

Baseline Study of *Striga* Control using Imazapyr-Resistant (IR) Maize in Western Kenya

An agricultural collaborative study on *Striga* control by the African Agricultural Technology Foundation and the International Institute of Tropical Agriculture

VM Manyong, AD Alene, A Olanrewaju, B Ayedun, V Rweyendela, AS Wesonga, G Omanya, HD Mignouna and M Bokanga

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Acronyms and abbreviations

AATF	African Agricultural Technology Foundation
BASF	A German chemical company
BMI	Body Mass Index
CIMMYT	The International Maize and Wheat Center
FEWs	Front-line extension workers
GIS	Geographic Information Systems
GPS	Global Positioning System
HIV/AIDS	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
IITA	International Institute of Tropical Agriculture
IR	Imazapyr Resistant
KARI	Kenya Agricultural Research Institute
NGO	Non-Governmental Organisation
SRLF	Sustainable Rural Livelihoods Framework
UNICEF	United Nations Children's Fund
WeRATE	Western Regional Alliance for Technology Evaluation
ZWFA	Z-score on weight-for-age
ZWFH	Z-score on weight-for-height
ZHFA	Z-score on height-for-age

Summary

This report presents the results of the baseline study undertaken to assess the status of *Striga* damage, the general livelihoods and livelihood strategies of the rural poor in western Kenya. A stratified random sampling method led to the selection of 8 districts, 16 sub-locations, 32 villages and 800 households. A combination of techniques for data collection was used, including literature review, GPS recordings, focus group discussions and interview of individual households. Various econometric models were also developed and estimated for data analyses. A stochastic frontier production function was used to measure the technical efficiency of maize production. A logistic regression model of poverty was estimated to examine the determinants and correlates of poverty in western Kenya.

The study revealed that households are small in size and the dependency ratio is high. There were about 26% of households headed by females. The level of education is low for the heads of households and all members of farm families. Households are endowed with a multitude of assets for their livelihoods. However, the level of assets was found to be low or of very poor quality. Maize is the major food crop and a source of cash income. Farmers grow both local and improved (hybrid) maize varieties, but the productivity is low. There is a considerable gap between potential and actual maize yields. Major factors constraining crop production include *Striga* infestation on maize, low soil fertility, drought and erratic rainfall. *Striga* is the major threat to livelihoods of smallholders and its economic importance has increased over the past three decades. Traditional methods of *Striga* control include uprooting, burning and manuring, which have proved to be ineffective. Alternative technologies exist but they have not been adopted and used as they should because the level of awareness is very low.

Analysis of the determinants of poverty revealed that the poverty status of a household in western Kenya is significantly related to *Striga* damage, *Striga* control, dependency ratio, age, education, technology adoption, land per capita, farm assets, off-farm work, cash crop production, and location.

More than 70% of the sampled households experience food shortage lasting as long as five months every year. Coping strategies include off-farm short-term jobs, disposal of assets, and informal safety nets especially through remittances received from relatives. The anthropometric Z scores calculated on children indicate that about 30% were wasting, 50% were underweight and 48% were stunted. Similarly, the results on body mass index (BMI) on women showed that 36% were underweight while 18% were overweight.

One of the possible strategies to reduce poverty and vulnerability is to increase the efficiency in maize production. Considerable variation in maize production efficiency was found among the sample maize farmers. The results point to the possibility of increasing maize production through improved efficiency and best local practices adopted

by the most efficient farmers in the sample, such as integrated *Striga* control. While technical efficiency increases with educational attainment, it has a significant non-linear relationship with farm size where it first increases but eventually declines with farm size. The direct farm size-efficiency relationship for smaller holdings coupled with the fact that most farmers in western Kenya cultivate tiny plots of land suggests that re-allocation of more land to maize would enhance farmer efficiency. Increased efficiency could be achieved through, for instance, more optimal application of inputs and greater intensity of adoption of improved maize varieties. Therefore, efforts must be made to enhance adoption of both hybrid maize and *Striga* control technologies to help increase maize production. Maize yields in Kenya have continued to decline despite increased use of new maize varieties, largely due to lack of effective *Striga* control technologies. Promoting both high-yielding varieties and *Striga* control technologies should thus be an important goal for research and extension in Kenya.

Chapter 1

Introduction

Background

Striga hermonthica is a root parasite that infects cereal and legume crops in Sub-Saharan Africa. It constitutes the most important biological constraint to cereal production and accounts for more than 50% of yield losses in the region. This yield loss affects the livelihood of about 300 million people in Sub-Saharan Africa (Lagoke et al., 1991; Parker, 1991). In Kenya, *Striga* infestation is most severe in Nyanza and Western provinces. The parasitic weed is found in about 75,000 hectares of farmland and results in crop losses estimated at about US$ 10–38 million per annum (Woomer et al., 2004).

