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Improved Fallows in Kenya: History, Farmer Practice, and Impacts

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ABSTRACT

This case study explores the development, dissemination, adoption, and impact of improved tree fallows in rural western Kenya. The processes of technology development and dissemination throughout the region are described and analyzed. To analyze adoption and impact, the paper applies a variety of different data collection methods as well as samples from both pilot areas where researchers maintained a significant presence and non-pilot areas where farmers learned of the technologies through other channels. Sample sizes for the quantitative analysis ranged from almost 2,000 households for measuring the adoption process to just over 100 households for measuring impact indicators. Qualitative methods included long-term case studies for 40 households and focus group discussions involving 16 different groups. The paper describes the ways in which farmers used and modified improved fallow practices. Discussion also examines the types of households using fallows and benefiting from their use.

Empirical results suggest that improved fallows almost always double on-farm maize yields. In addition, the data indicates that poor households use improved fallows at much greater rate (about 30 percent) than they do fertilizer (8 percent), though, on average, the size of fallow plots remains small, at 440m^2. As a result, despite these promising signs, the improved fallow systems were not found to be linked to improved household level food security or poverty indicators primarily, primarily because the size of the fields under the agroforestry systems was on average, quite small.

Conclusion

To conclude, improved fallows represent a technically effective and financially profitable technology that is attractive to poor households with little cash available for investment. They are being used and adopted by a significant proportion of households in areas of western Kenya where they had been disseminated in the late 1990s. On the other hand, farm sizes are small and the ability of farmers to set aside land, even for a season is limited. Hence, the average size improved fallow is small among adopting farmers.

Looking to the future, it is best to view improved fallows as a component of a broader integrated soil fertility management strategy for farmers. Farmers will also use manure, compost, and to some degree, fertilizer. Improved fallows have a comparative advantage in that they are relatively labor saving over manure or compost, they have a low risk of failure in supplying nutrients on the farm (because of extensive rooting systems), and they offer some by-products. Our evidence suggests that they may serve as an entry point for improved soil fertility management for farmers who had previously not invested in soil fertility management.

Nonetheless, the scaling out of improved fallows to other areas will face challenges. It is not a traditional practice and therefore must be learned. There are several stages involved in managing fallows -- choice of species, fallow establishment, and cutting and incorporation. Technical backstopping may be important for each of these stages. Yet ensuring that it is available is no easy feat with scattered NGOs and sub-optimal extension services. These dissemination problems affect the scaling out of most technologies, but particularly affect the more knowledge-intensive technologies such as improved fallows. Making germplasm available is also a challenge, though many fallow species are prolific seeders and farmers can in theory become self-sufficient quite easily. Moving germplasm into new areas is more problematic. Markets for seed may play a limited role in this because farmers need a high quantity of seed, but do not care much about quality of these "input trees" and therefore are not willing to pay much, if anything for the seed. These challenges are not minor. But neither are they insurmountable. Many other tree species and other knowledge-intensive practices, such as integrated pest management (IPM), have spread throughout pockets of smallholder Africa. It will require, however, considerably more efforts to mainstream improved fallows – and indeed the concepts of integrated soil fertility management -- into extension systems.

Keywords: agroforestry, soil fertility, Kenya, adoption, impact, technology

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1. OVERVIEW

OBJECTIVES

Many scientists consider declining soil fertility to be the fundamental root cause of agricultural stagnation in Sub-Saharan Africa (Sanchez et al. 1997). With the highest fertility rate in the world, Sub-Saharan Africa clearly faces increasing demographic pressure on its natural resource base, the physical capital on which the continent's agriculture depends. Consequently, farmers across the continent and agencies working on their behalf have experimented with a broad range of both soil and water conservation technologies (Reij, Scoones and Toulmin 1996). Given the high cost of petroleum-based fertilizers imported into Africa, many agencies and farm groups have focused on solutions using local resources and low external inputs (Pretty and Hine 2001). Among these technologies, a recent survey of African agriculturalists has pointed to recent work on improved fallow systems as a budding success story in African agriculture (Gabre-Madhin and Haggblade 2001).

This paper explores ongoing work on improved fallows in Western Kenya. It describes the process by which the technology is being developed, tested and scaled up. A companion paper in this series focuses on related improved fallow technologies developed in the very different ecological environment of Eastern Zambia, where a single rainy season and surplus land lead to different technical solutions (Franzel et al. 2003). Using the same diagnostic procedures and inventories of leguminous species, the roughly 40 partner institutions in Kenya have developed different improved fallow systems appropriate to the high population density, heavy land pressure, and dual rainy season of Western Kenya. This paper examines the process by which the Kenyan collaborators developed their situation-specific improved fallow technologies. It likewise reports early findings on the impact they have had on farm incomes and welfare.

SCOPE OF THE CASE STUDY

The research in western Kenya is focused largely on medium to high potential highland areas. Rainfall is good, ranging from 1200 -1800mm/year with two cropping seasons annually: the long rains from March to July, and the short rains from August to November. The short rainy season is traditionally less reliable in terms of total rainfall and length of growing season, but the rains have been good during the post 1998 period. The altitude is between 1250 and 1600 m above sea level with rather moderate slopes. The topography is undulating with moderate slopes. Soils are of generally good physical structure but are low in nutrient stocks. In many parts of the region, phosphorus is the major limiting nutrient, but nitrogen and potassium limitations are also prevalent (Shepherd et al. 1996; Jama et al. 1998a). Moreover, heavy infestation with *Striga hermontica*, a parasitic weed that devastates the maize crops, is common (Oswald et al. 1996).

High population densities prevail, ranging from 500 - 1,200/km^2 in Kakamega, Siaya, and Vihiga Districts. The Luhya inhabit Kakamega and Vihiga Districts while the Luo reside in Siaya. The farming system incorporates crops, livestock, and trees. Maize (local varieties) and beans are the most common agricultural enterprise. The food situation was reported as deficient by 89.5 percent of the households in Siaya and Vihiga, who had to buy food to supplement their own harvest (Wangila et al. 1999). Only 8.9 percent of the households were food secure from their own production. Average household income for western highland households was only $1,014 and crop income a paltry $321 according to a recent study (Argwings-Kodhek et al. 1999). Average agricultural labor productivity (per year) was about $76 in western Kenya, only one-fourth the level achieved by farmers in central Kenya.

In fact, many of the communities under study are among the poorest in all of Kenya and clearly the poorest among the medium to high potential areas. For example, a recent national study of poverty found Western Province (including Kakamega and Vihiga among its 4 districts) to be one of the poorest in the country (Government of Kenya, 2000). It was estimated that 31.5 percent of households in western Kenya are among the hardcore poor, as opposed to 19.6 percent for all rural areas. Western Province and Nyanza Province (including Siaya District) also had high incidences of sickness which were twice as high as those reported in Central Kenya, an area with similar farm sizes (median of about 1 hectare).

HISTORICAL BACKGROUND

Following diagnostic studies revealing perceived poor soil fertility as being a major constraint, ICRAF tried out the improved fallow technology in Western Kenya in 1991, both under experimental circumstances and under farm circumstances. At that moment the only species used was *Sesbania sesban*, an indigenous species that had proven its potential in Southern Africa (Kwesiga and Coe 1994) and was a prolific biomass producer under West Kenyan conditions (Onim et al. 1990). The agronomic performance and economic profitability of Sesbania fallows were studied in detail (Hartemink et al. 1996; Swinkels et al. 1997; Jama et al. 1998b). At that time, testing of alley farming was also taking place and a major review of that research raised questions as to its performance and viability in western Kenya. Thus, there was a period of stagnation (1994-95) where there was little dissemination of soil fertility technologies to farmers.

In 1996, new fallow species had been introduced with promising results and the directors of ICRAF, KARI, and KEFRI decided to intensify efforts in research and dissemination of improved fallows (and biomass transfer systems too). This was also catalyzed by recent success in Zambia where yields and profits were found to increase substantially from improved fallows, compared to the low-input farmer practice.[1] Screening trials resulted in the selection of new species that in most cases were shrubs and had a shorter life cycle than *Sesbania sesban*. Most promising and widely used species are *Crotalaria grahamiana* and *Tephrosia vogelii* (Niang et al. 1999). Other aspects and management options that were tested under research conditions are planting densities (Niang et al. 1999), the addition of inorganic phosphorus fertilizer (Jama et al. 1997; Jama et al. 1998b), the effect on weeds (Niang et al. 1996), effect on nematodes (Desaeger and Rao 1999) and minimum-tillage planting. Extensive on-farm experiments have been conducted to assess the potential of fallows using these species, often in combination with phosphorus fertilization during the years 1996 to 2001. Agronomic and economic performance was studied within these trials.

