Enhancing Ecologically Resilient Food Security through Innovative Farming Systems in the Semi-Arid Midlands of Kenya

IDRC Project #106510

A project of

Kenya Agricultural Research Institute and McGill University

in

Machakos, Makueni and Tharaka-Nithi Counties, Kenya

Final Technical Report

by

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covering the period

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1. Executive Summary (2 page max.):

This project proceeds from a recognition that ‘proven technologies,’ such as high value traditional crops, indigenous chickens and integrated farm management practices, though scientifically validated, were not being widely adopted by small scale farmers in semi-arid Kenya. Our project set out to develop and scale-up an approach to spur the adoption of agricultural technologies and practices known to be well-adapted to semi-arid conditions. Our extension model is formally referred to as the ‘Primary (and Secondary) Participatory Agricultural Technology Evaluations’ (PPATEs/SPATEs) or, in lay terms, the ‘farmer-led adoption approach.’ The model was designed for technology evaluation and scaling-up of adoption of the improved practices on the basis of farmers’ priorities, ranked according to selection criteria including equity, ecological, food security, nutritional and economic values. The model constitutes both technology and technique; it contains what to adopt to build resilient farming systems, and how to scale up that adoption.

The positive results of the project can be measured by the increasing numbers of farmers adopting resilience-enhancing agricultural technologies and practices. More than 10,000 farmers are counted here as new adopters (See 2.1.1. in Excel report). Moreover, the project’s group-based research design sets these new adopters within a matrix of farmer groups, researchers, extension officers and market actors, who together embody diverse value chains as well as a network of support and knowledge diffusion. This network constitutes another key measure of our success, as it provides the socio-economic vehicle for sustained diffusion and adoption. County agricultural officers emerged as primary agents within this network when, spurred by the success of the group-based research design, they established links with 61 additional farmer groups (some 1,300 women and 700 men), across seven sub-counties, in evaluation and adoption of resilience-enhancing farming practices and technologies. Knowledge diffusion pathways and learning networks in the project serve to build the resilience capacities of farmers (majority female), in particular through training for peer-to-peer extension in a variety of agronomic practices including nutrition, poultry management, seed selection, post-harvest practices and participatory market development. Some 300 ‘community champions’ have in turn trained an estimated 3,000 other farmers, and thereby multiplied the reach of the project’s activities, and the impact of the resilience-building skills and practices, into households well beyond those originally involved in the research.

Perhaps our most important achievement was to improve household food security measures. We registered, in the project’s research sites, an increase in farmers’ access to sufficient quantities of diverse, nutritious foods. A 2014 survey conducted by the gender stream measured a significant drop in months of food insufficiency, especially within households most closely associated with the project (see Figure 1, Annex 2). In addition, the nutrition stream’s end-line survey further recorded observable differences in the nutritional status of women and children, including a decrease in childhood stunting from 33.8% to 19.6%. Another measure of impact is the degree to which the project activities have increased farmers’ knowledge, skills and engagement with local input and output markets. One example is that by August 2014, approximately 3,000 farmers representing over 60 groups sold some 219.5 tonnes of green grams valued at a total of KES 19,932,540 (approximately CAD 234,500) to a private grain trading company, Amerti Enterprise Ltd.

This brief summary of results illustrates the project’s significant impacts, both in terms of the efficacy of its technologies and the effectiveness and potential of its farmer-led adoption approach. The technologies (high-value traditional crops, indigenous chickens and a range of farm management practices) were selected, evaluated and prioritized by farmers. They resulted in
increased dietary diversity, consumption of foods of high micro-nutrient content, and farmers’, especially women’s, access to markets. The farmer-led adoption approach catalyzed both horizontal and vertical scaling-up of adoption of resilience-building technologies and practices. Farmers reached out to others horizontally through peer to peer learning and farmer group interactions, as mentioned above. The approach was also scaled-up vertically through adoption by Ministry of Agriculture sub-county officials, who are piloting the approach in new areas beyond the project’s original sites. Farmers, agricultural officers and our research team thus found the model to be an effective extension and scaling-up approach to reach large numbers of farmers with technologies and practices that bring nutritional, ecological, socio-cultural and economic benefits.

The PPATE/SPATE model, or farmer-led adoption approach, builds on strengths of collective action, learning networks, participatory process, social capital and established peer extension practices. It supports pluralist, integrative and bottom-up extension that starts with farmers themselves. In comparison, whereas the Common Interest Groups (CIGs) approach is limited to a focus on single commodities, our model emphasizes practical experimentation on a range of crop varieties, plus Indigenous Chicken, blending introduced and indigenous practices and technologies (such as farmer seed varieties and local chicken breeds), and learning-by-doing. In addition, our approach supports multiple micro-enterprise pathways, from seed multiplication, and small livestock service providers, to value-addition, agroforestry tree nurseries, small-scale packaging (and branding) and collective action for input and output marketing (e.g., purchase of seeds, fertilizers; sale of crops). In this sense, the approach leverages social capital into micro-enterprise development. Other models emphasize production. Our model incorporates all the integrated aspects of rural livelihoods and farming systems. It encourages ‘multi-functional agriculture’ (embracing nutritional outcomes, ecological agriculture, agro-forestry, value addition); ‘multi-level development’ (prioritizing household consumption first, sales second; founding local and export Agricultural Product Value Chains; and informing policy from county to regional levels). It recognizes the complexity of the food security question and therefore proposes an integrative scientific answer that is not a ‘silver bullet’ but rather a holistic method of building resilience through farmer-led technologies and techniques.

The results of the project have implications for the direction of future research, development and policy. Key questions for further study focus on the efficacy and onward evolution of the farmer-led adoption approach; the extent and effectiveness of peer-to-peer extension (specifically in nutrition, seed production, poultry management, post-harvest processing and value addition); private sector engagement in semi-arid regions; and prospects for strengthening gender equity for food security outcomes. In terms of agricultural development, our key finding was the importance of a multi-sectoral approach to building resilience in the farming system. Sectors from health to infrastructure to finance and marketing are critical to supporting any progress made in agronomic performance. Integrative approaches which advance productivity gains simultaneously with nutritional improvements, market linkages, youth engagement and gender equity help to embed, extend and sustain on-farm resilience to weather economic uncertainties. This reflects, as well, the types of policy recommendations emerging from the research, which underline the transformative potential of farmer-centred policy aimed at supporting, at multiple levels and sectors, the food security priorities of cash-poor farmers by strengthening the overall resilience of local farming systems.
2. The research problem (1 page max.):

Decades of research, development and policy efforts aimed at ending chronic food insecurity and malnutrition in Africa have generated a wealth of scientific insight, but a paucity of workable solutions. Our inter- and multidisciplinary research has demonstrated that critical elements necessary to the achievement of food security lay lodged within socio-economic relations characterizing given farming systems, including (weak or robust) social capital, governance and institutional arrangements. This project has focused on socio-economic, cultural and knowledge-based challenges, in addition to agronomic, technological and ecological concerns, to identify new adoption pathways capable of impacting large numbers of farmers in semi-arid areas. Farmers’ links to local markets for high value traditional crops, and engagement within newly-devolved governance structures, are two such pathways we have studied and strengthened.

We have made significant progress towards meeting the project’s objectives and development goals. Farmers have actively adopted and adapted the ‘resilience-building’ technologies and practices introduced by the project through a group-based, participatory evaluation and selection process. In January 2014, we completed field evaluations, as farmers then continued on with their prioritized technologies and practices through the last eight months of the project’s active research phase. During this time, the team was able to turn more focused attention to the scaling-up of positive adoption trends recorded over the project’s term. Concretely, we affected ‘horizontal’ scaling-up through peer-to-peer learning networks, targeted group activities (e.g., market groups, seed multipliers) and project-trained Service Providers and Farmer Nutrition Champions. ‘Vertical’ scaling-up was accomplished by linking with established Ministry of Agriculture extension services. Our model was adapted by county-level officials and piloted with 61 farmer groups in seven sub-counties.

The project’s main contribution to science is the achievement of an innovative and integrative farmer-led adoption approach that combines researchers’ and farmers’ technology, knowledge and skills, as well as novel and time-tested associated agronomic and economic practices. This adoption approach owes its effectiveness, in part, to the highly participatory process through which farmers selected the agricultural technologies (high value traditional crops (HVTCs) and Indigenous Chickens) and practices (e.g., water-harvesting, composting, dietary diversity, tree seedlings) to be evaluated in the project. This, in fact, echoes the project’s key contribution to development. We demonstrate that through a participatory, holistic approach to adoption, and the gender-balanced, farmer-led prioritization of chosen technologies and practices, farmers do adopt that which meets their nutritional, ecological, food security and income challenges and needs. Development goals, such as ending hunger and poverty, are significantly advanced by wider-spread adoption, which undergirds the building of resilient farming systems. A central contribution to policy, then, focuses on implementation of the farmer-led adoption approach through Ministry of Agriculture, Livestock and Fisheries extension services, specifically to promote HVTCs, which have been a Ministry priority for almost a decade, and Indigenous Chicken, which is a priority agricultural enterprise in all of the project’s semi-arid counties.

