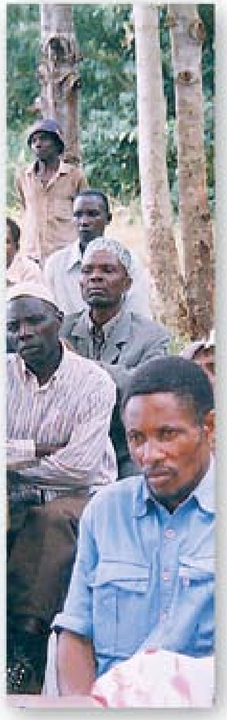

AHI Methods Guides

AHI METHODS GUIDE No. A1

TECHNOLOGY SPILLOVER: A Methodology for Understanding Patterns and Limits to Adoption of Farm – Level Innovations

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Version 1.0

The AHI Methods Guides

The AHI Methods Guides series was developed as a medium for AHI staff and partners to synthesize the innovative methods and approaches developed, tested and validated in AHI benchmark sites and from institutional change work carried out in the region. Contributions to the series include methods for system diagnosis and planning; targeting intervention strategies; facilitating change at farm, watershed, district or institutional level; monitoring and evaluating change or impacts; and structuring the innovation process overall. AHI Methods Guides are organized under five thematic areas:

- *Theme A* – Strategies for Systems Intensification (with an emphasis on the farm level)
- *Theme B* – Participatory Integrated Watershed Management
- *Theme C* – Collective Action in Natural Resource Management
- *Theme D* – Policy and Institutional Reforms
- *Theme E* – Improving Research-Development Linkages

The targets of these papers include agricultural research, development and extension organizations and practitioners with an interest improving their practice and impacts; and policy-makers interested in more widespread application or institutionalization of methods in their areas of jurisdiction.

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INTRODUCTION

The primary emphasis of agricultural research and extension in eastern Africa is on technology generation and dissemination. The consequences of technology dissemination are given limited attention, despite the limitations of conventional agricultural research in bringing about widespread livelihood improvements (deGrassi and Rosset, 2003; Havens and Finn, 1974; Hightower, 1972; Shiva, 1991). While farming systems approaches have enabled improved "fits" of technologies into complex farming systems (Eklund, 1983; Hagmann, 1999) and adoption studies have provided theoretical and methodological frameworks for understanding patterns and impacts of technology innovation (Rogers, 2003), research involvement following adaptive on-farm research trials is often limited to assessing the numbers and characteristics of adopters (Nkonya et al., 1997; Wozniak, 1987). Impact is often measured through the number of technologies developed and introduced into the supply chain or by the total numbers of adopters and the factors influencing adoption. Little attention has been given to social and agroecological impact, negative consequences of technological innovation, farmer innovations enabling improved 'fits' of technologies into the existing farming systems, or how technologies spread within communities. Yet capturing such information can enhance impact by improving upon approaches for disseminating technologies and the design of technologies themselves.

The following guide describes a methodology for tracking the fate of technological interventions in agriculture. The methodology emphasizes technology "spillover" – spontaneous farmer-to-farmer spread of technologies in the absence of outside mediation – which gives greater insights into adoption and impact than research- or extension-mediated diffusion. Findings from the application of the methodology in two benchmark sites of the African Highlands Initiative, an ecoregional program of the CGIAR and ASARECA, are selectively presented to illustrate the methodology's application in practice. These include Lushoto District in the Usambara Mountains of Tanzania, and Vihiga District in Western Kenya.

JUSTIFICATION

Many factors influence the success and rates of technology adoption. These include farmer or household characteristics (wealth, age, gender, labor availability), farming system characteristics (land and livestock holdings, slope, access to irrigation), resource access (social networks, planting material, information), properties of the technology itself (how quickly it generates returns, required capital and labor investments) and farmer access to social networks (Adamo, 2001; Bunch, 1999; Negi, 1994; Perz, 2003; Shaxson and Bentley, 1991). If technological innovation is seen as a one-off step (introducing new technologies) rather than a process that proceeds from problem definition to technology targeting, testing, monitoring, troubleshooting and dissemination/discontinuation, many of these patterns and lessons will be lost. Substantial risks may also be introduced into the system through a bias toward wealthier farmers (socio-economic gap-widening) or negative agroecological impacts.

Technology 'tracking' or periodic monitoring is important for several reasons. First, blanket recommendations which fail to take into account household and farming system characteristics do not work given the highly heterogeneous nature of farming systems, household resource endowments and farmer priorities (Chambers et al., 1987; Scoones and Thompson, 1994). There is therefore a need to understand the specific farming system "niches" where technologies are most easily adopted. We define niche as the suite of social and farming system variables – including gender, household labor, resource endowments (land, irrigation, livestock) and the like

– that facilitate or inhibit easy integration of an innovation into a farming system. Second, technology tracking enables the identification of major bottlenecks to technology access and adoption by different social groups. This knowledge is important for identifying specific interventions that would enable more widespread access to technologies among different social groups. Third, it enables identification of farmer-led modifications of the technology (farmer "innovation" or "re-invention") – departures from recommended practice and that nevertheless enable technologies to fit more easily into local farming systems (Bentley, 1990; Reij and Waters-Bayer, 2001). Fourth, such studies can increase the efficiency of research and development (R&D) interventions by identifying existing social networks that enable or hinder widespread access to benefits in the absence of extension agents or other outside mediators (Adamo, 2001). Finally, technology tracking provides a means to document positive *and negative* impacts of technological innovation on livelihood, equity and the environment can be tracked (see de Grassi and Rosset, 2003; Haugerud and Collinson, 1990; Shiva, 1991), adding a much-needed ethical dimension to technological interventions (Cooley, 1995).

OBJECTIVES

The overall aim of this methodology is to better farmers' livelihoods through improved design and delivery of agricultural technologies. This is meant to be achieved through two primary objectives:

Objective 1. To gain insights into the spread and adoption of technologies that can be used to design strategies for scaling out, specifically:

- To identify the pros, cons and major adoption barriers for each technology, so that technologies can be improved upon, strategic interventions designed, and technologies made more accessible or attractive to farmers;
- To identify the characteristics of households and farming systems where the technology most easily "fits," so that impacts on different types of farmers, households and farming systems can be monitored;
- To identify innovations introduced by farmers to enable the technology fit more easily into local farming systems and be more easily disseminated; and
- To characterize social networks through which technologies flow spontaneously, so that these can be effectively tapped into or avenues to reach socially marginalized groups identified.

Objective 2. To document positive and negative social, economic and environmental impacts of introduced technologies, so that positive impacts can be spread and negative impacts managed.

RESEARCH QUESTIONS

The following research questions were designed to operationalize the above objectives:

1. What are the pros and cons of each technology, and the primary barriers to more widespread adoption?

2. What were the social and farming system 'uptake niches' of different technologies?

3. What innovations & adaptations were made to introduced technologies, and why?

4. How far have technologies spread, and through which social groups and networks?

5. Did introduced or modified technologies have any positive or negative impact on livelihood?

6. Did introduced or modified technologies have any positive or negative impact on agroecosystem resilience[1]?

SCENARIOS

The methodology may be applied to any context in which technologies have been introduced or disseminated by outside extension or development agencies, to track the fate of those technologies as they are either modified in context, shared with other farmers or discontinued. It may be used as a one-off, retrospective analysis two or more years after introduction of the technology(ies), or adapted to an ongoing participatory monitoring and evaluation system in which lessons are captured throughout a technological innovation process and used to improve upon it. In each case, the idea is to capture lessons that may be fed back into technology development research or to assist farmers and communities to trouble-shoot in overcoming some of the barriers to adoption and livelihood improvement.

TARGET GROUPS

This methodology is designed for use by researchers involved in studying technology dissemination and adoption processes, or by extension agencies and NGOs wishing to enhance the impacts of their efforts through close follow-up and consultation with the end users. Ultimately, the methodology will be most useful for innovative professionals and organizations who wish to use the lessons captured to design and test new ways of doing business.

KEY STEPS IN THE APPROACH

While the research questions are many, the methodology has been condensed into five sequential steps that enable each question to be addressed.

STEP 1: CONCEPTUAL UNDERSTANDING AND BRAINSTORMING ON KEY TECHNOLOGIES TO BE TRACKED

The first step of the methodology is to reach a common understanding of your overall objective, and the implications for both the way the methodology is carried out and the technologies that are selected. While the methodology has a pre-defined objective, it may be applied in different ways and for different purposes. The following choices must be made:

1. Whether the methodology is to be applied as a one-off retrospective study to observe the patterns of spillover several years after an intervention, or as a more ongoing participatory M&E method – as an adaptive management approach to technology innovation;

[1] Resilience is defined as the capacity of a system to experience wide change and still maintain the integrity of its functions (adapted from Gunderson and Holling, 2002), and may be used to describe social and natural systems. In the context of agroecological systems, it encompasses system nutrient, water and genetic characteristics – as well as management systems – that enable a system to adapt to change.