Initial efforts at disseminating information on the fallows were focused in a pilot project area involving 17 villages distributed mainly in the districts of Vihiga and Siaya at the beginning of 1997. Village committees were established to help facilitate information flows between the community and research staff. In addition, field technicians were made available to many of the villages for a period of about two years. Wide-scale dissemination of improved fallows across

[1] Many farmers had been using fertilizer in Zambia, but the government subsidization of fertilizer price and credit halted after structural adjustment policies were adopted.

western Kenya started at the end of 1998, initiated by the research institutions that organized the procurement of seed and trained extension and development organizations.

The research partners trained extension and development organization staff on the establishment and management of improved fallows and provided them germplasm of species new to the area. Many field days were conducted first at researcher managed sites and then later at farmers' own fields. Finally, extension materials were developed for use by development agents.

BACKGROUND SOCIO-ECONOMIC STUDIES

ICRAF undertook several studies in the main pilot project area (and beyond, in some cases) at the outset of the project. This includes a characterization census of all households in the main 17 pilot villages, a participatory wealth ranking exercise in selected pilot villages, and a survey of traditional fallowing practices in several locations in W. Kenya. The results of these are summarized here. In addition, subsequent studies were undertaken to assess the performance of improved fallows, farmers' assessments, dissemination pathways, adoption behavior, and impact. These results are discussed in the relevant sections below.

A wealth ranking exercise was conducted in five villages to determine indicators of differences in endowments and assess how these differences can create opportunities and constraints for adoption of agroforestry technologies among farmers of different economic status within each village. Farmers identified indicators which make differences in their lives and which can be used for impact assessment. These criteria included the ability to use fertilizer, hire labor, and to acquire cattle. These criteria were then included in a census instrument given to all pilot area households. The purpose of this was to be able to include wealth status as a sampling stratification variable for trials and monitoring surveys.

Some of the results of the characterization survey are presented in order to describe the rural economy of Siaya and Vihiga Districts (Wangila et al. 1999). Male headed monogamous households were the dominant household type (63.6 percent), female headed widowed (17.8 percent), female headed with husband absent (7.7 percent), male headed polygamous (6.8 percent), single male headed households (3.7 percent), and male headed widowed (0.3 percent). The distribution of education of the decision-makers were 39.5 percent with upper primary school, 23.9 percent with lower primary education, 19.5 percent with no education and 17.0 percent with secondary education. High literacy levels mean that understanding of extension messages should not be a problem, though formal education levels were lower for female adults than for male adults. The average household size was 5.81 persons per household.

The average farm sizes are 1.75 acres for owned land and 0.11 for leased land, and per capita land holdings were 0.42 acres of owned land and 0.43 acres for both owned and leased. Landholdings were generally small with 95 percent of the population holding less than 5 acres and only 0.6 percent of households having 10-31 acres of land.

Farm management -- especially land preparation, input use, hiring in and out labor and use of hybrid seeds -- varies from farm to farm. Most of the households (88 percent) prepare their land by hand, 11.5 percent use an ox-plow. Only 24.8 percent of the farmers used chemical fertilizer compared to 68.9 percent who applied animal manure, and 38.3 percent compost. Most farmers (78.6 percent) used local varieties of maize seed, 16.3 percent used a mixture of local and hybrid seeds, and only 5.0 percent planted pure hybrid maize. A pattern emerging from this description is that chemical fertilizer and hybrid maize seed, which are sourced from markets and depend on farmers' purchasing power, are used sparingly. This is despite significant efforts to extend these modern practices and despite relatively favorable levels of market opportunities in the region.

Maize was the most predominant crop in the villages with only 10 households not growing any. Other common crops include local beans, bananas, cassava, sweet potatoes, and kale/cabbages. The other food crops – sorghum, tomatoes, and groundnuts were found on less than half of the farms. Sugarcane was grown by 31.2 percent of the households. Other crops not listed on the questionnaire but known to be grown by farmers include yams, tobacco, millet, onions, cow peas, groundnuts, finger millet, coffee, sisal, sesame, and soybeans. Some of these crops are grown for home consumption and others for the market. All production is rainfed– there is no irrigation used among the households.

Livestock production in western Kenya is mainly based on a semi-intensive dairy-meat-draft-manure system. Western Province has 10 percent of the national indigenous herd and 3 percent of the dairy herd while Nyanza Province has 21 percent and 5 percent, respectively. Because of land scarcity, confined grazing on farms or roadsides is dominant. Crops are fed to cattle and manure used to fertilize crops. Livestock production in the area is based on local cattle, sheep and goats (sheep & goats), pigs, and poultry. Almost three-quarters of households had poultry and just over half had local cattle. On the other hand, only 4.3 percent of households had an improved cow.

In addition to crops and livestock, trees are an important feature of the agricultural landscape. In the Vihiga / Siaya sample, 80 percent of households reported to have woodlots, mainly comprised of Eucalyptus. The trees are used for firewood and poles both on-farm and for sale. About 70 percent of the households derived some income from off-farm activities. For the poor households, the main off-farm source is through agricultural labor provided to other farms. Households with members who sometimes worked on surrounding farms represented 24.4 percent of all households.

Farmers organize themselves in a large variety of ways. Village groups can vary from a few members to an entire village and groups are formed around a large variety of issues or themes. Organization diagrams were developed by the project in each village or group of villages to identify the major organizations e.g. self-help groups, women and youth groups, and church groups. Farmers social ties, complemented with wealth and soil fertility classes, can be used to determine which type of social organization the poor or disadvantaged may belong to. This information was used to develop a dissemination strategy that targeted such disadvantaged people. Poor farmers belong to church groups and of course clan-based groups, but few others in comparison to other wealthier farmers. It was found that the number of farmers not affiliated to any group in five Luhya villages is higher (14 percent) than in three Luo villages. In one particular Luo village (Luero), all the farmers were affiliated to at least one group. In Luo villages, each farmer belonged on average to four groups, whereas in Luhya villages, each farmer is a member of only two groups.

2. PROCESS

HOW DID THE IMPROVED FALLOW PRACTICE ARISE

Soil fertility was long recognized as a problem in the area, as noted in section 1. Moreover, it was clearly recognized (and later confirmed by formal surveys) that most farmers were not able to make cash investments in soil fertility management. Following up on this, testing began on alley farming and improved fallow systems in W. Kenya.

This process is described in more detail above, but a key element in the process was a survey to study the practice of traditional fallows in various agro-ecological zones of Western Kenya (the following draws largely from De Wolf and Rommelse 2000). This was done mainly to see if there was already an existing practice of fallowing in which a niche for improved fallows could be found. The occurrence, duration, reasons and uses were inventoried.

The study zone was stratified according to rainfall, altitude, soils, population density, and estimated land occupation by fallow. Five homogeneous but contrasting areas were identified following this stratification. Within each area 36 farmers (total of 180) were randomly selected and interviewed.

It was found that fallowing is a common and important practice in the area.

Depending on the location, between 22 and 61 percent of the farmers practice traditional fallow. On these farms, the fallows occupy between 23 and 47 percent of the total farm size. About two thirds of these fallows are kept for 2 to 4 seasons. This was confirmed with the characterization census (n = 1,636) that found 35.2 percent of households reporting some fallow land. In this case, about 60 percent of fallows lasted for at least 2 seasons. These results surprised many who assumed that fallowing would be negligible in an area with such high population density. The ages of traditional fallows are as shown in Table 1 below.

Table 1--Traditional fallows by age, characterization census from 17 villages in Siaya and Vihiga Districts

Age of fallow	Frequency	Percent
1 season	251	41.6
2 seasons	165	27.3
3 seasons	16	2.6
4 seasons	64	10.6
> 2 years	108	17.9
Total	604	100.0

Source: Wangila et al., 1999.