3. Progress towards milestones (5 pages max.):

3.1 First set of Milestones (March 2011-August 2011)

Project inception documents covering strategic vision and implementation framework. This initial six month period was essentially used to prepare our workplans for the entire project and gather the necessary human and material resources.
Milestone 1.1 Insights from proceedings of the Inception Workshop. The Inception Workshop was well attended by guests drawn from all stakeholder groups. Television, internet (https://www.youtube.com/watch?v=tL2nzg4EOBA) and newspaper coverage helped disseminate information to the general public.

Milestone 1.2 Participatory identification of research sites and technological packages. Eighteen Focal Research and Development Areas (FRDAs) located in semi-arid areas were identified in the three project Counties. Sites of the 54 Primary Participatory Agricultural Technology Evaluation (PPATE) were then selected in the 18 FRDAs. Site selection was participatory but purposive. The list of improved farm practices to be evaluated in the project was selected jointly by farmers and researchers in time for the start of the October 2011 short rainy season.

Milestone 1.3 Procurement of project vehicles, motorcycles and computers. The procurement of vehicles and other equipment was completed before the end of 2011.

Milestone 1.4 Project governance framework. A Memorandum of Understanding (MoU) was jointly drafted and signed by KARI and McGill in July 2012. MoUs between KARI and third-party organizations Kenya Medical Research Institute (KEMRI) and Freshco Seed Company were also drafted and signed. A project management unit team was then constituted.

Milestone 1.5 Project Management tools. A first version of the Logic Model, Performance Measurement Framework, and Risk Management Strategies were drafted during that reporting period. A publication planner was also prepared to guide the publication process. A number of workplans were drafted earlier in the project and revisited on a regular basis, especially during the Review and Planning Workshops organized each February.

3.2 Second set of Milestones (September 2011-August 2012)

Characterization of the dimensions of the food security problems and prospect in the project. This second reporting period was associated with the gaining of a better understanding of the drivers of food insecurity and constraints to farmers’ capacity to implement resilient farming systems. To accomplish this, a number of studies were initiated by Kenyan and Canadian graduate students and McGill and KARI scientists.

Milestone 2.1 Recruitment of key personnel and graduate students. Most of the personnel required in the project were recruited within the reporting period including a KARI Research Associate, an administrative assistant and nine research assistants. The majority of the graduate students were also recruited at this time. In total, we recruited nine graduate students at McGill and six students at Kenyan Universities. A number of research assistants were hired by KARI to assist with data management. Dr. Kim Bothi, joined as a McGill post-doctoral fellow in June 2013.

Milestone 2.2 Procurement of project equipment. Procurement of all equipment was finalized within the reporting period.

Milestone 2.3 Baseline studies for the different research streams. The baseline survey for the nutrition and health stream was completed during the reporting period. Survey data were collected from 324 pairs of mothers and children in Machakos and Makueni counties. A baseline survey for the indigenous chicken activity of PPATE evaluations was also completed. Data were collected from 743 respondents in the three counties. In November 2012, a general household survey was administered in the three counties (1258 households). Problems with the new system used to create the electronic database have led to important delays in compiling and analysing the data. In August
2013, a preliminary analysis of part of the survey data was performed and presented in a series of fact sheets submitted with our 3rd interim report. The database issues have been solved recently and we are currently working on the preparation of a comprehensive report.

**Milestone 2.4 First indicators of location specific biophysical constraints to food security through PPATE trials.** From a list of 16 potential technologies/practices, PPATE farmer groups selected eight that they felt were appropriate for their biophysical and socio-economic conditions. In each group, a host farmer volunteered his/her farm as a learning site. At the end of the first season, the need to also evaluate different water harvesting techniques (e.g., open furrows, tied-ridges) was identified and led to the establishment of new experimental plots in each of the 54 sites.

**Milestone 2.5 Gender research stream workshop.** The first edition of the project gender strategy was shared and reviewed in two project workshops (McGill, May 2012; Machakos, July 2012) where project team members reviewed and collaboratively edited the strategy, as well as discussed different means of incorporating gender analysis across the research streams.

**Milestone 2.6 Stakeholder appreciation of the dimensions of the food security problems and prospects, and charting of the way forward at the first end-of-year stakeholder workshop.** In February 2012, we held the first end-of-year stakeholder workshop in Machakos. There were representatives of most stakeholder groups in attendance. Their participation in the collaborative efforts at the workshop enhanced both the advancement of the research instruments and their own understanding of, and engagement with, the project, its activities and its objectives.

3.3 Third set of Milestones (September 2012 – August 2013)

**Participatory identification and promotion of effective interventions to address or arrest erosion of food security and environmental degradation.** Promotion of the adoption of resilience-enhancing interventions took place primarily through evaluative and research activities with 54 primary farmer groups and 133 active secondary farmer groups spread across the project area.

**Milestone 3.1 Implementation of SPATE trials of technical solutions identified and preferred by smallholder households based on their first season PPATE performance and experience.** The PPATE groups recruited other groups, identified as SPATE (Secondary Participatory Agricultural Technology Evaluation) groups. Originally, 216 SPATE groups were recruited by the PPATEs, but of this original number, 133 groups remain active at the time of writing. In addition to testing the technologies promoted in the PPATE sites, the SPATE groups also became directly involved in the training on participatory market system development offered by the project and the creation of market opportunity groups at the FRDA level.

**Milestone 3.2 Experimentation and development of seed and other input supply models with a commercial angle.** Insufficient access to certified seeds for drought tolerant crops is a key challenge faced by smallholder farmers. To address this challenge, Freshco obtained HVTCs seeds from KARI and, with the participation of project farmer groups, multiplied certified seeds for the purpose of availing them to farmers across the region. Three farmer groups, one in each county, have thus been trained on growing certified legume seeds and managing their own farm grown seed. In the short rains of 2012/2013, the three groups grew 8,696 kg of assorted seeds on contract with Freshco (reported in third interim report).

**Milestone 3.3 Participatory experimentation with the various models with potential to effect flow of relevant information between and among stakeholders, the main vehicle being PLAR.** Events
organized to facilitate the flow of information among stakeholders include inter-PPATE exchange visits in which the most successful PPATEs hosted members of other groups; visit by farmers to the 2012 KARI Biennial conference; visit by other PPATE farmers to KARI Embu and KARI Katumani to interact with researchers and Ministry of Agriculture officials; and Farmer Field days.

**Milestone 3.4** Stakeholder evaluation of the potential for the proposed interventions to alleviate the food security problems and charting of the way forward at the second end-of-year workshop. Key points raised by the group of stakeholders present at the Review and Planning workshop of February 2013 were the need to put in place a project “exit” strategy; organize a writeshop to document results from the field in peer-reviewed journal articles; organize a workshop for a better understanding of Knowledge Integration; address issues of post-harvest storage; revisit gender mainstreaming activities.

**Milestone 3.5** Education/awareness activities on traditional food utilization and post-harvest practices. In February-March 2014, the nutrition stream organized training sessions to enhance nutrition knowledge and dietary intake practices among community members (see Bukania ‘Farmer Nutrition Champions’). In July and August 2013, the post-harvest team organized two training workshops in Wote and Embu, which aimed at exposing the KARI-McGill team and extension staff to the various types of pests that affect the crops being evaluated in the project. Following the workshop, field research assistants then set-up local demonstrations, which have reached an additional 234 farmers (113 men, 121 women).

**Milestone 3.6** Presentation of results and/or proposed approach at an international conference. See Annex 3 for a list of conferences at which we presented our results (oral, posters).

**Milestone 3.7** Mid-term Evaluation report. Following consultations with IDRC, it was decided to replace this external review by a self-evaluation that took place at the Review and Planning workshop of February 2013.

3.4 Fourth set of Milestones (September 2013-August 2014)

**Documentation of change in farming systems, food security, health and nutrition, supporting institutions, and up-scaling of innovations in the project area.** The last reporting period focusses primarily on documenting the impact of the project and how we have achieved our objectives.

**Milestone 4.1.** Report on rates of adoption of innovations. Three surveys following a probabilistic sampling procedure were administered to permit statistical inference about adoption rates in the study area: a gender survey, administered in April 2014 to 405 households; an adoption survey, administered in August 2014 to 600 households; and the baseline-end-line surveys administered by the nutrition stream (n = 324). For the first two surveys, the sample was stratified by PPATE, SPATE and non-project households and included before-and-after questions to capture information on changes in practices and behavior. Preliminary findings from these surveys are presented in this report (see Annexes 2, 4 and 6).

**Milestone 4.2.** End of project component report on health and nutrition. The report by the nutrition and health stream (Bukania ‘Farmer Nutrition Champions’). It includes a description of their activities – e.g., baseline and end-line surveys, nutrition education campaigns. The final analysis and interpretation of the end-line survey will be completed shortly.
Milestone 4.3. Reports on impact of project on farming and land use systems, nutrition and health, market access by farmers, social capital in local communities. Included in the survey instruments described under Milestone 4.1, are questions designed to assess the potential impact of the project on a number of indicators such as food security, access to information, awareness, consumption patterns, access to markets. We have included preliminary findings in this report (Annex 2, 6).

