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THE IMPACT OF AGROFORESTRY-BASED SOIL FERTILITY REPLENISHMENT PRACTICES ON THE POOR IN WESTERN KENYA

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Abstract

This case study explores the relationships between agroforestry-based soil fertility replenishment (SFR) systems (improved fallows and biomass transfer) and poverty reduction in rural western Kenya. It further examines the role that different dissemination approaches play in conditioning which segments of society gain access to information to the technologies and then uses them. The study made use of many different qualitative and quantitative data collection methods and samples from both pilot areas where researchers maintained a significant presence and nonpilot areas where farmers learned of the technologies through other channels. Adoption processes were analyzed quantitatively using almost 2,000 households while changes in impact indicators were measured for just over 100 households. Qualitative methods included case studies for 40 households, where researchers lived in the villages for six months, and focus group discussions involving 16 different groups.

The findings showed that poverty is rampant among households and appeared to worsen during the study period. The poor were reached by many different information providers and liked certain aspects of almost all types of organizations, from government extension to community group-based methods. Access to information is mediated by social relationships of wealth, gender and status; nevertheless, poor farmers acquired a significant amount of knowledge about soil fertility management. Adoption rates are not outstanding but they are encouraging, with about 20% of all farmers using the technologies on a regular basis, and a sizable percentage of farmers newly testing. Unlike some agricultural technologies historically, SFR was found not to be biased toward people controlling and managing resources above a certain threshold. The study also found that the poor were using the agroforestry technologies to a much greater extent than they were fertilizer (about 33% of farmers not using any other soil fertility practice were trying the new systems). The technologies were almost always at least doubling yields of maize. Despite these promising signs, the systems were not found to be linked

to improved household-level food security or poverty indicators, primarily because the size of the fields under the agroforestry systems was, on average, quite small.

Keywords: poverty, agricultural research, sustainable livelihoods, vulnerability, agricultural extension, social capital, soil fertility replenishment, agroforestry, Kenya

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1. Introduction

This study examines the impact of tree-based improved fallow and biomass transfer systems on the rural poor in western Kenya. Western Kenya is one of the most densely populated areas in Africa—densities of over 1,000 people per square km are not uncommon. Much of western Kenya is considered to have good potential for agriculture, with medium elevation (1,100–1,600 m), deep, well-drained soils, and relatively high rainfall (1,200–1,800 mm per year) that permits two growing seasons. The history of farming in the area, however, is characterized by low input-low output farming. Recent studies have found that crop productivity is very low (less than 1 ton of maize per ha per year) and that nutrient balances are seriously in deficit. As a result, along with swelling population and decreasing farm sizes (now around 1 ha per household), poverty is rampant in the region. Fifty percent or more of the population are estimated to be in poverty in several of the districts, which is significantly higher than in other good-potential regions of Kenya.

The International Centre for Research in Agroforestry (ICRAF), the Kenya Agricultural Research Institute (KARI), and the Kenya Forestry Research Institute (KEFRI) developed an agroforestry research program that had as one of its pillars systems to improve welfare through soil fertility replenishment (SFR). Initially, several systems were tested, including alley farming, but the two that appeared most promising were improved fallows and biomass transfer. “Improved fallow” refers to the intentional planting of a fallow species. Improved fallows are more efficient than natural fallows and can normally achieve the same effect on crop productivity in a much shorter time. In western Kenya, two main fallow species are being used by farmers. *Crotalaria spp.* and *tephrosia spp*. are shrub species that develop a good canopy and leaf biomass in a short period of time and both fix nitrogen from the atmosphere. They are left for fallow for one season, normally the short rainy season (October–December), after having been planted toward the end of the long rainy season (April–May). Farmers then plant their crop

(normally maize) the following long rainy season and may continue to cultivate the crop for more seasons, using the residual fertility effect from the fallows.

Biomass transfer systems are those where organic nutrient sources are grown in one place and then transferred to crops in another place. In western Kenya, the most popular shrub species used is *tithonia diversifolia*. This species was selected among many locally found species because it is a prolific grower (found throughout the region), is easy to establish and work with, and its leaves contain high concentrations of nutrients, especially nitrogen. Farmers gather the leaves off-farm or plant the shrub on boundaries or contours on their own farms. They then incorporate the leaves into the soil at planting and sometimes use new leaf growth as a mulch later in the season. This system allows farmers to grow crops continuously, which is an advantage over the improved fallow system, but the available space for producing organic nutrient sources on-farm is limited. As a result, farmers are using biomass transfer systems significantly and increasingly on high-value crops such as kales and tomatoes rather than maize.

This study of SFR technology is one of a set of CGIAR case studies examining the impact of agricultural research on poverty. This particular ICRAF technology was selected for this study because it is an example of natural resource management research as opposed to the more common crop variety research. Because the agroforestry technologies offered an affordable option for soil fertility improvement, it was expected that rates of use and adoption would be relatively high among the poor. Further, there was some question whether the nonpoor would perceive any benefits of agroforestry compared to fertilizer. Even if there were such a perception, it is still an empirical issue as to whether the poor actually can substantially benefit from the use of agroforestry technologies. This would seem to depend on their understanding of how to effectively manage the systems as well as their capacity and willingness to increase their land and labor investment in these systems.

The study was also unique in its focus on comparing approaches to technology dissemination. Exploring dissemination processes speaks to debates around social capital, empowerment, and participatory development. Technology is mediated by social

processes and the social relationships into which it is introduced. In addition to examining how these processes unfold, the study explores several hypotheses related to the use of local organizations and other forms of participation for dissemination: that social capital will be enhanced, that social divisions will emerge, that farmers will be newly empowered in certain dimensions, and that existing power relationships will be reinforced. Although these may appear contradictory, it is hypothesized that they will occur simultaneously, with a range of effects on different individuals. Also, in disaggregating the dissemination study focus groups into women and men, and poor and less poor farmers, a hypothesis suggesting socially differentiated impacts is implicit. The findings have implications for policy and program choices related to forms of farmer participation in technology development and dissemination, suggesting the importance of understanding local social dynamics when designing program interventions.

It should be pointed out that the range of issues covered in the study required the use of a mix of research methods and interdisciplinary perspectives. Issues pertaining to local perceptions of poverty, the mediation of technology by social processes, and the role of gender, power, and other social constructs in understanding adoption and impact could only be explored using qualitative research methods and sociological perspectives. These were combined with quantitative measures of adoption and impact and economic analysis. The quantitative analyses proved valuable in identifying how common patterns of adoption and impact relationships were among the general population and the poor. We also drew on long-term knowledge of the region, based on work by members of our study team and others. The study was designed using the sustainable livelihoods conceptual framework as a starting point, drawing on concepts of vulnerability, access to and limitations on combinations of assets (e.g., natural, human, and social capital), and the importance of institutions and processes. However, other constructs from economics and sociology were introduced as required. This was done not so much as to promote a particular alternative paradigm as much as to handle important research questions raised by the entire team, comprising individuals of diverse backgrounds and experiences.

Section 2 presents the methods used in this study, and explains the sampling procedures and outcomes. Section 3 provides a contextual background for the study areas, including an overview of people's livelihood strategies, the reasons behind these strategies, and concepts of poverty from official, researcher, and local perspectives. Section 4 focuses on adoption of soil fertility practices, describing the process in the pilot and nonpilot villages. This section then explores in depth patterns of adoption across different types of households, including poor and nonpoor. Section 5 examines the extent to which various productivity and welfare impacts occurred as a result of adoption of soil fertility replenishment practices. Section 6 explores approaches to dissemination taken by different institutions in the study areas and related impacts, covering methods, knowledge acquisition, sustainability, and the implications of and for social capital and social relationships. Section 7 summarizes the methodological and empirical findings and suggests considerations for future poverty alleviation programs in western Kenya.

2. Research Methods

This paper synthesizes results from the application of a range of analytical methods in several sites. Sites are selected from Luo and Luhya communities. An important distinction is between those communities within an initial pilot project area covering parts of Vihiga and Siaya Districts and those from outside. Communities within the pilot project area received high levels of technical support from project staff from 1997 through early 2000. In addition, all researcher-managed trials were conducted with farmers in the pilot villages, and all tree seed purchased from farmers was again from these villages. Qualitative analyses covered four villages in the pilot project area and four villages outside the pilot project area, both Luo and Luhya areas. The quantitative analysis covered 17 villages within the pilot project area and eight villages outside the area.

Qualitative and quantitative methods have been used in conjunction throughout the study to address issues of impact. Qualitative wealth ranking exercises were

undertaken several years ago to assist in the identification of who the poor are and what types of indicators are important to measure the effect of any research program. Quantitative surveys were then implemented to capture such wealth indicators over wide areas, and these formed the basis for stratification and sampling of households in both the qualitative and quantitative impact assessment studies within the pilot project area. Qualitative analyses used mainly techniques of focus group and individual cases studies. Focus group discussions were used to discuss the concepts of poverty and livelihoods and served as the main research tool for assessing the effectiveness of alternative dissemination methods in reaching the poor. Case study methods were used for 40 individuals and their households/families. Field assistants interacted with the individuals over a six-month period. Data were analyzed with the assistance of the qualitative data analysis software. Dissemination approaches used by different organizations in western Kenya were later studied through 24 focus groups across six villages, disaggregated by gender and wealth status. In addition to discussions, these involved some selected visual (PRA-type) exercises. These were designed to yield information directly relevant to the research questions and generated both qualitative and quantitative data. Table 1 shows overlap between the quantitative and qualitative methods across villages.

Quantitative analyses relied on data collected from surveys. Within the pilot project area, adoption was analyzed from annual monitoring data on the use of agroforestry from over 1,600 households. Impact was analyzed from a cohort of 120 households that were part of a baseline survey on assets, expenditure, and food consumption in 1999–2000. In the nonpilot project sites, no baseline was collected, so all the data come from a survey that included 360 households, stratified on the basis of use of agroforestry. From this survey, issues of dissemination, adoption, and impact were analyzed. In all cases, analyses employed descriptive and econometric analytical methods.

The empirical evidence of both the qualitative and quantitative parts of the study suggest that lessons can be context-specific, differing across communities and

Table 1—Villages studied and research methods[a]

	Type of dissemination approach	Disseminating organizations[b]	Survey	Focus group discussions	Case studies
Luo villages					
Sarika	Village approach	**ICRAF**, KEFRI	●		●
Muhanda Arude	TRACE approach	**CARE-Kenya**, ICRAF, MoARD	●	●	●
Sauri	Village approach	**ICRAF**, KEFRI, KARI, MoARD		●	
Gongo	Catchment area approach	**MoARD**, ICRAF		●	
West Kanyaluo	Sub-chief visited Maseno	**Local leaders**	●		
Ugunja	Local CBO through ICRAF	ICRAF	●		
Luhya villages					
Eshikhuyu	Village approach	**ICRAF**, KEFRI	●		●
Mwitubi	Catchment area approach	**MoARD**, ICRAF	●	●	●
Mutsulio	PLAR	**KARI**, MoARD, ICRAF, KIT	●	●	
Bukhalalire	Umbrella group approach	**KWAP**, MoARD, ICRAF	●	●	

[a] In addition, survey analysis was undertaken in about 14 other pilot villages not listed here.