Farmers in Kenya respond to the problem of *Striga* through various traditional control methods. These methods include use of manure, hand weeding, uprooting and burning of affected fields. However, research findings show that these methods are insufficient to eradicate *Striga* once it is well established on a field (Woomer et al., 2004). A new technology, Imazapyr resistant maize variety, was developed by the International Maize and Wheat Improvement Center (CIMMYT) and the German chemical company BASF. The African Agricultural Technology Foundation (AATF) in collaboration with other stakeholders such as the Western Regional Alliance for Technology Evaluation (WeRATE) and private seed companies are spearheading and facilitating the dissemination of Imazapyr-herbicide resistant maize variety (IR maize) in western Kenya.

Prior to the large deployment of the technology, a baseline study in support of the IR maize project was commissioned by AATF. The goal of the baseline study was to establish benchmark data against which changes brought about through the promotion of IR maize will be assessed and measured objectively in the future.

AATF contracted the International Institute of Tropical Agriculture (IITA) to lead the implementation of this baseline study, as part of a collaborative project between the two institutions.

This report presents the results of the baseline study that was undertaken to assess the status of *Striga* damage and the general livelihoods and livelihood strategies of the rural poor in western Kenya.

Methodology

Study area

The baseline study was implemented in Nyanza and Western provinces in Kenya where *Striga* is causing huge damage to the major staple, maize, for millions of smallscale farmers. Nyanza province occupies a total area of 12,547km^2 and a population of 4,392,196 persons as per the 1999 census or a population density of 350 persons/km^2, against 49 persons/km^2 for the country as a whole (Republic of Kenya, 2001). Western province also has a high population density of 406 persons/km^2 on a total area of 8,264km^2. These two provinces have the second highest population density after Nairobi province.

Nyanza province is divided into 12 districts, 70 divisions, 346 locations and 968 sub-locations while Western province is made up of 9 districts, 45 divisions, 204 locations, and 647 sub-locations. There were about 968,014 households in Nyanza in 1999 and 701,323 in Western (Ministry of Agriculture, 2004a and 2004b).

Sampling strategy

Two factors guided the sampling strategy for this baseline study: the importance of maize and the severity of *Striga* in maize production. Maize is grown in all the districts of the two provinces. Therefore, each district could be selected for this study. The rating of *Striga* infestation can be quantified as follows on the basis of seed banks (Dr George Odhiambo, personal communication) low: <1 million seeds/ha; moderate: 1–3 million seeds/ha; and high: >3 million seeds/ha. Using the above rating, experts identified all the districts or parts of districts in each province with high *Striga* infestation. Using an administrative map of Kenya, four districts with high ratings of *Striga* infestation on maize were purposively selected in each province on the basis of their geographic closeness in order to minimise the research cost given the limited resources. The Ministry of Agriculture was then asked to purposively choose in each district one division and then one location with high *Striga* infestation on maize. All the sub-locations in the chosen location were listed and two sub-locations were randomly selected; thus a total of 32 sub-locations for the two provinces. The extension agents of the Ministry of Agriculture, known as front-line extension workers (FEWs) in Kenya, who had received a prior special training during a methodology workshop were tasked to make the list of all the households within each sub-location from which they selected 25 households randomly.

Sample size

Eight districts out of a total of twelve districts were identified in Nyanza province. These districts had the highest *Striga* infestation. They were Bondo, Kisumu, Homa Bay, Migori, Siaya, Suba, Nyando and Rachuonyo. The four districts retained for this baseline survey and the number of randomly selected households were Bondo, Kisumu, Siaya and Nyando. In each district 100 households were randomly selected. However, in Bondo district the FEWs mistakenly selected two additional households, thus a total of 402 households.

Six districts out of a total of nine districts were selected in Western province. These districts had the highest *Striga* infestation. They were Bungoma, Busia, Butere/Mumias, Kakamega, Teso and Vihiga. The retained districts for this baseline survey were Bungoma, Busia, Teso and Vihiga. In each district 100 households were randomly selected, thus a total of 400 households.

The large sample size (802 households) was required as a result of the wide distribution of *Striga* across several zones in western Kenya and as a result of the high population density in the region. The selected villages and districts in the two provinces are shown in Figure 1.1.