Milestone 4.4. Report on integrated assessment (i.e., integration of different research streams). Integrated assessment refers to the synthesizing of the information generated from the different streams into a coherent set of key findings and messages. Key integrated messages from the project are presented under Section 4 of the report.

Milestone 4.5. Recommendations for policies that are supportive of technology up-take and resilience in farming systems. A series of resilience-focused policy recommendations generated from our project findings and activities is provided under Objective 5 in Section 4 of this report.

Milestone 4.6. Series of dissemination activities in the different FRDAs. Activities to disseminate and share information about our project activities have been implemented on an on-going basis. These include the Farmer Field Days, the up-scaling pilot project, which was implemented by sub-counties’ officers but also a series of meetings that took place with the PPATE and SPATE groups in early 2014 to discuss the exit strategy.

Milestone 4.7. Presentation of results at an international conference and research findings submitted to international peer-reviewed scientific journals. A number of presentations (oral, posters) have been made at international conferences and are listed in Annex 3 which also provide information on technical reports and scientific papers.

Milestone 4.8. Final evaluation report (external). At project mid-term, a decision was made jointly with IDRC to not conduct these external reviews (mid- and final).

3.5 New set of project Milestones

In mid-2013, discussions took place with IDRC to identify important project outputs. In order to ensure that these would be achieved, it was decided to consider these outputs as New project Milestones to be added to those already in the Memorandum of Grant Conditions (MGC).

NM1. Assessment of effectiveness of the PPATE/SPATE as a technology up-scaling model. An important deliverable from this project is to clearly highlight how the PPATE/SPATE model works in view of current and past extension models, but also on the basis of evidence gathered during its implementation. A working paper is under preparation based on the presentation made at the African CIFSRF conference in Naivasha (Maina et al, ‘PPATE SPATE Extension Model’).

NM2. Conduct economic assessment of performance of traditional food crops “technologies”. There was a need to assess the improved varieties promoted in our project from an economic perspective, taking into account input and labour costs, and market opportunities. A working paper has been submitted by Dr. Richard Mulwa’s team of the University of Nairobi (Now partnered with the project). The report is now being revised following comments by members of our team and the final report will be ready in a couple of weeks (mid-September).

NM 3. Mechanisms for private sector engagement in farm inputs and produce marketing (e.g. seeds, fertilizers and grain). The private sector is considered as a potential key player in addressing constraints faced by smallholder farmers. Many of our project activities involved the private sector
but no systematic study had been performed to better understand the mechanism of engagement of the private sector in semi-arid Kenya. We hired a researcher, Dr. Catherine Kilelu, to conduct an exploratory study on constraints and opportunities for engaging the private sector in semi-arid areas of Kenya (Kilelu 2014).

**NM4. Assessment of demand and forecast of supply for traditional food crops improved variety certified seeds.** Limited information is available regarding the supply and demand of traditional high value crops in the semi-arid areas of Kenya. A study was conducted under the guidance of Dr. Mulwa from U. of Nairobi. As for NM2 above, a report has been submitted but is now under revision following our comments.

**NM5. Assessment of labour constraints in farm operations and options for addressing the problem.** Although the issue of labour constraints had been considered in some of our other studies (e.g., economics, household survey), we felt the need to conduct a separate study that would systematically look at this issue. This study was undertaken by Dr. Mulwa’s team from U. of Nairobi. The report has been submitted but is now under revision following our comments.

**NM6. Report on technical feasibility and economic viability of labour saving interventions e.g., introduction of small scale motorized farm machinery.** The specific issue of the mechanization of some of the farm operation was discussed, in particular with regards to land preparation. A study on the feasibility of such interventions was conducted under the supervision of Dr. Mulwa. Like the other three studies, a report was submitted and is currently under revision following comments from the Project Management Unit.

**NM7. Implement, document and report on enhancing the gender mainstreaming activities in project as proposed in the Gender strategy.** A report has been prepared (Annex 4) highlighting key issues related to gender mainstreaming in our project but also presenting findings from the gender survey administered in April 2014.

**NM8. Develop protocols on redesigning the NRM activities within the project as a follow-up to the visit to West Africa for resilience and sustainability.** In Oct 2013, a team of ten, including from the Ministry, visited Burkina Faso to investigate whether the water harvesting techniques and market interventions being used in the Sahel project could be adapted to our project areas (Sila et al 2014).

**NM9. Protocols and Report on enhancing consumption of nutritious traditional local food crops in the project areas through value addition e.g., processing.** Information about changes in consumption of local food crops will be generated from the adoption survey and end-line survey of the nutrition team.

**NM10. Protocol and Report on Nutrition education campaigns by the nutrition and health stream.** The report on the Nutrition Educational campaigns includes a description of their implementation and effectiveness (Bukania ‘Farmer Nutrition Champions’).

4. **Synthesis of research results (10 pages max.):**

**Objective 1: To gain a shared understanding of traditional food and indigenous knowledge systems, and key social, institutional, environmental and economic drivers of food insecurity among women and men in communities included in the study**

1.1. **Conducted household baseline survey; finalized cleaning and preparation of data for analysis**

The project team conducted a household survey in the three counties between July and November, 2012 in a total of 1,258 households to contribute to our understanding of drivers of food insecurity.
Two innovations were used in the process: (i) creating e-forms of the survey questionnaire to ease data entry and (ii) organising for data entry to take place concurrently with data collection to reduce the lag between data collection and production of the database. The innovations did not live up to their promise, however, leading to lengthy delays in data cleaning and analysis. In August 2013, a preliminary analysis of part of the survey data was performed and presented in a series of fact sheets submitted with our 3rd interim report. Preliminary results indicated that, using the HFIAP indicator, more than 73% of all households in the study area could be considered moderately to severely food insecure and that female-headed households were significantly more food insecure than male-headed households. Additional studies indicate that inadequate market linkages, high cost of seeds, lack of irrigation, pests and frequent droughts hinder agricultural development in the semi-arid regions (see Appendix 6 and xxx Mulwa studies).

1.2 Farmer field days in the counties at the end of the season Over the 3.5 year project, some 24 farmer field days were organized to give farmer groups a chance to demonstrate their success, share results with peers, draw together stakeholders, including other farmers, county-level policy-makers, private sectors actors and researchers from various fields. In 2014, a total of seven field days were organised in Kathonzweni, Tharaka North, Tharaka South, Makindu, Makueni, Mwala, Yatta sub-counties, and attended by 709 men, 1269 women and 221 youth. These events served to diffuse knowledge and strengthen value chains within and beyond the study sites.

1.3. Research streams conducted studies on elements of the livelihood and farming systems

1.3.1 Economics One Master’s student joined McGill economics stream in August 2013 and analyzed data from the three counties to provide policy insight based on on-the-ground data. His preliminary results were submitted for publication in August 2014; however, his research will continue into 2015, with a specific focus on technology, food sovereignty and climate mitigation. Two additional papers focusing on technology, collective action and food security will be written in 2014-2015. Examining smallholder agro-economic data from two Agro-Ecological Zones (AEZ), LM4 and LM5, the economics stream analysed barriers to increased household income and the greater adoption of ‘drought-resilient,’ High Value Traditional Crops (HVTCS). Research findings in this stream are reported in detail below, under objective 4, and in section 5 below.

1.3.2 Nutrition and Health For results of the nutrition and health stream, please see objective 3; as well as section 5 that follows, where we examine the degree to which, in the achievement of our specific research objectives, the project met expected nutrition-related AFS outcomes.

1.3.3 Gender A study of gendered group dynamics in the adoption of Indigenous Chicken (IC) management practices offers a glimpse of ways the project team generated fuller understandings of the farming system as a whole. The study examined results of project training activities and how these mobilized women-oriented value chains in chickens and eggs (Brownhill et al, forthcoming). In Jan-Mar 2013, 61 farmers were trained in management of household flocks of indigenous chicken. Since that time they have in turn trained several hundred other farmers and offered vaccination services in their communities. We assessed adoption patterns in the groups impacted by this training. All farmer groups were eager to adopt improved IC management. Many groups identified secondary groups with whom to share skills and enterprise development. Our survey showed a 65% increase in vaccination rates among PPATE farmers, and 23% and 12% increases among SPATE and non-participating farmers (Figure 4, Annex 2). One set of women’s groups in Wote took their organizing efforts farther, to form an innovative chicken producers’ association, in which different groups focus on different links on the IC value chain, such as eggs (for hatching,
for eating), cock exchange and feed production. The same groups recorded improved feeding, watering, housing, bird survival, breeding, egg production and marketing outcomes after training (Brownhill et al forthcoming). These results highlight the efficacy of collective action and suggest the rich potential for our farmer-led adoption approach to find ready acceptance among other farmers, especially women’s groups in the sub-counties we have studied and beyond.

