondary
Urea Deep Placement	Primary				Secondary
Artificial Insemination	Primary				
Integrated Pest Management	Primary				Secondary
Small Ruminant Introduction Program	Primary			Secondary	
Tools for Women	Primary			Secondary	
India's Potato Production System	Primary				
Digital Green		Primary			
ICT in Agriculture	Secondary	Primary	Secondary	Secondary	Secondary
Kisan Credit Card	Secondary		Primary		
Rural Business Hubs		Secondary	Primary		
Linking Smallholder Farmers To Commercial Value Chains			Primary		
CoolBot and Other Low-Cost Post-Harvest Methods	Secondary		Primary		Secondary
Producer Companies			Primary		

Best Practice	IR 1 Increased Agricultural Productivity and Output to Increase Farmers' Incomes	IR 2 Expanded Use of Knowledge, Innovations and Research by Farmers and Agribusinesses	IR 3 Farmers Linked to Markets and Expanded Trade and Investment	IR 4 Improved Household Nutritional Status, Particularly of Women and Adolescent Girls	IR 5 Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes
Home Gardens				Primary	
Multi-Sectoral Nutrition Education				Primary	
Micronutrient Fortification in Staples		Secondary		Primary	
Climate Analogues					Primary
Carbon Finance for Adaptation					Primary
National Initiative on Climate Resilient Agriculture (NICRA)					Primary
Conservation Agriculture	Secondary				Primary
Laser Land Leveling	Secondary				Primary
Stress-Tolerant Varieties of Cereals	Secondary				Primary
System of Rice Intensification (SRI)	Secondary				Primary
Weather Index-Based Crop Insurance	Secondary				Primary
Ridge to Valley Integrated Watershed Management	Secondary				Primary
Livestock Insurance	Secondary	Secondary			Primary

TABLE 2: SCORES OF BEST PRACTICES ON FIVE KEY CRITERIA

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
IR1 - Increased Agricultural Productivity and Output to Increase Farmers' Incomes					
Improving Fertilizer Use Efficiency Using Soil Testing and ICT	Yellow	Green	Yellow	Green	Yellow
Urea Deep Placement	Green	Yellow	Yellow	Green	Green
Artificial Insemination	Yellow	Red	Red	Green	Yellow
Integrated Pest Management	Green	Red	Yellow	Green	Green
Small Ruminant Introduction Program	Yellow	Yellow	Green	Green	Green
Tools for Women	Yellow	Yellow	Yellow	Green	Green
India's Potato Production System	Yellow	Yellow	Green	Green	Green
IR 2 - Expanded Use of Knowledge, Innovations and Research by Farmers and Agribusinesses					
Digital Green	Green	Green	Green	Green	Yellow
ICT in Agriculture	NA	NA	NA	NA	NA
IR 3 - Farmers Linked to Markets and Expanded Trade and Investment					
Kisan Credit Card	Yellow	Green	Yellow	Yellow	Yellow
Rural Business Hubs	Yellow	Red	Yellow	Green	Yellow
Linking Smallholder Farmers To Commercial Value Chains	Yellow	Green	Green	Green	Green
CoolBot and Other Low-Cost Post-Harvest Handling Methods	Yellow	Yellow	Yellow	Green	Yellow
Producer Companies	Yellow	Green	Green	Green	Green

Best Practice	Effectiveness	Scalability	Transferability	Relevance	Sustainability
IR 4 - Improved Household Nutritional Status, Particularly of Women and Adolescent Girls					
Home Gardens	Yellow	Yellow	Green	Green	Green
Multi-Sectoral Nutrition Education	Yellow	Green	Yellow	Green	Red
Micronutrient Fortification in Staples	Yellow	Green	Green	Green	Green
IR 5 - Improved Natural Resource Management Practices & Agricultural Systems Adapted to Projected Climate Changes					
Conservation Agriculture	Green	Yellow	Green	Green	Yellow
Laser Land Leveling	Green	Yellow	Green	Green	Yellow
Climate Analogues	Yellow	Green	Green	Green	Green
Climate Finance for Adaptation	Yellow	Green	Green	Green	Green
National Initiative on Climate Resilient Agriculture (NICRA)	Yellow	Green	Green	Green	Green
Stress-Tolerant Varieties of Cereals for Climate-Resilient Agriculture	Green	Yellow	Yellow	Green	Green
System of Rice Intensification (SRI)	Yellow	Yellow	Green	Green	Green
Weather Index-Based Crop Insurance	Yellow	Green	Green	Green	Green
Ridge to Valley Integrated Watershed Management	Yellow	Green	Green	Green	Green
Livestock Insurance	Yellow	Yellow	Green	Green	Yellow

Scores on the five criteria were assigned to each best practice as follows:
Green Meets criterion fully Yellow Meets criterion partially Red Meets criterion very little

NA = Not applicable.

3. BEST PRACTICES INCREASING AGRICULTURAL PRODUCTIVITY (IR 1)

This chapter presents the assessments of potential best practices that primarily contribute to IR 1 - Increased Agricultural Productivity and Output to Increase Farmers' Incomes.

3.1 IMPROVING FERTILIZER USE EFFICIENCY USING SOIL TESTING AND ICT

3.1.1 SUMMARY

Fertilizer use efficiency (FUE) is a primary goal of the GOI. India provides billions of dollars per year in subsidies for fertilizer, and there is a noted imbalance of fertilizer application on a national scale, indicating significant waste. The impacts, however, are not only financial but environmental and relatively ubiquitous. Due to the scale of the problem, it must most likely be addressed under a national program that seeks the least-cost mechanism for reaching a large number of farmers; therefore, the use of ICT in this solution is likely to be very appropriate. There is one known ICT application, developed by Ekgaon that has focused on the issue of FUE. FARMS will explore the possibility of improving upon this model and scaling it up as a means to address this critical issue for Indian agriculture.

3.1.2 DESCRIPITION

Indian farmers have been applying nitrogen-phosphorus-potassium (NPK) fertilizer in inappropriate quantities and incorrect ratios for years. This has led to the pollution of water tables with excess nitrogen, wastage of valuable resources, and loss of GOI money via subsidies. It has also led to reduced competitiveness of the Indian farmer and reduced gross margins.

Farmers are not necessarily to blame for this problem. The fertilizer subsidies of the GOI have distorted incentives and have favored the production of nitrogen at the expense of potassic and phosphatic fertilizers. This has led to an oversupply of nitrogen-based fertilizers and their consequent over-application. This scenario has in many cases mined the soil of sulfur and phosphorus, leading to a lower response rate to the application of nitrogen fertilizer. This created a negative feedback loop, increasing even further the demand for nitrogen fertilizer. Furthermore the single-minded focus on applying NPK (mainly N), has caused farmers to neglect micronutrient deficiencies such as in zinc, boron and sulfur.

There are several programs aimed at correcting this problem, including the GOI's Nutrient-Based Subsidy program. The NBS, however, is a supply-side solution, as the fertilizer subsidies go to the supplier, not the farmer. Farmers should also be able to estimate the amendments needed for their soils and be able to ask for the right quantities and types of fertilizer from suppliers.

One ICT firm, Ekgaon, has used ICT in a unique way to address this and other farmer needs. Ekgaon sells a subscription to their SMS and voice-based service via a simple, credit-card-like product having a

unique code. When the farmer enters the code his geographic coordinates are recorded. His cropping history and intended cropping cycle for the coming year are recorded via a phone interview or franchisee-filled form. If the farmer has done a soil test, this information is also recorded as his baseline soil fertility level. If the farmer has not done a soil test, the farmers' location is cross-referenced with the soil survey maps of India to determine his soil type and the typical nutrient deficiencies that may exist in this type of soil in that location, which is used as proxy for his/her baseline fertility level.

From the baseline fertility estimates and knowledge about the past and future cropping pattern, detailed down to specific cereal varieties in some cases, Ekgaon can provide recommended fertilizer application rates via SMS or voice to the farmer's cell phone. This information includes recommendations on micronutrient applications, as needed. The farmer will also receive timely reminders of when to weed and when to do top dressing. S/he is also given weather forecasts, pest warnings and price information specific to his/her crops throughout the season.

3.1.3 INNOVATIVE FEATURE

Appropriate fertilizer application that provides maximum response from the crops without wastage should be the goal of all farmers throughout India (and the rest of the world). Ekgaon provides a much-needed advisory service for a fraction of what it would cost an extension agent to do the same thing.

3.1.4 TECHNICAL AREA

This best practice increases agricultural productivity (IR 1); it also leads to adoption of better crop nutrition practices and can provide information about current weather and climate change adaptation strategies (IR 5).

3.1.5 CONSTRAINTS ADDRESSED

This best practice addresses the yield gap and lack of access to information.

3.1.6 APPLICABLE AGROECOLOGY/LANDSCAPE

This best practice is applicable in all rainfed and irrigated crop production systems where fertilizer is normally applied. The use of mobile phone-based ICT is restricted to areas with high cell phone ownership and cell phone network coverage.

3.1.7 RESOURCE ORGANIZATIONS OR INDIVIDUALS

Ekgaon has developed a fairly comprehensive model for service delivery via mobile phones that includes fertilizer application recommendations, weather data, market data and information about the timing of certain agronomic practices.

The Integrated Nutrient Management Division (INM) is in the Ministry of Agriculture and has the mandate to "ensure adequate availability of quality fertilizers to farmers through periodical demand assessment and timely supply, promoting integrated nutrient management, which is soil test-based judicious and balanced use of chemical fertilizers in conjunction with organic manures and bio-fertilizers, promotion of organic farming and ensuring quality control of fertilizers through implementation of Fertilizer (Control) Order, 1985."[1]

The National Bureau of Soil Survey and Land Use Planning of India has developed detailed maps of georeferenced soil types in India. Ekgaon currently uses these data to make recommendations about soil amendments that are recommended for farmers in particular geographies.

[1] http://india.gov.in/sectors/agriculture/fertilizers.php (accessed 10 Aug 2011).

The Acharya N. G. Ranga Agricultural University has developed a low-cost soil test kit that has the potential to greatly improve the efficacy of this best practice.

3.1.8 EFFECTIVENESS

Effectiveness. Ekgaon has evaluated the benefits of their service and has found a 15% average increase in gross revenues for farmers who use their service in the first year (Grimshaw and Kala, 2011) This increase is largely attributed to increased fertilizer use efficiency.

Impact. A mere 15% increased efficiency of fertilizer application for most or all Indian farmers who currently use chemical and organic fertilizers could have a significant impact on Indian agriculture. The average application rate for fertilizers in India is 116 kg/ha/year (INM Division of MOA 2011).[2] With an average cost of $107/MT, the average expenditure of Indian farmers on fertilizers is only $12.40/MT. A 15% increase in efficiency would only amount to about $1.80/year. This would not be enough to pay for the Ekgaon yearly subscription of Rs. 120 ($2.72). Application rates, however, in India vary by state and by farmer. Many farmers apply double and triple these amounts; these farmers could possibly be targeted through proper market segmentation.

In the Ekgaon target group, where subscribing to the program provided a return of $11/ha, one must assume that the average rate of fertilizer application per farmer was higher than the national average and/or farmers were able to save on weeding and obtain slightly higher yields than the control group of farmers.

Indian farmers applied a total of about 25 million MT of fertilizer in 2008-09 and, based on the minimum support prices, national expenditures would then be $5.7 billion. At this rate, a 15% increase in efficiency amounts to a savings of about $855 million. Thus a program such as this has great potential to bring a high return on investment for the money that USAID would expend. It would also reduce the subsidy burden on the GOI. Furthermore, increasing factor productivity and fertilizer use efficiency contributes to reductions in greenhouse gas emissions, which may provide another means to supplement the economic benefits of the program through CDM monies.

3.1.9 SCALABILITY

This program is scalable to all farmers around the world, but mostly to those who apply fertilizer. It seems that medium-sized farmers would be the ones who could most benefit from this program, as the scale of their operations could provide a return on investment to the approximately $3 subscription fee. Perhaps the service providers can work on a differential pricing scheme, while also striving to add more value through other services they offer as a means to make this service more valuable and affordable to smaller farmers.

3.1.10 TRANSFERABILITY

Conditions for success. For such a system to have the intended effect, several conditions would have to be in place in the operating environment, such as:

- **A high rate of mobile phone penetration**
  The breakdown of the digital divide has meant that this condition for success has already been met in almost all developing countries around the world.
- **A network of rural vendors**

[2] http://india.gov.in/sectors/agriculture/fertilizers.php. Accessed on 18 Aug 2011.

Vendors, such as general goods stores or agricultural input suppliers, are required to sell the subscriptions to the farmers located in remote rural areas. A literate vendor is also required for the entry of the initial data from each subscriber, which can be quite complex at times. Using these vendors or the farmers themselves for the input of the baseline information will require extensive quality control on the part of the provider.

- **Low-cost soil test kits**
  Providing low-cost, timely and ubiquitous soil testing in India is a major challenge for the Indian government. The Integrated Nutrient Management Division in the Ministry of Agriculture has been working on an initiative to make soil testing more available. Currently, however, India has about 680 soil testing labs, and about 20% of them are mobile; yet Indian farmers still complain that soil testing is either unavailable or unreliable, or that the results come too late to be of use.

In India, these conditions for success could still use some improvement. They are, however, met to a higher degree in India (aside from mobile phone penetration, which is high the world over) than in other developing countries, especially Africa.

The transferability of this technical solution cannot be a success in Africa unless it is first a success in India. The conditions in Africa, i.e., often low fertilizer usage by farmers, the network of input vendors, and the availability of soil testing, are even more limiting.

Mechanisms of transfer. There are mobile network operators, like Airtel (under its IKSL joint venture) and Vodafone, who are actively seeking to transfer service packages between India and Africa to increase their subscriber base and their revenue per subscriber. They are the most likely mechanism for transfer of this technology. If it the business model is proven to be profitable, they can make the transfer from India to Africa.

3.1.11 RELEVANCE

This technology is meant to improve yields and farmer revenues, which directly contributes to IR 1. It also contributes to IR2 (knowledge sharing), IR3 (market linkages). It is relevant to the FARMS project, especially in that it represents one of the most integrated uses of ICT to improve smallholder livelihoods.

3.1.12 SUSTAINABILITY

It is meant to be a purely private sector model and should thus be self-sustaining if the business model can be refined.

3.1.13 POSSIBLE ACTIVITIES FOR FARMS

FARMS will initially assess Ekgaon and other models in India that use ICT to deliver services to farmers. This assessment will be conducted in collaboration with knowledge management and ICT experts with CIMMYT, CABI, IFPRI and ILRI. It will attempt to distill a model for using ICT in agriculture that offers the best return on investment to the provider while also optimizing value to the smallholder. FARMS will assess the different aspects of such a model, including the channel of delivery, payment scheme, package of products and services, and mechanisms for regulating content and controlling its quality.

Once the elements of that model are determined, FARMS may use this information to generate interest in a broad spectrum of private sector firms for its application.

After conducting a preliminary overview of the existing models, the FARMS team is particularly impressed with the potential to include a mechanism to improve soil health and fertilizer use efficiency, somewhat along the lines of the Ekgaon approach, as a piece of any such business model. We have

already determined, however, that the Ekgaon model could benefit from certain improvements. One of the most important improvements is to integrate, to the degree possible, the use of actual soil tests and thereby reduce the incidences where soil type is used as a proxy for baseline soil fertility. To that end, the FARMS team has identified a low-cost, farmer-generated soil testing method that may be appropriately integrated into the Ekgaon application, wherein the franchisees of Ekgaon, usually local storekeepers or input suppliers, make the soil test kit a part of their over-the-counter offerings.

The FARMS team sees this as an opportunity to run a pilot based on this small set of best practices, i.e., low-cost soil testing, ICT applications and the integration of a human interface in the delivery of farmer services through ICT. If a pilot is run, it will be done after the assessment of ICT in agriculture, which will provide more certitude as to the best elements to incorporate into such a business model.

3.2 UREA DEEP PLACEMENT

3.2.1 SUMMARY

Urea Deep Placement (UDP) is a method of fertilizer application that consists of pressing fertilizer into pellets that are then placed underground in the root zone of plants. It is thus far used exclusively in rice cultivation. It increases fertilizer use efficiency by acting as a low-cost, slow-release fertilizer product. It is best adapted to rice-producing zones, as the pellets are easiest to place in the swampy soils into which rice is typically transplanted. This is a good technology that is sometimes constrained in its adoption, since the placing of the pellets is labor-intensive. FARMS may work to develop mechanized placement and test the degree to which offering a mechanized placement method increases adoption of UDP.

3.2.2 DESCRIPTION

Urea Deep Placement, also known as Urea Super Granules, is a method of fertilizer application that increases the fertilizer use efficiency in rice. It was developed in Bangladesh by the IFDC. The method involves pressing urea fertilizer into briquettes. The briquettes are then inserted in the puddled rice paddy by hand, or with a non-motorized machine, one briquette in each row between the two rice seedlings. This is a "low-tech" method for obtaining a slow release of nitrogen fertilizer close to the roots for efficient uptake. UDP reduces the amount of nitrogen leaching into the soil and hence the pollution of ground water with excess nitrates.

FIGURE 2: FERTILIZER BRIQUETTE-MAKING MACHINE

The urea briquettes are made locally using a special-built machine. There are over 2,000 of these machines operating in rural Bangladesh. As the cost of the fertilizer is 10% more than the regular, prilled fertilizer product, there is a business opportunity for a local entrepreneur to own and operate the machine and to add value to the prilled urea.

3.2.3 TECHNICAL AREA

UDP is primarily an improvement in agricultural productivity (IR 1) but also contributes to better natural resource management (IR 5).

3.2.4 INNOVATIVE FEATURE

UDP provides a low-cost, low-tech way to greatly increase fertilizer use efficiency in rice.

3.2.5 CONSTRAINTS ADDRESSED

It addresses the constraint of access to inputs, by reducing the cost of inputs required to obtain optimal yield levels.

3.2.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

This is most applicable to flood-irrigated rice production systems throughout the world.

3.2.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

- The IFDC developed UDP and Urea Super Granules.

- IRRI is a proponent of this technology and is working with it in parts of their Rice/Wheat Consortium and through the CSISA program.

3.2.8 EFFECTIVENESS

Effectiveness. This methodology is reported to greatly increase fertilizer use efficiency and yields. IFDC has shown in Bangladesh that the UDP technology, which they pioneered, reduces the amount of urea fertilizer needed for irrigated and rainfed paddy crops by as much as 40 percent and at the same time increases yields by 20 to 40 percent.[3]

Impact. In Bangladesh farmers who used UDP earned an extra $188/ha[4], which is significant in Bangladesh, where annual average incomes are $520/person/year. UDP in Bangladesh thus creates a 34% increase in annual revenues. The method is said to have been used by 2.6 million Bangladeshi farmers since the program began in 2006. There are 2,000 briquette machines in operation in Bangladesh. It is unknown whether these machines were introduced with a capital subsidy.

Cost-Effectiveness. The low-cost programs in Bangladesh have saved $22 million in fertilizer imports and $14 million in subsidies. The funding level of the IFDC program is not known.

3.2.9 SCALABILITY

This technology is applicable to all farmers who produce rice in irrigated fields. The technology is rather simple to introduce, and the program in Bangladesh has now reached 2.6 million farmers.
UDP technology has been introduced and is being tested in Burkina Faso, Madagascar, Malawi, Mali, Niger, Nigeria, Rwanda, Senegal and Togo.[5]

3.2.10 TRANSFERABILITY

Conditions for success. UDP is most appropriate for irrigated rice systems, which are primarily concentrated in Asia. India and Bangladesh also have advantages in the transfer and adoption of such technology due to the relatively high availability and usage of fertilizer, compared to Africa, and a higher-density population, making the business proposition for the urea briquette makers more attractive.

To introduce the technology, there must be a local/regional manufacturer of the briquette machines. Credit is most likely required for the purchase of the machine by the entrepreneur.

Mechanisms of transfer. The IFDC works in both Africa and Asia and could be a champion for the transfer of this technology. IFDC is also working within the Rice/Wheat Consortium of the CGIAR in India, and this institution can serve as a mechanism for transfer throughout the Indo-Gangetic Plains.

3.2.11 RELEVANCE

This technology addresses many aspects of food security programming by increasing productivity, increasing incomes, generating employment and protecting the environment from excess nitrogen run-off.

3.2.12 SUSTAINABILITY

This technology can be easily taken up by the private sector.

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[3] Dr. R.K Gupta,Regional Facilitator,RWC,India.
[4] http://www.ifdc.org/Expertise/Fertilizer/Fertilizer_Deep_Placement_(UDP) (accessed August 18, 2011).
[5] http://www.ifdc.org/Expertise/Fertilizer/Fertilizer_Deep_Placement_(UDP). (accessed August 18, 2011).

3.2.13 POSSIBLE ACTIVITIES FOR FARMS

This is a high-potential best practice for FARMS. The FARMS team will continue to seek potential partners and explore the possibility of running a pilot during its first year of operations. We understand that one of the constraints to adoption lies in improving the mechanized placement of the briquettes in puddled rice. FARMS may therefore work with the Central Institute for Agricultural Engineering in Bhopal and other appropriate technology developers to seek a solution to this problem.

3.3 ARTIFICIAL INSEMINATION

3.3.1 SUMMARY

Artificial Insemination (AI), if practiced correctly, can create efficiencies in livestock herd management, especially when the goal is to alter the genetic composition of the herd for increased productivity or to introduce special adaptive traits. The effectiveness of AI in India is relatively low due to its technical complexity and unskilled inseminators. Given these considerations, FARMS views AI as potential best practice, but one that will require significant modification if piloted. FARMS believes that the AI program of BAIF offers some valuable lessons for improving AI as it is practiced with smallholder farmers in developing countries.

3.3.2 DESCRIPTION

Artificial Insemination is a technique for inseminating and impregnating livestock animals using semen taken from a sire animal and artificially injecting it into the reproductive organs of the female animal. The two animals do not necessarily have to be together, as semen can be stored cryogenically in liquid nitrogen for long periods of time. In the countries of northern Europe, Israel and Japan, dairy farmers use AI almost exclusively (80 to 90%) as the service method for breeding cattle (Peters and Ball, 1995). The benefits of AI compared to natural service insemination methods (NS) and do-it-yourself AI are greater when herd size is smaller, as only the larger herd size justifies the cost of keeping and maintaining a bull. In India, where herd sizes are very low with many families having just one or two animals, AI services are more likely to be economically advantageous, but the introduction of AI systems in India has been limited, and AI services are rarely present in most developing countries, possibly due to cash flow issues with consumers and the low success rate of insemination.

BAIF, however, has developed an AI program that has brought AI services to remote rural areas through a decentralized distribution network that makes use of trained, local inseminators connected to their breeder stock farm in Pune. This system has driven the cost of a single insemination down to Rs. 90 and made it available in remote rural areas.

In India, BAIF offers a fee-based service for artificial insemination of cattle and buffaloes. The BAIF program extends to several states in India, including Bihar. In Pune BAIF has a genetically diverse herd of improved breed sires, both for cattle and buffaloes. It has multiple trained veterinary agents in all the districts of its program. The agents are the primary interface between the farmer and BAIF. The veterinary agents spend considerable time building a relationship with the livestock owners in their areas. They provide advice, products and services as a part of the program. The veterinary agents are connected to the Pune center via smart phones, which provide the center regular updates on the products (semen, salts, medicine) consumed, so that the Pune center can keep them in continuous supply.

The agents also use cell phones to stay in touch with their customers, who are taught to recognize an animal in heat and call them for AI services when there is a high probability that the animal can become pregnant. Recognizing an animal in heat and getting the insemination service in place in time can be a major constraint to AI services in India. This can be the downfall of an AI system, even with commercial dairy farmers in developed countries.

Some studies cite an increase in average calving interval with AI compared to NS (Gonzalez-Recio et al., 2004) due to the inability of the owners and veterinary specialists to recognize the heat. Keeping the calving interval low is a major challenge for Indian AI programs.

3.3.3 INNOVATIVE FEATURE

AI can be much more efficient than natural service insemination methods (NS) and can greatly increase milk yields in subsequent generations of the animals. BAIF's program makes this service affordable to smallholder farmers.

3.3.4 TECHNICAL AREA

This best practice falls in the technical area of agricultural productivity (IR 1).

3.3.5 CONSTRAINTS ADDRESSED

This best practice addresses low animal productivity and access to inputs.

3.3.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

AI is most applicable to cattle and buffalo production zones with a large dairy industry. AI is used less in beef cattle production, but can also play a role there, especially in developing the genetic potential of 'seed' stock.

3.3.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

The National Dairy Development Institute in Karnal is a leading authority on AI practices throughout India.

BAIF is one of the leaders in AI in India and has devised one of the most functional models of AI service delivery.

The state agricultural universities are a good resource, particularly the Sardarkrushingar Agricultural University that has made great improvements in the Kankrej variety of cattle and some breeds of goat that are very well adapted to the semi-arid regions of Rajasthan.

3.3.8 EFFECTIVENESS

Effectiveness. AI is proven to be economically advantageous when compared to NS methods (Valergakis et al., 2007) for herd management, especially for dairy farmers.

There is anecdotal evidence, however, that AI programs in India have not produced results as expected. The primary issue is the training of the farmers and the inseminators in recognizing animals in heat.[6] There is also an issue with maintaining the cold chain for the semen in many programs, yet BAIF claims to have greatly improved this system using liquid nitrogen.

Impact. AI programs can double the daily production of milk from a single animal. This can have a large impact for any livestock owner in India. Livestock sometimes makes up more than 50% of a family's income, even when it keeps a single buffalo.

One mitigating factor, however, is that these animals consume more fodder, and fodder can be quite limiting at certain times of the year and in certain communities in India. There is a fodder "crisis" in many of the rural areas, and the benefits that AI programs provide can be annulled when the lack of fodder or the lack of available cash to buy fodder force families into distressed sales of their animals.

[6] Personal communication. Dr. A.K. Srivastava, Director of the National Dairy Research Institute, Karnal, India. 18 July 2011.

3.3.9 SCALABILITY

A well-run successful AI program has the potential to be scaled up all over India, as most farmers keep animals. BAIF's AI program works from a central farm in Pune where the bulls are kept. They have devised a system for distribution of the semen to all of their AI centers, extending their reach even into the rural areas of Bihar.

AI programs that aim to work on a broad geographic scale, however, would have to greatly increase the diversity of genetic stock available to account for the genetic variability required in diverse agro-climatic zones, thus mitigating some of the benefits of working at scale.

3.3.10 TRANSFERABILITY

Conditions for success. A successful AI program is possible primarily in areas where there are commercial dairy farmers and commercial dairy processing centers that create a regular demand for milk. It is also successful where herd sizes are traditionally small. India's unique dairy sector bodes well for the success of an AI program, but in other developing countries with large animal populations, e.g., Mali, Ethiopia and Sudan, the likelihood of success is not as high due to the underdeveloped nature of their dairy industries. Kenya, however, has a large commercial dairy sector, and AI is more prevalent there; there may be some lessons to share between India and Kenya. Pakistan is also very similar to India with regards to its dairy sector and could also benefit from an exchange of information on this best practice.

Mechanisms of transfer. The Kenya Agricultural Research Institute (KARI) works with AI and would be a natural institute for transferring any improvements in the technology offered by the Indian model. KARI claims that in Kenya there is a need to strengthen the local breeding programs to produce bulls of higher genetic merit to offset the dependency on imported semen (Murage et al., 2008).

3.3.11 RELEVANCE

Milk production can be a very significant portion of an Indian farmer's annual income. AI would increase the milk yields of these farmers and therefore would contribute to IR 1, increasing agricultural productivity.

3.3.12 SUSTAINABILITY

All AI programs are meant to be fully integrated into the private sector and are therefore meant to be self-sustaining in that way.

Many AI programs, including the BAIF program in India, do depend on GOI or donor support.

3.3.13 POSSIBLE ACTIVITIES FOR FARMS

AI programs have been established in India, but they have not reached the expected scale, nor have they produced the expected results. This may be due to inefficiencies in recognizing when an animal is in heat (which is apparently more difficult for buffalo than for cattle). The lack of sterling success may also be attributed to the temporal and spatial variations in the Indian fodder supply (Raghavan, 1990), which creates a natural barrier to increased milk production in many parts of India.

Therefore, AI is considered a secondary priority for FARMS, to which we may return to at a later date once other good options have been exhausted.

Furthermore, the relevance of AI programs to Africa is thought to be quite limited, given the lack of development in commercial dairy in most African countries.

3.4 INTEGRATED PEST MANAGEMENT AND NON-PESTICIDE AGRICULTURE

3.4.1 SUMMARY

Integrated Pest Management, or IPM, is a systems approach to reducing damage caused by pests to an acceptable level without harming the environment. IPM combines biological, cultural, physical and chemical tools in a way that minimizes economic costs and health, and environmental risks. Specifically, IPM includes the adoption of pest-resistant varieties of crops, biological and physical control methods, biopesticides, and when absolutely necessary, non-residual, environmentally-friendly and low mammalian-toxic chemical pesticides[7]. Non-Pesticide Management (NPM) is a method that seeks to eliminate the use of pesticides on farms. IPM and NPM are expected to have many benefits that include: 1) lower production costs (at the farm level), 2) reduced environmental pollution, particularly improved soil and water quality, 3) reduced risk to farmers and consumers from pesticide poisoning and related hazards, and 4) ecological sustainability by conserving natural enemy species and biodiversity.

There are several institutions in India, such as the National Institute of Plant Health Management (NIPHM), the National Center for Integrated Pest Management (NCIPM) of the ICAR and the Regional Agriculture University for in Imphal who have a competency and interest in IPM. FARMS can add-value to the existing work in IPM by: working to develop a community of practice amongst these institutions and individuals, build their technical capacity by bringing in International expertise, systematize approaches to IPM, work towards specific solutions to key problems and eventually provide technical and organizational assistance to bear on the establishment of an IPM center of excellence.

3.4.2 DESCRIPTION

Integrated Pest Management, or IPM, is a systems approach to reducing damage caused by pests to an acceptable level without harming the environment. IPM combines biological, cultural, physical and chemical tools in a way that minimizes economic costs and the health and environmental risks. Specifically, IPM includes the adoption of pest-resistant varieties of crops; biological and physical control methods; biopesticides; and when absolutely necessary, non-residual, environmentally-friendly and low mammalian-toxic chemical pesticides.[8]

Non-Pesticide Management (NPM) is a method that seeks to eliminate the use of pesticides on farms. IPM on the other hand, seeks to reduce pesticide usage, but accepts intermediate solutions that use chemical-based pesticides and genetically modified organisms if other solutions are not available. Both IPM and NRM adopt measures that include pheromone traps, sterile male insect introduction, sticker plates and biopesticides (*Agniastrum,* which is a mixture of chili, garlic, neem and cow urine; *bhramastram,* which is a mixture of neem leaves, custard apple, castor, papaya, bitter gourd and cow urine).

The term NPM was coined in 1998 by M. S. Chari, scientific adviser to the Centre for World Solidarity, a non-profit that helped to solve the problem of the red hairy caterpillar that was affecting the red gram crop in the Telangana region. NPM has been tested and implemented in Andhra Pradesh through the Society for Elimination of Rural Poverty (SERP), which implements the state's rural development

[7] USAID's Collaborative Research Program in Integrated Pest Management (IPM CRSP). http://www.oired.vt.edu/ipmcrsp/AboutUs/What_is_IPM.html

[8] USAID's Collaborative Research Program in Integrated Pest Management (IPM CRSP). http://www.oired.vt.edu/ipmcrsp/AboutUs/What_is_IPM.html

programs. It was started in 2004, and as of 2009 over 300,000 farmers were using it covering 1.36 million acres of farmland according (Kumar et al., 2009) The agriculture department, through the Agriculture Technology Management Agency (ATMA), is now poised to work with the Rural Development Department to reduce the cost of cultivation and move toward pesticide-free cultivation in the state.[9] This is expected to scale up the effort state-wide. In addition, the Government of India, through its National Rural Livelihoods Mission, is rolling out the best practices of NPM nationwide.

In the initial stage of NPM, farmers are taught diagnostic skills to observe, document and understand the behavior and life cycle of pests and the role of natural predators. These important training elements of NPM exist to some degree in IPM programs, but the approach of some IPM programs is a little more top-down. While IPM technologies are developed by scientists and passed down to farmers, in NPM, as practiced by SERP, farmers participate in technology development and extension. The widespread introduction of these training elements in India can have additional benefits that justify the costs, as understanding pests, their lifecycles and their diagnosis may protect farmers from the vendors of spurious pesticides, who profit from the ignorance of their customers. Such a general awareness-raising may serve to reduce this pervasive practice in India. In addition, it can also lead to better adoption of NPM approaches.

IPM technologies for specific crops are developed in collaboration with research institutions, agricultural universities and crop protection scientists, and shared with farmers through extension. ICAR through its National Centre for Integrated Pest Management (NCIPM) has developed IPM technologies for several crops: cotton, pulses, rice, vegetables and oilseeds.[10] In addition, ICAR has also developed Pest Management Information System (PMIS) software for cotton, basmati rice, chickpea, mustard and groundnut. PMIS gives information about agronomic practices, pests, nematodes, weeds, nutrient disorders, natural enemies, and resistant varieties, and it includes high-resolution color photographs of insect pests, disease symptoms, weeds and nematodes. NCIPM has also developed Pesticide Advisor, which gives information on different pesticides registered in India and can be used to choose safer pesticides. NCIPM works with SAUs, government agencies, industries, NGOs and farmers. NCIPM plans and conducts eco-friendly IPM research and development programs, essentially required for sustainable agriculture. IPM technologies are disseminated through the 26 Central Integrated Pest Management Centres (CIPMC); at present there are in all 26 such stations in the country. Uttar Pradesh, Madhya Pradesh, Andhra Pradesh and Jammu and Kashmir have two, while other states have only one such center.

In addition, the IPM Collaborative Research Support Program (CRSP) has extended and replicated the participatory IPM approach in Nepal, and strengthened the network of linkages in IPM knowledge and expertise across South Asia. Under this program, participatory appraisals, baseline surveys, and crop pest monitoring are conducted to help prioritize fruit and vegetable crops and pests. These are followed up by research activities that include pest and beneficial insect surveys in priority crops; laboratory, greenhouse, and on-farm field experiments on pest management components; assessment of socioeconomic constraints to adoption of IPM; development and testing of IPM packages; transfer of results and recommendations to technology transfer organizations; and assessment of social, economic, and gender impacts.[11]

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[9] http://agrariancrisis.in/2011/05/24/andhra-to-promote-chemical-free-cultivation/

[10] Salient research achievements, National Centre for IPM, http://www.ncipm.org.in/research-achievements.htm#Forewarning, Accessed August, 2011.

[11] IPM, CRSP, http://www.oired.vt.edu/ipmcrsp/WhatWeDo/SouthAsia.html

3.4.3 INNOVATIVE FEATURE

IPM and NPM are methods of pest control that maintain or improve yields of crops, often at lower cost than traditional pest management methods, while also reducing the negative impact of using chemicals on human health and the environment. IPM and NPM also systematically create better awareness about pests and pest lifecycles among trained farmers, which can sustain the impact of these programs in the long term.

3.4.4 TECHNICAL AREA

The primary contribution of IPM will be to IR1- Increased Agricultural Productivity, and its secondary contribution is to IR 5 - NRM Improved and Farming Systems Adapted to Climate Change.

3.4.5 CONSTRAINTS ADDRESSED

The practices address the constraint of lack of access to low-cost approaches to managing pests.

3.4.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

IPM as well as NPM is applicable in any geography, although individual solutions may be quite localized.

3.4.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- Society for Elimination of Rural Poverty (SERP)
- National Rural Livelihoods Mission (NRLM)
- DRCSC
- M. Revathi, Tamil Nadu Organic Farmers Association

Technical Partners:

- National Centre for IPM
- IPM/CRSP and Virginia Tech University
- Tamil Nadu Agricultural University, Assam Agriculture Universities and other SAUs
- Parmesh Shah, World Bank who has managed the loan for IKP program
- Center for Sustainable Agriculture, Hyderabad
- Subhash Palekar, who pioneered NPM under zero-budget agriculture

3.4.8 EFFECTIVENESS

IPM is an evolving field that is making gains in approaches to certain problems, such as the use of predatory wasps and the use of sterile male introductions; its approaches have been adapted and replicated in different countries. In fact, the IPM CRSP in collaboration with TANU has made an early intervention in India's battle with the papaya mealy bug that has been incorporated into a bulletin by NCIPM and disseminated to farmers. (Tanwar et al., 2010)

IPM and NPM are expected to have many benefits that include 1) lower production costs (at the farm level), 2) reduced environmental pollution, particularly improved soil and water quality, 3) reduced farmer and consumer risks from pesticide poisoning and related hazards, and 4) ecological sustainability by conserving natural enemy species, biodiversity, and genetic diversity.

Tamizheniyan (2001) reports the per acre costs across IPM and non-IPM plots for rice and finds that the total cost per acre on IPM farms was Rs. 10,452 compared to Rs. 10,032 on non IPM farms. The gross return was Rs. 16,213 compared to Rs. 14,900, which amounted to a benefit-cost ratio of 1.62 for IPM,

compared to 1.43 for Non-IPM farms (Tamizheniyan, 2001). Garg (1999) finds similar results for an IPM system in basmati rice. Additional research is required to identify studies that have examined the impact of IPM or NPM on farm incomes.

Given that IPM leads to lower pesticide use, and given the evidence in the laboratory that it can lead to greater yield (and some evidence from field that backs this claim), another aspect of understanding the effectiveness is the extent to which IPM has been adopted. Krishna et al. (2007) aim to assess the status of IPM in India but do not provide the extent to which IPM has been adopted in India. If farmers see the returns in terms of gains in incomes, IPM should be readily adopted. Constraints to adoption could include the inability to implement IPM, access to materials required to implement the practices (e.g., biopesticides), or the inappropriateness of practices for the locality.

SERP claims that in their implementation of NPM, the yields are either maintained or increased (based on monitoring of 400 farmer fields over time), although it is not clear if this occurs on plots that only practice NPM or the full package as under CMSA, or to what extent this is the case even on plots where farmers are not able to fully adopt even NPM. Further they note that the cost of cultivation (using additional soil fertility management approaches also) was reduced by 33 percent. Additional gains in income can be realized if the products are certified as pesticide-free. Although these certifications have not begun, SERP claims that there is a common perception about this fact that can lead farmers to realize a 14-33 percent increase in prices for vegetables, red gram, chili peppers, cotton and rice. These claims have not been verified by external agencies, and have not been assessed in a rigorous way. That said if the SERP data on the state-level adoption of NPM is accurate, then the high adoption itself suggests that farmers are realizing the gains from lower costs of cultivation.

3.4.9 SCALABILITY

IPM is not a single, one-size-fits-all solution; in fact it is an approach to developing solutions to pest-related problems, wherein the pest problem and its solution can sometimes be quite local. The key constraint to its scalability is the initial cost for developing IPM in a region, since it relies on understanding the cycle of pests in specific agro-climatic regions, and the cost of transferring this knowledge to farmers. Therefore, it requires the commitment of state agricultural universities in localizing the research conducted at the center, in training extension agents and promoting it.

Currently, NPM is being brought to scale in Andhra Pradesh through cooperation between its rural development and agriculture departments. NRLM is expected to scale it up nationwide, starting with Orissa. The current implementation approach is based on using the strong base of a community infrastructure of self-help groups (SHG), which require several years to develop. It is not clear the extent to which these practices will be adopted without these SHGs. The current roll-out of NPM through NRLM and its partnership with Digital Green is likely to shed more light on this issue.

3.4.10 TRANSFERABILITY

Conditions for success. This best practice requires initial research in developing IPM and NPM approaches for the specific agro-climatic region to which it is being transferred. The IPM technologies also need to be validated in the field. It requires commitment by local research institutions to adapt existing research on IPM technologies, particularly to assess the cultural practices and biological controls that can be developed locally. Implementation of NPM also requires a strong network of SHGs or similar community institutions to manage and implement the best practice.

Mechanisms of transfer. NCIPM , TNAU and the IPM CRSP are champions of IPM. The IPM CRSP also has a mandate to work in other countries and has already been an important mechanism of transfer. SERP and NRLM are the primary implementing agencies of NPM in India. In addition several

individuals are champions of this approach in India, although the approach to NPM varies slightly among these individuals, and the majority may not see NPM as separable from sustainable agriculture.

3.4.11 RELEVANCE

IPM and NPM are environmentally sustainable approaches to agriculture that are claimed to increase the returns to land by reducing the cost of cultivation while maintaining or increasing yields. For all these reasons, the best practice is relevant to FARMS.

3.4.12 SUSTAINABILITY

If there are actually realized benefits from IPM and NPM, the practice should be self-sustaining in terms of its adoption. The practice is otherwise environmentally sustainable.

3.4.13 POSSIBLE ACTIVITIES FOR FARMS

The FARMS activities in IPM may involve the following four types of interventions.

They are:

- **Needs Assessment:** Identification of India's most pressing pest issues that have the possibility to be resolved through biological pest controls or attenuated through non-pesticide based techniques at the farm level. We can also assess the existing expertise and capacity in IPM and the gaps.
- **Systematization and Capacity Building:** Establish an exchange of expertise between the IPM CRSP at Virginia Tech (and possibly other US universities) with that of the ICAR; specifically the National Centre for IPM (NCIPM) for the research aspects of IPM and, for training and dissemination, the National Institute of Plant Health Management (NIPHM) and the National Plant Protection and Training Institute, now merged with the NIPHM. This exchange should serve to share expertise, while also develop a more robust and coordinated framework for bio-control and a more systematized approach to the processes for developing specific solutions to pest problems through IPM. FARMS will also seek to develop an understanding of the role of the public sector and private sector in assuring the production, availability and distribution of biological control products and other 'hardware' for IPM solutions.
- **Targeted Problem Solving:** Seeking solutions for a short-list of priority pest issues in select value chains; i.e. the lychee fruit borer in Bihar using techniques such as sterile male insect introduction and the development of pheromone traps.
- **Center of Excellence for IPM:** Ultimately the three actions above may lead to the establishment of a Center of Excellence for plant management. Such a center could be housed within an existing body, such as the National Institute of Plant Health Management in Hyderabad. Such a center would be asked to maintain an international focus to its work by drawing on international expertize, linking with international forums and offering training programs consultancies that have clients from multiple developing countries, including those in Africa.

In terms of specific solutions, FARMS may work on a resolution to the lychee fruit borer in Bihar through sterile male insect introduction or other IPM techniques. In addition, given the early success of the IPM CRSP and its work with TNAU on the papaya mealy bug, FARMS could encourage the expansion of this work in other papaya-growing areas within FARMS states, while developing the capacity of other partners.

And, learning from the experiences under AP's NPM program, FARMS could seek the development of models for improving adoption rates for IPM amongst smallholders. Such an approach might incorporate the participatory elements of NPM, as practiced in Andhra Pradesh, in which farmers are trained in

observing pest behavior and understanding their lifecycles, and are engaged to suggest approaches to adapting the approach to the local context.

3.5 SMALL RUMINANT INTRODUCTION PROGRAM

3.5.1 SUMMARY

Small ruminants (goats in this case) represent a great opportunity to generate income and increase the availability of animal based products to improve nutrition. FARMS will look at the possibility of integrating a small ruminant introduction program as a part of its examination of food-based nutritional improvement strategies.

3.5.2 DESCRIPTION

Goats are sometimes called the poor man's cattle. Goats, however, may be a smarter investment than cattle and one of the better means to improve rural livelihoods in extremely poor communities or in extremely harsh climatic conditions.

One version of a small ruminant introduction program works through the initial establishment of user groups of 10-20 members (often women). In India under the BAIF program, these are usually women's self-help groups (SHG). Women are in many ways the appropriate target for such program, as women are often the ones responsible for raising small ruminants. In the BAIF model, the group is supervised and trained in the breeding and rearing of goats by a trained field agent. The agent will train the group members in improved nutrition, veterinary care—vaccinations are rarely done for goats, although they are recommended—and marketing. The program involves giving a viable buck to this group. The buck is of an improved breed of the group's choosing. In India, this breed is typically the Black Bengal, Sirohi, Jamanpari or Barbari breed. After the training, one member of the group is assigned to rear the goat and oversee the breeding program.

The buck will be bred with the female goats owned by the members of the SHG to improve the genetic stock of their herds. Although most goat farmers usually leave goats to forage naturally, the SHG members are taught to supplement the feeding using locally produced, often wild-sourced, fodder such as that from the branches and leaves of *Prosipis juliflora*, *Leucena leucophilia* or various acacias. The members are taught to regulate the collective size of their herd to match the available forage in the surrounding areas. This reduces the degree of distressed sales and improves the health of individual goats because they are fed optimally. The group is encouraged to develop internal credit mechanisms or seek external credit sources for its members as another means of avoiding distressed sales. The SHG is encouraged to market their stock collectively to increase their bargaining power and the revenues from the goats.

3.5.3 TECHNICAL AREA

Small ruminant introduction encompasses multiple technical areas like veterinary care, animal productivity and the organizational development of producer groups, but is primarily for improved income generation (IR 1). Animal-source foods are also highly nutritious.

3.5.4 KEY CONSTRAINT(S) ADDRESSED

This activity addresses the lack of diverse income generation activities for the rural poor, especially those in the remote rural areas in hot and arid landscapes

3.5.5 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

Goats are very drought-hardy and can withstand nutritional shock. They are adapted to semi-arid regions with long dry periods, because they can survive when other livestock cannot.

3.5.6 INNOVATIVE FEATURE

The key innovation is that goat rearing is often overlooked as a powerful development tool that responds to different aspects of food security, namely, income generation, improved nutrition and gender equity. In terms of livestock, they survive drought situations better than cattle and have a shorter gestation cycle.

Finally, in India there is little stigma around eating goat meat as opposed to pork or beef, so goats can make a greater contribution to a diversified diet and might serve to improve nutritional outcomes.

There is some concern that the owners of goats will not necessarily be the primary consumers of the meat, especially if production is commercialized. Increasing the number of goats in any community, however, will obviously increase the availability of animal sources of food and should put downward pressure on prices. At that point, other pieces of the puzzle must be in place, namely, education about the importance to nutritional outcomes of consuming animal sources of food and economic access to animal products by the rural poor.

3.5.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

BAIF is the primary resource organization for this work. It has implemented small ruminant programs throughout India.

3.5.8 EFFECTIVENESS

Effectiveness. A study conducted in Bangladesh showed that a ruminant introduction program provided significant increases in incomes for the women participants (Saadullah et al., 2005).

There is also anecdotal evidence of effectiveness from BAIF, which claims that this is one of its most successful livelihood improvement strategies and success stories from USAID programs in Afghanistan and Ethiopia. But overall there is not a lot of literature that discusses the viability of a ruminant introduction program for income generation, creating gender equity or improving nutritional outcomes.

Impact. The Bangladesh report showed that the goat introduction program earned extra money for all ten participants. Their average earnings were $5 within just the first year, with the potential to earn much more as herd size increased.

Cost-Effectiveness. This single program can address many aspects of recommended food security programming. The cost effectiveness depends on the degree to which the goat herd grows and thrives and the degree to which the community consumes the meat or purchases diversified food sources with the additional income.

For greater cost effectiveness, the program should target zones that have the preconditions in place (see transferability) and substantial sources of fodder.

3.5.9 SCALABILITY

The program is scalable to the extent that there are groups that raise goats and enough bucks are available. The training is not too intense, and a single field agent should be capable of covering multiple villages.

3.5.10 TRANSFERABILITY

Goat rearing is practiced in many parts of India and Africa. The lessons from this approach to introducing improved goat production, aside from the types of breeds used to improve the genetic stock, are non-specific to geography.