[b] The main disseminating organization is in bold. The rest joined in after the approach was in place and used it to reach farmers. Note that other organizations were also active with projects that may have included soil fertility in some of these villages, but were not the main SFR interventions of interest to this study. Acronyms: CBO, community-based organization; ICRAF, International; Centre for Research in Agroforestry; KARI, Kenya Agricultural Research Institute; KEFRI, Kenya Forestry Research Institute;; KWAP, Kenya Woodfuel Agroforestry Programme; MoARD, Ministry of Agriculture and Rural Development; PLAR, Participatory Learning and Action Research; TRACE, Training of Resource Persons in Agriculture for Community Extension.

households. The inherent heterogeneity of activities and strategies is part and parcel of a livelihood perspective that aims to capture processes of change and that perceives development as intrinsically nonlinear. Nevertheless, some findings were sufficiently widespread to enable the distillation of certain patterns of outcomes related to combinations or limitations on assets, institutional environments, vulnerability contexts, and other factors. These emerge at different stages in this paper and in our conclusions.

3. Context of the Research

Livelihood Context

Generally, rural households pursue and combine several livelihood strategies, both on- and off-farm. In Siaya and Vihiga Districts of western Kenya, most households interviewed pursued at least one of the following sources of livelihood: rainfed farming, livestock rearing, business, employment, and remittances from family members. In the pilot areas, most family members were children who were mainly occupied as students and depended on adults for their subsistence. Next to this, as the case studies show, they also devoted time to assisting their parents or as caretakers in some kind of productive activity, such as weeding, planting, and herding, as well as activities related to housekeeping. The adults of the immediate household were all engaged in some kind of productive work on and off the farm. In terms of allocation of time, farming as farmers or as farmworkers is an important activity, but difficult to quantify. Among the adults, females are slightly more likely than males to be farmers. Males, on the other hand, are more likely than females to have nonagricultural casual jobs. Among other categories, there are hardly any distinctive differences according to gender. Full-time work off-farm was an important livelihood, mentioned by nearly one-third of surveyed households. Casual labor, while common and, in terms of monetary income, very important, was not often cited as a major livelihood source. Remittances and pensions are only mentioned as important in a couple of cases.

For those that rely on agriculture as a source of livelihood, maize and bean production dominates throughout, though some of the nonpilot villages are in drier zones where sorghum or millet and increasingly sweet potatoes are more common. Among the "higher value" crops, vegetables are also important sources of livelihoods, but there are hardly any "industrial crops" such as tea, coffee, or sugarcane grown in these villages. It must be emphasized that there are different types of farmers and farming systems and these are not static, but have changed over time.

One of the main features of the livelihood strategies pursued in rural Kenya is that several strategies are applied sometimes in combination, while others are applied in succession with the possibility of making reversals. The question, therefore, is how these strategies are applied and under what circumstances. Many of the case studies show that households attempt to engage in several livelihood strategies. In some cases, the livelihood strategies are contradictory and therefore interfere with the success of individual strategies. For example, those that combine off-farm with farm-related livelihood activities compete for the limited amount of labor available. The labor that is required, for instance, for agricultural production is often absent—particularly for those households whose adult labor force is partly in town—and where the ability to access outside labor is problematic due to complex kinship relations. In other situations, however, these livelihood activities complement one another to the extent that many of them cannot be pursued in isolation. For example, not all off-farm activities compete for resources; they may also render resources that are used to strengthen the use of agricultural resources (for example, financial resources generated from urban employment has benefited agricultural investment for some households).

The set of livelihood strategies pursued and the importance of any given one may also change over time, sometimes because others have suggested changes or other reasons. Hence, in spite of investments already made in terms of farming knowledge and skills, some farmers easily shift labor from their own farm to take up casual employment. It is also apparent that the types and combinations of livelihood strategies that households are able to manage are often dependent on availability of labor. Labor can be hired from outside the household, but poor households generally lack financial resources with which to employ labor.

Among the issues that therefore emerge as central to this impact assessment is the need to understand the driving forces behind the choices people make and why they sometimes persist with strategies that seem unprofitable. The various case study accounts suggest that, generally, choices depend on the resources at hand, perceptions of incentives (rewards and costs), the desire to belong (and the fear of isolation), and how

events unfold both for the individual and his networks. Some of the issues that could explain choice among rural households include people's notion of good farming and how this influences the type of strategies they pursue to earn a livelihood, and the nature of investments that they put in place, including the SFR technologies adopted. But intentions are easily thwarted by lack of resources or keen competition for them. Therefore, whereas the rural poor may be in a position to appreciate the dynamic changes around them, they are often unable to take full advantage of opportunities that are perceived as capable of uplifting their welfare.

Local notions about good farming are based on people's aspirations, and these largely hinged on output and recognition from neighbors and friends. Hence people's livelihoods need to be interpreted as culturally embedded. Other evidence, however, suggests that reluctance to use inorganic fertilizer goes beyond finances to include how people perceive the dangers associated with these technologies. For example, we noted views that argue that "fertilizers are spoiling the soil." This therefore means that the choices that people make regarding farming activities and which end up characterizing their farming styles are dependent on how they perceive any of the practices that they engage in, irrespective of whether they are recommended or not. The qualitative studies were unfortunately not able to probe into this in further detail.

Are there different types of farmers? Generally, the livelihood strategies that households pursue vary with gender. Women diversify much more than men do. Nevertheless, all these strategies and livelihood approaches are linked up by the fact that they constitute a people's identity and therefore provide a sense of belonging. This is largely because almost all the people tend to want to do that which is commonly undertaken in their home area. For instance, in spite of seeming quite unprofitable, subsistence farming has persisted sometimes just because people wonder about what the neighbors "will say." Hence, the struggle to belong and the continued search for some identity forces some people to undertake operations that they would otherwise gladly put aside. The relatively progressive farmers will still produce some low-value maize to prevent an accusation of stealing maize of others. Other farmers may continue to practice

natural fallowing as was customary, even though seasonal fallows are not effective in raising yields.

Concept and Measurement of Poverty

As expected by the small farm sizes and low agricultural production, most of the study sites include many poor households. Indeed, national statistics show that over 50 percent of the population in many of the districts in western Kenya live below the poverty line of 1,240 Kenya shillings per adult per month (about US$16). In our study sites, qualitative and quantitative methods were used to better understand the local concept of poverty and to estimate the extent of poverty among our study households.

Poverty or being poor appears to be a very slippery concept. Most commonly heard was the perception that "nobody is poor." The notion of "poor" or "poverty" is often not accepted and rather represents a rejected kind of personality, a deformed person. This comes through in statements such as "Poor are people who are handicapped. The poor stay and beg in towns, as they do not have land and shelter. At least I have a shelter."

Generally, most people are reluctant to classify themselves or others as poor. Instead, these people described their condition as a result of lacking various things and, according to most of the people interviewed, this is different from being poor. Poverty is perceived as a state of being unable and this, it was felt, can only be the case for those people that are physically disabled. The people therefore prefer to say that they are "lacking something." Poverty is then associated with lacking income both from employment and business. Poor people have small pieces of land, grass thatched houses, and large families with children walking in tattered clothes and who have fallen out of school.

This gives the feeling that whereas poverty is real and evident, there is an attempt by all people, the poor included, to run away from both the state of and the reference to being poor. But the main descriptors of poverty in the words of respondents are

- lack of land
- no daughter or son on the farm
- inability to feed one's family
- inability to pay for education, health care, etc.
- wearing of tattered clothes
- having unemployed children
- being physically disabled
- housing with a leaking roof

The perception is that poor people engage in casual jobs and must always buy food that is not enough. Diseases like mental disorders are very common among the poor because they are unable to manage the condition. Physical disability is seen as a cause of poverty, and many people in this village who are physically challenged engage in begging at the market. Sometimes laziness and drunkenness are cited as causes of poverty within the community.

It is equally challenging to uncover many rich people. The "rich" are those that have something extra. Yet, nobody admits to having anything extra. The notion of rich is not favored or used at all in everyday discussions. The rich, according to general standards, would not admit they are rich. Notwithstanding the murkily defined notion of "rich" or "poor," it is widely acknowledged that the rich have more land (to leave fallow and thus profit more from improved fallow technologies), and they have more capital with which to hire labor.

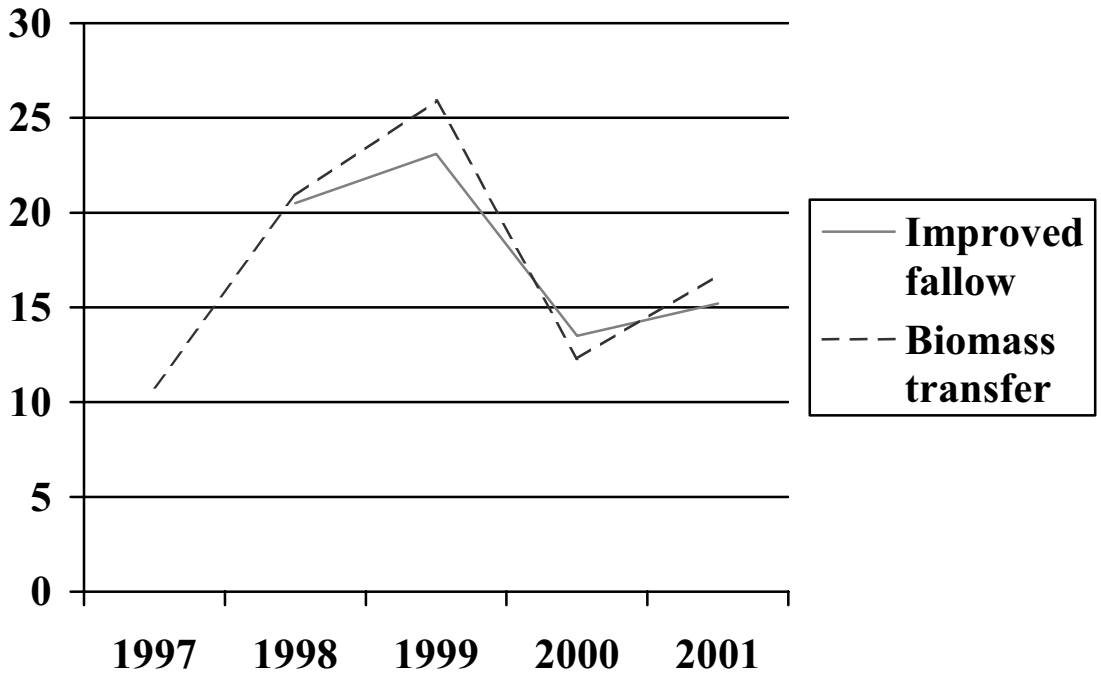
In terms of measuring the degree and extent of poverty, we used different methods, ranging from quantification of assets, expenditures, and consumption to using farmers' own perceptions of their own poverty to enumerator assessments. Though the different measurements were not always strongly correlated, each resulted in the estimation of a large number of poor households. In the pilot villages, 50–66 percent of households are classified as very poor, depending on the measure used (58 percent of households were ranked as very poor in two of three measures used). Similarly, in the

nonpilot villages, 41–50 percent of households were classified as very poor (41 percent of households were classified as poor in at least two of the three measures).