Although some farmers fallow because of lack of labor or seed for planting crops, it was felt that a niche did indeed exist for improved fallows. The research partnership of ICRAF, KARI, and KEFRI began some experiments initially based on technology design from Zambia. This system was a Sesbania sesban multi-season fallowing system. This prototype was not promising from a socio-economic view as the opportunity costs of foregone maize were too high and the yield effects of the fallows by themselves were not always high due to widespread phosphorus deficiency. Early cost-benefit analysis showed that improved fallows could however be profitable if the fallow period could be trimmed to a single short rain season (Swinkels et al. 1997). Researchers began testing other systems and interactions with farmers led to a focus on establishing a short fallow system within an existing crop relying on species that could be directly seeded. The short rain, between October and December, is an ideal fallow niche because of its increased riskiness for maize production.

HOW DID IMPROVED FALLOWS SPREAD

As noted earlier, within the pilot project area, information was actively spread through the use of village committees. These turned out to have mixed effects. They certainly did help to organize people and disseminate information fairly cheaply. But in some cases, individuals used the committees to gain local power, posing as 'agents' for ICRAF, and this turned some households against participating (Omosa 2002). In addition, the fact that some of these contact farmers had been watchmen at the demonstration site somehow contradicted people's perceptions that a good technology should be brought in by knowledgeable and unique persons. Since the fallows were a highly visible and new feature of the landscape there was also considerable more informal dissemination of information, for example when relatives came to visit or large groups gathered for a funeral. As noted earlier, there was considerable technical backstopping support in many of pilot villages and this no doubt increased the rates of testing in early years. The technical backstopping was reduced significantly from 1999 when there was a more concerted effort to reach other locations in western Kenya.

Within the pilot villages several incentives were operating. Most farmers indeed began testing fallows because of an interest to improve their crop yields. However, in 1997-98 when there was some significant expansion in the number of farmers trying fallows in nearby villages, the research project began purchasing tree seed from farmers. That also spawned interest from another set of farmers. A final incentive that was apparent was a desire for some farmers to participate in the agroforestry program in the hope that they would gain other benefits, such as social status from the hosting of high-level visitors or access to benefits from other NGOs. These other motivations were largely negligible in the non-pilot areas because ICRAF did not have the resources to visit or backstop them.

To broaden the dissemination of the technology, the research partners developed partnerships with the Ministry of Agriculture, NGOs such as CARE-Kenya, Kenya Woodfuel Agroforestry Project-Busia, Hortiquip-Vihiga, Siaya Community Development Project-Siaya, VI-Agroforestry Project-Kitale, Africa 2000 – Vihiga, church groups and many community-based organizations. Some interaction with these partners took place in earlier phases of the technology development process, but these were intensified in 1998, beginning with a training phase. Other organizations heard of the large yield increases from improved fallows from researcher managed trials and from within the early pilot villages. The NGO partners integrated agroforestry options into their existing portfolios of options for communities and disseminated them using their existing developed approaches, including training of primary contact farmers, field days, and exchange tours.

There were also examples of organizations, communities or individual farmers taking the initiative to seek information. From 1999, almost every day, the research center at Maseno received visitors requesting information or germplasm about improved fallows or other agroforestry systems. One particularly interesting case was of West Kanyaluo, located in Rachuonyo District. A sub-chief (government appointed leader of a sub-location) heard about the fallows and led a small group of farmers to Maseno. Having received some seed and information a few farmers planted the fallows. The following year, he returned to acquire additional seed for the community. Over 100 farmers are practicing improved fallows in the community without ever having any technical assistance from research or extension.

FARMER PRACTICES USING IMPROVED FALLOWS

During a survey of 1999, farmer preference among improved fallow species was discussed at length with the farmers. They were asked to score the species they had experience with on a scale from 1 to 5 (Pisanelli et al. 2000). *Crotalaria grahamiana*, *Tephrosia candida* and *Sesbania sesban*, received highest ranking from farmers, closely followed by *T. vogelii*. The farmers' explanation for these scores related to the good impact on soil and crop production of *Sesbania sesban*, *Crotalaria grahamiana* and *Tephrosia candida* (in that order); the weed suppression by *Crotalaria grahamiana*; and the fuel wood from *Sesbania sesban*. *Tephrosia vogelii* achieved its high overall score mainly from its contribution to pest control (repellent of moles). As is indicated in Table 2, organizations have recognized these preferences and responded by giving more attention to the priority species (Tutui 2002). The disadvantage of Sesbania sesban compared to the other popular species is that it is difficult to establish through direct seeding and thus there is the added efforts in producing seedlings.

Table 2--Species being promoted for Improved fallows (number of times and percentage of organizations mentioning)

Species	Frequency	Percentage
Crotalaria grahamiana	31	79
Tephrosia vogelli	27	69
Sesbania sesban	18	46
Crotalaria pancilla	13	33
Tephrosia candida	13	33

Source: Tutui 2000

Most of the fallows are planted during the long rains, which begin in late February or early March and last into June. In the 1998 survey 61 percent of the fallows were planted during that period and another 13 percent during the preceding months (in 1997 –1998 there was hardly any dry spell between the short rains and the long rains). In the1999 survey these figures were 47 percent and 23 percent respectively. In most cases, these fallows were allowed to grow throughout the rest of the year and then cut in January prior to the next long rain season. The long rains were regarded as the best planting time by 74 percent of the farmers for *C. grahamiana*, *T. vogelii*, *T. candida* and *S. sesban* (Pisanelli et al. 2000).

In a 1998 survey, the majority of the fallows (62 percent) were established within a long rain maize crop, so that the trees would grow as a fallow during the following short rains. During a 1999 survey, the proportion of fallows planted in between the crop had increased to 70 percent. This differed slightly according to the species. Purestands of *C. grahamiana* and purestands of *S. sesban* were very often (44 percent of cases) planted in a weedy plot after the harvest of the crop.

The recommended duration of an improved fallow is about 9 months. During the 1998 survey in Yala (Siaya), 83 percent of the fallows were at least that old when they were cut and the average duration was about 10 months. The situation was different in Emuhaya (Vihiga). On average fallows lasted only 247 days or about 8 months. The Siaya farmers also reduced their average fallow period to 8 months in 1999. The best practice is to plant after the long rain maize crop is maturing so that the tree will not interfere with maize performance – this is typically in May. The 8-9 month fallow period then lasts until January or February when the trees are cut down and the biomass ready for incorporation into the soil during land preparation for the long rainy season, that begins in March. The suggested practice is for farmers to grow maize for 3 seasons after cutting the fallow (a long rain, a short rain, and a long rain) before again intercropping the tree into the maize. The reason this can be done in many cases is that there can be a strong residual effect from the accumulation of nitrogen in the biomass.

While the trees can provide large amounts of nitrogen through biological fixation, they cannot manufacture phosphorus or potassium and recycle only modest amounts from the subsoil. Thus, on soils that are depleted in these two elements, it will be necessary to acquire and apply these nutrients. Farmers have been testing a rock phosphate that comes from Northern Tanzania and is cheaper than the imported mineral fertilizers.

Farmers and partners alike have made a number of modifications / innovations to the practice of improved fallows. Recognizing the value of different species in producing a variety of benefits, farmers adopted fallows of mixed species. One common case is the mixing of crotalaria and tephrosia, the former for its high biomass and ground cover and the latter for its pest control. Other innovations that were identified include (Tutui 2002):

- Interplanting with cassava, sweet potatoes or legumes
- Incorporating farm yard manure with the green biomass
- Planting fallows immediately after harvesting
- Planting fallows during short rains
- Using cajanus cajan as a fallow species
- Planting trees at edges and boundaries of farm
- Shortening or extending length of fallow periods

3. IMPACTS

ADOPTION RATE

In this section we discuss separately the data collected from the pilot villages and the non-pilot villages.

Pilot Villages

In the pilot villages, monitoring of the use of improved fallows has been ongoing each year since 1997. As might be expected, patterns of use were quite varied and the decision as to who is an adopter and who is not is not straightforward. After reviewing the data, it was decided to classify households into one of four mutually exclusive groups:

1. Households that never used an improved fallow (non-adopters)
2. Households who used an improved fallow early on but never again (dis-adopters)
3. Households who did not use improved fallows early on but used recently (recent testers)
4. Households who used improved fallows throughout the period (adopters)

For the most part, adopters will have used fallows more often than dis-adopters and testers, but some dis-adopters may have used fallows two times (i.e. 1997 and 1998) which could be equal to the total number of fallows used by some adopters. Table 3 shows that the highest proportion of households had not tried improved fallows as of 2001, just over 60 percent. Nonetheless, about one-fifth of households (22 percent) have adopted improved fallows. The number of recent testers is lower than the number of dis-adopters.