Conditions for success. There are, however, certain preconditions for the success of this program, but many of these preconditions are, or could be, met easily in many poor rural areas in developing countries. For example:

- As these programs are targeted to remote rural areas, which oftentimes have limited access to veterinary care and/or animal breed improvement facilities, the introduction of these improvements in small ruminant production often require the intervention of a government or donor-funded project with trained animal husbandry personnel.
- The country in which the program is executed must also have a source of improved bucks.
- Also required is the ability to build social capital amongst a group of participants, although the level of interaction and cooperation between the members in such a program is probably less than for other activities.
- There must be an existing stock of local goats owned by the members of the group.
- It is helpful if there is a nearby livestock market.
- The participants will require adequate forage and/or the availability of land to grow forage.
- Goats are destructive of certain crops, especially vegetables, and are sometimes incompatible with certain production systems, so a reliable source of low-cost fencing material is required if the goat population is to be significantly increased.
- The existence of veterinary agents, or paravets, and vaccination materials will greatly enhance the success of any such program.

Mechanisms of transfer. The FARMS team was initially instructed to identify and work on only best practices that could be transferred to Africa and that have champions in India and in Africa who could facilitate that transfer. This could be a determining factor as to whether FARMS would work with this best practice or not. As we have not been able to assess the landscape of potential partners or champions for receiving the best practice in Africa, we cannot really rate the best practices on this sub-criterion.

3.5.11 RELEVANCE

This best practice is highly relevant to the FARMS program in that it addresses agricultural production, market linkages, nutrition and, in some ways, climate change adaptation, since goats are more tolerant of climatic stresses than cattle.

Since goat rearing is typically done by women, this addresses a cross-cutting aspect of FARMS, gender.

3.5.12 SUSTAINABILITY

The initial introduction of the goats is an element that mitigates the sustainability of the program, but once this initial introduction is made, the program can be self-perpetuating.

3.5.13 POSSIBLE ACTIVITIES FOR FARMS

FARMS is considering the possibility of coupling a home garden program with a goat introduction program. Although goats are often a physical threat to the survival of a garden, FARMS feels that introducing a source of animal products with the home gardens may be a good way to reduce nutritional deficiencies. FARMS will also consider poultry as another animal source in this program where it is more appropriate.

3.6 TOOLS FOR WOMEN

3.6.1 SUMMARY

The Central Institute for Agricultural Engineering (CIAE)has developed several tools for women that are designed to reduce the drudgery of tasks that women undertake in agriculture. These tools are scientifically assessed by CIAE for their efficacy in doing the tasks, and in reducing and/or improving the labor effort by women. Currently, CIAE's program is limited to only assessing scientific efficacy for women; there have not been any efforts to generate awareness about the tools or to evaluate their effectiveness in real-world situations. FARMS can potentially add value by working with Digital Green[12] to increase the adoption of the most promising tools, and generating empirical evidence on current constraints to adoption and their impact on households. This activity may add value to the recent approval of Rs. 18 crores by the GOI toward the cost of hardware for women-appropriate tools.

3.6.2 DESCRIPTION

This best practice comprises a range of farm tools for women that are designed to take into account women's different physical needs and reduce drudgery. The Indian Council for Agricultural Research (ICAR) is conducting research in this area under their Ergonomics and Safety in Agriculture initiative, which is led by the CIAE Bhopal. (CIAE 2008)[13] So far, CIAE has scientifically evaluated and refined 23 tools for women:

- Seed treatment drum
- CIAE seed drill
- PAU seed drill
- Naveen Dibbler
- Four row paddy drum seeder
- CRRI two row rice transplanter
- CRRI four row rice transplanter
- Twin wheel hoe
- Improved sickle
- Groundnut decorticator (sitting type)
- Groundnut decorticator (standing type)
- Groundnut stripper
- Tubular maize sheller
- Rotary maize sheller
- Cono weeder
- Cotton stalk puller (wheel type)
- Cotton stalk puller (jaw type)
- Groundnut stripper
- Fruit harvester
- Pedal operated paddy thresher
- Diaphragm pedal pump
- Hand ridger
- Improved sickle

[12] Digital Green is an extension and educational tool using short video spots mediated by local facilitators to introduce new concepts, knowledge or technologies to rural populations.

[13] CIAE Product Catalogue, Central Institute for Agricultural Engineering, August 2007. Available at http://www.ciae.nic.in/

For each tool, the CIAE tools handbook lists its function; specifications that include its weight and cost; its benefits over traditional practice in terms of number of workers required, force needed, areas covered, heart rate during work, and work pulse savings in cardiac cost; and source of availability. A couple of these tools are described in greater detail below, while details on the remaining tools are available from their publication and website (Singh et al., 2006).

Hand Ridger for Women. The equipment can be used by farm women to make ridges and furrows for ridge-planted vegetables, sugarcane planting, and making field channels for irrigation. The ridger weighs three kilograms and has to be operated by two women for forming small ridges where crops are to be grown under irrigated conditions. It consists of a handle, ridge maker share and t-type pulling beam. The two women have to stand and face each other to operate the ridger (CIAE, 2008).

Groundnut Decorticator or Groundnut Stripper. This tool was displayed at the USAID technology exposition that President Obama visited. This is manually operated equipment used to separate kernels from groundnut pods; it is operated in a sitting posture. The unit consists of a frame, a handle, and an oscillating arm sieve with an oblong hole. The pods are fed in batches of two kilograms and crushed in between concave and oscillating arms having cast iron/ nylon shoes.

3.6.3 INNOVATIVE FEATURE

Tools for women focus on reducing both drudgery and the ergonomic problems of tool use for women by developing tools that take into account the specific physical needs of women in agriculture and the specific tasks in which women are typically engaged.

3.6.4 TECHNICAL AREA

The primary contribution of tools for women will be to IR 1 - Increased Agricultural Productivity. Indirectly use of these tools may contribute to improved nutrition in the household if women's burden in agriculture is lessened.

3.6.5 CONSTRAINTS ADDRESSED

This best practice addresses the lack of availability of time-saving tools that are appropriate for use by women farmers. The best practice does not address the constraints in accessing the tools, or any socio-cultural reasons for not adopting the tools.

3.6.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

Tools are specific to the crops (e.g., groundnuts), and will work in only a geography where the specific crop is grown.

3.6.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

In India, CIAE, which is under ICAR, and its six cooperating centers located in TNAU Coimbatore, OUAT Bhubaneswar, PAU Ludhiana, MPUAT Udaipur, NERIST Nirjuli and IIT Kharagpur, are potential partners. In addition, manufacturers of agricultural equipment would be important partners in taking the technology to the private sector and in assessing the ability of the private sector to provide it sustainably. An initial list of agricultural tool manufacturers has been developed by the FARMS team and is quite large. Specific manufacturers can be invited to join the community of practice by narrowing down this list in consultation with CIAE, CII and, potentially, expressions of interest to an open announcement.

3.6.8 EFFECTIVENESS

There are several important components in measuring effectiveness of tools for women. First, the tool should be scientifically proven to reduce the physical burden, and drudgery, of the tasks for which the tool is an aid. Second, the women should find it economically, culturally and socially acceptable so that there is high adoption of the tool. Finally, tools for women can be transformative for a household to the extent that it frees up women from drudgery, reduces the time they take to complete agricultural tasks, improves their health and nutrition, and increases their time available to take care of their children. Its ability to impact households will depend on the hours and effort the women were exerting in the specific activity that is aided by the tool.

ICAR's research has been on addressing the first aspect of its effectiveness, and has assessed and refined these tools based on their ergonomic evaluations. The final ergonomic performance of the tools is detailed in their publications. However, there is a need for a systematic and rigorous study to understand the adoption of tools in India, the constraints to their adoption, the reduction in labor, and the final impact on the household.

Dr. Laxman.P. Gite, who leads the development of tools for women at CIAE, noted that a key constraint that they face is the lack of effort in generating knowledge of, and demand for, these tools, since CIAE's mandate is not extension.[14] A recent assessment by CIAE found that the adoption rate is approximately 5% -10%. Dr. Gite noted that so far CIAE efforts have meant that 200,000 tools have been adopted by women in Madhya Pradesh.[15] According to Dr. Gite, another critical gap in increasing the adoption rate is the manufacture of these tools (which is largely being done by CIAE and some local manufacturers).

Cost-Effectiveness. CIAE has information on the cost of manufacturing these tools. However, no systematic review has been conducted that estimates the comprehensive costs of a behavior change campaign to introduce the tools or the additional cost borne by households in using them. To the best of our knowledge, the costs have also not been compared with the benefits that they generate in terms of labor savings, income, and improvement in women's health.

3.6.9 SCALABILITY

Scalability will vary for each tool, and the specific crop for which it is used; it will be higher for tools that are not for specific crops. Scalability will be limited to the areas that grow the specific crop, and it would be high for crops that are grown in large areas and rely on women for labor. Another factor affecting scalability is the cost of the tool (which in 2007 ranged from Rs. 30 for a tubular maize sheller to Rs. 6,000 for a four-row rice transplanter). In addition, an initial cost would have to be incurred to tailor the tool to the specific needs of the region. IFAD recommends a participatory approach for developing and testing implements that includes input from the women farmers who use the tools, from the men who may play a significant role in the purchase of the tool, and potentially from the blacksmith or other entities that play a major role in making and repairing these tools.

The higher the cost of the tool, the lower will be the household's willingness to purchase it. Although the tools are quite cheap, a factor that can limit adoption at scale is the fact that households could be unwilling to make a purchase of equipment that reduces the burden on women, given their often low status in the household.

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[14] Dr. Gite, who met Raj Shah for half an hour during his trip to India noted this issue and requested that USAID assist in improving the extension of these tools. Phone conversation between Dr. L.P. Gite, CIAE and Tulika Narayan, Abt Associates Inc. on June 2, 2011

[15] Ibid.

3.6.10 TRANSFERABILITY

Conditions for success. Farmers will adopt these tools if using them leads to net positive gains. Second, the tool should be appropriate for the rural women and address their key constraint(s). Third, the tool should take into account the socio-cultural practices for the region. A 1997 IFAD study on the use of agricultural implements in Africa noted that socio-cultural reasons—rather than technical reasons—are often why new tools are not adopted. (IFAD, 1998) The study cites an interesting case from Zambia.

In Zambia, a German-financed project attempted to introduce the wheeled push-hoe, which is commonly used in Asia and appeared to be appropriate for local conditions. However, at the time of the study, its introduction had been unsuccessful. One of the main barriers to its adoption by women farmers was suspected to be the requirement that its user be in an upright position. This position is culturally defined as inappropriate and associated with lazy people, nomads, prisoners and paid workers on commercial farms.

The study points to several factors that should be taken into account when assessing the extent to which tools for women would be adopted. These factors include:

- traditional working posture;
- whether the tools will be used in conjunction with animal traction;
- whether tools will be used on family or individual plots;
- specific taboos associated with certain types of activities, animals or tools (these appear to vary tremendously even within a small area, and according to such factors as women's age and pregnancy);
- requirements for the transport of tools to distant plots (when people tire of carrying them, heavy implements and tools are sometimes dragged, and thus ruined);
- tool-sharing patterns within the family or between groups of women or households;
- local repair potential (by people themselves or local blacksmiths or handle-makers); and
- cost

Mechanisms of transfer. CIAE Bhopal and Dr. L. P. Gite are the champions of these tools and can be the mechanisms for transfer from India. Transferability of the tools will vary by tool, and will depend on the crop for which the tool is designed, whether women work in that role in target areas, and the possibility to manufacture the tools locally.

3.6.11 RELEVANCE

Tools for women, is a suitable area of intervention for the FARMS program. It is beneficial to women in agriculture, which is one of the cross-cutting areas of focus for the project. One of the tools – the groundnut decorticator – is also one of the new technologies that was showcased to President Obama and Dr. Rajiv Shah, the USAID Administrator, during their visit to India. Drs. Gite and Shah also met for half an hour to discuss these technologies. Furthermore, according to Dr. Gite, the GOI recently approved Rs. 18 crores to pay for the hardware cost of these technologies.

If a specific tool for women is effective, in that it is adopted by women farmers, has an impact on the welfare outcome for women in agriculture, and the benefit from the tool is greater than the cost for a household, then as long as the aggregate demand justifies the initial cost of investment to manufacture it, there would be demand that a supplier could meet profitably. The biggest impediments to creating demand may be the initial cost of information campaigns and cultural barriers to adoption.

3.6.12 POSSIBLE ACTIVITIES FOR FARMS

FARMS can add value to the existing work on customized tools for women done by CIAE to generate stronger evidence of their effectiveness in-real world applications (including their cost-effectiveness) and acceptability of some of the tools that have the largest potential for scalability (i.e., tools that are used for crops that are grown more widely). FARMS can work closely with Digital Green, another best practice that it has identified, to improve the current efforts to increase adoption of some of these tools. FARMs could also add value by addressing the supply constraint that potentially exists in this area by engaging with agriculture tool manufacturers to share our results on demand creation, or by working with them during demand creation.

3.7 INDIA'S POTATO PRODUCTION INDUSTRY

3.7.1 SUMMARY

India has a vibrant, prosperous and self-contained potato production industry. India is the world's number two producer of potato and its productivity is much higher than the other top three producers (Singh et al.,2011). This is a sector that has seen rapid growth and development over the last 40 years during which time production has increased nearly ten-fold. Much of this growth can be attributed to the work of the Central Potato Research Institute (CPRI) in varietal development, seed multiplication and combating disease. Over 70% of the cold storage facilities in India are dedicated to potato and this too has spurred the industry to greater growth. The systems which serve to organize the Indian potato industry could possibly serve as a model for Malawi and other countries having similar agro-climatic endowments, i.e., a combination of mountainous areas adjacent to low-land production zones suitable for potato and a strong market.

3.7.2 DESCRIPTION

India is the world's number-two potato producer and now producers over 37 million MT of potato per year. The growth in India's potato industry can be largely attributed to the work of the Central Potato Research Institute (CPRI) in varietal development. Over the years they have developed over 49 indigenous varieties that match the various agro-climatic zones of India, including the development of varieties that are adapted to: high-heat conditions, disease resistance and industrial uses. Also, the CPRI has developed a high-tech system of seed production that relies on the production of micro-tubers at CPRI and their subsequent multiplication at lower altitudes closer to the zone of production.

Some of the achievements of the Indian potato industry are[16]:

Varietal Development. The CPRI has over 2000 accessions and several parental lines that are resistant to late blight, nematodes and various other potato diseases. These are all used as genetic stock for its breeding program. They use both cryogenic tip storage and propagation at its Kufri station to maintain these lines.

India has developed 49 indigenous potato varieties. These varieties are uniquely adapted to the agro climatic zones in which they are grown, including the short day/short season growing conditions in the Indo-Gangetic Plains. India has also developed varieties that combine these characteristics plus the high solids content necessary for industrial potato processing.

Seed Multiplication.

There are many scenarios under which the production of seed potato occurs in India:

1. Some farmers in the Indo-Gangetic Plains save their own seed and reuse portions of their own harvest for the next season's crop.
2. Some farmers have become commercial seed multipliers and use breeder seed obtained from the CPRI to multiply and sell to fellow farmers. .
3. CPRI also supplies breeder seed to state agricultural universities, which then multiply and sell seed to farmers in their states.

[16] http://cpri.ernet.in/ . Accessed 25 September 2011.

4. Finally, there are large commercial seed multipliers, like ITC India, that buy breeder seed from CPRI and multiply it for their own needs and for sale to farmers or producer companies.

The breeder's seed and also the FI, FII and certified seed are purchased by both public and private sector entities for the purpose of multiplication and sale. Even the state agricultural universities pay for the breeder's seed and then sell the multiplied seed potato on to the farmers in their area. They compete with the private sector for this market and each is able to cover their costs. The Indian government does intervene to set prices and provide subsidies, which may create slight distortions in this market, but in all this system seems to be quite sustainable and a model of public-private cooperation in a commercial value chain.

India has adapted its multiplication system to make optimal use of areas that are known to have low aphid populations and lack of other disease vectors like white flys, thrips and and other insect populations, that in turn reduces their susceptibly to diseases that can remain latent in the seeds and emerge in the farmers' fields.

There is an interest in both the private and public sectors to multiply and export potato seed. India has a competitive advantage in this commercial trade, as it has both the conditions for varietal development (high mountain areas with little aphid, and thus little virus, pressure) and seed multiplication (late blight pressure is low in the Indo-Gangetic Plains because of very little rainfall from 15 Dec – 15 Jan when potato plants are susceptible). Pakistan and Bangladesh have already imported small quantities of potato seed from India.

True Potato Seed. Purchased potato seed accounts for up to 60% of the farm gate price of potato; therefore efficiencies in the systems that produce, store and distribute potato seed could greatly add to the bottom line of the farmer.

Many potato-producing countries, like Mali and Guinea, import seed potato from Holland or France or South Africa. Israel is also another major potato seed-producing country. India actually produces its own seed and is close to meeting its demand. Production, storage and distribution are managed by both the public and private sectors.

Uttar Pradesh, Bihar and West Bengal are all large potato producing states in India and also some of the poorest states. The western Indo-Gangetic Plains region accounts for 1 million of the 1.2 million ha of potato produced in India. With yields at 20 MT/ha, potato is a valuable cash crop for the farmers in this region. This is a $10 billion business for this very poor area.

India, through the CPRI is also a leader in attempts to make true potato seed a viable technology for the industry. True Potato Seed represents a potential alternative to the use of seed potato (tuber pieces) as seed stock for potato production as it would eliminate the need to store, handle and distribute seed potato, which can make up as much as 60% of the farm gate value of potatoes. True potato seed, however, is still an innovative technology that has some pitfalls too. The following are the complications involved with TPS[17]:

- Potato seedlings grown from TPS are very delicate, and there is extensive mortality during transplanting even under the best of conditions. Direct seeding is not possible due the very fragile nature of the seedlings.

[17] Personal interview with Dr. Jai Gopal, Principal Scientist & Head Division of Crop Improvement Central Potato Research Institute. 3 March 2011.

- Growth of the TPS transplants is very slow and almost always extends the season by 30-45 days over that of the same varieties grown from potato seed.
- Tubers from TPS are typically much smaller than their counterparts grown from potato seed.
- It is very difficult to get potato plants to flower and produce seed. Most varieties require long day lengths (14 hours) and a narrow range of temperatures for any of the plants to go to seed. Still, under optimal conditions, only 20% of some varieties will actually go to seed, thus making TPS production a hit-or-miss proposition.
- Potatoes grown from TPS are highly variable genetically, and plants in the same plot not only have different phenotypic traits but also vary in days-to-maturity, yield and storage characteristics.

Indian researchers at CPRI, however, continue to look into this technology, which if perfected for the commercial production of potato, could revolutionize the industry.

Integrating biotechnology. The CPIR has a unit that is working to introduce better disease resistance and longer storage life into its varieties through advanced biotechnological techniques.

3.7.3 TECHNICAL AREA

This best practice is primarily meant to reduce the cost of inputs and increase agricultural production, thus is relevant to FARMS' Intermediate Result 1. Potatoes are a great source of protein, B vitamins and vitamin C. They produce much more protein and micro-nutrients per hectare than rice or wheat, therefore increased potato production can address IR 4, nutrition as well.

3.7.4 INNOVATIVE FEATURE

The Indian potato industry is full indigenous and self-contained, whereas most potato producing countries rely on varietal development and import of seed potato from external sources.

3.7.5 CONSTRAINTS ADDRESSED

This BP addresses the high cost of inputs in in an input intensive industry and is reducing the entry barrier for smallholders to enter into the production of this commercial crop.

3.7.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

This practice is suitable for countries that have a diverse and distinct set of agro-climatic zones, but several of the best practices practiced by the Indian potato industry can be applied in any potato-growing region of the world.

3.7.7 RESOURCE ORGANiZATIONS AND INDIVIDUALS

- The Central Potato Research Institute (CPRI) is the primary resource in India.
- Dr. Jai Gopal has written several books on potato and is India's authority on the subject of potato breeding and TPS.
- CIP is a CGIAR Institute specializing in potato research on a global scale.

3.7.8 EFFECTIVENESS

Effectiveness.
The Indian potato industry has grown from the production of 3.9 million tons in 1970 to 37.7 million tons in 2010.

Impact. The potential impact of this technology is huge, given the great contribution of potato production in some regional economies and the household economies of the farmers in these regions.

Cost-Effectiveness. In large part because of the work of the CPRI (Central Potato Research Institute), potato production in India has grown over ten-fold since the 1970's and is now nearly a $7 billion dollar industry. The funding for the CPRI is unknown, but its return on investment is likely to be quite substantial.

3.7.9 SCALABILITY

Potatoes are not produced by a broad cross-section of the rural poor as production zones are typically found in distinct pockets. Although it is an easy matter to target these pockets with efforts aimed at developing the sector, the improvements are only scalable within these pockets.

3.7.10 TRANSFERABILITY

This technology could be transferable to other countries and have a large impact on the rural poor. Countries like Mali, Guinea, Cote d'Ivoire and Malawi all import seed potato and their per-hectare productivity is much lower than in India. The cost of seed potato is high, so reductions in the cost of this principle input could have a transformative effect on profits for the farmers.

Conditions for success. The best practice spoken of here, involves the integrated development of an industry, thus there are many pre-conditions for deploying such a 'best practices. The political will must be there, with the attendant expertise, natural resources and markets.

Mechanisms of transfer. The CPRI is a potential champion in India of any potato technology. Its lead scientists have already done work overseas, including in Kenya and Malawi.

3.7.11 RELEVANCE

Potato production is an excellent income earner for farmers, as production levels are typically 17-35 MT/ha, and the per-kilogram sale prices are similar or higher than for most grains. There are, however, added costs in terms of inputs, harvesting and post-harvest handling.

3.7.12 SUSTAINABILITY

This effort will involve an intimate articulation between the private sector and the public sector, thus the risks to sustainability are high, since there are many disparate interests that must converge. Although, once developed, the attraction of potato production for the income generation and nutritional prospects that it offers would likely encourage further growth.

3.7.13 POSSIBLE ACTIVITIES FOR FARMS

The CPIR and its collaborators the state universities and private sector seed multipliers have created a self-sustaining potato production system that does not rely on external imports.

The CPRI and its partners:

- Develop their own varieties, including many locally-adapted and disease resistant strains;
- Develop breeders' seed using micro-tuber propagation; and
- Have developed a viable distribution network;

The system:

- Is almost completely self-sustaining, in that the sale of micro-tubers supports all the costs of the center; and
- Has a unit that is working to introduce better disease resistance and longer storage life into its varieties through advanced biotechnological techniques.

There are many lessons to be taken from this system. As Malawi is looking to further develop its potato production system, there may be a future opportunity to transfer some of the elements of this system from India to Malawi. Malawi is Sub-Saharan Africa's biggest potato producer, with a 2007 harvest of 2.2 million tons. The potato is grown mainly in highland areas in the country's southern and central regions. In parts of the southern region, farmers can grow two crops each year.[18]

[18] http://www.potato2008.org/en/world/africa.html#malawi (accessed 18 Aug 2011).

4. BEST PRACTICES EXPANDING THE USE OF KNOWLEDGE (IR 2)

This chapter presents the assessments of potential best practices that primarily contribute to IR 2 - Expanded Use of Knowledge, Innovations and Research by Farmers and Agribusinesses.

4.1 DIGITAL GREEN

4.1.1 SUMMARY

Digital Green is an extension and educational tool using short video spots moderated and commented on by local facilitators to introduce new concepts, knowledge or technologies to rural populations. It has generated widespread interest in the development community. Evaluations have proven it to be many times more effective and cost-efficient than traditional Training and Visit (T&V) extension in promoting the adoption of agricultural best practices. FARMS would like to work with Digital Green to expand the application of their extension model to many other development practitioners and NGOs, possibly including those in the FARMS' targeted African countries.

4.1.2 DESCRIPTION

Digital Green is an extension and educational tool using short video spots moderated and commented on by local facilitators to introduce new concepts, knowledge or technologies to rural populations. The founder of Digital Green estimates that about 20% of the technologies are farmer-generated innovations or farmers' adaptations to introduced techniques and the remaining 80% are introduced techniques from the research and extension sources. One of Digital Green's most innovative feature is that the video content of the featured best practices, technologies and/or techniques, are generated by rural residents who are preferably similar in socio-economic status, culture and language to the members of the target audience. It is presumably this sense of closeness and familiarity with the presenter that hastens the adoption of the technologies by other farmers.

Digital Green has been primarily employed to introduce new agricultural production techniques to rural farmers in India, but could have much broader applicability for rural development around the world in the domains of health, nutrition, climate change adaptation and natural resource management. The videos are stored online and can be accessed from the web and/or saved, stored and transferred on inexpensive micro-SD cards.

Digital Green was developed in India by Rikin Gandhi, who is now the CEO of digitalGREEN, a Delhi-based NGO that shares the name of the educational tool he developed. digitalGreen continues to expand the use of this educational tool by training NGOs and extension workers in its use.

Digital Green works on several key principles that are seen to be instrumental to its success:

- **Video content,** as opposed to written content, is much more effective for low-literacy communities.

- **Locally-generated content** helps farmers more easily relate to the subject matter.
- The videos are always **viewed in the presence of a skilled facilitator**.
- Digital Green uses **low-cost equipment** that is adapted for use in rural areas, e.g., $100 camcorders and battery-operated pico projectors.

digitalGREEN is now in a start-up and expansion phase. It has developed a set of Standard Operating Procedures for scaling up the Digital Green methodology of extension. It now has more than 20 full-time employees, including a cadre of program managers, trainers and technicians. It is currently working with four NGOs in four Indian states to help them employ Digital Green as a tool in their existing rural development programs. It is also starting a program with the National Rural Livelihood Mission (NRLM) to employ the Digital Green techniques to improve efforts to expand the adoption of certain sustainable agricultural best practices. The NRLM will initially only use the Digital Green techniques in a few eastern states of India such as Jharkhand and Bihar, but plans to use this technology in conjunction with its nationwide roll-out.

Another key feature of digitalGREEN is its use of an online monitoring tool linked to an analytics dashboard to monitor video screenings and adoption rates. Its Connect Online Connect Offline (COCO) software allows local facilitators and development agents to enter data on the number of videos shown, farmer attendance, and farmer adoption rates while offline. The data entry system does not require a full-time connection, so field agents can register the data on their computers and then, when they eventually connect to the web, the data can be uploaded and combined with that of all Digital Green users around the world. digitalGREEN has also designed its Analytics tool, which takes data from the COCO uploads and provides day-to-day business intelligence on field operations, performance targets, and basic ROI metrics relevant to the overall program.

4.1.3 INNOVATIVE FEATURE

Digital Green is an extension tool that makes use of farmer-generated video content to promote adoption of technologies. The video content is generated by farmers who have cultural, agricultural and linguistic links to the target audience as a means to improve the uptake of technologies and best practices. It appears more effective in gaining adoption of technologies because of this fact and also because video is more captivating than verbal training offered during via Training and Visit extension methodologies.

4.1.4 TECHNICAL AREA

This best practice addresses expands the use of knowledge by small, illiterate farmers, thus addressing IR 2.

4.1.5 CONSTRAINTS ADDRESSED

Digital Green provides more and better access to information, especially for illiterate farmers.

4.1.6 APPLICABLE LANDSCAPE/ AGRO-ECOLOGY

This is applicable in any location where agricultural extension is needed.

4.1.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

digitalGREEN, the Bill and Melinda Gates Foundation and the National Rural Livelihood Mission of India are major proponents of Digital Green and its approach to extension.

4.1.8 EFFECTIVENESS

Effectiveness. Digital Green is considered to be very effective in promoting adoption of new technologies by farmers. One study that compared the effectiveness of the classical T&V approach to

Digital Green showed that Digital Green improved adoption rates of the same agricultural techniques from 11% with T&V to over 80% with Digital Green while also being 33% cheaper to deploy (Gandhi, Veraraghvan, Toyama, and Ramprasad, 2009). Another study in Benin showed that video can greatly enhance adoption rates and comprehension of new farming techniques in contrast to training workshops where no video was used (Zossou et al., 2009). As it is cheaper to execute as an overall program and more effective in promoting adoption, the cost per adoption via Digital Green is one tenth of that for T&V. In countries like Ethiopia and India that have huge public sector extension systems, this can have substantial implications on these countries' agricultural budgets, and it can certainly increase the effectiveness and efficiency of many donor-funded programs.

Impact. Digital Green has the potential to improve individual or household livelihoods considerably, but this would obviously depend on the quality and potential of the technologies themselves to improve livelihoods. Digital Green is an improved method of delivery for technologies and best practices. Impact, as defined for this analytical framework is difficult to assess and will be considered more or less neutral by that measure.

Cost-Effectiveness. Digital Green is 33% cheaper to deploy than Training and Visit (Gandhi, Veraraghvan, Toyama, and Ramprasad, 2009), it is therefore considered cost effective.

4.1.9 SCALABILITY

Digital Green can be deployed in any place where extension and rural education is needed. Digital Green can be used by national-level extension agents, as well as by NGOs in their outreach and training campaigns. Digital Green is typically deployed in a decentralized way. There are usually centers, such as an NGO regional office, that will serve as a content development and management hub. From this hub many villages can be reached with extension videos, but those targeted can also generate new content, spreading best practices throughout the reach of the regional hub.

Scaling up Digital Green requires simply training and equipping a central agency or regional hub. The concept, moreover, is rather simple and one could even imagine spontaneous adoption by development agencies, NGOs and extension personnel after initial exposure.

Digital Green is highly scalable.

4.1.10 TRANSFERABILITY

digitalGREEN, the NGO, is currently working on expanding the use of its technology throughout India. The National Rural Livelihood Mission (NRLM), which is using Digital Green as one of its methods of training and providing extension services, is a well-funded program of the Indian Government; it has the resources to establish many hubs where a local agency is trained and equipped to deploy Digital Green as an extension tool.

The Digital Green methodology is most likely easiest to introduce through strong, existing government extension programs or through national initiatives like NRLM. Some African countries, like Liberia, lack this sort of structure. The management team of Digital Green has been to Kenya, Uganda and Ethiopia to discuss its potential deployment in these countries. It has been in discussions with the Ethiopian Ministry of Agriculture to explore deployment of the tool in Ethiopia's extension service, which has the highest density of agents per citizen in the world. There is potential in some African countries and also throughout India.

While the political will may be there in the Feed the Future countries to address issues with extension and in reaching the last mile, the failures and difficulties in getting to the last mile are indicative that

more than political will may be needed. Despite the simplicity of Digital Green, it still requires that trained and equipped facilitators go to rural villages and hold short, focused training sessions. In African societies in particular, the human capacity and physical infrastructure needed to deliver extension, even in the form of Digital Green, is subpar (Holmner et al.,2010) and may be an unmet condition for the deployment of Digital Green there.

4.1.11 RELEVANCE

For many reasons Digital Green is a suitable best practice for the FARMS program. It is most beneficial for the rural poor. It is an innovative solution that has been shown to be effective for catalyzing the adoptions of agricultural practices that can have a significant impact on food security. Digital Green received a grant from the Bill and Melinda Gates Foundation (BMGF) in its early phase. It has also been a part of the high-level public discourse, so it has many champions, including Dr. Rajiv Shah, the USAID Director.

Digital Green is considered most effective when the extension is targeted to populations with lower levels of literacy and limited access to other media. It is therefore very applicable to those areas where food and nutrition security is an issue, i.e., in many South Asian and African countries.

Furthermore, given that the African Feed the Future countries have all signed CAADP compacts, which calls for increased investments in agriculture, and given that one of those investments will likely be to improve national level extension so as to create an effective delivery system for technologies, Digital Green does address a key constraint in many of the Feed the Future countries as well as in developing nations around the world.

4.1.12 SUSTAINABILITY

Digital Green will most probably always require the support of a donor, NGO and/or a government agency or extension service. There has been some discussion within digitalGREEN of making the videos a for-fee service and the Digital Green model comes close to cost recovery, but digitalGREEN has no evidence or experience in accepting payments from farmers for the video screenings.

4.1.13 POSSIBLE ACTIVITIES FOR FARMS

Currently Digital Green is set to be rolled out in the National Rural Livelihood Missions' nationwide program for rural development. As such, Digital Green's scale-up within India is fairly well on track. Concurrent to Digital Green's roll-out in NRLM, Innovations for Poverty Action will conduct an evaluation of Digital Green.

Digital Green is seen as a high-potential best practice, and the FARMS project has the potential to add value to this concept in two possible ways.

FARMS envisions using Digital Green as a mechanism for transferring agricultural, nutrition, natural resource management and climate change adaptation best practices from one Indian state to another and from India to Africa. To accomplish this, FARMS would like to assist digitalGREEN to establish a dedicated training center (which might be) called the Digital Green Institute. The Digital Green Institute would be designed solely to offer a relatively standardized training to eligible organizations around the world for the integrating the Digital Green method of training and extension into their current operations. FARMS would help digitalGREEN to establish this institute by providing assistance in strategic planning, infrastructure and working capital for its initial 30 months of operations.

In parallel to this grant to digitalGREEN, FARMS would establish a separate grants program targeted to Indian and African NGOs, extension services and other rural development organizations. The grants

would allow these organizations to attend the Digital Green training and obtain a starter set of the equipment required to integrate this as a tool in their development approach. If FARMS were to be given the full mandate of transferring best practices to Africa, the project could offer these grants as a priority to African organizations, and thereby effectively transfer the Digital Green concept to Africa. By developing a network of African development organizations that are using Digital Green, FARMS would have a viable platform by which it could transfer new technologies and knowledge from India to Africa, as well as a means to monitor remotely the transfer and adoption of these technologies by African stakeholders using the COCO and Analytics software of digitalGREEN. The COCO system and accompanying Analytics can, at least partially, solve one of FARMS' biggest challenges: monitoring technology transfer and adoption in African countries.

The Digital Green Institute and the network of Indian and African organizations that would employ the Digital Green methodology could serve as a platform for the transfer of new technologies. This could occur naturally by field agents' uploading to the website local content that is subsequently downloaded by any other field office anywhere in the world. FARMS could also seek to create videos of the best practices identified and evaluated in India that can be directly shared with target organizations in locations around the world when and where appropriate.

Alternatively, FARMS sees an opportunity to assess the effectiveness of SRI under Digital Green's roll-out under NRLM. This potential evaluation is discussed in this document under the section on SRI.

4.2 ICT IN AGRICULTURE

4.2.1 SUMMARY

Information and Communications Technology (ICT) will increasingly play a greater role in the development of smallholder agriculture. Already, many private and public sector entities have developed models and applications that use ICT as a means to provide their products and services to farmers. As India is on the cutting edge of this development and has a large number of stakeholders in this space, the FARMS team feels this is the ideal place to understand the numerous potential applications of ICT in smallholder farmer development and to distill a set of best practices in this emerging domain. FARMS will therefore initially conduct a broad assessment of ICT in agriculture with the view of setting up a pilot program to test a few of the most innovative and potentially successful models.

4.2.2 DESCRIPTION

Cell phones, smart phones and greater internet connectivity have broken down the "digital divide" that once existed between developed and developing countries and between urban centers and rural areas in developing countries. There are more than 45 ICT applications designed for smallholder farmers in India alone, each with their own degree of efficacy, financial success and relevance for the consumer. There are many potential applications for ICT in agriculture, food security, nutrition and climate change programs, and it is easy for development professionals to recognize the potential to improve development outcomes using ICT. Mobile network operators and hardware manufacturers also see the potential to tap into vast new markets if they can reach rural populations in developing nations.

This recognition on both sides has led to the development of many new tools and services for smallholder farmers, the target population of the FARMS project.

Many of the models of ICT in agriculture seek to transfer different types of information. This information could be grouped into three categories: agronomic best practices; real-time weather information; and price information and buy/sell offers. Many models are focusing on providing information on general agronomic best practices like seeding time, seeding rate, top dressing timing, and pest and disease diagnosis. Other models focus on providing price information. Price information is reputed to give the farmer an advantage when negotiating with itinerant traders. There is also a tremendous opportunity to create a virtual trading platform on which many buyers compete efficiently for the same product. This may ultimately serve to increase the farmgate price for smallholder producers.

4.2.3 TECHNICAL AREA

ICT expands the availability and use of knowledge and has the potential to reach smallholder farmers more cheaply and more often than other traditional means of extension and service provision. ICT has the potential to contribute to all of the Intermediate Results of FARMS.

4.2.4 INNOVATIVE FEATURE

The appeal of ICT is that it can reach a large number of smallholders in very remote areas at a fraction of the cost of traditional extension programs. There is also the potential to provide price discovery mechanisms and trading platforms that increase small farmers' links to markets.

4.2.5 CONSTRAINTS ADDRESSED

This best practice addresses constraints to productivity and access to information.

4.2.6 APPLICABLE AGROECOLOGY/LANDSCAPE

This best practice is applicable in all agricultural areas where cell phone penetration is relatively high, although it is good to note that knowledge dissemination can also be done effectively using radio, television and portable video (e.g., Digital Green).

4.2.7 RESOURCE ORGANIZATIONS OR INDIVIDUALS

There are over 40 types of ICT applications in India. For each of these, there is a range of potential stakeholders, such as: mobile network operators (MNO) like Bharti Airtel and Vodafone; software developers like Ekgaon and ZMQ; retailers like IFFCO, Reliance and ITC; and many interested development agencies and donors like ILRI, CABI, IFPRI, CIMMYT, USAID, ARD and DFID. Each of these stakeholders has its own interest in refining these models and finding the ones that work best for smallholder farmers.

4.2.8 ANALYTICAL FRAMEWORK CRITERIA

ICT is not considered a best practice in its own right, but is a tool used in the delivery and operation of different types of best practices. As such, ICT was not analyzed according to the framework criteria, but different best practices that employ ICT have been, such as Ekgaon and Digital Green.

4.2.9 POSSIBLE ACTIVITIES FOR FARMS

The FARMS team will assess and evaluate some of the most prevalent ICT interventions in India, to understand the different elements of each, the types of services they do provide and can provide, and ultimately their relative effectiveness in providing these services.

An initial assessment will be conducted as a means to understand the landscape of ICT interventions for smallholder farmers. The assessment will distill a set of lessons learned about the application of ICT to food security and development issues and make recommendations for the developers of new models seeking to utilize this potentially valuable tool to address food security and rural poverty issues. These tools may include: providing extension services, making market linkages, sharing market price information, and delivering behavior change messages designed to improve nutrition outcomes.

This assessment will not simply list and describe all of the existing models of ICT used in agriculture; it will use the existing models, and evaluations of existing models, to infer preliminary responses to the following questions.

1. What is the scope/necessity of providing market linkages via ICT?
2. How should quality control of the content be assured?
3. Is content more effective/cost-effective when there is a human interface between the mobile content and the farmer?
4. What degree of customization and localization is required to benefit the farmers and sustain the system in the private sector?
5. What is the role that commodity exchanges are/could be/should be playing in the use of ICT for creating market linkages?
6. Who can/should pay?
7. What is the set of preconditions required to make ICT an effective tool for improving food security and alleviating poverty within the smallholder farmer community?
8. Information can now be supplied to farmers in almost real-time. Now that the information inertia can be mostly overcome, are those that are generating the information positioned to work within this new scenario?

There is substantial flexibility in ICT as a tool for providing extension information, promoting market linkages and price discovery, and facilitating rural banking for FARMS' target beneficiaries. Small farmers need all of these things to varying degrees. Almost any tool can be developed to meet the needs of FARMS' target beneficiaries. Answering the above questions will help to determine what an effective and sustainable ICT application should look like. Armed with this information, donors, governments and the private sector will be more adept at picking the right application and/or developing one from the bottom up.

5. BEST PRACTICES LINKING FARMERS TO MARKETS (IR 3)

This chapter presents the assessments of potential best practices that primarily contribute to IR 3 - Farmers Linked to Markets and Expanded Trade and Investment.

5.1 KISAN CREDIT CARD

5.1.1 SUMMARY

The Kisan Credit Card (KCC), which was introduced in India in 1998/1999, provides short-term credit to all farmers, small and large, as a revolving fund based on the land area the farmer wants to mortgage (usually always the same as the amount of land owned by the farmer) and the specific crop grown. The loan limit is determined by a state- or district-level technical group and is pre-fixed and valid for three years. A recent National Bank for Agriculture and Rural Development (NABARD) study has identified several issues with the KCC scheme. The study finds that there are significant constraints in obtaining a KCC, which requires a large list of required documentation, particularly for loans greater than Rs. 50,000, and several visit to the bank. In addition, households face significant transactions costs to make withdrawals and deposits, which include transportation costs, lost wages and wasted time due to the lack of availability of the branch manager. This is one of the reasons that households are not using the KCC as a cash credit facility, which as a key innovation of KCC was expected to be a main attraction.

FARMS could consider adding value by generating more awareness about the cash credit facility benefit of KCC, potentially using behavior change communications and working jointly with Farmer Technology Transfer Fund efforts. Second, FARMS could consider designing, implementing, and evaluating pilots that improve KCC in one of the areas of improvement highlighted by the NABARD study. For example, FARMS could work with Reserve Bank of India-approved business correspondents to implement KCC and assess if this approach increases the number of transactions and uptake of KCC.[19] This could be implemented in coordination with Sub-K of BASIX, or other similar organizations that are implementing the business correspondent model. Any of these activities will require significant interaction and consultation with implementing entities and individuals who have been engaged in research on KCC. Finally, given the lack of defensible evidence on the impact of KCC, FARMS could conduct a rigorous evaluation of the impact of KCC on farm income. The GOI is planning to replace paper passbooks with smartcards to administer KCC. One possibility might be to assess the impact of implementing the KCC as a smart card before it is scaled up nationwide.

5.1.2 DESCRIPTION

The Kisan Credit Card (KCC) provides short-term credit to all farmers, small and large, as a revolving fund based on the land area the farmer wants to mortgage (usually always the same as land owned) and

[19] A business correspondent is a third party (NGO, microfinance Institution, or non-bank financial company) that performs activities on a continuing basis for banks. The banking activities include (i) disbursal of small-value credit, (ii) recovery of principal /collection of interest (iii) collection of small-value deposits (iv) sale of micro-insurance, mutual fund products, pension products, or other third party products and/or (v) receipt and delivery of small-value remittances/other payment instruments. Reserve Bank of India, Financial Inclusion by Extension of Banking Services – Use of Business Facilitators and Correspondents, January 2006, RBI Circular RBI/2005-06/288.

the specific crop grown. The loan limit is determined by a state- or district-level technical group and is pre-fixed and valid for three years. The KCC scheme covers (i) production credit, (ii) working capital requirements for allied activities (non-farm activities), (iii) consumption needs and (iv) accident insurance of KCC borrowers.

The credit is extended as a revolving cash credit, with no limits on the number of withdrawals and repayments. The rate of interest is subsidized by the state and the GOI. For loans below Rs. 300,000, the rate of interest is 9 percent, and the GOI provides a subsidy of 2 percent to the financial institution, so the net rate of interest is 7 percent. Borrowers get a paper pass book or an electronic card (not universally available) that they can take to a local bank – technically any bank but operationally some banks may opt out of it – and withdraw cash. Farmers can deposit any time to reduce their interest cost. This system therefore requires the presence of a bank in close proximity to the farmer, as well as good land records and land titling, particularly for women, based on which land ownership can be easily verified. Furthermore, banks may at their discretion fix sub-limits either based on an assessment of default rates, or on the seasonality of credit requirements. In the event of default, banks refuse to lend to the farmers even if they have KCC. There are three different credit sub-limits for production, assets maintenance, and consumption. KCCs are typically issued for loan amounts greater than Rs. 5,000. Since 2001/02, personal accident insurance has also been introduced that insures all KCC holders against accidental death/permanent disability.

The KCC scheme was introduced in 1998/1999, initially for production credit. Later it was expanded to cover term loans, consumption and non-farm activities. By the end of 2008-09 according to the KCC management information system, approximately 8.6 crore KCCs have been issued, with average lending of approximately Rs. 47,000 per KCC (NABARD, 2010). KCC has done well in the states of Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttaranchal, where the coverage of KCC (ratio of number of cards to operational holdings) is greater than 70 percent. A recent NABARD study, which is based on data from 1,876 KCC holders across14 states, estimates that 7.18 crore cards were disbursed in the sample states; this estimate was revised downward to 4.73 crores after correcting for issues in duplication.[20] Overall, the number of KCCs is approximately equal to 50 per cent of number of the operational holdings in the 14 states. Among various states, the maximum coverage of KCCs (ratio of number of cards to operational holdings) were Punjab (78%), Haryana (74%), Andhra Pradesh (64%) and Karnataka (63%).

5.1.3 INNOVATIVE FEATURE

KCC reduces the cost of borrowing, because it provides a credit limit that is valid for three years (based on the size of the operational land holding and the crop), instead of the annual approvals that were previously required. Additional savings in the cost of borrowing can be realized, since the farmer only has to pay interest on the amount she uses. KCC also provides credit as a revolving cash credit facility, allowing farmers to have any number of withdrawals and repayments within a year, as long as the amount outstanding is within the specified credit limits and sub-limits. Consequently, the effective (total) loan amount within a year can be a multiple of the initial approved amount, as long as the farmer pays back the loan and interest amount.

[20] The selected states include Odisha and West Bengal from the eastern region, Maharashtra and Gujarat from the western region, Rajasthan and Madhya Pradesh from the central region, Punjab, Haryana, Himanchal Pradesh and Uttar Pradesh from the northern region, Andhra Pradesh, Karnataka and Kerala from the southern region and Assam from the North-eastern region.

If implemented correctly, KCC reduces or eliminates the paperwork and delays required to obtain short-term credit by having prescribed amounts by land holding size and crop. Another innovation is that farmers can go to any bank, not just the issuing bank (although some banks may opt out).

5.1.4 TECHNICAL AREA

The primary contribution of KCC will be to IR 3 - Farmers Linked to Markets and Expanded Trade and Investment, and it will have a secondary contribution to IR 1 - Increased Agricultural Productivity.

5.1.5 CONSTRAINTS ADDRESSED

High transaction costs in access to credit is the main constraint addressed.

5.1.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

Areas with a banking structure that can support the scheme and where there is the political will to provide subsidized agricultural credit and require private banks to participate in this provision.

5.1.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- NABARD
- Relevent implementing departments of states that have performed well in terms of KCC per operational land holding (Andhra Pradesh, Gujarat, Haryana, Karnataka, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and Uttaranchal)

Researchers:

- Sameer Samantara, NABARD, Mumbai
- Anjani Kumar, National Centre for Agricultural Economics and Policy Research, New Delhi

Technical Experts:

- P.K. Joshi, IFPRI

5.1.8 EFFECTIVENESS

KCC is expected to reduce the constraints to accessing formal credit, thereby allowing farmers to buy inputs, make expenditures to maintain their assets, and ultimately increase their agricultural productivity. Several papers have reviewed the progress of the KCC scheme since it was launched in 1998/1999 (Sajane et al., 2010; NABARD, 2010; Kumar et al., 2010; Kumar et al., 2007; Vedini and Durga, 2007; Kallur, 2005). These papers focus on the extent to which KCC has been made available to eligible households, the number of KCC issued as a ratio of operational land holdings, the total value of credit made available, and the cost of credit. Only the NABARD study assessed the impact of access to KCC on farmer yields and returns. It found that the average yield of paddy for KCC farmers was 13.3 percent higher than for farmers who did not have KCC, the cost of cultivation was 7.6 percent lower, and the value of output was 13.6 percent higher. However, it is not clear how the farmers who did not have KCC—the "control" group—were chosen. It appears to be not randomly chosen, which may have been infeasible given the coverage of the program. Nonetheless, other quasi-experimental approaches could have been used, but it is not spelled out in the paper if they were. Thus it is possible that the farmers who used KCC were also those who already had better access to inputs and information and were able to utilize KCC, and that the farmers who did not have KCC were systematically different from the KCC users. Consequently, the improvement in agricultural productivity across the two groups cannot be attributed to KCC. Other than the NABARD paper, to the best of our knowledge, there are no other papers that have evaluated the impact of KCC on farmers' income and yield.