2. Whether to use a social network approach to sampling that follows patterns of "spillover" (farmer-to-farmer sharing) to enable greater understanding of who shared with who, or to use a more random or stratified sampling technique to understand "average conditions" in adoption; and

3. How technologies will be selected strategically to give you the information you most need. If the interest is in a single technology that was disseminated in isolation from others, this is less important. If multiple technologies were disseminated simultaneously, however, it must be decided whether to track the most "popular" or "fast-moving" technologies to demonstrate impact – or whether to track technologies with diverse characteristics (short- and longer-term returns; knowledge intensive vs. not; readily accessible by most households vs. more discriminate) so as to acquire a deeper understanding about the challenges and opportunities associated with particular classes of technologies.

STEP 2: FOCUS GROUP DISCUSSIONS TO IDENTIFY BASIC ADOPTION PATTERNS

While personal experience and familiarity with the literature gives researchers knowledge of important factors influencing the adoption of technologies in their area of expertise, not all causal factors can be predicted by researchers given the specificity of local agroecological, cultural and socio-economic conditions. Interactions between farmer goals and decision-making, farming system characteristics and resource endowments, properties of the technology and adoption decisions are complex. This complexity limits the degree to which researchers can alone identify all the relevant variables influencing adoption. It is essential, therefore, that surveys designed to track technologies begin with a broadly participatory assessment of patterns of adoption as observed by farmers themselves.

This methodology uses focus group discussions with diverse groups (adopting and non-adopting farmers, primary and secondary adopters, or gender- and wealth-based groupings) for this purpose. Ideally, additional focus group discussions would be carried out until significant overlap is found in the patterns identified by farmers, and it can therefore be assumed that a comprehensive understanding of such patterns has been attained.

STEP 3: TRACKING SURVEYS WITH ON-FARM INTERVIEWS

Adoption variables identified by farmers in Step 1 are compiled and integrated with variables identified by researchers. Together, they form an integrated set of variables to be systematically measured during more formal "tracking surveys." These surveys consist of household interviews with a representative number of adopting and non-adopting households to track each of the variables identified above and to systematically track the social and agroecological impacts identified by farmers in Step 1. This survey captures household and farming system characteristics of large numbers of adopters, enabling correlations to be made between adoption and farm and household characteristics. Since surveys require on-farm visits, they also provide a good opportunity for selective interviews to address research questions that require more qualitative data – namely, technological innovations, livelihood and environmental impacts, and the steps associated with technology adoption.

Sampling procedures will depend on the ultimate objective. Random or purposive sampling of adopting and non-adopting households may be used if a rigorous econometric analysis of adoption variables is required. If the interest is to understand social networks through which technologies spread in the absence of outside interventions, or how adoption levels and technologies themselves change through successive levels of 'spillover', a form of snowball sampling can be more useful. The latter is illustrated in Figure 1, where the "level of spillover" is defined as the distance the technology has spread from the original "source" farmer, measured by the number of social transactions between host and recipient farmers. Since technology adoption by farmers directly involved with project personnel may be biased by motives that are de-linked from the perceived benefits of the technology itself[2], it is important to designate such farmers as "L_0" (level zero) – meaning that technology spillover has not yet occurred. Successive levels of spillover are therefore defined in relation to how many transactions the technology has passed through to be adopted. Farmers adopting from "project farmers" are designated "L_1" or level one of spillover, those adopting from level one farmers "L_2", and so on.

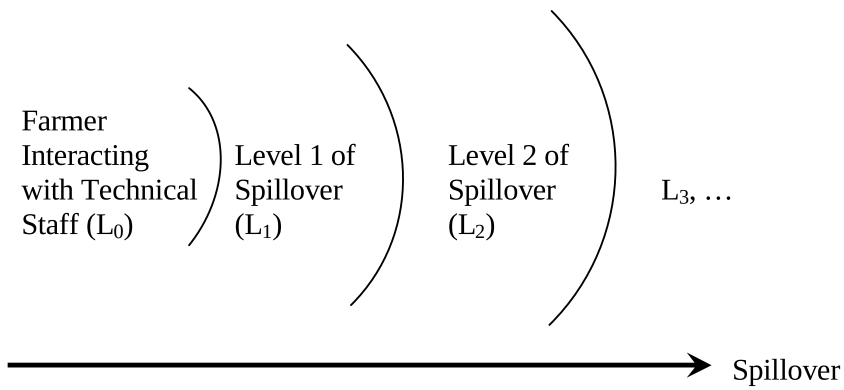

Figure 1. Levels of Technology "Spillover" Relative to Project Interventions

Following these farmer-to-farmer sharing pathways, a percentage of farmers at each level of spillover are interviewed to document household and farming system characteristics, the nature of social networks through which the technology was acquired, and with whom they in turn shared the technology (to compile a list of adopters at the next level of spillover).

Tracking surveys should target not only adopting farmers, but also randomly selected non-adopters. This allows the emerging patterns – for example, access to irrigation water (i.e. 80% of adopters have access to irrigation water year-round) – to be compared with the demographic of the community at large (a "control group"). If 80% of the population at large has access to irrigation water, then access to irrigation water is not likely to be a causal factor influencing uptake of that technology. Random and purposive sampling techniques have built-in controls, eliminating the need for a separate control group.

STEP 4: DATA ANALYSIS

The third step involves statistical analysis of data collected through the tracking surveys, and qualitative analysis of data from semi-structured interviews and farm visits. Basic patterns observed for each objective and research question are discerned at this time.

The analysis of *pros and cons of the technology* or technologies is qualitative only, and distilled from focus group discussions with adopting and non-adopting farmers. *Major adoption barriers*

[2] For example, social status derived from interacting with outsiders or a desire to extract other benefits from project personnel.

are also distilled from preliminary focus group discussions, but then verified through tracking surveys by translating each barrier (i.e. labor) into a quantitative variable (i.e. number of household labor units) and assessing the number of adopting and non-adopting households exhibiting different levels of the variable. Three methods for identifying *social and farming system niches* are triangulated – namely, focus group discussions (to capture the perceptions of farmers), household surveys (to quantify household variables defining these niches) and more in-depth on-farm interviews (to understand in more detail how key variables restrict uptake niches). *Farmer innovations* are most easily distilled through qualitative methods, including focus group discussions, semi-structured interviews and farm visits. *Livelihood and agroecosystem impacts* are assessed qualitatively during preliminary focus group discussions and then validated through tracking surveys – where impacts are converted to quantitative variables and quantified by household. They are also addressed during the more in-depth semi-structured interviews so more detailed information on the way in which these impacts are manifest can be captured. *Social networks* through which technologies flow are researched through the tracking surveys, where the gender, age and social relationships of the transaction (host and recipient farmers) are captured.

The final question, *total numbers of adopters*, is assessed by follow-up with "host" farmers to identify the total numbers of farmers with whom they shared the technology. As only a representative sample of recipient farmers is interviewed at subsequent levels of spillover, the total number of adopters must be estimated through extrapolation. If farmers have not been asked to keep records on technology sharing from the start, care must be taken in interpreting these numbers – as total numbers of adopters can be significantly underestimated. Despite these shortcomings, the data are useful in understanding relative numbers – such as the percentage of exchanges characterized by kinship ties or the percentage of female adopters.

STEP 5: FOCUS GROUP DISCUSSIONS TO INTERPRET EMERGING FINDINGS

Step 3, data analysis and interpretation by researchers, is generally the final step of adoption studies. Yet in the absence of interpretations by other actors, a number of assumptions must be made about the reasons for observed patterns. An additional stage of focus group discussions with farmers to interpret emerging patterns in the data can be useful for several reasons. First, patterns that would otherwise be difficult to observe are fed back to farmers, giving them a chance to contribute further in interpreting their own behavioral patterns. Second, it allows local logic (for example, why certain types of farmers are adopting a given technology) to be integrated with scientific logic in interpreting observed patterns, giving a more complete picture of farmer behavior.

A summary of the methodological steps utilized to answer each research question is provided in Table 1. Methods are matched to research questions on the basis of whether the question can be best answered through quantitative data, qualitative data or both.