4. Adoption of Improved Fallows and Biomass Transfer

There are distinctive patterns inside and outside the pilot area. Inside the pilot villages, there was a rapid surge of users between 1997 and 1999. The use rates reached about one-quarter of households for each technology (see Figure 1). There was then a significant decline in use in 2000 followed by a recovery in 2001. In 2001, 16.7 percent of households were using improved fallows, and 15.2 percent were using biomass

Figure 1—Adoption patterns of improved fallows and biomass transfer in the pilot villages, over time, 1997-2001 (percent of 1,630 households)



transfer. A likely interpretation is that considerable technical support along with the bandwagon effect may have led to early high rates of testing. This was followed by disadoption by those who did not receive sufficient benefits or were unable to manage the

technology after ICRAF and partners reduced backstopping efforts (see below). Finally, in 2001 when the villages adjusted to being weaned from ICRAF support, some early testers retried the systems and new testers surfaced.

Outside the pilot villages, the dynamics were much different, with steady increases found over time for both technologies (and other SFR technologies as well).[1] Starting with just about 5 percent of households using agroforestry in 1997, by 2001, 12.4 percent were using improved fallows and 21.6 percent were using biomass transfer. There appears to be a leveling off of interest in improved fallows, while the trend for biomass transfer continues upward. In both pilot and nonpilot areas, there are a number of new testers of the technologies, so, for example, many of those contributing to the 2001 rebound in the pilot villages are "new testers."

There are further differences in the use of SFR within and outside the pilot villages. Within the pilot villages, 54 percent of those who use agroforestry use both the improved fallows and biomass transfer. Outside the pilot area, only 38 percent of users are using both systems. Thus, when households have less interaction with researchers, they more often than not prefer only one system. Where ICRAF technicians were present, it may be the case that some households used both systems to please the scientists. This is further supported by the fact that of the new testers in the pilot villages, 88 percent are trying just one of the systems.

Because of reasonably lengthy exposure to agroforestry within pilot villages, it is possible to classify households into different categories of adoption. The adoption dynamics for each technology were summarized into four mutually exclusive outcomes:

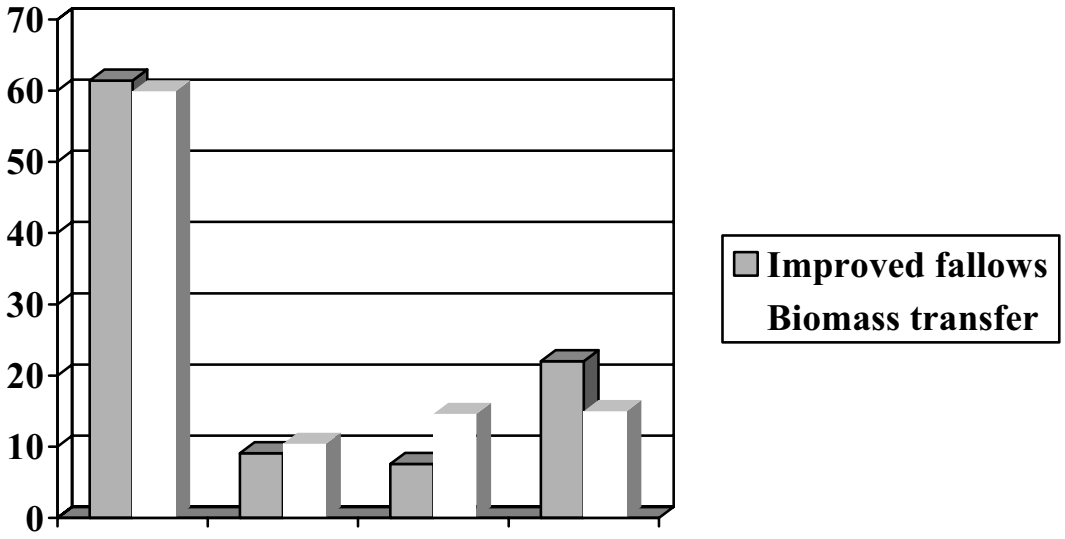
1. households that never used the technology (nonusers);
2. households that used the technology early on but never again (disadopters);

[1] Note that while use of agroforestry was monitored annually for all households within the pilot villages, the data for the nonpilot villages were based on recall from 2001. Moreover, the nonpilot village sample was stratified on the basis of use of agroforestry, so actual percentages of adopters are not necessarily representative.

3. households that did not use the technology early on but used it recently (recent testers);
4. households that used the technology throughout the period (adopters).

As indicated in Figure 2, the highest proportion of pilot village households had not tried either technology as of 2001, about 60 percent in each case. A greater percentage of households have adopted improved fallows (22.0 percent) than biomass transfer (15.0 percent). However, about twice as many households have recently tested biomass transfer than have tried improved fallows (14.6 percent to 7.6 percent). For each technology, about 10 percent of households tried and then dropped the practice. This may be due to disappointment with the performance of the technology, the realization that the investment required is too much to bear, or the farmer was initially using the technology for other purposes, such as to sell tree seed to ICRAF or develop closer ties to external organizations.

Figure 2—Adoption patterns of improved fallows and biomass transfer in the pilot villages by 2001 (percent of 1,630 households)



Outside the pilot villages, censuses were done for six different sites (about 1,000 households). Because the rates of use are expected to be relatively high compared to other nonpilot villages (indeed, this is one of the variables for stratification), these should not be taken to be representative of dissemination success. Rates of use are very high in five of the six sites, with rates ranging from about 24 to 59 percent. This is encouraging, given that technical support from the project in these sites has been relatively low.

Average fallow area was highest in 1998, dropping to a low in 1999, and recovering somewhat in 2000 and 2001. Fallow size was reduced in 1999, partly due to lower rainfall and seed supply constraints and because ICRAF began diverting some attention from the pilot areas to scale-out information to other places. In 2001, the mean fallow size (among practitioners) was 440 m^2 (.04 ha). While this does not sound like much, it should be recognized that farm size for many is about .6 hectares, of which perhaps .3 to .4 is under maize. Further, the fallow system calls for a rotation of a fallow followed by three seasons of maize. If this pattern is followed, one would expect only one-fourth of the maize area to be under fallow at one time—this would be .075–.1 ha. Viewed this way, adoption intensity among those using fallows appears to quite high.

Planting *tithonia* to provide the organic matter for biomass transfer systems is perceived as increased investment in the biomass transfer system. It also reduces the subsequent labor required for collection of the material off-farm. Considerable planting occurred in 1998, 1999, and 2001, when over 11 percent of households planted in each year. Curiously, the percentage of households planting in 2000 was much lower (4.2 percent). Whether this is a sign of saturation or an anomaly is unknown but will be monitored over time.

Who Adopts Agroforestry Systems—Qualitative Findings Related to Decisionmaking and Social Contexts

The issue of who decides to adopt SFR technologies is tricky. Among the Luo and Luhya, the husband customarily makes such decisions. In our study sites, women have to ask their husbands' permission to attend seminars and meetings called by ICRAF and

other agencies to disseminate SFR. This does not imply directly that women do not participate or that they have no say in such matters. In fact, in some of the households, women farmers took the lead in acquiring information about and testing agroforestry on their farms. Decisions appear to be made at nuclear household levels in many cases. For instance, one cowife may adopt and another may not. One son in a Luo compound may adopt and the others may not. Nonetheless, women hardly mention that they decide what to do and prefer to give their husbands the credit. It is also evident from some of the case studies that the decision to adopt or not to adopt has brought about disagreements, some of them at the level of the family unit.

An interesting difference occurs at the level of pilot versus nonpilot villages. Women are active adopters of the new SFR technologies in the pilot villages, but this was not the case in nonpilot villages, where men were more often mentioned as the main adopters. This could be due to the fact that new knowledge has to be searched for from a distance as compared to the pilot villages, where the knowledge is brought close to home and women are able to attend the learning sessions. In fact, there were significant efforts to provide information to all social groups and individuals within the pilot villages.

The men who had adopted in the nonpilot villages were those who were known to have connections with people from outside the village, and they have been exposed to other development work through exchange visits by different organizations within and outside the village. This difference is due to two factors. First, looking at their schedules of household chores, men have a lot of time that they can be away from home to acquire new knowledge. Second, due to their larger "social space," they can easily interact with other people, and go for exchange visits and other meetings that are not yet well known to many people in the village.

Education was not found to play a major role in farmers' decision to adopt. Women, who were apparently of lower education, excelled in the uptake of the new technologies as long as the explanations were given in the simplest terms possible. This did not seem to hinder their understanding as the data on knowledge before, during, and after the project clearly show that women understand SFR technologies better than men.

Generally, there is a lot of appreciation for the work of the ICRAF/KEFRI/KARI staff based at Maseno, but notwithstanding, mixed feelings also exist. They "love the Maseno people" for their inputs, but do not like the "agents."[2] With agents, or more specifically "ICRAF agents," what is meant is that certain villagers gained a lot of attention from ICRAF/KEFRI/KARI as they introduced and disseminated agroforestry technologies. These individuals were not democratically elected by the villagers but were hand-picked by ICRAF staff. Because of the perception of bias, some farmers stopped attending meetings and workshops organized by ICRAF staff. The farmers blame the ICRAF staff for heavily relying on the agents to choose people to attend seminars and workshops. Questions were raised about how the agents maneuvered themselves in such strategic positions. In both the Luo and Luhya villages, "clanism" and political party affiliations appeared to play an important role.

In the pilot villages, the different modes of interaction with villagers (in some cases, researchers rented land to conduct experiments) created confusion and led to perceived social differentiation among villagers. Another related issue the case material points at is ownership of trees. Often trees are seen by farmers as "CARE trees" or "ICRAF trees" rather than their own trees.

This suggests that we need to interpret such images and views as well as favoritism as part of the patterns and nature of social relationships that emerge over time between institutions such as ICRAF and individual farmers and communities. It is important to stress that such images (whether right or wrong) and favoritism has shaped people's negative views of agroforestry-based technologies.

The SFR-project generated money, particularly in the beginning when seeds from improved fallow trees could be sold at high prices. Quite a few people took advantage of this situation and made a lot of money from the early seed market. Farmers decided to adopt after ICRAF promised to purchase the seeds; others adopted with the hope that many whites who used to come to the demonstration site could give them money and

[2] This is referred to in Section 6 as the "contact farmer" and is discussed further there.

farm implements. When the market for seed stagnated, disadoption started as farmers' expectations were not met.