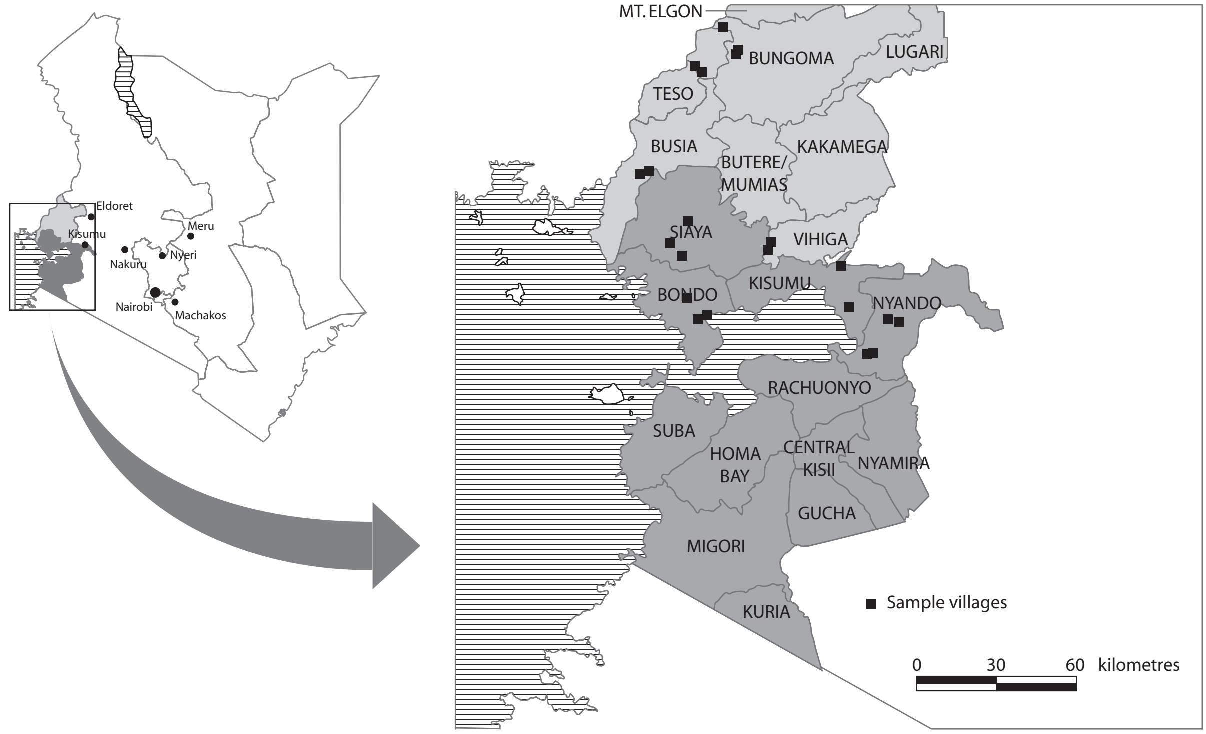

Figure 1.1. *GIS map showing sampled districts and villages in Nyanza and Western provinces*

Data collection and analysis

Data was collected between October 2005 and February 2006 by means of structured questionnaires administered with the assistance of the FEWs. Themes included in the questionnaire were related to household demographics; access to land, input use and crop production; decision-making process in farming; *Striga* and *Striga* control technologies; vulnerability; capital assets; and livelihood strategies and outcomes. In addition to survey questionnaires, each FEW received a United Nations Children's Fund

(UNICEF) weighing scale and a meter to take anthropometric measurements of children aged six years and below, and mothers. One agricultural officer per district was trained during the methodology workshop organised before the launching of data collection to supervise FEWs in his/her jurisdiction in an effort to ensure the quality of outputs of FEWs. The agricultural district officers were also trained in organising focus group discussions and in using GPS handsets to record the geo-referenced coordinates in each village. Descriptive Geographic Information Systems (GIS) and econometric models were used for data analysis.

Econometric models, discussed below, were developed and estimated for analyses of maize production efficiency and determinants of poverty.

Stochastic frontier analysis of maize production efficiency

Technical efficiency is defined as the ability of a firm to obtain maximum output from a given set of inputs. It is simply the ratio of the observed output to the corresponding potential or frontier output, conditional on the level of inputs. However, the frontier or frontier output is not observable and is estimated empirically from the best-practice production in the sample. The estimation of firm-specific technical efficiencies involves a comparison of actual levels of outputs to the estimated frontier output. The measurement of production efficiency has been an important topic in agricultural economics research because of its relevance for policy makers in showing whether it is possible to increase output by simply increasing farmer efficiency through effective extension and education programmes.