Table 1. Methods Utilized to Address each Research Question

Research Question	**Methods**
Pros and Cons of the Technology	- Focus group discussions (pre).
Major Adoption Barriers	- Focus group discussions (pre & post). - Tracking survey.
Social and Farming System Niches	- Focus group discussions (pre & post). - Tracking survey. - Semi-structured interview. - Farm visits.
Farmer Innovations	- Focus group discussions (pre). - Semi-structured interviews. - Farm visits.
Social Networks & Spread	- Focus group discussions (pre). - Tracking survey. - Focus group discussions (post).
Livelihood Impacts	- Focus group discussions (pre & post). - Semi-structured interviews. - Tracking survey.
Agroecosystem Impacts	- Focus group discussions (pre & post). - Semi-structured interviews. - Tracking survey.

DETAILED DESCRIPTION OF THE METHODOLOGY AND DATA ANALYSIS

1. FOCUS GROUP DISCUSSIONS

Planning for focus group discussions

While focus group methodologies may vary, in our experience six to ten participants is usually the upper limit of the number of people who can participate effectively in such discussions. The small number of people involved requires that participation be intentionally structured according to the aims of the research and to ensure representation of diverse views. In almost any focus group, representation by gender and wealth is generally paramount. Yet selection of participants in different focus groups is generally done according to your aims. For example, if you are interested in soliciting the responses of adopters and non-adopters, then you might call two focus groups together based on whether or not they have adopted the technologies in question – ensuring each group has a good representation by gender and wealth. In other cases, if there are strong social norms against the effective participation of certain social groups within social gatherings, then it may be more important to mix adopters and non-adopters within focus groups and divided the group according to those parameters affecting participation, for example gender or age. Ultimately, the selection of focus groups requires not only attention to the research question but an understanding of the society within which you are working – and a bit of creativity in the selection of focus group participants. Whatever your choice, you should be able to defend it according to a strong logic of representation, participation and your ultimate aims. Yet effective participation is not only about "who comes" but about how the discussions are facilitated. The facilitator must be able to bring out the full participation of all those present, and to tactfully minimize the participation of individuals who tend to dominate discussions. The tendency for people to agree with what is said first requires that the facilitator also probe deeper, giving space for other opinions to be expressed.

Secondly, it is important to carry a checklist of questions to the focus group discussions. Table 1 tells us that the first set of focus group discussions in the spillover methodology must generate information on all six research questions. These questions must be concise, to avoid keeping people for too long. Generally, after one and a half or two hours, levels of participation drop due to fatigue, affecting the quality of responses. Rather than prolong a discussion beyond this duration, it is best to break and re-convene at a later date. The checklist in Box 1 is one example of how these questions can be jointly addressed; the reader is encouraged to innovate with other ways of asking these questions so they are more easily understood in your areas of work.

Utilizing findings from focus group discussions

Data from focus group discussions can be used both directly for improved design of technologies or improved dissemination strategies, and indirectly – through the integration of variables identified by focus groups into formal tracking surveys.

(a) Direct use of findings to improve technologies or technology dissemination strategies

Advantages (pros) and disadvantages (cons) identified by farmers can be used directly by research or extension to improve upon the technology and its mode of delivery. Select pros and cons from Western Kenya are presented in Table 2. The first thing to note is the sheer number of advantages and disadvantages identified for each technology. This illustrates the challenges researchers face in "getting it right". The second observation is the nature of the disadvantages and what this implies for subsequent actions. Some disadvantages (denoted by italics) highlight issues for researchers – mainly regarding the re-design of the technology itself. These variables can be used in trait selection by breeders to improve upon the varieties. Other disadvantages

Table 2. Pros and Cons of Select Technologies Introduced in W. Kenya

Technology	Advantages	Disadvantages
Kale	- Income - Early maturation - Family nutrition, taste - Resistant to drought - Long life span - Frequent harvest	- Labor intensive - Risk (loss from theft, livestock) - *Susceptibility to aphids, disease* - ***High input requirements*** - Requires pure stand - Market saturation
Maize variety	- Striga tolerance - Higher yields - Cob form (resists rotting) - Early maturation - Seed may be re-used - Taste - Can plant in both seasons	- ***Heavy feeder*** (high fertilizer demand) - *Poor germination* - *Short cobs* - Theft - *Susceptible to disease*
Compost	- Use of local materials - Soil improvements last - Increases yield - Makes soil easy to dig - Does not scorch seeds like inorganics	- **Limited dung / livestock** - Time lag from preparation to use - Labor intensive - Difficult to know when it is ready

Box 1. Sample Protocol for Focus Group Discussions

1. *What are the technologies you have been exposed to or adopted in your farms?*

Pros, Cons and Adoption Barriers

2. *For each technology (or formerly prioritized technologies):*
   a) What do you like most about each technology?
   b) What do you like least?
   c) What are the primary factors hindering adoption by more farmers?

Social and Farming System Niches

3. *For each technology (or formerly prioritized technologies):*
   a) What types of farmers are most adopting technology x (by gender, age, wealth, farm characteristics, etc.)? Why?
   b) What are the most important resources required to adopt technology x (i.e. labor, land, nutrient resources, capital, water)?

Farmer Innovations

4. *For each technology (or formerly prioritized technologies):*
   f) Among yourselves or other farmers you have observed, what have been the most useful changes made to the technology after it as introduced? How was it changed and why?
   i) Were there any social innovations that emerged to enable adoption or maximize benefits from the technology, such as shared labor, organization to access inputs, or others?

Social Networks

5. *Considering that people generally do not share technologies equally with relatives, friends, acquaintances and strangers:*
   a) Was there a tendency to share the technology(ies) with certain types of people?
   b) If so, who tends to share most with whom, and why?
   b) Does this vary by technology? If so, why?

Livelihood and Agroecosystem Impacts [a]

6. *For each technology (or formerly prioritized technologies):*
   a) Has the introduction or adoption of the technology had any impact on your livelihood or the community? We are interested in knowing about *both* positive and negative impacts, if any.
   b) Has the introduction or adoption of the technology had any impact on your farming system? Please mention both positive and negative impacts, if any.

[a] After hearing farmers' responses, more direct questions can be asked targeting livelihood impacts (yield, income, labor, food security, use of farm resources), community impacts (land distribution, conflict, tendency to cooperate, wealth distribution), and farming system impacts (weeds, disease, pest dynamics, soil fertility/moisture/erosion, and impacts on other on-farm activities).

(bold font) suggest complementary technologies that might be introduced jointly with the technology under discussion to minimize adoption barriers, such as the introduction of livestock or improved feed together with nutrient-demanding crops to enhance availability and/or quality of dung. The third and final set of disadvantages (underlined) suggests strategies that might be used by extension to develop innovative means to disseminate technologies that minimize adoption barriers. For example, traditional labor exchange practices can be integrated into technology dissemination strategies where labor is a known constraint to adoption. Strategies to mobilize communities to limit livestock movement or theft can be used where crop destruction/theft is a problem. The issue of market saturation may be addressed through integrating participatory market assessments into technology prioritization processes (prior to dissemination), fostering collective action in the sale of produce to minimize the extent to which buyers can manipulate the price, or by a strategy aimed at enterprise diversification so that diverse market niches may be tapped. Finally, some disadvantages relate to farmer capacity – suggesting that capacity-building efforts be aligned with dissemination processes. It should be kept in mind that the disadvantages identified by farmers simply "suggest" improvements that may be made; they do not represent proof that such innovations will work in practice. Ultimately, a creative or experimental approach must be taken in which innovative ways of reaching more households are identified, tested and adapted through their practical application and observations of how such innovations influence farmer perceptions and adoption levels.

Information from focus group discussions on social networks (who shares with who) and social niches (who is adopting) may also be utilized directly to improve upon extension practice. If it is noted that a certain group of people is not benefiting from any given technology, it is important to ask why this is the case and design strategies together with farmers that may improve access by these groups of people. If the barrier has to do with a tendency to share only with kin, then mechanisms to disseminate technologies through clan elders or local institutions with widespread membership (i.e. religious organizations) may be tested. If the barrier to adoption is related to wealth and limited ability to make up-front investments in inputs, labor or material resources then financial or in-kind credit (i.e. seed, fertilizer) or rotational savings associations (already present in most communities) can be explored as means to enhance access by resource-poor households.

(b) Indirect use of findings to improve structured household surveys and semi-structured interviews

Variables identified through focus group discussions that lend themselves to quantitative analysis can be directly integrated into structured household surveys ("tracking surveys"). These variables are extracted from focus group discussions and integrated with adoption variables identified by researchers. Together, these variables are integrated into household "tracking surveys" – household interviews that assist in characterizing adopters and in systematically tracking social and agroecological impacts of the technology. These surveys capture household and farming system characteristics of large numbers of adopters. Since surveys require on-farm visits, they also provide a good opportunity for selective interviews to gather more detailed qualitative data on farmer innovations, livelihood and environmental impact, and the steps associated with technology adoption.