Gains made in transforming gender relations require continued assessment and monitoring, with a view to safeguarding women’s entitlements, including their customary duty and entitlement to produce food for the family, often linked to control over shambas, or kitchen gardens, and poultry production and local sales. Studies carried out elsewhere have demonstrated that with commercialization, men often take over women’s enterprises, as these move from subsistence provision to cash generation. One option explored in the gender team’s analysis of adoption is to assess and negotiate the limits of women’s typical ‘radius of mobility’ (for accessing markets) to find the starting point for building women’s sustained control over resilience-building enterprises in their domain (Njuguna et al forthcoming). Further findings on gender themes under each objective are detailed throughout the report (see Annex 4 for a report on gender mainstreaming).

1.3.4 Land tenure The Land Tenure Stream focused primarily on analysis of land related questions and household profiles in the baseline household surveys. Preliminary analysis shed light on conflicting pressures on land ownership (including uneven or contentious titling processes) which can present barriers to investment in agriculture. Data are still being analyzed; a preliminary report (Galaty 2014) summarizes observations arising from field studies in Tharaka and Makueni.

1.3.5 Policies and institutions Key activities in this stream centred on a study of devolution and agricultural policy-making; and the completion of various student studies that illuminated various strengths and weaknesses of local farming systems. Results of the devolution research include farmers’ need for greater access to extension services, as through peer-to-peer extension models, and for increased involvement of farmers in forums addressing agricultural policy-making (Brownhill et al 2012; and forthcoming).

In an analysis of Kenyan forest laws and the institutions that enforce them, Stephanie Shumsky used a gendered lens to analyze how these regulations affect use of state-managed lands for wild food harvest, farming, grazing and commercial purposes. She found that activities traditionally undertaken by women, such as subsistence level wild food harvesting and collecting water, are less clearly defined in the forest laws; they often require expensive license fees, community-level permissions and stiff penalties for non-compliance. In contrast, male dominated domains like charcoal burning are well-delineated in the laws and require only minimal fees, organization and support to access (Shumsky et al forthcoming).

Colleen Eidt’s doctoral research shed light on how institutions can better govern knowledge, to foster agricultural innovation for enhanced food security. Results of an early study found a disparity between the values and networks of small-scale farmers and agricultural policy makers, researchers, and agricultural extension officers (Eidt et al 2012). These findings led her to further study, which determined that many of the forums designed to tackle the issue of misaligned values are ineffective due to failures to address underlying issues of inequalities in power and knowledge. In some circumstances, attempts to conduct participatory agricultural extension have institutionalized existing power relations, while at the same time increasing farmer knowledge. The reinforcement of the status quo had negative effects on trust, on the establishment of shared values
and networks, and, ultimately, on innovation, all of which are central to building resilient systems. Where participatory interventions were found to be effective in improving innovation and food security, local leadership was identified as key to their success.

A final household survey in 2013 (n=147) reconfirmed the importance of local leaders in promoting innovation, due to their ability to tap into existing social networks, to leverage their own social capital, to increase the trust and perceived legitimacy of projects, and to foster formation of shared values. Findings indicated that within a more networked and innovative community, power was more dispersed among multiple local leaders and community members, rather than highly concentrated in the hands of a few (see Figures 2 and 3 in Annex 2). These findings underlined for us the importance of democratic and inclusive policy processes as well as the efficacy of collective action among farmers for advancing food security goals.

1.3.6 Environment and Natural Resources Management A key achievement of the E&NRM stream has been the success, in terms of technical performance and adoption rates, of the soil and water conservation technique combining organic and inorganic fertilizers with open or tied ridges. This is significant due to the predominance of low soil fertility and poor water harvesting practices, which negatively impact food production in the region (Gitari et al, Evaluation report). Tied ridges were shown to be an especially important innovation in the first year of the project, and were by the third year, being evaluated in all 54 PPATE trials. Results suggest that its application is most successful under certain soil/weather combinations that minimize the risk of water-logging. For example, in the 2012 long rains in Kathonzweni, yields of green grams were lower under tied-ridges than open furrows because of the abundant rains. The trials also highlighted the labour required to implement this technique, which has led to initiatives to identify labour-reducing implements (mechanization) and possible linkage with youth groups focused on pre- and post-harvest agricultural enterprises. In Tharaka, a number of farmer groups involved in the project have established tree nurseries for fruit trees and agroforestry practices. Please see Box 1 in Annex 2 for a further review of findings of five graduate students’ studies (see also Gitari et al Evaluation report).

1.3.7 Knowledge Integration The knowledge integration stream identified cross-cutting mechanisms to improve the knowledge flows among stakeholders in the farming system. Our aim was to translate the integrated knowledge arising from our diverse research streams into key messages to improve food security research, practice and policy. We reached this target by:

- Creating an innovative conceptual framework to re-frame the challenge of food insecurity as a complex problem, and using it to identify key messages from a highly interdisciplinary project (http://karimcgill-foodsecurity.org/publications/conference-posters/);
- Utilizing the framework features, including the environmental, organizational and relational (inter- and intra-personal) contexts, to guide the research and integrate findings;
- Implementing this integrated approach to facilitate farmer-led decision making, peer-to-peer learning and multi-stakeholder collaboration in the local farming system;
- Analyzing the institutional arrangements that facilitate this knowledge integration with policy and social network analyses; and,
- Employing the framework to clarify findings connecting ecological, social, institutional and economic factors influencing scaling-up of resilience-enhancing technologies.

On a project team level, the primary mechanisms to promote knowledge exchange included trainings, workshops and writeshops. These occasions facilitated a continuous process of team-building, project planning, evaluation, reflection, adaption and joint publication. The stream also
undertook a study focusing on farmer participation and decision-making in local farming knowledge systems. This study assessed the process of knowledge networking via the extension tools employed in project, in particular the Farmer Field Days (FFDs). Over a 3.5-year period, some 5,665 women and men from the three project counties participated in 24 FFDs. The study, conducted in early 2014, identified FFDs as an effective tool for knowledge dissemination: 86% of participants indicated that they were able to apply what they have learned at FFDs and over 50% reported sharing new knowledge on a frequent basis. The study also identified opportunities to improve the effectiveness of these extension mechanisms, particularly in terms of wider stakeholder inclusion (Bothi et al., in preparation).

Objective 2: To catalyze and upscale the adoption, and assess the social, economic and environmental impacts, of high value traditional crops, integrated livestock, soil, water and pest management practices, and postharvest technologies

2.1 Set up and monitor primary participatory agricultural technology evaluations and secondary participatory agricultural technology evaluations

The participatory evaluation of improved crop varieties in the PPATEs took place over five seasons, thus providing valuable information on their potential to contribute to resilient farming systems in semi-arid Kenya. Although there was some regional variation, green grams and cowpea varieties performed well across the sites. Similarly, the water-harvesting trials conducted in all 54 PPATE sites highlighted the potential, and limitations, of tied-ridges and open furrows to cope with the scarcity of water. Key results from these experiments are being prepared as peer-reviewed articles. Some of the key findings have been summarized in presentations made at the African CIFSRF Conference in Naivasha in June 2014 (Wangari et al Farmers Voice; and Gitari et al Evaluation report).

Another important aspect of the field evaluations was the expansion of learning networks among farmer groups and the training of individual champions who disseminated knowledge to other farmers and farmer groups. This included the training of 61 Indigenous Chicken Service Providers in 2013 and 121 Farmer Nutrition Champions in 2014 who, in turn, reached out to others in their communities to improve skills, knowledge and practices for better backyard poultry management and household nutrition and dietary diversity. Indications of the people reached through these methods include the following illustrative examples: In April 2014, two months after nutrition education trainings, evaluations of just 15 of the 121 trainees recorded that these ‘champions’ had held a total of 53 training session, reaching 715 community members. Final evaluations of the other FNCs are expected to show similar results. Further, a gender survey in April 2014 recorded increases in use of vaccinations to treat common poultry diseases. Vaccination, which was central to the IC training curriculum, has been one of the key factors in improving poultry flock survival and productivity (see Figure 4 in Annex 2).

2.2 Extension of the farmer-led adoption approach beyond the originally-planned farmer groups

Through an iterative process and participatory engagement in project activities, Ministry of Agriculture Sub-County Agricultural Officers took the initiative to establish sets of tertiary farmer groups, what we call ‘TPATEs,’ to extend learning and technology adoption in Machakos, Makueni and Tharaka-Nithi. The Agricultural Officers had learned about the approach through their continuous involvement in project activities from its inception. In 2011-2012, they worked in tandem with researchers and farmers in the primary and secondary farmer group evaluations. In
October 2013, they initiated tertiary evaluations with 36 farmer groups in four sub-counties. By the April 2014 planting season, they had expanded the piloting to 61 groups in seven sub-counties, with some 715 men and 1,387 women members. This development undergirds the efficacy of the approach we have developed, and provides an indication of the potential for much wider uptake of the approach, and of the associated resilience-building agricultural technologies and practices evaluated in this project.