At this point we can elaborate in more detail the typology of agroforestry users. *Seed adopters* are those that saw the opportunities that the seed market in the early start of the project presented. Fetching the then relatively high prices of seeds stimulated these adopters to grow the seeds that were collected by ICRAF. Most seed adopters dropped out of seed provision as the prices for seeds went down and the seeds were not collected by formal organizations any longer. *NGO networker*s are individuals that, through their early involvement with agroforestry and ICRAF, maneuvered themselves into strategic positions to gain access to resources distributed by NGOs and other projects or programs. Their involvement with agroforestry in their capacity of village elder or secretary of a community committee made them known to other agencies. *Keeners* are those that perceive agroforestry as a good addition to the many ways to replenish soil fertility. They are keen on agroforestry as it increases yields and reduces monetary costs of maintaining soil fertility.

Nonadopters and *disadopters* are those who never tried or stopped using agroforestry because of labor requirements, lack of or shortage of land, or the small size of the fields. The major factors behind disadoption or nonadoption are explored in more depth in the quantitative analysis.

Quantitative Findings from Pilot Villages

In both the pilot and nonpilot study areas, multinomial logit regressions were run to examine the effect of several explanatory variables on the different classifications of adoption (or not) of improved fallows or biomass transfer (examined in separate models). The explanatory variables pertain mainly to household-level factors such as household structure and resource levels. All the explanatory variables included in the model are predetermined in relation to the adoption variable, as they were collected at the beginning of the study period. In the pilot villages, regressions tried to distinguish between

nonusers, disadopters, recent testers, and adopters. In the nonpilot villages, analyses tried to distinguish among nonadopters, occasional users, and frequent users. The key results from the pilot and nonpilot villages are summarized in Table 2.

Table 2—Summary of quantitative analyses of adoption of improved fallows and biomass transfer

	Fallows		Biomass	
Variable	**Pilot villages**	**Nonpilot villages**	**Pilot villages**	**Nonpilot villages**
Wealth–asset measure	No	No	No	+
Wealth–farmer measure	...	++	...	++
Wealth–measure	...	No	...	No
Female head of household	No	+	No	No
Farm size	++	No	++	No
Household size	++	No	++	+

Notes: No = tested, but no significance found; ... = not tested, ++ = robust positive effect; + = weaker positive effect; - - = robust negative effect; - = weaker negative effect.

Improved Fallows

In the pilot villages, wealth was not related to use of the improved fallows, suggesting that the different use patterns are neutral with respect to wealth—the poor are as likely to adopt as the wealthy. Household type was also not related to adopting improved fallows—the technology is being adopted by female-headed and other nontraditional household structures as frequently as by the more common male-headed monogamous household. A final variable linked to poverty[3] shows a different pattern. Nonadopters of fallows have smaller farm sizes than disadopters and adopters. Somewhat encouraging is that households who are newly trying improved fallows tend to have farm sizes indistinguishable in size from nonadopters. Using the land/adult labor ratio in an alternative regression, it is found that greater ratios are positively related to the adoption of fallows (though not significant for disadoption or recent testing). Thus, for adoption, land is a more important household constraint than labor.

[3] Note that farm size is not always identified by rural households as a key criterion for wealth differentiation among households.

Among other variables, being in one of the focal pilot villages (10 of 17 villages in the pilot area) was instrumental in testing fallows at an early date, whether the practice was continued or not. However, location is not important for recent testers—this is suggestive that recent testing is less related to technical backstopping, other external motivations, and to the sheer number of existing users. Early use was similarly higher among Luos as compared to Luhyas. However, as was the case with the pilot location variable, new testers are equally likely to be Luhyas as Luos.

Education levels and age of the household head were not related to adoption of improved fallows (or to early testers). But older household heads and those with a secondary education were less likely to have disadopted fallows rather than having never used one. In other words, comparing disadopters to nonusers, the former tend to be younger than the latter.

Biomass Transfer

For biomass transfer in the pilot villages, the wealth index variable was again not related to adoption of biomass transfer compared to nonadopters (thus wealth is not linked to the adoption of either agroforestry practice). However, more wealthy households are more likely to have disadopted or recently tried biomass transfer. This means that should the recent testers become adopters, the profile of those who adopt will be described as more wealthy. The structure of household is not related at all to the pattern of use of biomass transfer so that the technology is completely neutral with respect to household decisionmaking structures. The size of farm is positively related to the adoption of biomass transfer, though not to decisions to disadopt or test in recent times. However, the supply of labor is also very important in the use of biomass transfer (for all three outcomes where use has taken place). When the land-labor ratio is used as a regressor (rather than the two variables independently), it is not significantly related to any of the outcomes, implying that neither land nor labor dominates as a constraint.

Luo ethnicity and being in a focal pilot village are positively related to adoption. The lowest adoption rates are among Luhya households in nonfocal villages. New testers

are likely to follow these patterns. Because external assistance has largely been withdrawn from these sites, the emergence of new testers may indicate that there has been significant farmer-to-farmer learning in which large concentrations of early users leads to large concentrations of new testers. The reason for higher use of biomass transfer among the Luo is not clearly known. One hypothesis is that their strong subclan affiliation may lead to increased use among clusters of households. But we find only partial support for this, with very high or low rates of adoption in about half the Luo villages, but moderate levels in the other half.

Education and age play a stronger role in use of biomass transfer than they do for improved fallows. More educated household heads are more likely to have adopted biomass transfer than uneducated. Similarly, there is some support that more education leads to less disadoption than nonadoption. Age of household head is not statistically related to adoption, but younger heads are more likely to be recent testers as well as to be disadopters, compared to those who had never tried biomass transfer. So younger household heads seem to show great interest in biomass transfer but have not always had sustained interest or the ability to maintain the practice.

Quantitative Findings: Nonpilot Villages

One key result is that there are hardly any statistically significant results among the household variables, contrasting the results from the pilot villages.[4] One possible reason for this is that the number of observations are about 20 percent of those in the pilot villages, and standard errors of estimates will be higher, all else equal.

The only household variable that was linked to the frequent use of improved fallows was one of the wealth variables (farmer perception of relative wealth), in which case the more wealthy households were more likely to be frequent users as opposed to non-using households. The same variable was positively related to infrequent use and the enumerator evaluation of household wealth was also positively related to infrequent use.

[4] There were many significant results among the location dummies.

So, although not all the wealth variables are producing similar results, there are indications that wealth is important in the use of improved fallows. The only other significant result in the fallow regression was that Luhya households were much more likely to be infrequent users than were the Luo.

A similar pattern emerges for biomass transfer. Only the wealth variables are related to the use of biomass transfer. In particular, the asset and farmer measures are positively related to frequent use of biomass transfer. The farmer measure is also related to infrequent use and the enumerator evaluation of wealth is weakly positively related to infrequent use. No other household variables were statistically significant in the regressions. When the wealth variables are omitted altogether, the only change in statistical significance is with the labor variable in the biomass transfer regression, which now becomes significantly positively related to frequent use.

There is a positive link between wealth and the uptake of the technologies in contrast to the findings in the pilot villages. This may reflect the extra attention given to reaching the disadvantaged groups within the pilot villages. It could also be partly attributable to different measures of wealth, due to the fact that the surveys were not identical within and outside the pilot villages. Also, while farm size and labor constraints were apparent in reducing the uptake of improved fallows and biomass transfer in the pilot villages, such constraints did not emerge in the nonpilot areas. There is a marginally positive effect of labor on biomass transfer in the nonpilot areas, but the impact of farm size is almost nil. This issue requires further investigation.

5. Impact on Livelihoods

Evidence of Impact from Qualitative Case Study Syntheses

It is generally observed that from the farmers' point of view, the various SFR technologies adopted have increased farm yields, raised household incomes, and improved food security and the ability to mitigate vulnerable situations. There is a general preference across technologies and much of this is influenced by what the

farmers see as incentives or disincentives. The biggest incentive is the incomes deriving from the sale of seed, increase in yields, reduction in the "hunger period," the medicinal value derived from some of the shrubs, and general improved welfare due to raised farm incomes. The various case study accounts, however, also suggest that actual impact depends on the circumstances under which these SFR technologies are adopted.

Generally, the SFR technologies adopted have given some members of the community an amount of social capital, especially in terms of their being seen as successful farmers and people who attract visitors from "far away." Indeed, some of these visits have been so eventful that several families have named their children after these personalities. On the other hand, the decision to adopt or not to adopt SFR technologies as a livelihood strategy has created jealousy and discord, some at the level of the family unit. In one case, both husband and wife now pursue different farming practices just because they would like to be different and even be seen to be pursuing different styles. In this case, it was the man that came into contact with the new SFR technologies, and because he had been a "drunkard" and held in low esteem within his community, the wife was not convinced that his farm practices would be anything to emulate. In at least one instance, then, the introduction of these SFR technologies has resulted in status inversion.

On the other hand, the full potential of some of the SFR technologies is realized on only a few farms. The qualitative studies show that where some of the larger impacts have occurred, the successful households had above average human capital resources or more diverse livelihood strategies on which to build. Some farmers were not yet able to benefit from SFR to a significant extent because they were too old or too poor to undertake the complimentary investments (e.g., buying of improved maize seed) to realize good yields. So these agroforestry technologies appear to have mixed implications for reducing poverty. On the one hand, the fact that the poor households are using them is a positive sign. However, once adopted, the success of these SFR technologies in generating significant welfare impacts depends on the household's ability to manage the complexities and opportunities stemming from the introduction of SFR. To summarize, the impacts of SFR are noticeable in terms of yield increases, but for most households,

these have not been large enough to translate into significant welfare impacts. Even in cases where yield impacts were large, the additional income was used by a couple of men to take a second wife or to enter into the commodity market, and this has taken away the control that women had over subsistence production.[5]

Nevertheless, there are those households that have succeeded anyway. The question is why? Generally, adoption is intertwined with ongoing social processes, and the success of SFR technologies then depends on the entire social framework within which it takes place. As such, who benefits and why can only be understood within the context in which these technologies are disseminated and implemented. Some of the key points of differentiation include people's resource base, the type of livelihood strategies that they choose to pursue, the nature of vulnerabilities facing them, the likelihood that these risks can be easily mitigated, and the gender and power relations governing their social system.

The various case studies suggest that social networks are crucial to one's ability to derive benefits from SFR technologies. For instance, some of the farmers only got to know about SFR from friends and neighbors who were already enjoying the benefits (see Section 6). Besides being able to transfer the knowledge and skill required, such association was testimony to the potential benefits and a driving force behind the decision to take up SFR technologies. This means that in cases where people may be unable to have direct contact with formal disseminators, there is still the possibility of acquiring information from other farmers.

Households that have diversified their sources of income cope better with some of the demands of implementing SFR technologies. Those households with little land or the inability to cope with unpredictable labor demands (e.g., through substituting household

[5] This is consistent with other research showing how technology impacts are "gendered." For example, Carney (1992, 1993), in a study of technology change among Gambian subsistence farmers, shows how policies promoting a shift to irrigated rice and vegetables in wetlands initially increased women's production and household earnings. However, they also caused men to enter these activities, leading to arguments over work and income distribution. Eventually, many women lost control of the income they previously had.

labor with hired labor) found it difficult to participate in SFR. The various SFR technologies have managed to improve availability of cash incomes. However, as would be expected, the direction taken when it comes to sharing these resources depends on what else is going on in each household.