A generic survey form integrating standard farming system and household variables likely to be important, irrespective of the particular technology being tracked or other contextual factors related to the region where work is being carried out, is shown in Table 3. Additional variables particular to a technology (in this case, soil conservation technologies) – whether identified by farmers or researchers – were added to the generic survey, thereby "ground-truthing" the tracking survey in the characteristics of the specific technology and the local context. These technology-specific variables are summarized in Table 4. By systematically tracking variables of interest to farmers *and* researchers, all actors in the system (research, extension, farmers) can gain more awareness of the impacts of interventions as viewed by other actors in the system.

Table 3. Survey Instrument for Technology Tracking (Generic Entries)

Name of Adopter	Nature of Exchange (Free, Sold, Exch.)	Exchanged (Germplasm, Assistance, Working Knowledge)	**Age** [a]	Gender	Spill-over Level (L_0, L_1, $L_{2,...}$)	Relation [b] (N, Fr, R/E, R/N, Other)	Household Characteristics						Other Techno-logies Adopted [e]	***Total Area where Applied*** (m or Ha)
							House-hold Labor [c]	Plots Land	Acres Land	# Cattle (E/I)[d]	# Small Rumi-nants	Off-farm Income (specify type)		
Hassani Bakari	F	G	30	M	L_1	N	1.35	1	4.5	3/0	0	Petty trade	T, B, ISFM	
Mariamu Hussein	S	G	45	F	L_1	R/E	3.8	3	1.2	1/1	3	Crafts	T, VB	
Shekigen da Musa	E	WK	62	M	L_1	R/N	2.0	2	0.8	0/0	2	Wage labor	B, VB	

[a] Bold font indicates farmer-identified variables.

[b] N = Neighbor, Fr = Friend, R/E = Relative (extended family), R/N = Relative (nuclear family), O = Other.

[c] In man-equivalents (Fried et al., 1993)

[d] E = Exotic breeds, I = Indigenous cattle.

[e] T = tomato; B = banana; Ca = cabbage; VB = vegetative barriers; Co = compost; ISFM = integrated soil fertility management; etc.

Table 4. Supplementary Survey Instrument for Tracking Soil and Water Conservation (SWC) Technologies ('ground-truthed' with technology-specific variables identified by farmer and researchers)

Name of Adopter	Soil Conservation Technology Tracked [a]	**Access to Technical Assistance on SWC Technology** [b] (High, Med, Low)	**Farm or Landscape Location of Structures** [c]	Farming System Characteristics				Impact (Positive, Negative, None)				
				Soil Quality Prior to Conserving (Good, Medium, Poor)	**Access to Irrigation Water**	**Access to Organic Nutrient Resources** (High, Med, Low)	**Crop Type** (Annual, Perennial)	Soil Water Holding Capacity	Soil Fertility	***Weeds***	Crop Vigor	***Income***
Hassani Bakari	BT	M	40%/HH/IL	Poor	Y	H	A	Pos.	Pos.	Neg.	Pos.	Pos.
Mariamu Hussein	FJ	M	30%/HH/NIL	Medium	N	L	P	None	Pos.	None	None	Pos.
Shekigenda Musa	BT/GS	H	50%/OF/NIL	Poor	N	M	A	Pos.	Neg.	Neg.	Neg.	None

[a] GS = Grass strips/fodder contours; BE = Bench terrace; FJ = Fanya Juu.

[b] Bolded black font denotes variables identified by farmers, and other fonts those identified by scientists.

[c] Slope (%); proximity to household (HH = near household, OF = in outfields); access to irrigation (IL = irrigated land, NIL = non-irrigated land).

To illustrate how variables identified by researchers and farmers are integrated into the tracking survey, sample findings from Lushoto, Tanzania are presented. Table 5 summarizes results of question 2c (Box 1) on major adoption barriers for each of four introduced technologies.

Table 5. Adoption Barriers Identified through Focus Group Discussions

Technology	**Adoption Barriers Identified by Farmers**
Banana Germplasm	Low availability of planting material (suckers); susceptibility to drought.
Cabbage Germplasm	High cost of seed.
Organic nutrient resources	Limited knowledge of how to make compost; limited alternative uses of *Mucuna*; lack of compost materials; limited awareness.
Soil and Water Conservation	Presence of annual crops; labor requirements and old age; organic nutrient resource requirements; limited access to technical assistance.*
Tomato Germplasm	Labor requirements; input requirements; limited access to irrigation & quality land; dislike of industrial pesticides; limited access to technical assistance (for agronomic practices).

* Tables 5 and 6 illustrate how locally-identified variables such as these identified for soil and water conservation technologies are integrated into formal tracking surveys.

As discerned from Table 5, the following variables were identified as influencing adoption of soil conservation technologies and integrated as new variables in the tracking survey: (a) limited access to technical assistance due to limited number of village para-professionals; (b) limited access to organic nutrient resources for the implementation of bench terraces, required to off-set the decline in soil fertility resulting from topsoil disturbance; (c) labor requirements, including total numbers of household members and their age; and (d) presence of permanent crops, hindering the ability to implement physical structures. These farmer-identified adoption barriers either confirm generic entries in Table 3 or must be integrated into technology-specific variables in Table 4. Farmer-identified variables are highlighted in bolded black font.

In addition to these variables, scientists identified through their own experience and observations a number of additional variables likely to influence the adoption of soil and water conservation technologies. These included: (a) soil quality prior to implementing soil conservation measures, presumably influencing a farmer's motivation for conserving his or her fields; (b) access to irrigation water, assuming that farmers are more likely to invest in activities with longer-term returns (i.e., natural capital) in areas where cash crops are cultivated; and (c) landscape position, including the proximity of conserved plots to households (which influences the ability to transport manure to terraces and keep watch over cash crops) and water resources. These farmer-identified variables are indicated in bolded grey font in Table 4.

Impacts stemming from the adoption of soil conservation practices were also identified through focus group discussions with adopting farmers and from researchers and integrated into the tracking survey. Those impacts identified by farmers included increased crop vigor, soil fertility and soil water holding capacity (Table 6). These have also been integrated into Table 4 (indicated by underlined font). Researchers, wishing to monitor the influence of these locally identified variables on related factors, included additional variables related to farmer income (presumably enhanced through increased crop vigor and soil fertility) and incidence of weeds (presumably increased through soil fertility improvements). They also wished to know the total area under which the new technologies had been applied, as an additional indicator for measuring impact. These researcher-identified variables have again been integrated into Table 4 and are indicated by bolded italicized font.

Table 6. Agroecosystem Impacts of Select Technologies Identified by Farmers [a]

Type of Impact	**Banana**	**Soil and Water Conservation**	**Tomato**
Impact on other system components	*Favorable effects on other crops when intercropped.*	*Positive effect on banana (soil fertility and moisture) and livestock (fodder production).*	*Increased fallowing of hillside plots as more time is allocated to cash crop cultivation in valley bottoms.*
Input requirements	Increased demand on fertilizer at farm level given high organic matter inputs during establishment.	No outside inputs identified.	More pesticide and inorganic fertilizer use given crop demands and extended periods of cultivation.
Land, labor and nutrient allocations	Recommended spacing takes up land; increased labor investments during planting and mulching.	Organic nutrients and labor diverted from other activities during terrace establishment.	Substantial diversions of land, labor and nutrients from coffee and maize.
Pests and disease	None observed.	*Reduction in maize stem borer.*	Increase in pests and wilting disease due to decreased crop rotation and diversity.
Soil	*Mulching increases soil fertility and SWHC and reduces erosion.*	*Positiv*e or negative, depending on levels of organic amendments.	*Increased water holding capacity and fertility from manure usage.*
Weeds	*Sharply reduced through mulching*.	Increase in weeds near Napier grass.	Increased along with soil fertility.

[a] Italics represents positive impacts, while grey font represents negative impacts.

Variables identified through focus group discussions that lend themselves to qualitative analysis, on the other hand, can be followed up through a select number of in-depth semi-structured interviews and farm visits. These include, most notably, farmer innovations and social and agroecological impacts since these can be best understood through descriptive data and visits to the plots where innovations and impact may be seen directly. The methodology for this deeper qualitative exploration is described in more detail in the next section.