2.3 **Promote and evaluate improved and indigenous crop health and post-harvest practices for storage and value addition**

A baseline survey and focus group discussions were undertaken across the project areas between September and October 2012. The objectives of the survey were to (i) identify the major field pest challenges within the region and (ii) assess the current post-harvest challenges faced by smallholder farmers and the various coping strategies used to address these challenges. For insect pests, farmers use various insecticides available in the market in consultation with extension officers. Some farmers use indigenous practices such as ash and smoke from burning donkey dung or tobacco as a spray for insects, and physical traps for vertebrate pests. Field Research Assistants received training in identifying field pests and diseases and applying the appropriate control, which they shared with PPATE farmer groups. Farmers then closely monitored the occurrence of field pests and diseases, and the control measures that were taken. In July and August 2013, two training workshops on post-harvest storage were organized in Wote and Embu. These workshops were aimed at exposing the KARI-McGill team and extension staff to the various types of pests that affect the crops that were being evaluated in the project. The training addressed issues related to timely harvesting, proper drying of grains using hygienic method, storing grains in well aerated environment, timely treatment with recommended pesticides, application of the right dose, and store inspection during storage. Discussions about farmers own approaches also took place. Field research assistant then organized a series of demonstrations at the FRDA level, reaching an additional 234 farmers.

2.4 **Identify factors influencing adoption and mechanisms for up-scaling of innovations** In August 2014, an adoption survey was implemented to assess changes in knowledge, attitude and practice of participating (PPATEs, SPATEs) and non-participating smallholder farmers. Data analysis is underway and will contribute to our understanding of how farmers in the region mobilize, disseminate and use knowledge, and the associated technologies and practices most supportive of resilience. Results from a preliminary analysis of the data suggest the potential role played by project activities in facilitating changes in both knowledge and practices among smallholder farmers involved in the project. In effect, for a wide range of agricultural practices, the percentage of households that have made a change during the lifetime of the project (2011-2014) is significantly higher (using $\chi^2$ test of independence) for project households (PPATE, SPATE) than for non-project households (Annex 6). Farmers have also identified KARI and the KARI-McGill project as key sources of knowledge for the implementation of these changes. A study on the gender dynamics of adoption found that women’s relatively limited radius of mobility might impinge on their market participation, but it does not seem to limit their levels of adoption of high value traditional crops and improved natural resource and livestock management practices. This choice by women reflects the value that they place on non-priced benefits of adoption (Njuguna and Brownhill 2014, under revision).
Objective 3: Increase the household consumption of locally produced food and improve levels of nutrition and health among hunger-prone women and children

From the inception to the close of Phase 1 the KARI-McGill project, several nutrition studies and activities have been undertaken by the nutrition and health stream. McGill MSc student, Heather Tufts completed field work in August 2011 with a study of anti-oxidant and anti-inflammatory properties of the most commonly used local plants in Makueni County with potential benefit for treatment of kwashiorkor. *Mangifera indica* (leaves used medicinally) showed the greatest antioxidant activity and total phenolic content but *Amaranthus dubius* (leafy vegetable) showed the greatest anti-inflammatory (inhibition of TNF-α) activity (IC50 = 9 ± 1μg/mL), followed by *Ocimum americanum* (medicinal plant) (See Figure 5 in Annex 2). The findings served to increase knowledge on the benefits, especially to women and children, of local leafy green vegetables and fruits for health, food security, and biodiversity promotion. Findings could also aid in promoting more research into the aetiology, prevention, and treatment of kwashiorkor.

A nutrition baseline survey was undertaken in Machakos and Makueni in May-June 2012. Some 293 woman-child pairs aged 15-46 years and 6-36 months respectively were recruited and assessed for nutritional status, dietary diversity, nutrient intake, food security, anaemia and malaria, in addition to socio-demographic characteristics. Characterization of respondents showed that the populations were similar in every respect across the two agro-ecological zones (LM4 and LM5). Findings showed very low dietary diversity patterns among children and women. The prevalence of stunting and anaemia in children (70%) and women (33%) was high.

FGDs were subsequently undertaken to address food and dietary intake patterns and special food provisions for children and women. Key outcomes showed that pregnant women and children were vulnerable because of taboos that restricted them from consuming high-protein foods such as chicken and eggs. Responding to these findings, the nutrition stream developed and organized training sessions to enhance nutrition knowledge and dietary intake practices. Dialogue cards were developed to pass eight clear messages to trainees concerning dietary diversity, ideal feeding practices for children and other critical issues (see Annex 5). A total of 121 nominated ‘Farmer Nutrition Champions’ (FNCs) were trained in Machakos and Makueni in Feb-Mar 2014. Follow-up evaluations of 15 FNCs in April 2014 showed that within two months of training, the FNCs held 53 training session, reaching 715 community members with nutritional and dietary information (see Bukania ‘Farmer Nutrition Champions’ for report on this campaign).

To understand the changes in nutrition and dietary practices, an end-line survey was undertaken in Jul-Aug 2014 in 207 of the 293 households that had participated in the baseline survey. The survey demonstrated observable differences in dietary diversity patterns in both women and children. Women consuming foods from more than six food groups (high DD) increased from 8% to 72%, while low DD decreased from 30.3% to 11.2%, and moderate DD reduced from 62.5% to 16.5% (see Figure 6, Annex 2). The changes in Dietary Diversity were observed across both AEZ. In addition, a reduction in the underweight population was observed in the treatment group, from 10.1% at baseline to 7.9% at end line. This was different for the control group where an increase from 14.1% to 16.5% is observed. Following the project intervention, an increase in the mean Hemoglobin level is observed. The mean difference within the groups was significantly higher (P<0.002) in the treatment group than in the control (p<0.214). The findings also show that the proportion of anemic women reduced from 17.4% to 8.4% (see Table 1.0 below).
In 2014, McGill MSc student, Hellen Okochil undertook FGDs with a special focus on children’s nutritional status and associated nutrition knowledge of caregivers. Findings indicate that the staple diets of all the communities are cereal based; the main food items were maize, millet and sorghum. The main meal reported for the entire family was ‘githeri’ (mixture of maize and beans, or any other legume), consumed nearly every day. Vegetable and fruit consumption was reported as very low across all regions, and varied depending on season. FGDs further revealed that the community is aware that nutrition and health outcomes are closely related and diet is very important in management of diseases such as diabetes and HIV. However, information is inaccessible, being available only in schools, while NGOs’ activities on nutrition were almost non-existent. Findings point to promising avenues for improving and promoting infant and young child feeding practices in Makueni and Machakos, including: (i) Porridge mixtures that increase energy density (maize and millet or sorghum and wheat); (ii) If foods that make up the community’s bread basket also form part of the foods consumed by children of age 6-59 months, this would reduce limitation of variety and availability of nutrient-rich foods; and (iii) Limiting myths and taboos relating to feeding infants and young children.

Table 1.0 Mean hemoglobin levels in women and children

<table>
<thead>
<tr>
<th>HB levels in women</th>
<th>Experimental</th>
<th></th>
<th>Control</th>
<th></th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td></td>
<td>SD</td>
<td>IQR</td>
</tr>
<tr>
<td>Baseline HB</td>
<td>85</td>
<td>12.98</td>
<td>1.91</td>
<td>12.56</td>
<td>13.39</td>
</tr>
<tr>
<td>End line HB</td>
<td>85</td>
<td>13.53</td>
<td>1.68</td>
<td>13.17</td>
<td>13.89</td>
</tr>
<tr>
<td>p value</td>
<td></td>
<td>0.002</td>
<td></td>
<td>0.214</td>
<td></td>
</tr>
<tr>
<td>End line Mean HB - Baseline HB</td>
<td>85</td>
<td>0.56</td>
<td>1.57</td>
<td>0.22</td>
<td>0.89</td>
</tr>
</tbody>
</table>

| HB levels in Children    |             |          |         |       |         |         |         |         |
|--------------------------|-------------|---------|---------|-------|---------|
|                          | n    | Mean |          | SD    | IQR      | n    | Mean |          | SD    | IQR      |
| Baseline HB              | 78   | 11.03| 1.50     | 10.69 | 11.37    | 78   | 11.61| 1.31     | 11.31 | 11.90    | **0.011** |
| End line HB              | 78   | 12.59| 1.52     | 12.25 | 12.94    | 78   | 12.79| 1.04     | 12.56 | 13.03    | **0.035** |
| p value                  | <0.001   |        |         |       |         | <0.001 |        |         |
| End line Mean HB - Baseline HB | 78 | 1.57 | 1.69    | 1.19  | 1.95     | 78   | 1.19 | 1.44    | 0.86  | 1.51     | 0.134    |

**Objective 4: To strengthen the links to local and external input and output markets to allow women and men to diversify household livelihoods**

4.1 Analyze constraints to market development John Wambua’s doctoral study examines smallholder characteristics that negatively affect connectivity to markets and market functionality. Results are expected in March 2015. Margaret Njeri Mwangi (MA, Egerton) conducted a study on access to output markets in the Yatta sub-county of Machakos County and how this access differed between men and women, and youth and adults. A key finding of her study, which was based on a survey of 160 households, was that many of the factors influencing access to markets differed among these groups (e.g., group membership, access to extension, land size). Dr. Catherine Kilelu also conducted an exploratory study on constraints and opportunities for engagement in input and output markets in semi-arid areas of Kenya (see Kilelu 2014).