Whether these technologies have been successful in targeting the poor depends on who is classified as poor in the study area and whether they are actually capable of implementing these practices profitably. Generally, both biomass transfer and cultivation of improved fallow do best among smallholder farmers, most of who engage in subsistence production and could therefore be classified as poor. But this category of rural dwellers is vulnerable to many things beyond their control, e.g., rainfall patterns and poor infrastructure that inhibit the strengthening and use of people's resources (development of skills through education, and marketing of crops). And, even in the event that they do have a surplus for sale, they are faced with obstacles that include lack of markets and market information, poor and noncompetitive prices, and a relatively small amount of negotiating power at the economic and political levels. This emphasizes the existence of multiple constraints that smallholder farmers face and underlines that the impacts from any single intervention area, e.g., technology, cannot be significant unless accompanied by other interventions to overcome other constraints.

Furthermore, the possibility that the SFR technologies will succeed in involving the most destitute households becomes remote with a reduction in the farmers' resource base. Therefore, whereas the physical location of the project could be appropriate, the requirements of the technologies may not always accommodate farmers that are absolutely poor. This is because most of the inputs required, including labor, are not necessarily available even among the poor. Moreover, even in situations where the poor manage to meet the basic requirements, this is neither sustainable nor adequate to make the expected difference.

Evidence of Impact from Quantitative Assessments

Effect of SFR on Maize Productivity

In the nonpilot villages, farmers were asked to provide estimates of the effects of several soil fertility replenishment practices on maize yields in comparison to a control case of maize production with no soil nutrient inputs. We report on the results using those households who used a given improved SFR practice. Fertilizer, improved fallows, and biomass transfer all led to positive yield changes in most cases—in 93 percent of cases for fertilizer and 88 percent of cases for biomass transfer and improved fallows. In terms of a percentage increase, the median increase in yields from improved fallows and biomass transfer were 167 percent, while the means were slightly lower (due to some negative impacts) at 128 percent and 114 percent, respectively. These were actually slightly above the increases reported for fertilizer use. However, it is difficult to compare across techniques because the amounts of nutrients applied are only well established in the case of fertilizer application.[6] The median estimated area for which these practices are applied were one acre for fertilizer and .25 acres for each agroforestry system. Because of obvious rounding of area estimates by farmers, we cannot calculate reliable absolute differences in crop production coming from the use of SFR. Furthermore, we are thus unable to calculate reliable estimates of the financial returns to the use of these systems from the survey data.[7]

Previous work from over 50 farmer-managed trials showed that improved fallow systems with maize were profitable. The seasonal per acre net gain to *tephrosia* fallows was $22.33 and for *crotalaria* was $19.96 (compared to the returns from continuous maize with no nutrient inputs). The same set of trials also assessed the returns to labor from fallowing systems, which were found to be around $2.17—33 percent higher than that from the no-input continuous maize production system. Returns to biomass transfer

[6] Fertilizer applications are on the low side, while fallows and biomass transfer systems are likely to be associated with high concentrations of at least some nutrients.

[7] As part of a separate study on Poverty Traps, more detailed plot-level information on investments and yields will be forthcoming for the 2002 long rain season.

on maize in trials fared poorly due to high labor costs against relatively low value return from maize, but amounts of biomass in the treatments were substantially above amounts that are commonly applied by farmers.

These returns, while not large, are important to very poor households. To find more profitable opportunities, farmers have directed soil nutrient inputs to higher value crops, rather than maize. Farmer-managed biomass transfer trials with kales and tomatoes have shown that similar increases in yields are obtained on these crops and because they fetch much higher prices, gross revenue is as much as 10 times that of maize on a per hectare basis and returns to land and labor can be five times or more than those from maize. In fact, we found that households shift the destination of biomass from maize to vegetable plots. In the nonpilot villages, vegetables constituted only 7 percent of biomass transfer plots in 1998, but by 2001, this figure had risen to 21 percent.

While the above analysis was based on nonpilot village farmer comparisons of "with SFR" and "without SFR" situations on a cross-sectional basis, they were also asked to describe how their maize production levels have changed between 1997 and 2001. These changes were compared against the use of SFR practices and wealth level of households. These measures of change are intended to reflect an overall farm-level pattern and are important to gauge, given the general pessimistic attitude of many farmers in western Kenya. In terms of perceived changes in maize yield, 36.8 percent were thought to have been unchanged, 28.5 percent were lower, and 34.7 percent improved. Cross-tabulations were run contrasting the use of different SFR practices and perceived maize change over the 1997–2001 period. Fertilizer is most strongly associated with perceived positive maize productivity change. Households who are frequent users of fertilizer rarely report declining maize yields (8.5 percent) whereas 35.2 percent of households who do not use fertilizer report decreasing yields. There are similar positive patterns with biomass transfer, improved fallows, and animal manure, but they are not statistically significant.

Effect of SFR on Assets

If the yield impacts from SFR investments are going to lead to sustainable increases in livelihoods, then one would expect to observe some degree of asset accumulation. The qualitative research found that this was indeed occurring for some households, but not all. Patterns were difficult to detect with a small sample, but it was evident that because of rampant poverty, households were hard placed to convert any gains from increased yields into tangible assets. The few that were able to increase assets reported gains in livestock and housing. Several quantitative analyses were undertaken to confirm whether these mixed results hold across larger populations.

Before discussing the links between SFR and assets, it is important to understand the context of assets and their change during the study period. Looking at the actual values, livestock composes 70–80 percent of the value of all liquid assets. The mean total liquid wealth held by households was $408 in the current year in the nonpilot villages and $236 in the pilot villages, while that of livestock was $302 and $178, respectively. A large number of households suffered through disinvestment in both livestock assets and total assets over the period. This is remarkably consistent in both sites with percentages incurring disinvestment ranging tightly between 47 percent and 54 percent. In general, households with higher initial wealth fared poorly compared to the less wealthy. Some of the more wealthy households saw their livestock holdings collapse, through the selling for obligations (e.g., funerals) and disease (especially for poultry).

Two-stage methods are used to first predict the use of SFR and the second stage to measure the effect of the predicted SFR variables on assets (similarly, the two-stage method is used for consumption and expenditure). Neither agroforestry use variable is significantly related to the change in assets. In fact, the only significant variable is farm size, where it is found that asset-holding positions changed in more positive directions where farm sizes were smaller. This suggests that nonland assets are not highly correlated with land assets, a reflection of market imperfections in land relative to other assets. The

general lack of significance among other variables indicates the existence of complex relationships that are not easily captured by more structural household variables.

Effect of SFR on Expenditure

In this section we examine the effect of the use of the SFR technologies on household expenditures. We begin with a brief description of expenditures and then follow up with econometric analysis. Expenditures were collected for the pilot village subsample of 103 households both in 1999–2000 and in 2002. The April 2000 survey matches exactly the time period of the 2002 resurvey and thus we report on and examine only the expenditures reported at these two visits. Expenditures were collected on a three-month recall, and therefore we exclude all food expenditures from this analysis (they are too difficult to estimate over three months, and food consumption is handled separately below).

We analyzed changes in nonfood expenditures per household and per capita. For the latter, we divided by the number of household members. Mean nonfood expenditures in 2000 were $97, while the median was $60, indicating that there are relatively wealthy households bringing up the mean. The mean level of nonfood expenditures rose slightly to $104 over the period, and the median behaved similarly over time. Per capita nonfood expenditures, on the other hand, were flat over time, with a mean and median of $16 and $10 respectively. Despite this sign of stability, there is also a large number of households (44–48 percent) experiencing a setback in welfare as measured by nonfood expenditures.

Turning to the econometric analysis, the two agroforestry variables have the opposite side. The coefficient estimates for the fallow variables are significant at around the 5 percent level (although in the tobit model, the significance level is somewhat reduced after bootstrapping). Why this is the case is not apparent, because households with improved fallows report real yield gains. Users of fallows may be driven by few other alternatives and thus the use of fallow may be capturing effects of omitted variables on changes in other livelihood strategies. Yet, why it occurs for expenditures and not for any other indicator is unclear. None of the other included variables were significant. In

another model, the base period measure of expenditure was negative and highly significant, showing that those who had declining expenditures over the period were mainly from the group of relatively big spenders in 2000.

Effect of SFR on Consumption

Food consumption and nutritional measures were based upon 24-hour-recall surveys of households (three visits in 2000 and two visits in 2002) during a relatively hungry period before the long rain harvest. Household-level indicators of intake and nutrition were calculated based on age requirements of consuming members. Nutritional indicators were taken from Food and Agriculture Organization of the United Nations (FAO) and U.S. Department of Agriculture (USDA) sources, depending on which was able to more accurately reflect the specific type of food consumed (e.g., cooked kales).

The average household scores well in terms of energy, carbohydrates, iron, riboflavin, and niacin in both years. Much of this comes from maize, as an analysis of baseline data revealed that maize accounts for 75 percent of total energy. There is some diminished sufficiency in folic acid in 2002 and there are low levels of protein sufficiency reported in 2002. But even for those indicators that appear favorable in the aggregate, often there is a large number of households unable to meet the recommended needs. For instance, in 2002, 42 percent of households had consumed less than the required intake of energy, 53 percent were deficient in folic acid, and 73 percent were deficient in protein. There was also a general decline in nutritional status over the two-year period—in fact, none of the variables exhibits improvement over time.

Econometric analyses focused on those that exhibited significant change over time: energy, protein, iron, and folic acid. Neither of the agroforestry adoption variables were found to be significantly related to changes in food intake and nutritional status. In fact, the only significant variable in each regression was gender of the household head, where female heads are associated with positive change (or less negative change) in each of the three indicators. In another model, the beginning of period measure of the dependent variable was found to be negative, indicating that the households whose

nutritional status fell by larger amounts were mainly those with high initial levels. Therefore, the dynamics of food intake and nutritional status are very complex processes. They are not easily pinned down to initial characteristics of households. They are likely to be related to a myriad of decisions and livelihood changes that take place during the period.

6. Dissemination of SFR Technologies: Comparing Methods, Experiences, and Impacts

While much of the study focuses on impacts of the technology itself, the dissemination processes themselves were also studied. This was important because dissemination approaches used by organizations in western Kenya are intended not only to disseminate technology, but to strengthen human and social capital such that farmers can continue the dissemination process inside the village and ultimately in other villages. In addition, dissemination methods and experiences affect these organizations' ability to reach the poor and women—in other words, the process of dissemination can have as much impact on adoption as the nature of the technology itself. It is thus important to understand the different approaches used by different organizations in western Kenya, people's perceptions of the implementation in practice, and the effectiveness in achieving the objectives identified above.