2. TRACKING SURVEYS WITH ON-FARM INTERVIEWS

Once the primary adoption and impact variables have been identified and integrated into formal tracking surveys, it is necessary to identify interviewees with whom household surveys will be carried out. The method favored within AHI is the "snowball" method in which social networks through which technology has passed from farmer to farmer are followed.

Tracking spillover using the "snowball" method

The snowball method of sampling interviewees was used in the AHI studies due to the desire to understand who is sharing with who, as well as the rate at which technologies flow, in the absence of project intervention. The form in Table 2 was used to document Level 1 farmers receiving technologies from project farmers (Level 0), and to select Level 1 interviewees. Every 5th Level 1 farmer, or 20% of Level 1 adopters (indicated in bold italicized font), was selected as an interviewee for formal tracking surveys. This same form may be used to identify Level 2 farmers with whom Level 1 farmers have subsequently shared technologies, and so on along the networks through which the technology flowed.

Table 7. Form for Tracking Technology Sharing ("Spillover") and Selecting Interviewees for Structured Household Surveys

	1	**2**	**3**	**4**	**5**	**6**	**9**	**10**
Name of Level Zero Farmer	**No.**	**Name of Level 1 Farmer**	**Sex**	**Age**	**Relation-ship** [a]	**Village/Hamlet coming from**	**Tech-nology Taken**[b]	**Exchange Type** [c]
Shekigenda Abdalla	**1**	**Vincent Seng'enge**	**M**	**22**	**A**	**Kwalei-Kamajia**	**T**	**S**
	2	Daniel Salehe	M	26	P	Baga - wanga-Ukorogwe	T	S
	3	Mnami	M	40	P	Kwekitui -K.Mbogo	T	S
	4	Shabani Saidi	M	30	P	Mamba - Mbelei	B, T	S
	5	Abdi Omari	M	32	P	Mamba - Mbelei	B, T	S
	6	**Hassani Seif**	**M**	**62**	**Fr**	**Kwadoe - Maao**	**T**	**S**
	7	Ramadhani Athumani	M	28	Re	Kwalei - Muu	T	S
	8	Mathias Bakari	M	34	P	Kwalei - Kibaoni	T	S
	9	Mwl. B.Mbwambo	F	45	**A**	Kwakei - Kibaoni	T	S
	10	Jumanne Hassani	M	18	Re	Kwalei - Shule	T	G
	11	**William Ezekieli**	**M**	**24**	**A**	**Kwalei - Kamajia**	**T**	**E**
Bakari Mshahara	12	Hassani B. Zuakuu	M	29	Km	Mgwashi	B	G

[a] Fr = friend; A = acquaintance; P = parent; S = sibling; C = child; Re = Extended family (uncle/aunt/cousin/neice/ nephew); Km = Kin by marriage
[b] T = tomato; B = bench terrace; etc.
[c] S = sold; E = exchanged; F = gift / free

Quantitative data entry and analysis

(a) Social networks

Social networks are assessed by analyzing the relationships between host and recipient farmers. These relationships are analyzed by entering the data from technology sharing forms (Table 7) into an excel spreadsheet. Each spreadsheet should be labelled according to the level of spillover (i.e. "L_0 to L_1"), with the number of spreadsheets equal to the number of exchanges that were tracked. Slight modifications of data are required to quantify the number of exchanges exhibiting different characteristics, for example converting actual ages to age categories of local relevance. Farmers can assist in providing cut-offs for the categories "youth", "middle aged" and "elder", for example. Once these modifications are made, analysis simply consists of quantifying the number of exchanges characterized by different age classes, genders, relationships and exchange types. More detailed geo-referencing of networks can be done by mapping exchanges from village to village, but this is not necessary for getting a sense of how far technologies spread and through which social channels. A few sample findings help to illustrate research outputs.

Gendered patterns of exchanges for Lushoto (northeastern Tanzania) and Vihiga (western Kenya) are highlighted in Table 8. While an initial attempt was made by project personnel to enhance gender equity by working with equal numbers of men and women, inherent social dynamics caused male farmers to capture more of the benefits over time. Furthermore, since the percentage of source farmers that are female declines with successive levels of spillover due to gender biases at lower levels of spillover (only 22% of farmers are female by level 1 in Lushoto site), these differences are even more striking than they seem. For cash crops, exchanges with women were found to be negligible in Lushoto site, indicating that this gender bias in the spontaneous sharing of technologies could have far-reaching implications for wealth equity.

Table 8. Gendered Patterns of Technology Sharing in Lushoto and W. Kenya

Site	Source Farmer	Level 1 Adopters (%)		Level 2 Adopters (%)	
		Female	*Male*	*Female*	*Male*
Lushoto	Female	50.0	50.0	60.6	39.4
	Male	13.2	86.8	25.1	74.9
W. Kenya	Female	66.3	33.7	55.6	44.4
	Male	34.5	65.5	0.0	100.0

Data on types of exchanges in Lushoto site (Table 9) further reveal that most exchanges occurred at no cost to adopting farmers. This represents a positive trend with regards to maximizing access by resource-poor farmers. However, while knowledge-intensive natural resource management technologies are never characterized by cash exchanges, 12% to 43% of exchanges of cash crop technologies are. This suggests that financial barriers may exist to technology access for those technologies that can make the most immediate livelihood impact.

Table 9. Exchange Type for Different Technologies

Technology	**Exchange Characteristics**
Banana Germplasm & Management	88% given free of charge; the remaining **12%** was **sold**.
Soil Conservation Measures	75% given free of charge; the remainder was exchanged.
Tomato Germplasm & Management	57% was given for free; the remaining **43%** was **sold**.
Soil Fertility Management	67% was given for free; the remainder was exchanged.

These data illustrate the need to understand how the social context conditions patterns of inclusion and exclusion resulting from introduced innovations. Patterns of exclusion point to new avenues for experimentation, namely strategies to minimize social biases in the capture of benefits from introduced technologies. Focus group discussions with farmers to share these findings and elicit their recommendations on how such biases can be overcome will help research and development actors to identify and test more equitable dissemination strategies in the field.

(b) Household and farming system niches

Focus group discussions and formal tracking surveys assist in identifying social and farming system niches of different technologies, the former to identify basic patterns of uptake (types of farming systems or households accessing the technology) and the latter to quantify these patterns. Results of the former from Lushoto site are summarized in Table 10.

Table 10. Niche Breadth Associated with Adoption Constraints in Lushoto Benchmark Site

Technology	**Adoption Constraints**	**Niche Breadth**
Banana Germplasm & Management	- Lack of suckers - Susceptibility to drought	Broad – all farmers can readily adopt due to limited resource requirements.
Soil Conservation Measures	- Labor demands & age - Permanent crops - Availability of organic nutrient resources - Limited access to technical assistance	Medium – technology places substantial demands on labor and organic nutrients, but is not overly prohibitive as these are locally-available resources.
Tomato Germplasm & Management	- Spacing recommendations are time consuming - Harmful effects of industrial pesticides - Susceptibility to blight - Limited capital to purchase inputs - Requires quality land - Requires irrigation	Narrow – adoption highly dependent on favorable farming system characteristics (access to valley bottoms and irrigation), wealth (high input requirements), and labor.

Quantitative data on niche breadth is summarized in Tables 11a and b for tomato, which included germplasm, crop husbandry and integrated nutrient management. Given the use of the snowball method of sampling, these data provide information on adopters only. The data must be compared with a "control" (random sampling of the population) to understand how social and farming system niches of adopters compare with the population at large. The data is nevertheless useful when identifying characteristics of the farming system that restrict niche "breadth" – or the range of households and farming systems that may adopt the technology. For example, 100% of adopting households are shown to have access to valley bottoms and 93% to irrigation water, suggesting that niche breadth for tomato is very restrictive to families with certain types of assets. Information may also be gleaned from these tables on social niches. For example, 86% of all adopting farmers are male, a reflection of the tendency for men to control cash crop production in this site – and indeed throughout much of eastern Africa. Secondly, while elders tend to own much of the land, youth and middle-aged farmers are nevertheless adopting the technology and putting it to use, illustrating how local land markets (land hire) and social innovations (pooling of land and labor, as illustrated in the next section) may help to overcome land tenure constraints – at least by male farmers. The data also tell us with whom technologies are most shared (relatives vs. others) and whether they are sold or provided free of charge. While the total number of exchanges shown is small in number, from larger data sets one could make more conclusive statements about how social networks enable or restrict access to new technologies. For example, data show that all exchanges within nuclear family are free of charge but limited in number, suggesting a preference to share with those who will pay to gain access.