The methodologies for measuring production efficiency have evolved over the last several decades from deterministic frontier methods (Farrell, 1957), which attribute deviations from frontier output solely to technical inefficiency, to stochastic frontiers (Aigner et al., 1977; Meeusen and van den Broeck, 1977), which attribute deviation to both statistical noise and technical inefficiency. Aigner et al. (1977) and Meeusen and van den Broeck (1977) independently proposed the stochastic frontier production function to account for the presence of measurement errors and other noise in the data, which are beyond the control of firms. The (translog) stochastic frontier production function can be given by:

$$\ln Y_i = \beta_o + \sum_{k=1}^{K}\beta_k \ln(X_{ki}) + \frac{1}{2}\sum_{k=1}^{K}\sum_{j=1}^{K}\beta_{kj} \ln(X_{ki}) \ln(X_{ji}) + v_i - u_i \qquad (1)$$

Where: ln denotes the natural logarithms; Y is the quantity (or value) of agricultural output of the i-th farmer; X is a vector of the input quantities; β is a vector of parameters; $k = j = 1,\ldots,$ K are input variables; v is a random error term, assumed to be independently and identically distributed as $N(0, \sigma_u^2)$, independent of u, which represents technical inefficiency and is identically and independently distributed as a truncated normal, with truncations at zero of the normal distribution (Battese and Coelli, 1995). The maximum likelihood estimation of the production frontier yields estimators for β and γ, where $\gamma = \frac{\sigma_u^2}{\sigma^2}$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The parameter γ represents total variation of output from the frontier that is attributed to technical inefficiency and it lies between zero and one, that is $0 \leq \gamma \leq 1$. The closer γ is to one the greater the deviations of actual output from the frontier and hence the greater the technical inefficiencies.

Battese and Coelli (1995) proposed a model in which the technical inefficiency effects in a stochastic production frontier are a function of other explanatory variables. In their model, the technical inefficiency effects, u, are obtained by truncation (at zero) of the normal distribution with mean, μ_i, and variance, σ_u^2, such that:

$$\mu_i = Z_j{}'\delta \tag{2}$$

Where: Z is a vector of farm-specific explanatory variables, and δ is a vector of unknown coefficients of the farm-specific inefficiency variables. In this study, the Battese and Coelli (1995) model to estimate the efficiency scores and identify the socio-economic and institutional factors influencing the technical efficiencies of adopters of improved cowpea varieties in northern Nigeria has been applied.

The empirical stochastic frontier and inefficiency model

For the investigation of the farm-specific technical efficiencies of maize producers in western Kenya, the following translog stochastic frontier production function was estimated:

$$\begin{aligned}\ln(\text{maize output}_i) = {} & \beta_0 + \beta_1 \ln(\text{Land}_i) + \beta_2 \ln(\text{Labour}_i) + \beta_3 \ln(\text{Fertiliser}_i) + \beta_4 \ln(\text{Oxen}_i) \\ & + \beta_{12} \ln(\text{Land}_i) \ln(\text{Labour}_i) + \beta_{13} \ln(\text{Land}_i) \ln(\text{Fertiliser}_i) \\ & + \beta_{14} \ln(\text{Land}_i) \ln(\text{Oxen}_i) + \beta_{23} \ln(\text{Labour}_i) \ln(\text{Fertiliser}_i) \\ & + \beta_{24} \ln(\text{Labour}_i) \ln(\text{Oxen}_i) + \beta_{34} \ln(\text{Fertiliser}_i) \ln(\text{Oxen}_i) \\ & + \beta_{11} {}^1/_2 \ln(\text{Land}_i)^2 + \beta_{22} {}^1/_2 \ln(\text{Labour}_i)^2 + \beta_{33} {}^1/_2 \ln(\text{Fertiliser}_i)^2 \\ & + \beta_{44} {}^1/_2 \ln(\text{Oxen}_i)^2 + \alpha_1(\text{Hybrid}_i) + \alpha_2 (\textit{Striga}\text{ control}_i) \\ & + \alpha_3 (\text{Gender}_i) + \lambda_1 (\text{Kisumu}_i) + \lambda_2 (\text{Siaya}_i) + \lambda_3 (\text{Nyando}_i) \\ & + \lambda_4 (\text{Busia}_i) + \lambda_5 (\text{Teso}_i) + \lambda_6 (\text{Vihiga}_i) + \lambda_7 (\text{Bungoma}_i) + v_i - u_i\end{aligned} \tag{3}$$