4.2 Strengthen capacity for farmer links to markets Farmers capacities to link to input and output markets were strengthened through the series of specific activities outlined below, which unfolded in an iterative step-wise development, with lessons in one year informing progress in the next. These activities took off in 2012 with training on participatory market systems development for
farmers from 54 groups, and 16 research assistants. Three priority enterprises with the highest potential for development were identified: green grams, cowpeas and indigenous chicken. Interestingly, two of these, cowpeas and IC, are ‘women-friendly’ enterprises highly preferred by women. Farmers formed 18 Market Opportunity Groups (MOGs) and began producing for the market in Oct 2012. In December 2012 one MOG in Katangi designed a production regime to aggregate and sell chicken as a group. They further produced and sold green grams worth over KSh. 920,000 in 2013. In 2012-2013, the project also linked farmer groups to various private sector partners. Marketing activities were the focus of Freshco Seeds Co and Osho Chemicals, which trained farmers on use of certified seeds, crop agronomy, post-harvest handling, and vaccination of indigenous chickens. The role of Freshco was to provide seeds to farmers, capacity build farmers to be producers of certified seeds, which the company purchased and sold to other farmers. The company also trained stockists to be traders of seeds of dryland crops varieties. During the five seasons (April 2012-April 2014) when the company engaged three farmer groups in the three counties to be seeds producers, 502 farmers were cumulatively involved, and produced 28 tonnes of cowpeas, green grams and beans, all valued at KES 2,521,00 (CAD 29,659) (Tables 2 and 3 in Annex 2). Freshco also ran a promotional campaign coupled with road shows and radio marketing to disseminate information about the technologies which farmers are evaluating.

Links with the market were further strengthened in 2013-2014 through three initiatives, which built on the skills, experiences and group accomplishments of prior years. The first activity was to advance 10 kg of seeds to every PPATE, depending on the members’ variety choice. The amount of seed advanced to the individual PPATE was to be paid back in kind at the end of the season in order to distribute to other groups for the technology adoption and scaling-up. The second activity was the engagement of three selected PPATEs in contract seed production for KARI’s Kenya Seed Unit (one in each county). KSU provided “foundation” seed to the 3 PPATEs (clusters) each with 5-10 farmers. The third activity was linking the PPATEs or Market Opportunity Groups (MOGs) to Amerti Enterprises Ltd, an international grain trader, for contract farming. Whereas at the start of the project in March 2011, the price of green grams ranged from KES 40-50 per kg, in July 2014, Amerti began buying green grams from farmers at an average price of KES 89-92 per kg. By August 2014, about 3,000 farmers representing over 60 groups sold some 219.5 tonnes of green grams at farm gate, valued at a total of KES19,932,540 (approximately CAD 234,500).

4.3 **Build capacity in Kenyan and Canadian students** Under this objective, Margaret Njeri completed a MA degree at Egerton University, with a study on factors influencing the access of output markets for traditional food crops grown in the project area. John Wambua advanced towards his doctoral degree, with a focus on smallholder farmers’ “heterogeneity, output fluctuation and growth and market participation in high value traditional commodities.” Other students trained in the project are listed in the Excel questionnaire under the Grad Students tab.

4.4 **Analysis of barriers to increased household income**: Examining smallholder agro-economic data from two Agro-Ecological Zones (AEZ), LM4 and LM5, Matthew Ainsley and Nicolas Kosoy analysed barriers to increased household income and the greater adoption of drought-resilient High Value Traditional Crops (HVTCs). A combination of multiple and logistic regression analyses was applied to examine the impact of Agro-Ecological Zone (AEZ), cropping system and crop choice on agricultural production. Overall, the study confirmed the importance of HVTCs, finding green grams and millet to significantly increase the likelihood of farmers ‘breaking even’ in both good and bad seasons. ‘Breaking even’ here means making a positive (>0) economic rent, calculated as
yield * selling price minus cost intensity and the opportunity cost of labour. LM4 and LM5 farmers of green grams, for example, have a 91% and 82% chance, respectively, of breaking even in either good or bad season. Farmers of maize plots, however, have only a 6% chance of breaking even in both seasons in the LM4 zone, while LM5 farmers have only a 2% chance (See Figure 7 in Annex 2 for HVTC regression analysis). Finally, we verify the prevalence of mixed crop plots in the region but question the ability of such plots to promote household food security. In a good season, monocrop plots in LM4 and LM5 zones are 31% and 45% more likely to break even than mixed crop plots, respectively. In a bad season, the trend is even more pronounced: LM4 monocrop plots are 67% more likely to break even, while LM5 monocrop plots increase the likelihood by 70%.

The economics stream also examined a particular barrier to the greater adoption of HVTCs: crop raids by birds in Tharaka-Nithi. While the role of birds as a pest in Africa is well documented, labour allocation to pest management and collective action by farmers remain understudied. Using the same survey data, we find 100% of millet and sorghum farmers scare birds from their plot, devoting on average 43-66% of all labour time to this activity, in stark contrast to farmers of all other crops who dedicate no time to bird scaring (See Figure 8 in Annex 2). Farmers can address this challenge through collective action.

Lack of sufficient labour, access to markets, communication and road networks all proved important barriers to greater profitability of agricultural enterprises (Mulwa, ‘Economic Analysis’). High costs are incurred in purchase of seeds, labour costs and soil and water conservation technologies. Despite the barriers, farmers involved in the project achieved greater returns than control groups not engaged in the project (Mulwa, ‘Reward for labour’). It was observed that for the majority of the crops, except pigeon peas and millets, the farmers who participated in the project obtained higher gross margins. For instance, the gross margin for green grams was higher for the project farmers (Ksh20,578/ acre/year) than for the non-project farmers (Ksh16,360/acre/year). Maize had a gross margin of Ksh18,777 for the project farmers, compared to Ksh 10,678.70 for non-project farmers (Table 2.0).

<table>
<thead>
<tr>
<th></th>
<th>Project farmers</th>
<th>Non-Project farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Other costs</td>
<td>Labour costs</td>
</tr>
<tr>
<td>Maize</td>
<td>994.79</td>
<td>268.74</td>
</tr>
<tr>
<td>Beans</td>
<td>640.67</td>
<td>110.27</td>
</tr>
<tr>
<td>Cowpeas</td>
<td>513.46</td>
<td>223.03</td>
</tr>
<tr>
<td>Green grams</td>
<td>517.01</td>
<td>256.92</td>
</tr>
<tr>
<td>Pigeon peas</td>
<td>114.25</td>
<td>98.77</td>
</tr>
<tr>
<td>Cassava</td>
<td>57.24</td>
<td>1.98</td>
</tr>
<tr>
<td>Dolichos</td>
<td>61.05</td>
<td>48.19</td>
</tr>
<tr>
<td>Sorghum</td>
<td>78.45</td>
<td>49.39</td>
</tr>
<tr>
<td>Millet</td>
<td>120.00</td>
<td>17.80</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3,096.90</td>
<td>1,075.10</td>
</tr>
</tbody>
</table>

Table 2.0: Comparison of the annual gross margins (Ksh/acre/year) between Project and non-project farmers

Objective 5: To contribute to the formulation of resilience focused policies to enhance food security, livelihoods and environmental sustainability across the semi-arid regions
5.1 **Assess main food security and environment policies** Literature reviews and studies covering a range of specific policy areas were undertaken by students and project scientists. Key findings are summarized here. McGill PhD student Megan Mucioki focused on seed systems. Her study showed that the Kenya Seeds and Plant Varieties Act, Cap 326 is focused on a delegative model (Thomas et al., 2011) or top-down, linear model of seed distribution (Tripp, 2006), which excludes the informal seed system and related complex realities of functional seed systems in Kenya (Dilbone, 2014). Recognizing this gap, her work suggests that seed policy in Kenya approach seed systems in an integrated model, embracing both formal and informal seed sectors (Louwaars et al., 2013).

June Po’s doctoral research on women’s land entitlements demonstrated that there is little attention given to how household food security may be affected by changes to constitutional law (and attitudes towards those changes) concerning women's land inheritance. The study suggests that targeted effort is needed to increase awareness on the benefits of women’s inheritance of land as a measure for long-term food security.

5.2 **Identify pathways for local issues within policy processes** Agriculture officials from county and national levels, including Sicily Kariuki, the Permanent Secretary in charge of the State Department of the Ministry of Agriculture, Livestock and Fisheries, have participated in our field activities and conferences. A study on devolution of agricultural policy-making reviewed the new and existing platforms for local farmer participation in county policy processes, including town halls, budget reviews and consultative forums (Brownhill et al., under preparation). In a related effort to understand and link with policy processes in the projects’ unique context, Sub-County Agricultural Officers (SCAOs) and frontline extension staff were invited to two meetings with project staff to discuss the possibility for scaling up of the PPATE-SPATE model beyond the project study sites. From the discussions it emerged that for the formulation of resilience focused policies related to the project, the following key actions were proposed: (i) Articulation of the PPATE-SPATE model among local institutions; (ii) Strengthening and institutionalization of Market Opportunity Groups; (iii) Creation of leadership structures within the farmer groups and MoGs; (iv) Capacity building on value addition, utilization and nutrition; (v) Development of participatory research-extension-farmer learning sites; (vi) Exchange visits to encourage peer-to-peer learning; (vii) Strengthening the roles of service providers and other trainers-of-trainers.