Table 11a. Household Characteristics for Adopters of Tomato Technology (germplasm, management practices) in Lushoto, Tanzania

							HOUSEHOLD CHARACTERISTICS					
Name of Adopter	**Exchange Type (Acquisition)**	**What Exchanged**	**Age**	**Sex**	**Level of Spillover**	**Relationship with Host Farmer**	HH Labor	Plots land	Acres land	Tenure (# plots)	# cattle (local/ exotic)	# small rumi-nants
Martin Msumai	S	G	30/Y	M	2	Fr	1	3	1.75	M	0 / 0	0
Abdi Mazimatai	S	G, A, K	25/Y	M	2	Fr	2.5	4	1.25	M	0 / 0	0
Ramadhani Athumani	F	G, A, K	31/M	M	1	Rn[a]	2	3	1	M/F	0 / 0	0
Wiliam Ezekiel	S	G, A, K	25/Y	M	1	Re	3	4	2.5	2M; 2 sons	1 / 1	0
Hassan Sefu	S	G	60/E	M	1	Re	9	15	15.5	M	10 / 8	9
Kundaeli Salehe	S	K	40/M	M	1	A	4	5	3.5	M/F	2 / 2	0
Sharifa Salim	F	K	35/M	F	1	Re	1	2	0.5	F	0 / 0	0
Vincent Seng'enge	F	K, A	30/Y	M	1	A	8.5	6	4	M/F	2 / 2	1
Juma Ibrahim	F	G, A	37/M	M	1	Fr	2	3	3	M (2); hired (1)	0 / 0	0
Mariam Musa	F	G, A	70/E	F	1	A	3	7	4	M	2 / 0	4
Daniel Wilson	F	G, A, K	32/M	M	1	Re	2.5	7	8	M/F	0 / 0	0
Charles Richard	S	G, A, K	25/Y	M	1	Re	2	4	1.5	M (1); hired (3)	1 / 1	0
Paulo Mbilu	F	G, A, K	59/M	M	1	Rn	4.5	9	17.5	M(8); sons (1)	2 / 2	2
Adamu Salehe	F	G, A, K	46/M	M	2	Re	3.25	7	4	M/F	1 / 1	1
TOTALS	**8 Free**	**11 Germp.**	**5 Y**	**12 M**	**L1 = 11**	**2 Rn**	-	-	-	**M = 42**	-	**-**
	6 Sold	**10 Assist.**	**7 M**	**2 F**	**L2 = 3**	**6 Re**	-	-	-	**M/F = 28**	-	**-**
	0 Exchanged	**7 Knowl.**	**2 E**			**3 Friend**	-	-	-	**F = 2; H = 4**	-	**-**
						3 Acquaint.	-	-	-	**B = 3**	-	-
PERCENTAGES /	**57% Free**	**79% G**	**36% Y**	**86% M**	**L1 = 79%**	**57% Related**	**3.5**	**5.6**	**5.1**	**53% Male**	**L = 1.5**	**1.2**
AVERAGES	**43% Sold**	**71% A**	**50% M**	**14% F**	**L2 = 21%**	**14% Rn (100% free)**				**35% Shared**	**E = 1.2**	
		50% K	**14% E**			**43% Re (75% sold)**				**3% Female**		
						21% Fr (66% sold)				**5% Hired**		
						21% A (66% free)				**4% Bequeath**		

[a] Rn = Nuclear family. These categories vary by society, making it best to write the specific relationship (i.e. paternal uncle, brother-in-law) and classify them later.

Table 11b. Household Characteristics for Adopters of Tomato Technology (germplasm, management practices) in Lushoto, Tanzania

Name of Adopter	**Access to Technical Assistance**	**Area with New Variety** (Acres)	**FARMING SYSTEM CHARACTERISTICS**				**IMPACT (P**ositive, **N**egative, **0)**					
			Area dark soil	Irrigation	Valley bottoms	Change in tomato area	Yield	Income	Labor	Pathogens	Water	Soil
Martin Msumai	M	1	1	Y	Y	+ (1.0 Ac)	P	P	0	0	0	P
Abdi Mazimatai	M	0.5	0.5	Y	Y	+ (0.5 Ac)	P	P	0	0	0	P
Ramadhani Athumani	H	0.5	0	N	Y	+ (0.5 Ac)	P	P	P	N	0	P
Wiliam Ezekiel	L	1	0.25	Y	Y	+ (0.75 Ac)	P	P	N	N	N	P
Hassan Sefu	L	1	0.25	Y	Y	+ (1.0 Ac)	P	P	N	N	0	P
Kundaeli Salehe	H	0.75	0.75	Y	Y	+ (0.5 Ac)	P	P (x 2)	N	0	0	P
Sharifa Salim	H	0.5	0.25	Y	Y	+ (0.25 Ac)	P	P (x 3)	0	0	0	0
Vincent Seng'enge	H	3	3	Y	Y	+ (3 Ac)	P	P (x 2)	N	N	N	P
Juma Ibrahim	H	1	2	Y	Y	+	P	P	N	N	0	0
Mariam Musa	M	0.5	1	Y	Y	+	P	P	N	N	0	P
Daniel Wilson	H	1.5	1.5	Y	Y	+	P	P	N	N	0	0
Charles Richard	M	1.5	1	Y	Y	-	P	P	N	N	0	P
Paulo Mbilu	H	3	2.5	Y	Y	no change	P	P	N	0	0	0
Adamu Salehe	H	2	0.25	Y	Y	no change	P	P	0	0	0	0
PERCENT. / AVERAGES	**57% High** **29% Med** **14% Low**	**1.3 Acres**	**0.88 Acre**	**93% Yes** **7% No**	**100% Yes** **0% No**	**79% Pos.** **7% Neg.** **14% None**	**100% +** **0% -**	**100% +** **0% -**	**64% Neg.** **29% None** **7% Pos.**	**64% Neg.** **36% None** **0% Pos.**	**14% Neg.** **86% None** **0% +**	**64% Pos.** **36% None** **0% Neg.**

(c) Livelihood and agroecological impacts

No control is required to assess livelihood and agroecological impacts from introduced technologies; however, triangulation with qualitative data from on-farm visits and supplementary biophysical measurements can assist in understanding the transformations taking place on the farms. Data that show positive trends are mere indications of the success of the technology, serving only to confirm that adoption translates into positive impact. However, a number of indicators show disturbing negative trends. For example, the introduced technology is showing negative trends in pathogens and placing greater demands on household labor (Table 11b). The reasons behind some of these trends were identified through farm visits and follow-up focus group discussions. Enthusiasm over the income generated from the new varieties of tomato caused farmers to marginalize traditional practices of crop rotation, enabling a build-up of pests and disease. This was causing them to use increasing levels of pesticides, which were seen as having a negative effect on health. Diversions of household labor from other farm enterprises to tomato must also be viewed with concern, given well-documented cases of how shifts to cash crop enterprises impact on women and children. Impacts have been demonstrated for women's labor burden, access to and control over income (diverting labor to cash crop enterprises whose income if often controlled by men), and household nutrition and food security through decreased attention to staple crops and increase male control over household expenditures. Such observations can only be made through complementary modes of inquiry, including participant observation in the daily lives of households and gender-disaggregated focus group discussions.

Sample findings from western Kenya illustrate the large number of social and agroecological impacts that can be precipitated through the introduction of a single technology. Livelihood impacts identified by farmers for Kale and quantified through tracking surveys are summarized in Table 12. While negative effects were seen on household labor and theft (of the harvest), positive effects were observed on relationships within Farmer Research Groups and the household as well as on income and food security (through direct consumption, given its perceived nutritional and medicinal value).

Table 12. Livelihood Impacts of Kale in W. Kenya Site

Impact	**Household Labor**	**Food Security**	**Income**	**Theft**	**Employment**	**Relationships**
Positive	0%	100%	100%	0%	82%	82%
Negative	73%	0%	0%	55%	0%	18%
None	36%	0%	0%	45%	18%	0%

More interesting are the observed agroecological impacts. First, many diverse impacts were observed. This case also illustrates how farmer attention to a cash crop "attracts nutrients" and leads to improvements in soil fertility. While this was seen to have a positive effect on crops cultivated in these same areas following the harvest and on soil water holding capacity, diversions of labor and nutrients from other farm enterprises were seen as having a largely negative impact on other crops. In most locations it would also lead to an increased labor burden due to the increase in weeds, yet in this site it is seen as having a largely positive effect on weeds given the unique characteristics of Striga (adapts best to conditions of low soil fertility) and the extreme burden it places on the farming system. Use of pesticides and fertilizers had gone up, a trend often seen by researchers as positive (farmers are "modernizing") but is seen by farmers themselves as negative – as it places a burden on household income, health and the amount of capital that must be invested in the enterprise.