Another intended outcome of KCC is reduction in the cost of credit, because the loan is approved for three years, alleviating the need for getting approval every year. In the NABARD sample, farmers noted the reduction in the cost of credit as the primary benefit of KCC. The study also notes that evidence on the actual cost-effectiveness of KCC is not so clear. The study estimates the real cost of credit, taking into account the card fee, the stamp duty, and other costs (NABARD, 2010). It concludes that there has been a 12-14% decrease in the cost of short-term credit from formal sources after farmers were given KCCs. However, the NABARD study concludes that costs can be reduced further, and points to the high stamp duty on large loans as a factor that can inhibit the use of KCC. Sajane et al. (2010), who base their analysis on data from Karnataka and Maharashtra, make a comparison between costs across KCC farmers and farmers who do not have KCC and find that the total cost of credit for KCC farmers is approximately 5% of the amount borrowed as compared to 11% for non-KCC farmers.

The study finds that KCC made a significant impact on the availability of short-term credit from formal sources. The amount borrowed by KCC holders increased by 70% after receiving the KCC card. There was a corresponding drop in borrowing from informal sources by all categories of KCC holders, including tenants. There was also a significant drop in the number of farmers borrowing exclusively from informal sources.

Other reasons why KCC may not be adopted widely include because:

- farmers may face limitations in accessing cash because some cooperative banks may limit cash disbursements to branches only;
- some banks may not implement the scheme through all branches, which increases the travel cost and time to farmers;
- some banks have high, fixed lower limits on the loan amount for KCC that excludes small and marginal farmers;
- some banks have limits on the frequency and number of withdrawals or may not allow withdrawal after repayment;
- in order to reduce their default rates, farmers with small landholdings may be excluded by some banks; and
- where default rates are high, banks may not participate in the scheme.

Other interesting findings of the NABARD study that are relevant to assessing the effectiveness of the programs are as follows.

> The majority of the KCC holders were not using the revolving cash credit feature of the scheme (68% of the sample farmers used it as a one-shot loan). This was because of the lack of awareness that the credit limit can be used in this way. In addition, the participating banks discourage repeat withdrawals and deposits, because it increases their transaction costs. This suggests that one of the innovative features of the program is not being utilized and is potentially not incentive-aligned: the providers of credit do not find it profitable to provide the loans as a revolving cash credit facility. Other reasons for not using the cash credit facility are the transaction costs borne by farmers in conducting multiple transactions, such as transportation costs, lost wages, and wasted time due to the lack of availability of the branch manager. The NABARD study makes a case for using the business correspondent being promoted through financial inclusion schemes to reduce transactions costs.
>
> Forty-eight percent of the farmers interviewed in the NABARD study found the credit limit to be inadequate. This also means that the other stated goals of KCC are not being met: the majority of

the farmers are not able to take consumption loans or loans for non-farm needs. In fact, in many cases the loans do not cover the cost of cultivation.

Other potential improvements in KCC schemes include expanding coverage to land taken under oral lease, or extending credit to joint liability groups so that farmers who do not have land, or own very small plots, can come together as a group to access KCC.

In addition, the assessment finds several issues with the implementation of the KCC program; these include:

The documentation process for KCC is burdensome, particularly for loans above Rs, 50,000, and severely limits the utilization of KCC (these large loans are also levied a stamp duty that increases the cost and impedes uptake). Furthermore, the process takes a fair number of visits and about a month to complete.

The management information systems (MIS) that track performance have several shortcomings. In several instances more than one family member has been issued a KCC on the basis of the same operational holding, the same person has been issued multiple KCCs by various banks, lapsed KCCs were counted as valid ones in the MIS, and finally in some cases KCCs that were renewed after their three-year expiry period were showing up as new KCCs. This suggests that the information on KCCs issues has a lot of measurement error.

5.1.9 SCALABILITY

KCC is already being implemented at scale in India. In other countries, programs similar to KCC are scalable in areas where there is an existing scheme for providing subsidized agricultural credit. In such a case, KCC will require an initial investment in developing and implementing the scheme, and buy-in by the government. If there are no existing schemes for providing agricultural credit in an area, then it will be difficult to scale up.

5.1.10 TRANSFERABILITY

Conditions for success. This BP requires a reasonably well functioning rural banking infrastructure, political willingness for providing subsidized credit and public resources to invest in developing this scheme. Other aspects of the program that would be essential to its success include:

- An apex credit institution(s) for refinance and monitoring of the program;
- A technical committee to determine the loan amounts by crop and land ownership size;
- Basic literacy by farmers;
- An information mechanism to relay the details of the program so that its benefits are fully realized;
- Well- functioning input and output markets for the credit to result in high returns to the farmer;
- A subsidy on rural credit (as implemented in India);
- Good land records and titling; and
- The ability to support bank pass books or electronic cards.

Mechanisms of transfer. NABARD is the primary implementing agency; it has also conducted studies on the scheme.

5.1.11 RELEVANCE

Access to credit is recognized as one of the important constraints to accessing inputs and to making capital investments for agricultural production. In terms of the constraint it addresses, this BP is relevant to FARMS. However, the BP relies heavily on subsidized credit and government-run agricultural credit banks, and can be operated only through existing banks.

5.1.12 SUSTAINABILITY

The sustainability of KCC as it is designed currently rests heavily on political will and on the subsidies provided by the GOI. Its long-term sustainability will rest on reducing the cost by optimizing the implementation of the program and reducing the high transaction costs associated with it. Cost savings by better implementation can effectively reduce the cost of borrowing to the farmers and increase the uptake of KCC. Ultimately, sustainability will also depend on the performance of the agricultural sector: a better performing agricultural sector will mean better returns on the loans and the financial viability of KCC.

5.1.13 POSSIBLE ACTIVITIES FOR FARMS

There are several areas where FARMS can add value to the ongoing KCC scheme. First, it appears that borrowers are using the KCC as only a one-shot loan, and are not aware of the full benefits of KCC. The government of Gujarat has had some success in delivering this information through k*rishi mahotsavas* (farmer festivals).[21] Nevertheless, the results from the NABARD study suggest that majority of the farmers do not take advantage of this benefit. FARMS could consider using behavior change communications, working jointly with Farmer Technology Transfer Fund efforts and other innovative approaches to increase take-up.

Second, FARMS could consider designing, implementing and evaluating pilots that improve KCC in one of the areas of improvement highlighted by the NABARD study. For example, FARMS could work with business correspondents to implement KCC and assess if this approach increases the number of transactions and take-up of KCC. This could be implemented in coordination with Sub-K of BASIX or other similar organizations that are implementing the business correspondent model. Alternatively, FARMS could work on designing a pilot to increase the borrowing through KCC by joint liability groups. Any of these activities would require significant interaction and consultation with implementing entities and individuals who have been engaged in research on KCC. Finally, given the lack of defensible evidence on the impact of KCC, FARMS could conduct a rigorous evaluation of the impact of KCC on farm incomes. The GOI is planning to replace paper passbooks with smartcards to administer KCC. One possibility might be to assess the impact of implementing KCC as a smartcard before it is scaled up nationwide.

[21] In person meeting between Tulika Narayan and U.M. Vaishnav at the Gram Vikas Nigam, Gandhinagar, Gujarat, February, 2011.

5.2 RURAL BUSINESS HUBS

5.2.1 SUMMARY

Rural business hubs (RBHs) are a "one-stop shop" for farmers that provide key farm inputs and services, and in some cases output buy-back, credit services, and other retail products. In India, there are several rural business hub models run by different companies (Gulati and Ganguly, 2008) These rural hubs are similar in the core products and services provided to the farmers (inputs, technical services), with variations in the breadth of products and services provided, and in the states covered (Narang and Singh, 2008). There have been no studies that have examined the effectiveness of RBHs in impacting farm income. Recently IFPRI conducted a study on RBHs focused on understanding the key input and output markets that farmers access. Given the lack of clear evidence on the efficacy of RBHs, FARMS can add value to this ongoing intervention by generating better evidence on RBH. FARMS can work with IFPRI and assess the possibility of using the survey data it gathered for the PIKA study, and possibly commission some follow-up surveys to answer questions about efficacy. The financial viability of RBHs is a key constraint, possibly because of RBHs' lack of knowledge about each local area to inform the choice of products and services to offer. In this context, FARMS can also consider a pilot to transfer the management of one *Hariyali Kisan Bazaar* **(**HKB) center to a producer company. This pilot can help test an alternative approach to managing a RBH to improve its financial viability.

5.2.2 DESCRIPTION

A RBH is a "one-stop shop" for farmers that provides key farm inputs and services, and in some cases output buy-back, credit services, and other retail products. In India, there are several rural business hub models. Overall, the rural hubs are similar in the core products and services provided to the farmers (inputs, technical services), with variations in the breadth of products and services provided, and in the states covered. Some models differ in the core focus of their work. For example, Reliance and ITC hubs are based on procuring products through contract farming. Of the rural business hubs, *Hariyali Kisan Bazaar* (which has the largest number of outlets) and ITC e-choupal are the two largest RBH models. These and other RBH models are described in some detail below.

Hariyali Kisan Bazaar. The first HKB was launched in 2002 by DSCL, which is a very old and large conglomerate with gross revenue turnover of about $1 billion per year as of 2009. Its primary business is in the agricultural sector, which comprises 60% of its revenue and is the key driver of its growth. DSCL's products include agricultural outputs (sugar, seeds), and agricultural inputs (urea, DAP) that have very good brand recognition in rural areas; the Shriram brand is an example. DSCL has a large network of retail outlets throughout India – 10,000 as of 2009 – that it leveraged to create *Hariyali Kisan Bazaar*. By 2010, HKB had 300 outlets in two formats: centers (85) and stores (215).

HKB offers five key services to farmers, as follows.

1. Complete range of quality inputs (seed, fertilizer, pesticides, irrigation equipment, farm implements); HKB considers its wide range of products as a key differentiator.
2. Technical guidance. HKB is the sole delivery partner for CSISA (as of 2009) and it considers agricultural services (customized advice, farm visits, field demonstration, seminars) as the foundation of its model.[22]
3. Crop finance.

[22] Uppal, Arjun, Presentation at Workshop on Agri-Services for Inclusive Rural Growth, Tuesday June 28, 2011, IFPRI and USAID.

4. Output linkages (output buy-back, including milk and seed; output finance; output warehousing).
5. Among the innovative products, the larger HKBs offer fuel, mobile handsets (Motorola), and health care services. HKB has tied up with ICICI Lombard to also offer various insurance products, including life and health insurance. HKB keep a customer database that tracks purchases. Financial services are not as successful; the private sector has not found them profitable.[23]

As the organized retail sector grows in India—India's rural retail market is expected to grow by 29 percent to Rs. 1.8 trillion by 2010[24]—HKB sees its niche as the interface between retailers and smallholders. Although some companies like Reliance and ITC are entering into direct contract farming, HKB anticipates that it will be impossible for these companies to create a nationwide network, and HKB proposes to fill this gap. HKB differentiates itself in the choice of products it offers, which include buy-back of seed and milk, and vocational training.

ITC led *e-Chaupal* (established in 2000) and *Chaupal Saagar* (CS) (established in 2004). E-Chaupal's key feature is its output buy-back. It is a procurement-led initiative that provides similar services as HKB and in addition provides a multi-category "hypermarket" or, in other words, a virtual market. In this market sales and purchases of goods are completed over the internet with the help of a *sanchalak,* or administrator. ITC CS has a hub-and-spoke model, with CS as hub and e-chaupals as spokes. The spoke locations are within "tractor-distance" from the hubs, providing good accessibility to its customers. ITC provides information on prices and extension for free.

Reliance (Rural Business Hubs). These hubs are designed for procuring vegetables and fruits for Reliance Fresh markets. The hubs are focused on the handling, storage and processing of these products, and in addition provide inputs and other services to farmers.

Godrej Aadhar (established in 2003). This RBH was *d*esigned as a multi-category retail outlet with a broad range of services and products, including the good and services provided at HKB. In addition, it also provides soil and water testing, and weather and price data. (HKB may also provide these now.)

Tata Kisan Kendras/Sansar (established in *1998).* This RBH has a hub-and-spoke model, where each hub is a resource center for several outlets that serve the villages. The services and products offered are similar to HKB. As of 2008 these centers were being expanded to provide fuel, mobile services, lifestyle products and solar-powered products. It was rechristened as *Tata Kisan Sansar in 2004.*

Public-Private-Panchayat Partnership (PPPP) Initiatives by CII and the Ministry of Panchayati Raj (established in 2004). PPPPs have a very broad mandate of building linkages between industry and villages through the village panchayats so that there are better markets for resources and skills available at the village level. The concept is roughly modeled around Thailand's One Tambon (District), One Product. These initiatives are overseen by the Rural Business Hubs Council, which is jointly chaired by the Ministry of Panchayati Raj and CII representatives.

Triveni Khushali Bazaar (established in 2005*).* This EBH has a similar model to HKB. Some reports suggest that Triveni was looking to sell the rural hub business and focus on its core activities. Some earlier reports also suggest a Reliance and Triveni tie-up.

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[23]. Uppal, Arjun, Presentation at Workshop on Agri-Services for Inclusive Rural Growth, Tuesday June 28, 2011, IFPRI and USAID.
[24] Ibid.

Indian Oil Corporation Ltd. ***Kisan Seva Kendra*** (KSK, established in 2006). Similar to HKB, KSKs sell pesticides, vegetables, banking products and other fast-moving consumer goods (FMCGs). Indian Oil has tied up with Indo-Gulf for fertilizers and National Seeds Corporation for marketing seeds and agricultural inputs; it also has alliances with NABARD, the Oriental Bank of Commerce and the Bank of Baroda for banking products. Some KSKs have installed internet kiosks or communication facilities. Business alliances have been signed to market products from Dabur, Airtel, Tata Chemicals, Godavari Fertilisers, Gokulam Fertilisers, Hindustan Unilever and Godrej Agrovet. Other alliance partners are Emami for personal care products, Money Gram for money transfer, MILMA and OMFED for milk products, and Supplyco for convenience stores.

5.2.3 INNOVATIVE FEATURE

RBHs leverage the private sector incentive to access rural markets for the sale of their products and to improve the quality of products sourced from the farmer by bringing together various public sector resources for the farmers (e.g., extension services, subsidized credit and insurance products).

5.2.4 TECHNICAL AREA

The primary contribution of RBH is to IR 3 - Farmers Linked to Markets and Expanded Trade and Investment. These hubs are also a source of extension services and information.

5.2.5 CONSTRAINTS ADDRESSED

RBHs address the constraints of access to input and output markets, information, credit, and technology.

5.2.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

Applicable geographies are those where there is an adequate concentration of farmers for business hubs to be financially viable.

5.2.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- Hariyali Kisan Bazaar (contact: Arjun Uppal, CEO New Initiatives)
- ITC Chaupal Saagar (contact: S. Sivakumar)
- Reliance Rural Business Hubs
- *Godrej Aadhar*
- Tata *Kisan Kendras*/*Sansar*
- Public Private Panchayat Partnership (PPPP) Initiatives by CII and Ministry of Panchayati Raj
- *Triveni Khushali Bazaar*
- Indian Oil Corporation Ltd. *Kisan Seva Kendra*

Researchers:

- Thomas Reardon, Michigan State University, research lead for the PIKA study on rural business hubs
- Sunipa Dasgupta, IFPRI, who is one of the primary researchers on the PIKA study, and Bart Minten
- Meeta Punjabi, independent consultant who conducted the qualitative research on the PIKA study
- Dr. Ashok Gulati, who has been the author of several papers on rural business hubs, and lead for the PIKA study

- Srinivasalu Rajendran, Jawaharlal Nehru University

5.2.8 EFFECTIVENESS

The effectiveness of RBHs can be measured as the impact they have on the net returns to farming by providing access to input and output markets, bridging the knowledge gap in prevailing input and output prices, and providing access to extension services. There have not been any systematic studies that have evaluated the effectiveness of the rural hub centers in improving farm productivity or the incomes of smallholder farmers through better access to input and output markets. There is anecdotal evidence given by HKB managers (several farmer-specific success stories) that illustrate the impact HKB had on farmer incomes. IFPRI recently completed a study on HKB in Uttar Pradesh and ITC's CS in Madhya Pradesh under USAID India's PIKA program that has some information to assess HKB. The focus of the study was something else: to assess farmer's access to input and output markets in the catchment areas of these RBHs. IFPRI conducted two surveys, one on farmers in the catchment area of each of the two rural business hubs in Madhya Pradesh and Uttar Pradesh, and another on input retailers (RBHs, state and traditional input retailers) in the catchment area of HKB to compare the services and products provided.

The first survey collected information from two types of farmers in the RBH catchment area: farmers that chose not to use the RBH and farmers that used the RBH. A simple comparison of outcomes (farmer incomes or yields) across those two groups does not provide evidence of effectiveness, because the choice to use a rural hub center is likely to be based on the same factors that determine the outcomes. However, the IFPRI study was not designed to assess the impact of RBH on smallholder farm incomes and did not collect information on farmer incomes and yields. Instead, it focuses on the use of extension services, fertilizer, farm chemicals and seed by farmers in RBH command areas, both in Uttar Pradesh and Madhya Pradesh. In the case of fertilizer, farm chemicals and seed purchases, it assesses the extent to which farmers rely on RBH relative to other providers, the factors that determine farmers' decisions to use RBHs, and the extent to which poor farmers are able to access RBHs.[25]

The survey finds that in the catchment area of HKB in Uttar Pradesh, 17 percent of the farmers purchased fertilizer, 25 percent purchased seed, and 26 percent purchased farm chemicals from HKB. The majority bought the fertilizer (59 percent), seed (53 percent) and farm chemicals (61 percent) from small private retailers. In Madhya Pradesh, only 7 percent of the farmers purchased fertilizers from *Chaupal*, and the majority (54 percent) relied on government-run primary agriculture centers.

The study also finds that farmers in the HKB catchment area continue to face major constraints in the timely availability of fertilizer (49 percent of farmers) but do not face significant constraints in the purchase of seed or farm chemicals. In contrast, in the Madhya Pradesh catchment area only 15 percent of farmers reported timely availability of fertilizer as a key constraint (there is no information on availability of seed and farm chemicals in Madhya Pradesh). Another constraint was the price of fertilizer. Twenty six percent of farmers in the HKB catchment area noted price to be a major constraint in using HKB, while in the *Chaupal* catchment area of Madhya Pradesh, only 10 percent of farmers considered the price of fertilizer to be a major constraint in using *Chaupal*. The data from both Uttar Pradesh and Madhya Pradesh, on the other hand, suggest that quality is not a major constraint in purchasing fertilizer in the RBH catchment areas.

These results from the study cannot be used to compare *Chaupal* and HKB, because the data are from two different states that are different in their overall governance and other indicators of development.

[25] Farm chemicals and seed purchases were assessed only for HKB.

Neither can they be used to evaluate the effectiveness of RBHs in removing bottlenecks to the timely availability of fertilizer, or their impact on input prices paid by farmers, because we do not know the extent to which farmers would have faced these bottlenecks without RBHs, or the extent of these bottlenecks before RBHs were introduced in the area.

The farmer study collected information on the main reason cited by non-users of HKB and *Chaupal* for not using these RBHs for any of their needs, which can give us some indication of the demand for RBHs or the constraints faced in accessing them. The data suggest that the main constraints in using HKB were that the price was too high, or that HKB did not provide the inputs on credit. This provides some evidence that credit-constrained farmers are not able to access HKB. Farmers in the catchment area of *Chaupals* in Madhya Pradesh, on the other hand, did not transact with *Chaupals* because they did not know about them.

The survey of input retailers assesses the diversity, quality and prices of products and services sold by input retailers. It includes an assessment of the clientele using self-reported data. It finds that small and marginal farmers comprise one-third of the RBH's clientele, while small and marginal farmers comprise half to two-thirds of the clientele of state and other traditional stores. The RBHs are not designed to cater only to the marginal and small farmers, and this result suggests that their clientele is not exclusively medium-sized and large famers. The results of the farmer survey also suggest that the poor farmers—farmers with BPL card and farmers of scheduled caste/tribe—also transact with RBHs.

In summary, the IFPRI study does not provide evidence of the effectiveness of RBHs in addressing constraints for smallholder farmers, or in improving their incomes. The study results indicate that RBHs are used by small and marginal farmers, but that they do not cater to the needs of the credit-constrained farmers; in Uttar Pradesh, a large number of non-users cite prices as a key impediment in transacting with a RBH. Among the farmers that are able to access HKB, the impact may come from the extension services that are provided along with inputs. However, the IFPRI study did not measure farmer incomes or yields to measure this impact.

In addition to assessing the impact of RBHs, an important factor in assessing RBHs is to determine their financial viability. In addition to assessing the impact of RBHs, an important factor in assessing RBH is to determine their financial viability. A 2008 review of *Hariyali Kisan Bazaar* notes that fast-moving consumer goods, which were added to the hubs to attract consumers for agriculture-related products, comprised the bulk of HKB sales. This suggests that without FMCG HKBs would not be financially viable. In fact, an HKB executive noted that despite the introduction of FMCG, as of 2011 none of its rural hubs are financially viable. The executive also noted that ITC has not expanded since the last four years, and many companies have stopped their RBH operations. An HKB executive noted that as of 2011 none of the RBHs are financially viable: HKB is not currently financially viable because of its high initial investment cost, ITC has not expanded since the last four years, and many RBHs have stopped operations.

RBHs are implemented as profit-making initiatives, with no investment of social capital. Therefore, cost-effectiveness is not a concern for this best practice.

5.2.9 SCALABILITY

As implemented in India, the best practice is market-led and incentive-aligned. The best practice can be tailored to meet the needs of a specific geography based on an initial analysis of the area that considers several factors (progressiveness of farmers, infrastructure, land holdings, market accessibility, and availability of finance). The two biggest constraints on scalability are that 1) it requires an adequate density of farmers and rural demand to make the RBHs viable, and 2) it requires private sector entities

with "deep pockets" that can make a large initial investment in a venture that may take several years to be sustainable, if at all.

5.2.10 TRANSFERABILITY

Conditions for success. Successful start-up of rural business hubs requires large private sector companies that have a commercial interest in the rural markets either as a seller of inputs, as a buyer of output, or as a seller of other products. The company would ideally be well diversified and have "deep pockets," as the rural hub centers require high initial investment, and have a long gestation period before they are profitable because of high operating costs, low margins on inputs, high labor costs, and the low purchasing power of the clientele.

To be commercially viable, a typical RBH would require a critical minimum rural farmer base within its area of geographical reach. Since the demand for agricultural products is seasonal, for the hubs to be profitable, they may need to carry products that have a demand throughout the year, such as FMCGs. This means that geographical area that it caters to must have adequate purchasing power for FMCGs or other products that are offered.

In addition, the following are additional critical factors for success, some of them proposed by HKB managers.[26]

- Availability of technically qualified manpower will be critical to delivering agriculture-related services. This would also depend on institutional support for training and educating skilled manpower, or else it would require additional public resources to train individuals.
- The rural hub provider should be enterprising enough to run a complex, high-effort business. Rural hubs such as HKB require localization to meet regional variation in taste and consumption patterns, they need to account for the low literacy level of consumers, and they need to obtain government approvals and surmount other institutional impediments.
- The availability of existing technologies that have proven to be effective for the local geographies will be key in delivering extension services to the farmers.
- The potential for visible improvement in farm returns is important, so farmers can be convinced to purchase inputs or adopt technologies promoted by the hub.
- Existing credit and insurance that can be offered to the rural consumers (rural hubs will be best positioned to deliver the schemes of both the private and public sectors)

Mechanisms of transfer. Mechanism to send from India: HKB appears to be a very well developed business model. In India business representatives at HKB have already invested some effort in determining how this model can be transferred to Kenya and Malawi.

Mechanism to receive from India: CNFA has already tried this model in Kenya and Malawi. In addition, HKB managers cite small enterprises such as the "Tisaiwale Variety Shop" that can be expanded to provide a wider variety of products. HKB also proposes a combination of an NGO, an association and a commercial enterprise to implement RBHs.

5.2.11 RELEVANCE

Access to input and output markets and extension services in developing countries is weak, particularly for smallholder farmers. RBH seeks to address this key constraint.

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[26]Chabbhra, Sanjay, Head Retail Operations, Hariyali Kisaan Bazaar –The Experience from India. Presentation at International Fertilizer Industry Association (IFA) Africa Forum, June 2009.

5.2.12 SUSTAINABILITY

RBHs are a private sector initiative and are expected to be sustainable if they result in positive net returns. So far the information suggests that these hubs are not profit-making; if that is true, their long-term sustainability is questionable.

5.2.13 POSSIBLE ACTIVITIES FOR FARMS

Given the lack of clear evidence on the efficacy of RBHs, FARMS can add value to this ongoing intervention in India by generating better evidence. FARMS can work with IFPRI and assess the possibility of using their survey data, and possibly commission some follow-up surveys to answer questions about efficacy.

The financial viability of RBHs is a key constraint, possibly because of RBHs' lack of knowledge about each local area to inform the choice of products and services to offer. In this context, FARMS can also consider a pilot to transfer the management of one *Hariyali Kisan Bazaar* (HKB) center to a producer company. This pilot can help test an alternative approach to managing a RBH to improve its financial viability.

5.3 LINKING SMALLHOLDER FARMERS TO COMMERCIAL VALUE CHAINS

5.3.1 SUMMARY

To increase the food security of the Indian smallholder, there is a need to increase incomes from farm and non-farm activities. Incomes can ostensibly be increased by improving on-farm productivity, but this is not the only factor that can positively affect farmers' incomes. Improving market infrastructure and market operations, and diversification into higher-value products, will also play a significant role. FARMS will work to identify the elements of this best practice that improve market operations and send proper price signals to farmers so that diversification into commercial production is seen as an attractive option.

5.3.2 DESCRIPTION

The average land holding in India is 0.8 ha, and India has one of the highest rural population densities in the world. Three of the FARMS' focus states have an average of over 800 persons/sq. km: Uttar Pradesh, Bihar and West Bengal. India also has one of the highest percentages of arable land under cultivation at nearly 60%, leaving many farmers with little latitude to expand their farm size. The smallholder farmer in India is a subsistence farmer by default, and there is little chance that industry and non-farm labor opportunities will ever make the number of smallholders negligible, as has happened in the West. India is on a different trajectory, so it is imperative that it find solutions to link smallholders into commercial value chains.

Many smallholders are now living below the poverty line; they also suffer from malnutrition and a dwindling natural resource base and are faced with greater uncertainty in productivity due to the effects of climate change. To increase the food security of the Indian smallholder, there is a need to increase incomes from farm and non-farm activities. Many of the solutions for increasing agricultural productivity and farmers' profits are known: i.e., timely access to high-quality inputs and pest control, improving water use efficiency, adoption of pest-, flood-, drought- and/or heat tolerant varieties, the balanced use of fertilizers, integrated pesticide management, production of higher-value products, and integrating value addition into post-harvest operations.

In order to encourage farmers to invest in these productivity and income enhancing strategies, however, markets must provide proper incentives to do so. The issues with India's markets today fall in two general categories, as follows.

1. **Market "Hardware":** Market infrastructure is poor. This includes roads and value-adding mechanisms like packaging, grading, cold chains, storage and processing. The government needs to either invest in these areas (those that, like roads, are public goods) and encourage the private sector to invest in the other areas.
2. **Market "Software":** In order to pay a consistent and fair market price to farmers, processors, exporters and value adders require regularly spaced purchases, appropriate quantity lots, assured quality and market intelligence. India needs better mechanisms to increase the communication and direct linkage between India's smallholders and larger buyers. Mechanisms to reduce transactions costs, more efficient procurement markets, quality standards and electronic exchanges enforcing compulsory delivery can address this need.

FARMS has identified a few nascent initiatives that could lead to improvements in both market hardware and software. FARMS considers these as a set of best practices that have the potential to link smallholders with higher-value markets and improve their income from on-farm activities.

FARMS is capable of documenting and consolidating these initiatives into a set of recommendations and guidelines that will equip and encourage the private sector to work with smallholders. They will also inform public policy, so that the policy environment works in favor of smallholders as its first priority.

Current State. Farmers predominantly sell their produce through *mandis*, Agriculture Produce Marketing Committee (APMC) regulated markets. These markets are self-regulating under the guidelines of individual state agriculture marketing boards empowered by state APMC Acts (Sinha and Kumar, 2010).

Ninety percent of Indian farmers' sales go through APMC markets. Some eight to twenty percent of a farmer's income is spent on market intermediaries' commissions, interest, transportation, warehousing charges and the like. Due to outdated infrastructure, there are also losses incurred due to wastage and pest attack during transportation, storage and handling. There are systemic inefficiencies at *mandis* and a dominance of commission agents.

To pave the way forward, the GOI has made policies meant to encourage the private sector to progressively take on more of the infrastructure development and of the management of markets for grain, fresh fruits and vegetables.

The GOI is encouraging modernization and private sector investment in market infrastructure, including warehousing for grain, cold chains and wet markets. Electronic spot exchanges such as NSPOT have been in operation since 2006. NSPOT exchanges and collection centers are providing an alternative to the *mandis*. Farmer participation and response has been encouraging.[27]

The Future for Grain. To further modernize trade, state governments will need to work harder to create a policy environment that allows and/or encourages the development of futures markets, standardized warehouse receipts, quality certification, and migration to an electronic platform. In doing so, they would create greater efficiency and transparency in transactions and thus, reduce the cost of transacting in these markets and reduce the dominance of certain market participants that exist today.

The Warehousing Development and Regulation Act of 2007 set the stage for collateral management to become more effective in improving risk management by warehouse receipt holders. The pledging/collaterization of agricultural produce with a legal backing in the form of negotiable warehouse receipts will lead to an increase in the flow of credit to rural areas, reduce the cost of credit and spur related activities like standardization/grading, packaging, insurance and the development of chain-of-quality warehouses (Chaturvedi, 2007). There are shortcomings to the Act, insofar as the liabilities on a warehouse operator and the duties prescribed appear to be onerous and the receipts are not standardized and transferable across state boundaries.

Already NSPOT is an electronic trading platform that is demonstrating the efficiencies and transparencies that are possible in modern markets, but they also feel that the final step is to allow warehouse receipts to be tradable and transferable across state lines. NSPOT has shown too, how electronic spot market exchanges can easily integrate with commodity markets and that there is potential to find a role within these modern markets for all or most of the current participants, thus reducing some of the perceived threat to modernization they feel. For example, *Pakka adityas*,

[27] Testimonials and illustrations of farmer experiences by IFMR Ventures (http://www.ifmrtrust.co.in/ventures/ifmrventures.php)at collection centers linked to the National Spot Exchange Ltd (NSEL) an electronic, demutualized commodity spot market. The Exchange is promoted by Financial Technologies (India) Ltd (FTIL) and National Agricultural Cooperative Marketing Federation of India Limited (NAFED).

permanent commission agents, of APMCs could become members of spot exchanges, and *Kachha adityas*, temporary commission agents, could become promotion agents of the exchange, operate information kiosks, interface with NGOs, *krishi vigyan kendras* and self-help groups, and function as aggregators.

> **The Future for Fresh Fruits and Vegetables.** The GOI has published guidelines for the development of terminal market complexes (TMC), but state governments must adopt these after amending their respective APMC Acts and inviting expressions of interest to improve markets. The TMC legislation provides a subsidy to a private entrepreneur for capital investment in a modern terminal market facility and its linked collection centers. The legislation also encourages producer companies and farmers' associations to take an equity stake in these markets and potentially manage the collection centers. At least three states, Tamil Nadu, Delhi and Maharashtra, have issued bid documents for TMCs(Tamil Nadu State Agricultural Marketing Board, 2009) Both the Tamil Nadu and Delhi bids have been accepted, and work is underway to build these TMCs.

The TMCs are meant to greatly improve market infrastructure, market operations and price transparency over the traditional wet market *mandis*, but they must re-locate trading activity from the existing *mandis* in order to be successful. Infrastructure alone will not address the development of the ecosystem supporting APMCs that includes traders, commission agents, loaders, transporters, warehousing companies and the like. While traders and commission agents do not have the resources to develop APMC infrastructure, efforts to develop new infrastructure do not involve existing market participants.

Aggregators are the critical "software" link for integrating smallholders into these markets. They are involved in: creating awareness among farmers in village clusters; signing agreements: bundling lots; conducting pre-inspections; operating collection centers; supplying packaging material; weighing, loading and unloading freight; depositing goods at accredited warehouses; and crediting farmers for their produce. It is at this level that smallholders may be able to increase their vertical integration into the value chain by learning to perform some of these functions as a producer company or association. Producer Companies, Krishi Vigyan Kendras (KVK) and Self Help Groups (SHG) can function as aggregators. Where farmers cannot perform these functions, there is a great opportunity for aggregators to develop a good business model around performing these functions. Encouraging greater competition at this level by training unemployed youth to work in this domain will develop competition, leading to better price discovery and realization for farmers.

Certain wholesalers, processors and exporters are looking to link with aggregators and with groups of smallholders who have been able to integrate some of these operations as a means to get higher-quality product and to reduce the transactions costs and losses that are incurred by going through the government *mandis*.

The FARMS team has already identified a few successful examples of smallholder integration in India and would like to build upon this list to distill a set of best practices that has led to successful smallholder integration into commercial supply chains. The currently known examples are the following.

Mela Ram Jaggi & Sons (MRJ) wholesale food brokers in Delhi. The MRJ Company works with a network of over 300 smallholders as their clients and suppliers. They have been in this family business for over 165 years and insist on maintaining their intimate ties with the smallholder farm families that have been a part of their business throughout this time. The MRJ Company, however, is now making an investment in a large Terminal Market Complex (TMC) in Delhi. Its goal is to provide for-fee services to farmers for the sorting, grading, packaging, storing and marketing of their produce. Its $10 million investment on processing lines, controlled atmosphere cold storage and sub-zero storage will provide an opportunity to greatly expand services to more farmers and provide the opportunity to add value to a large volume of the existing fresh fruits and vegetables that enter the Delhi market. Furthermore, this company is poised to link its network of smallholders directly to organized retail as it grows in Delhi and throughout India. The FARMS team feels that this is a unique opportunity to examine their operations as a case study to learn how to combine this significant capital investment with a unique philosophy of working with smallholder farmers as primary suppliers/clients to establish a platform for more inclusive growth in Indian agriculture.

FieldFresh in Punjab. Field Fresh is working with smallholders to supply fresh vegetables for its processing and export enterprises. FieldFresh has invested considerable resources in the state of Punjab, where it has growing operations via contract farming. FieldFresh Agri Center of Excellence, an integrated research and development facility spread across 300 acres, focuses on crop and varietal trials, progressive farming techniques, identification and adoption of appropriate technologies. The center serves as a hub to disseminate knowledge to partner farmers. The ongoing knowledge and best practice sharing has benefited farmers not only by increasing their yield per acre through optimum utilization of resources, but also by increasing the number of crop cycles on the land considerably.[28]

PepsiCo in Pune. PepsiCo contracts up to 1,200 outgrowers/contract farmers (CFs) in order to procure more than 10,000 MT of potatoes for its Lay's potato chip factory. It does this to ensure the quality and quantity of potato supply needed each year.

PepsiCo provides training and other incentives to farmers to recruit and keep them as faithful suppliers. The following are some of the aspects of their program, which does more than just acquire produce at a good price;

- Providing good quality seed;
- Providing training and technical advice to improve yield;
- Gathering soil samples and sending them to chemical companies for analysis;
- Organizing bulk purchase of fertilizers for farmers;
- Linking farmers to bank loans with reduced interest rates;
- Arranging appropriate chemical kits from reputable companies;
- Orchestrating crop insurance for CFs;
- Paying a fixed buy-back rate so farmers can easily calculate projected income for the season; and
- Providing farmers with a reliable, steady market.

5.3.3 INNOVATIVE FEATURE

Linking smallholders to markets can be and has been done in various ways, many of them idiosyncratic to the situation. In this work, we will attempt to distill the elements that make these instances successful

[28] http://www.fieldfreshfoods.in/Fresh%20Baby%20Corn.html. On 27 July 2011.

and share them with other private sector players, donors and development agencies that also seek to improve the integration of smallholders into commercial agribusiness value chains.

5.3.4 TECHNICAL AREA

Linking smallholders to markets falls under the primary technical area of making market linkages (IR 3).

5.3.5 CONSTRAINTS ADDRESSED

This BP will address farmers' limited access to markets.

5.3.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

This BP can be applied anywhere, but is best adapted to areas with good market and road infrastructure already in place.

5.3.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Organizations:

- Many of the agricultural universities have recently established agribusiness management departments and degrees, and they are a source of "boots on the ground" should we conduct case studies on a country-wide basis.
- The National Horticulture Mission and the National Horticulture Board are two entities that have an interest in promoting these types of linkages and their subsidy program for terminal market centers. The Ministry of Food Processing Industries is offering subsidies and other incentives for the establishment of processing centers closer to the production zones in rural India.
- NCMSL provides end-to-end commodity and risk management services across the country. NCDEX and MCX are commodity exchanges that potentially would be interested to reach out to smallholders with services.
- MART is a consulting firm with considerable experience in this domain. ASI is also working in Lucknow, specifically on creating links between farmers and commercial markets.
- Field Fresh, Pepsi, ITC and Reliance are private firms that made an express effort to link to smallholders.
- The National Multi–Commodity Exchange of India Ltd. (NMCE) is an existing commodity and futures exchange.
- IFMR has also worked with NCDEX to develop a model trading floor and plans to establish a repository of trade data.

5.3.8 EFFECTIVENESS

NCDEX[29] has created the NCDEX Spot Exchange (NSPOT), which is one successful example of an electronic commodity exchange in India. NSPOT is an institutional, demutualized, real time, online, transparent electronic spot market with compulsory delivery, counterparty guarantees and services including pledge finance and quality certification.

[29] National Commodity and Derivatives Exchange Limited (NCDEX), a company with about eighty percent market share in the agricultural commodities derivatives markets, is promoted by Canara Bank, Punjab National Bank, Life Insurance Corporation of India (LIC), National Bank for Agriculture and Rural Development (NABARD), Indian Farmers Fertilizer Cooperative Limited (IFFCO), Credit Rating and Information Services of India Ltd.(CRISIL), National Stock Exchange (NSE), Goldman Sachs and the Intercontinental Exchange (ICE)

Spot trading on NSPOT is possible for multiple commodities at specific delivery centers. Procurement and sale of commodities are handled through an online trading platform. Associated services provided include grading, quality certification and standardization of commodities, collateral finance and loans against warehousing receipts, storage, transportation, logistics, handling, and shipment.

Farmers are able to obtain quality certificates and realize the best possible spot price, transparently, for their produce and access market intelligence reports. They are able to avail of trade and payment guarantees. There are also reduced handling, storage and warehouse charges.

The spot exchange makes available transparent spot prices to futures exchanges for due date rate calculations. It allows for compulsory delivery contracts.

NSPOT was created in 2006 and has been steadily increasing the number of markets and its volume of trading in each subsequent season. NSPOT is involved in various collaborations. An illustrative list is in Table 3 below.

TABLE 3: PARTNERS AND ACTIVITIES OF NSPOT

Organization	Nature of Association
Haryana State Cooperative Supply and Marketing Federation Limited (HAFED), Haryana	HAFED-NSPOT electronic market development
Maharashtra State Warehousing Corporation, Maharashtra State Agriculture Marketing Board	Electronic markets to farmers in 40 locations
Food Corporation of India, Delhi	Electronic auction service provider under OMSS scheme. Electronic trading of coarse grain and wheat.
PEC, Delhi	Electronic trading of imported pulses
Karnataka Government	Electronic spot markets to help tur (pigeon pea) growers in Gulbarga, Karnataka
State Trading Corporation of India, Minerals and Metals Trading Corporation of India, National Agricultural Cooperative Marketing Federation of India	Electronic trading of commodities

5.3.9 SCALABILITY

NSPOT claims that it is cost-effective for it to establish a market center if it can have access to a warehouse and there is at least 1,000 MT of product exchanged annually through its market.

NSPOT has modernized 10 pilot *mandi*s, and plans to be involved in the modernization of more than 7,500 *mandis*. There is the potential to scale this on a national level.

There are also many programs, such as the support to mega food parks, subsidies for TMC creation, subsidies for the investment into cold chain infrastructure and the Asian Development Bank's program in Jharkhand and Bihar to improve post-harvest infrastructure that can be brought to bear on the hardware and software issues facing Indian markets. Most of these are national or multi-state programs; thus the potential for scalability of linking smallholders to commercial value chains through these particular channels is high.

5.3.10 TRANSFERABILITY

Indian markets and the government's role in these markets are quite different from the African situation. Many of the improvements needed in India may not be applicable to the African context. The common thread is the need to link smallholders into commercial markets. In fact, the potential for African farmers to produce at a commercial scale is greater than for Indian farmers who lack access to land.

Africa's constraints lies primarily in market infrastructure and thin market volumes. The East Africa Grain Council, which is based in Kenya, has made great strides in developing improved warehousing and a warehousing receipts facility for East Africa's grain (mostly maize) producers.

To determine transferability, a needs assessment has to be carried out in each of the focus countries in Africa, taking into consideration existing institutions and laws and the situation on the ground. Lessons learned and technical assistance can be extended to Africa by each institute involved in linkages in India individually and assisted by FARMS.

5.3.11 RELEVANCE

Promoting smallholder farmer market access is a core focus of FARMS.

5.3.12 SUSTAINABILITY

Efforts to provide more incentives—subsidies on capital investment, streamlined regulations, and industrial parks—for the private sector to invest in and manage market infrastructure and to create more transparency in market operations will lead to a sustainable, private sector-led market system. Such a system will encourage more participation, greater efficiencies, fewer opportunities for corruption, and less physical wastage.

5.3.13 POSSIBLE ACTIVITIES FOR FARMS

In the examples referring to FieldFresh, PepsiCo and Mela Ram Jaggi, we see that the private sector must be much more interactive with, and in many cases supportive of, its suppliers in order to be successful in linking smallholders to markets. The FARMS team has preliminarily concluded that these examples will have some common denominators that will provide valuable insights into how smallholder farmers can be more broadly integrated into commercial supply chains. The FARMS team is also tangentially aware of other examples of smallholder integration that came primarily from the impetus of the smallholders themselves, such as the producer companies of grapes and mangoes in Maharashtra and the certified seed multiplying producer companies in Madhya Pradesh. These examples could also provide valuable insights into how smallholders organize themselves and what preconditions must exist for this to happen.

FARMS may also integrate some of the following activities into future work plans once the team has had more time to understand the issues and possible ways forward.

- Supporting NSPOT and the modernization of *mandis* by establishing institutions that build the capacity of local stakeholders to create and adhere to quality standards and regulations.
- Developing scientific methods of storage and an efficient warehouse receipt system to reduce transactions costs in the supply chain and provide greater confidence to financial institutions to extend financing.
- Bringing together partners for improving warehousing and road infrastructure.

- Providing technical assistance to enable private sector entrepreneurs, farmer associations and producer companies to take equity stakes in terminal market complex bids, as is mandated in the GOI legislation.

5.4 COOLBOT AND OTHER LOW-COST POST-HARVEST HANDLING METHODS

5.4.1 SUMMARY

Reducing post-harvest losses is a great, and often overlooked, opportunity to increase the food supply. Most post-harvest technologies are capital-intensive, but India is on the forefront of the development of low-cost post-harvest handling methodologies, which include the CoolBot cold storages, insulated trucks for 'cool transport' and other no-cost methods for handling product that will enter the cold chain, such as simple shade structures used to cool freshly picked harvests. FARMS would like to work to develop these solutions that are affordable and accessible to the smallholder farmer, but understands that these technologies cannot be introduced in isolation, but must be integrated into value chains that offer a premium for properly handled product. If FARMS sees an opportunity to develop value chains and integrate the use of the currently available technologies, it will establish a pilot activity along those lines.

5.4.2 DESCRIPTION

Post-harvest losses in developing countries are very high and are said to account for over 20 million MT of food losses in Africa and 40 million MT of losses in South Asia (Kitinoja et al., 2011). Deploying a set of improved, cost-effective post-harvest handling methods is thought to be able to reduce those losses by two-thirds and to save over $12 billion annually.

Reducing post-harvest losses in developing countries has always been met with one primary hurdle, which is the initial investment required to invest in any new technology. Cold storage is one of the most commonly thought of examples of improved post-harvest handling. The typical investment cost, however, for a cold a storage facility can be $2,000-$5,500 per cubic meter of storage space (approximately 700-800 kg of product), depending on the types of materials used and the country in which it is installed. Even at this price the system, if properly managed, can provide a good return on investment. However, lack of investment capital, lack of steady, year-round markets, and lack of knowledge about this technology mean that there is very little investment in cold storage in developing countries.

There are, however, lower-cost technologies and methods of improved post-harvest handling that are accessible to smallholder farmers, both financially and technologically. FARMS may be well positioned to promote a small suite of these technologies. That could put smallholders on the path to reducing losses and understanding the physiological processes behind post-harvest handling, which could in turn lead to an even greater reduction in losses through further investment.

The following are a proposed suite of post-harvest handling technologies and methodologies that are thought to be adapted to the smallholder commercial farmer.

1. **Use of improved containers.** Farmers and traders in developing countries tend to use locally-made, low-cost containers for the transport of product from farm to market. These low-cost materials are not regular in shape and hold too large a volume of product, leading to crushing. They are not stackable or nestable, and often have sharp edges that damage fresh fruits and vegetables.
2. **Use of shade.** Placing freshly harvested product immediately in shaded structures at the side of fields or at the farm gate can significantly improve the storage life of product.
3. **Field Curing of Tuber Crops.** When tubers are going to be stored for a long period of time, long-term losses are reduced and quality is maintained if the tubers are first field cured. Field

curing calls for placing the tubers in a hot and humid environment just after harvest for 24-36 hours, depending on the tuber, where injuries to the skin can heal though the production of a layer of cells over cuts incurred during harvest.

4. **Low-cost cold storage.** The CoolBot is a technology that uses a standard window-unit air conditioner to create a cold chamber with the aid of a CoolBot controller device. The CoolBot is a controller attached to a standard window-unit air conditioner that overrides the temperature control, allowing the room to reach temperatures as low as 7° C. The CoolBot also has a frost sensor that shuts the machine off long enough to defrost the evaporator portion of the unit.
5. **Hermetically sealed bags and cocoons for grain storage.** Grain and beans stored in hermetically sealed bags just after harvest can suffocate insects in their larval and pre-larval stages and greatly reduce the damage they could cause in grain stored under aerated conditions. In one experiment in Benin, hermetically sealing storage containers of beans and soybeans asphyxiated insect larvae that had infested the beans, cutting losses substantially (World Resources Institute, 1998)

   The hermetic seal, coupled with the natural respiration of the stored material reduces the oxygen content to a level that cannot support insect life. Both the *IRRI Superbags* and the *GrainPro* bags and cocoons work on this principle.

   > Super Bags reduce the flow of both oxygen and water between the stored grain or seed and the outside atmosphere. When properly sealed, respiration of grain and insects inside the bag reduce oxygen levels from 21% to 5%. This reduction reduces live insects to less than 1 insect/kg of grain without using insecticides – often within 10 days of sealing (IRRI, 2005).

Each of these technologies and methodologies create additional costs, but can produce a good return on investment under the right scenario.

5.4.3 TECHNICAL AREA

This best practice addresses access to markets and, indirectly, agricultural productivity.

5.4.4 INNOVATIVE FEATURE

These innovations are low-cost and effective, which is just what is needed to encourage more investment in PHH technologies.

5.4.5 CONSTRAINTS ADDRESSED

These best practices address the lack of enough post-harvest technology.

5.4.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

These best practices are broadly applicable in all commercial agricultural situations.

5.4.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

FARMS could work with the NHM, NHB, the Horticulture CRSP, UC Davis, the GCCA and Amity University.