Table 3--Patterns of use of improved fallows and biomass transfer (percent of 1,598 households)

	Improved fallows
Non-adopters	61.4
Dis-adopters	9.1
Recent testers	7.6
Adopters	22.0

In terms of the intensity of adoption, records were also kept on the size of fallows used. Table 4 shows that average fallow area was highest in 1998, dropping to a low in 1999 and recovering somewhat in 2000 and 2001.

Table 4--Size of fallows (square meters)

	Mean	Median
Size in 1998[1]	480	244
Size in 1999	364	225
Size in 2000	457	270
Size in 2001	440	234
Change over time[2]	-137	-81

1 Size of fallow was not measured in 1997
2 Calculated only for those farmers with at least two fallows occurring at least two years apart (2001 size -1998 size, or 2001 size -1999 size, or 2000 size -1998 size). Sample size is 351 adopting farmers.

Fallow size was reduced in 1999 partly due to lower rainfall and seed supply constraints in addition to farmer preferences. In 2001, the mean fallow size was 440 meters squared or .04 hectares. While this does not sound like much, it should be recognized that the average 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 3 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 between .075 and .1 hectare. Viewed in this way, adoption intensity among those using fallows, appears to quite high at .4 to .53.

Non Pilot Villages

Efforts were underway since 1998 to disseminate information and germplasm to a number of sites in western Kenya, initially through partnerships with development organizations. By 2000, training and dissemination activities were ongoing to some degree in as many as 16 districts. This is of course too recent to be able to define and measure "adoption." Further, there have not been any thorough attempts by ICRAF to assess the number of "users" of improved fallows in the entire region. What we describe here are two exercises that provide some indication of the level of use in some of the sites where follow up was made.

Two exercises were done to assess the uptake of improved fallows outside the pilot area in western Kenya. The first was a joint monitoring exercise involving development and extension partners who had decided to disseminate information on and germplasm for improved fallows (Tutui 2002). Table 5 shows the coverage of these partners, who numbered 39 in all. This process is conceived to be long-term and it is hoped that more and more partners will participate over time.

Table 5--Geographical coverage of monitoring exercise with partners

District	Divisions
Kisumu	Winam, Maseno
Siaya	Boro, Ukwala, Wagai, Uranga, Yala, Ugunja
Busia	Budalangi, Matayos, Nambale, Funyula, Butula
Rachuonyo	West Karachuonyo, West Karachuonyo
Migori	Awendo, Rongo
Central kisii	Mosocho
Homabay	Nyarangi
Vihiga	Emuhaya, Tiriki West, Luanda
Kakamega	Shinyalu
Nyando	Miwani, Nyando
Bondo	Madiany
Butere–Mumias	Khwisero
Teso	Chakol

Source: Tutui 2002.

Table 6 shows that on average the dissemination partners are reaching 70 farmers each year for training.

Table 6--Number of new farmers trained on using improved fallows from 39 dissemination partners in 28 divisions of western Kenya

Year	Number New Farmers Trained	% Female
2000	2905	51%
2001 (Long rain season only)	2632	42%

Source: Tutui 2002.

The 39 respondents reported that between 2,500 and 3,000 farmers had been trained on improved fallows in 2000 and 2001. The proportion of females to all farmers trained is relatively high, but is based on information from only half of the disseminating organizations. The reason is that some respondents did not keep records on gender.

A second exercise was a one-time exercise as part of an impact assessment study. Censuses were done for 6 different sites outside the pilot villages (about 1,000 households in all). Using the census, more detailed adoption analysis was completed on 360 households in all. These sites were selected on the basis of early dissemination (from 1999 or earlier), mainly by collaborating NGOs, but sometimes CBOs or extension, and the expectation that a significant number of households would be using fallows (so that quantitative adoption analysis could be undertaken). Thus, the rates of use found in this exercise may well biased upwards in comparison with a representative sample.

As indicated in Table 7, rates of use of fallows are quite high, in most cases higher than the rates of use in the pilot areas.

Table 7--Rates of use of improved fallows in early non-pilot area villages

Site	Number of Households	Percentage of Households with Improved Fallows or Biomass Transfer*
Bukhalahire (Busia)	110	33.6
West Kanyaluo (Rachuonyo)	233	58.8
Shinyalu (Kakamega)	90	44.4
Mwitubi (Vihiga)	118	30.5
Muhande-Arude (Siaya)	150	23.3
Central Gem (Siaya)	105	3.8

* In some of the sites improved fallow use was not distinguished from the other agroforestry practice for soil fertility.

This is encouraging, given that technical support from the project in these sites has been relatively low. In fact, the site with the highest adoption rate (West Kanyaluo) is the site that has received the least amount of attention, by either ICRAF or any other intermediary. An umbrella NGO works in the Bukhalahire site and has assisted farmers there. Muhande is a former CARE village and along with Mwitubi hosts ICRAF technicians from time to time because of their proximity to the research center in Maseno. Shinyalu is a site that hosts many of the researchers from KARI-Kakamega. Finally, Central Gem is a site where the main conduit for improved fallow dissemination was a catchment committee (a group formed by extension for the purpose of soil and water catchment activity).

In summary, there has yet to be a definitive count of improved fallow users in western Kenya, but the figure is somewhere between 10,000 -20,000 in any given year. It is a practice that is sufficiently different from traditional practices to require considerable knowledge transfer. While in certain localities, farmers have established relatively large improved fallow plots and these can be observed on aerial photos, improved fallow land use represents a yet insignificant proportion of total land use.

WHO ADOPTS IMPROVED FALLOWS

Qualitative and quantitative studies were undertaken to assess the adoption of improved fallows. We begin with a review of the quantitative evidence from within the pilot villages and conclude with a summary of the qualitative evidence.

QUANTITATIVE EVIDENCE -- PILOT VILLAGES

As noted earlier, dissemination of improved fallows in Kenya began in 1997 in about 17 villages in Siaya and Vihiga Districts. These 17 villages were clustered in 3 main areas and considerable technical backstopping was provided in 10 of the villages (labeled "pilot village" in table 8). One cluster of many villages is in Siaya District, occupied by the Luos, the other two being in Luyha Vihiga District. The study of this first dissemination has its advantages and limitations. The limitation is that early testing and use was affected significantly by the presence of the project. Besides farmer motivation to test and use fallows, they were also motivated by increasing their social standing, by the hope that interest might gain them access to other agricultural technology, and because for some seasons the project purchased tree seed from farmers. These disadvantages are partially overcome by the advantage of this dataset – that being its longevity. In covering 5 full years of monitoring, patterns of consistent use, disuse, and recent testing can be discerned. Since project backstopping ended in 2000, those remaining users are now motivated mainly by the performance of technology. In addition to the dataset's longevity, the monitoring also covered a large number of households – nearly 1,600 in all.

A multinomial logit regression was run to examine the effect of several explanatory variables on the likelihood of being a dis-adopter, a tester, or an adopter relative to having never tried an improved fallow. We hypothesized that adoption would be positively related to farm size (due to opportunity costs of land taken out of production), household labor and male headed households (due to extra labor and physical effort required for cutting of fallows). Researchers have actually measured some labor savings with the operation of a dynamic fallowing system, but farmers are not able to reflect on this until after a few years and the initial labor of planting and cutting may tend to dominate. As for non-land household wealth, the relationship is not clear since it is expected that the wealthy households are already users of fertilizer, but on the other hand, the poor may be limited by access to information and other constraints of high discount rates. For early testers who dis-adopt, one may expect that the wealthy may be willing to test in order to compare to their other methods for nutrient management and may more likely find that the advantages of improved fallows are not sufficient to induce change in their practices.

Table 8 shows the results of a multinomial logit analysis of dynamic use patterns of improved fallows in the pilot project areas between 1997 and 2001.