Table 13. Agro-ecosystem Impacts of Kale

Nature of Impact	**Positive** (%)	**Negative** (%)	**No Impact** (%)
Soil Fertility	91	0	9
Use of Fertilizers	11	78	11
Pests & Diseases	40	40	20
Use of Pesticides	18	55	27
Weeds	64	27	9
Soil Erosion	45	0	55
Soil Water-Holding Capacity	70	30	0
Impact on Other Crops/Activities	20	54	26

It is clear from these data that technologies are not morally neutral (Cooley, 1995). Rather, they catalyze a host of social and biophysical impacts – some positive and some negative. This information can be used in the design of dissemination strategies that seek to maximize the positive and minimize the negative spin-offs. All too often, R&D actors treat such impacts as somebody else's responsibility.

Qualitative on-farm interviews

While tracking surveys are conducted in a representative sample of the population (in this case, 20% of adopters), more qualitative on-farm interviews are conducted with a select number of households selected either randomly or because they exhibit certain features that can help illustrate relationships. For example, farmer innovations identified during focus group discussions were noted so that we could later follow up with the innovating farmer to understand more about the innovation. Many of these innovations are best understood through visits to the plots where they have been applied, not only to clarify the innovation in the mind of the researcher but to stimulate more detailed explanation than what would have been possible through a verbal exchange.

(a) Biophysical innovations

In western Kenya, a number of biophysical innovations were identified for each introduced technology. Those cited by farmers for Kale are illustrated in Table 8.

Table 8. Biophysical Innovations in Kale in the Western Kenya Site

Aspect	**Researcher Recommendations**	**Farmer Innovations**
Fertilization	- Farmyard manure + *Tithonia diversifolia*; direct application	- *Tithonia* incorporation before planting - Incorporation of Urea - Substitution of *Tithonia* with *Canasis* - Fermentation of *Tithonia* prior to use
Spacing	- 60 x 45 cm	- From 45 x 45 cm to 15 x 15 cm

There is a tendency among researchers to treat such innovations as negative, leading to sub-optimal yields. However, farmers always have their own rationales for making such modifications and these need to be given greater attention by research and extension. Modifications in fertilization levels have to do with the need to optimally allocate limited organic nutrient resources to diverse enterprises, while researchers are generally focused only on the introduced technology. Changes in spacing are generally made due to a perceived efficiency in the use of space or, in the case of both crops and trees, the desire to harvest / thin gradually over time so that income is spread out. Rather than criticize such practices outright, researchers should begin to take an interest in the rationale for these modifications – and even to measure them. This requires extending research into farmers' areas of interest – namely observing how allocations of nutrient resources across multiple enterprises can be optimized, and measuring total income and the temporal distribution of income when using closer planting densities. This type of research is likely only to confirm farmer innovations, but will give research and extension the necessary confidence to encourage the spread of farmer innovations to new households as an alternative to research recommendations.

(b) Social innovations

During the tracking survey and on-farm interviews, a number of social innovations were identified in Lushoto, Tanzania that enabled technology adoption and improved livelihood. For the implementation of bench terraces, one of the most common complaints was the high demand placed on household labor and organic nutrient resources (Table 4). Farmers in Kwalei village were found to have adapted the traditional labor-sharing practice of *Ngemo* to assist one another in the construction of bench terraces. Another important social innovation identified during household interviews emerged from the introduction of a variety of tomato with high market value, coupled with optimal use of manure and urea. Youth with little access to land had made an agreement with an elder landowner with ample access to valley bottoms (ideal for tomato) but limited labor and organic nutrient resources. While the cost of inputs and all proceeds were shared equally, the labor-intensive work (including transporting farmyard manure and the preparation of stakes to support the tomato plants) was done by the youth. Such synergies were beneficial to all involved, complementing their respective resource endowments (labor vs. land). This also highlighted a potentially negative environmental side-effect of this social innovation, namely the transfer of a limited resource (organic nutrient resources) from some households and landscape niches to others. While this may simply be a way of making more economically and mutually beneficial use of existing resources, it also introduces risk into the system by restricting the use options of niches from which these resources are diverted.

Other innovations included synergies between technologies and resource investments. For example high-value crops were combined with investments in bench terrace construction so that organic nutrient resources could be utilized to ensure economic returns while also enhancing soil fertility long-term. A social innovation associated with this practice included the joint hiring of a lorry to bring manure to the village for use in tomato production and bench terrace fertilization, off-setting the high organic nutrient resource demands of new technologies. Such social innovations need to be captured by research and extension, in order to incorporate some of the principles (e.g., social synergies, off-setting negative spin-offs from new organic nutrient resource flows) into dissemination strategies to enhance adoption by minimizing known adoption barriers.

(c) Impacts on livelihood and agroecosystem resilience

Farm visits and more qualitative, open-ended interviews can also assist in understanding the reasons behind observed impacts on livelihood and agroecosystems. This can be achieved through visits to the household and farm, where impacts may be observed and recorded, or through semi-structured interviews (see Annex I). These additional research instruments are optional, and are one of many ways to explore impacts in more detail.

(d) Other information gaps

The instruments in Annex I were also used to understand how adoption occurs, given that it is not a one-off process but a sequence of steps. If a decision to adopt fails at a specific step in the process, interventions may seek to overcome the specific barrier encountered at that step. Formal ranking can also be done to understand more about identified adoption variables or characteristics of the technology most crucial to adoption, which can in turn serve as inputs to technology generation processes.

3. FOCUS GROUP DISCUSSIONS: INTERPRETING FINDINGS

The final stage of the methodology consists of focus group discussions to aid in the interpretation of findings. Each of the main research outputs can be summarized for farmers in simple graphs or text, and explained to them verbally during focus group meetings. The farmers are then asked to: (a) explain why the observed patterns exist; and (b) suggest what could be done to overcome some of the negative patterns – for example, biased patterns in farmer-to-farmer sharing, negative social and agroecological impacts, or key disadvantages and adoption barriers. These recommendations become the guiding framework for subsequent research and technology dissemination activities.

CONCLUSIONS AND IMPLICATIONS

This methods guide outlines a methodology for tracking the fate of technologies after introduced, after technologies have been shared and adapted independently from outside research and extension influences. The simple five-step methodology is presented as a means to expand the conventional approach to adoption research by integrating the observations of farmers and researchers (for pattern identification and interpretation), inserting farmer-identified variables into household surveys, and expanding the range of observed processes. The approach integrates the conventional emphasis on major adoption barriers and numbers of adopters with research on diverse types of adoption impacts (both positive and negative), social networks through which technology flows in the absence of outsider intervention, and farmer innovations that enable technologies to more easily fit into smallholder farming systems. Findings demonstrate the critical importance of tracking patterns of technology sharing and related impacts and adoption barriers, so that positive impacts can be enhanced while negative impacts minimized or managed through complementary interventions. It is argued that professionals in agricultural R&D are acting irresponsibly if the implications of their interventions are neither fully understood nor managed. This methodology represents an attempt to move us in the right direction.

So what are the implications of such findings for agricultural research and development efforts? Far from being an academic exercise, findings illustrate the critical importance of knowing the fate of introduced technologies. On the one hand, ground-truthing adoption surveys in farmer observations (both the instrument and the interpretation of findings) provide a means for integrating the aspects of greatest relevance to farmers into the methodology, thereby enhancing researcher awareness of the variables of greatest importance locally. It also ensures that findings are interpreted with respect to the local context by integrating these variables into household interviews, monitoring related spin-offs, and involving farmers in the interpretation of findings.

Examples from the dissemination of soil and water conservation technologies in Lushoto, Tanzania (Tables 3 and 4) illustrate how farmers contribute to the identification of key causal variables influencing technology adoption and impact indicators of high local importance. Identification of adoption barriers through focus group discussions and surveys (in which the breadth of the adoption niche and speed of spillover are each tracked) also enable the more strategic design of interventions that enhance desired (and minimize undesired) impacts. Identification of the slow rate of propagation of banana suckers as a key adoption constraint in Lushoto, for example, led to the targeting of collective multiplication plots through the involvement of schools and community-based organizations. Identification of the gender imbalances in technology spillover despite an original emphasis on gender equity (equitable membership in farmer research groups), on the other hand, suggests that new approaches to gender inclusiveness must be tested. Third, the identification of farmer innovations enables the dissemination of more relevant practices and avails a wider suite of management options to farmers, while the identification of social innovations provides insight into the most appropriate organizational strategies for disseminating these innovations. The synergies established between youth and elders with complementary resources, collective action to import organic nutrient resources into the system and build upon traditional labor sharing practices, are examples of social innovations that should be highlighted along with other aspects of technology dissemination. The final and perhaps most important justification is the realization that solving one problem may create another, as illustrated in the diversion of farm resources from staple to cash crops, increases in some types of weeds accompanying decreases in others, and the skewed benefit distributions among men and women. Tracking such “trade-offs” enables research and extension to identify and test novel, complementary interventions to help minimize the negative spin-offs of adoption, thereby making the technology more attractive to more farmers.