5.4.8 EFFECTIVENESS

Effectiveness. In general it appears that these technologies and techniques are still at the pilot and experimental stage. Under laboratory conditions, all of the proposed technologies are found to decrease losses. Most of these programs, however, have not been able to gain large-scale adoption.

Impact. To farmers, the damage done by improper handling just after harvest is somewhat invisible. They do not perceive the losses that will be incurred further along the value chain due to high heat, bruising and exposure to the sun. Traders only hold onto the product for a day or two, and may also be oblivious to losses provoked or incurred at their level. The damage is already done, however, and the losses will be spread among the other players in the value chain. Getting farmers and traders to invest in these technologies has been an uphill battle, as farmers do not see the potential to increase their revenue. The only solution is to make a linkage to a buyer who is willing to pay more for a product that has been handled properly.

Cost-Effectiveness. One of the hindrances to large-scale adoption of these technologies is cost. Their cost is relatively low, but not zero. All of them should provide a good return on investment (ROI), and do in most scenarios, but this ROI is not immediate. Many smallholders resist or refuse to make the investment due to constraints on cash flow.

These technologies must be made as low-cost as possible, while also demonstrating a quick return on investment so that the smallholder is less hesitant to invest. When the technologies have a clear benefit, but their initial cost is substantial, e.g., the CoolBot, one might need to accompany their introduction with an appropriate credit mechanism or an alternative means of finance: e.g., through a cooperative.

5.4.9 SCALABILITY

Most production systems in the developing world need improved post-harvest handling. Post-harvest handling investments are more likely in urban and peri-urban settings where there is market differentiation calling for higher-quality, improved shelf-life products.

5.4.10 TRANSFERABILITY

Conditions for success. For fresh fruits and vegetables, it is believed that a consistent market that is rewarding to producers of higher-quality product with longer shelf-life is a key element to encouraging more smallholders to employ these methods and technologies. As such, it is recommended that these technologies be deployed in scenarios where farmers are producing and marketing a higher-value product and when they have secured a relatively sophisticated buyer who understands the value of improved PHH and is willing to pay for it. Until there is a market for properly-handled product, programs promoting improved post-harvest handling will have difficulty in succeeding, so establishing market linkages, or at least identifying strong prospective market opportunities, is a precondition for success.

If India ultimately allows foreign direct investment in multi-brand retail, large format supermarkets like WalMart and Tesco will come in and almost immediately create that demand. Will Indian farmers and traders be ready?

Mechanisms of transfer.

- The Horticulture CRSP of USAID overseen by UC Davis is working in many countries around the world to reduce post-harvest losses.
- The WFLO, via their expert Lisa Kitinoja, has been a proponent of reducing post-harvest losses. It trained several agents with the Indian National Horticulture Mission (NHM) in the above-mentioned PHH methodologies and in cold storage management. The NHM personnel are a potential vehicle for disseminating these technologies.

In addition to these potential partners, the Meridian Institute has set up an incubator program in Southern Africa that seeks to identify and promote the most innovative and successful post-harvest

handling technologies (Meridian Institute, 2010). It will be a good partner for the FARMS project with regards to post-harvest technologies and could serve as a transfer mechanism from India to Africa and vice versa. This initiative is funded by the Bill and Melinda Gates Foundation.

5.4.11 RELEVANCE

Reducing post-harvests losses is included in the FARMS Task Order as a specific objective of the project. Promoting these technologies and finding the key to increasing their adoption all along the supply chain is highly relevant to FARMS.

Increasing the supply of food through programs that reduce post-harvest losses improves the financial outcomes of those in possession of the product and also reduces the adverse effects that producing, transporting, storing and marketing this product may have had on the environment. This manner of increasing the overall food supply does not require bringing additional land under cultivation or the application of additional farm inputs like fertilizer, seed and crop protection products. Thus, the value of programs promoting reductions in post-harvest losses extends beyond just protecting from the loss of the product itself.

5.4.12 SUSTAINABILITY

All involved with reducing post-harvest losses accept that this must be a private sector-led effort and that there must be a good return on investment for those adopting these practices or technologies. This will assure sustainability. The difficulty seems to lie in making the benefits clear to smallholders, while also providing credit and access to the technology.

5.4.13 POSSIBLE ACTIVITIES FOR FARMS

Study or Survey. There has yet to be large-scale, spontaneous adoption of any of these technologies by farmers. Yet, in the developed world, wholesalers, transporters and traders invest heavily in technologies that reduce losses. This gap in adoption is poorly understood. Understanding this gap in adoption might be a good subject for an evaluation or survey.

Pilot for Grains. GrainPro produces bags and cocoons (from 1 MT to 10,000 MT units). They are operating on a purely private sector model and offer solutions for small subsistence farmers, cereal banks, mid-sized warehouses and government cereal reserve programs. FARMS is in contact with this company and will look into the possibility of developing a pilot introduction of their technology after some more vetting.

Pilot for Fresh Fruits and Vegetables. FARMS is developing a nucleus of people and organizations in India that are interested in developing the CoolBot Technology. So far we have linked together Bayer Materials Science, Amity University, the Horticulture CRSP, Mela Ram Jaggi and Lisa Kitinoja.

The FARMS team is still investigating the best way to approach the reduction in post-harvest losses through this and other technologies. Working from the premise that the market must demand produce with higher quality and longer shelf-life before these technologies will be widely adopted, we feel that we must work backward from the end of the value chain to create demand for this product.

One possibility is to test CoolBot-equipped storage chambers at the common neighborhood produce markets in Delhi. This will test the technical and economic viability of the CoolBot-equipped storage chambers by reducing losses at that point.[30]

Ultimately FARMS would strive to link these neighborhood markets that have adopted the CoolBot with Mela Ram Jaggi, which will build Delhi's first terminal market complex (TMC) with a partial subsidy offered by the National Horticultural Mission. The TMC will provide the intermediate cold storage node. Since Mela Ram Jaggi is a company that works primarily with smallholders, FARMS may be able to find a few farmer candidates to adopt the CoolBot technology on their farms or in their villages. Once this chain is linked together, it could provide fertile ground for evaluating the effectiveness and financial feasibility of having a continuous cold chain from farm to market in one of the most populous cities in the world.

[30] This has one technical flaw, in that most of the storage life of any fresh fruit or vegetable is lost within hours after harvest; thus the reductions in losses for a technology applied only at this point in the value chain will not be nearly as effective as having a consistent cold chain from the farm gate to the consumer.

5.5 PRODUCER COMPANIES

5.5.1 SUMMARY

Cooperatives as they exist in India do not serve very well the needs of rural smallholders and allow a surprisingly high level of government intervention. Because of this, the Companies Act was modified to designate a new type of entity, producer companies, that would look and behave much like cooperatives do outside of India. In fact, the producer company legislation provides a very helpful and clear set of guidelines to farmer groups wanting to create a legal entity that will serve their needs as members. This cannot be seen as an innovation in India, as these producer companies operate in much the same way cooperatives do in the rest of the world. There are, however, some efforts in India that may have some innovative features due to their success in clustering producer companies to create producer centers that attract and maintain the attention of large wholesalers and exporters.

5.5.2 DESCRIPTION

Producer companies (PCs) are simply cooperatives in the true sense of the term. The innovation that they represent is unique to India in that the Producer Company Act provides a mechanism for circumventing the very restrictive laws relating to traditional cooperatives as specified under India's Cooperatives Act. The Indian Cooperatives Act gives the GOI a surprising level of control over cooperatives and the right to intervene in their affairs.

The following describes clauses from the Cooperatives Act; it illustrates the degree to which the GOI may intervene in the normal functioning of a cooperative.

- Power of the Registrar/government to give directives
- Compulsory amendment of bylaws
- Compulsory amalgamation/division
- Power to nominate directors and veto power over the nominated directors
- Power to annul or rescind board resolutions
- Supersession and suspension of the board
- Restriction on simultaneously holding office in a number of cooperatives

Participating in cooperatives in India is known to be a purview of the rich and powerful; it is rare that a person below the poverty line participates. Indian cooperatives are said to be under the control of powerful politicians, so the Indian masses needed an alternative.

The concept of producer companies came about in 2002 based on recommendations from an expert committed headed by Y. K. Alagh. The excerpt below is from an article by E.V. Murray entitled, *Producer Company Model - Current Status and Future Outlook: Opportunities for Bank Finance.*

> **Producer Companies**
> The concept of producer companies was introduced in 2002 by incorporating a new Part IXA into the Companies Act based on the recommendations of an expert committee led by noted economist, Y. K. Alagh, that was given the mandate to frame a legislation that would enable incorporation of cooperatives as companies and conversion of existing cooperatives into companies, while ensuring the unique elements of cooperative business with a regulatory framework similar to that of companies.

Salient Provisions of Companies Act relating to Producer Companies

- In a `Producer Company', only persons engaged in an activity connected with, or related to, primary produce can participate in the ownership. The members have necessarily to be `primary producers.'
- Any ten or more individuals, each of them being a producer, that is, any person engaged in any activity connected with primary produce, any two or more producer institutions
- Members' equity cannot be publicly traded but only transferred.
- Every producer company is to have at least five and not more than 15 directors. A full time chief executive is to be appointed by the board. He shall be an ex-officio director and will not be liable to retire by rotation and shall be entrusted with substantial powers of management as the board may determine.
- Members will initially receive only such value for the produce or products pooled and supplied as the directors may determine. The withheld amount may be disbursed later either in cash or in kind or by allotment of equity shares. Members will be eligible to receive bonus shares.
- Every producer company has to maintain a general reserve in every financial year and in case there are not sufficient funds in any year for such transfer, the shortfall has to be made up by members' contribution in proportion to their patronage in the business.

TABLE 4: MAIN FEATURES DIFFERENTIATING A PRODUCER COMPANY FROM A CONVENTIONAL (INDIAN) PRODUCERS' COOPERATIVE

Feature	Producer Cooperative	Producer Company
Registration	Cooperative Societies Act	Companies Act
Membership	Open only to individuals and cooperatives willing to federate	Only those who participate in production
Relationship with other corporates/ business houses, NGOs	Relationship only through sales transactions	Producers and corporate entity can together establish a producer company
Shares	Not tradable	Not tradable but transferable
Voting Rights	One person, one vote, but Government and RCS holds veto powers	One person one vote. Those not supplying product or availing of services cannot vote
Reserves	Created if there are profits	Mandatory to create every year
Role of Registering authority	Significant	Minimal
Administrative control	Overbearing	None
Borrowing Power	Restricted	More freedom and alternatives
Dispute Settlement	Cooperative mechanism	By arbitration

Producer companies, therefore, are more closely aligned with the concept of cooperatives as established in the United States and promoted through many development programs worldwide, including in Africa.

5.5.3 INNOVATIVE FEATURE

There are many producer company initiatives in India that may be interesting from a business strategy perspective. Each will have their unique business model, which may be of interest to African companies or cooperatives operating in similar sectors. The innovation will come from the application of these unique business models and not from the common statutory aspects of the producer companies operating under the Producer Companies Act. This act only served to release cooperatives from the restrictions imposed by the cooperatives law.

5.5.4 TECHNICAL AREA

This best practice contributes to IR 3 - Farmers Linked to Markets and Expanded Trade and Investment.

5.5.5 CONSTRAINTS ADDRESSED

Producer companies can help farmers who have limited or no access to higher-value markets.

5.5.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

Producer companies can be set up in almost any farming community, but they are best adapted to high-density areas where farmers grow similar commodities. Smallholder farmers who struggle to attain the minimum salable lots accepted in most markets or whose volumes of production cannot justify the costs of investing in capital assets can derive the greatest benefits from joining a producer company.

5.5.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

- The World Bank's DPIP (District Poverty Initiatives Program) program in Madhya Pradesh is working with 14 producer companies and has an interesting model to investigate.
- Y.K. Alagh is the 'father' of the modern producer company in India and sometimes consults for development programs.
- The National Dairy Development Board is experienced in the development of both classic cooperatives and in making the transition to producer companies.

5.5.8 EFFECTIVENESS

Effectiveness. The effectiveness of producer companies in India, as with cooperatives in other countries, is as varied as the success of new businesses, but probably at a lower rate. African countries, as well as many other countries around the world, have examples of failed cooperatives.

An example of the successful formation of producer companies is found in the World Bank-supported program, DPIP, in Madhya Pradesh. It must be noted that this success comes at the expense of intensive intervention by a large number of community development workers from NGOs and support organizations.

DPIP is a World Bank Funded-program which began in 2000. It is administered under the National Level Panchayat Rural Development. The DPIP operates mostly in Madhya Pradesh and also in Uttar Pradesh.

DPIP has a large number of community development workers. They began by focusing on Common Interest Groups, small village level groups made up of about five persons each, as their unit of operations and their target for development initiatives. In 2008 they evolved to working with self-help groups, which are federated under Village Development Committees (VDCs) and are further grouped to form producer companies.

DPIP seems to be a very well executed and successful program. It targets the poorest of the poor. In its initial assessment it determined that the best thing it could do for its beneficiaries was to improve the quality and availability of seed and fertilizer.

PCs are run like very good cooperatives. They respect to the letter the rules laid out in the PC Act, such as always appointing a professional, non-member to the CEO position, only allowing producers to be members, and limiting the number of shares per member.

Impact. Any one member of a producer company can benefit by accessing higher-value markets or getting post-harvest handling, storage, processing or marketing services at an affordable rate compared to the alternative of doing these things as an individual. The increase in household revenue depends on the degree to which the individual or household takes advantage of the services offered by the producer company of which s/he is a member.

Cost-Effectiveness. The degree of social capital that must be built up in order to create successful producer companies is vast; this is where the formation of producer companies as a development initiative falters.

5.5.9 SCALABILITY

Producer companies are created one by one; spontaneous adoption of the model by a group of farmers is somewhat rare. In this regard, the producer company model is not exceedingly scalable, as each one will require virtually the same level of effort.

On one level, though, there are efficiencies to be gained in large programs that promote the formation of producer companies, namely:

1. The implementing agency can develop a set of behavior change communication methods and messages that can be applied across a region or within a country.
2. Existing successful producer companies can be used as examples during study tours and farmer-to-farmer visits to speed the formation of new producer companies and the adoption of standard operating procedures.

5.5.10 TRANSFERABILITY

The ability to transfer any parts of the DPIP program for PCs (aside from their excellent execution and community outreach strategies) is questionable, because much of its success depends on accessing several types of GOI subsidies for both seed and fertilizer, as well as having the GOI as buyers of 50% of the production of certified seed. It is hard to say that outside of India, in a free market system, that they would be successful. Indeed, even in Ethiopia the quasi-governmental Ethiopian Seed Company is having trouble creating a sustainable business out of certified open-pollinated wheat seed. The certified wheat seed is in low demand at any price above the price of grain in the market, because so many farmers have not understood the benefit of using certified seed.

Conditions for success. In general producer companies and cooperatives require several things for success, as follows.

- A policy environment and tax regime that favor cooperative establishment and functioning. Cooperatives are not required to pay taxes on profits (in contrast with private corporations), because according to cooperative law, the revenues they recognize over and above their costs are not considered profits (provided that these profits remain limited and that the cooperative returns them to the members as dividends and keeps the remainder in a reserve account). Cooperatives do offer dividends to its members, which is a form of income for them. These dividends are taxed differently in different countries, but usually less than corporate profits.

- Cooperatives require the existence of a cohesive group of individual farmers who produce a common commodity and are in need of a common service(s).
- There must also be a culture of good cooperation and compromise within the society, and an understanding and willingness to work toward a common good, sometimes at the expense of an individual good.
- A cooperative requires good organizational structure, bylaws and good managers.
- A cooperative must have good access to markets, preferably with a diversity of buyers.

The success of the DPIP producer companies stems from their ability to successfully navigate the maze of regulations and subsidies put in place by the GOI. Because of a lack of efficiency and because of corruption in the GOI seed production companies (the National Seed Company and the state seed companies), the GOI decided to create a mechanism whereby the private sector could get into the seed production business. It is, however, almost impossible for an individual to get into this business on his own due to the amount of red tape required. Another value-added that DPIP brings to its beneficiaries is providing assistance in wading through the red tape to conduct all of their current operations. DPIP currently helps each producer company to get eight licenses, including a license to sell certified seed and to sell fertilizer on a wholesale and retail basis (separate licenses). Without this assistance, it is assumed that the farmers would not be able to conduct all the business ventures that they currently practice nor take advantage of all the subsidy programs. Thus, their success depends on the technical assistance provided by the program and on the fact that the regulatory framework and subsidy programs have created an environment that keeps many other competing firms out.

5.5.11 RELEVANCE

The development and promotion of producer companies strikes at the essence of IR3 - Farmers Linked to Markets and Expanded Trade and Investment. This is highly relevant to the FARMS program.

5.5.12 SUSTAINABILITY

The formation of producer companies may require donor support, but once the lessons of the business model are learned, the members themselves may be capable of carrying on the work and grow the business.

Twelve of the 14 PCs under DPIP in Madhya Pradesh produce certified seed as their primary activity. Most of their seed production is of wheat, mustard and soybeans. They federate about 250 villages under one producer company. They seem profitable and successful. There is admittedly a considerable amount of "hand-holding" by the staff of DPIP, but DPIP has a clear sustainability strategy whereby the PCs will transition to fully autonomous operations by 2014. There is even evidence of member-initiated expansion and diversification within the DPIP producer companies.

Some of the PCs of DPIP are now looking to diversify into new businesses. HAMPCO Seeds, for example, is considering getting into dairy and hybrid maize production in the near term and in the long term considering hybrid vegetable seed production.

It is interesting to note that the skills obtained by the farmers in seed production are being leveraged to diversify into related businesses, such as hybrid seed production for maize and vegetables. Certainly many of the skills the and discipline that these farmers already possess can be easily transferred and applied to these businesses. The GOI seed certification bodies will be familiar with the PCs and their members and have most likely increased their capacity to provide services to these very active seed producers. This is very akin to a cluster development approach, where the concentration of many individuals or companies practicing the same or similar businesses attracts services, vendors and buyers to the area, eventually creating a cluster for a particular industry. This has happened in many small and

large ways around the world, e.g., the Chilean grape growers, the Detroit auto industry and Silicon Valley.

5.5.13 POSSIBLE ACTIVITIES FOR FARMS

The producer company concept is similar to the general concept of farmer cooperatives throughout the world. As such, the concept itself does not have the potential to serve as a transferable best practice. Cooperatives are known in Africa just as they are known in India, but under the name of producer companies. The Indian method provides no new insights about cooperative function. It just allows traditional cooperatives to conduct themselves as cooperatives do throughout the world.

This best practice is closely allied with the best practice of linking smallholders to commercial value chains, and is one of the potential models that will be explored in the case studies proposed by the FARMS team.

There are potentially some lessons to be learned about creating successful cooperatives by comparing PCs in India that have been successful with those that have failed or are failing. A World Bank program in Maharashtra has had many successes in the establishment of producer companies for commodities like mangoes and grapes, whereas producer companies established in other states and even in Maharashtra under this program have failed. It might be worthwhile to examine the conditions of success of the Maharashtra cooperatives and distill a set of conditions or requirements for success. An initial investigation seems to indicate the success of producer companies depends on the existence of at least some of the following conditions or lack of certain constraints.

1. The members and the group must be dynamic and entrepreneurial.
2. Many producer cooperatives have failed because the commodity that they are working with does not have a stable market from year to year. Either they need to work with stable commodities or build into their planning reserves to cover bad years.
3. The most successful cooperatives have been created through the sole impetus of the members and not by an external catalyst like an NGO. There have been, however, some successful cooperatives created by NGOs.
4. Some producer companies in India have failed, or at least failed to grow as they should and failed to get loans or accumulate capital assets, because the sustained (and possibly misguided) NGO influence pushed the cooperatives to focus too much on creating equitable outcomes for all members at the expense of the best business interest of the entity.
5. Some cooperatives have failed because the markets and market prices available for individual members outside the producer company program have provided better returns that the producer company program itself. Side selling ensued, and the cooperative was weakened or did not survive.

Refining this list and understanding the true underlying causes of success and failure could provide a valuable lesson for establishing farmer-based organizations.

6. BEST PRACTICES IMPROVING HOUSEHOLD NUTRITIONAL STATUS (IR 4)

This chapter presents the assessments of potential best practices that primarily contribute to IR 4 - Improved Household Nutritional Status, Particularly of Women and Adolescent Girls.

6.1 HOME GARDENS

6.1.1 SUMMARY

A homestead garden is a garden near a home that is designed to provide vegetables and/or income to the family throughout the year. As practiced in India, homestead gardens also include a poultry and/or small ruminants component for animal-based protein and to diversify the diet. Hellen Keller International also includes a nutrition education component; it claims this is a very important component to ensure that the increased availability of nutritious vegetables and meat leads to consumption of these products. FARMS can implement a tailored home gardens best practice that includes all these components and conduct a rigorous evaluation to understand whether these features add value to the program and whether they are cost-effective. FARMS has identified several potential partners to implement a homestead gardens pilot with the purpose of rigorously evaluating its efficacy in improving household nutritional status. In order to refine the specific questions that the evaluation should ask, and to design a pilot that identifies the key elements that contribute to its success – nutrition education, animal-based protein, and women's empowerment, FARMS will conduct a thematic workshop with several Indian and international experts.

6.1.2 DESCRIPTION

A homestead garden is a garden near a home that is designed to provide vegetables to the family throughout the year, as well as supplemental income if surplus production results. The vegetables are carefully chosen so that they contain the key necessary vitamins and micronutrients, are suitable for the climate of the region, and can provide a continuous supply. The FARMS team has reviewed in detail the potential Indian best practices of three organizations: AVRDC (The World Vegetable Center), Hellen Keller International (HKI), and Development Research Communication and Services Centre (DRCSC).

AVRDC conducts considerable initial research to develop vegetable charts with information on vegetables that can be grown in the region, can provide a supply throughout the year, and provide vitamin A, calcium, and iron. Thus far, they have developed vegetable charts for Punjab and Jharkhand.

Hellen Keller International (HKI) has a long history promoting home gardens, which have been extensively researched and assessed, in a large part because of HKI's own emphasis on monitoring and evaluation. Recently, its model was included by IFPRI as a success story in its "Millions Fed: Proven Success in Agriculture Development." HKI's initial emphasis was on increasing the intake of vitamin A, which it later expanded to include iron, zinc and overall food security. A couple of noteworthy

modifications that HKI made in their model are that 1) it includes small animals and poultry in their gardens given their recent work noting the lower bioavailability of vitamin A from fruits and vegetables as compared to animal products,[31] and 2) it includes nutrition education on essential nutrition actions, given the growing understanding that just the availability of nutritious food does not lead to greater consumption of nutritious foods.

In India, the Development Research Communication and Services Centre (DRCSC)[32] has also developed a model that it implements itself and trains other NGOs to disseminate across the region. DRCSC implements the garden for the nutritional security of the households and specializes in agronomic techniques to optimize the use of water, sun, soil, air and organic matter for a productive and nutritious home garden.

The three organizations have some key common factors:

1. Objective of attaining overall food security of the rural household (although HKI and AVRDC have a slight difference in the specific nutrients addressed);
2. Year-round supply of vegetables;
3. Open-pollinated varieties, so that families can save their own their seed; and
4. Focus on women, to improve the nutritional status of women and children.

To the best of our knowledge, none of these three organizations conducts an analysis of the (micro)nutrient deficiencies in the target population; they focus more on the baseline analysis of the consumption patterns and may deduce the impact on micronutrient status from intake. This would be somewhat problematic, given that vegetables generally contain inhibitors of absorption that prevent much of the micronutrient content in vegetables from being absorbed by human beings.

Table 5 presents a comparison of the three approaches.

[31] Meat is not generally a good source of vitamin A, but eggs and liver are good sources.
[32] DRCSC is a non-government development organization working in 12 districts of West Bengal and other states. Its major concern is food and livelihood security of the rural poor through sustainable management of natural resources.

TABLE 5: COMPARISON OF THREE APPROACHES TO HOME GARDENS

Comparison Point	HKI	AVRDC	DRCSC
Key expected outcome	Initial goal was to increase consumption of vitamin A; later expanded to cover iron, zinc, and overall food security	Improve consumption of micronutrients (vitamins A, B, and C, calcium, iron), and protein.	Food security is the main target; no specific goals on micronutrients.
Key defining features	Year-round supply of vegetables. Includes nutrition education. Includes small animal production to improve bioavailable vitamin A. Standardized but flexible design. Clear plan for sustainability: HKI supports NGOs for 3 years, and NGOs stay in community for 2 years. Each NGO supports 25-30 village model farms (VMF), and there are two mothers' groups (these already exist) and 40 households per VMF. Empowerment of women is a key objective. Income generation through sales of vegetables is also a key objective, and the cost sharing is done through the VMF. Initial seeds are provided by HKI to the NGO, which then provides them to the local community. Monitoring and evaluation is built into the program.	Year-round supply of vegetables. Conducts research (baseline survey and participatory rural appraisal, consults with local resources (SAUs) to identify area-specific vegetables that will meet the nutrient objectives. It takes 1-2 years for formative research. This may also result in an attempt to introduce new vegetables to the area. Works through existing NGOs on the ground. Initial seeds are provided by AVRDC to NGO, which then provides them to the local community.	Year-round supply of vegetables. Focuses on locally available vegetables, and also tries to re-introduce traditional vegetables. Has developed models based on water availability. Includes small animal production; culinary & medicinal herbs, ornamental plants, erosion control plants. Has developed specialized knowledge on optimizing the use of sun, air, water, soil and types of vegetables that maintain the nutrient balance and promote proper aeration of the soil. Implementation occurs through a women's group, and seeds are saved at the group level.

Comparison Point	HKI	AVRDC	DRCSC
Implementation approach.	Trains local NGOs and supports them for three years.	1-2 years of initial formative research (includes baseline survey and PRA) is conducted to identify vegetables for the area. AVRDC resource person trains NGOs through training-of-trainers. The NGOs then conduct training of villagers. Different NGOs use different approaches. Typically, they call a village-level meeting to talk about home gardens. Recipe development and demonstration. Seed saving is encouraged, but at the household level.	DRCSC implements home gardens directly, and it also trains NGOs in areas where it does not have staff. The first step is developing women's groups. Garden maps & seasonal calendars are prepared for each household to identify present production & consumption patterns and identify factors that limit productivity, length of growing season. 2-3 women of the group start the first home gardens, which are used for demonstration and learning. Remaining women are encouraged to start 2-3 activities. Seed sharing is done within the group.
Land Requirement	6 meters x 6 meters that serves 4-5 family members	6 meters x 6 meters; Plots can be smaller, or of different shapes if the family does not have the 6m x 6m area	Average plot is 60-70 sq. m. Plots can be 19 sq. feet or smaller. They also prescribe different shapes, depending on the topography, water needs, etc.

Comparison Point	HKI	AVRDC	DRCSC
Labor and other inputs	Water source is preferred near the garden. Requires additional labor for the activity but there could be labor savings from having the vegetables nearby. Compost and pesticides (not clear if HKI only promotes organic/bio pesticides). There are village nurseries and linkages with commercial seed producers.	Water source is preferred near the garden. Requires additional labor (1-2 hours daily),[3] but there could be labor savings from having the vegetables nearby. Compost and bio-pesticides. Seeds are ideally saved but sometimes have to be purchased.	Water source is preferred near the garden. Requires additional labor for the activity but there could be labor savings from having the vegetables nearby. Compost and bio-pesticides. Seeds are ideally saved by groups of women.
Evaluation	Several assessments completed, none have randomized design, one RCT underway in Burkina Faso.	Assessments to inform the design, no control groups.[2]	Internal evaluation but with no control groups.

Notes: [1] Phone conversation with Anshuman Das, Director, DRCSC on June 21, 2011
[2] Conversation with Warwick Easedale, Ray-Yu (on Skype) and of AVRDC, Hyderabad.
[3] Anecdotal responses from women from Kooti district, Jharkhand. Village visits by Tulika Narayan/Abt Associates Inc, June 23, 2011

6.1.3 INNOVATIVE FEATURE

Homestead gardens exploit the available land and water to grow vegetables near the house to improve nutritional outcomes, particularly of women and children.

6.1.4 TECHNICAL AREA

The primary contribution of home gardens will be to IR4 - Improved Nutritional Status of Women and Adolescent Girls.

6.1.5 CONSTRAINTS ADDRESSED

Home gardens address the lack of access to nutritious food and lack of knowledge about nutritious food (not all homestead garden interventions implement this aspect).

6.1.6 APPLICABLE LANDSCAPE/ AGRO-ECOLOGY

Any geography or landscape that has access to a water source and at least 150 square feet (14 square meters) of land that gets direct sunlight for at least six hours is suitable.

6.1.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Hellen Keller International is a key international NGO with a long history in implementing home gardens, particularly in Bangladesh and Nepal. They are recognized to be the pioneers of this best practice. IFPRI currently is focusing on evaluating HKI's efforts in Burkina Faso and Cambodia using rigorous approaches to understand their impact and to tailor the best practice. In India, there are numerous NGOs that implement home gardens as part of their community-based programs. In eastern India, DRCSC implements approximately 5,000 home gardens directly; it is also a resource NGO that trains other NGOs upon request, provided they meet certain requirements. DRCSC specializes in the horticultural aspects of the home gardens; it incorporates the concepts of sustainable agriculture, water harvesting, permaculture and integrated farming systems in its implementation. In addition, AVRDC is implementing home gardens through an effort that is funded by the Sri Ratan Tata Trust. Its core value added is in conducting research to identify the nutrient content of vegetables, with the objective of identifying a mix of vegetables that can meet the dietary needs of individuals, although they do not assess the extent to which these nutrients are absorbed. In summary, the resource organizations and individuals and members of the community of practice are:

- AVRDC
- DRCSC
- IFPRI (Washington and New Delhi)
- HKI
- Local implementing partners such as PRADAN
- Nutrition experts

6.1.8 EFFECTIVENESS

The intended outcomes of implementing homestead garden programs vary depending on the implementing organization and the initial goals. Some organizations stop at increasing the vegetable intake to 200 grams of vegetables per person per day; others, such as HKI, aim to improve the micronutrient status of the target communities. HKI notes that there is lower bioavailability of vitamin A from fruits and vegetables as compared to animal products.

According to HKI, the effectiveness of the intervention in improving nutritional outcomes hinges on:

1. Behavior change communications that articulates the need for balanced diet and the allocation of resources for feeding children and mothers;
2. A multidisciplinary approach that engages the health sector to provide health care for disease treatment and prevention;
3. Incorporation of local practices and local organizations for greater receptivity;
4. Standard but flexible design that can be modified to local needs; and
5. Monitoring and evaluation to understand what works and what does not (Iannoti et al., 2009).

Table 6 presents a summary of the evaluations completed for homestead garden projects (Iannotti et al., 2009). Overall, the paper concludes that several evaluations have been completed of homestead gardens, but evaluations have not been rigorous in terms of evidenced-based studies of blood nutrients so that there is skepticism about the impact of home gardens on maternal and child micronutrient status, particularly at scale. Further, there is insufficient data on the cost-effectiveness of this approach compared to other approaches to improve nutritional status. That said, the evaluations have established some evidence of increased intake of micronutrient-rich foods by mothers and young children.

TABLE 6: IMPACT OF HOMESTEAD GARDENS: EVALUATIONS COMPLETED AND ONGOING

Country and Reference	Type of Intervention	Evaluation Design	Nutrition and other Impacts Assessed
Bangladesh Greiner and Mitra, 1995	Homestead gardens with provision of seeds, farming education and nutrition education	Pre-post with control; not randomized	*Slight decrease in night blindness*, increase in percentage of households growing vegetables and fruit in both treatment and control and increased knowledge of function of Vitamin A.
Bangladesh HKI/AVRDC 1993	Homestead garden with vegetables, training on agriculture, provision of seeds, nutrition education	Pre-post with control; not randomized	*Improvements in stunting and in underweight*, increase in vegetable production, size of plot cultivated, year-round availability of vegetables, income, women's control over income, vegetable consumption per capita, children's vegetable intake. Intervention children had fewer respiratory infections.
Bangladesh IFPRI et al. 1998	Vegetable production, fish ponds and credit and agricultural training	Pre-post, with 3 groups, fish-ponds and vegetable garden, vegetable gardens only and control.	*No change in hemoglobin in any group, implying no change in iron status.* Increased production of fish and vegetables. No increase in consumption of fish in fishpond group. Increase in vegetable intake in vegetable group.
India Chakravarty, 2000	Homestead gardening and nutrition and health education	Pre-post; no control.	*Decrease in ocular signs/symptoms of vitamin A deficiency.* Increase in percentage of households growing vegetables. 40% of households sold 10%-25% of produce. Better knowledge, attitudes, and practices on vitamin A, and weekly intake of vitamin A-rich garden produce more than doubled.
Nepal CARE/Nepal 1995	Homestead gardening, irrigation, agriculture extension, seeds	Pre-post; no control	*Deterioration of nutritional status of children during study.* Increase in percentage of households producing vegetables. Insufficient Vitamin A intake for mothers and children pre and post.
Niger Parlato and Gottert, 1996	Promotion of home production, multimedia education campaign promoting consumption of vitamin A-rich foods	Pre-post	*No data on nutrition indicators.* Increase in women's knowledge of vitamin A, intake of vitamin A-rich vegetables (children), and purchase and consumption of liver, a food targeted by the intervention to increase vitamin A intake (by women and children)

Country and Reference	Type of Intervention	Evaluation Design	Nutrition and other Impacts Assessed
Peru Carrasco Sanez et al. 1998	Nutrition education in community kitchen with capacity building; awareness about organ meats	Pre-post members/non-members	*Reduction in prevalence of anemia.* Increased quality of diet and intake of iron-rich foods as well as vitamin A, heme iron, and proportion of absorbable iron.
Philippines Solon et al. 1996	Promotion of homestead gardens with some targeted vegetables; provision of seeds and cuttings; mass media campaigns, social marketing and nutrition education.	Pre-post, with control.	*No data collected on nutrition indicators (only dietary indicators).* Increased production of 5 types of vegetables with increased vegetable consumption and vitamin A intake in intervention group. Decrease in vitamin A intake in control group by 48%.
Senegal Burn et al. 1989	Promotion of homestead gardens and sale of produce; nutrition education and agriculture education.	Survey of those with and without homestead gardens (Baseline; 10-12 years later)	*No data collected on nutrition indicators only (only dietary indicators).* Consumption increased for some nutrients decreased for others.
Tanzania Kidala et al. 2000.	Promotion of home production, consumption and storage of vitamin A-rich foods; health and nutrition education.	Treatment/control; Post	*Lower serum vitamin A and higher worms in treatment area. (Overall, higher intake of vitamin A-rich foods associated with higher serum vitamin A.)* Higher percentage of households with homestead gardens and producing vitamin-rich vegetables in treatment area. Better knowledge, attitudes, practices about vitamin A, higher % using solar driers for vitamin A foods, higher 7-day frequency of intake of vitamin A foods.
Thailand Smitasiri and Dhanamitta 1999 Smitasiri et al. 1999 Attig et. Al. 1993	Seed distribution; training of women farmers; promotion of gardens, fishponds, and raising chickens; nutrition education and social marketing.	Pre-post with control.	*Increased serum retinol, decreased vitamin A deficiency (in school girls). Increased mean hemoglobin, decreased anemia, and low serum ferritin (not significant) implies improved iron status.* Increased KAP on vitamin A and iron; increased vitamin A intake; not change in fat intake; increase in iron intake in some targeted groups; increase in vitamin C intake in lactating women. No change in controls.

Country and Reference	Type of Intervention	Evaluation Design	Nutrition and other Impacts Assessed
Vietnam English et al 1997 English and Badcock, 1998	Homestead gardens, fishponds, animal husbandry, nutrition education	Treatment/control Post	*Data collected only on dietary indicators.* Treatment group: lower severity and incidence of respiratory infections;; better growth; greater fruit and vegetable intake; greater energy, protein, and vitamin A and C intake in children. Better KAP in mothers.
Vietnam Ngu et al. 1995	Promotion of homestead gardens with a focus on vitamin A-rich crops, nutrition education for mothers	Pre-post	*Clinical eye signs of severe vitamin A deficiency decreased to almost zero, implying improved vitamin A status.* Per capita vegetable production increased fivefold and increase in intake of energy, protein, and fat.
Bangladesh, Nepal, Cambodia HKI 2003, 2004, 2004a, 2006	Integration of animal components into existing gardening activities: poultry, and eggs in all countries, milk and fish in Banladesh. Nutrition education targeted to women, nutrition improvement targeted at preschool children.	Before and after including quarterly monitoring data –Cambodia, Nepal. Bangladesh, before and after, includes control groups and quarterly monitoring data.	Household chicken liver consumption increased. Proportion of liver from own production increased (Nepal, Cambodia). Increase in egg consumption (Bangladesh, Cambodia). Children in project area consume double the number of eggs per week compared with rural Bangladesh. 30%-66% of income from selling poultry used to purchase food. Addition food purchased in Cambodia 55% fish, 8% beef/pork. In B'desh addl. Income used to purchase milk, fruit and fish. Program in Chars (temporary small islands) of Bangladesh targeted toward women. Endline data show that women's engagement in decision making on household expenditures is greater.

Country and Reference	Type of Intervention	Evaluation Design	Nutrition and other Impacts Assessed
Bangladesh. HKI (Based on abstract) Bushamuka et al (2005) [1]	Homestead gardening program	Active participants, former participants and control groups, Pre-Post	Impact on food security and social status of women. About 64% of the active-participant households generated a median garden income of 347 taka (US$1 = 51 taka), which was spent mainly on food, and 25% of the control households generated 200 taka in the same period ($p < .001$). The garden production and income levels of formerly participating households three years after withdrawal of program support were much higher than those of the control households, illustrating the sustainability of the program and its ability to increase household food security. Significantly more women in active- and former-participant households than in control households perceived that they had increased their economic contribution to their households since the time the program was launched in their subdistricts (> 85% vs. 52%).
Bangladesh Endline report, Jibon O Jibika (HKI and Save the Children), 2009[2]	Homestead food production, health(including antenatal care), nutrition and sanitation education of mothers, preparedness for emergencies through community-level intervention	Pre-post, participants, past participants and non-participants	*Quality of current food consumption in terms of number of different food categories eaten improved between baseline and endline (Dietary Diversity Score_*, Food Consumption Score (FCS), which weights different food categories based on their nutritional values, did not show a measurable increase from the baseline to the end-line survey rounds; the percentage of households categorized as severely food-insecure falling from 44 percent in the baseline to 33-40 percent in the end-line samples. Production of green leafy vegetables increased from baseline to endline. (Mother and child nutrition behaviors, WASH impact also measured.)
Cambodia (Based on abstract) Olney, et al (2008)[3]	Homestead food production program	Pre-post, with treatment and control (not matching in certain characteristics)	*No measured impact on mother and child nutrition. (Measured intake of micronutrient-rich foods, anthropometry, hemoglobin, and anemia prevalence and found no impact).* Assessed pathways of impact on maternal and child health and nutrition.

Country and Reference	Type of Intervention	Evaluation Design	Nutrition and other Impacts Assessed
Burkina Faso *Ongoing Evaluation* Andrew Dillon etc. IFPRI, Results expected 2012	Homestead gardens, ENA communications through two strategies –mothers and grandmothers, and influential people.	Randomized treatment, control, pre-post	*Anthropometric and anemia outcomes in children.* Adoption of ENA by women.

Note: Updated Table 3 from "From Agriculture to Nutrition: Pathways, Synergies and Outcomes, ARD, World Bank 2007 (all references unless otherwise noted are available from this publication).

1. Bushamuka, V. N., S. de Pee, A. Talukder, L. Kiess, D. Panagides, A. Taher, and M. Bloem. 2005. Impact of a homestead gardening program on household food security and empowerment of women in Bangladesh. *Food and Nutrition Bulletin* 26 (1): 17–25.
2. Tango International, Jibon O Jibika Save the Children, *Endline Survey Report, September 2009*, Bangladesh.
3. Olney, DK, A Talukder, LL Iannotti, MT Ruel, V Quinn. Assessing Impact and Impact Pathways of a Homestead Food Production Program on Household and Child Nutrition in Cambodia. Food and Nutrition Bulletin, 2009 Dec;30(4):355-69.

Cost-Effectiveness. The evaluations of homestead gardens have not examined the cost-effectiveness of homestead garden implementation alone or in comparison to other approaches to improve nutritional outcomes. The implementation of homestead gardens is fairly complex, and that can add to the human and financial resources needed to carry out the programs. Human, financial and institutional resources are needed for almost three years to 1) convince households to adopt the homestead gardens, 2) conduct research to identify the appropriate vegetables, 3) procure and deliver vegetable seeds, 4) train local institutions/NGOs on homestead gardens 5) educate households about appropriate horticultural practices to maintain the garden and poultry, 6) educate households on the importance of homestead gardens, and 7) provide follow-up messages and inputs. In the HKI model, HKI stays involved in a region for approximately three3 years, and the local organization stays involved for another two years, which can give some sense of the cost of the program.

6.1.9 SCALABILITY

Several factors will affect the scalability of homestead gardens. Cost-effectiveness will be an important factor in scaling up the best practice. Thus far, homestead garden projects have been funded through cost sharing between international NGOs, local partner organizations and the participating households. To the extent that it is not a financially sustainable model, scalability would be limited by the donations or aid to introduce and sustain this activity. Even if funds are available, the best practice can be scaled up only in areas where there are already existing NGOs with an established presence in the community and sufficient donor funding.. Often the practice is introduced as an additional activity, layered over other activities in the area. Olney et al., 2009 also note this as a constraint in scaling up the activity.

Research institutions that are doing area-specific research on appropriate seeds and horticultural approaches would be important to support local NGOs in refining the horticultural model, and possibly in supplying seeds. Availability of seeds can itself be a key constraint to supporting operations at scale. The initial time taken to conduct research for developing the mix of crops in a region is long, at least in the model developed by AVRDC. This can mean more resources and time in scaling up the practice.

Internal implementation challenges can impede operations at scale because of the large network of NGOs that would have to be managed, their limited capacity (and therefore training needs), their coordination, and the required supply of seeds and saplings. Olney et al, 2009 provides additional challenges of scaling up the home garden program to the national level: connections with a market; development of innovative regional and national marketing systems for garden produce; the establishment of stronger linkages with commercial seed producers; and integration of food production with other farming or income-generating schemes by women and at the household level.

6.1.10 TRANSFERABILITY

Conditions for success. There are several conditions that are necessary for the success of homestead gardens. If these conditions are not met in the area where the best practice is transferred, it may not be successful. The key conditions of success of homestead gardens include the following.

- An existing local NGO network is essential for understanding the local context, to gain acceptability, and to implement the project; particularly in tribal areas working in new areas may not be possible as 5-6 years may be needed to develop trust.
- Knowledge of local language and dialects is also important for successful communication.
- The traditional practice of home gardens will increase the acceptability of a more scientific method of gardening. In areas where families are very poor and do not eat vegetables, where families do not have any kind of vegetable garden, or where individual families do not have access to land near the homestead, acceptability will be harder.
- Availability of women labor to plant, maintain, and harvest these crops, as well as carry out the

necessary tasks (haul water, weed, buy seeds).

- Access to a water source near the house increases the chances of acceptability and continuity. Our field visits suggested that households that were close to a water source were more likely to continue with the home gardens than those who were not. Extreme water conditions—both scarcity and overabundance—have been identified as obstacles by HKI. HKI has been working on adaptation strategies for flooding on its HFP char project 2.
- Effective strategies for understanding and mitigating local constraints to adoption will be important, particularly in the early stages. For example, villagers are least inclined to work on home gardens at the time of planting (and harvest), because villagers want to be in their fields to plant their crops.[33] However, for the same reason that farmers are in the field, planting home gardens is also better during the monsoon. It is possible, however, that there are benefits to introducing home gardens in the winter, when villagers are free, even if that is not the best time to plant from the horticultural standpoint.
- Easy availability of seeds for new families and families who are not able to save seeds. Although AVRDC promotes seed preservation, most women responded that they would take the seeds from the field coordinator (KGVK) staff. Only when they were quizzed more did they sheepishly respond that they could keep the seeds from their plants. This suggests that communicating the method to save seeds may be difficult and may have poor adoption. This implies that the supply of seeds could be an important constraint. The AVRDC regional coordinator at Hyderabad did mention their internal availability of seed as a constraint to scaling up the activity in new locations.
- Depending on the knowledge of the households, sharing knowledge on growing healthy and productive gardens can be complex. In addition, since the households also have to adopt and understand information on appropriate nutrition behaviors, the flow of information can be large, and that may limit the ability of households to understand and adopt fully.
- Availability of household labor can also constrain households in taking up vegetable gardens. In the field visit to Jharkhand, one household that we met with had stopped gardening because there was only one old lady and a child living in the household, and her sons had left for other work.

Mechanisms of transfer. AVRDC already has a presence in Africa. It is an important resource organization that is conducting research in understanding the nutritional content of vegetables, the mix of vegetables that are needed to meet the nutritional requirements, and the vegetables that can be grown in specific agro-climactic zones. However, it does not consider the bioavailability of micronutrients. Other organizations will be needed to complement this program with nutrition education; HKI has the most developed program and would be an important resource organization.

6.1.11 RELEVANCE

The best practice is expected to contribute to improving the nutritional status of rural households. Currently, there is not complete clarity on whether the FARMS nutrition component will focus on women and adolescent girls, or if it will focus on infants and young children also. Either way, homestead gardens should be relevant to FARMS, and we hope to include orange-fleshed sweet potatoes to impact vitamin A status for infants, young children and breastfeeding mothers.

Given the absence of any rigorous evaluations to assess the impact of homestead gardens on household micronutrient status, FARMS can add value by generating defensible evidence of its effectiveness. This is

[33] Conversation with Ravihankar Manickam, Site Coordinator, AVRDC, June 23, 2011.

particularly important because several funding organizations see homestead gardens as an important way to improve households' nutritional status.

6.1.12 SUSTAINABILITY

The long-term sustainability of homestead gardens has not been systematically assessed. In the current model, the cost of homestead gardens is shared between households and implementing agencies. Once the best practice is initiated in a village, there have been instances of adoption by additional households; however, that is often based on implementing agencies' also providing the seeds and initial training. Therefore, it is possible that spontaneous adoption may not happen without external input. That said, the long-term sustainability could come from several funding agencies' interest in this initiative and their willingness to provide funds for implementation. Otherwise, the best practice is sustainable environmentally—home gardens typically use organic matter and do not rely on chemical fertilizers—and does not impose any other negative externalities. The only tradeoff could be on the allocation of labor resources by women, which needs to be evaluated and addressed more systematically.

6.1.13 POSSIBLE ACTIVITIES FOR FARMS

A review of literature suggests that several aspects of home gardens that appear to be critical to their success are not incorporated in the AVRDC model or in the DRCSC model. FARMS can implement a tailored home gardens best practice that includes some of the features of these models, with the hope to improve the effectiveness of AVRDC's program. It would conduct a rigorous evaluation to understand whether these features do add value to the program and if they are cost-effective. The proposed additional components are the following.

1. Nutrition education focusing on essential nutrition actions for mothers and children. A review of HKI assessments suggests that home gardens impact the nutrition outcomes of mothers and children, particularly children only when they are accompanied by behavior change communications on essential nutrition actions (ENA). [34]
2. Since vitamin A and other micronutrients are not highly bioavailable in vegetables and to meet the protein requirements of rural households, small animals need to be incorporated where household traditionally do not keep them. Integration of small animals into home garden will have to be carefully thought out so the two can coexist (one of the constraints in keeping home gardens in Jharkhand was chickens and pigs that encroached on the area). DRCSC appears to have experience with this in India.
3. Introduction of biofortified orange-fleshed sweet potatoes that have been already introduced in Orissa and are available in India.[35] The focus of the work can be on introducing orange-fleshed sweet potato as an infant food, since boiled and smashed potatoes are suitable as supplemental foods for infants. A recent evaluation by IFPRI suggests that consumption of orange-fleshed sweet potatoes improves the vitamin A intake of children.
4. Clear articulation of a behavior change approach to increase the adoption of home gardens by women and other villagers. DRCSC starts its activity by creating a women's group (sometimes including adolescent children), which could be a potentially effective approach to increasing adoption. HKI develops village model farms and works with a mothers group to communicate the advantages of home gardens. AVRDC does not have a clearly defined strategy for encouraging families to adopt the gardens; the approach depends entirely on the implementing NGO and can vary across NGOs without any learning about which mechanism works best. The

[34] This aspect was also reiterated in an in-person conversation by Suneetha Kadiyala, Research Fellow, IFPRI on June 28, 2011.