Table 8--Household factors related to adoption of improved fallow in the pilot villages 1997-2001 (n= 1583)

Outcome	Used early and dropped	Used recently only	Used throughout period
Variable			
Constant	-3.0833**	-2.7064**	-2.5034**
	(.000)	(.000)	(.000)
Pilot village	.6555**	-.1494	.8041**
	(.001)	(.451)	(.000)
Luo household	1.3505**	.2413	.9998**
	(.000)	(.268)	(.000)
Number of adults	.2685**	.1331**	.0944**
	(.000)	(.019)	(.023)

Table 8--Household factors related to adoption of improved fallow in the pilot villages 1997-2001 (n= 1583) (continued)

Outcome	Used early and dropped	Used recently only	Used throughout period
Female head – husband away	.6750** (.031)	.4922 (.125)	.0461 (.858)
Female head – no husband	.1070 (.691)	.3812 (.151)	.0262 (.893)
Male head – polygamous or single	.6628** (.013)	-.3149 (.423)	.1717 (.416)
Secondary education	-.8548** (.024)	-.2650 (.511)	.2335 (.358)
Upper primary education	-.2314 (.399)	-.1058 (.741)	.1763 (.407)
Lower primary education	-.2194 (.434)	.2804 (.346)	-.0686 (.754)
Age	-.0168** (.039)	-.0055 (.533)	-.0059 (.307)
Owned land area	.1417** (.024)	.0846 (.244)	.2306** (.000)
Wealth index	.0418 (.590)	.1270 (.125)	.0395 (0.473)
% of cases observed	9.1	7.6	22.0

Omitted outcome is the group of farmers never trying improved fallow
Significance level in parentheses; ** significant at least 5% level; * significant at 10% level

In general, the included variables appear to be very important in distinguishing between dis-adopters and non-adopters, to some extent between adopters and non-adopters, but not very relevant to distinguishing between recent testers and non-adopters. Rather than describing results outcome by outcome, we shall instead analyze by variable across the different outcomes. First, we shall discuss the variables most closely linked to poverty, the wealth index, the type of household, and farm size. The wealth index was not statistically significant in any of the pairwise comparisons suggesting that the different use patterns are neutral with respect to wealth – e.g. the poor are as likely to be adopting as the wealthy. Household type was also not related to adopting improved fallows – the technology is being adopted by female headed and other non-traditional household structures as by the more common male headed-monogamous household. A final variable linked to poverty[2] shows a different pattern. Non-adopters of fallows have smaller farm sizes than dis-adopters and adopters. Somewhat encouraging is that households who are newly trying improved fallows tend to have farm sizes indistinguishable in size from non-adopters. 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 dis-adoption or recent testing). Thus, for adoption, land is a more important household constraint than is labor.

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. One interpretation is that because fallows and their effects are highly visible, many farmers were able to make early decisions about whether to test them (hence the relatively few recent testers) and thus there are few patterns related to recent testers. Early use was similarly higher among Luos as compared to Luhyas. However, just like the case with the pilot location variable, new testers are equally likely to be Luhyas as Luos. These patterns indicate that there was greater early interest among the Luos, especially those in pilot villages. Observations by field technicians attributed this to stronger leadership and greater social cohesion. Obviously, many of those who agreed to test the technology at the outset, became unmotivated to continue its use.

Education levels and age of the household head were not related to adoption of improved fallows (or to early testers). Thus, those households using fallows in 2000-01 are similar in

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

terms of household head characteristics as households who never tried fallows. Older household heads and those with a secondary education were less likely to have dis-adopted fallows rather than having never used one. In other words, younger household heads were more likely to have been adventurous and try a fallow but then to have abandoned it than the typical household head who has never tried a fallow.

To better assess the types of households being reached by improved fallows, table 9 shows how the same explanatory variables affect the use of chemical fertilizer, animal manure, and composting by farmers (Place et al. 2002). Some interesting similarities and contrasts emerge. The likelihood of practicing most of the options increases as land and labor increases. The exception to this rule is the use of chemical fertilizer that seems scale neutral. Results on the wealth variable show that unlike improved fallows, the poor are less likely to use other soil fertility replenishment methods. In terms of gender, households where females are heads while husbands are away are much less likely to use chemical fertilizer but more likely to be using composting, than male headed monogamous households. Education is an important criterion in the use of chemical fertilizer where the impact is positive, and in the use of composting, where surprisingly the impact is negative. Lastly, older household heads appear to be less likely to use compost and chemical fertilizer. Looking at the set of soil fertility management options, there appears to be some to satisfy different characteristics and demands of households, with the possible exception that none of the inorganic techniques seemed highly attractive those operating the smallest farms.

Table 9--Logit regression analysis of household factors affecting the use of non-fallow soil fertility replenishment options from 17 villages in Vihiga and Siaya districts, Western Kenya

Independent Variable	Chemical fertilizer	Animal manure	Compost
Constant	-3.3823	-.0555	-.1618
	(.0000)	(.8575)	(.5634)
Age of household head	-.0111	-.0005	-.0210
	(.0372)	(.9086)	(.0000)
Lower primary education	.1984	.3382	-.0568
	(.4307)	(.0600)	(.0000)
Upper primary education	.6334	.0716	-.3768
	(.0077)	(.6924)	(.0286)
Secondary education	.7877	-.0040	-.3682
	(.0036)	(.9861)	(.0761)
Male headed - single or polygamous	-.0692	-.5240	.0829
	(.7491)	(.0052)	(.6348)
Female headed – widowed	-.1289	-.2370	-.2016
	(.5326)	(.1500)	(.1980)
Female headed – husband away	-.9199	-.2904	.5487
	(.0014)	(.1937)	(.0051)
Wealth index	.5904	.3368	.3147
	(.0000)	(.0000)	(.0000)
Owned farm land	.0414	.0700	.0878
	(.2557)	(.0903)	(.0095)
Number of household members	.0062	.1010	.0244
	(.7806)	(.0000)	(.1564)
Luo	1.5595	-.7975	.0717
	(.0000)	(.0000)	(.5288)
Number of observations	1620	1623	1621
% of users of technology	20.5%	71.0%	40.6%
% correctly predicted by model	80.8%	72.5%	63.8%

Source: Place et al., 2002
Note: p value of Wald ratios in parentheses

There are apparent differences in the types of households using the different soil fertility practices. A crosstabulation was made to determine the extent to which improved fallow users were reaching farmers who were not using other types of soil fertility practices. Most of the users of improved fallows also used at least one other soil fertility strategy (because many households had used animal manure or compost). However, of those not using other soil fertility practices, 25.4 percent were using improved fallows in the pilot villages and 29.1 percent were using them in the non-pilot villages. So, while for the most part the improved fallows were seen as an additional option, they also have spur new activity by some households.

Quantitative evidence – non-pilot villages

For the non-pilot villages, we created three categories of households: (1) non-users/dis-adopters, (2) infrequent users, and (3) frequent users. The fewer number of categories as compared to the pilot villages is due to fewer observations (361) and less precise information on date of information dissemination. In the case of improved fallows, 15.8 percent were frequent users and 13.6 percent were infrequent users, with the remaining 70.6 percent not having tried the fallows as of yet.

Table 10--Multinomial logit results for adoption of improved fallows in non-pilot villages (n=361)

	Technology Use	
Variable	Infrequent	Frequent
Constant	-4.29878	-2.17411
	(.018)	(.094)
Luhya	2.12689	.07481
	(.090)	(.940)
Female headed household	-.85369	.54207
	(.108)	(.188)
Polygamous male headed household	.314404	.63845
	(.465)	(.148)
Primary education of head	-.39231	.42404
	(.448)	(.433)
Secondary or greater of head	-.54811	.81062
	(.381)	(.178)
Age of household head	-.01312	.00523
	(.354)	(.690)

Table 10--Multinomial logit results for adoption of improved fallows in non-pilot villages (n=361) (Continued)

	Technology Use	
	Infrequent	Frequent
Number of adult family laborers	-.09237	.01692
	(.489)	(.885)
Farm size	.00534	.03497
	(.921)	(.442)
Wealth – Log of Assets	.14644	.06647
	(.269)	(.549)
Wealth – Farmer Generated Index of	.12201	.15760
Wealth Indicators	(.030)	(.002)
Wealth – Enumerator generated middle	.93985	.25707
wealth level	(.015)	(.458)
Wealth – Enumerator generated high	1.39998	.32137
wealth level	(.023)	(.595)

(8 location variables not reported)

We used the same household explanatory variables as in the case of the pilot villages with the following exceptions. For household type, all female-headed households were combined into a single dummy variable due to insufficient numbers in several more dis-aggregated categories. Second, we reduced the number of variables depicting the education level of the household head to include primary and secondary/above (as opposed to further splitting the primary education variable in the pilot villages). Third, for wealth we actually have more varied and rigorous measures and include three alternative specifications in our model. Lastly, because the non-pilot villages cover a wide geographical area, we include location dummies for each site.