This methodology is unique in its robust integration of views (farmers and researchers, adopters and non-adopters), consequences (social and biophysical), and qualitative and quantitative methods (the latter providing, rather unexpectedly, the key insight on gender inequality). Application of such methods as part of standard research practice, and the integration of findings into more informed and ethical dissemination processes, is sorely needed in the eastern African region to enhance accountability of the agricultural R&D establishment. This will only happen if improved awareness is coupled with institutional learning processes on successful ways to enhance positive and minimize negative social and environmental impacts of technological innovation. This is where the ethics of science and development comes in – by ensuring that interventions are not only sought by the end users but are accompanied by mechanisms to account for and manage the full range of impacts they may create – and where greater attention needs to be placed in the future.

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ANNEX I: SUPPLEMENTARY RESOURCES FOR ON-FARM INTERVIEWS

A. ADOPTION SEQUENCE

1) How did you learn about this technology?

2) What steps did you take before putting it into practice on your farm (observed others, experimented with it, modifying it, etc.)?

[If experimented, what were you looking for/comparing?]

3) What was the most significant challenge you faced in adopting the technology or integrating it into your farming system? What is the biggest barrier to more widespread adoption?

4) When you adopted the technology from [host farmer name], did you get seed only or also management advice? What sort of advice did he/she give?

5) Were these recommendations modified to improve upon them? How? Why were these changes made?

6) How was the farming system modified to accommodate the new technology? (i.e. allocation of labor, nutrient resources, land, income)

7) Were there any social innovations (shared labor, group seed provision, etc.) that emerged to enable uptake?

B. IMPACTS

Tables or semi-structured interviews can also be utilized to understand the nature of identified impacts, and the degree of change they represent.

Table 1. Impact of Tomato Technology on Identified Household and Farming System Variables

Variable Impacted:	**+ Impact**	**None**	**− Impact**	**Comments/Figures**
Yield/production				*Amt. of change:*
Area under tomato (before/after)				*m^2/Ha change:*
Household labor				
Food security				
Income				*Amt. of change:*
Pests and disease (name it)				*Name:*
Soil fertility or erosion				
Incidence of weeds				
Soil water-holding capacity				
Amount of required inputs				*Specify type:*
Use of industrial pesticides				
Impacts on other crops or on-farm activities				*Which:*

[If positive change in income] *How did you invest the extra income derived from tomato?*

C. ADOPTION VARIABLES

Explanations for Responses to Identified Adoption Variables

Explanations for farmer responses to identified adoption variables can assist in explaining divergent responses and in giving more detailed understanding of how different barriers and determinants to adoption are manifested.

Table 2. Assessing Adoption Variables

Variable	Response	Explanation
1. Attitude toward industrial pesticides	Positive Mixed Negative	
2. Availability of botanical to control pest/disease	High Medium Low	
3. Knowledge of tomato seed multiplication	Good Medium Limited	
4. Knowledge of tomato management	Good Medium Limited	
5. Access to valley bottoms	Acreage:	
6. Access to irrigation	Abundant Interm. Low	
7. Soil fertility	Area of dark soil:	
8. Availability of seed	High Medium Low	

Ranking Identified Adoption Variables

Pair-wise ranking may also be used to assess the relative importance of identified advantages or disadvantages of the technology, which can in turn be used in breeding and research efforts.

Table 3. Ranking the Importance of Diverse Technology Characteristics in Adoption

Factor Influencing Adoption	1	2	3	4	5
1. Extended harvest					
2. Fruit size					
3. Length of storage					
4. Resistance to blight					
5. Market reliability					

D. FARM NICHES WHERE TECHNOLOGY IS APPLIED

Additional tables may be used to understand how farmers select niches within their farms where any given technology is to be applied, highlighting both rationales for this choice and niches that should be targeted in future technology generation / adaptation activities (Table 4).

Table 4. Assessing Farming System/Landscape Niches for Diverse Soil and Water Conservation Technologies

Variable	**SWC Technology**		
	Terrace	Fanya juu	Grass strip
Proximity to household			
Permanent crops vs. annuals			
Slope			
Access to irrigation water			
Soil quality (**before** conserving)			

Comments/explanation:

Terrace –

Fanya juu –

Grass strip –

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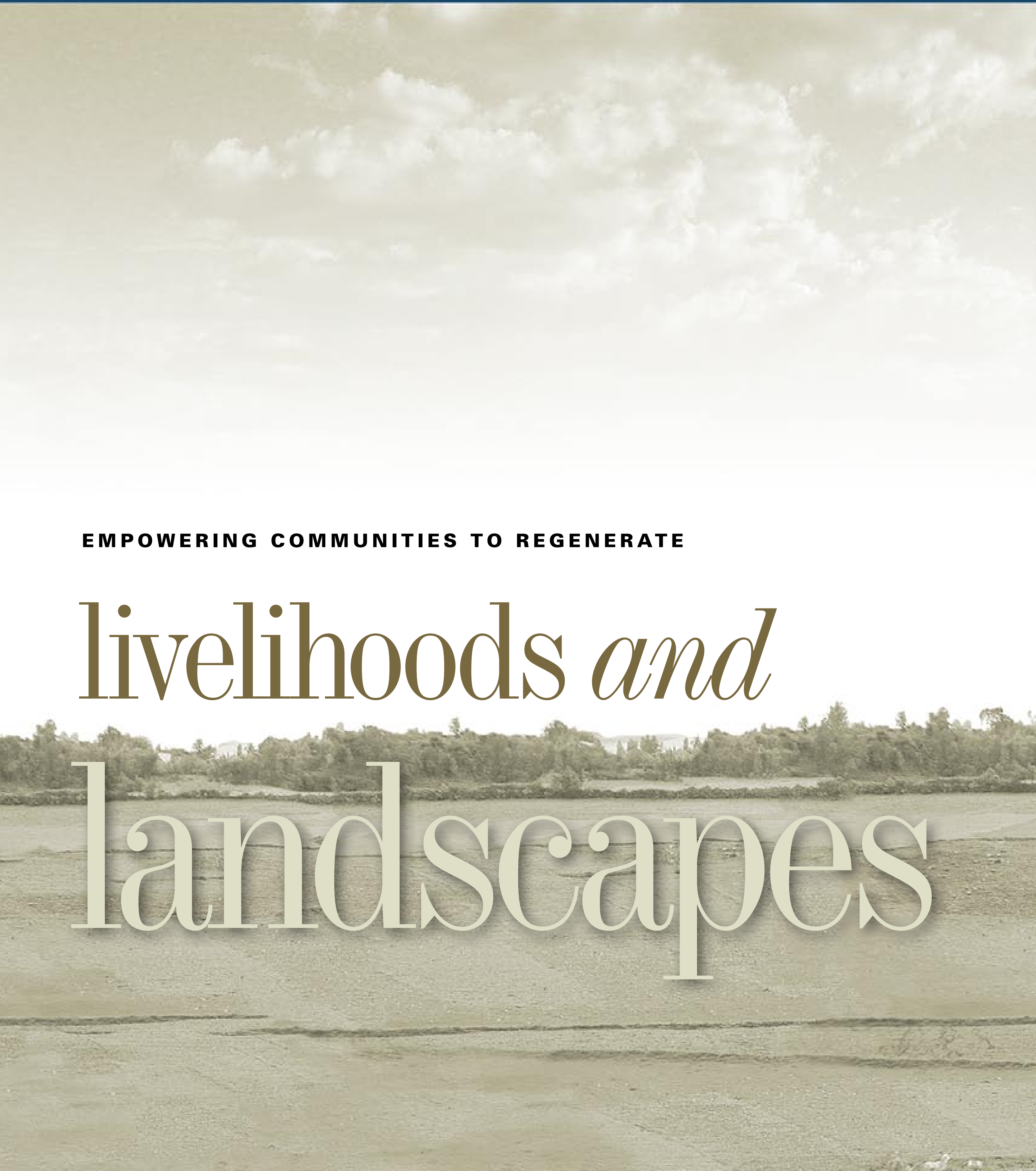

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