[35] Prof. J.V.Meenakshi of Delhi School of Economics, who has served as consultant with IFPRI on Harvest Plus has contacts that can provide vines for orange flesh sweet potatoes.

mothers' or women's group will be important to convince farmers to take up home gardens; it is also a mechanism to share experiences and ideas for problem solving, for sharing recipes, and for sharing information on essential nutrition actions (similar to the positive deviance program of UNICEF).

An evaluation would assess the value-added of the nutrition education component and the introduction of animal-based protein on the micronutrient status of the households. The questions we ask will of course depend on the elements included in the BP. Some outcomes that would be of interest are:

1. The proportion of villagers that adopt home gardens, and the proportion of villagers that continue with the home gardens;
2. The impact of the intervention on the micronutrient status in the target population and/or the intake of micronutrients;
3. Food consumption (purchased and own consumption of food);
4. Income from the sale of home garden products as a proportion of income from all sources;
5. The impact on the distribution of household labor, including child care;
6. The factors and preconditions that favor the adoption of home gardens, e.g., water source close to home, available labor, fencing material easily available, availability of land near to homes, lack of poultry, goats or pigs that disturb and destroy gardens; and
7. The probability of taking up commercial vegetable production.

The most important knowledge that would be generated by this BP pilot and its evaluation might be in addition to nutritional improvement a better understanding of women's labor use and how it was affected by the intervention, since women have an important impact on both the nutrition and the health of young children.

Before undertaking the BP implementation and evaluation activities in a pilot activity, FARMS will use inputs from a thematic nutrition workshop, and inputs from IFPRI, Washington DC to inform the activity. Some questions to which we hope to get answers on are the following.

1. Are there other examples of homestead gardens and related interventions that have been implemented in India? Have they been evaluated?
2. What should be the main and other objectives of a homestead garden-based intervention?
3. What elements would you include in a homestead garden-based intervention? Why?
4. What would be the most important questions to ask in an evaluation of a home gardens BP?

6.2 MULTI-SECTORAL NUTRITION EDUCATION

6.2.1 SUMMARY

In India, one of the main platforms for the delivery of nutrition programs is the primary health care systems of the Ministry of Health, including the Integrated Child Development Services (ICDS). In the implementation of ICDS, different states have adopted innovative approaches to enhance the effectiveness of their efforts to reduce infant and maternal mortality. *Anchal se Angan Tak* (ASAT), Positive Deviance and Dular are three such projects. ASAT has an integrated approach with a focus on improving the knowledge and skills of mothers, caregivers, family members, and community and service providers. Positive Deviance relies on extensive behavior change of mothers brought about by other mothers who have had positive experiences in child and maternal nutrition. In addition to the programs within ICDS, *Indira Kranti Pratham* (IKP) in Andhra Pradesh has an Integrated Health and Community Managed Nutrition Program, which has a fee-based nutrition-cum-daycare-center (NDCC) that is managed by women.

There are several possible activities that FARMS could undertake to add value to the existing nutrition education efforts in India. The specific activities will be identified in the nutrition thematic workshop. Given that Dular, ASAT and Positive Deviance are all pilots to enhance nutrition education, a potential activity could attempt to 1) conduct a rigorous assessment of the comparative costs and benefits of these programs, 2) develop a more detailed understanding of the specific context in which any of these are successful, and 3) provide information on which programs are most suitable for scaling up within ICDS. Alternatively, FARMS could implement a pilot that expands the Positive Deviance pilots in areas where it does not exist, while working on a rigorous evaluation to assess its cost-effectiveness and impact. Another interesting possibility would be to implement NDCCs in areas where there is an already existing self-help group structure, and perhaps in areas where other community-based structures are strong, and assess both the sustainability and impact of NDCC and also how different community structures affect its impact.

6.2.2 DESCRIPTION

In India, one of the main platforms for the delivery of nutrition programs is the primary health care systems of the Ministry of Health, including Integrated Child Development Services (ICDS). The ICDS scheme is one of the flagship programs of the Government of India and represents one of the world's largest and most unique programs for early childhood development. It has been functioning since 1975. ICDS is India's response to the challenge of breaking the vicious cycle of malnutrition, impaired development, and morbidity and mortality in women and children. Specifically, it targets children 0–6 years and pregnant and lactating women.

In the implementation of ICDS, different states have adopted innovative approaches to enhance the effectiveness of their efforts to reduce infant and maternal mortality. Several development partner organizations have supported these initiatives, of which several initiatives have been implemented for a considerable period of time at a significant scale. Based on the experiences of implementers and on (not necessarily rigorous) quantitative and qualitative evaluations conducted by supporting agencies, many of these initiatives are considered as effective approaches and are often referred to as either potential or promising practices.

Of these *Anchal Se Angan Tak* (ASAT), Dular, and Positive Deviance are innovative overlays to the ICDS program that focus on nutrition education and behavior change.

Dular. This program was initiated in 1999 and is being implemented in Bihar and Jharkhand. Dular enhances the existing ICDS structure by forming additional components at the village, district and state levels. At the village level, Dular introduced a new cadre of volunteers named Local Resource Persons (LRPs) to assist the *angan wadi* worker (AWW). At the district level, Dular has added a District Mobile Monitoring Training Team (DMMTT) to monitor progress and provide on-the-job guidance to village teams. A District Support Team (DST) has also been constituted to improve coordination between sectors, review overall progress, and ensure effective implementation across the district. At the state level, there is a task force dedicated to assessing and developing communication and training needs. There is also a Dular Cell, whose main role is to monitor the progress of Dular and link it to the overall improvement of ICDS. The Dular Management Information System (MIS) is integrated into the ICDS MIS. At the household level, a Dular Card is provided to caregivers to monitor the progress of their children. An adolescent card provided to adolescent girls tracks iron and folic acid tablet intake and provides information on key health, nutrition and hygiene issues. Dular also has developed a Dular Kit consisting of 10 flash cards that is used by the LRPs and the AWW to counsel households and for training purposes.

Positive Deviance (PD). Under PD, the main idea is to identify and share the best nutrition and health practices that exist within the community through initial formative research, which is conducted in participation with the community. The focus is on identifying those practices that are leading to better outcomes for families that are in the same economic conditions. Once these practices are identified, behavioral change is emphasized through participatory learning and community mobilization to bring about the desired results. PD was introduced to accelerate the process of reduction and prevention of under-nutrition among children in the age group 0-3 years by enabling communities to adopt the best local practices of childcare on a sustained basis. PD acts as an improvement tool for ICDS to improve the process and outcomes. Currently, it is operating in 24 blocks in West Bengal, targeting children under three and their mothers.

***Anchal Se Angan Tak* (ASAT).** ASAT focuses on improving the knowledge and skills of mothers, caregivers, family members, and community and service providers. It takes a life-cycle approach and addresses women, children and adolescent girls. This program enhances the existing ICDS structure by additional components at the village, district and state levels to reduce malnutrition. ASAT introduced a new cadre of local volunteers at the village level named *Gram Sampark Samooh* (GSS). At the block level ASAT has constituted a Block Support Team. Its role is to assist the staff at the block and village levels to implement the program. At the district level, ASAT has added a District Mobile Monitoring Training Team (DMMTT) to monitor progress and provide on-the-job guidance to village teams. A District Support Team (DST) improves coordination between sectors, reviews overall progress, and ensures effective implementation across the district. A State Level Training and Monitoring Unit has been formed. This is four-member team headed by the ASAT Nodal Officer in Charge, Training and Monitoring. Three officers work under the supervisor, focusing on the field level. The Mamta Card is used to monitor the progress of children. The MIS system has been improved with new tools.

Community-Managed Health and Nutrition Interventions. *Indira Kranthi Pratham* (IKP), which is implemented through the Society for Elimination of Rural Poverty, Andhra Pradesh (SERP), has an innovative platform for nutrition education through its community-managed health and nutrition interventions, which are centered on an enterprise model of nutrition-cum-daycare-centers (NDCC). These centers are a "one-stop shop" for access to nutrition, reproductive, and child health services. They provide a balanced diet to pregnant and lactating mothers and children, provide daycare for children, implement community gardens, and bring together the work of various line departments of the government on this topic (and others). The services of the center are available for a fee that the mother can finance through micro-credit; at the same time the center can be a source of employment for

pregnant and lactating mothers. These NDCCs also provide nutrition (and health) education to communities (including mothers and mothers-in-law) through daily discussions under their Nutrition and Health Education component. As with all SERP interventions, the NDCC is also implemented through the social capital they have built of SHGs and their federations.

In addition to NDCC, this integrated program includes fixed Nutrition and Health Days for regular ICT-enabled growth monitoring, social auditing of nutritional outcomes, and health institution building, which focuses on water and sanitation and on curative care through case managers. Financing and service delivery is another component that includes microfinance products for nutrition (to pay for meals at NDCC), health investment funds, health insurance, community owned pharmacy and hospitals.

The core strength of the IKP model is that it improves the partnerships between nutrition and health facilities and the communities, has continuous capacity building of peer groups and community workers, involves other community institutions and champions to engage in health and nutrition education, and uses a community investment fund to finance its activities.

6.2.3 INNOVATIVE FEATURE

ASAT's key innovation appears to be the additional level of monitoring through the Mamta Card and district level monitoring. Dular's innovation is the local resource person who is armed with flash cards and tools to monitor adolescent girls. The PD approach is applicable to all community- based nutrition programs. It introduces an initial Positive Deviance analysis to identify with active community participation the practices associated with positive outcomes and then uses these as the basis for scaled-up programs.

The key innovation of IKP's NDCC program is that it is community-owned and -managed, is fee-based, and relies on continuous interaction of the community with the trained community resource person.

6.2.4 TECHNICAL AREA

The primary contribution that multi-sectorial nutrition education will make is to IR4 - Improved Nutritional Status of Women and Adolescent Girls.

6.2.5 CONSTRAINTS ADDRESSED

The main constraint addressed by this BP is access to information on nutrition.

6.2.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

This BP is applicable to any geography.

6.2.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- Society for Elimination of Rural Poverty, Andhra Pradesh
- CINI, West Bengal
- Various NGOs, and state-level ICDS units

Technical Partners:

- UNICEF
- ICMR
- Ministry of Child and Women Welfare
- World Bank, SUN Initiative
- SAFANSI

6.2.8 EFFECTIVENESS

In the nutrition literature there is consensus on the types of messages that need to be relayed to households, whether it is about the need to take deworming pills, feeding practices for mother and child, or breastfeeding. Furthermore, there are multiple routes through which the nutritional outcomes of a household can be affected, including their access to safe drinking water, disease burden, availability of food, and various other socio-economic factors that may not be under the scope of a given nutrition education program. Often the effectiveness of nutrition education programs is measured by the extent to which the targeted communities demonstrate improved nutrition behaviors. Measuring the impact of nutrition education programs on anthropometric outcomes can be difficult, because there are numerous external factors that can affect the final outcomes, such as access to clean drinking water and the disease burden. This increases the importance of rigorous evaluations that carefully develop the counterfactual comparison group (to measure what would have happened if there was no program).

The Impact Evaluation Group (IEG) at the World Bank has recently published a document (IEG nutrition study, 2010)[36] that summarizes the learning from impact evaluations on nutrition programs (including nutrition education programs), and cites only one rigorous impact evaluation of nutrition programs in India (Gupta, et al. 2005).use a rigorous quasi-experimental evaluation design on NHFS data between 1992-1993 and 1998-1999; they find no impact of ICDS on nutrition outcomes. They link this result to regressive program placement such that states with the highest prevalence of child malnutrition had the lowest coverage by the program and receive the lowest funding for it. Within states, the distribution seems to be more progressive but likely suffers from poor implementation.

Each of the three best practices identified by ICDS—Positive Deviance, Dular, ASAT—and SERP's nutrition and health program have all been evaluated. It is not always very clear, however, from the evaluation designs if the counterfactual was carefully chosen, which determines the rigor of the evaluation. The final evaluation of Dular (unpublished report) uses a control group that appears to have been randomly chosen (Bassett et al., 2005). This evaluation finds a significant difference in underweight outcomes (55% versus 65% between Dular and non-Dular villages) and in stunting outcomes (62% versus 72% between Dular and non-Dular villages).

ASAT does not appear to have been rigorously evaluated. The 2007 evaluation did not have baseline information and did not use either randomization or quasi-experimental methods to develop a control group (McDonald et al., 2007). The tabulations of basic household characteristics reveal that these characteristics differ systematically across the control and the treatment groups. For example, the control and treatment groups on average are different in terms of land ownership and mother's education, which have a significant impact on nutritional outcomes. This means that nutritional outcomes can be different across these groups systematically, and their response to the intervention may also differ. This means that any comparison of treatment with control will not measure the pure effect of the ASAT program. Given these caveats, the evaluation finds that ASAT only had an impact on stunting among the anthropometric indicators, the improved breastfeeding practices, the complementary feeding practices and the hand-washing practices of mothers.

The IEG nutrition study notes that to improve nutrition programs, the evaluations need to consider not only whether the programs worked, but under what conditions they worked, whether there were differential impacts based on gender, age and income status, and *what part of the program worked.* To the extent that the Dular, ASAT and Positive Deviance are all "overlays" to the ICDS program, the

[36] World Bank, 2010, "What Can We Learn from Nutrition Impact Evaluations? –Lessons from a Review of Interventions to Reduce Child Malnutrition in Developing Countries."

evaluations do assess whether these overlays had an impact. However, the rigor of these evaluations is not comparable. Finally, the IEG nutrition study also calls for assessing the cost of the programs, which ICDS appears to do quite well. Mason et al. report the cost of ICDS to be approximately $2/per child/per year (Mason et al., 2006). The comparative cost of implementing Dular, and ASAT are listed below.[37]

Dular: $273 per anganwadi center (AWC) for the first year above the regular ICDS budget, $173 recurring in subsequent years, which amounts to 13% and 10% more than the ICDS budget in the first and subsequent years. The cost takes into account technical support, trainings, meetings and the required materials.

ASAT: $295 per anganwadi center (AWC) for the first year above the regular ICDS budget, $240 recurring in subsequent years, which amounts to 13% and 11% more than the ICDS budget in the first and subsequent years. The cost takes into account technical support, trainings, meetings and the required materials.

Positive Deviance: The average cost of positive deviance was estimated at $442 per AWC per year. This is based on a 3-year CINI project that supported 96 AWCs.

To the best of our knowledge, no rigorous evaluation of NDCCs has been conducted. Their program literature suggests that an external evaluation was completed, but the results are reported only for NDCC beneficiaries after the program, so at best these results can be compared with the district or state average of those areas for the same indicators. In terms of cost-effectiveness, the NDCC model seems to be more sustainable. As compared to AWCs that cost Rs. 11,5200 per year every year (according to IKP's estimate), NDCC only need a one-time fee of Rs. 350,000, which includes a Rs. 250,000 corpus fund for loans. However, they note that an NDCC serves 30 beneficiaries, while an AWC benefits 80 beneficiaries. In addition, NDCCs have a recurring cost for capacity building that is not provided.

6.2.9 SCALABILITY

All nutrition education programs require public resources for scaling up; therefore resources can be a constraint in scalability unless there is both political will and donors that can support the initiatives. Leaving aside the need for resources, these programs require a cadre of community workers that need to be trained to carry out the program. They build on a large institutional infrastructure and have a fairly complex implementation strategy. In the case of NDCC, the model builds on its existing social capital of SHGs, its federations and a strong cadre of community workers. If there is already an existing nutrition education program, then these innovations can be potentially scalable as overlays to the programs. For example, existing SHG networks can be used to start NDCC programs.

6.2.10 TRANSFERABILITY

Mason et al. make an interesting point, namely, that contextual factors have a significant impact on community-based health and nutrition programs, and therefore impact their transfer to new areas. They suggest five contextual factors that need to be assessed in determining the impact (and transferability) of such programs: women's status and education, lack of social exclusion, community organization, literacy, and political commitment (Mason et al., 2006). They emphasize that any changes in these factors can improve outcomes without any direct action. They develop indicators along these factors to assess the impact of various community nutrition and health programs, including ICDS. They make these important points:

[37] Annual Report, ICDS, 2010-2011.

1) If the assessment along these contextual factors (women's status, social exclusion, community organization) is poor, then resources may be better spent in improving the contextual factors. As a corollary, investments should be targeted in areas where the contextual factors are favorable.
2) Even if all the social contextual factors are favorable, political will is important for success, and it may need to come from within the country (e.g., Thailand's case).
3) Economic and political factors can impact the outcomes of the program.

Conditions for success. All these approaches require strong political or donor commitment that provides the resources to implement the programs. They require strong local-level organizations and NGOs to develop and train community workers. Successful programs will need local knowledge to understand the current constraints and other socio-cultural factors that will affect the efficacy of the program. In the case of NDCC, an existing network of SHGs will be needed to fully implement the enterprise model, which requires initial capital.

Mechanisms of transfer. From India, the relevant coordinators for Dular, Positive Deviance and ASAT will be the obvious choice of people who can help in the transfer. For NDCC, SERP will be the champion.

6.2.11 RELEVANCE

These best practices are relevant to FARMS because it is intended to impact the nutritional status of women, young children and adolescent girls.

The primary contribution of multi-sectoral nutrition education will be to IR 4 - Improved Nutritional Status of Women and Adolescent Girls.

6.2.12 SUSTAINABILITY

The three ICDS programs are not financially sustainable, in that they require sustained funding for continuation. The NDCC program requires an initial capital outlay, after which it has a largely sustainable model that requires additional funding but not to the full amount of their initial activities. Ultimately the sustainability of NDCC will depend on the value it generates for the women. Because it provides food and daycare for the children, it may be attractive to women.

6.2.13 POSSIBLE ACTIVITIES FOR FARMS

The eventual BP nutrition education pilot will be selected based on input from experts at the FARMS nutrition thematic workshop and other stakeholders. Currently, Positive Deviance appears to be an interesting approach to enhance the effectiveness of existing nutrition education programs. Initial formative research, which is conducted in participation with the community, can help the program identify the existing behaviors and practices that are leading to better outcomes for families that are in the same economic conditions. In addition, PD analysis can be integrated in an evaluation design to understand what elements of the intervention had the largest impact on nutritional outcomes, controlling for household income status. For example, Levinson et al. (2007) conducted a positive deviance evaluation of a Dular program and identified interventions that had a measurable impact on nutrition outcomes among households with a similar economic and social environment (Levinson et al., 2007). FARMS can consider expanding PD pilots in FARMS geographies and evaluate them rigorously for their cost-effectiveness and impact. The evaluation can assess the core benefit of the program assess whether just conducting the positive deviance analysis provides the core impact of the program.

A second possibility for a FARMS pilot BP is to implement NDCC in areas where there is an existing SHG structure, and perhaps in areas where other community-based structures are strong. FARMS would assess the sustainability and impact of NDCC, and how the existing community structure affects impact. An interesting aspect of NDCC is that it has the potential to impact women's participation in agriculture and increase yields. It would be interesting to measure this and build knowledge on the impact a nutrition activity has on agriculture, providing an RCT can be implemented.

Third, given that Dular, ASAT and Positive Deviance are all pilots to enhance nutrition education, it could be useful to conduct a rigorous comparative assessment of the comparative costs and benefits of these programs. This would develop a more detailed understanding of the specific context in which any of these alternatives is successful and provide information on which programs are most suitable for scaling up within ICDS.

Since ICDS is a very complex program with a long history of implementation, before conducting any activity in this area, FARMS will conduct a nutrition thematic workshop to identify its core value-added and the key questions for evaluation.

6.3 MICRONUTRIENT FORTIFICATION IN STAPLES

6.3.1 SUMMARY

Fortifying staple foods with micronutrients means adding iron, vitamin A or some combination of such micronutrients to foods like rice, wheat or edible oil, usually during processing. Fortification at the industrial level is not new, and there are specific combinations of micronutrients and staples where it has been very successful. India's food rationing program, the Public Distribution System (PDS), has moved into distributing fortified wheat flour instead of wheat grain in several states. The Cargill Nourishing India program claims to reach 25 million consumers with edible oil fortified with fat-soluble vitamins including vitamin A. Fortification in small, local mills has not yet been successful and sustainable at acceptable levels of quality.

Fortification of cereals has generally been successful in the milling process, where a micronutrient "premix" is incorporated into the ground grain. By contrast, Ultra Rice[38] creates a micronutrient-dense look-alike grain that is mixed into whole grain rice--quite a different approach. Tests of fortification at small-scale mills and of Ultra Rice are both underway in India.

Some gaps in the FARMS team's current knowledge about micronutrient fortification of staples in India are:

- It is not clear to what extent India's PDS reaches the poor in rural areas.
- It is not clear if the unsubsidized economics of Ultra Rice or its private market feasibility have been studied yet.
- It is not clear if the Cargill Nourishing India program operates profitably or if Cargill is implicitly providing a subsidy to these consumers. At the scale of 25 million beneficiaries, one imagines that the subsidy would be small or zero.

Among several possible activities for FARMS, the most likely seem to be pilot testing or scaling up Ultra Rice, evaluation of a state-level program to improve implementation, and evaluation of a flour fortification program at small scale.

6.3.2 DESCRIPTION

The FARMS Task Order mentions that "General malnutrition and specific micronutrient deficiencies contribute to infant, child and maternal morbidity; decreased learning capacity; lower productivity; and higher mortality. Studies show that stunted children lose years of education because they enter school at later ages. Anemia causes 19% of all maternal deaths in India. Some 33% of infants are born with low birth rate due mainly to poor nutritional status of the mother. An estimated 70% of Indians are affected by iron deficiency anemia, and 40% are at risk of iodine deficiency disorders."

Fortification and supplementation are two primary ways of reducing micronutrient deficiencies. Fortification is the delivery of micronutrients via incorporation in food. It includes biofortification, which incorporates micronutrients through breeding; mass fortification, which does so during milling or through other centralized processes; and home fortification, which envisages the use of fortificant sprinkles or sachets by the consumer. By contrast, supplementation is the delivery of micronutrients via pills or drops, or in other non-food forms.

[38] Ultra Rice is a trademark of Bon Dento International, Inc.

According to the Innocenti report (August 2009), the already known successes in scaling up micronutrient programs are: 1) Preschool vitamin A supplementation, and 2) Some mass fortification programs, namely, salt iodization, vitamin A-fortified sugar, and folic acid-fortified wheat flour. Programs that still needed further confirmation are: 1) Maternal iron and folic acid supplementation, and 2) Iron fortification programs. Some newly emergent programs are: home based fortification, zinc treatment for diarrhea, and poverty reduction strategies.

In addition some members of the FARMS team met with representatives of EarthSpring, a US company which has a process for improving the bioavailability of iron and other micronutrients in legumes like soybeans. If this process works cost-effectively with all legumes (including pulses like *dal),* as EarthSpring believes it would, the use of this technology in India might be revolutionary.

Addressing iron deficiency anemia is extremely challenging, especially among poor populations that cannot afford better sources of iron like animal-source foods. Many plant-source food contain inhibitors to iron absorption, so even though these foods may contain important quantities of iron, their consumption will generally not lead to significant absorption of usable iron. According to Dr. Omar Dary, writing in The Guidebook, Nutritional Anemia (p 43) (Badham et al., 2007) "iron is a difficult nutrient to be provided through mass fortification, especially for satisfying the needs of women of reproductive age. Therefore, targeted fortification and preventive supplementation should be kept in mind for the comprehensive management of nutritional anemias." It is also well known that anemia can be the joint result of health status, sanitation, malaria, worms, and other factors. Thus attacking any one aspect of anemia, like inadequate intake of iron, may not be sufficient to make a measurable impact.

This best practice assessment covers fortification of staples because there could be potential food-based approaches that would be relevant to FARMS. Supplementation is a well-known strategy that is not food-based, so it is not considered as a candidate best practice for FARMS. In implementing any fortification strategy, however, it is important to be aware of all strategies being implemented in the micronutrient and geographic areas.

Centralized wheat flour fortification in India. Flour fortification, which entails mixing micronutrients into wheat flour during milling of the grain to flour, is common in developed and other countries. Centralized wheat flour fortification is also ramping up in India, mostly through the efforts of state governments; it is currently being carried out in at least ten states, including West Bengal, with Bihar just starting. Gujarat was the early starter. Fortification is so far voluntary, with the exception of Tamil Nadu, where it is now apparently mandatory (Kotecha, 2011).

In Gujarat, there is an iron and folic acid fortification program using private mills (Gujarat State Civil Supplies Corporation Limited (2011)). This program is being implemented in the open market and in the Targeted Public Distribution System. In addition in Gujarat, since about 2006, nine micronutrients have been added to the food provided by ICDS to accomplish the supply of 50% RDA to the beneficiaries. This program provides whole wheat flour fortified with nine micronutrients in place of wheat. A pilot project was started in 2006 in Daskroi Taluka of Ahmedabad District. As of 2011 fortified wheat flour is being distributed in all the districts of the state and approximately 40,000 *anganwadis* are benefiting.

Wheat flour fortification at small mills and in households in India. Gujarat is also piloting wheat flour fortification at small mills (Gujarat State Civil Supplies Corporation Limited (2011)). This is an open market program. Under it 34 flour miller members of GRFMA initiated the sale of iron and folic acid-enriched flour in the market in January 2006. In addition however, about 50 organized *atta chakki* plants across the state were incorporated in the project since March, 2006. Iron and folic acid

premix pouches were introduced in the market in order to encourage fortification at the *nookad chakki* level, as well as at the level of the households that grind their own wheat.

Vitamin A fortification in India. According to the FARMS Task Order, Cargill's Nourishing India program fortifies all of Cargill's refined oils with 40% of the recommended daily allowance (RDA) of vitamin A, a 16% RDA of vitamin D, and a 5% RDA of vitamin E. Cargill reaches about 25 million people in India through this program.

In Gujarat, there are programs that provide vitamins A and D in oil for targeted distribution. Initially, edible oil fortified with vitamins A and D was produced in two oil mills in Rajkot. After analyzing the success of this venture, it was decided by the millers, producers and refineries to sell only fortified edible oil (from February 2006). There is a ban on the sale of loose edible oil. The edible oil consumed under all government schemes like the Public Distribution System, the Mid-day Meal scheme and the Integrated Child Development Scheme is fortified with vitamins A and D (Gujarat State Civil Supplies Corporation, 2011).

Iron fortification in India. Ultra Rice is a pasta product that contains a high concentration of micronutrients. It has various desirable properties for combatting micronutrient deficiencies. Ultra Rice grains are designed to look exactly like locally acceptable rice. They are mixed into batches of unfortified rice at prescribed dosages to achieve the target level of fortification. The intellectual property rights to Ultra Rice are owned by PATH, which has conducted some tests of efficacy in India. PATH partnered with Naandi, GAIN and the local manufacturer of Ultra Rice, Swagat Food Products, to conduct an iron-targeted pilot and efficacy study, which was implemented in Andhra Pradesh. It has conducted similar trials in Brazil and Mexico. [39]

6.3.3 INNOVATIVE FEATURE

The main feature of fortification is adding nutrients to foods to enhance their nutritional value. This in itself is not considered innovative. Ultra Rice should be considered an innovation, in that it creates a totally different type of vehicle for fortification, one that mimics the grain into which it is mixed. Any program that created a sustainable way to reliably fortify staples at small, local mills would also be innovative, as that has not been accomplished yet in a sustainable fashion.

6.3.4 TECHNICAL AREA

Best practices in micronutrient fortification in staples are targeted primarily at improving nutritional status. They also contribute to agribusinesses' making better use of knowledge.

6.3.5 KEY CONSTRAINT(S) ADDRESSED

Access to nutritious diet.

6.3.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

Food fortification programs are generally not geography-specific, but program details might make access in some locations, like rural areas, more difficult than in other areas.

6.3.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

The federal government of India and several state governments have considerable experience in fortifying flour and other foods and distributing them through different government programs. PATH is the owner of the rights to Ultra Rice and has considerable knowledge about its use. The world and

[39] Since October 2009, fortification of salt with iodine has also been carried out in Gujarat under the ICDS and PDS programs.

Indian nutrition communities have vast knowledge on fortification, and it would be somewhat presumptuous to single out only a few organizations or individuals on a topic this large.

6.3.8 EFFECTIVENESS

To date, many large-scale iron fortification programs have failed to demonstrate a measurable impact on anemia prevalence because they used iron fortificants with low bioavailability and/or because consumption by the at-risk population was low. More evidence is needed from iron fortification programs using bioavailable forms of iron (Klemm et al., 2009).

Despite significant progress in India, there is "no sustainable mechanism to introduce fortification in small *chakki* mills operating in villages," according to Dr. Subratta Dutta, coordinator of the India Flour Fortification Network. There are some pilots underway to bring fortification to the local level, among them by CARE under a Title II program. A local program in Udaipur implemented by Seva Mandir and evaluated by JPAL was basically a failure.[40] An NGO was critical in making the premix available, but there seemed to be no behavior change communications (BCC) campaign, and the uptake fell off after the program ended.

According to Dr. Omar Dary, writing in The Guidebook, Nutritional Anemia (p 42) (Badham, Zimmermann and Kraemer 2007), "The low cost of using mass fortification only holds true in industrial settings where the product is produced by formal, centralized production centers." Quality control is also much easier at these scales. As Dr. Dary writes, "Success of any intervention depends primarily on ensuring that the target population/s receive the micronutrients in the amount and quality required. This makes quality control and assurance actions by producers, and inspection and enforcement by governmental authorities, essential." Another issue in efficacy is that "The content of vitamin and minerals is determined by the individuals who consume the food in large amounts, and hence the additional supply of micronutrient given to the most at-risk individuals, frequently consuming the food in lower amounts, may be insufficient using only one fortified vehicle." Finally, "technological barriers might limit the levels and forms of micronutrients in specific vehicles due primarily to undesirable organoleptic [taste, color, odor, and feel] changes. This is the main limitation to supplying sufficient amounts of iron through fortified flours." These issues, taken together, make it extremely difficult to sustain a high-quality fortification program at small scale.

There are three micronutrient premix manufacturers in India. Fortification expert Dr. Omar Dary has raised some concerns about the possible poor quality of these products.

If the rural poor in India got their wheat from the PDS, then fortification that reached the poor would not be too difficult to implement: it could be done through the PDS. It is not clear to what extent the PDS actually reaches the poor in rural areas.

PATH and its partners in India claim easy and cost-effective blending of Ultra Rice in centralized kitchens, and even more consistent blending results in mills. Consumption of the fortified cooked rice is said to lead to higher serum ferritin levels in children and lower morbidity (PATH 2010 powerpoint by Hariprasad/Galloway). Acknowledged variable results in kitchens seem to confirm the supervision/quality control issue mentioned by Dr. Dary. A presentation by Dr. Glen Maberly at the World Bank on March 3, 2011 cited data showing that the retail price increase in India resulting from the use of cold extrusion methods of rice fortification (like Ultra Rice) would be in the vicinity of 2 percent, which is a figure similar to those he presented for China and Costa Rica for the same technology. However it is not clear what scale of operation is assumed in deriving this figure.

Beyond the studies and assessments cited above, the FARMS team is not at this writing aware of any evaluations of staple fortification programs either in India or that would be directly relevant to India.

6.3.9 SCALABILITY

Centralized (industrial) fortification of flour and other products has been successful at scale in many countries. Fortification by small, local mills is looked on with skepticism, in particular because the cost of supervision to maintain quality might be prohibitive at scale.

A producer of Ultra Rice would require some minimum scale of operation to be profitable, but the FARMS team does not know what that level is. If Ultra Rice were blended into normal rice at a centralized facility at large scale, quality control would not seem to present a significant problem. If the blending were in smaller kitchens, then scalability would apparently be more of a challenge.

6.3.10 TRANSFERABILITY

There is no inherent reason why successful fortification programs could not be transferred from one area or country to another. This would apply to Ultra Rice, since it does not rely on resources difficult to obtain; PATH is committed to distributing the technology to countries that can make good use of it. The proliferation of programs in Gujarat may depend on its political leadership, but this does not seem to be an important requirement. Programs implemented under the banner of corporate social responsibility might not be available in other areas or countries. Fortification programs in India that rely on the Public Distribution System, a food rationing system with a very long history, might not be transferable to another country if the other country did not have a similar vehicle for the program. From the point of view of transferability, small-scale programs seem the more relevant pilot activity, although they suffer from skepticism on other grounds.

6.3.11 RELEVANCE

Staple fortification programs are highly relevant to FARMS, as they are food-based and strive to improve nutrition.

6.3.12 SUSTAINABILITY

Fortified foods that are sold in an open market without any subsidy would seem to be the most sustainable type. India's PDS has been in operation for a very long time and does not seem about to go out of operation, so food fortification through the PDS would seem to be highly sustainable in India. In general the cost per person of fortification is probably very small compared to the other subsidy costs involved in the program. Sustaining a food fortification program operated at the level of small mills seems to be the least sustainable option.

6.3.13 POSSIBLE ACTIVITIES FOR FARMS

Further investigation will be necessary before FARMS can determine whether there is an Indian best practice for piloting and evaluation or any intervention that could be usefully evaluated by FARMS. Some candidates are:

- Cargill's Nourishing India program: it is already fairly large in the market; would any type of evaluation be useful?
- Ultra Rice: it seems to be at a good stage for pilot testing or scaling up.
- Evaluation of a state public sector program: this might be useful to assess implementation.
- Evaluation of a state public-private partnership program: this might be useful to examine what drives success or failure.

- Evaluation of a flour fortification program being tested at small scale, if any: to be useful this would have to help answer lingering questions about cost-effectiveness and quality control.

7. BEST PRACTICES HELPING AGRICULTURAL SYSTEMS ADAPT TO CLIMATE CHANGE (IR 5)

This chapter presents the assessments of potential best practices that primarily contribute to IR 5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes.

7.1 CONSERVATION AGRICULTURE

7.1.1 SUMMARY

Conservation agriculture is a combination of agronomic practices that seeks to maximize the efficiency of use of inputs and natural resources such as soil, water, seed, fertilizer and fuel. India is pioneering an effort to adopt and adapt conservation agricultural practices in the Indo-Gangetic Plains. It falls within the mandate of FARMS to conduct rigorous evaluations that determine the economic viability of these practices for the farmers that adopt them and their actual effectiveness in conserving agricultural resources. We may do so after further consultation with CSISA and USAID/India and if a need for this research is determined.

7.1.2 DESCRIPTION

Conservation agriculture (CA) has 3 basic principles: 1) Minimal soil disturbance, 2) Leaving crop residue on the surface, and 3) Crop rotations that build soil and maximize yields. Conservation agriculture is about increasing factor productivity and using all agricultural resources efficiently. Conservation agriculture in India is many integrated good agricultural practices. The most notable one is zero till/low till, but it also includes other aspects of soil building and water conservation, such as: direct-seeded rice, surface-seeded rice, precision laser land leveling, furrow-irrigated raised-bed (FIRB) cultivation, crop residue management, crop diversification, intercropping, advanced crop rotations, and increasing fertilizer use efficiency.

The individual best practices may be applicable in multiple geographies, but not all geographies. The degree, manner and ways in which they are combined to create improvements in efficiency will also vary across geographies; thus conservation agriculture is not a single best practice, but a number of practices combined in a way that is appropriate for each agro-climatic zone and for the cropping systems in which the practices are introduced.

The main goal of conservation agriculture is soil conservation and soil building. By minimizing tilling and maintaining ground cover of either live plant material or crop residue, one can greatly reduce wind and water erosion of the soil, while also increasing the soil organic matter, the microbial activity within the soil, the nutrient availability of the soil, and the soil water retention capacity. Improved water retention capacity has a specific benefit in rainfed systems prone to low rainfall or droughts. When comparing

organic systems to conventional systems, the Rodale Research Institute found that the increased soil organic matter in the organic system led to much greater yields than conventional systems in exceptionally low rainfall years (Figure 3). This has implications for climate change adaptation (and also for mitigation). Many of the climate change adaptation strategies are based on finding systems and methods that are resilient to droughts. Conservation agriculture provides that benefit. Increasing soil organic matter is also a means of achieving greater carbon sequestration. It has been shown that soil can absorb about 1 MT of carbon per hectare per year in systems where green manure and aged cow manure is used to amend soil nitrogen (Pimentel et al., 2005).

FIGURE 3: CROP CONDITIONS IN EASTERN US IN 1996, A LOW RAINFALL SEASON

Conservation agriculture can therefore increase factor productivity, increase yields and improve the management of natural resources. It can lead to reduction of mineral fertilizer use, reductions in water requirements and reduced amount of fossil fuel usage (since low/no till reduces the time and energy expended on tractor usage).

Conservation agriculture as it is practiced today, however, has some drawbacks that are more or less important depending on the agricultural systems and the types of farmers who apply its techniques. They are as follows.

1. Almost all systems today require a relatively high degree of mechanization.
2. Many systems require fairly extensive herbicide usage, creating a potential ecological cost. This cost is thought to be minimized when only glyphosate, a relatively benign and short half-life herbicide, is used, but most systems require the use of other more environmentally damaging and persistent herbicides, e.g., paraquat (Bissdorf, 2008) in order to avoid building weed resistance.
3. The system must be adapted to each agro-climactic region; thus there is no universally applicable system of conservation agriculture.
4. The systems sometimes require a high degree of precision in the timing of sowing, herbicide application and harvesting. The practice may be rather complex, and this degree of precision can pose a constraint to the application of CA methods, especially by smallholders.

7.1.3 TECHNICAL AREA

This best practice primarily improves natural resource management and can be considered a climate change adaptation strategy, but it also can increase agricultural productivity.

7.1.4 INNOVATIVE FEATURE

Conservation agriculture takes a new approach to producing crops that reduces input usage (water and fertilizer), while also increasing yields, especially under drought conditions.

7.1.5 CONSTRAINTS ADDRESSED

Conservation agriculture addresses the lack of technology to both build climate change resilience and maintain productivity, and it alleviates the constraint of limited water availability.

7.1.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

The principles of conservation agriculture can be applied to most agricultural systems, but the specific techniques must be adapted to the agro-ecological zone in which they are to be applied.

7.1.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

- In India the CSISA program, implemented by IRRI, CIMMYT, IFPRI and ILRI, is the primary resource for conservation agriculture practices. It has, however, developed partnerships with over 300 private sector firms and government entities that provide services related to conservation agriculture.
- The Punjab Agricultural University is conducting research on conservation agriculture and is testing new forms of mechanization related to the wheat-rice system.
- Dr. M. S. Swaminathan is a major proponent of conservation agriculture and possibly the most highly respected voice in the world on agriculture.

7.1.8 EFFECTIVENESS

Effectiveness. The main goal of conservation agriculture is soil conservation and soil building, and most of the practices are geared towards achieving this goal. Furthermore, CA strives to conserve water, fossil fuels and all agricultural inputs without reducing yields relative to the traditional or conventional systems.

Most CA systems succeed in in achieving this goal, but many of the CA systems greatly increase herbicide usage.

Impact. Studies on CA in Brazil have shown that the primary impact of CA techniques is to reduce the amount of labor required for cultivation by 68% (de Melo, 2000) In India CSISA claims that zero-tillage increases farmers' profit by $50-$70/Ha.[41]

In systems where water is paid for or the electricity to pump water is paid for, the reduced costs to farmers using CA would potentially be much greater than in situations where just labor costs are saved.

Cost-Effectiveness. Introducing CA techniques to a community of farmers can require significant project resources. As each set of practices must be adapted and refined for each new farming system, there is less benefit to increasing scale than with other best practices.

However, once the system is in place, once farmers are well versed in the techniques, and once custom hiring opportunities for small farmers have been established, the spread of the technology within a fairly well circumscribed geographic range (a 50-75 mile radius) could well be spontaneous.

[41] Tillage and Crop Establishment; Fact Sheet. CSISA, 2011.

7.1.9 SCALABILITY

Conservation agriculture is applicable in many farming systems, but must be adapted to each new farming system. The principles will be differentially effective, depending on the system. Current practices in CA require a high degree of mechanization, extensive herbicide usage and precise adherence to an agricultural calendar. All of these factors can limit the number of situations in which it can be applied.

CA is not highly scalable.

7.1.10 TRANSFERABILITY

Conditions for success. Conservation agriculture requires quite radical changes in a farmer's cropping system and agricultural practices. From the perspective of development programs, this requires a considerable investment in time and financial resources to bring about adoption.

In (Landers, 2001), several of the preconditions required for adoption of zero-tillage are listed. They apply to CA systems in general.

1. A predisposition for fundamental change and an awareness that long-term benefits will outweigh the short-term ones, which are usually positive but may show no immediate advantages over conservation tillage.
2. Correction of soil chemical and physical properties limiting maximum plant growth.
3. Gradual and planned adoption over several years.
4. A planter or seed drill specifically adapted for zero till, or a new specialized model must be available.
5. Overhaul of the farm sprayer and fitting of new nozzles.
6. First planting in an easy situation and on less than 10% of total area.
7. Avoidance of areas with troublesome perennial weeds.
8. Availability of technical assistance, even if only from an experienced neighbor.

Mechanisms of transfer. There are many proponents of conservation agriculture both in India and in Africa. IRRI and CIMMYT work on both continents and could therefore serve as a transfer mechanism.

7.1.11 RELEVANCE

Conservation agriculture increases farmers' gross margins, increases yields (in some cases), uses natural resources more sustainably and creates more climate-resilient systems. For all of these reasons, CA is highly relevant to the FARMS program.

However, unless custom hiring options are in place, the application of CA techniques will be more applicable to medium-sized and large farmers as opposed to the poor, small farmers who are the primary target beneficiaries of FARMS.

7.1.12 SUSTAINABILITY

Although there is a fairly high barrier to entry in getting farmers or communities of farmers to adopt CA techniques, once adoption takes place, the application of these techniques is based on economic incentives.

Policies that put a proper price on natural resources and that compensate farmers for developing climate-resilient agricultural systems and/or for sequestering carbon in their soils can increase the adoption rate and sustainability of conservation agriculture techniques over time.

7.1.13 POSSIBLE ACTIVITIES FOR FARMS

The FARMS team is probably best placed to conduct an evaluation of the economics of CA in India, but we have yet to discuss this possibility or need in great detail with the management of CSISA.

FARMS may target the integration of a carbon accounting tool within the ICAR's NICRA program, and we are capable of applying a similar system to monitor and account for the carbon stored on all lands managed under conservation agriculture principles.

7.2 LASER LAND LEVELING

7.2.1 SUMMARY

In the resource-constrained regions of South Asia, which are home to almost half of the world's population, there is a need for adopting natural resource-conserving technologies and practices in both rainfed and irrigated regions. There are also pressures from the diversion of water and other resources for non-agricultural use. Current practices for growing rice and wheat in these regions are very water-intensive.[42]

Laser-assisted precision land leveling is a water-conserving technology. It has been traditionally practiced in western countries, which have large fields for mechanized cereal production, but the Cereal Systems Initiative in South Asia (CSISA) program has reduced the cost of laser land leveling and made it accessible to smallholder farmers. A level farm field improves water-use efficiency, reduces irrigation time, reduces soil erosion, eliminates puddle formation, promotes even crop height[43], decreases weed burden and encourages the even maturing of crops. This is nearly a transfer-ready best practice that may have implications for several African regions. FARMS will transfer this technology to Africa if and when appropriate.

7.2.2 DESCRIPTION

Laser-assisted precision land leveling is that act of moving soil from high portions of a field to low areas to achieve a level field with less than a 2% difference in height between any two locations. It permits for the even and rapid distribution of water from flood-type irrigation systems. The soil is moved progressively from high to low areas using a bucket drawn by a tractor. The bucket alternately picks up soil from the higher portions and drops it in the lower portions of the field. A laser beam, set at the average height of the field, is transmitted by a stationary laser transmitter on a tripod outside the field. The height of the bucket is controlled by a hydraulic valve that raises or lowers the bucket guided by the laser beam receiver. The bucket is usually drawn by a four-wheeled tractor with adequate power, typically 30 to 100 hp in Asia.

The field is leveled by driving the tractor along circular paths, moving the bucket along with soil as soon as it is nearly full to regions where the soil has to be deposited. A twice-leveled field should not require leveling for another eight years. If there were previously bunds or levees in the field to demarcate ownership or variably water parts of the field, they are repaired after the land is leveled (Rickman, 2002).

7.2.3 INNOVATIVE FEATURE

The key innovation here is making laser leveling adapted and affordable on small-scale farms, whereas before it was primarily practiced only on the expansive commercial farms in the United States and elsewhere. Laser land leveling, with the innovations developed in India, are now practical for farms as small as 0.5 ha. Adaptations have been made that allow two-wheel tractors to perform the leveling.

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[42] "The average difference in height between the highest and lowest portions of rice fields in Asia is 160 mm. This means that in an unlevelled field an extra 80 mm to 100 mm of water must be stored in the field to give complete water coverage. This is yearly an extra 10 percent of the total water requirement to grow the crop." Chia, Raymond. Laser Land Levelling. The Global Magazine for Leica Geosystems.

[43] "Unevenness of the soil surface has a major impact on the germination, stand and yield of crops through nutrient water interaction and salt and soil moisture distribution pattern." Rickman, J.F., 2002. Manual for laser land leveling, Rice-Wheat Consortium Technical Bulletin Series 5. New Delhi-110 012, India: Rice-Wheat Consortium for the Indo-Gangetic Plains. pp.24

Laser leveling in India is often offered as a custom hire service and managed by entrepreneurs who have been shown to recover costs with a solid profit margin.

7.2.4 TECHNICAL AREA

Laser land leveling is primarily used as a part of conservation agriculture to increase water use and fertilizer use efficiency, but it also improves agricultural productivity.

7.2.5 CONSTRAINTS ADDRESSED

Laser land leveling can address the water conservation challenge faced by farmers in India.

7.2.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

Laser land leveling, with the innovations developed in India, is now practical for farms a small as 0.5 ha. It is most useful in flood-irrigated agriculture, but can benefit rain-fed farms to some degree.

7.2.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Organizations:

- IRRI and CIMMYT, in their collaboration on the CSISA program, have moved forward many of the developments for laser land leveling in terms of both the technology and the means of dissemination. They are a primary partner.
- The Centre for Advanced Technology (CAT), Indore has developed a laser land leveling system indigenously.

7.2.8 EFFECTIVENESS

It has been estimated and reported in a study that extension of laser-assisted precision land leveling system to two million hectares of area under the rice-wheat system could save 1.5 million hectare-meters of irrigation water, up to 200 million liters of diesel, improve crop yields, and reduce greenhouse gas emissions equivalent to 500 million kilograms. Laser-assisted precision land leveling is also likely to increase the cultivable area by 3-6%, due to the reduction in bunds and channels in the field. On laser-assisted precision-leveled fields, the performance of crop establishment practices such as zero tillage, raised bed planting, and surface seeding are known to improve significantly (Jat et al., 2006).

7.2.9 SCALABILITY

Over the five-year period from 2005 to 2010, the number of laser-assisted precision land leveling systems available for hire in Punjab has grown from eight to 4,100. However, there have been challenges in eastern Uttar Pradesh, for example, with smaller and fragmented land holdings, underdeveloped credit and finance, the absence of private sector participation in agribusiness, and recurrent floods.