As Table 1 shows, a range of organizations are disseminating SFR technology using different approaches. All share certain characteristics but differ in other ways. They all enter villages with the assistance of local administrators, and seek to determine local problems and solutions through broad meetings or local groups. They then work with groups to facilitate the dissemination of new locally adapted technologies in a sustainable manner. These may be existing community groups (e.g., women's, youth, church, self-help groups, or groups based on clans or SFR practices), or new groups formed for this purpose. In some approaches, the long-term goal is for these groups to disseminate to other villages. Some also use umbrella structures formed of representatives from groups

across different villages, to provide support structures and link to external organizations. All approaches use a variety of teaching methods, involving field days and demonstrations, observation, use of schools, and others (see below), though they have different emphases. For example, the TRACE (Training of Resource Persons in Agriculture for Community Extension, used by CARE) and PLAR (Participatory Learning and Research Action, used by KARI-Kakamega) approaches emphasize substantial training of lead farmers who are then to disseminate knowledge to others (the PLAR approach selected farmers to include a range of farmer types). The village approach (used by ICRAF) worked both with groups and individuals, through a more formalized representative committee. The extension service's catchment approach was also implemented through a committee down to farmers, but did not interact much with existing groups. Figure 3 provides an example of the complex relations of institutions involved with SFR information exchange through the eyes of a group of poor male farmers in Bukhalalire.

Evaluation of External Disseminating Organizations

Most villages in the study had one or more governmental or nongovernmental organizations working with SFR at some point. In each of the six focus group villages, there were multiple interventions that we touch on where villagers raise them. However, an effort is made to focus on the approach and institution that were particularly influential. Comparing organizations across communities is an imperfect measure because not all organizations were equally active in each village. However, the rough uniformity in evaluations and the fact that the most active organizations usually score higher suggests a basic degree of satisfaction. Aggregating across all focus groups, the four most active organizations (ICRAF, the Ministry of Agriculture and Rural Development [MoARD], CARE, and KARI) score approximately equally in the PRA exercises that evaluate them according to their usefulness and importance. Only ICRAF scores slightly higher. The Kenya Woodfuel Agroforestry Programme (KWAP) was also

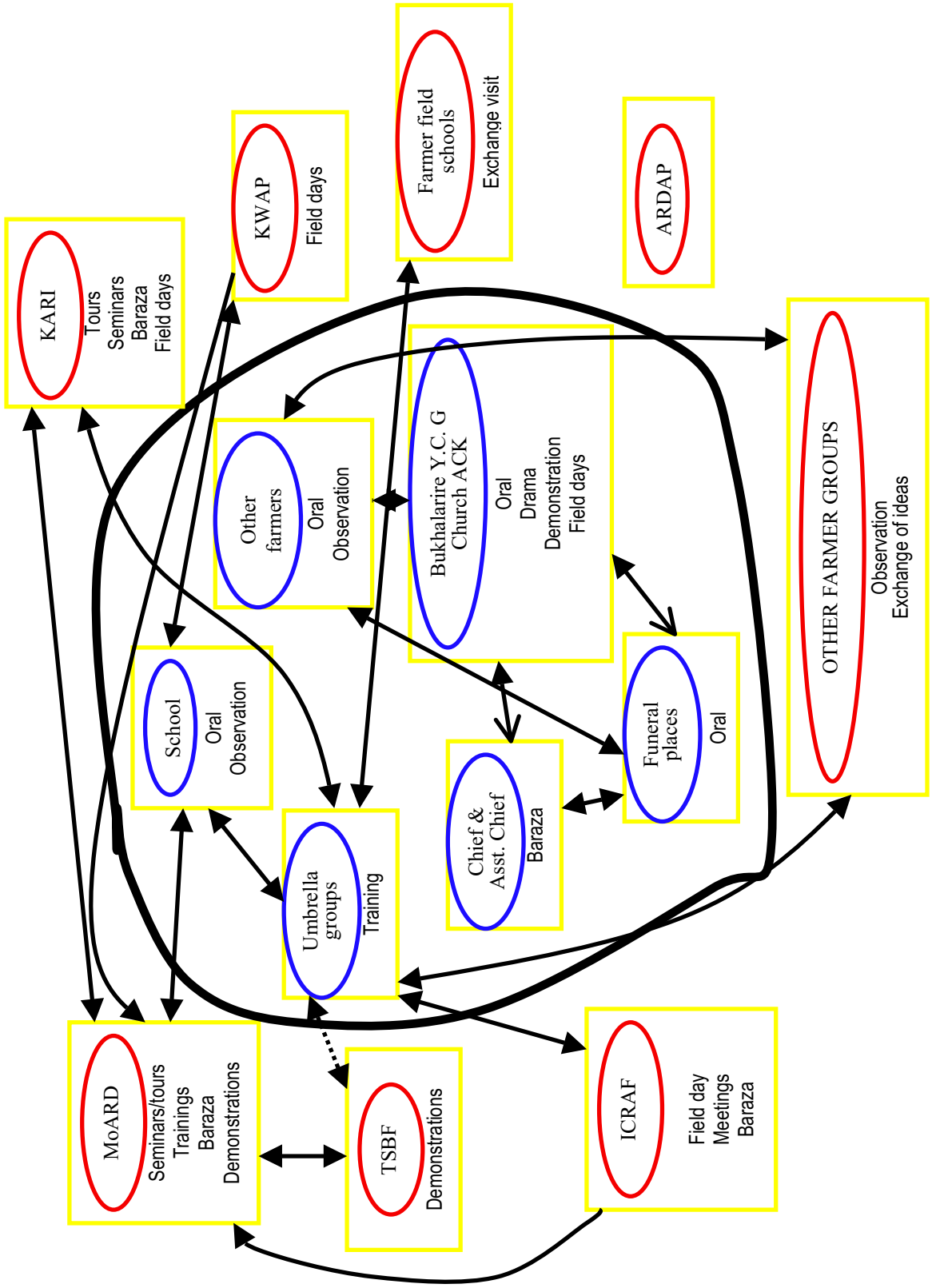


Figure 3—Village map of institutions involved with SFR information exchange (Bukhalalire poor men's focus group)

very popular in the one village where it worked. ICRAF also was favored for the links it was said to have with farmers. One of the main criticisms of external organizations is that they do not spend enough time with farmers.

There are still few differences when groups are disaggregated by gender (holds for the qualitative and quantitative analyses). In the aggregate, CARE, KWAP, and KARI score higher among nonpoor residents, while ICRAF and MoARD score higher among poor residents. It is not clear why this would be the case. However, since poor farmers seem to have had less positive experiences with groups, they might appreciate ICRAF's and MoARD's greater use of direct farmer visits. Overall, the assessment of disseminating organizations is positive. The main problems raised were insufficient staff, insufficient time given to farmers, and their leaving too soon. As noted in a focus group of nonpoor women: "what limits full implementation is that they are usually left before standing on their feet." Insufficient monitoring was also a problem.

Farmers' Assessments of Teaching Methods

Each dissemination approach uses a combination of teaching methods. These respond to criticisms of earlier dissemination approaches that were found to be overly top-down, insufficiently aware of local conditions, and favoring better-off farmers. Newer approaches used in the villages studied sought to correct this. The first group of methods involves forms of training organized by external organizations, e.g., demonstrations, field days, tours, exchange visits, and farm visits. A second set involves different types of meetings, formal or informal, that target specific individuals or are open to the public and discuss future plans, resolve issues, monitor progress, or identify needs. Finally, there is observation of others' fields and conversations.

All three forms of teaching were popular, and people prefer a mix of all of them. Although they varied greatly by village, informal means such as learning through observation are highly rated, despite the fact that they did not involve external resources or organized activities. According to the focus group of nonpoor women in one village,

"few people learn from formal ways...but many do so informally through observation on other farmers farms or orally from other farmers."[8] Poor men rank meetings very low, consistent with their comments that meetings are often dominated by elite men. Nonpoor men's preference for conversation may represent their ability to rely on their social ties for information, or education and experience may be at play, where wealthier farmers may be more easily able to digest verbal descriptions and convert them to achievable plans. But synthesizing all the results shows that very few differences in opinions on methods emerge based on gender and wealth status. An important finding to emerge is that people value the formal methods a great deal. Some specifically said that they would prefer more visits in their homes—the more traditional approach. This reinforces the key challenge for dissemination—how to balance the need for engagement with individual farmers with the need to reach a large number of them.

For the most part, the picture painted is one of information flowing mainly from disseminator to farmer, and less in the other direction. However, some degree of farmer input was solicited in all approaches, and groups from at least three of the six villages mentioned this specifically. For example, in one study village, poor women said that "in the initial stages, when contact is strong, our ideas are usually taken into consideration." In another study village, both poor men and women noted that ICRAF asked for their input in developing training manuals.

Logistical issues raised were problems with meeting times interfering with funeral and market days, dissemination staff arriving late, overly long meetings, and use of Swahili.

[8] These findings support other studies that have found social networks to be very important to the diffusion of other types of innovations in the region. For example, informal women's groups were found to have facilitated adoption of birth control where cultural values and beliefs discouraged adoption, and where other programs had failed (Behrman, Kohler, and Cotts Watkins 2002; Rodgers et al. 2001).

Local Institutions and Dissemination

In each of the dissemination approaches, the external organization introduces technologies and conducts training. However, these organizations cannot reach all farmers effectively, and a range of local institutions can be used to further the process. Furthermore, one objective of these approaches is to build capacity within the villages, including human and social capital, so that residents can continue carrying out dissemination activities with other farmers, and eventually in other villages. There are several means by which dissemination takes place using local institutions. These include *barazas* (community-wide meetings called by the local administrator); informal learning from other farmers; schools, where training is given to schoolchildren who are expected to teach their parents; and "local leaders," referring to administrators, chiefs, and others. People also learn from the "contact farmer." The contact farmer experiments using the technology and adapting it to local biophysical conditions. Finally, there are what we call "SFR groups"—village committees, catchment committees, and umbrella groups, or sometimes women's groups, church groups, etc. Because of the importance of the groups to each approach, and the implications they have for human and social capital, they are given considerable attention here.

Aggregating all villages, there is not a great deal of variation in ratings of the importance/usefulness of these internal providers. *Barazas* rank consistently highest, possibly because no one is excluded from them. However, although it is very good for imparting information, it does not facilitate exchange of information among participants, nor is it regular enough to provide follow-up support for a new innovation. There are also few significant differences in the ranking of the local institutions based on ethnic groups, wealth status, or gender, suggesting that these have worked fairly and that there are no inherent cultural biases. Although it was hypothesized that Luhya farmers might be less comfortable in groups, this did not emerge from the data. Women's, church, and SFR groups got roughly equal evaluations from poor and nonpoor women, implying group-based approaches are working well for poor women.