Finally, the Sub-County Agricultural Officers took the initiative to organize 61 additional farmer groups, to further the project’s farmer-led adoption approach, thereby extending the impacts of the project to a whole new set of farmers, and establishing a starting point for possible incorporation of our model into the county-wide extension policy.

5.3 **Identify potential for contribution to resilience-focused policy** The technologies which are featured in our project include HVTCs, which have been a Ministry of Agriculture priority crop for almost a decade, and Indigenous Chicken (IC), which is a newly-identified priority agricultural enterprise in all of the project’s semi-arid counties (and in a total of 23 of Kenya’s 47 counties). By working with technologies that are widely recognized as priority areas for development at national and county levels, the project maintains a strong position to contribute to policy debates as research results are finalized in all of the project’s disciplinary and inter-disciplinary streams.

A large number of peer-reviewed articles (see Annex 3) and some five graduate theses are also currently under preparation. These publications, and policy briefs drawn from them, are critical to sustaining ‘policy impact,’ because they serve as the scientific support for any recommendations arising from the project thus far, and into the future. Our potential to inform policy debate is further
supported by the continued activity of KARI and McGill scientists from the project, who maintain an active interest in food security research and policy in Kenya even after the project concludes. KARI team members, in particular, maintain strong institutional links with the legislators and policy processes. The potential for our continued impact beyond the end of the project can be further seen in openings presented by the devolution of agricultural policy-making to county level. We have demonstrated an innovative and effective means through which to improve household food security; and we have the institutional links with which to mobilize this knowledge at the policy level. The dedicated team intends to keep working on their analyses and policy recommendations in order to meet the full potential of our research, to ensure that our innovations contribute to society, and to help solve the entrenched problems of food insecurity that we set out to address.

5. Synthesis of results towards AFS Outcomes (5 pages max.):

1. New technologies and/or farming systems and practices Our main contribution here was in the form of both resilience-building technologies and a scaling up approach. Our extension model (PPATE-SPATE) is a farmer-led adoption approach directly involving over 5400 women and men farmers. This model provided the foundation for all project activities and has been adopted by the Ministry of Agriculture sub-county offices in the three project counties (TPATEs). It has offered a new extension model that has had the effect of increasing farmer adoption of, and health and income benefit from, resilience-building technologies and practices (as detailed in section 4 above).

From a more conceptual standpoint, the project has developed several complementary frameworks that have guided our examination of farming systems, in terms of: gender (Gendered Resilience Umbrella to assess our interventions and provide ground for defining resilience indicators to mitigate risk for farm communities vulnerable to hunger and malnutrition); resilience (framework that considers specific resilience trade-offs under varied shocks to form a matrix of possible resilience measures, proxies and indicators to help guide research and policy); and, knowledge integration (framework using complexity science to help strengthen how we build research teams, identify research priorities and target funds, allowing us to produce integrated knowledge that better informs policy and practice). These frameworks have been employed internally and illustrated externally at conferences, in book chapters and peer-reviewed publications to contribute this project-generated knowledge across broader academic and practitioner communities.

2. Dietary diversity & nutrition. From laboratory analyses on the nutritional composition of locally available vegetables (see Figure 5 in Annex 2), to 293 household interviews with women of reproductive age and their children to assess a variety of food security indicators (see Figure 6 of Annex 2), researchers have shown a commitment to understanding and improving diet and nutrition in vulnerable populations. A number of community outreach and education interventions deepen farmers` understanding of dietary diversity and food security. Drastic shift were observed in food consumption patterns as shown in Figure 3. When compared to baseline, more women reported to be consuming more organ meats, meats, fish and eggs as sources of protein and other vitamin A rich fruits and vegetables.
3. Engagement of Canadian researchers with Southern researcher organizations. The cross-disciplinary, integrated approach of this project relied greatly on the collaborative expertise of both Canadian and Kenyan researchers, with Canadian students and researchers working closely with Kenyan counterparts from multiple public and private institutions in research design and implementation, providing valuable opportunities that improved Canadian scientists’ understanding of food and nutrition security in Kenya. While Kenyan collaborators provided essential field presence and expertise, Canadian researchers were instrumental in leading the development of conceptual frameworks and methodologies (e.g., gender, resilience and complex systems frameworks; research methodologies) that provided the scientific foundation for many field activities. This research has been translated into dozens of peer reviewed publications, building Canadian and Kenyan contributions to the science behind food and nutritional security.

4. Research groups. The project brought together multiple research streams consisting of over 70 scientists and practitioners from a wide range of institutions, working jointly on various project deliverables. The integrated nature of the project meant that researchers were pushed to think beyond their specific disciplines and areas of expertise, to not only think about a particular innovation, but to consider elements of gender, nutrition, environment and policy (among others), building an appreciation among partners for the complexity of food and nutrition security research for development. Canadian and Kenyan researchers have benefited from improved understanding of the nuanced processes of cross-cultural collaboration, which can only be gained through time and experience. These experiences will contribute to strengthened Canada-South research partnerships in the future. Furthermore, more than 5400 smallholder farmers were key participants of the project’s research groups. Farmer’s direct engagement in decision-making and experimentation provided collaborative, multi-directional learning among all stakeholders, and produced clear development benefits (e.g., drop in months of food insufficiency).

5. Food distribution. The project spurred informal exchanges of seed, other material inputs, and produce (e.g., grain, cassava and vegetables) among members of the participating groups, as well as between these group members and neighbours. Farmers also evaluated of a model of farmer-led HVTC seed production for distribution in remote farming communities that typically lack access to such inputs. Additionally, the nutrition education campaign focused in part on the importance of inter- and intra-household food distribution to improve food security, to meet the nutritional needs of women, men and children and to underline the importance of the consumption of high-nutrient foods. These initiatives improved access to higher quality foods essential to nutritional security, as seen in Table 3.0 above.
6. Food processing and storage. Post-harvest handling and storage, as well as value addition were important considerations to improve household food and nutrition security among participating farmers, through improved harvest preservation for household consumption and sale. These activities engaged scientists and practitioners from KARI, Freshco, Ministry of Agriculture and Kenyan universities. Post-harvest handling trainings conducted by Ministry of Agriculture and KARI staff helped farmers make informed decisions on timely harvest, grain drying, grain storage and pesticide use, with safe, economical options to retain harvest qualities and quantities. Research also examined various foods and processing techniques (traditional and introduced), highlighting opportunities for greater consumption of indigenous foods with preparation methods that reflect changing tastes and improved marketability in local markets. A study on the use of sorghum-legume flour blends as a high-nutrient weaning food by Phillip Kinyua (M.Sc. candidate, Jomo Kenyatta University) revealed differences in the nutrient composition of sorghum and pigeon pea varieties grown in different agro-ecological zones (varieties generally showed higher crude protein in Machakos and Makuene than in Tharaka-Nithi). As a result of this research, a new sorghum-pigeon pea instant weaning food was developed.

7. Risk-mitigation. The project has adopted a number of measures to mitigate risks. Risk of crop failure, drought and other weather related risks; as well as risks of ecological harm caused by practices promoted by the project, were mitigated through: 1) drought tolerant crop varieties; 2) water harvesting practices; 3) indigenous practices blended with researcher-introduced practices and, 4) resilience-focused monitoring and evaluation, research activities and policy impact. By encouraging the adoption of locally-sourced and -adapted inputs and technologies, the project contributed to mitigating the risk of farmers losing access to markets for agricultural products due to global price hikes or local commodity chain disruptions through: 1) IC “smoothening” food and income access over dry and rainy seasons; 2) building local agricultural value chains and collective marketing and production to reduce price volatility (e.g., Amerti contracts). Educational campaigns promoted home-consumption of HVTCs with good nutritive value, to protect farmers from the risk that farmers will sell all their crops, to the exclusion of consuming sufficient quantities of own-harvest within the household. The team also addressed the risk of increasing women’s labour burden by: 1) promoting crop varieties and livestock breeds preferred and prioritized by women, (and men) and 2) developing a measure of gendered benefits of technology adoption, accounting for priced and non-priced benefits. Team publications attest to the positive health, nutrition and economic impacts (e.g., Njuguna et al, forthcoming; Bukania et al 2014)

8. Access to resources. Starting in 2012, there has been an increase in the availability of HVTC seed varieties in ‘agro-vet’ shops in the seven districts under study. Sales of certified seeds by Freshco Seed Company have increased. As of August 2014, 42 project-related farmer groups have engaged in seed multiplication for the KARI Seed Unit, which has contributed to improving local access to certified, open-pollinated HVTC seed varieties. Amerti Enterprises Ltd. has also entered into contract with 60 project-related farmer groups, as well as others in the surrounding areas, for the supply of green grams for domestic and export sales, increasing farmer access to markets and incomes. Collective action in PPATE and SPATE farmer groups has led many to open new land for agriculture and to access capital that was underutilized, as well as to engage in collective marketing activities. The formation and operation of 18 Market Opportunity Groups has improved farmers’ access to output markets and to negotiating power for higher sale practices. Sub-County Agricultural Officers took initiative to organize additional farmer groups, which we refer to as
“TPATES”, to further the project’s model of extension, farmer evaluation and collective action, thereby improving a whole new set of farmers’ access to seed, learning networks, labour and output markets. Studies by Dr. Mulwa and team demonstrated that majority of the farmers who adopted improved technologies were registered members of farmer groups, thus indicating the contribution of group membership to improved food security status (Mulwa ‘Eliciting farmers’ willingness’).