7.2.10 TRANSFERABILITY

In the flood-irrigated areas of Africa, the constraints to the widespread adoption of laser land leveling, such as limited wiliness to pay and small land holdings, exist to the same degree as in India.

Several customizations have been made by state agricultural universities and partner implementing agencies in India that alleviate these constraints, including at least ten changes to the scraper bucket of the laser unit attached to the tractor (even two-wheeled tractors) to improve fuel efficiency and the life of the bucket and the tires. These changes and indigenous production can further reduce upfront costs, making transfer to Africa particularly promising.

7.2.11 RELEVANCE

Laser land leveling is relevant to FARMS in that it represents a true example of the types of technology transfer we are seeking under this program. India has taken a "western" technology and adapted it to its smallholder farmer conditions, thus making it transferable to other countries with a predominance of smallholders, such as those in Africa. Laser land leveling also increases water conservation, which is one of the greatest natural resource management issues facing this world today.

7.2.12 SUSTAINABILITY

CSISA is having relative success in making laser land leveling a self-sustaining private sector business, using the principle of custom hiring.

A business model including labor, maintenance and driver costs has been shown to break even in three to five years. This factors in the cost of the tractor, and usually the tractor is also leased for other purposes.

An emerging business model involves farmer cooperatives' purchasing and leasing a tractor with implements, including laser-assisted precision land leveling equipment that includes the laser, bucket and hydraulic system. They often also lease out rotovators and the "happy seeder," which is a no-till drill-cum-fertilizer-application instrument. When rentals are at low rates, the scale generates acceptable profits. One such cooperative believes that they are profitable, as the time was right and the appropriate mix of new technologies was introduced, as were the amounts of diesel required, the price of rentals, and the quality and quantity of services offered. Often progressive farmers are early adopters of such technologies and practices. In an ongoing evaluation study on dissemination and adoption patterns of newly introduced technologies in agriculture, dissemination through early adopters is seen to have positive spillover effects among neighboring farmers and in neighboring villages. Their openness to partnerships helped them find clients. A model that distributes investment risk and promotes outreach is inherently sustainable and scalable.

7.2.13 POSSIBLE ACTIVITIES FOR FARMS

For the hilly regions of Uttarakhand, efforts are underway to significantly reduce the width of buckets for use with two-tire tractors with smaller turning radiuses. Efforts are also underway to move east to the states and regions that coincide with those in which FARMS is mandated to work. The challenges of developing a sustainable business model in those regions and evaluating the impact of adoption of precursor techniques (such as laser-assisted precision laser leveling and other natural resource conservation strategies) on incomes and livelihoods must be addressed in the field.

The Centre for Advanced Technology (CAT), Indore has developed a laser land leveling system indigenously. The cost of production of such systems can potentially be brought down, further benefiting from local sourcing of parts and mass production. These fixed-cost reductions, combined with the customizations that have been made to suit Indian conditions, will be invaluable for transfer to the states of eastern India and to Africa.

FARMS will continue its dialogue with IRRI and CIMMYT to determine where it can add value in improving the dissemination of this technology to poorer eastern states and in streamlining the training programs to improve the rate of adoption. These are potential pilots for FARMS' second or third year of operations.

7.3 CLIMATE ANALOGUES

7.3.1 SUMMARY

Changes in climate conditions, including average seasonal weather, variability and extremes, will affect agricultural ecosystems and the crops that can be grown in different regions of the world. Understanding anticipated shifts in world cropping patterns can be a valuable tool for adaptation planning. Climate Analogues, a web-based tool developed within the CGIAR system with CIAT and Bioversity International responds to this need: it facilitates the visualization of agro-ecological zones, and the crops suited to these, under a changing climate. It is particularly useful for comparing geographic areas with respect to the cropping systems they can support, and identifying similarities across these. In addition, the tool addresses a variety of existing challenges to integrating climate forecasting into agricultural investment planning. Indeed, Climate Analogues synthesizes vast, complex and disparate data to offer decision-makers a quick, low-cost and user-friendly means of visualizing and analyzing those data for planning and decision-making purposes. Though it is particularly robust in its coverage of India, the geography for which the tool was initially developed, the tool is global in coverage. It can therefore be used for activities in the Indian states targeted by FARMS. It may also be useful for comparing conditions in these states with those prevailing or anticipated in African countries in the context of FARMS' technology transfer activities.

7.3.2 DESCRIPTION

Climate Analogues is a web-based tool that facilitates the visualization of agro-ecological zones, and the crops suited to these, under a changing climate. The name, Climate Analogues, underlines the tool's usefulness for comparing geographic areas with respect to the cropping systems they can support, and hence identifying similarities (or analogous conditions) among these. The term, climate analogues, refers to areas with similar agro-ecological conditions (e.g., rainfall, temperatures, soil attributes, water resources) as they exist today, or are anticipated to evolve over time.

The tool combines climate projections in 2030 and 2050 for average temperature and precipitation from the 2007 IPCC Fourth Assessment Report's A2 scenario for moderate climate changes derived from Global Circulation Models – and enhanced by Regional Global Models that have been downscaled using medians values with available agronomic and farming systems data to compute an index of some sort, which is then rendered visually into maps using Google Earth™. The tool can provide information at a very high level of resolution—1 square kilometer—which, in the Indian context, implies that it can support district-level analysis and planning efforts. That said, caution is in order to the extent that even with the developers' attempts to include probability functions the forecasted data inputs do not systematically support robust predictions at this scale. While the tool's coverage is global, it is currently more robust for South Asia, the region for which the tool was initially developed.

The tool was developed by the Indian branch of Bioversity International, which is part of the Consultative Group for International Agricultural Research (CGIAR) system. Although the tool is currently global in scope, it emerged from an effort focused on the Indian subcontinent, and from extensive consultations involving the Indian Council for Agricultural Research and several other Indian agricultural agencies.

Context and value. Changes in climate conditions, including average seasonal weather, variability and extremes, will affect agricultural ecosystems and the crops that can be grown in different regions of the world. Understanding anticipated shifts in world cropping patterns can be a valuable tool for adaptation planning.

Navigating and integrating climate forecasts into decision-making, however, currently remains a challenge. For any given region, the multiplicity of climate forecasts—resulting from combinations of different climate models and scenarios—can be daunting. In addition, retrieving, mapping and understanding the economic and social implications of climate forecasts is technically complex and effortful.

While a growing body of literature is helpful for understanding potential climate change impacts on agriculture, accessible, digestible and actionable information remains limited. In particular, worldwide comparisons of agro-ecological zones are difficult to derive from existing studies. A multiplicity of studies assesses economic or yield impacts of anticipated climate change on crops. However, studies that include multiple regions of the world tend to produce low-resolution outputs (e.g., they might give forecasts for Sub-Saharan African or South Asia). Meanwhile, studies that are higher resolution tend to focus on a single region of the world. Comparisons across studies are complicated by their use of different methodologies and assumptions, and output units—geographic scale, and the measurement of value (e.g., agricultural GDP versus yield).

More importantly, existing climate forecasts and agricultural impact studies do not lend themselves easily to visualization and analysis, or hence to the identification of new patterns or similarities among the shifting agro-ecological zones of the world. Improving decision-makers' ability to detect such patterns could lead to valuable insights for adaptation planning in general, and for agricultural research and technology commercialization in particular.

Climate Analogues has the potential to help address these challenges to the extent that it synthesizes vast, complex and disparate data, and offers a quick, low-cost and user-friendly means of visualizing and analyzing those data for planning and decision-making purposes.

7.3.3 INNOVATIVE FEATURE

Climate Analogues brings together climate forecast, agronomic and crop data, and puts them in a format that makes them accessible and interpretable by planners, decision-makers and others that may not have a background in climate or agronomic science.

7.3.4 TECHNICAL AREA

Climate Analogues can contribute to achieving IR 5 – Improved NRM Practices and Farming Systems Adapted to Projected Climate Changes.

7.3.5 CONSTRAINTS ADDRESSED

Changes in climate conditions, including average seasonal weather, variability and extremes, will affect agricultural ecosystems and the crops that can be grown in different regions of the world. A general lack of understanding by scientists and planners of anticipated shifts in world cropping patterns due to potential climate changes makes it difficult to select the appropriate adaptation interventions to build resilient farming systems. As described above, there is currently a lack of user-friendly tools to readily access and interpret available climatological, agronomic and other data for the purposes of detecting such patterns.

7.3.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

The tool is global in coverage, and can therefore be used for activities in the Indian states targeted by FARMS. It can also be used to compare conditions in these states to those prevailing or anticipated in African countries in the context of FARMS' technology transfer activities.

7.3.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- Bioversity International
- CGIAR
- ICAR
- NICRA zonal centers
- State agricultural agencies
- KVKs and Agricultural Science Centers

Individuals:

- Dr. Prem Mathur, Director of Bioversity International
- Dr. A.K. Singh, Deputy Director General, ICAR, NICRA

7.3.8 EFFECTIVENESS

Climate Analogues is currently undergoing peer review. Provided that it meets the standards of the scientific community involved in this process, the tool could add value to planning sustainable investments in agriculture. For example, it could help avert investments in farming systems that are unlikely to be suited to anticipated agro-ecological conditions. It could also help direct planners to relevant sources of knowledge, technology and innovation, by pointing out similarities among regions, both within India and beyond.

Cost-Effectiveness. The costs involved in developing the tool are being borne by the CGIAR and Bioversity International. FARMS expenditures would likely relate primarily to disseminating its use—by helping potential users integrate it into their activities. FARMS could also potentially fund small improvements in the tool, or its customization for specific users or applications. The benefits of tool use, measured in terms of long-term increases in resilience, are expected to largely outweigh these costs.

7.3.9 SCALABILITY

The use of Climate Analogues is expected to be highly scalable in light of the tool's global coverage and broad applicability. The tool incorporates data on thousands of traditional rice varieties and other major crops grown across India. That said, the density and quality of the data on which the tool relies may be uneven across regions; data is seemingly best suited initially for India.

Given the tool's recent development, its potential uses by state and local planners, agricultural planning boards, and even farming communities, remain to be explored.

7.3.10 TRANSFERABILITY

Transferability should be relatively straightforward from a technological perspective, provided that the tool is introduced in environments in which computer equipment, literacy and internet connectivity can be taken for granted. The incorporation of tool use into existing planning or decision-making processes, however, could represent a greater challenge, particularly if the tool requires changes in habits, challenges commonly held assumptions, or is poorly understood or undervalued.

Conditions for success. Conditions for success include the project's ability to:

- Identify, communicate and demonstrate to decision-makers applications that are understood as adding value to existing planning or other decision-making processes;
- Build users' capacity to integrate the tool in planning processes and decision making; and
- Link information provided by the tool with realistic options for action.

Other conditions for success may need to be addressed if beyond the project's control. They include:

- Computer equipment, literacy and connectivity (though the project could address this constraint to some extent if it so chose); and
- Proper functioning of the tool.

Mechanisms of transfer:

- FARMS and other adaptation knowledge dissemination platforms (e.g., APAN, ALM)
- GOI/NICRA network to state agricultural extension agents, District and local agricultural science centers (ASCs, KVKs)

7.3.11 RELEVANCE

Climate Analogues is relevant to FARMS' objective of enhancing farming systems' resilience within targeted areas, both in India and in Africa. The tool will allow decision-makers to factor in predicted climate change and farming system impacts into planning efforts, from the national to the district level. It will also shed light on potential for technology transfer and learning across regions and continents.

The cost and time needed to move this tool from the research to the implementation stage should be feasible with respect to FARMS resources. The time frame for assessment may be limited due to FARMS' limited project life, but probably suffices to establish preliminary indications of success and effectiveness with respect to the tool's integration into established planning processes, and its influence on decision-making.

7.3.12 SUSTAINABILITY

Use of this tool should be highly sustainable in light of the low investment it requires from users. Access to data and software is online and free, it is user-friendly, has no external data requirements, and Bioversity International is commitment to continue updating and improving the tool over time. In addition, it is reasonable to expect that the data upon which the model relies (climate forecasts, agronomic data) will continue to improve going forward.

7.3.13 POSSIBLE ACTIVITIES FOR FARMS

Potential activities for FARMS include:

- Identifying and testing possible uses for the tool at the local, state and national levels;
- Raising awareness of the tool and its potential applications;
- Guiding potential users to integrate the tool into their activities;
- Monitoring the use of the climate analogue tool; and
- Eventually supporting continued tool development, and its possible customization for specific users/uses.

FARMS has asked Bioversity International to outline options for collaboration with FARMS, namely with respect to technology transfer from India to African countries.

7.4 CLIMATE FINANCE FOR ADAPTATION

7.4.1 SUMMARY

India has generally proven successful at accessing certain forms of climate finance. Climate finance encompasses a broad variety of funding sources and mechanisms designed to support both climate change adaptation and mitigation objectives. India has benefitted from both adaptation and mitigation finance, both of which are relevant here. Agriculture is a key focus of adaptation funding; and mitigation finance (specifically carbon finance) has supported, and will likely continue to support, adaptation in the agricultural sector. The overlap between the climate adaptation and mitigation benefits of certain agricultural practices suggests potential for carbon markets (a form of mitigation finance) to help finance and promote climate-smart agriculture on a large scale going forward. Carbon finance can help overcome the lack of incentives for adopting practices that are thought to have long-run benefits for adaptation, but that agents either lack awareness and understanding of, or do not fully value for a variety of reasons. Based on its past success in shaping and harnessing carbon finance, India is well positioned to be a trailblazer in the demonstration and mainstreaming of land-based agricultural carbon. At this time receptivity to agriculture playing a larger role in mitigation and carbon finance is on the rise. Several applied research projects are already being funded by the GOI to help lay the scientific groundwork for the inclusion of farm-based activities in carbon finance. FARMS could make a variety of contributions to these, in particular to pilot projects that aim to demonstrate and offer insights into the dual mitigation and adaptation benefits of certain agricultural practices (e.g., SRI, water-saving technologies, conservation agriculture and soil fertility management). With respect to accessing climate and adaptation finance more generally, FARMS stands ready to support the GOI in conceptualizing, designing and packaging projects in pursuit of the grant funding that is or will become available for agricultural adaptation activities in India.

7.4.2 DESCRIPTION

India has generally proven successful at accessing certain forms of climate finance. Climate finance encompasses a broad variety of funding sources and mechanisms designed to support both climate change adaptation and mitigation objectives. Both the adaptation and mitigation subsets of climate finance are relevant here: agriculture is a key focus of adaptation funding; and mitigation finance (specifically carbon finance) has supported, and will likely continue to support, adaptation in the agricultural sector, as described in more detail below. Moreover, India has benefitted from various types of climate finance for both purposes. Two types of finance it has benefitted from are: (1) grants from public sector funds to carry out government-led, adaptation and mitigation projects, and (2) carbon finance—that is the purchase, by public and private sector buyers, of certified greenhouse gas emission reductions from carbon markets.

India's experience and prospects with climate finance. In terms of grant funding, the GOI has secured USD 17 million in Global Environmental Facility (GEF) funds for two adaptation projects in the areas of sustainable land and ecosystem management, and USD 23 million for a mitigation project in the area of sustainable transportation. And though it has not had requests approved to date, India is eligible to access monies from the internationally-managed Adaption Fund, a creation of the Parties to the Kyoto Protocol. Going forward, the GEF has set aside an envelope of over USD 93 million for climate change projects in India. The country recently decided to submit requests for funding for mitigation activities under the internationally-funded Climate Investment Funds' Clean Technology Fund. As public sector climate funds are on the rise, India will no doubt face other opportunities besides those mentioned here.

Looking beyond grant funding, India has also been a major player in carbon markets, on the mitigation side of climate finance (in this case, both the public and private sectors have been involved). It has well-developed carbon market infrastructure and private sector capacity. In addition, it has made significant technical contributions to the development of carbon finance: many widely-used emission reduction accounting methodologies, for instance, originated in India. As a result, India has proven successful at accessing finance through carbon markets, including the Clean Development Mechanism (CDM) and voluntary carbon markets[44]. It is the second largest supplier of emission reductions to the CDM market, behind China. In 2008 and 2009 India supplied (by volume) 4% and 2%, respectively, of primary certified emission reductions (CERs)—the credits that trade on the CDM market (the largest project market) [World Bank State and Trends of the Carbon Market reports]. Looking forward, though carbon finance is in flux and faces an uncertain future, strong commitment on the part of governments and private investors worldwide to ensuring its continued relevance suggests that it will continue to represent a source of funding for India to draw on for mitigation activities—including ones that may prove to be resilience-enhancing (mainly in the agriculture, land-use and forestry sectors). The rest of this write-up examines this area of overlap in greater detail, with a focus on carbon finance opportunities for adaptation.

Mitigation finance for agricultural adaptation. A number of adaptation best practices in agriculture (as well as land-use and forestry) have mitigation co-benefits, in that they reduce, or avoid increases in, atmospheric greenhouse gases. Practices that build top soil, for instance, both enhance resilience to stress factors (e.g., drought, erratic rainfall, excess rainfall) and store carbon, thus withholding it from the atmosphere. This overlap suggests the potential for mitigation finance to help finance and promote the adoption of resilience-enhancing agricultural practices. The fact that farmers do not spontaneously adopt certain resilience-enhancing practices suggests that they may lack the economic incentives to do so (though other factors, such as knowledge, certainly have a role to play in some cases).

In particular, carbon markets—a form of mitigation finance involving payments for the reduction or removal of atmospheric greenhouse gases—may emerge as a way to finance and promote the adoption of resilience-enhancing agricultural practices in India going forward. This appears to be the case both in light of India's particular past success at accessing carbon finance, and in light of increasing international efforts to more fully integrate agriculture into carbon finance. Other forms of mitigation finance may become relevant to agricultural adaptation in the future; however, grant funding for activities that build the agricultural sector's resilience are currently more likely to come from adaptation than mitigation funds.

To date, it is important to realize, the types of agricultural emission reduction activities that yield adaptation co-benefits make a very small—indeed, almost experimental—contribution to existing carbon markets. Land-based agricultural carbon projects[45] have largely been excluded from the leading project-based carbon market, the Clean Development Mechanism (CDM), due to concerns about the

[44] The Clean Development Mechanism, as defined in the Kyoto Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol to implement an emission-reduction project in eligible developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO2, which can be counted toward meeting Kyoto targets. Voluntary carbon markets involve the buying and selling of verified emission reduction (VER) credits on a voluntary basis. A variety of standards exist against which to verify VERs. Due to their non-regulatory nature, voluntary markets have allowed for experimentation, including in land-based carbon asset development.

[45] By contrast, agricultural methane destruction and biomass-based energy generation projects are already widely accepted and mainstream in carbon markets, as are, though to a lesser degree, projects that reduce CO2 emissions related to fossil-based energy use in fertilizer product.

measurement, additionality, ownership[46] and permanence of related emission reductions. While voluntary markets have allowed increasing experimentation with land-based carbon projects over the past few years, these transactions represent a small slice of carbon finance.

Presently, increasing recognition that agriculture offers vast mitigation potential, and that this potential largely overlaps with adaptation benefits, is driving increasing interest in finding ways of bringing agriculture more fully into the fold of carbon finance. Growing acceptance of forest-based carbon projects (particularly avoided deforestation and degradation projects) in the context of carbon markets is also contributing to increasing acceptance of land-based agricultural carbon, as these pose many of the same challenges.

Several recent developments offer evidence that receptivity to land-based carbon is on the rise. In the spring of 2011, the CDM Executive Board approved an accounting methodology for methane reductions resulting from modified water management practices in rice cultivation. Another accounting methodology for carbon sequestered through agro-forestry on degraded lands is on its way to approval. Importantly, the European Union has indicated that, going forward, it will allow previously proscribed land-based carbon offsets into its Emission Trading Scheme (EU-ETS), the largest absorber of international carbon offsets (specifically CDM credits). Adopted in August 2011, Australia's Carbon Farming Initiative—which will complement the country's forthcoming carbon pricing program—will allow farmers and investors to generate carbon credits from land-based agricultural projects. In the United States, Congressional climate bills proposing national carbon markets have systematically carved out a key role for land-based emission reductions; these types of reductions are also on the path to inclusion in California's forthcoming carbon market.

India well-positioned to lead the mainstreaming of agricultural carbon. India is well positioned to be a trailblazer in the demonstration and mainstreaming of land-based agricultural carbon. India is already demonstrating leadership with respect to integrating emission reductions from land-based agricultural practices into carbon markets. ICAR's National Agricultural Innovation Project, for instance, is funding ICRAF to lead a project focused on "enabling smallholders to improve their livelihoods and benefit from carbon finance." Its central aim is to develop a framework for developing carbon accounting protocols that are consistent with CDM rules for below-ground carbon sequestration—or soil carbon sequestration—associated with livelihood- and resilience-enhancing farming practices. These protocols will be called SMART-CDM, for Specific, Measurable, Achievable, Realistic and Tangible Clean Development Mechanism.

Objectives and outcomes targeted by the project are:

- Validation and approval of SMART-CDM framework for four major ecological settings (semi-arid, arid, humid and sub-temperate);
- Indian scientists trained to apply the framework for developing carbon protocols and seeking approval of these;
- Pilot testing of smallholder carbon trading options using carbon markets and other available vehicles;
- Development of a manual on accessing carbon finance for the benefit of smallholders in different farming systems, social situations and resource contexts in India;
- Identification of modified land uses that improve productivity and livelihoods;
- Increased carbon sequestration and reduced emissions;

[46] Title to land-based carbon emission reductions can be challenging to ensure over time due to land tenure issues.

- Enhanced capacity of NARS to improve the enabling environment for smallholders to benefit from carbon markets;
- Improvements in farm income, including in the form of revenue from carbon credits;
- Communities sensitized to climate change and mitigation, as well as to the potential benefits of carbon markets; and
- Policy briefs supporting national action plans and policies that may help mainstream and scale up interventions, and raise them on the climate change agenda.

Although the National Initiative for Climate Resilient Agriculture (NICRA), which has its own entry in this document, is not exclusively focused on agricultural carbon, it too plans to invest resources into laying the scientific groundwork for the inclusion of land-based activities in carbon finance. Its investments will specifically focus on rice cultivation including SRI, large-expanse cropping systems, and aquaculture.

7.4.3 INNOVATIVE FEATURE

India's success at becoming an important player in climate finance and carbon markets in particular has involved innovation with respect to the development of new institutions, the shaping of carbon market rules and transactions, and the elaboration of greenhouse gas accounting protocols. Likewise, bringing agriculture more fully into the fold of carbon finance will involve moving into uncharted territory in many respects, and require innovation in all of the above areas.

7.4.4 TECHNICAL AREA

This best practice contributes to IR 5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes.

7.4.5 CONSTRAINTS ADDRESSED

Climate finance can help address adaptation finance needs. Carbon finance in particular can help overcome farmers' and others' lack of incentives for adopting practices that are thought to have long-run benefits for adaptation, but that these stakeholders either lack awareness and understanding of, or do not fully value (e.g., due to a tendency to discount future benefits, or due to an inability to fully appropriate benefits where these have public good characteristics, as in the case of erosion reduction).

7.4.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

Carbon finance can theoretically become relevant wherever activities emit or withdraw greenhouse gases into/from the atmosphere.

7.4.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Organizations:

- Indian Council of Agricultural Research (ICAR)
- The World Agroforestry Centre (ICRAF)

7.4.8 EFFECTIVENESS

As noted, India has effectively positioned itself to take advantage of carbon finance opportunities in the past. There is reason to believe that it can continue to play a leading role in the development of carbon finance for agriculture, paving the way for India's full participation in carbon market and other climate finance opportunities that arise. These could open up new sources of financing for adaptation activities.

Cost-Effectiveness. It is probable that India's past (public and private sector) investments in climate finance and carbon markets—be it in project design, the development of carbon market infrastructure

or carbon accounting methodologies—have largely paid off in terms of finance leveraged over the past decade.

Going forward, because land-based agricultural carbon remains experimental despite its growing acceptance, investments in this niche sector are risky. Relevant investments will vary widely in nature and in public sector involvement. Areas of investment could include natural science research to quantify and establish methodologies for quantifying carbon sequestered or emissions reduced by specific activities; developing techniques, installing hardware or purchasing services that enable carbon measurement and estimation; developing and building consensus around emission accounting principles and protocols; building the capacity of designated national authorities to accredit emission reduction verifiers; and providing education and training in relevant sciences and skills to public and private sector players. Financial returns on many current adaptation investments will likely materialize several years down the road. If anything, this speaks to the need for judicious public investment in this sector.

7.4.9 SCALABILITY

The scale of climate finance, overall, will largely be a function of government commitments to climate funds, and India's eligibility to access climate funds. Agricultural adaptation activities will likely be eligible for a subset of these.

The scalability of carbon finance for agriculture, specifically, will depend on multiple factors, including:

- The size of carbon markets going forward (a function of demand for emission reductions/carbon credits, including ones deriving from land-based activities), and on
- Program/market design that ensures that transaction costs involved in pursuing carbon finance do not outweigh its returns.

7.4.10 TRANSFERABILITY

On one level, various forms of learning (institutional, scientific, business, etc.) involved in accessing climate finance in the past should be largely transferable, in that it will guide and inform attempts to access climate finance going forward.
On another level, carbon market investments are generally highly transferable, notwithstanding possible implementation, transaction cost and capacity issues. Once emission reduction accounting protocols are vetted, for instance, they become part of the public domain. Anyone can then make use of them provided that the protocols are technically applicable, that those applying them have the know-how and financial ability to do so, and that it is viable from a financial perspective.

Conditions for success. On the first level, these include:

- Political will, translated into ministerial and other efforts, to access climate finance, learning from past experience with carbon finance and other forms of climate finance.

On the second level, these include:

- Acceptance of land-based carbon in existing and new carbon markets or other emerging carbon finance mechanisms, and
- Ability to marshal appropriate scientific resources and relevant expertise to make contributions to the demonstration of credible ways of incorporating agriculture into carbon finance.

Mechanisms of transfer:

- Ministry of Environment and Forests
- Ministry of Agriculture
- Tata Energy Resources Institute (TERI)
- Indian Council of Agricultural Research (ICAR)
- The World Agroforestry Center (ICRAF)

7.4.11 RELEVANCE

Climate finance is relevant to FARMS in so far as a portion of it can help finance resilience-enhancing investments in agriculture.
Carbon finance is highly relevant to FARMS to the extent that it represents a promising way of mobilizing financial resources and encouraging agricultural actors to adopt climate-resilient practices on a wide scale.
As far as timing is concerned, FARMS is more likely to make contributions to laying the groundwork for improving access to climate finance going forward, than to leveraging funds within the lifetime of the project. That said, it is conceivable that FARMS support the development of carbon finance activities that lead directly to carbon finance revenues in roughly a three to five year timeframe.

7.4.12 SUSTAINABILITY

The sustainability of climate finance is primarily tied to international political will and capital to sustain in. In the case of carbon finance, it is specifically tied to the will to put policies in place that *leverage carbon finance* mechanisms to *achieve real reductions* in atmospheric greenhouse gases in an attempt to mitigate climate change. To a lesser extent, the sustainability of carbon finance also hinges on compliance, and voluntary buyers' continued willingness to pay for emission reductions achieved outside their operations. In the case of agricultural carbon finance in particular, sustainability will depend on its proponents' ability to establish its soundness and viability from the standpoints of science, economics, and law enforcement, as well as its consistency with internationally accepted (if evolving) principles relating to carbon finance.

7.4.13 POSSIBLE ACTIVITIES FOR FARMS

FARMS could support Indian public and private efforts to access climate finance, or to lay the groundwork for accessing it (or making it accessible) going forward.
With respect to adaptation grant funding, FARMS could support government entities in project conceptualization, design and preparation.
With respect to carbon finance, FARMS could make a variety of contributions to existing Indian initiatives involving agricultural carbon. In particular, it could support pilot activities that aim to demonstrate, and improve understanding of, the dual adaptation and mitigation benefits of specific agricultural practices. Examples include but are not limited to:

- Identifying activities with known agricultural mitigation and adaptation benefits that are of relevance to India;
- Describing the adaptation/resilience co-benefits of emission-reduction practices in agriculture;
- Supporting the development of adaptation co-benefit criteria/principles;
- Supporting the development of principles for, and actual, protocols for measuring carbon fluxes related to agricultural activities; and
- Piloting the use of approved agricultural carbon protocols (soil carbon, SRI, other).

7.5 NATIONAL INITIATIVE ON CLIMATE RESILIENT AGRICULTURE (NICRA)

7.5.1 SUMMARY

The National Initiative on Climate Resilient Agriculture (NICRA) is a GOI program that aims to enhance the resilience of India's agricultural sector in the face of climate change. Its focus is on filling research gaps, demonstrating integrated packages of adaptation technologies at the village level—in some of India's most vulnerable districts—and to build scientific research capacity relating to climate change adaptation. Based on the large degree of overlap between NICRA's and FARMS' respective missions, namely with regard to enhancing the resilience of Indian agriculture and evaluating promising approaches and technologies for this purpose, FARMS may be able to support NICRA across a variety of technical areas. For example, FARMS could be involved in field testing and evaluating technology packages in vulnerable districts, identifying strategies for reducing greenhouse gases in rice and other farming systems that can be linked to adaptation, and integrating NICRA-identified practices for enhancing livestock heat tolerance. FARMS also is contemplating developing protocols and tools to support NICRA in tracking and managing greenhouse gas emission baseline and reduction data associated with various traditional and climate-resilient agricultural practices and farming systems. In addition, NICRA's applied research findings may lend themselves to scale-up and transfer efforts on the part of FARMS. Finally, NICRA's selection of vulnerable districts and villages to work in could guide FARMS in its choice of pilot activity sites.

7.5.2 DESCRIPTION

The National Initiative on Climate Resilient Agriculture (NICRA) is a two-year government program that began its activities in 2010 to enhance the resilience of India's agricultural sector in the face of climate change. And, as it began as a two-year program, it is likely to receive additional funding under India's twelfth five-year plan beginning in 2012. It follows from the National Action Plan on Climate Change, which recognizes that climate change is already taking a negative toll on certain cropping systems, and could have significant negative impacts on India's agricultural sector going forward. Crop yields could decline between 4.5% and 9% between 2010 and 2039, depending on the severity of climate change, and cost the Indian economy—which is 15% dependent on agriculture—some 1.5% of GDP per year [NICRA document].

NICRA's objectives are threefold, namely, to: 1) develop and apply improved production and risk management technologies that enhance the climate resilience of crops, livestock and fisheries, 2) demonstrate site-specific technology packages on farmers' fields for adapting to current climate risks, and 3) enhance scientists' and others' capacity for relevant research and its application.

NICRA's implementation will rest on the four following pillars:

- Strategic research on adaptation and mitigation;
- Technology demonstration;
- Capacity building; and
- Sponsored competitive research.

First, public research efforts are to be by 21 institutes within the Indian Council of Agricultural Research.

Planned areas of research include the following

- The vulnerability of major food crops and production zones
- Contingency planning incorporating agro-advisories, and field testing of best practices
- Identifying promising genetic material in food and horticultural crops for tolerance to climatic stresses (drought, heat, flooding, change in season length)
- Strategies for reducing greenhouse gas emissions and enhancing carbon sequestration through approaches to adaptation involving aquaculture, conservation agriculture, agro-forestry, and precision irrigation and nutrient application.
- Approaches to rice cultivation (e.g., aerobic rice, SRI) that reduce greenhouse gas emissions and conserve water
- Erosion, water harvesting and ground water recharge potential linked with intense rainfall
- Resilience traits of indigenous livestock and management practices that increase livestock heat stress tolerance
- Spawning behavior and potential positive effects of temperature rise in marine and inland fisheries
- Climate change effects on pest and disease dynamics

As part of its efforts to study the climate mitigation benefits of adaptation strategies, the initiative plans to install equipment to measure and understand the impact of agricultural adaptation practices on greenhouse gas emissions. Equipment will be placed in large fields and rice-growing areas.

NICRA's second pillar will involve demonstrating integrated packages of proven technologies in 100 districts that have been assessed for vulnerability to climate change. These demonstrations will be carried out through KVKs, with support from ICAR research institutes and state agricultural universities.

Third, the capacity-building program will expose senior scientists to current climate change science and adaptation best practices by offering them opportunities for training, participation in events, and networking.

Fourth, NICRA will sponsor research designed to achieve targeted outcomes. Examples include the identification of best practices based on the technology demonstration component, the empowerment of farmers to cope with climate variability, and the selection of promising, climate-tolerant crop genotypes and livestock breeds.

7.5.3 INNOVATIVE FEATURE

NICRA is mainly innovative in that it is focused on climate resilience in agriculture, an emerging area of research. Moreover, it specifically emphasizes research on livestock and fishery systems, which have received less attention as relates to climate change than other agricultural systems.

7.5.4 TECHNICAL AREA

This best practice contributes to IR 5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes.

7.5.5 CONSTRAINTS ADDRESSED

NICRA addresses a number of research gaps. Examples include the adaptation needs and potential of fishery and livestock systems, the overlap between climate adaptation and mitigation strategies, and the effectiveness of technology packages for adaptation.

7.5.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

There is overlap between the 100 vulnerable districts selected for NICRA's technology demonstration component and FARMS' priority geographies in India.

7.5.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- ICAR NRMD
- CRIDA
- NICRA agro-climate zonal leaders for FARMS states
- State and district level organizations (farm boards, ASC)
- Local organizations (KVKs, producer associations, self-help groups) and farmers

Individuals:

- Dr. A.K. Singh, Deputy Director General of ICAR NRMD and his team of state leaders for NICRA.

7.5.8 EFFECTIVENESS

As NICRA was launched in February 2011, it is too soon to make a determination as to its effectiveness as a program. The same holds true for the technology packages it will demonstrate in vulnerable districts of India.

7.5.9 SCALABILITY

It seems likely that NICRA research and demonstration efforts will help identify and prove technologies that are suitable for scale-up in relevant agro-ecological zones, whether in India or in other countries and NICRA provides a platform for immediately disseminating new technologies at scale.

Note that the climate analogues tool discussed in this document could prove useful for determining the potential for scaling up specific agricultural technologies and practices that emerge from NICRA.

7.5.10 TRANSFERABILITY

Given sufficient human, institutional and financial resources, and political buy-in, there is reason to believe that NICRA could serve as a model or inspiration for similar government programs in other countries.

NICRA research results, and adaptation technology packages developed as part of the initiative's demonstration component are likely to be highly transferable within India. Some learning and technology may also prove to be transferable to other parts of the world. As noted, the climate analogues tool could help in determining the potential applicability of technologies and practices based on agro-ecological characteristics.

Conditions for success. With regards to the potential transfer (i.e., replication) of NICRA in other countries:

- Human, institutional, financial resources and political buy-in
- Partnerships with the private sector

With regards to the transfer and scale up of NICRA-demonstrated technologies in India or in other countries:

Relevance of technology given physical attributes of target geography and social context
Human, institutional, financial resources and political buy-in
The existence of comparable institutional platforms like ICAR and the KVKs.

Mechanisms of transfer:

Implementing research institutes, including the 21 that belong to the Indian Council of Agricultural Research
Entities selected competitively to receive applied research grants

7.5.11 RELEVANCE

NICRA's focus on climate-resilient agriculture and the specific research themes outlined above make the initiative highly relevant to FARMS. In addition, the 100 districts that NICRA has identified for technology demonstration could provide guidance for where FARMS carries out climate change adaptation pilots.

7.5.12 SUSTAINABILITY

NICRA's sustainability as an initiative seems relatively high. The Government of India has indicated that NICRA is likely to be carried forward beyond 2012. This, moreover, is consistent with the GOI's broad commitment, as captured in the National Action Plan on Climate Change, to invest in research and other forms of support for enhancing the resilience of Indian agriculture in the face of climate change and other pressures on the sector.

7.5.13 POSSIBLE ACTIVITIES FOR FARMS

The important overlap in FARMS' and NICRA's respective mandates suggests strong potential for synergies, and in particular, opportunities for FARMS to support NICRA's ongoing programs. While these opportunities remain to be explored jointly with NICRA, areas where FARMS may be able to make meaningful technical contributions include, *inter alia,* the following.

- Field testing of best practices in vulnerable districts
- Evaluating the effectiveness of piloted technologies and approaches
- Integrating practices identified or developed by NICRA for enhancing livestock heat stress tolerance into the livestock insurance pilot that FARMS is contemplating, in view of reducing mortality risk and premiums
- Developing strategies for reducing greenhouse gases linked to adaptation, namely in rice cultivation and specifically SRI
- Tracking and managing greenhouse gas emission reduction and adaptation co-benefits data. FARMS could help NICRA design and implement clear, transparent, and standardized data collection, reporting and data management protocols. Supporting this, Abt's CarbonCounts™ tool could potentially be customized to help NICRA track and manage emission reduction data associated with a variety of agricultural practices and technologies, production systems and

geographies. The customized tool could also help track information relating to adaptation and other social co-benefits.

- Factors to consider in determining whether and how FARMS can support NICRA include:

- Timely production of results by NICRA (coinciding with FARMS' timeframe);
- Relevance of results to FARMS intervention areas (relevance is likely, given the overlap in targeted geographies); and NICRA's interest in FARMS' support.

7.6 STRESS-TOLERANT VARIETIES OF CEREALS FOR CLIMATE-RESILIENT AGRICULTURE

7.6.1 SUMMARY

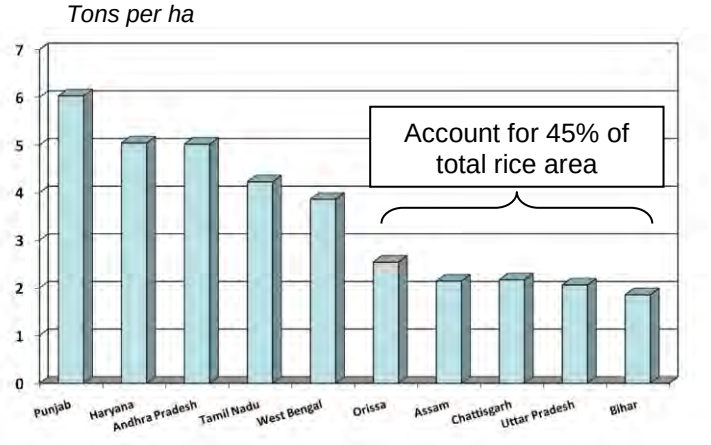
Much work has been done to introduce stress tolerance into varieties of the major cereals: rice, wheat and maize. In South and Southeast Asia, IRRI, through its STRASA program, has had excellent success in improving the most popular rice varieties through marker-aided selection, a modified traditional breeding technique. This has improved greatly the plight of farmers who regularly suffer crop losses due to flooding, saline encroachment and variable rainfall. FARMS proposes to work with STRASA to improve the part of their program that makes linkages with farmers by understanding the best mechanism for introducing and disseminating these new varieties and developing a model for village-level seed production.

7.6.2 DESCRIPTION

Rice productivity in the Indian states of Uttar Pradesh, Bihar, Assam and Orissa is decidedly lower than productivity in other rice-producing states in India. There are many reasons behind this discrepancy, including the inertia of poverty and politics. The Indian Government is attempting to address these issues through its Evergreen Revolution program, which has the objective of bringing the benefits of the green revolution to the east of India, while also creating more sustainable and climate-resilient agricultural systems.

One factor seen to be significantly affecting yields in these states is that large percentages of this rice-producing area is prone to various stresses, i.e., drought, floods and soil salinity/sodicity. These stresses serve to keep yields chronically low, while also creating episodes of total crop failure when they are occur in their most severe forms. This low-yield scenario is further exacerbated by the fact that farmers whose fields are subjected to the chronic and acute forms of these stresses tend to avoid investments in inputs like improved seed and fertilizer, since the probability of loss is higher. These farmers are stuck in a low-yield, negative feedback loop. Finally where the episodes of flooding and drought have become more difficult to predict, presumably due to the effects of climate change, the severity and frequency of loss is becoming higher still (Parry et al., 2007).

FIGURE 4: PADDY YIELDS, INDIA (2007/08)



Data: *Rice Almanac India, Directorate of Rice Research.*

Introducing and popularizing stress-tolerant varieties of rice and wheat is seen as one of the best ways to address these problems. The International Rice Research Institute (IRRI) under its program funded by the Bill and Melinda Gates Foundation (BMGF) called STRASA has made significant progress in this domain. It is actively introducing recently identified genes into the most common rice varieties grown in

these regions using marker-assisted selection (MAS). They are introducing the following genes, or quantitative trait loci (QTLs):

- ***Sub1*** - for flash flood tolerance;
- ***AG*** - 1for anaerobic germination;
- ***SF*** - for stagnant flood tolerance;
- ***Saltol*** - for salinity tolerance; and
- ***DTY1.1***, ***DTY2.2***, ***DTY8.1*** and ***DTY9.1*** - for drought tolerance.

The introductions are typically made in locally known and locally adapted varieties. The major rice variety in India into which many of these genes have been introduced is Swarna, but there are 12 varieties that contain one or more of these genes in India.

With the excellent collaboration of the state agricultural universities and other public and private sector partners—286 in all across three countries and 123 in India alone—in addition to the extreme popularity of these varieties among farmers once introduced, STRASA has been successful in disseminating the varieties to more farmers every year. The STRASA staff does not see introduction or seed multiplication as a highly constraining issue going forward. STRASA has so far multiplied more than 15,000 MT of seed, and has introduced this seed to 400,000 farmers in South Asia.[47]

There are other Indian programs that are also developing and disseminating varieties with stress tolerance, including heat tolerance in wheat and maize. As terminal temperatures during the wheat production season in the Indo-Gangetic Plains increase, these heat-tolerant varieties of wheat are becoming relatively important. The Rajendra Agricultural University in Pusa, Bihar and the Chandra Shekhar Azad Agricultural University in Kanpur are both working to develop heat-tolerant wheat varieties.

7.6.3 INNOVATIVE FEATURE

There are several innovative features of the technology of stress-tolerant varieties for climate change adaptation. One is the fact that, at least for the rice varieties developed by IRRI under the STRASA program, the traits have been introduced into locally accepted varieties and there is clearly no compromise on the yield as is often expected with the introduction of other stress-tolerant traits(Blum, 2005)[48] These traits have been introduced into rice using an improved natural breeding process, MAS, and not through genetic modification. This method is closely allied with traditional breeding programs and will therefore not be subject to the distrust, extra precautions and scrutiny that come about when genetically modified organisms (GMO) are used. This innovation facilitates adoption.

7.6.4 TECHNICAL AREA

This best practice addresses climate change adaptation; it also contributes to agricultural productivity.

7.6.5 CONSTRAINTS ADDRESSED

This best practice addresses the constraints of access to inputs and low agricultural productivity.

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[47] STRASA predicts that 1,000,000 farmers in India will use the Swarna sub1 variety in 2011. Personal communication from U.S. Singh of STRASA (Aug 2011).

[48] Prof. Elizabeth Sadoulet, Deparment of Agriculture and Natural Resource Economics. University of Berkeley. Personal Communication 7 Sept 2011.

7.6.6 APPLICABLE LANDSCAPE /AGRO-ECOLOGY

Stress-tolerant varieties are localized in their usefulness. There are stress-tolerant varieties of maize, wheat and rice. The drought-tolerant varieties are adapted to areas where rainfall has a high year-on-year variability. The rice varieties with the *sub1* gene are useful in areas that are prone to flash flooding and short-term stagnant water. Salt-tolerant varieties are best suited to agricultural areas where flood irrigation is common and also in watersheds that are close to the ocean, where saline encroachment is possible. Heat tolerance is especially important for wheat crops that suffer high terminal heat during the seed ripening stage, such as in the Indo-Gangetic Plains.

FIGURE 5: *SUB1* LINES AFTER 17 DAYS' SUBMERGENCE

All lush plots have *sub1* genes and the others are their non-*sub1* source vars.

7.6.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

IRRI is an excellent resource and partner for this work. It is managing the STRASA program for the BMGF. Also ICAR and CIMMYT are potential partners and resource organizations.

7.6.8 EFFECTIVENESS

Effectiveness. In order for climate change adaptation strategies to be effective, it is generally understood that the strategies should provide an added value to the status quo, or at least be cost-neutral to the farmer. The introduction and dissemination of stress-tolerant varieties among the populations most susceptible to climate change meets this criterion for success. Stress-tolerant varieties increase the resilience of agricultural systems in the face of weather vagaries, but do not compromise livelihoods (yields) when conditions are normal.

This technology drastically reduces the incidence of catastrophic loss due to severe weather events. Numerous trials in Indonesia, Philippines and Laos have proven that the *sub1* gene, when inserted in local rice varieties through marker assisted selection, has improved yield under conditions of inundation, with no compromise in yield under normal conditions (Vergara et al., 2009). The picture in Figure 5 tells this story very well. In this photo traditional local varieties are planted in plots next to these same varieties that also have the *sub1* gene. The entire plot was submerged for 17 days. Only the plots having the varieties with the *sub1* gene are thriving.

Impact. The potential impact on the average family that adopts this variety can be significant, depending on the prevailing weather conditions during the year in which the impact is assessed. This variety can save an individual, families and whole communities from total crop failure (or in many cases loss of seedlings at the nursery stage) in certain years.

We can very roughly estimate the impact that using stress-tolerant varieties can have on an individual farmer by making a few logical assumptions about the average farmer in these climate stress prone areas. If we suppose that rice represents 30% of a farmers' income and that episodes of extreme

drought or flooding that create a total loss scenario occurred every 10 years, then we can estimate that the total contribution to a farmers' revenue from growing stress-tolerant varieties would be 3% of his/her total revenues. If one were to also take into account the chronic yield reductions that these stresses impose upon yearly production, this figure could be estimated to climb to 5-6% of total revenues.

The real gains, however, come when we assume that using stress-tolerant varieties encourages farmers to invest more in inputs. Adding optimal amendments of urea to an average rice farmer's field when previously s/he used none has the potential to increase yield by 63%. Taking this into account increases the potential impact on a farmers' total revenue by 17%-23%.[49] By this measure, this single technology has the potential to have a moderate to high impact on household revenues.

There are, however, other circumstances that must be taken into account when a family or individual is spared total crop loss in any single season. Protection from catastrophic loss might preclude these farmers from having to take on debt at usurious rates, protect young children from acute malnourishment during their first 1,000 days, and possibly even save lives.

Cost-Effectiveness. STRASA was funded at $19.9 million during 2007-2010 and reached 400,000 farmers by the end of 2010. The STRASA program is expected to reach 1 million farmers with stress-tolerant varieties in 2011 and 20 million farmers by 2016. The Bill and Melinda Gates Foundation claims that this program will generate $1.5 billion in return on their investment by 2016.[50]

Although Dave Mackill took over 25 years to isolate the *sub1* gene in the Orissa $FR_{13}A$ rice variety, and that painstaking work is not taken into account in this calculation, we can safely say that this technology provides a highly-cost effective means to improve the livelihood of smallholder rice farmers subject to climatic stresses.

7.6.9 SCALABILITY

The technology is potentially scalable to all rice farmers who are subject to extreme climatic stresses. This technology has also proven valuable to farmers in the Nepalese Terai, Bangladesh, and the Philippines. In Southern Guinea, Liberia and Sierra Leone, some rice fields are subject to flash floods and developing good drainage systems is one of their major challenges. These varieties may have applicability in that region.

Furthermore, there are many zones in Senegal and Mali that are subject to drought and salinity in addition to occasional flooding. Heat and drought tolerance, especially for maize, can be very appropriate for farmers in East and Southern Africa. Farmers from the Pakistani Punjab all the way to West Bengal are in need of better heat tolerance in their wheat varieties as terminal temperatures continue to rise.

7.6.10 TRANSFERABILITY

Conditions for success. The transfer of this technology requires good research and extension systems. The breeding system used by STRASA, whereby they insist on introducing the genes through MAS in locally known and locally adapted varieties is an effective approach. It requires a decentralized network of competent plant breeders to spread this technology to new areas.