Social Capital, Social Relationships, and the Experience of SFR Groups

As discussed above, each dissemination approach relies on local groups for disseminating the technology across a wide group of farmers, and for ensuring sustainability. These groups were scored as a relatively important source of information, and in some cases were said to be working well, as noted by the poor women's focus group in one village: "committee members participated very much in organizing and mobilizing farmers." Yet they have also experienced many problems. In most cases, the groups were said to have provided benefits to their members. However, in most villages there were reports that they had performed poorly with respect to providing information to other farmers. One problem is the lack of participation in the groups, either because of self-exclusion or exclusion by group members. Low levels of participation directly in the groups would not be as large a problem if the groups were conducting dissemination activities with other farmers as envisioned. However, this has also been insufficient. Five of the six villages reported one or both of these problems, suggesting that these problems are not specific to Luo or Luhya villages. In some cases, group members serve as models for other farmers to observe, as in one study village where they were said to "envision commitment and hard work as ways to spread technology, so that other farmers can observe the technologies as practiced by the committee members." Although this is helpful, they are intended to engage in more active dissemination. Another of the study villages presents a very different picture from the other villages, however. All four focus groups described training and dissemination that the groups were carrying out, inside and outside the catchment. Women were particularly vocal about the group's activities. Although it is not possible to know whether this is the result of the umbrella group approach or a more socially cohesive community, it is probably a combination of both factors.

In general, women tended to be more positive in their evaluation of groups than men, particularly about women's groups.[9] Poor and nonpoor women alike said that domination by men in the groups reduces women's participation and learning. This reiterates the importance of having separate groups for men and women. In one study village, some women, church, and welfare groups were also agriculture groups that contributed to funerals, which can support social capital as well as addressing people's priorities in the context of widespread AIDS. Existing groups that incorporate dissemination tend to be more active and sustainable than new groups formed for this purpose.

The study began with four hypotheses concerning social capital and social relationships: (1) dissemination through local groups will enhance a community's social capital—the social networks, relationships, and organizations that facilitate access to resources provide support; (2) at the same time, these interventions might introduce new social divisions; (3) the interventions, through skills training and participation in groups, would increase the confidence of farmers, leading farmers to make more demands of the groups and groups to make demands on external institutions; (4) these same activities could reinforce existing power relationships.

All four hypotheses were found to be true to varying extents. In five of the six villages, at least some groups said that SFR interventions and extension activities had brought their community closer together. However, local groups also introduced social tensions and politics. One or more of the following issues were reported in all villages except one: uneven distribution of resources, discord over extra attention that some farmers received from external organizations, failure of extension staff to visit farmers, the ability of some to amass wealth through the process, conflicts over resources, rivalry among leadership, and mismanagement of funds. In most of the villages, it was

[9] This is also supported in the studies referred to earlier (Behrman, Kohler, and Cotts Watkins 2002; Rodgers et al. 2001) on the importance of women's informal networks.

recognized that the interventions led to competition and conflict in some ways and to cooperation and cohesion in others.

The exclusion of people from the groups is one way in which power relationships were reinforced. In five of the six villages, elites or better-off farmers were said to dominate the groups to some extent, and in some cases the intervention strengthened their position. It is very difficult to avoid domination by local elites, especially new ones formed for managing new resources. Also, the propensity to seek community leadership positions often hinges on the socioeconomic status of an individual. In some cases, poor participants saw the process as less equitable than nonpoor participants, though even the latter sometimes acknowledged uneven capturing of benefits. Sometimes poor farmers acquired some power through the process, however. In one village, poor men said that farmers made demands on the committee when it was active and the committee, in turn, made demands for extension services on MOARD. This brings us to the third and fourth hypotheses. There were some reports that the interventions increased people's confidence, and in at least two villages, there were explicit reports of people making successful demands for changes to the external disseminators. Of the nine focus groups where confidence came up, six were women's and five were in poor groups.

The contact farmers are mainly seen as the point of contact for outside organizations. Focus groups in three of the six villages indicated problems with the contact farmer method (though in one, only poor men were critical). Although most groups were positive about the method, they provide important insight into unintended social consequences that dissemination methods can have: first, the contact farmer was seen as unfairly receiving too much attention from external organizations, as illustrated by comments from poor men in two of the villages: "the wealthy and educated who are frequently visited and make others feel left out and different from the preferred farmers;" and "model farmers gained more prestige and control over other farmers as they trained them." Second, contact farmers in two of the villages were not seen to have shared information with other farmers. Although it was possible to observe his fields, others did not copy what they observed because they were not sensitized to believe that what was

being done was for their own benefit. There was also the perception that contact farmers were selected by the external institutions, although according to the organizations, they are to be selected by the villagers. Nevertheless, contact farmers are important for testing technologies and practices and adapting them to local conditions before they are disseminated to other farmers. There may thus be a period in which there is considerable contact between the contact farmer and the external organization, before many other farmers are brought into the process. However, it is also important to recognize that technological interventions involve social processes: social context affects adoption outcomes, and interventions affect social relationships. It may be necessary to bring the community more widely into the process at an earlier stage, to make sure people understand the role of the contact farmer and approve of the choice.

School Programs

In each village under study there was evidence that school children had been reached in the schools with dissemination messages. Students had made efforts to train their parents, albeit weakly in some instances. In one of the study villages, women said that children made vegetable gardens, planted trees, and trained their parents. Children are said to still be practicing what they learned and have earned income through the activities. In some cases, parents "learn through observation in the school compounds." However, this means has been weakening over time. In three villages, focus groups agreed that trees from school woodlots were a source of income and building materials for the schools.

The major challenge identified with the schools approach was that in some villages, students hardly convinced their parents to adopt technologies. Additionally, it was argued that formal agriculture lessons in the schools were so theoretical that students had nothing tangible to disseminate. In the short run, the approach has shortcomings in that not all parents in the farming community have children in school so as to be reached with the approach. Moreover, in an African rural setting where children are considered

ignorant and have no established forums for discussion with their parents and other adults in the community, the flow of information from students to their parents and communities is largely hampered.

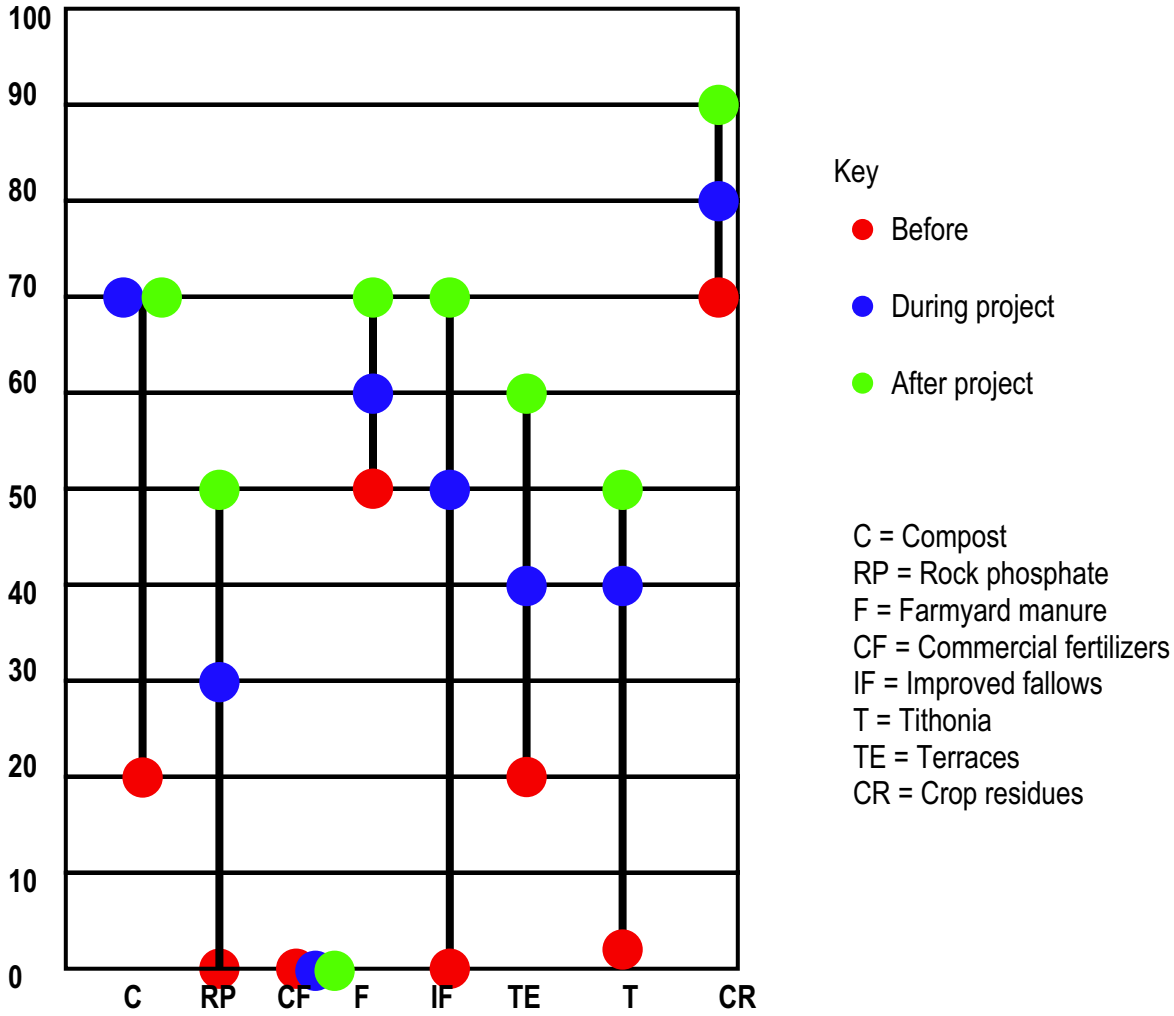
Knowledge Acquisition

Although focus group participants have varying opinions of disseminating organizations and their methods, the best measure for assessing the performance of these organizations is the amount of knowledge people gained through the dissemination efforts. A total of seven SFR technologies were mentioned as introduced across all six villages: *tithonia*, farmyard manure, compost, commercial fertilizer, rock phosphate, improved fallow, and terraces. Crop residue was mentioned in all but one village.

Focus-group participants used "ladders" to show the amount of knowledge on the technology they had before and since the intervention, with zero meaning no knowledge and 100 being full knowledge (see Figure 4 for an example from a group of poor women in Sauri). For the vast majority of groups, the starting point was zero. The most surprising finding about the amount of knowledge gained is its uniformly high levels. Although the range is from 33.3 to 76, most are clustered around the mean of 49. The two lowest scoring technologies are rock phosphate and commercial fertilizers, probably reflecting that they are more expensive to obtain.

For the two technologies of primary interest to this study, *tithonia* and improved fallows, knowledge gain was 47 and 44 percent, respectively. The highest gains were claimed in the village that also reported the highest levels of satisfaction with the dissemination process, including success with group-based methods, suggesting that there might be a correlation. Participants in this village generally claimed to have learned more than the average on most technologies. Quantitative analysis found that agroforestry knowledge acquisition was linked to direct contact with ICRAF, NGOs, or community-based organizations (CBOs), but not to direct contact with extension or other farmers.

Figure 4—Sauri poor women's group, at least four years of primary education



According to participants, those with more education generally learn more about the technologies than those with less. Nonetheless, the difference is less dramatic than one may expect, indicating that disseminators are reaching vulnerable groups. There are not particularly large differences by gender and wealth. For improved fallows, poor participants reported learning more than did nonpoor participants (the reverse was true for commercial fertilizers). There was no difference for *tithonia*. Men claimed they gained more knowledge on *tithonia* than women, at 55 percent versus 43 percent.