The results for the improved fallow regression are given in Table 10. There are hardly any statistically significant results among the household variables, contrasting the results from the pilot villages.[3] One statistical reason why this may be expected 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

3 There were many significant results among the location dummies.

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. So although not all the wealth variables are producing similar results, there are indications that wealth is important in the use of improved fallows in the non-pilot villages. The only other significant result in the fallow regression was that Luhya households were more likely to be infrequent users as opposed to the Luo. This is difficult to interpret because the same variable has almost no influence whatsoever in regards to frequent use of improved fallows.

It is interesting to note the positive link between wealth and the uptake of the fallows 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 by project staff as compared to other dissemination pathways used in other sites, or could also be partly attributable to different measurements of wealth in the two sets of regressions. It is equally interesting to note that while farm size and labor constraints were apparent in reducing the uptake of improved fallows in the pilot villages, such constraints did not emerge in the non-pilot areas. This issue requires further investigation.

Qualitative evidence

A detailed analysis of adoption factors was made in two pilot and two non-pilot villages using focus group discussions and household case studies. Factors found to influence both adoption and the actual choice of improved fallows and soil fertility management practices in general include the following, in no particular order (Omosa et al. 2002):

- Fluctuation in the price of tree fallow seed

- Infestation by pests from introduction of new plant species
- Small land sizes
- Amount of land owned or accessible
- Unavailability of the youth following their dislike for farm work
- Absentee heads of households
- Reluctance by men to stay on the farm
- Discrimination from technology transfer contact farmers
- Attitude of the contact farmers
- Imposition of contact farmers on the community/recipients
- The health status of household members, especially the impact of HIV/AIDS
- The amount of labor/effort demanded by the technology
- The possibility of realizing immediate returns
- The rigorous nature of some of the practices
- Feeling of unequal relations with ICRAF
- Natural calamities such as hailstones
- Theft and other social crimes
- Political alignments

In addition to the above, the case studies uncovered some additional difficulties facing women farmers (Omosa et al. 2002). Some women have found it difficult to participate because they lack sufficient land, they cannot attend the demonstrations/ field days due to restrictions from their spouses, or their domestic workloads are too heavy. It was noted that whereas majority of the people that went on field trips were men, it was the women that undertook most of the farm work.[4] Nevertheless, there are examples of households that cooperate in the conduct of their farm activities with great success. In other words, while there is evidence to show that gender disparities have a negative impact on adoption and continued implementation of improved fallows, it is also the case that this technology has managed to interest men in (subsistence) farming with some amount of success. And, as would be expected, the direction taken depends on what else is going on in particular households.

Education was not found to play a major role in the decision of farmers to take up technologies. In any case, women who were apparently of lower education excelled in the uptake of the new technologies as long as the explanations are given in the simplest terms possible. Because many of the technologies were practically taught it was easy for the farmers to pick them.

SOCIO-ECONOMIC IMPACTS OF IMPROVED FALLOWS

Economic impacts of improved fallows

Input, yield, and profit impacts. The improved fallow system was described above and it is clear that it adds two labor operations, one for planting of fallows and a second for cutting them down. Further, there are the possibilities for implications on weeding and land preparation. We will consider these in turn. As for planting, where seedlings are concerned, that is for Sesbania sesban, labor required is about 16 days per hectare. Most of the farmers in our villages and those in the trials described below, use direct seeding methods however, which only require 2-3 days per hectare. As for cutting of the trees, careful monitoring of farmers revealed that on average, this operation took 9.5 days per hectare (Rommelse 2001a). If a fallow were to be

4 In one case when women did take a field tour, the bus broke down requiring the women to stay overnight away from home. This led to the development of suspicions among the husbands that further entrenched their reluctance to allow wives to travel.

planted on a bare field and weeded, it would result in an additional 15 days of weeding (Jama et al. 1998). However, the majority of farmers establish the fallow in a maize field and the weeding time is already captured by the cropping labor. Some farmers actually claim that improved fallows reduce the amount of labor time required in the following season due to weed suppression, but this has not been quantified. Farmers cut the trees low to the ground and do not destump. While many claim that the soils are easier to work with, the presence of stumps and roots on average means that farmers spend an extra 10 days per hectare on land preparation the season after cutting (66 days/ha as opposed to 56 days/ha). For comparison, the total amount of labor for a maize/bean crop is 136 during the long rains and slightly less during the short rains (about 120). The fallow system enables the saving of the 120 days, while adding 23 days (when direct seeded into a maize field), giving a net savings of about 97 days per hectare. At the average improved fallow size of .04 hectares, this amounts to about 4 days.

As for non-labor inputs, fallows require that land be taken out of production. The opportunity cost of this is the production foregone and in all the following analyses these lost outputs are directly measured. Typically, yields are significantly lower during the short rains than the long rains (20-30 percent, for instance). As for cash costs, the purchase or production of seedlings can be costly, which is a reason farmers opt for direct seeding. For the commonly used species, the cost of tree seed is about $8.50 per hectare.

Table 11 presents an analysis of two farmer-managed trials in western Kenya (Rommelse 2001a). The first trial was for four seasons and the second trial was for three seasons.[5] The crop following the fallow was maize or maize/bean. In both trials, continuous cropping meant the production of maize/bean for 4 and 3 seasons respectively. Total maize yield from the fallowing

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5 For both trials, the pattern was for a fallow-crop combination in season one, a fallow in season two, and then crops in the seasons that followed.

systems would be for one fewer season in each trial, with the fallow occurring in the second season. The only fertilizer applied was TSP (for phosphorus) which was applied at rates of 0, 50 and 250 kg per hectare for different land uses. The results from some of these alternatives are presented in Table 11.

Table 11--Economic analysis of improved fallows on maize and beans for multiple seasons in Western Kenya (farmer-managed trial)

Land Use System	P rate	Average total yield: maize[1]	Average total yield: beans	Total Costs[2]	Return to land[3]	Return to labor[4]
	kg	*kg*	*Kg*	*$*	*$*	*$/day*
Trial 1 (four seasons, total N = 34)						
Continuous	0	4390	969	585	405	1.74
Cropping	250	5025	1191	1047	108	1.14
Natural	0	2626	519	442	148	1.36
Fallow	250	3573	681	904	-131	0.63
Crotalaria	0	3964	855	484	397	1.87
Fallow	50	5191	1035	588	528	2.13
Tephrosia	0	5122	962	495	588	2.31
Fallow	50	5440	867	588	534	2.14
Trial 2 (three seasons, total N = 61)						
Continuous	0	4160	0	388	242	1.53
Cropping	50	4505	0	481	189	1.40
Crotalaria	0	4498	0	313	351	2.04
Fallow	50	4414	0	404	249	1.71

1 Average total maize yield is the total yield over the 4 seasons (2 per year) averaged across the farmers applying the system. For continuous cropping it is the cumulative maize yield for all seasons averaged across all farmers. For the fallowing systems, it is the cumulative yield for one fewer season than for continuous maize, with the second season being under fallow.
2 Includes purchased inputs and all labor time valued at current wage rate. All costs except for modest seed costs are labor in the treatments with zero P inputs.
3 This is the per hectare net present value over all seasons of the trial
4 Includes all labor time.
Source: Rommelse 2001a

In the first trial, the natural fallow system was found to be unproductive and not financially attractive compared to all other systems. The tephrosia fallow without phosphorus inputs was the most economically attractive by both returns to land and returns to labor criteria. The crotalaria system gave poor results in the first season and thus was superior to the continuous cropping practice only in returns to labor. For this system, the addition of phosphorus increased returns substantially. A second trial involving more farmers (about 30) found that the crotalaria fallow system without any additional fertilizer was far superior to that of the continuous cropping system. The returns to land and labor were 45 percent and 33 percent higher respectively. Synthesizing across all trials undertaken by ICRAF, improved fallows are found to be attractive financially. But it is not possible to identify a particular species that is best under all circumstances nor is it true that using fallows with added phosphorus is always the more profitable.