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[49] Variables and their values used for calculation: *Response of rice to Urea = 63% increase in yield. Average yield = 2 MT/Ha. Recommended dosage of Urea = 150 Kg/Ha. MRP urea = Rs4830/MT. Average land holding = 0.8 Ha. MSP rice = Rs9.5/Kg. Total farmer revenue = Rs63,000. The extra cost of the seed = Rs316 when replaced at 3-year intervals.*

[50] http://www.gatesfoundation.org/learning/Pages/grantee-irri-stress-tolerant-rice-development-for-farms-africa-asia.aspx

Mechanisms of transfer. In the three years that the STRASA program has operated, it has been able to partner with over 250 intuitions, in both the private and public sectors, that have played a role in scaling up the technology. There have been multiple incidents where farmers have propagated these varieties both through informal sharing of seed and through commercial transactions. With this level of enthusiasm for the technology, the dissemination of the technology is relatively assured.

STRASA is currently being implemented in the following countries:

- In Africa: Benin, Burkina Faso, Ethiopia, Ghana, Guinea, The Gambia, Madagascar, Mali, Mozambique, Nigeria, Rwanda, Senegal, Tanzania, and Uganda.
- In Asia: Bangladesh, India, and Nepal.

Its partner in Africa is the Africa Rice Center (WARDA), so there is a viable champion that has the potential to work throughout Africa.

There are many options for the transfer of this technology and many potential partners and champions in Asia and in Africa; therefore the transferability of this technology should be considered relatively high.

7.6.11 RELEVANCE

This technology both increases productivity and creates a climate-resilient agricultural system for rice farmers. It is relevant to both IR 1 and IR 5 of the FARMS project. This seems to be the most viable and relevant climate change adaptation activity, and the one for which farmers have no trouble seeing the immediate benefits.

The STRASA program seems to be well funded and well run. As a research institution, however, IRRI's strength is in plant breeding and research station trials. In spite of the numerous partnerships they have developed, STRASA still admits some weakness in transferring and disseminating the technology, as well as in making refinements at the farm level. Thus FARMS can add value if it is able to find ways to speed the transfer and dissemination of this technology and improve the on-farm performance of these varieties once they are adopted.

This best practice is relevant for FARMS provided we can find a way to add value to the existing programs.

7.6.12 SUSTAINABILITY

The sustainability of the program is dependent upon which stress-tolerant varieties are being considered.

The rice varieties promoted by STRASA are open-pollinated and non-GMO, therefore once the introduction of the QTL has been done in the local varieties, the seed can be multiplied locally and even saved by farmers. As with any rice variety, however, the recommendation is that the seed is replaced with certified seed every three years to maintain genetic purity.

In this case, the program is relatively sustainable, but it works best in situations when a viable seed certification program is in place and the multiplication of new varieties is done locally.

7.6.13 POSSIBLE ACTIVITIES FOR FARMS

Much of the work related to the development and introduction of stress-tolerant varieties is in the domain of the research and extension agencies. The FARMS project, however, may be able to add value

to these programs at the interface between extension and farmers. Dr. U. S. Singh of IRRI confirmed that this is where they could use some assistance. He suggested three areas where FARMS might be able to add value, as follows.

1. **Develop a model for village-level seed production and multiplication.** Although IRRI is having great success in finding partner organizations to multiply seed for its current program, it realizes that it may need to institute village-level seed production and multiplication in order to reach more effectively into more remote areas. To do this it is advocating the establishment of village-level seed multiplication. It notes that this will not be a one-time need. Given the rate at which it is developing new varieties with additional traits and the addition of multiple stress-tolerant traits into a single variety, it estimates that it will have a new variety release every three years. In order to multiply this seed more quickly, it feels that having a strong network of institutions and villages ready to serve as platforms for multiplication and quick introduction of the new varieties would serve the project and its beneficiaries well into the future.

2. **Mapping and targeting of climate-stressed zones.** There is scope to further refine and customize the introduction of the stress-tolerant varieties, especially as IRRI increases the number and combination of stress-tolerant traits it is able to put in any single variety. Defining in a more granular way which parts of the country require which combinations of traits and in which varieties will help breeders plan their varietal development more accurately. FARMS can help in creating these maps and a detailed varietal development plan through a grant or sub-contract to a non-governmental local partner. Furthermore, this information can be layered with other information on climate and climate change adaptation hot spots and used for broader climate change adaptation programming using the climate analogue mapping technology of Bioversity International. The NICRA program under the ICAR may be the natural place where this information should be centralized and housed. The FARMS team will explore this possibility in greater depth and move forward with an activity should it prove useful.

3. **Refine on-farm management practices.** Stress-tolerant varieties of rice require a specific set of management practices to optimize their value in resisting climate impacts. IRRI has noticed that its program has failed to gain uniform adoption among those farmers who are using the improved varieties. FARMS could refine the package of best practices and develop a model approach to gaining uniform adoption.

7.7 SYSTEM OF RICE INTENSIFICATION (SRI)

7.7.1 SUMMARY

The System of Rice Intensification (SRI) is a package of rice production practices that has been demonstrated to reduce the amount of seed needed per hectare, reduce water usage and produce more rice per liter of water than standard management practices (SMP). It is also purported to give better yields. The system appears to have many benefits, but it may also make greater demands in terms of increased need for biomass to amend soils and increased labor requirements for incorporating organic matter into the soil, for transplanting and for weeding. Most agree that SRI is better adapted to certain scenarios of rice production, i.e., typically smallholder systems with water and input limitations and high levels of manual labor availability, but there also have been attempts to introduce the method in upland systems (Barah and Narendranath, 2011) and in large-scale commercial production systems. FARMS can add value to the current research on, and implementation of, SRI by throwing light on unanswered questions on SRI, as it is applied in a smallholder, farm-level setting. If FARMS implements an SRI pilot, it is likely to assess the variability and degree to which SRI saves water in on-farm applications in various Indian rice production settings. FARMS feels that more information is needed on SRI's impact on women's labor demands compared to traditional rice production systems. Finally, FARMS may work with the Central Institute for Agricultural Engineering (CIAE) to test and design better weeders for SRI. FARMS has the opportunity to address the first two questions (SRI's impact on water conservation and on women's' labor) through an evaluation of SRI that is being implemented by the National Rural Livelihoods Mission (NRLM) with help from Digital Green (an NGO that uses video for enhancing the extension services). Currently, Innovations of Poverty Action (IPA), a US-based evaluation group, is planning an evaluation to assess the efficacy of Digital Green. FARMS has had discussion with IPA, NRLM and Digital Green to expand the scope of this evaluation, and all three parties have agreed to this idea.

7.7.2 DESCRIPTION

The System of Rice Intensification (SRI) is a package of rice production practices, which depending on the source, comprises up to seven principal practices. They are: 1) use of organic soil amendments as much as possible and completing needed amendments with chemical fertilizer only when necessary, 2) planting in rows or a grid with very low relative transplant density, 3) early transplanting of single seedlings, typically at the 12-day stage and within the range of 8-16 days, 4) transplanting isolated seedlings, as opposed to bunches of two or three, 5) irrigating by providing alternate wetting and drying periods (AWD) to maintain optimum soil moisture, while avoiding the use of a continuous water layer as a weed control mechanism, 6) regular weeding using a non-motorized mechanical weeder, and 7) growing seedlings in a carefully managed nursery (which some practitioners speak of as another component of SRI).

It has been demonstrated that SRI reduces the amount of seed per hectare, reduces water usage and produces more rice per liter of water than standard management practices (SMP). It is also purported to give better yields. The system appears to have many benefits, but it may also make greater demands in terms of increased need for biomass to amend soils and increased labor requirements for incorporating organic matter into the soil, for transplanting and for weeding. Most agree that SRI is better adapted to certain scenarios of rice production, i.e., typically smallholder systems with water and input limitations and high levels of manual labor availability, but there are attempts to introduce the method in upland systems (Barah and Narendranath 2011) and in large-scale commercial production systems.

It may be important to mention that SRI seems to have sparked emotions and created some controversy in agronomic and development circles. It is difficult to gauge why this controversy exists, but it seems to be because a person who is not an agricultural scientist is credited with the development of SRI and because there is a lack of peer-reviewed studies that examine the technique. The FARMS team intends to take an objective and balanced view towards SRI. The Central Rice Research Institute of India (CRRI) is conducting controlled research trials on SRI and has found intriguing and favorable results.

7.7.3 INNOVATIVE FEATURE

SRI is innovative on many fronts, but primarily because it is a method of rice production that refutes the need for one technique that has been assumed to be a primary tenet of rice production, i.e., maintaining a continuous layer of water for greater productivity and weed control. This method works fine when water is a cost-free non-limiting resource. However, as soon as one accounts for the cost of water and the energy required to extract water from below ground, the equation can change quickly to favor alternative methods. In exploring these alternative methods, i.e., employing an alternating wetting and drying of the soil, it seems that many other benefits were discovered, such as a reduction in seed usage, physiologic changes in the rice plant during growth and seed setting, potentially increased yields, and potentially reduced methane emissions. In fact, many claim that SRI is the best method for rice production, reversing many paradigms.

7.7.4 TECHNICAL AREA

The primary contribution of SRI will be to IR 5 - Improved NRM and Farming Systems Adapted to Climate Change, but may also contribute to IR 1 - Increased Agricultural Productivity.

7.7.5 CONSTRAINTS ADDRESSED

SRI addresses the constraint of water scarcity and the yield gap in Indian rice production.

7.7.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

This practice is applicable in rice-growing areas with access to irrigated agriculture.

7.7.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- NRLM
- DRCSC, GEAG, PRADAN, Agragamee, BASIX (Krishi Samruddhi is S. Amarnath, Managing Director) and other NGOs.

Researchers:

- Dr. T. K. Adhya, Director, CRRI
- Dr. C. Shambhu Prasad, Prof. XIMB school of management
- AgSRI
- Tamil Nadu Agriculture University

Technical Partners:

- Mei Xie, World Bank Institute

7.7.8 EFFECTIVENESS

The SRI system has one undisputed benefit in that as little as 10% of the seed required in traditional systems is used in an SRI system. Most practitioners claim that SRI uses about 30% of the water used under SMP. The method of spacing in SRI also seems to substantially increase the number of tillers per plant, and some hypothesize that this improves the physiological and morphological traits of the rice plant, e.g., greater leaf area index and root mass, providing for greater yield per hectare as well as decreased susceptibility to pests and disease. Finally, SRI is presumed to be a climate change mitigation measure, as there is relatively less methane emitted as compared to the traditional system that fosters an anaerobic breakdown of soil organic matter because of the constant submersion of the soil under a layer of water.

Proponents of SRI claim that this package of practices increases yields and that the synergistic effect of the sum of these practices is greater than its component parts (Glover, 2011). Proponents of SRI cite several studies that find evidence of yield improvements in the range of 25%-50%. Uphoff (2007) provides a summary of results from 11 evaluations across eight countries and finds average yield increase of 52% and a 44% reduction in water requirements.

There is a concern that there is great variability in the actual practice of SRI in the field, and that as practiced SRI is not any different than the best management practices that have been recommended previously. Therefore, it is not clear if the gain in yield is simply because of SRI's practices themselves or because the farmers are reducing inefficiencies in their existing practices because they absorb the message better as part of an understandable package of practices. Those who doubt these synergistic effects claim that certain practices may produce better yields, but it is not clear which of the individual practices contribute to the yield increases and how much. Some claim that the single practice of amending soil organic matter accounts for all or most of the yield increases. This is particularly true in the case of Africa, where many rice production systems have not incorporated the use of either chemical or organic fertilizers. There is also speculation that the increase in yields may be partially attributed to increased attention to weeding.

Yet, in carefully controlled studies[51] of SRI versus standard management practices (SMP) in India by Thakur et al. (2010), it was determined that SRI increased yields by 48% and decreased water usage by 22% (Thakur et al., 2010). These results were obtained under trials where the treatment and control fields had identical soil fertility measures and levels of soil amendments. Because of these studies, one is led to conclude that the soil amendment practices alone do not account for yield increases for SRI. In this same study, the researchers also noted measurable differences in the physiological characteristics of the plants grown under the two systems, including: a faster leaf elongation rate and a greater photosynthetic rate during the reproductive and grain-filling stages (Thakur et al., 2010) It may be that the growth habit of rice under wide spacing, i.e., more tillering and larger root mass, is actually more conducive to productivity than the traditional spacing accepted by those using SMP. (Ceesay and Uphoff 2004) find that the improved productivity of rice under SRI practices might be due to increased nitrogen availability caused by the alternate wetting and drying of fields.

ICRISAT has also published case studies of 34 SRI farmers who have all documented increased yields and decreased levels of input usage (Gujja et al., 2008).

There are still some unanswered questions around SRI as a practice, but since there is substantial empirical evidence that the system is better in many ways, many of the questions revolve around *why* SRI is effective and not *whether* SRI is effective.

Rice farmers who rely on rice, both as a staple for home consumption and an income generation mechanism, would certainly benefit from improved rice productivity. For some marginal farmers in India, rice can be up to 50% of on-farm income; if the yield gains are real, the potential impact on household revenues could be quite important.

The benefit of conserving seed is less substantial. It is estimated that farmers can conserve 40 or more kilograms of seed per hectare if SRI techniques are deployed. This represents only 2% of production, in systems where 2 MT/ha is the average yield. Since many rice farmers around the world use mostly saved seed in rice production, the savings will not be too great. Furthermore certified seed is sold for a very small margin (3%-10%) above the grain price. Therefore, even in the case where farmers buy certified seed, the impact of seed conservation on revenues is small. The impact will obviously be more substantial when hybrid rice seed is used. Farmers need to buy this every year, and the cost can be two to five times the imputed cost of saved seed (Virmani et al., 2002).

7.7.9 SCALABILITY

Rice is grown and consumed throughout the developing world. Rice is primarily produced in Asia, but there are significant production areas in West and East Africa that also depend on rice as a staple food and as a livelihood. Rice accounts for 26% of the total caloric intake in the developing world. Rice is widely grown and consumed throughout West Africa. Mali is nearly self-sufficient in rice production, while Senegal is by far a net importer. Therefore, any method that improves rice yield, reduces production costs or reduces its natural resource consumption is bound to be important to the developing world. SRI is particular to irrigated rice systems and preferably small-scale ones, but there are a substantial number of hectares when aggregating under such systems.

Programs to introduce SRI work best at scale and once set up, can be extended to all smallholder irrigated rice farmers in a particular geography.

Although good farmer-to-farmer extension is probably required, SRI is not limited to any specific geography. On the other hand, there has been evidence of spontaneous adoption of the practice of non-target farmers learning from first adopters.

Another factor that makes SRI more scalable is that it does not require the cooperation of many individuals or institutions. Adoption is done by individual farmers and not communities.

The information that needs to be relayed is a package of techniques required. They are easily grasped, but may not always be easily accepted by long-time rice farmers.

7.7.10 TRANSFERABILITY

Conditions for success. Smallholder irrigated rice farmers anywhere in the world can adopt SRI techniques, but SRI is most attractive where water is a limiting resource. Where farmers are paying for water, as in Mali (where farmers must purchase diesel fuel to pump irrigation water), one could presume that SRI is more likely to be adopted. The same would apply for systems where farmers are paying for rice seed every year (or every third year), but to a lesser degree, since the overall impact of the saved seed is a smaller part of the production costs than water or fuel in those systems where the latter are paid for.

Alternatively, it is likely that in the rice production systems where farmers do not pay for water, but rely on flood irrigation or rainfall for their upland rice and where certified seed is not readily available or readily purchased, the incentives for adopting SRI are lessened. Examples of such systems are found in the West African countries of Guinea, Senegal, Sierra Leone and Liberia. Thus, the ideal conditions for adoption exist only in limited areas, unless SRI practices are definitively proven to increase yields and are promoted on that basis.

SRI requires that a standard, functional extension program is in place. This is not always the case in many FTF countries, but where programs do exist in irrigated rice production areas, it would be easy to integrate SRI into their training curriculum.

Mechanisms of transfer. CRRI, which is located near Cuttack in Orissa, is doing extensive field research on SRI. ICRISAT, WWF and AgSRI, a private sector firm, are all interested in SRI and have programs in Africa and in other FTF countries.

SRI techniques are being variably deployed across many Indian states, as well as in many African countries such as Mali, Guinea and Madagascar. Africare, Oxfam, Abt Associates, the World Bank and many smaller NGOs have programs outside of India to promote SRI and are interested in bringing these techniques to other rice production areas. Therefore, there are many potential projects and organizations that can work towards its transfer to new environments.

There are many programs in Africa designed to promote improved crop production. SRI, since it conserves water, is also seen as a NRM strategy. SRI may reduce GHG emissions, so it is also a possible component of a climate change mitigation program. SRI includes organic soil amendments, and therefore improves soil water-holding capacity, making systems in marginal rainfall areas better able to produce in drought years, so at least this component can be considered a climate change adaptation measure.

7.7.11 RELEVANCE

SRI is a suitable subject of study and piloting in India under the FARMS program for many reasons. One of India's most formidable challenges is to conserve water for agriculture and for urban domestic consumption. The availability of water is increasingly becoming a constraint in agricultural production in India. Over time the problem has become particularly acute in areas where agriculture relies on groundwater. Large subsidies on electricity supply for agriculture, which have meant free electricity in many states, have led to declining water tables and shortages of water. This is troubling given that groundwater is one of India's major sources of irrigation. In a rapidly growing economy, the competing demand for water from urban areas and Indian industries is going to put increasing pressure on all sources of fresh water for irrigation. This means that the Evergreen Revolution will have to rely on technologies that increase water-use efficiency, while increasing yields. Since 18% of the water available for irrigation is utilized for rice production (Thiyagarajan and Selvaraju, 2001), the potential impact of SRI on water use in India is very high.

There is not conclusive evidence on the gains in water-use efficiency from SRI, and some papers often rely on farmer estimates to document water use. These studies note that the reduction in water application under SRI can be 25%-50%. Recent evaluations of SRI in Andhra Pradesh and Tamil Nadu suggest water savings of 40%-50% (Satyanarayana et al., 2007). The average yield gain in these studies was 22%. The SRI evaluation in Andhra Pradesh relied on farmer estimates, while in Tamil Nadu it was estimate using a Parshall flume. The Tamil Nadu evaluation focused on several components of SRI; it varied the water management practices (SRI and conventional) across both SRI and conventional planting practices.

Furthermore, India is the world's second largest rice producer, accounting for more than 20% of global production (Barah and Narendranath, 2011) India produces more than 90 million MT of rice per year, and rice is a very important staple for India. India also has various examples of how SRI has been applied over many geographic areas. SRI has been deployed and is being scientifically tested by several Indian scientists, but there are still questions, and SRI remains a topic of debate. The debate extends to other FTF countries as well, including those in Africa.

There is a call for more scientific and empirical evidence of its effectiveness as a best practice, especially in applied, on-farm trials, and the FARMS program is in a position to provide more evidence.

If SRI can increase rice production, it can have an effect for a large number of farmers in India and other Feed the Future countries. Since SRI is most appropriate for smallholder systems, it is more relevant for the FARMS project, since FARMS' target beneficiaries are those earning less than $1.25/day.

7.7.12 SUSTAINABILITY

SRI may not work well in all rice production scenarios. It would seem to work best when water is paid for or is a seriously limited natural resource. In India this presents a problem, since water is not costed, and there are large subsidies for electricity to pump water in systems where underground water provides most of the irrigation. If the real effects of SRI are going to be felt on natural resource use in India, especially in the Punjab where one could speculate that it is needed the most, the political will to assess a cost for water will have to be in place.

SRI does lower the cost of seed, but also raises the cost of labor for soil amendment and weeding and requires the purchase of a mechanical weeder. Thus, SRI might be considered a low-cost or no-cost technique to adopt.

The costs of promoting SRI come primarily from supporting the initial knowledge dissemination of the technique, which can be considerable.

7.7.13 POSSIBLE ACTIVITIES FOR FARMS

SRI is relevant to food security and relevant to FARMS. There are many organizations, NGOs and research institutions that are working with SRI in one way or another. In India the CRRI is taking the lead on SRI research; in a personal communication with the Director, Dr. T. K. Adhya, we were informed that these are the perceived future research needs in SRI:

- Varietal response to SRI and designing a suitable plant type;
- Identification of areas/zones most suited for the SRI method;
- Precise quantification of savings in water;
- Effective weed management and refinement of machinery;
- Detailed studies on soil health and microbial activity;
- SRI vis-à-vis pest and disease incidence and their management;
- Detailed economics of SRI and a cost/benefit analysis;
- Farmer participatory trials to fine-tune the technology in terms of its economic viability and sustainability;
- Development of machinery for weeding and planting; and
- Studies on mitigating the effects of climate change, if any, with SRI adoption.

The FARMS project is best situated to examine questions of SRI in applied, farm-level settings. We will therefore exclude those research needs that are best suited to research farms, research scientists and academics. FARMS will probably address one or more of the following.

1. Water conservation is a critical goal for India and increasingly for the rest of the world. FARMS may therefore attempt to quantify the actual water-saving ability of an SRI system over traditional practices in various Indian on-farm scenarios.
2. According to Biksham Gujja of AgSRI, there are over 20 different types of SRI weeding tools that have been developed in India, but farmers still complain that these tools are inefficient and the search continues for more appropriate tools. FARMS can work with the CIAE in Bhopal and their regional center in Coimbatore to develop better weeders for SRI; we will explore the possibility of a pilot designed to develop and test better weeders, particularly for women.
3. FARMS will provide more insights about the real costs and benefits of SRI in applied settings. It is understood that more labor is required, but there are no data on exactly how much more labor. Nor are there data on how the increase in the labor requirement affects women and men differentially. FARMS could try to answer these questions and try to make a determination as to the costs and benefits of switching from SMP to SRI.

SRI and other best practices are being rolled out within the NRLM's program of zero-budget agriculture. As designed, NRLM is intended to roll out its activities nationwide, but its implementation is contingent upon the states' expressing an interest in receiving NRLM assistance, and on their meeting certain non-negotiable requirements that include setting up an implementing agency and building of social capital so that the program is implemented using a participatory and people-led approach. To date, NRLM is being rolled out in Andhra Pradesh, Rajasthan and Orissa.

NRLM is working with an NGO – Digital Green – to implement the program. Digital Green uses an innovative ICT approach that involves developing videos on best practices using a participatory approach, and screening videos facilitated by moderators. Currently, there is a proposal waiting for final approval by the Gates Foundation to evaluate the efficacy of Digital Green in improving the roll-out of NRLM. The evaluation will be led by Prof. Dean Karlan, a Yale University professor who is the founding head of Innovations for Poverty Action (IPA), along with Kentaro Tayoma of the University of California, Berkeley. FARMS is considering the possibility of adding value to this planned evaluation by adding questions to understand the efficacy and constraints to adoption of SRI. FARMS staff have had conversations with the head of Digital Green, Rikin Gandhi, the director of NRLM, Mr. T. Vijaykumar, and Kentaro Tayoma. All three parties concur with the idea and see great value expanding the scope of the planned evaluation. The specific questions that the evaluation can answer will be identified after additional conversations with SRI experts in India, but they will center around understanding the water-use efficiency of SRI, and potentially the impact on female labor demand.

7.8 WEATHER INDEX-BASED CROP INSURANCE

7.8.1 SUMMARY

Weather index-based crop insurance (WBCI) has payouts linked to weather data, whether temperature, rainfall or moisture. The payments are triggered by prespecified and agreed patterns of the weather index, as opposed to actual yields. In India several entities are implementing WBCI. Among these, AIC is the largest provider of credit-linked insurance, which is required on crop loans given by the government. IFFCO-Tokio and ICICI Lombard are the two largest private providers of WBCI. WBCI has been extensively researched, although a large majority of this research has not established an impact of WBCI on farmer incomes and consumption. Some papers have established the impact of insurance on agricultural investment, and others have focused on the factors that determine its take-up. Organizations such as the World Bank, IFPRI, the Microinsurance Innovations Facility, the BASIS program, and the Micro Insurance Centre have invested significant effort in developing innovative indexed insurance designs and implementing pilots to evaluate their efficacy. Several of these evaluations are ongoing. Therefore, a possible next step for FARMS could be to work with these organizations to identify the areas where FARMS can contribute.

7.8.2 DESCRIPTION

Index insurance has payouts linked to an index that is highly correlated to local yields. In the case of weather index-based insurance, the index is based on weather data, whether temperature, rainfall or moisture. The payments are triggered by pre-specified and agreed patterns of the weather index, as opposed to actual yields. This eliminates the administrative cost of in-field verification, and reduces the time taken to make the payment. In addition, because the insurance product is based on an independently verifiable index, it can be reinsured, which allows insurance companies to transfer part of their risk to international markets (Hazell et al., 2010). All buyers in a given region pay the same rate of premium. Once an event has triggered payouts, they all receive the same rate of payout; their total payout depends on the value of the insurance coverage purchased. Payouts can be structured in a variety of ways, ranging from a simple zero/one contract (i.e., once the threshold is crossed, the payment rate is 100 per cent), through a layered payment schedule (e.g., a one-third payment rate as different thresholds are crossed), to a proportional payment schedule.

Index insurance is available at the macro level for governments and relief agencies in development and disaster management, at the meso level for financial service providers, input suppliers and traders to balance their portfolios and manage certain business constraints, and at the micro level for farmers. This discussion focuses on weather index-based insurance for farmers at the micro level.

Drought and other weather-related risks are recognized as significant contributors to income shocks. Almost nine out of ten farmers surveyed in a recent study in the semi-arid states of Andhra Pradesh and Gujarat hold this view (Cole et al., 2011) Weather plays an important role in agriculture even in wetter states because of the reliance on the monsoon in India, particularly among those farmers practicing rainfed agriculture. Lack of adequate rainfall is a common cause for crop failure, and low returns from agriculture affects the food security of farmers, particularly poorer farmers in rainfed areas.

WBCI allows smallholder farmers to insure against adverse weather incidents that affect crop production, such as droughts, floods, deficit and excess rainfall, frost, excessive heat and relative humidity. As offered in India, payouts from weather index-based crop insurance are often proportional to the difference of a measurable weather event (rainfall or temperature for example) from a certain trigger, as measured at regional weather stations or rain gauges. Payouts are automatic and made without requiring the filing of a claim. Among established weather index-based crop insurance providers

in India, ICICI Lombard and AIC provide temperature-based insurance as well as rainfall-based insurance, and IFFCO-Tokio is a major provider of rainfall-based insurance.

Currently cereals, pulses, oilseeds, and commercial and horticultural crops grown during the *rabi* season including wheat, barley, gram, lentil, mustard, potato, onion, cumin, coriander, fenugreek and isabgol (psyllium) are insured against crop- and region-specific weather risks by established insurers. Also insured are *kharif* crops, including paddy, soybeans, maize, cotton, groundnuts, *bajra* and pulses. All-India coverage is on the horizon, boosted by a government-subsidized scheme, with all the major players having the technical and operational ability and adequate capital to enter states and villages where there is demand, at the invitation of state governments.

The main providers of WBCI in India are described below.

AIC (Public Insurance). The Agriculture Insurance Company of India Limited (AIC) is a public sector undertaking that provides subsidized weather index-based crop insurance through the Weather Index Based Crop Insurance Scheme (WBCIS) in most states of India.[52] The insurance is credit-linked and provided through the formal credit delivery channels. AIC also administers the National Agricultural Insurance Scheme (NAIS) that provides premium-subsidized insurance cover that is mandatory for farmers taking loans and available voluntarily to farmers who do not take loans. It insures against reduced yield and the failure of crops from natural calamities, pests and disease. The scheme provides an incentive to adopt higher-value inputs and technologies, but the presumed critical importance of agriculture insurance remains unverified through randomized controlled trials. Furthermore, NAIS is known to have delays in payout (Kalavakonda and Mahul, 2005). AIC adopts a reference area approach for indices. A reference weather station is at the center of the geographical area, as determined by the State Level Coordination Committee on Crop Insurance. Measurements of weather variables are made and used as reference points for triggers in an area circumscribed by a circle with a radius of 25 km for rainfall and 100 km for frost, heat, relative humidity and the like.
In the near future, NAIS is likely to be replaced by WBCIS in a few states of India. The NAIS scheme relies on the verification of crop yield post-harvest and routinely there are long delays and opportunities for manipulation, labor issues and graft. Certain WBCIS payouts are during the cropping season and as a consequence are income-sustaining. The Government of India is promoting a merged scheme, which is consistent with recommendations from multilateral institutions for comprehensive coverage.

IFFCO-Tokio (Private Insurance). IFFCO-Tokio is a private insurer that has run successful WBCI pilots. It started providing index insurance in 2004, and since the 2007 *rabi* season, when the Government allowed public and private index insurance programs to take advantage of subsidies, it started using the government subsidy. IFFCO-Tokio relies on the network of farmers within the IFFCO cooperative and offers WBCI as a package with credit for seed and fertilizer.

ICICI (Private Insurance). ICICI, a private insurer, works with several external organizations, including BASIX and the Self-Employed Women Association (SEWA), who have a rural presence and the trust of farmers, as a means to determine the feasibility of WBCI, to educate farmers and to assess demand. However, BASIX, which was the first to launch WBCI in India, has not offered WBCI since 2010 due to failed negotiations with ICICI Lombard. On the other hand, ICICI Lombard is moving toward the utilization of their own distribution networks, predominantly insurance agents, to reach farmers. They are no longer relying on micro-finance institutions (MFI) or NGOs such as BASIX (which is a livelihoods group with MFI and not-for-profit wings), for their reach. Since 2010 ICICI Lombard has

[52] AIC also has other insurance products such as Varsha Bima, Apple Weather Insurance, Mango Weather Insurance, coffee insurance (IFAD, 2010).

begun to participate in the government-subsidized scheme at the invitation of state governments. It significantly increased the size of its portfolios to such an extent that weather index insurance has become a key part of its portfolio of insurance products.

Pepsico (Private Insurance). Pepsico (in collaboration with ICICI Lombard) provides index insurance to cover potato crop losses due to late blight disease, which in turn is associated with temperature and humidity. The insurance comes with credit and a market contract, and it offers substantial income gains to participating farmers. The program states the insurance premium and benefits clearly, and it integrates the premium payment into the overall package.

HDFC ERGO. HDFC ERGO is implementing an innovative pilot that moves away from single insurance policies in favor of several simple weather securities—" weather tickets"—with fixed payments. These securities solve a number of problems faced by standard weather index approaches: they are easy to understand and they are flexible, allowing farmers to choose a portfolio of securities depending on their particular risk profile and allowing all economic agents facing weather risks to participate. This innovation was a winning entry for the Marketplace for Innovations Development, 2010(Hill and Robles, 2010) HDFC ERGO is providing weather securities in Karnataka and Madhya Pradesh that are being evaluated by IFPRI in collaboration with the Centre for Risk Management (CIRM). The evaluation is expected to be complete by 2012 (Magnoni and Zimmerman, 2011). These states were chosen because of their high rainfall risks and because HDFC ERGO General Insurance, one of the project's collaborators, is seeking to expand the use of weather-indexed insurance products in these areas.

7.8.3 KEY INNOVATIVE AREA

The advantage of weather index-based insurance over other forms of agricultural insurance is that it is free of adverse selection and moral hazard, because the payouts are based on observable variables that cannot be manipulated by any individual. As a result, neither proof or additional information accompanying a claim from the claimant, nor verification by the insurer or their agents is required. Consequently, payouts can be processed automatically, significantly reducing both the administrative costs and delays in payouts, and allowing payouts during the cropping season.

7.8.4 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

WBCI is applicable to any geography with diversity in agro-climatic regions to make WBCI sustainable for a risk carrier.

7.8.5 TECHNICAL AREA

The primary contribution of WBCI will be to IR5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate. A secondary contribution of WBCI will be to IR 1- Increased Agricultural Productivity and Output to Increase Farmers' Incomes.

7.8.6 CONSTRAINT ADDRESSED

The main constraint addressed by this BP is access to formal insurance market to manage risks.

7.8.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Organizations:

- IFFCO-Tokio
- BASIX
- AIC

Risk Carriers:

- ICICI Lombard
- Royal Sundaram

Distribution Channels:

- IFFCO
- BASIX
- SEWA

Weather information providers:

- Indian Meteorological Department
- National Collateral Management Services Ltd.
- Karnataka State Natural Disaster Monitoring Centre
- Risk Management Solutions India

Research and Technical Inputs:

- Microinsurance Network
- Microinsurance Academy
- Rupalee Ruchismita, CIRM
- Xavier Gine, Oliver Mahul, World Bank
- ILO Microinsurance Innovation Facility
- Microinsurance Centre
- Europeoan Development Research Network
- Financial Access Initiative
- M. Patankar, ILO Microinsurance Innovation Facility
- Shawn Cole, Harvard Business School
- Ruth Vargas Hill, IFPRI
- BASIS, University of Wisconsin/Madison

7.8.8 EFFECTIVENESS

The ultimate objective of weather index-based insurance is to provide stability in returns to farmers. It is hoped that the reduction in risk results in both higher investment by farmers in agriculture and greater willingness to adopt technology. In the end this means that an effective insurance product should have value to the client. Several impact evaluation studies have been conducted to assess the impact of WBCI on farmers. Magnoni and Zimmerman provide a synopsis of completed and ongoing evaluations in India (Magnoni and Zimmerman, 2011). None of the evaluations examine the impact of insurance on cash flow smoothing or income protection or its impact on consumption. A couple of studies find a positive impact of microinsurance on farmer investment in agriculture, but these were not evaluations of WBCI products. No studies assess the impact of WBCI on asset protection or peace of mind.

Gine et al. have examined the determinants of adoption of WBCI, assuming that WBCI take-up is a desirable event. They find that a credit constraint can limit the demand for insurance; take-up rates are higher amongst the previously insured; risk-averse households are less likely to purchase insurance, but only among households not familiar with insurance; households connected to village networks are more likely to purchase insurance, especially when other members of the household's primary group participate; and respondents who likely have lower cognitive costs of understanding (Gine et al., 2008)

(Gaurav et al., 2011) conducted a field experiment and found that a financial literacy and education model significantly increases take-up. (Gaurav, Cole and Tobacman 2011).

Magnoni and Zimmerman (2011) list several ongoing evaluations that are focused on assessing different aspects of microinsurance. These include evaluation of ICICI, SEWA agricultural weather insurance that is expected to complete by 2015, and evaluation of innovative weather securities pilot by HDFC-ERGO. Cole, Tobacman, and Chattopadhyay (Indian Institute of Management, Kolkatta) are conducting an impact evaluation and product design of weather insurance; they are assessing its impact on income, consumption, and the investment decisions of households, and they are trying to ascertain the determinants of take-up. These evaluations are likely to shed more light on the effectiveness of WBCI, particularly its impact on food security.

Although the rigorous evidence on WBCI is still being developed, WBCI is being adopted by GOI and is going to scale. Insofar as insurance itself is considered an important tool in managing risks, there is no doubt that WBCI does reduce the cost of implementation, yields better value to clients by having quicker pay outs, and improves the ability to access reinsurers.

Another important determinant of effectiveness is the extent to which it is adopted. Despite the advantages indexed insurance provides, the adoption of such products has been quite low. Cole et al. (2011) find that in India, less than 10% of their sample purchased weather insurance, despite its relatively low cost. Studies on the barriers to household risk management (Cole et al., 2011) indicate that rural households have a limited understanding of rainfall insurance (Gine et al., 2008) A lack of trust impedes take-up, though Cole, Sampson, and Zia (2011) find no evidence that a short (less than five minute) financial literacy module was effective.

7.8.9 SCALABILITY

WBCI is applicable very broadly to farmers in any geography that is agro-climactically diverse. Therefore, it is scalable if the benefits of buying insurance outweigh the costs for a household. Furthermore, scale is necessary for sustainability of the best practice. Since weather risks in a single agro-climatic region are correlated systemic risks, an insurer must have exposure in geographically dispersed agro-climatic zones to prevent large simultaneous payouts and remain solvent.

The impediments to scale are the initial effort and the resources required to launch the product. Significant initial research and development is required to design the specific product in a way that minimizes basis risk (the risk of potential mismatch between trigger event and actual loss), particularly if there is significant variation in microclimates. Even after the product is designed, resources are required to build the capacity of the local insurers and the delivery channel to manage the insurance (sales of policies, collection of premiums, and payment of claims) and to raise the awareness of potential clients. In addition, to mitigate basis risk, localized weather stations are required. Although one can do without localized weather stations, the take-up would be more if farmers were convinced that more precise triggers for weather were being used for payout. Insofar as setting up these localized weather stations is expensive, it can impede scaling up of the best practice. In India these concerns are not as paramount because of the strong political will behind the insurance and because of the packaging of insurance as a required component of crop loans (although this can mean a low value of the insurance to the client).

7.8.10 TRANSFERABILITY

Conditions of Success. A key condition for providing weather index-based crop insurance is an enabling policy environment, including an effective legal and regulatory system to enforce contracts and supervise insurance. India's reforms in the insurance sector has been one of the key reasons that innovative rural insurance products can be on the ground. IFAD (2010) notes that there should be an

environment in which subsidized risk management options do not crowd out market-driven products (which is the case in India) (Hazell et al., 2010) On the other hand, in some instances subsidies might be needed to make the insurance affordable to the poor. Another important condition of providing insurance at the micro level to farmers is adequate, reliable weather monitoring infrastructure, on the ground, for determining triggers at the village level and the paucity of reliable long running historical data of weather variables for developing indices. In India there are several reliable weather stations, but the density is inadequate for the expansive geography that is to be addressed.

Second, national-level risk carriers (insurance companies) are needed whose payments are guaranteed by a credible authority.

Third, effective distribution channels that have a large rural network are needed. It is possible to leverage large existing networks such as postal departments; however, such networks need to be identified upfront and engaged as partners. Smith et al. (2011) discuss the pros and cons of various distribution channels and particularly note that credit-linked channels, such as those that exist in India, can often have a low value to the client Ideally, these distribution channels should market and package insurance with other financial or other products (e.g., weather data, technology inputs).

Mechanisms of Transfer. There are ongoing weather insurance pilots in several countries in Africa, particularly at the meso and macro scale, and in other parts of the world. Several among these have been introduced with technical assistance from multilateral agencies who have credited the pioneering work of BASIX, an Indian livelihoods promotion organization, in partnership with ICICI Lombard, a major private insurer. Other than BASIX, AIC, IFFCO-Tokio and other agencies that are engaged in the large-scale roll-out of WBCI can be possible mechanisms of transfer.

7.8.11 RELEVANCE

Ensuring sustained availability of food is one of the core elements of food security, therefore WBCI is relevant to FARMS.

7.8.12 SUSTAINABILITY

An important element of the sustainability of WBCI would be the demand for it, which depends on the product's proposition of real value to the insured. Insurance products have failed where there was not an adequate demand for it because of several reasons. Households may not perceive a threat in the risk, they could have other better mechanisms for managing risks such as non-farm sources of income, they may have access to existing subsidized insurance products, or they may have an expectation of relief packages by the government. The added value to farmers of formal insurance over other mechanisms to manage risks will affect the demand. Magnoni and Zimmerman (2011) define value from insurance (client value) as first, the value of the product when the claims are made compared with other coping strategies; second, the expected value the clients get because of peace of mind and other behavioral responses even when claims are not made (e.g., higher returns from investment made in the asset); and third, the value from externalities created by providing access to product-related services that provide some benefit to the clients (e.g., crop protection advice, credit, or other services provided by the insurance provider). Therefore, if the insurance creates a proposition of real value to the insured and includes insurance as part of a wider package of services, it is likely to be more sustainable and scalable. An important next step would be to ensure that clients understand the value offered by index insurance products through initial training and continuous capacity building (IFAD, 2010).

From the operational perspective, building capacity and ownership of implementation in stakeholders is important, because local stakeholders are critical to overcoming the initial challenges and to understanding the socio-economic fabric of the area.

Cost-effectiveness will also be important for long-term sustainability, which can be achieving by grafting the delivery of index insurance through efficient delivery channels that leverage existing rural networks (e.g., IFFCO-Tokio relies on its large network for parent company IFFCO's rural offices). Insurers rarely have their own rural networks, so they need to rely on delivery channels to deliver the products at an affordable cost to farmers.

On the supply side, reinsurance support is critical for scaling up index insurance, and this is an advantage of index insurance since it relies on triggers from a third party. An important condition for finding interested reinsurers is reliable and timely data on index values. This requires investments to improve infrastructure and the quality of weather data.

In summary, IFAD (2010) notes the following imperatives for ensuring the sustainability of index insurance products:

- Create a proposition of true value to the insured and offer insurance as part of a package of services;
- Build the capacity and ownership of implementation stakeholders;
- Increase client awareness of index insurance products;
- Graft onto existing, efficient delivery channels, engaging the private sector from the beginning;
- Access international risk-transfer markets;
- Improve the infrastructure and the quality of weather data;
- Promote enabling legal and regulatory frameworks; and
- Monitor and evaluate products to promote continuous improvement.

7.8.13 POSSIBLE ACTIVITIES FOR FARMS

Weather index-based insurance is an idea that has thus far appealed to implementers and researchers equally. Organizations such as the World Bank, IFPRI, the Microinsurance Innovations Facility, the BASIS program, and the Micro Insurance Centre have invested significant effort in developing innovative indexed insurance designs and in implementing pilots to evaluate their efficacy. Several of these evaluations are ongoing.

In India, meanwhile, WBCI has been taken to scale by AIC, which is now moving to WBCI as part of the required crop insurance that farmers have to buy along with crop loans. In addition, benefitting from the 2007 provision that allows private insurers to also avail of the government subsidy for crop insurance, several private insurers are also providing WBCI at scale, particularly ICICI Lombard and IFFCO-Tokio. Both these scale-ups present an opportunity to evaluate the scale-up of WBCI, and to assess its impact on farmer incomes. Both private providers, IFFCO-Tokio and ICICI Lombard, have expressed interest in facilitating independent evaluations of the impact of weather index-based insurance provision, and potentially other rural insurance products, on livelihoods and on the food and nutrition security of rural households. AIC has also expressed its willingness to cooperate in evaluations and in entering into a partnership following formal negotiations. However, it is not clear if some of the existing research organizations are already planning to conduct these evaluations. Therefore, a possible next step for FARMS could be to work with these organizations to activity, some potential ideas for further work in this area are as follows.

A few papers have found early evidence that financial literacy modules can increase take-up and potentially also increase the value of the insurance products to the clients, which should imply greater impact on farmers (Cole, et al., 2011, Gaurav et al., 2011). Since AIC and several other private partners

are scaling up WBCI in India, a potential activity for FARMS could be to implement financial literacy pilots to increase the take up and returns to WBCI. This activity would be coupled with an evaluation to understand its impact during scale-up. FARMS would collaborate with the researchers who worked on this initial evaluation to design and implement this activity.

Another possibility is that several insurers and studies have noted the need for higher densities of weather monitoring stations for better monitoring and for ground-truthing of weather observations from satellites, Doppler radar and weather aircraft. This could be in the form of collaborating to implement other innovative designs that improve the value- added of insurance products for the clients. Designs that improve the take-up would be particularly important, given that WBCI is being scaled up in India. The most prominent demand from farmers, which is acknowledged by all-weather index-based crop insurance providers, researchers and the Indian Meteorological Department (IMD), is for installing more automatic rain gauges (ARG) and automatic weather stations (AWS). Informed farmers are routinely reported to be demanding a reference weather station in their own village. While the number of inhabited villages in India is likely to exceed 593,731[53], IMD has officially recommended at least 30,000 AWSs and ARGs in aggregate, against an estimate in the low thousands at present, for facilitating country-wide coverage of weather index-based crop insurance, with higher densities in hilly regions, in rainfed agricultural areas, andin coastal and off-shore regions to better monitor both the vagaries of weather brought on by the monsoon and the influence of the ocean and river systems.

As weather index-based crop insurance is achieving scale in India, it would be worthwhile to evaluate the benefits that accrue from high-resolution weather data on assuaging the concerns of farmers for local reference data, providing an opportunity for greater customization of weather insurance options including of more appropriate triggers by insurers, and on the accuracy of weather forecasts. Where sizable numbers of weather variable sensors, if not stations, are being introduced across the country particularly for the benefit of farmers, an opportunity presents itself to add sensors and incorporate automatic data acquisition of soil moisture, acidity, toxicity, rate of water drainage and soil properties, physical, chemical and biological, or at least proxies as a cost benefit tradeoff, of reference areas for weather-index based insurance, that coupled with weather data would enable the provision of significantly more customized insurance products and the potential for village, or higher, resolution localized Agromet Advisory Services (AAS) by State Agricultural Universities (SAU) in partnership with IMD, Krishi Vigyan Kendras (KVK) and private providers. While the complete automation of soil testing may not be economically viable, high-resolution data from weather and other sensors could be merged with the results of chemical soil testing by village-based entrepreneurs and public providers, and that could also be aggregated to sustainably provide farm-specific advisories at low cost.

[53] Number of inhabited villages from the 2001 Census data.
http://www.censusindia.gov.in/Census_Data_2001/Census_data_finder/A_Series/Number_of_Village.htm

7.9 RIDGE TO VALLEY INTEGRATED WATERSHED MANAGEMENT

7.9.1 SUMMARY

In the early 1990s India developed a unique "Ridge to Valley" watershed management system to reach hundreds of thousands of villages. It is based on a cluster network and administered by the National Bank for Agricultural and Rural Development (NABARD). The Ridge to Valley approach addresses local community water demand and supply needs on a sustainable basis by involving all stakeholders in a water basin at the village level. India's approach involves direct village participation to make choices about watershed management systems for groundwater, rainwater and natural water systems (e.g., rivers, lakes). Village Water Communities (VWC) and district agencies form the backbone of this approach and work closely together to establish water rights and infrastructure. Over time the GOI has revised and improved these systems, so that by 2011 India has determined that these programs, while often having mixed benefits within a village, had contributed significantly to the conversion of degraded arable lands into productive farmland, especially for the Punjab and Gujarat. FARMS has the opportunity to extend this model to FARMS target states by applying successful elements of this watershed management model, as well as by integrating into the watershed model the best agroforestry practices, which are often poorly applied or underfunded.

7.9.2 DESCRIPTION

Out of India's total geographical area of 329 million hectares, about 146 million hectares (over 30%) is degraded and 85 million hectares is rainfed arable land. This includes degraded land not only under private ownership, but the departments of panchayats and forests according to the government. Over the past two decades, India developed a unique watershed management system – a "Ridge to Valley" participatory village-level approach – that was instituted in 1992 and managed by NABARD, which continues to manage the program. NABARD extends loans and subsidies for these watershed management projects. The GOI has focused on improving degraded and rainfed lands to regenerate depleted groundwater table and to increase the productivity of its arable lands. The initial projects were funded by donors and a special fund established by NABARD. Over time state agencies and governments have extended this pioneering approach around the country.

A Ridge to Valley project lasts approximately four years, with an initial phase in which the watershed zone and micro-watersheds are defined and management options are selected by the villagers. A cluster approach is used to capture watershed interactions across and within districts. The work is typically done through local NGO staff contracted by NABARD, ideally taking into account the community's inputs through a participatory process. Working with the community in Village Water Committees (VWC), the local NGO staff assists villagers to identify preferred interventions that could help improve water management. These interventions can include terracing, soil conservation barriers such as vegetation and fodder crops, crop diversification, and small dams to improve water percolation. Local villagers, partly through volunteer labor, help construct the structures. For any interventions that require technology transfer, such as new types of crops or techniques, the NGO works with local farmer groups to provide training.

Once the interventions have been identified, the NGO works with the community to determine the ownership of the land in the watershed, and identifies the public land and the owners of the private land to allocate water rights and distribution. Subsequently, a significant effort is required to enter into conversations with all land owners and the government to get approval for the interventions.
During 2008, the GOI, in collaboration with various water and land management agencies, published the *Common Guidelines for Watershed Development Projects* handbook, the official recommendations for

preparing such projects across the country.[54] During the 11th Five-Year Plan (2008 through 2012), a major new programmatic thrust has been proposed by the GOI on developing untreated areas. Currently, GOI's Ridge to Valley watershed management programs are to more fully focus on livelihood maintenance and improvements, and sustainable landscape management, using a cluster approach.