Sustainability

Sustainability has two main dimensions: financial and institutional. Project activity costs are an important challenge to sustainability after external initiating organizations phase out. In some of the villages, farmers demonstrated their willingness to share costs under certain conditions: A group of poor men in one village said that "farmers are ready to work...on a cost-sharing basis if only the organization is ready to stay in the village and tell farmers what will be benefited and steps to follow whenever problems arise." In another village poor women said that farmers also "provide plots and labor and take the risk associated with experimentation on the farm." Poor women in another village saw cost-sharing in a negative light: "Farmers explained that a mere mention of the word money, i.e., paying for something, is enough to send some members of social/farmer groups packing." However, the major problem with sharing costs relates to the high levels of poverty in the project areas.

In terms of institutional sustainability, local administrators came across as important, because of their influential positions and ability to convene *barazas*. However, their involvement was ad hoc, with no training, which limits their effectiveness. Some committees/groups set up or adopted for dissemination work by external organizations continued to exist after the latter left, though in some villages groups had collapsed. Poor management, especially of finances, had also kept some groups/committees weak and ineffective in dissemination, and led to collapse in some cases. It is worth noting, however, that financial mismanagement is not a pervasive problem. Still future projects should focus some more on leadership and management training, to provide safe grounding for project activities and approaches after external organizations phase out. Also, farmers emphasized the need for external organizations to monitor what happens in the village after they leave. This would help to identify problems and seek resolutions where possible.

7. Reflections on Research Methods

Use of the sustainable livelihoods framework. The sustainable livelihoods (SL) framework was used to identify the key research questions, and provided a cross-disciplinary language that facilitated an integrated research design. On the other hand, the research team was conversant in a number of paradigms and methods that included similar concepts, and it is not clear that the SL framework was necessary to achieve similar results. Still, the framework ensured that many key issues and relationships were not overlooked. The team introduced other concepts not included or explicit in the framework as needed. Because the SL framework is not specific with regard to major direct relationships among variables, all variables are related to one another and this resulted in the formulation of similar, overlapping, or duplicated research questions. In the implementation of the research, the SL framework was implicit but not explicitly discussed. This is less a criticism or complement to the framework than a reflection of the fact that the research team had agreed on the importance of a comprehensive and diversified research approach.

Integration of qualitative and quantitative methods. As much as possible, qualitative checklists and survey questionnaires were formulated to provide insights into common issues/questions. The integration was useful for understanding different types of information—quantitative results led to identification of general patterns of adoption and impacts, and qualitative results helped to explain processes behind adoption choices, information flows, and impacts. Quantitative results give a much stronger sense of representivity, given the large numbers, but qualitative data were essential for uncovering issues related to culture, normative frameworks, and social dynamics. The integration succeeded in issues such as meaning of poverty, adoption, and dissemination issues. It worked less well with impact analysis, mainly because the quantitative research had a baseline as a guide, but was limited to a small set of indicators, while the qualitative research did not benefit from a baseline, but was broader in its scope. While there is a great deal of complementary and supporting information, true integration requires the

researchers to sit together and compare/contrast results. Limitations on time and funding, and the timing of the last survey resulted in the team not being able to spend sufficient time to jointly analyze the research results. The paper is therefore too compartmentalized into results from different methods.

Another issue was the usefulness of generating numbers from PRA exercises. These were quite useful in understanding relative assessments of different institutions, methods, and knowledge acquisition within villages. However, they were less useful, and difficult to compare and analyze across villages, because of the different meanings attached to numbers, and the fact that different categories were identified across villages. This could have been controlled by standardizing categories, but would then undermine the participatory nature of the exercise, stifling generation of local categories. Still, there was enough comparability across categories to allow for some meaningful comparison, if in places in broad strokes.

Dialogue across different institutions and stakeholders. A key aspect of the research process was the stakeholder meetings that helped to plan and review the research. Having issues raised by residents of the region added a degree of objectivity and relevance to the research design that may not have been as defensible had the design been driven by ICRAF and its partners alone. It also increased the practical relevance of the results, and ensured an audience for the results. Some of the same stakeholders acted as sources of information for the project as well and therefore provided for some triangulation of results.

Arm's length data collection. The qualitative and quantitative fieldwork was undertaken almost exclusively by persons not attached to the project, as the intention was that field researchers be viewed by villagers as completely detached from ICRAF. It is not clear that this worked entirely, since ICRAF is well known in the area and much of the enquiries were related to agroforestry. The participation of sociologists from external institutions ensured independent critical analysis and provided ICRAF with potential collaborators for the future. The disadvantage is that capacity for doing such research was not built within ICRAF.

Viewing poverty from multiple perspectives. Poverty is a slippery concept. Yet, the task was to see what impact SFR technologies had on the poor. Rather than devising a single qualitative or quantitative classification, the team was open to alternative views and ways of comparing poverty levels across households. This approach best fit with the reality that households are vulnerable to poverty in different ways and engaged in a range of survival strategies. Certain types of poverty indicators may move together, while others may not. For example, we found that expenditure and consumption changes over time were quite similar, but asset portfolio changes behaved somewhat differently.

Highlights of Empirical Findings

1. While there is no doubt that poverty is pervasive in western Kenya, distinguishing the poor from nonpoor is not straightforward.

Poverty is a slippery concept and people often do not accept being labeled as poor. When pressed, people will admit that poverty implies the lack of certain basic needs. The study used a variety of methods to assess poverty levels, including quantitative measures from surveys, enumerator ratings, and farmer self-assessments. These produce different outcomes so that which households will be classified as very poor will depend on the criteria used.

2. Welfare or livelihood outcomes worsened for many households.

There was a general deterioration in welfare indicators during the period of study. This holds true for assets, expenditures, and food consumption. Particularly striking was that households with relatively high welfare indicators in the initial period suffered the greatest losses. This is due partly to the large number of adverse shocks affecting households and the cultural obligations felt by all community members (e.g., the wealthier households contribute animals for slaughter at funerals).

3. SFR technology interventions imply assumptions about the role of agriculture in people's livelihoods that have varying validity. The role of agriculture in people's livelihoods is determined by economic circumstances, culture, normative frameworks, and social identities.

The assumption that poverty can be reduced through farming is not necessarily reflected in the investments in livelihood activities made by people in the region. Their decisions are embedded in their economic circumstances (including assets and institutional environment), cultural, normative frameworks, and social identities. For example, people who perceive themselves to be farmers are more likely to adopt SFR or agro-technologies than those that in essence look down at agriculture as a way of life. Decisions about agricultural investments are also shaped by "structural" phenomena such as the squeeze on agriculture that does not guarantee adequate return to human and physical capital investments. In western Kenya, farmers are very aware of this squeeze in making livelihood decisions. While researchers may evaluate agroforestry in terms of its role in generating agricultural production, rural people will be assessing its ability to contribute to the variety of objectives they pursue.

4. Households do see the importance of SFR—and there have been many human capital impacts.

Both the qualitative and quantitative research found significant knowledge acquisition taking place, not only for agroforestry methods, but for general soil management and farming practices. People valued this information and have often put it into practice.

5. The poor are adopting SFR strategies at the same rates as the nonpoor.

Adoption rates are not outstanding but they are encouraging, with about 20 percent of all farmers using the technologies on a regular basis (a similar percentage among the poor) and a sizable percentage of farmers newly testing. This suggests that

unlike some agricultural technologies historically, SFR is not biased toward people controlling and managing resources above a certain threshold.

6. Adoption at early stage is at low levels of intensity.

While an encouraging number of households are using or testing the SFR practices, the size of plots on which they are applied remain small. It is not yet known whether this is indeed a ceiling or whether this is a consequence of the early stage of dissemination.

7. Farmers like to be exposed to multiple dissemination opportunities and methods.

The dissemination analysis found that farmers appreciated some aspects of different disseminating organizations and the many different methods tried. They particularly appreciated direct contact and field observation methods. However, as information flows were not guaranteed, individuals may not be able to make scheduled meeting times, and different methods benefit some social groups more than others; they favor being able to access information through a variety of channels.

8. Social status and social relationships within villages affect outcomes of different dissemination methods. New technologies can also reinforce or transform these relationships.

Although characteristics of SFR affect whether people adopt or not, aspects of the dissemination process also affects adoption. The dissemination analysis found that the main feature of most dissemination approaches—group-based methods—can strengthen human and social capital, and farmers of different social status have benefited from them. However, this analysis also found that group-based approaches may also disadvantage farmers of lower social status and women who are less likely to participate in or dominate groups. However, women's groups have worked well for women. Furthermore, the dissemination analysis and case studies found that the use of adaptive research farmers

generated new social tensions, due to the amount of attention received by individuals from outsiders. These findings reinforce the conclusion that use of a variety of methods are best, and point to the importance of understanding local social dynamics in designing dissemination interventions.

9. Sustainability of dissemination structures and processes is possible but tenuous.

Sustainability of dissemination structures and processes has proved to be possible, but challenging, because of problems encountered by groups, limited capacity of local administration, social dynamics within villages, and limited cost-sharing ability. Monitoring would help to pick up these problems so that resolutions can be sought where possible.

10. SFR does significantly raise crop yields.

Respondents in the case studies and formal surveys consistently report very significant increases in yields (> 100 percent) from the use of SFR practices. This is consistent with farmer-managed trial data that find similar increases.

11. SFR on its own cannot bring about a turn in poverty reduction.

This conclusion is drawn from the body of impact assessment work. Despite the fact that SFR is being used by a number of poor households and having an impact on yields, its impact at the household level is modest. This is due to the small land sizes under SFR and because the weak rural economy is not conducive for investment and development. This means that technological innovations alone are likely to have a limited short-term impact. Poverty alleviation should encompass other sectors as well.

Pathways out of poverty are varied and highly uncertain. Identifying clear strategies through agriculture is equally difficult due to low prices, variable climate, and high costs of profitable investments. Small land sizes in turn limit the amount of

diversification that households are willing to undertake. It seems that in order for widespread poverty alleviation to take place, many components of the rural socioeconomy need to be functioning well. Even if progress is made, the study has clearly shown that households can easily slip back into poverty. Therefore, in addition to generating production and income, there is need for insurance through investment in risk-buffering assets.

Within agriculture, poor households can take initial steps by building on crops/enterprises that they already have. The strategy under consideration in this study was a relatively safe one of increasing yields of the basic staples of maize and beans. What is the future for agroforestry in all of this? The soil fertility systems being disseminated are useful options for farmers, and these options are being tried by many with no prior record of investment in soils. There are clear limitations to the use of improved fallows and biomass transfer, however. Small farm sizes limit the extent to which niches can be found to produce the green manures. The technologies are therefore best perceived as feasible and viable components of farm-level integrated soil fertility management strategies. Consequently, dissemination strategies should encompass a range of management practices for addressing the problem of poor soil fertility.

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