We attempted to conduct a similar analysis using farmer recall data in the non-pilot villages. Responses on maize production increases suggested a median response of about 150 percent over the control of maize with no nutrient inputs. We were not able to calculate a financial return from these data because plot sizes were not measured and appeared to be highly rounded upwards. New efforts are ongoing to obtain more precise on-farm data from long rain season of 2002 in the pilot villages.

The qualitative analysis also indicated that many farmers were pleased with the maize yield responses to fallows. Many of the respondents that had used improved fallows said that they realized progressive increased yields (Omosa et al. 2002). The yield increases were especially felt in the first season following the fallow. However many farmers feel that the nutrient effect of fallows dwindles over time.

Effect of improved fallows on assets. Our hypothesis is that if yield impacts from improved fallow investments are to lead to sustainable increases in livelihoods, then we would expect to observe some degree of asset accumulation. The qualitative research found that this was indeed occurring for some households, but not all. For example, the case studies showed one Luhya farmer has been able to educate three children up to form four from sale of tomatoes and kales. These were grown on a piece of land that was under an improved fallow, and was then supplemented by farmyard manure and tithonia organic manure. Other farmers were able to sell extra yields to buy books and pay fees, and the increased yields helped reduced the period of buying maize from two months to one month for one case. But it was evident that because of rampant poverty, most households were hard placed to convert any gains from increased yields into tangible assets. The case studies are replete with stories of observed doubling of yields, yet an inability to religiously apply or even expand the systems. The reasons for this are manifold, including focus on other livelihoods and unpredictable shocks to the health and economy of the household. 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 improved fallows and assets, it is extremely important to understand the context of assets and their change during the study period. Looking at the actual values, livestock comprises about 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 non-pilot villages and $236 in the pilot villages, while that of livestock was $302 and $178 respectively. A large number of households suffered through dis-investment in both livestock assets and total assets over the period. This is remarkably consistent in both sites with percentages incurring dis-investment 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. a huge number of funerals) and disease (most notably for poultry).

Two-stage methods are used to first predict the use of improved fallows and the second stage to measure the effect of the predicted improved fallows variable on assets (similarly, the two-stage method is used for consumption and expenditure below). One requirement for this analysis is the identification of variables that may affect adoption intensity but not impact. This is not easy to do from a theoretical point of view because adoption and impact on assets are very closely related. The variables we selected as instruments to explain adoption but not impact relate to household perceptions of the importance of agro-climatic shocks for the village (the risks of drought, hail, and pests/diseases perceived prior to the period of study), the father's farm size, and the jobs and social positions held by their fathers. We also included whether either of the adult members of the household had previously held a job in the formal sector.

Results from the non-pilot and pilot villages are given in tables 12 and 13. The use of improved fallows is not significantly related to asset change in the pilot and non-pilot villages. The only consistency in results between the two sites is that it was mainly the wealthy who were most likely to worsen their liquid asset holding situation. In the non-pilot villages, additional variables positively impacting on asset change were farm size, household size, and education level of household head. However, none of these were significant in the pilot villages regression (note, however, that the number of observations in the pilot villages asset analysis was only 97). The mixed results suggest that there are considerable mitigating factors shaping asset management strategies of households and that these factors are not easy to discern.

Table 12--Econometric results from second stage regression of agroforestry on changes in assets in the non-pilot villages (n=359)

	Two-stage Least Squares		Tobit / OLS combination	
Variable	Coefficient estimate	Significance level	Coefficient estimate	Significance level
Predicted area under improved fallow	-2090.67	.81	-2902.80	.18
Predicted area under biomass transfer	11522.56	.03	6072.48	.00
Luhya ethnic group	-6308.54	.57	-7893.04	.34
Female headed household	1604.48	.76	4433.43	.26
Polygamous male headed household	508.77	.92	2497.60	.54
HH head obtained primary education	9754.96	.07	9352.13	.02
HH head obtained secondary education	17436.74	.01	18919.06	.00
HH head age	112.07	.44	129.43	.21
Household size	1763.52	.05	1735.32	.01
Farm size	1494.70	.02	1652.82	.00
Initial asset wealth	-0.9321	.00	-0.9487	.00
Constant	-2529.90	.88	9818.23	.44
Adjusted R-Square	.698		.835	

Note: 8 sub-location dummy variables were included but are not reported in the table.

Table 13--Econometric results from second stage regression of agroforestry on changes in assets in the pilot villages (n=97)

	Two-stage Least Squares		Tobit / OLS combination	
Variable	Coefficient estimate	Significance level	Coefficient estimate	Significance level
Predicted area under improved fallow	3.99	.49	2.89	.55
Predicted area under biomass transfer	-1260.62	.59	-777.09	.70
Luhya ethnic group	-3653.86	.17	-3511.64	.13
Female headed household	2326.88	.47	2144.49	.58
HH head obtained primary education	3033.91	.37	3652.72	.31
HH head obtained secondary education	-413.52	.90	122.31	.97
HH head age	2.03	.98	7.80	.09
Household size	699.03	.17	726.37	.16
Farm size	-265.80	.73	-301.84	.70
Initial asset wealth	-0.3258	.00	-0.3334	.00
Constant	-2832.33	.64	-3036.17	.59
Adjusted R-Square	.285		.265	

Effect of improved fallow on expenditure. In this section we examine the effect of the use of the improved fallow technology 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. Rommelse (2001b) describes the methods used and presents some empirical results from the 1999-2000 survey. 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 3-month recall and therefore we exclude all food expenditures from this analysis (they are too hard to estimate over 3 months and food consumption is handled separately below).

We analyzed changes in non-food expenditures per household and also per capita. For the latter we divided by the number of household members. Mean non-food 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 non-food expenditures rose slightly to $104 over the period and the median behaved similarly over time. Per capita non-food expenditures, on the hand, were flat over time with a mean and median of $16 and $10 respectively. However, there is also a large number of households (44 – 48 percent) experiencing a setback in welfare as measured by non-food expenditures.

Turning to the econometric analysis (Table 14), the use of improved fallows is not found to be significantly related to changes in expenditure levels.

Table 14--Econometric results from second stage regressions of agroforestry on changes in non-food expenditures and per capita non-food expenditures in the pilot villages (n=102)

Variable	Changes in non-food expenditures per household	Changes in non-food expenditures per capita
Predicted improved fallow area	-1.8371	-.6042
	(.793)	(.612)
Predicted # seasons with	1987.402	443.1089
biomass transfer	(.323)	(.196)
Luhya ethnic group	-336.3096	15.5879
	(.865)	(.964)
Female headed household	32.0576	88.5444
	(.990)	(.839)
HH head obtained primary	1428.062	175.0361
education	(.609)	(.717)
HH head obtained secondary	7529.403	1064.504
education	(.008)	(.027)
HH head age	77.3741	12.7443
	(.222)	(.244)
Household size	54.5092	-108.9548
	(.892)	(.115)
Farm size	242.5165	66.9287
	(.666)	(.496)
Initial level of expenditures (per	-.7914	-.7602
household or per capita)	(.000)	(.000)
Constant	-2290.494	225.6572
	(.639)	(.788)
Adjusted R-Square	.41	.29

Initial level of expenditure is the key conditioning factor and these are found to be negatively related to change over the period (similar to the asset change regressions). Thus, of the many declines in expenditures, most are occurring among households who had relatively high expenditure levels in 2000. In addition, some households with relatively low expenditures in 2000 were able to increase them by 2002.

Effect of improved fallows on food consumption. Food consumption and nutritional measures were based upon 24-hour recall surveys of households (3 visits in 2000 and 2 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 FAO and 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 their recommended needs. For instance, in 2002, 42 percent of households had less than required intake of energy, 53 percent for folic acid, and 73 percent for protein. It is also interesting to note that there is 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. These are presented in Table 15.