Concurrently, the World Agroforestry Centre (a part of the International Center on Agroforestry/ICRAF) has also undertaken a participatory, integrated approach to sustainable agroforestry management (Government of India, 2008) The Centre's approach presents villagers with various high value-added resilient crop and forestry options. It offers villagers the choice of 40 potential agroforestry practices that the Centre will support. In this way it can ascertain both villagers' priorities and the efficacy of varying agroforestry management practices. Already, according to ICRAF, there appears to be a winnowing of preferred adaptation practices by most villages to about 20 or fewer of these best practices. The Centre will be expanding its clusters of villages and districts over the coming years to see how this set of best practices differs by region, natural resource, and cultural conditions.

7.9.3 INNOVATIVE FEATURE

The key innovations of the Ridge to Valley watershed management approach are that it moves away from a plot-based approach to water conservation and considers the entire watershed when designing water management efforts. Also innovative is that India has shown that the most successful watershed projects rely on participatory village approaches and management systems to achieve consensus among a diverse community (some losers and some winners from the project) to achieve the overall common good of water distribution. The approach also includes rigorous evaluation and evidence-based improvements.

7.9.4 TECHNICAL AREA

The primary technical area for this best practice is IR 5 - Improved NRM and Farming Systems Adapted to Projected Climate Changes. A secondary area is IR 1 - Increased Agricultural Productivity and Output to Increase Farmers' Incomes.

7.9.5 CONSTRAINTS ADDRESSED

Access to sufficient and potable water is among India's major constraints on economic development in rural areas, especially degraded but arable lands. Poor farmers in these states face increasing vulnerability to droughts or floods due to potential climate changes. A degrading natural resource base and a depleting groundwater table are the major evidence about increasing water scarcity and the need for better watershed management practices. Farmers in highly vulnerable areas must find new, improved ways to sustainably manage their surface, groundwater, and rainfall sources across a watershed. FARMS target states and the selected African countries face this major development hurdle in terms of water availability and scarcity. Lessons learned from this BP can be introduced by FARMS to overcome or reduce such water availability problems.

7.9.6 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

The Ridge to Valley integrated watershed management approach will be applicable across a broad set of climatic, natural resource and other conditions in India and Africa, especially in areas with depleting groundwater, historic reliance on groundwater for rainfed agriculture, and severe degradation of land because of erosion and water run-off problems.

[54] Government of India. 2008. *Common Guidelines for Watershed Development Projects*. New Delhi, India.

7.9.7 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Institutions:

- World Agroforestry Centre
- National Rainfall Area Authority (NRAA)
- NABARD
- Indian Council on Agricultural Research (ICAR/NRM)
- National Watershed Development Programme for Rainfed Areas
- State Level Nodal Agencies (SLNA) and Central Nodal Agency
- District Watershed Development Units
- District Panchayat /Zilla Parishad
- Gram Sabha and Gram Panchyat
- Project Implementing Agencies (PIA)
- User Groups
- Watershed Committees
- Voluntary organizations, farmers, villagers, businesses, NGOs, and self-help groups

Individuals:

- Dr. V. Pal Singh (World Agroforestry Centre)
- Dr. A. K. Singh (ICAR/NRM Deputy Director General)

7.9.8 EFFECTIVENESS

According to studies by IWMP, IFPRI and others (Andreas Groetschel et al. 2000) these village-level watershed management efforts have shown mixed outcomes at the national and state levels in terms of effectiveness. Although there is a general feeling that these projects have been less successful in terms of equitable water distribution, many at the state and national levels believe that the Ridge to Valley approach has been the most important contributor to significantly expanding arable lands in states such as Gujarat, Punjab, and other northwestern areas. In 2002 IFPRI published a systematic evaluation of watershed development projects in India, using primarily quantitative data from a survey of 86 watersheds conducted in 1998. (Kerr, 2002). The evaluation found that the majority of watershed projects were not successful in sustainably conserving natural resources and improving agricultural productivity due to problems with implementation and fair water distribution across farmers. Success was concentrated heavily in areas where there was a strong NGO presence and where the projects truly relied on participatory approaches by poor and landless people to conceive and implement equitable distributions of agricultural and potable water systems. The study found that the success came at the expense of the poorest residents of the watershed, because the projects limited their access to common lands that they had traditionally relied on for obtaining water. There is anecdotal evidence of the success of Ridge to Valley projects in Maharashtra. In the Dharewadi Shelkewadi watershed in Maharashtra, where the project finished in 2001, the average depth of the water table decreased from 6.5m below ground to 3.5m below ground, making previously unproductive wells viable and improving access to groundwater. Irrigated areas in the watershed nearly doubled to 329 ha, and dairy and fodder production became key economic activities for the community.

No systematic evaluation of watershed projects has been conducted since the early 2000 IFPRI study. It is difficult, for example, to have the benefits of community-led watershed management projects to be equitably shared when villagers start out with such diverse combinations of assets (land, capital, and

labor). Poor marginalized farmers upstream or at higher elevations often do not share proportionally in receiving sufficient water for their lands due to the lack of water storage infrastructure on hilly sites. Watershed projects may also result in unequal distribution of costs and benefits: upstream residents, typically the poor, bear a distributional brunt of the costs, and the downstream, richer residents with larger tracts of land benefit the most. This creates an inherent tension that has to be addressed through careful discussions with the community and with agreement over the transfer of gains from winners to the losers.

There is a need, thus, to review the success stories in a rigorous manner to incorporate these lessons into ongoing watershed and agricultural management activities by the GOI and World Agroforestry Centre. We know that the participatory village approach is quite effective, but not why micro-level successes translate into better watershed practices in different geographic areas.

Cost-Effectiveness. The government, NABARD, and most organizations involved in these activities have not systematically developed the costs and benefits of Ridge to Valley projects. In the literature, there appears to have been very limited analysis of the total investment costs by NABARD, which handles the funding for village-level activities. Costs to farmers are also lacking, along with substantiated benefit assessments. There of course is much difficulty in estimating the environmental externalities and social opportunity costs and benefits associated with agricultural land improvements, but methods exist (net farm incomes and proxies for environmental service payments) that could be applied, if only to selected projects. The problem assessing the cost-effectiveness of this BP is that there do not appear to even be total capital outlays versus improved farm and other net revenues from introducing better watershed management practices.

A reason for the lack of financial and economic assessments may be the limited data collection and reporting capabilities of these projects, which rely heavily on (required) voluntary labor contributions from villagers. Another is the fact that these projects are heavily, if not totally, subsidized by the GOI. Knowledge of the cost-effectiveness of integrated watershed management projects is a gap where FARMS could add value.

7.9.9 SCALABILITY

Given that Ridge to Valley watershed management programs have been supported and expanded by the government for several decades, there is the ability to scale up such activities. Using NABARD as the general funding and implementing organization has been relatively successful, given its reach into rural areas. The latest GOI recommendations are to keep the program with NABARD, but possibly to assign certain implementation interventions at the village level to local NGOs or self-help groups.

7.9.10 TRANSFERABILITY

A major assumption underlying the Ridge to Valley watershed management approach is that it would be transferable across regions. The approach has been implemented in various regions of the country, but with mixed results, due to different environmental, farming, and socio-economic and cultural conditions.

Conditions for success. To successfully transfer improved watershed management practices to other degraded arable lands, the following conditions are needed.

- Ability to ascertain and transfer those key similar elements of success that occur across different projects realizing positive net benefits;
- Establishment of and conflict resolution support to NGOs and other advisors to the VWC who are without vested interests in the selection and implementation process;

- Full participation by all castes and stakeholders in the VWC and regional Distribution Development Units to ensure that their rights are protected;
- Identification of respected, fair village- and district-level champions;
- Capacity building support to understand the alternative options, and their labor and monetary costs and rewards;
- Availability in the village of surplus labor and capital to pay un- and/or under-employed workers to build, possibly operate, and maintain the necessary watershed management infrastructure;
- Sustained capital investment by the public sector and donors and the ability to transfer such programs to private-public-civil partnerships to maintain sustainability; and
- Equitable distribution of benefits among village beneficiaries to ensure long-term incentives exist for participation.

Mechanisms of transfer:

- National organizing/implementing agency such as NABARD
- Local and district-level NGOS that have been provided capacity-building tools
- Village self-help and producer associations to organize local support and promote behavior changes
- Village water committees/councils to manage disputes, programs, and distribution

7.9.11 RELEVANCE

The Ridge to Valley integrated watershed management BP primarily fits under IR 5 - the climate change and natural resource management objective. Secondary benefits fall IR 1.

7.9.12 SUSTAINABILITY

Sustainability of the past Ridge to Valley watershed management programs heavily depends on community relationships and access to the necessary inputs (technical, financial, and labor). To succeed, these interventions need an adequate mix of these factors for implementing and maintaining watershed projects, along with access to best practices in farm projection, market linkages, trade, and other environmental improvements.

7.9.13 POSSIBLE ACTIVITIES FOR FARMS

There are potentially several activities for FARMS in supporting the expansion and improvement of the BP for integrated watershed management. These activities include, but are not limited to the following.

- Initial assessment (review and analysis) of past successful watershed management practices, in collaboration with NABARD and other stakeholders;
- Needs assessment of the elements for success to integrate watershed management BPs with agroforestry BPs to produce a holistic package for faming system improvements;
- Analysis of the most cost-effective (highest social net benefits) management practices in terms of improved landscapes, livelihoods, and labor/job generation, especially for women and other vulnerable populations;
- Identification of the priority integrated agroforestry and watershed management best practices in collaboration with the GOI, NABARD, ICRAF, and other organizations;
- Establishment of effectiveness criteria and conditions for scaling-up and transferring integrated agricultural and watershed management practices to other regions in the target states and Africa;

- Focus on the development of viable, sustainable, and innovative local partnerships among businesses, farmers, and villager water management organizations;
- Preparation of a summary document that includes the findings and results from the above activities; and
- Integration and use of Digital Green and the FARMS knowledge platform to build capacity and inform new activities.

7.10 LIVESTOCK INSURANCE

7.10.1 SUMMARY

Livestock insurance, which covers death of the animal, is currently subsidized by the GOI. Innovations in livestock insurance come from: 1) agents (or intermediaries) who have reduced costs through the improved efficiency of the claim and data management processes, 2) risk mitigation through the provision of other support services (e.g., livestock support services), and 3) mitigation of fraud (e.g., through innovations in tags), moral hazard, and adverse selection. BASIX, a livelihoods promotion organization that implements livestock insurance, claims that it is the only company in the country that is providing a product that earns positive returns. Other than BASIX there are several innovative livestock insurance products that are being provided including BAIF's efforts to provide productivity insurance, and there is an integrated risk mitigation product incubated by the Institute for Financial Management and Research (IFMR) Trust. Information from providers suggests that livestock insurance cannot be financially viable without the simultaneous provision of other financial services, and possibly other services to manage risk. On the demand side, rural households also have diverse financial needs, including credit, savings, and insurance mechanisms. Both of these financial market supply and demand facts suggest that an integrated package of financial services is a more appropriate best practice than the current typical supply of single products. FARMS can add value to this area by evaluating the impact of these integrated financial products on household incomes. A concrete possibility is to collaborate with the IFMR Trust and expand the scope of their ongoing evaluation of integrated financial services.

7.10.2 DESCRIPTION

Since 2005-2006, livestock insurance has been subsidized by the Government of India under the "Livestock Insurance Scheme." Consequently, most of the products in the market are subsidized; the subsidy provided is 50% of the premium. More than 90% of the products are also credit-linked and provided through agents(Sharma, 2010) So far subsidized livestock insurance suffers from high fraud rates because of collusion by credit providers and customers, poor monitoring of insurance by credit providers, and underutilization of insurance by customers because of lack of knowledge about the breadth of services provided by these products.

Livestock insurance is provided in India largely through the partner-agent model, through direct sales (sales made by an insurance company directly to rural customers), or as community-based insurance (which is in the experimental stage). Private insurers entered the market in 2001 and provide livestock insurance products to meet their rural sector obligations, as required by the Insurance Regulatory and Development Authority (IRDA)(NDDB, 2010) The rural sector obligations for the insurers are intended to increase the penetration of insurance in the rural sector, but so far, of the 283 million head of cattle, only 7 percent are insured(NDDB, 2010)

Currently in India, the main insurers for this market are IFFCO-Tokio and Royal Sundaram (directly and through BASIX), while Bharti-AXA and HDFC-Agro also provide some livestock insurance. (ICICI Lombard has recently discontinued its livestock insurance product.[55])

Since 2005, under the micro-finance regulation, micro-finance institutions, NGOs and self-help groups can act as agents for insurance companies.[56] Typically the agents in partner-agent models are micro-

[55] ICICI Lombard recently stopped providing livestock insurance citing high administrative burden as the reason (Phone conversation between Aditya Jain, ICICI Lombard, and Rahul Bhargava, Consultant Abt Associates on July 8, 2011).

finance institutions or entities that provide credit to farmers. The insurance product is beneficial to agents in loan recovery, although it can create an incentive for the agent and the insured to collude. Insurers incur high transaction costs in direct sales in rural areas because their branch offices are not in rural areas. High transaction cost may also mean that banks enroll any customers that request a policy, leading to adverse selection (Sharma, 2010). The insurance fee or commission is small, so development officers prefer to pitch other financial products. Generally, direct sales of livestock insurance do not perform very well, i.e., they have a high loss ratio (ratio of total claims paid out to total premium).

A brief comparison of the three insurance models is provided in Table 7.

TABLE 7: A COMPARISON OF LIVESTOCK INSURANCE MODELS[57]

Attributes	Partner-Agent Model	Direct Sales	Community-Based Insurance
Risk Carrier	Insurer	Insurer	Community
Share of market (2009)	90%	10%	Experimental
Sales Channel	Intermediaries: MFI, Rural Institutions (NGO, Banks, Rural Companies like BASIX, Kshetriya Grameen Financial Services (KGFS) which are localized financial entities promoted by IFMR Trust.	Company (insurer) staff.	Community members
Verification	Certificate from veterinarian; trained agents (BASIX model)	Certificate from veterinarian	Community verification
Pros	Low transaction cost, can be expanded to cover the reach of intermediaries, low moral hazard because of close contact of rural institutions. High adverse selection by agent if insurance is credit-linked. Some rural institutions can also provide risk-mitigation livestock services (BASIX and KGFS do this)	Allows company to complete their rural obligations required by IRDA. Lower adverse selection, but still high because of the need to meet rural obligations with limited rural outreach	Low loss ratio as the moral hazard and adverse selection problem is minimized.

[56] For more details on history of livestock insurance in India, see Annexure 2, Sharma, Anupama, "Livestock Insurance: Lessons from the Indian Experience", Centre for Insurance Risk and Management, IFMR Research, no date listed but appears to be after 2009.

[57] Revised from various publications of Center for Insurance and Risk Management, IFMR, including Sharma (2009).

Attributes	Partner-Agent Model	Direct Sales	Community-Based Insurance
Cons	Credit-based rural institutions can collude with insure, limited by reach of rural institutions	High transaction costs, sales limited to the size of company staff	Community cannot bear large risks, therefore limits on expansion.
Key examples	BASIX (works in 10,000 villages) SKS (1,354 branches that can be leveraged) KGFS (relatively new)	Royal Sundaram IFFCO-Tokio Bharti-AXA HDFC-Agro	Vizianagaram District, DPIP initiative.

As shown in the table, the key challenges of providing livestock insurance are tackling moral hazard and adverse selection in rural areas, where insurance can be hard to administer. Since the premiums for these insurance products are low, the high administrative cost can make it a loss-making venture. As mentioned above, direct sales by insurers can have a very high loss ratio, but companies continue with these products to meet their rural obligations.[58] Other challenges to providing livestock insurance include: lack of data on cattle mortality, valuing cattle and buffaloes (whose prices vary by season), poor access to livestock-rearing services, and livestock identification.

Innovation in livestock insurance comes from: 1) agents (or intermediaries) who have reduced costs through improved efficiency of the claim and data management processes, 2) risk mitigation through provision of other support services (e.g., livestock support services), and 3) mitigation of moral hazard (e.g., through innovations in tags) and adverse selection. The Royal Sundaram and BASIX, a partner-agent model has innovated on several fronts to reduce their transaction costs. First, they rely on a network of trained livestock service agents, rather than working with the more expensive and hard-to-find veterinarians to assess the animal. Second, they work with rural business processing operations (BPOs) and a simplified ICT-based process, which significantly reduces the processing time and transaction costs. Finally, they rely on their existing rural network of professionals and unit offices that provide other livelihood services. BASIX claims that it has the only livestock insurance product in India that has positive returns.[59] More details on this product are provided below.

BASIX-Royal Sundaram Unbundled Partner-Agent Model. BASIX livestock insurance covers the death of livestock. It is sold to a rural household with no bundling with credit or other services. It is provided through BASIX, the partner in the partner-agent model. Although the insurance is not bundled, the majority of the insurance customers also take credit from BASIX, and very few customers only take insurance.[60] Insurance covers all livestock, including small ruminants, within a specific age range, which varies by the type of animal. For example, milk cows of only ages 2-10 years are covered by the policy.

BASIX serves as an agent of an insurance company, Royal Sundaram, that underwrites the insurance product. The key innovative features of the insurance product are as follows.[61]

[58] Bharti-AXA officials confirmed that livestock insurance is a loss-making product. AXA, the insurance company, also limits total livestock insurance to less than Rs. 2 crores per district. (Phone conversation between N.S. Prakash and Monalisa Bandhopadhyay, Bharti-AXA and Tulika Narayan (Abt) and Rahul Bhargava, June 17, 2011.)

[59] In-person conversation with Mr. D.Sattaiah, BASIX Delhi Office, June 3, 2011.

[60] The two insurance customers we met during our field visit on June 16th, 2011 were also borrowing from BASIX.

[61] Gunaranjan, Head of Insurance Business "Experiences in Livestock Insurance at BASIX", June 2008, BASIX

- Livestock insurance is one service provided via a window of various financial and insurance products for the rural sector. The other services include: microcredit, agricultural business development services, life insurance, health insurance, micro-enterprise insurance and weather insurance (not provided in 2010). Provision of multiple services is a key to its financial sustainability; without a range of products, no single insurance product would be financially sustainable from the providers' perspective. Of the multiple services, the single largest source of revenue for BASIX is microcredit. Overall, 78% of their revenue comes from microcredit, 12% from livestock and another 10-11% from their agriculture business development services (BDS).[62]
- Although it is not bundled, insurance and fee-based cattle health services are provided as a risk-mitigation strategy for enhancing the impact of micro-credit on livelihoods.
- There are three key design aspects of any insurance product: 1) an event that triggers the claim 2) the premium, and 3) the insurance amount. Ideally, historical data is needed to understand the prevalence of the trigger in the populations (e.g., information on cattle mortality). However, BASIX has been able to work with less data by piloting products that take into account any secondary information that is available, and by modifying its products based on their performance. BASIX believes that there are gains in having a simpler process compared to a complex model that minimizes moral hazard and adverse selection but is expensive to administer.
- Discounted premium rates are available for insuring multiple animals to reduce adverse selection and diversify the risks for the insurer; at the same time these provide broader protection to the customer.
- Insurance does not require a medical checkup by a veterinarian. An initial assessment of the animal is done by the livestock insurance agent (LSA), who is not a trained veterinarian. This allows wider coverage in areas where veterinarians are not easily available, and it also reduces the cost. On the flip side, the chance of poor risk analysis can also increase the loss ratio (i.e., the total value of claims divided by the total value of premiums).
- The claims settlement process is supported through rural business process outsourcing (BPO) and handled with minimum paperwork using IT products (mobile phones and email).
- Underwriting is enabled through electronic data transfer between rural BPOs, BASIX and insurers.

A BASIX LSA, who covers about a 20 km radius, or about 15 villages, with a motorcycle, makes the first visit to make an assessment of the animal and to talk to the farmer. The LSA is not a veterinarian but may be trained in some aspects of livestock management so that s/he can make a reasonable assessment. In the subsequent and final trip, the LSA collects the premium and tags the animal for identification (insurance is not valid without a tag and is suspended for 10 days after re-tagging). The information on the insurance is sent to BASIX, which then transfers the information to the rural BPO so that the information is immediately available to the insurer (Royal Sundaram).

Claims are settled using IT-enabled systems. The farmer uses a mobile phone to inform the BASIX field staff of the claim. That person informs the rural BPO via email and mobile phone, or directly to the rural BPO. The rural BPO informs the field facilitator by phone and email of the event, and the field facilitator visits the household to verify the claim. The rural household needs to have several documents

[62] In person conversation with Mr. D. Sattaiah, BASIX, Hyderabad. Furthermore, the LSA agent that we met with confirmed that large majority of her clients took loans from her, confirming that commission on loans accounts for the majority of commission earned by these agents. In summary, without credit and other financial services, the livestock insurance product cannot support the LSA.

to make the claim: 1) the claim form 2) an animal tag 3) a photograph and 4) the enrollment form. (It is not clear how they ensure that the customer has a camera). These forms are sent by the LSA for review by BASIX and are finally sent to the insurer for settlement.

There are several livestock insurance products available in the Indian market that include the following.

1. Community-Based Insurance Model: In this model, insurance is provided via self-help groups (SHGs) and involves community supervision and monitoring. It reduces the extent of false claims and thus far has reduced the loss ratio to 40 % (2008-2009), which can be as high as 100% for other partner-agent models in India. However, the scalability and viability of the model is constrained by the fact that there are limits on the amount of risk a community can bear. An example of this model is the Loan Protection Scheme in the Vizianagaram District Poverty Initiatives Project, which is done with cooperation and support from SHGs.[63] As of 2009, this type of model had 48,675 enrollments covering 85,000 animals.
2. Integrated Risk Mitigation for Dairy Farmers: An innovative product incubated by IFMR Trust integrates KGFS, which are localized financial services entities promoted by IFMR Trust, with dairy value-chain services of Dairy Network Enterprise (DNE) and cattle health services of local dairy healthcare services providers(Sharma et al., 2010) This product is innovative in that it provides a comprehensive risk mitigation tool for the farmers. Currently, this model is still in the experimental stage, and IFMR is inviting interested parties to replicate this model.
3. Radio Frequency Identification Tags (RFID): These tags are inserted inside the animal to address the problem of fraudulent claims that are possible because of poor animal identification. This innovation can be applied to any insurance model.[64] CIRM is currently conducting an evaluation of this identification technology in Gujarat and Punjab (ITGI Pasdhan Bima Project).[65] IFFCO-Tokio uses RFID technology and does not provide insurance without RFID tags.
4. BAIF Development Research Foundation in collaboration with CIRM is designing an innovative insurance product that provides productivity cover for cattle in BAIF operating areas. This research project began in May 2009 in Maharashtra and may well be complete by now. [66]
5. Weather-based livestock insurance: This is an increasingly popular product piloted in Mongolia and now in India, by the World Bank.

Although it is not an Indian BP, another innovative livestock insurance product has been researched recently by ILRI in collaboration with Cornell University, Syracuse University and BASIS: index-based livestock insurance.[67] This product has been tested in northern Kenya and in Malawi, among other countries. This insurance product is targeted to smallholder farmers and pastoralists who have low uptake of insurance in areas where there is drought-related mortality.

7.10.3 INNOVATIVE FEATURE

BASIX livestock insurance has several innovative features. Under its Samruddhi Marketing Assistance for Rural Territories (S-MART), BASIX has improved the claims process by instituting rural BPO and field process outsourcing (FPO). BASIX has identified BPO as a scalable idea to improve the delivery of various insurance products to rural areas. Under its S-MART program, BASIX also conducts a region-wide study before introducing its insurance program, to assess the supply of risk assessors, health

[63] See http://www.slideshare.net/IFMRCIRM/community-based-livestock-insurance-case-study for more details. Accessed June 28, 2011.
[64] Table 5 in Sharma, Anupama, "Livestock Insurance: Lessons from the Indian Experience", Centre for Insurance Risk and Management, provides the list of different identification techniques in India.
[65] http://www.ifmr.ac.in/cirm/projects-livelihood.htm (accessed April, 21, 2011).
[66] http://www.ifmr.ac.in/cirm/projects-livelihood.htm (accessed April, 21, 2011).
[67] http://livestockinsurance.wordpress.com/ (accessed April 21, 2011).

providers, and veterinarians, and to identify external factors that might affect insurance claims and risk. BASIX carefully prices its insurance so that it is financially sustainable and at the same time attractive to customers. Another innovation that has reduced transaction costs and time is its reliance on IT (mobile phones, email and electronic databases). In addition, discounts on premiums when insuring multiple animals have both increased outreach and reduced the adverse selection problem.[68] BASIX also provides preventive veterinary services in the areas where it operates, which reduces its insurance costs. This is a fee-based veterinary service that can be purchased separately from the insurance. Finally, BASIX provides a series of insurance packages that reduce the transaction cost per insurance product and also allow BASIX to diversity its risk while providing broader coverage to its clientele.

7.10.4 TECHNICAL AREA

The primary contribution of livestock insurance is to IR 5 - Improved NRM Practices and Agricultural Systems Adapted to Projected Climate Changes. The secondary contributions of livestock insurance will be to IR 2 - Expanded Use of Knowledge, Innovations and Technologies and to IR 1 - Increased Agricultural Productivity.

7.10.5 APPLICABLE LANDSCAPE/AGRO-ECOLOGY

This BP is applicable in areas with adequate ownership of livestock that allow the insurer to diversify its risk. It is applicable throughout the FARMS states and possibly in Africa in simpler versions.

7.10.6 RESOURCE ORGANIZATIONS AND INDIVIDUALS

Implementing Partners:

- BASIX, BAIF
- IFMR Trust
- Royal Sundaram, AXA General Insurance, IFFCO-Tokio and other general insurance companies

Researchers:

- Anupama Sharma, previously at Centre for Insurance and Risk Management, IFMR
- Michael Carter, Cornell University
- Thierry Van Bastelaer, Abt Associates Inc.
- Centre for Insurance and Risk Management, IFMR

7.10.7 EFFECTIVENESS

The core benefits of insurance products are that it provides a mechanism for the policyholder to mitigate his/her risk and smooth any income (and therefore consumption) shocks. For the rural poor, the income shocks resulting from the loss of livestock can often mean long periods of food insecurity. Therefore, livestock insurance can be an important tool for ensuring the food security of rural households. Another reason insurance can be important is that it can encourage investment in productive assets, particularly the assets or assets whose income stream is insured. For example, a farmer will be more willing to invest in artificial insemination or the vaccination of a cow that is insured, because s/he knows that the investment will not be completely lost if the cow dies. It could also mean greater investment in purchase of livestock.

[68] More information available in Gunaranjan, Head of Insurance Business "Experiences in Livestock Insurance at BASIX", June 2008, BASIX

Insurance can also lead to an increase in consumption by households, because they feel more secure in their assets, and insofar as this consumption competes with productive investment, the welfare impact of insurance could be less. However, if it leads to greater insurance of productive assets, then there will be positive welfare impacts. Therefore, whether insurance has a positive welfare impact is an empirical question.

Livestock insurance provides support to families in the event of an adverse event (death of livestock); it can be transformative if the family depends on their livestock for the majority of their income. However, as most households are only able to afford a very low value of insurance—and there is a minimum value required under IRDA— the impact would be limited. It is possible that insurance may propel households to make greater investments in livestock, which could put the households on a higher income path. However, we do not as yet have evidence if this is the case.

At a more basic level, claims should be settled within a reasonable amount of time and fairly. Most importantly, rural customers should have access to these products, as assessed via the area where the products are offered and the extent of take-up of the insurance. Since starting in 2006, BASIX has issued (as of March 31, 2010) 76,486 policies, of which 4,356 resulted in claims worth Rs. 31.59 million. The community-based model also appears to be growing, with about 48,675 enrollments. However, these data alone are not adequate to assess the effectiveness of the products.

So far there have not been formal evaluations or assessments of livestock insurance (whereas several assessments have been done of weather index-based insurance).

Another important factor in determining effectiveness would be whether the insurance products are financially sustainable and attractive to insurers. So far there have not been formal evaluations or assessments of livestock insurance, although several assessments have been done of weather index-based insurance. BASIX claims that their insurance products, including livestock insurance, are providing positive returns. Not surprisingly, the majority of the livestock insurance that is delivered through direct sales appear to be loss-making. ICICI Lombard has recently stopped providing livestock insurance, and Bharti-AXA notes that livestock insurance is a loss-making product.

7.10.8 SCALABILITY

Livestock insurance provided at scale diversifies the risk of the insurer. The biggest impediment to scale is that livestock insurance is a low-priced product, so that a large number of policy holders are needed to make it sustainable. At the same time, administering the insurance product over large rural areas can be a challenge unless existing rural networks can be leveraged. Conversations with BASIX and other providers of insurance suggest that livestock insurance can be sustained only it is provided as part of a package of integrated financial services.

7.10.9 TRANSFERABILITY

Conditions for success. Successful provision of livestock insurance requires several key players, social infrastructure and the right policy environments, as follows.

- Public or private insurance companies that have a mandate to enter the rural sector. In India, rural penetration of insurance products has been facilitated by government subsidies and deregulation, along with IRDA requirements that set targets for the rural sector obligations for all private insurance companies.
- Re-insurers to transfer risk.

- MFIs, NGOs, or SHGs and similar organizations with large rural networks that can serve as agents for insurers, and policies that allows such entities to serve as agents.
- Adequate data on livestock mortality (and/or morbidity) to inform actuarial pricing of livestock insurance.
- Cost-effective technology to identify animals.
- Availability of veterinarians or trained field technicians who can assess livestock, tag animals, and review claims.
- Rural BPOs and IT (mobile phone or email) or similar approaches to reduce transaction costs.
- Improved risk mitigation options for farmers such as health services for livestock, and business development services to improve returns from the livestock enterprise.

Mechanisms of transfer. There are several potential mechanisms for transferring this BP from India, including implementing organizations such as BASIX, KGFS, or research organizations such as IFMR Trust and CIRM. These organizations are also champions of these products. BASIX has been pro-active in sharing ideas with other agencies, including those that have been researching insurance products in Africa, and has a specific consultancy organization to handle such requests. The transfer could also include CIRM advisory institutions. For example, FARMS might use Dr. Neil Doherty of Wharton; Michael Carter, University of California Davis; and Dr. Richard Phillips, Georgia State University.

7.10.10 RELEVANCE

An important pillar of food security is stability in the availability, access and utilization of food. Rural insurance products such as livestock insurance enhance the stability of income by providing a cushion to farmers if they face the death of their livestock. Financial insurance is thus a priority for India, and given the importance of livestock in India, livestock insurance is an important element of the Eleventh Plan.

7.10.11 SUSTAINABILITY

BASIX livestock insurance is the only financially sustainable product on the ground in India. This suggests that it can be provided by the private sector if certain conditions are met: the provider has a good rural network and can provide other additional financial services in a comprehensive package of services.

7.10.12 POSSIBLE ACTIVITIES FOR FARMS

Discussions with BASIX and other providers suggest that livestock insurance cannot be provided sustainably without being bundled with other financial services. Rural households have other financial needs such as savings accounts and loans, which suggests that a more appropriate best practice to consider is a "one-stop shop" of financial services for the rural poor. BASIX and the IFMR Trust are both implementing such models in India. There are several possible activities that FARMS could pursue. Currently, the IFMR Trust is undertaking a randomized control trial (RCT) to assess the impact of its integrated financial services on village-level income and employment. FARMS could add value to this RCT effort by including questions to understand the impact of insurance, as separate from saving and loans, on food security and investments in agriculture. Alternatively or additionally, FARMS could implement and evaluate a similar program in collaboration with the IFMR Trust in one of the FARMS states.

There also are several innovative products that are being testing by CIRM: productivity insurance with BAIF, and integrated insurance with KGFS (which integrates livestock value-chain services and cattle health services). These could be replicated and tested for relative efficacy by FARMS.

ANNEX: ADDITIONAL POTENTIAL BEST PRACTICES

When the FARMS team was able to collect and analyze a reasonable amount of descriptive and evaluative material, the resulting best practice (BP) assessment was included in the body of this document. Where this was not possible for a potential best practice, that practice is listed in this annex, with a brief discussion of work to date and the BP's potential.

TEA PRODUCTION/BRANDING/MARKETING

Tea production is important for India, Kenya and Malawi. India is the world's largest tea grower at 750 million kg, which is 31% of global production[69]. India has made large increases in tea productivity per hectare since independence, higher increases than in any other country. India has a great range of branded teas, many of which are very well reputed, such as Darjeeling, Assam and Niligiri.
Kenya is Africa's biggest producer of tea and number four in the world. Kenya actually exports more than India, since India consumes much of its own tea production. Malawi is a relatively minor player in terms of global production and trade, but tea is one of Malawi's three major export crops and comprises 8% of total export earnings.[70]

As the objective of FARMS is to position India to share some of its technologies and best practices with the FTF target countries, the FARMS team thought that there may be some best practices in the tea sector in India that could improve these commodities and their production in Kenya or Malawi. The FARMS team will maintain this as a possible area of intervention, but since the FTF strategic plan of neither Kenya nor Malawi includes tea as a target crop, we decided not to pursue further information-gathering on this potential best practice until other, higher priority areas have been addressed.

SEED VILLAGES

The Indian Council of Agricultural Research (ICAR) and the state agricultural universities develop and release new varieties of crops on a regular basis, yet the seed replacement rate in India is lower than it should be. One of the bottlenecks in this system is the multiplication, distribution and availability of certified seed to remote rural areas. A Seed Village, whereby the entire village adopts the practice of multiplying seed for its community and the surrounding communities, is one way to address these issues. Several villages in Madhya Pradesh have had great success in multiplying soybean and mustard seed. They have successfully turned this into a commercial venture. This is possible in other places in India with other crop varieties, but it seems that there must be some external catalyst and solid social capital to initiate this process. The FARMS team will continue to examine Indian models of the seed village

[69] http://www.teauction.com/industry/indiantea.asp (23 Aug 2011).

[70] Fairtrade Tea: Early Impacts in Malawi.

concept to refine the practice. We may, starting with the multiplication of stress-tolerant varieties and possibly pulses, test the scalability of this model in remote areas where the need is greatest.

PROMOTING MAIZE, RICE AND OTHER HYBRIDS

Hybrid seed varieties can improve yields and confer other favorable traits, like disease resistance, on most crops. Hybrids, however, have two primary drawbacks: 1) seed cannot be saved from year to year and, 2) the purchased hybrid seed can be relatively expensive relative to open-pollinated varieties. This has meant that, in spite of great potential to improve yields, hybrid varieties are not used as much as they could be, especially in the developing world, where cash-flow issues come into play.

Over 80% of the rice crop in China is produced with hybrid varieties, yet in India the figure is around 3%. If India were to adopt the use of hybrid rice on a similar scale, it could increase rice production by 10-15%. Because of this very tangible means to increase grain production, many in India feel that this should be a priority, and the ICAR has set a target of 20% of rice production by hybrids.

Hybrid maize can increase yields by 2-3 times over the open-pollinated strains. Land dedicated to maize production is increasing in India every year, so hybrid maize is of increasing importance to India. Also, ICRISAT has developed hybrid millet varieties, which are used relatively widely in India. These hybrids have brought significant increases in yields of this crop, for which significant yield increases have eluded researchers for years. Transferring this technology to Africa has the potential to reduce food insecurity in some of the most food-insecure places, like the arid regions of Kenya, Mali, Burkina Faso and Niger.

Working to increase the use of hybrids originally seemed like a laudable best practice for FARMS, but as it is primarily the domain of classic research and extension, we decided to delay our investigations into this best practice until other more relevant options were exhausted. We think that the introduction of hybrid millet into parts of the millet-growing regions of African may have potential as a best practice for transfer, but more investigation will be required.

RECLAIMING SALINE SOIL

The Central Soil Salinity Research Institute (CSSRI) is a part of the Indian Council of Agricultural Research (ICAR) system. Its research focuses on the reclamation and sustainable management of salt-affected soils and on the rational use of poor-quality waters in agriculture. The institute has three regional stations that are in the FARMS zone of intervention and address different saline issues, i.e., at Canning Town (West Bengal) for research on problems of coastal salinity, at Bharuch (Gujarat) for salinity problems of black soil region, and at Lucknow (Uttar Pradesh) for research on Gangetic alluvial sodic lands.[71] FARMS will continue to look into the degree to which saline soil affects the food security of India and its need around the world before determining to invest any of its resources in these methodologies, which are now well known, but sometimes prohibitive in labor and/or cost. The CSSRI will be the primary partner helping us with this investigation.

[71] http://cssri.nic.in/introduction_regional.htm (28 August 2011).

MEDICINAL AND CULINARY HERB PRODUCTION

The FARMS team, in its search for best practices that could be applicable to the hilly areas of Uttarakhand, identified the production of high-value herbs as a potential best practice. Land area in the hilly regions comes at a premium, so high-value cash crops are sometimes the best alternative for these regions. Also, some herbs grow best in cool climates, making the hilly areas again appropriate. FARMS will look into this and other cash crops as an option for the hilly areas, if/when we work in this region.

WATER HARVESTING

Across India water harvesting to capture and store rainfall and replenish groundwater has been undertaken by villages for centuries. Indeed, India has in place across all regions extensive water-harvesting systems at the village and household levels. This BP is well known and technically advanced in India as contrasted with other emerging economies. On average water-harvesting systems are highly effective, scalable, and transferable, but not necessarily sustainable systems for water storage and groundwater replenishment, due to the lack of long-term capital and operational financing for system improvements. The latter is becoming increasingly problematic due to the extensive financial needs to improve, rebuild, and maintain many of the older stone village structures, especially in poorer villages. Recently the GOI submitted a request for climate financing from the Adaptation Fund to improve its water management systems, including water harvesting with rural labor provided under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), which is an Indian job guarantee scheme, enacted by legislation on August 25, 2005. The Adaptation Fund did not accept the project proposal in December 2010, so presumably there is still a need for such financing. Given the rather large financial, but not necessarily technical or capacity building, need for extending water-harvesting systems in FARMS-targeted states, it does not appear that FARMS might be able to contribute, given its limited resources.

VULNERABILITY ASSESSMENTS FOR CLIMATE CHANGE ADAPTATION BY THE FARMING SECTOR

Many vulnerability assessments for the country and most states have been prepared by Indian agricultural and environmental management agencies and scientists, as well as by NGOs. Most recently the Government requested the Indian Council of Agricultural Research (ICAR) under the National Initiative on Climate Resilient Agriculture (NICRA), which ICAR coordinates, to develop a map of the 100 districts most vulnerable to climate-change impacts on their agricultural systems. Several of these districts fall into the FARMs target areas. Presumably, NICRA identified these top vulnerable districts based on primary or secondary data collection. Hence, the contribution that FARMs can make to scaling up and transferring this best practice to its Indian target areas appears to be minimal given existing work. FARMS can however assist in transferring and disseminating knowledge about this BP to selected African countries. Liberia, for example, has requested capacity building in climate change planning and assessment, whereas several vulnerability assessments already exist for Kenya and Malawi. Process improvements in conducting and interpreting vulnerability assessments in all these countries may be an option for FARMS.

CLIMATE-SMART VILLAGES

India's NICRA appears to be heading towards supporting "climate-smart villages" through pilot activities that would give villages highly vulnerable to potential climate changes the resources and a set of best-bet technologies to adapt to such changes and build resilient yet cost-effective systems. The GOI has initiated Climate Smart Disaster Risk Management, which is an integrated, international climate change

and disaster prevention approach used in Africa and Asia. This approach enhances disaster risk management through various projects in climate-vulnerable villages. This BP is only now being formulated, although it is quite innovative. Its effectiveness, scalability and transferability as well as sustainability still need to be assessed. FARMS might decide to work with NICRA or another agency on the Climate Smart Village elements, with the goal of ensuring that food security and climate resilience reach the poorest farmers.

RED TRACTOR

Mahindra & Mahindra has developed the Yuvraj 215, a small, inexpensive tractor aimed at the small and marginal farmer seeking to increase productivity at an affordable price. The tractor, which costs Rs. 175,000 ($3,800), is about three times the cost of a pair of oxen but has five times higher production capacity. Since 2008, Mahindra has partnered with USAID to extend its network to be more responsive to small rural farmers. The red tractor was showcased in the USAID Agriculture and Food Security Expo at Mumbai in November 2010. Before working on this innovation, FARMS needs to assess the extent to which tractors in this price range are accessible to smallholder farmers, or if some custom-hiring arrangement is possible for farmers to benefit from this farm implement.

TRUCKS WITH INSTRUCTIONAL VIDEO

Aries Agro Limited is one of India's largest manufacturers of specialty plant nutrition solutions that has over 60,000 retailers and access to 7 million farmers. Aries Agro specializes in metal chelates to provide plant nutrients using environmental friendly products. Its core innovation appears to be in its innovative products for providing micronutrients to plants.

Aries Agro operates *Krishi Vigyan Vahan* (Farmer Science Vehicles) that have reached 8 million farmers in 26 states, primarily to increase awareness about these products. The KVV is equipped with audio-visual equipment, mobile soil-testing equipment, an agronomist and demonstration material. It visits six villages every day along predetermined routes to spread awareness of the innovative concepts that form the basis of Aries brands. The key objectives of KVV, as described on their website, are:[72]

Build awareness in remote, unserviced markets
Conduct farmer meetings and audio-visual shows on product applications
Visit six villages every day on a predetermined route
Book orders from farmers and collect token advances to confirm order bookings
Work with local distributor to liquidate stocks based on orders booked
Provide doorstep farmer advisory services, soil testing and query resolution
Incentivize farmers by providing special schemes on booking through the KVVs
Tracking of impact of extension work – farmers contacted vs. booked orders vs. actual sales
Advances will ensure dealers cannot push other competing brands at point of sale
Advances collected accrue to the company, with credit given to respective distributors after the sale is completed

Another innovation of Aries Agro is that it has partnered with CII's Young Indians to set up India 's first National Young Indian Farmers' Network.[73] Aries Agro has set up a Corporate Chapter for the specific purpose of providing access to young, progressive farmers to the wide spectrum of Yi Farmers Net

[72] http://www.ariesagro.com/rural-retail-vehicle.html (Accessed April 22, 2011)
[73] http://www.ariesagro.com/cii.html. (Accessed April 22, 2011)

activities and knowledge dissemination initiatives. The objective of the network is to enable information exchange between young farmers of India and to open a two-way communication between rural and urban areas, leveraging the fact that its Yi network includes youth from other professions. This network currently has 10,000 farmers, all aged 25 to 40 years. The purposes of the network are: 1) to use knowledge as a catalyst for rural development, for improving farm productivity, and hence farmer incomes, 2) to develop Indian Good Agricultural Practices standards (IndoGAP), 3) to develop activities like farmers' meetings (Suryodaya) and sessions in rural schools (*Bal Krishak Sambodhan*)to spread awareness in high school students of best agricultural technology and practices, and 4) connecting farmers and university professors to share latest agricultural research (UniConnect). The network also provides crop advisories using mobile text messages and soil-testing services, trains postmasters in 768 post offices to disseminate information in remote communities, pilots rural skill development certification programs, and conducts a series of flagship national conferences, called Agromax.

The growing base of youth enrolled in Aries Agros' network and the large coverage of KVVs without any public support is evidence that a market-led approach can provide another mechanism to provide extensions services. The best practice rests heavily on promoting products that appear to be effective, given the awards they have received. However, a more detailed review of these products, and a rigorous evaluation of the products' impact on farmer income is needed. Finally, it is not clear the extent to which the Aries Agro clients are smallholder farmers, or what percentage of the 10,000 farmers in the youth network are small and poor farmers. This is the role that FARMS can play.

INTEGRATED FARMING SYSTEMS

Integrated Farming Systems integrate agroforestry, horticulture, poultry, small ruminants, vermi-composting, and utilization of crop byproducts with the main goals of increasing farmer incomes and increasing the diversity of their income sources. ICAR has developed several integrated farming systems models that are researched extensively at their regional experiment stations. Several integrated farming models were identified as part of the all-India coordinated research program on biological integration of farming activities and resource management for resource poor small farmers (DRCSC, 2008).[74] These include integrated farming models developed for various regions in India: hilly regions, arid regions, semi-arid regions, and coastal regions. The models includes paddy-fish-azolla and duck-fish-azolla paddy systems. FARMS has visited the ICAR center in Jharkhand that has developed several integrated farming models for the region. These models have the potential to diversify farm incomes and make them more resilient to climate change. FARMS can work with ICAR and other institutions to identify the areas that can add value to the current work in this field. The biggest challenge in working with integrated systems is that they are heavily dependent on the specific agro-ecology of the region, and also the specific traditions of the region.

ALTERNATIVE ENERGY FOR IRRIGATION

In India alternative energy for irrigation is used primarily for water pumping. The alternative energy systems are: solar photolvoltaic pumping systems, water-pumping windmills, and biomass gasifiers (GEDA, http://www.geda.org.in/matrix.htm, accessed 02/08/11). Solar- and wind-powered pumping systems are used in India, but not yet on a large scale. The GOI and state governments, particularly Gujarat, have been providing financing for setting up solar- or wind-powered pumping systems. There are several manufacturers of SPV pumping systems and windmill-powered pumping systems. Gujarat has

[74] Development Research Communication and Service Centre, "Integrated Farm Models Developed under All India Coordinated Research Programme on Biological Integration of Farming Activities and Resource Management for Resource-Poor Small Farmers" Submitted to Department of Science and Technology, Gov.t of India, 2008.

the most developed program in providing wind mill-powered pumps and solar-powered pumps. In Gujarat, on average roughly 100 wind mills have been installed per year through GEDA's program during 2001-2006 for either minor irrigation, brine water pumping or drinking water. Several private sector partners can be leveraged for transfer of technology , includingTata Solar, Suzden, Jain Irrigation, and Husk Power Systems (the last only generates energy; it is not linked to pumping systems).

GEDA has been implementing a program for the deployment of water pumping-windmills for agriculture and related uses. A typical windmill under this program comprises an 18-bladed rotor of 3-meter diameter, installed on a tower of 10-meter height. The rotor, through the gear mechanism, drives the connecting rod and the pump, which can pump water from a maximum depth of 30 meters, when the average wind speed is 8-10 km per hour. The approximate rate of pumping under ideal conditions ranges from 1,000 to 1,200 liters per hour, which could cater to the irrigation needs of about one-half to one hectare of area, depending upon the cropping pattern and its water requirements. A windmill could be installed on an open well, bore well, or pond at a site that is free from any obstacles such high-rise buildings and tall trees that could restrict the availability of wind to the rotor . GEDA provides an application form for availing the benefit of the scheme that can be downloaded from its website.

Solar-Powered Pumps. The solar water pumping system is a standalone system operating on power generated using a solar PV (photovoltaic) system. The power generated by solar cells is used for operating a DC surface centrifugal mono-block pumpset for lifting water from bore, open well, or water reservoir for minor irrigation and drinking water purpose. The system requires a shadow-free area for installation of the Solar Panel (GEDA). The system is provided with 1,800 watt solar PV panel (24 nos. X 75 Wp) and 2 HP centrifugal DC mono-block / AC submersible with inverter. The average water delivery of a 2-HP solar pump will be around 1.38 to 1.40 lakh liters per day, for a suction head of 6 meters and dynamic head of 10 meters. The size of suction and delivery lines is 2.5 inches (62.5 mm).

There are three reasons why this may not be a good option to explore: 1) these types of pumps have a high capital cost and are prohibitively expensive for a single farmer, 2) To spread the cost of the pumps, they could be managed as a communal or cooperative resource, but there are always the attendant problems with communally managed property, 3) Energy for pumping water in India is subsidized and water is free, so an energy efficient pump has limited attraction, especially if it costs more than the normal electric pumps.

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