The project also undertook studies to identify and analyze key obstacles in the adoption of resilient agricultural practices. Research was undertaken on themes including seed diversity and security, access to wild edible plants, ecosystem services, micro-credit, knowledge, social capital and input and output markets. Findings include, for example, that collection of wild edible plants and non-timber forest products key to food security, which is predominated by women, are more strictly regulated and more highly priced (for permits, fines) than those dominated by men.

9. Income generation. The ability to purchase more and better quality food implies improved access to cash. The project did improve participating farmers’—and others who linked with participating farmers—access to income with which to purchase more and higher quality foods, and meet various other household needs (e.g., payment of school fees, as well as purchase clothes, farm inputs and hire labour). These efforts included training as service providers, contractual seed growing, and the testing of a model of farmers acting as agents for distribution of HVTC seeds, among other related research. Training in market development (716 men and 1007 women trained) and the formation of market opportunity groups allowed farmers to sell their produce collectively to obtain better prices, thus generating higher incomes, such as with sales of poultry products (see Table 4.0). The farmer groups were also able to buy farm inputs such as seeds and fertilizers collectively at lower prices.

10. Policy options. The project has led to two clear policy impacts with regards to county and sub-county level food and agricultural policies: 1) the adoption of the project’s extension model by sub-county Ministry of Agriculture officers in Machakos, Makueni and Tharaka-Nithi counties (TPATE described earlier), and 2) public-private sector partnership to enhance grain marketing in Tharaka-Nithi county. In terms of this latter policy impact, Amerti Enterprises and KARI personnel have received commitment from the Tharaka-Nithi County Government and other partners to establish a grain warehouse receipt system for grains marketing.

11. Information and Communication Technologies (ICTs). Although ICT was not specifically considered a research stream or development activity in the project, a number of related outcomes are identified: 1) the intelligent phone free application Sports Tracker was used by the Economics stream as a GPS to draw the contour of smallholder farmers’ field to obtain a precise estimation of the farm area, and then, with Google Earth, to map the exact location. KARI has expressed interest to incorporate this method in future assessments. 2) In terms of marketing activities, Amerti grain trading company, which is purchasing bulk grains from project-related farmer groups (and others), uses ICTs to monitor international grain prices and in turn uses cell phones and text messaging to
alert farmers about buyers’ prices and dates for sales; 3) mobile phones were used by nutritional champions (FNCs) and nutrition stream researchers to facilitate trainings and follow-up during service; 4) in collaboration with the Canadian NGO Farm Radio International, a free-lance journalist prepared four outcome stories. Google Analytics revealed that a total of 1498 unique views of the stories were registered on FRW (website) between September 16, 2013 and July 23, 2014; 5) a number of ICTs have been used in our outreach strategy—in March 2014, the project launched Twitter and Facebook accounts. By June 2014, the project launched an improved website. Finally, KARI and McGill researchers have been invited to appear on news features and documentary programs on private and public Kenyan media networks (KTN and KBC), providing the project with substantial national exposure and means of disseminating scientific findings.

12. Gender. Gender considerations were taken into account in the design of research activities. Two key expressions of this are seen in (1) the predominance of women in project farmer groups; and (2) the centrality of crop varieties and small livestock breeds which are culturally and historically women-oriented enterprises. The project also: Improved access to income: Through the project’s participatory adoption approach, we saw change in gendered power relations at the household level, as measured by decision-making, resource allocation, consumption and involvement in trade (Njuguna et al forthcoming). A majority of women surveyed (n=405) tended to have control over income from IC, and to gain multiple non-priced benefits, as well as some income, from sale of field crops. They gained nutritional values, dietary diversity and raw materials with which to make ecological investments (e.g., compost, humus, tied ridges). Their access to surplus also built their social capital, with the ability to give gifts, and contributions to not-infrequent community fund-raisers (Njuguna et al., forthcoming; Brownhill et al., 2015). Reduced drudgery: Group membership improved women’s access to labour and control over resources and incomes that accrued at group level. Collective activities such as weeding and group marketing saved time on agricultural activities, while fostering knowledge exchange and innovation.

13. Environment. The primary gains here were the high performance and adoption rates of the soil and water management practices, specifically the use of tied ridges. High labour requirements present a risk to the on-going use of this practice, so researchers worked with farmers to identify options for mechanization and other labour-saving solutions (see Mulwa ‘Assessment of feasibility’). Additional research by Kenyan and Canadian students illuminated the implications of traditional knowledge and alternative livelihood strategies on environmental sustainability, often with important gender implications on resource access and household food security. For instance, agro-forestry practices have proven to be an important project-generated activity with clear environmental and livelihood benefits (e.g., soil conservation, income, fuel), as illustrated by the research of J.M. Maluki (M.Sc. candidate, SEKU). Wild edible plants also provide an important source of nutritious food and income for food insecure smallholder farmers, yet findings by S. Shumsky (M.Sc., McGill) clearly showed that national forest policies are at odds with these vulnerable harvesters. Informal seed systems, where women are the principle actors, also provide an important mechanism for biodiversity as shown by M. Mucioki’s research (Ph.D. candidate, McGill). The knowledge gained by the project around these environmental issues provides the basis for improved integration of policy and practice in Kenyan semi-arid contexts.

Potential for uptake of project results for development purposes The project has strong uptake potential among development practitioners and policymakers internationally. The resilience-building technologies and practices promoted through the farmer-led adoption approach illustrate
the practicality of an integrated approach to building food security in difficult and shifting economic and ecological contexts. Government extension officers in the project area have already adopted our adoption approach as mentioned above. The project has established ties between farmer groups and public-private partners (Freshco, KARI Seed Unit, Amerti Enterprises), and has explored a likely future partnership with large-scale food distribution efforts such as the WFP’s school feeding program. These efforts, achieved over a relatively short time frame, indicate strong potential for further scaling-up. The expansion of knowledge-sharing platforms and ICT efforts would also contribute to improved innovation adoption among a broader smallholder farming population—particularly among women and youth farmers who are integral to food production and environmental sustainability, yet often lack the necessary resources. As this project has demonstrated, when proven technologies already exist, the processes of partnership, peer-to-peer learning, and collective engagement are instrumental to fill gaps in dynamic, local-regional-national agricultural innovation systems with sustained positive impact on food and nutritional security.

6. Problems and Challenges (1 page):
The main challenge faced by the project was the loss of key KARI team members during the course of project, including E. Kiruiro (livestock), C. Mutegi (value addition), M. Miruka (Gender), E. Njuguna (Research Associate) and two field Research Assistants. Having left within the last six months of the project, Dr. Njuguna’s absence was especially felt in terms of her capacity to coordinate the dispersed teams of researchers, students and farmer groups and to synthesize project outputs for the final technical report. Several students also began work with the project but did not complete their programs which closed opportunities to other potential students, and impacted the potential for in-depth field work on certain questions of interest, including natural resource management and local market access. The project had a large team but, for a majority, this was just one of the projects they were working on. In future projects, it would be helpful to identify more full-time researchers from all implementing institutions.

There was some degree of unevenness in the documentation of field activities. Though requested to keep logs or records, in practice, RAs and farmers used different methods, some kept records more diligently than others, while some kept no records at all, or tapered off after an initial period. This undermined the ‘vision’ of the research teams in terms of having an overview of the project as a whole. It also reduced the farmers’ and researchers’ capacity to track progress. The lack of equivalent documentation in the field is explained in part by the fact that record-keeping is not a familiar practice among many farmers. There is therefore a need for clearer communication with farmers and RAs on the importance of record keeping to research projects. Normal co-ordination-related challenges were also experienced due to the size, diversity and scope of the project, and when identified they were addressed collaboratively by the KARI and McGill project management teams.

7. Recommendations (1 page):
In situations where project funds need to be transferred to a third party partner, our experience suggests that the process can become complicated by different institutional procedures of accounting for funds, creating problems for the recipient institution. Trying to harmonize the different procedure at times led to delays in requesting additional funding and increased the risk of delay, inefficiency, missed opportunities and under-spending. Further support in working through these inter-institutional challenges would facilitate more responsive budget management.
References (See also Annex 3 for List of InReF project Publications)


See also Project Working Papers referred to in this Report (Available on request)


on the study tour to Burkina Faso.