Table 15--Econometric results from second stage regression of agroforestry use on nutritional measurements (n=102)

Variable	Energy	Protein	Iron	Folic Acid
Predicted improved fallow area	.0471	.0520	.1672	.1104
	(.198)	(.231)	(.101)	(.172)
Predicted # seasons with biomass	-9.4007	-9.8129	-33.3081	-28.2815
transfer	(.383)	(.455)	(.285)	(.240)
Luhya ethnic group	10.3813	7.5572	1.7205	15.7095
	(.342)	(.577)	(.956)	(.513)
Female headed household	12.3909	1.8963	33.0904	-5.5660
	(.401)	(.921)	(.435)	(.864)
HH head obtained primary education	22.4161	23.4920	49.7851	27.5557
	(.144)	(.215)	(.259)	(.432)
HH head obtained secondary	13.7830	14.8131	11.6058	1.0233
education	(.353)	(.417)	(.783)	(.975)
HH head age	.1173	.1814	.4492	.0225
	(.741)	(.676)	(.664)	(.977)
Household size	-.8934	-.3030	-1.4307	.4175
	(.691)	(.915)	(.836)	(.936)

Table 15--Econometric results from second stage regression of agroforestry use on nutritional measurements (n=102) (Continued)

Variable	Energy	Protein	Iron	Folic Acid
Farm size	-4.1624	-4.1243	-11.1446	-7.5496
	(.196)	(.290)	(.219)	(.279)
Initial level of indicator (energy, protein, iron, or folic acid)	-.9251	-.9863	-.8796	-.9905
	(.000)	(.000)	(.000)	(.000)
Constant	85.3049	63.3129	115.2536	99.3109
	(.016)	(.145)	(.220)	(.155)
Adjusted R-Square	.29	.46	.42	.77

None of the household characteristics, including the improved fallow adoption variable, were found to be significantly related to changes in food intake and nutritional status. The only significant variable in each regression was the beginning of period measure of the dependent variable. In all cases, this was found to be negative, indicating that the households whose nutritional status fell by larger amounts were mainly those with high initial levels (note that for decreases in sufficiency levels do not necessarily mean that the household is now facing nutritional insecurity).

Other economic impacts. In 1999, a village level workshop was held in Siaya District to discuss the impacts from the use of improved fallows (Place 1999). It was attended by about 60 farmers from 3 surrounding villages. They were asked to discuss impacts, positive and negative, of the improved fallows at plot and household levels. The socio-economic impacts are discussed here while the plot level ecological impacts can be found in section 3.4 below.

The first finding from the workshop is that on many farms, the size of plots under agroforestry system was still small, and therefore, the visible effects at the plot level did not always translate into significant effects at the household level. Another effect of improved fallows is on labor. Households like improved fallows because they save labor on an annual basis (Swinkels et al. 1997), and labor for land preparation can be saved because soils are easier to work with following an improved fallow. The saving in labor combined with greater productivity leads to the significantly higher returns to labor from improved fallows compared to the situation of continuous cropping with no nutrient inputs. A fertilizer strategy is superior in terms of returns to labor, but this is of course not a feasible option for the poor households. One indirect effect on labor is that money saved from reduced food purchases can be used to hire additional labor or oxen plough to allow for more timely land preparation. It was felt that the introduction of the systems have led to more labor demand at the village level simply because of the promise of better returns.

Social impacts

Findings from focus groups discussions and individual case studies further show that the various soil fertility replenishment technologies have given some members of the community some amount of social capital, especially in terms of their being seen as successful farmers and people who attract visitors from ‘far away’ (Omosa et al. 2002). Indeed, some of these visits have been so eventful that several families have named their children after these personalities. On the other hand, it is 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. In one particular case, both the husband and wife pursue different farming practices just because they would like to be different and even be seen to be pursuing different styles. In this particular case, it was the man that came into contact with the agroforestry technologies and because he had been a drunkard and with low social esteem within his community, the wife was not convinced that his farm practices were anything to emulate. Instead, she viewed them as a continuation and probably even a perpetuation of his wayward ways. In many ways therefore, the introduction of these agroforestry technologies has resulted in status inversion. This particular farmer is now a point of reference when it comes to describing a farmer that has adopted the ICRAF technologies successfully. However, the information gathered thus far does not show whether there is an emerging common identity amongst the adopters.

At the 1999 village workshop, there was some discussion about husband-wife relations. It was noted that with increased yields some of the men were taking a greater interest in the farm and putting in more labor. Increased job satisfaction was noted. With some positive outcomes, others noted a reduction in domestic violence. On the other hand, there are cases where wives may be trying the new practice on 'their' plot while the husband does not and this was noted to create more domestic problems. Related to this was a feeling of more food security on the part of households. Some participants mentioned that there was better health and nutrition among the children and that they were less likely to miss school.

The 1999 village workshop also revealed a greater sense of unity and togetherness and that communication among households has increased. There is greater networking between different organizations and between different villages. Villagers in the pilot areas felt that they have helped to enhance adoption of the agroforestry practices in other villages. There was a noted increase in capacity building. Farmers' understanding of their soils and options for improvement has been greatly enhanced and this has given them greater confidence to engage extension, NGOs, and other technical persons for assistance. One negative effect of the fallow systems noted was that the bushy fallows could become hiding places for wildcats or thugs. There was an echo of the concern about the communication mechanism between ICRAF and the village whereby certain contact farmers were not representing the interests of the wider community.

ECOLOGICAL IMPACTS

From the village workshop, the main benefits from improved fallows at the plot level are: improved maize crop performance, increased soil organic matter, improved color of soil, and elimination of serious weed. This was confirmed by a formal survey of farmers who also mentioned wood production and soil erosion control as other ecological benefits (De Wolf and Rommelse 2000). They assessed or likened soil organic matter by the ease of working soils. They insisted that soil color has changed in some plots even after one fallow due to high litter fall from the fallow species. In this particular aspect, *Crotalaria grahamiana* performed well and was able to smother all weeds. Farmers in the non-pilot villages were asked in the formal survey whether their soil fertility has decreased, increased, or remained the same between 1997 and 2001. These responses were then compared to the use of improved fallows. Of improved fallow users, 35.1 percent said that their soils had improved, while only 16.9 percent of non-users reported increased soil fertility. In turn, soil fertility change is strongly linked to maize yield change.

As for negative aspects, the main issue is with pests. The farmers have noted that Crotalaria, while being the highest biomass producer can also attract pests. One is a caterpillar that invaded the village in 1997-98. This pest eats the green vegetation of *Crotalaria grahamiana* (not other Crotalaria spp) but not other plants. The sheer number of caterpillars and then butterflies also put fear into some farmers and may cause delayed labor activities. The second pest that is also associated with *Crotalaria grahamiana* is the mole. Moles move underground and eat roots and will also damage food crops. Farmers noted however, that the moles do not like Tephrosia and an indigenous method is to sow Tephrosia around the predominantly Crotalaria fallow. A last problem noted concerns the cutting of the more woody species, such as *Tephrosia candida*, when they are allowed to grow for more than a season. The removal of stumps was cited as a difficult task but not a major deterrent.

SUMMARY OF IMPACTS

The main findings from the study of the impact of improved fallows on households in western Kenya are the following:

The poor are adopting SFR strategies at the same rates as the non-poor

Adoption rates are not outstanding but they are encouraging with about 20 percent of all farmers using improved fallows on a regular basis (a similar percentage among the poor) and a sizeable percentage of farmers newly testing. This suggests that improved fallows are not biased towards people controlling and managing resources above a certain threshold.

Adoption at early stage is at low levels of intensity

While an encouraging number of households are using or testing the improved fallows, 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.

Improved fallows do significantly raise crop yields

Respondents in the case studies and formal surveys consistently report very significant increases in yields (>150 percent) from the use of improved fallows compared with the continuous maize cropping system with no nutrient inputs. This is consistent with farmer-managed trial data.

Improved fallows on their own cannot bring about a turn in poverty reduction.

This conclusion is drawn from the body of impact assessment work. Despite the fact that improved fallows are 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 improved fallows 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.

4. RECOMMENDATION DOMAINS

The results from western Kenya show that improved fallows may be viable even in high population areas. Their potential recommendation domain may therefore be quite large in Sub-Saharan Africa. Moreover, evidence has indicated that improved fallows are not biased against the poor or women. Thus, extension agents should have no reservations about disseminating information about improved fallows as an option for soil fertility management.

There are some situations, however, that would appear to be less suited to improved fallows. Households that are landless or near-landless are unlikely to be able to leave even modest areas uncultivated. Small farms located in unimodal rain systems are equally less likely to set aside land for improved fallows when that would mean foregoing production on that field for at least one year. In this case, nutrient management systems that enable continuous cropping are preferred, such as biomass transfer or intercropping systems. Two other agricultural enterprise systems may compete with improved fallows. The first is intensive livestock production systems in which case non-cropped land may be put under fodder production. The second is where perennial cropping systems, e.g. coffee, predominate and offer few niches for improved fallows.

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