The dependent variable is (log of) maize output in kilograms. There are three categories of independent variables. The first category includes conventional factors of production: land planted with maize in hectares, labour in man-days, fertiliser in kg, and oxen power in oxen-days. The second category includes adoption of hybrid maize (adopter = 1, 0 otherwise) and integrated *Striga* control (uprooting and burning = 1, 0 otherwise) to account for intercept shifts in the production frontier due to improved technology or innovative local practices. In order to account for possible gender yield differentials in frontier maize output in the form of an intercept shift of the frontier, a gender dummy variable was included (Gender = 1 if male headed household, 0 if female headed). The third category includes district dummies (relative to Bondo district) to account for the influence of land quality and agro-climatic variations on maize production. The error term, v, is the symmetric random variable associated with disturbances in production; and u is a non-negative random variable associated with technical inefficiency and is obtained by truncation (at zero) of the normal distribution with mean, μ_i, and variance σ_u^2, such that:

$$\mu_i = \delta_0 + \delta_1 (\text{Age}_i) + \delta_2 (\text{Age-squared}_i) + \delta_3 (\text{Education}_i) + \delta_4 (\text{Farm size}_i) + \delta_5 (\text{Farm size-squared}_i) + \delta_6 (\text{Off-farm work}_i) \quad (4)$$

Where: $\delta i,'s$ are unknown parameters to be estimated. Age and education are important human capital variables that determine the efficiency with which farmers use available resources. The effect of age is usually non-linear, and to account for this effect, both age and age-squared were included in the inefficiency model. Farm size was included to account for possible inverse relationships between farm size and technical efficiency. It is hypothesised in this study that the effect of farm size could be non-linear, and hence both farm size and farm size-squared were included. In view of considerable involvement of the sample farmers in off-farm work, an off-farm work dummy variable was included to test whether this complements (for example input purchases) or competes (for example family labour) with maize production.

The elasticities of mean output with respect to each of the inputs are defined by:

$$\frac{\partial \ln E(Y)}{\partial \ln X_k} \; \beta_k + \beta_{kk} \overline{\ln X_k} + \sum_{j=1 \neq k}^{4} \beta_{kj} \overline{\ln X_{kj}} \quad (5)$$

Significance tests on the estimated elasticities were conducted based on the standard errors derived using the delta method (Greene, 2000). The elasticities are evaluated at the means of the natural logarithms of the inputs.

Logistic regression model of determinants of poverty

Interventions aimed at reducing rural poverty should be guided by empirical evidence relating to the factors that condition poverty. A better understanding of what factors induce or reduce the prevalence and severity of poverty enables policy makers to design appropriate poverty reduction strategies with the necessary enabling institutional and policy environment.

In constructing the logistic regression model or logit model, it is assumed that the probability of being poor is determined by an underlying response variable that captures the true economic status of an individual household. For example let T be the observed poverty status of a household, which equals one if household is poor and zero if otherwise, and T^* be a latent variable reflecting the combined effect of the explanatory variables inducing or reducing poverty. The observed poverty status relates to the classification of the sample households into poor and non-poor based on whether they are below or above a poverty line of two-thirds of mean household income (World Bank, 1996). However, T^* is not observable and is related to the observed poverty status, T, as follows:

$$\begin{aligned} T^* &= \beta' X + \varepsilon \\ T &= T^* \text{ if } T^* > 0 \\ &= 0 \text{ if } T^* \leq 0 \end{aligned} \tag{6}$$

where X is a vector of explanatory variables, β is a vector of unknown parameters to be estimated, and ε is independently and normally distributed random error term. The probability that a given rural household is poor ($P(T = 1)$) can be defined as:

$$\text{Prob}(T = 1) + \Phi = \text{Prob}(\beta' X + \varepsilon > 0) = \frac{\exp(\beta' X)}{1 + \exp(\beta' X)} \tag{7}$$

The logistic regression model of poverty, in the form of the ratio of natural logarithm of the probability of being poor to the probability of being non-poor (that is log odds ratio), can thus be given as:

$$\ln\left[\frac{\Phi}{1 - \Phi}\right] = \beta' X + \varepsilon \tag{8}$$

Where: Φ is the conditional probability of being poor.

Finally, the marginal effect of a given explanatory variable, j, on the probability of being poor for household i is given by:

$$\frac{\partial \Phi_i}{\partial X_{ij}} = \Phi_i(1 - \Phi_i)\beta_i \tag{9}$$

The choice of variables that induce or reduce poverty was made based on theoretical and empirical work in this area. Drawing on the sustainable rural livelihoods framework, a number of critical livelihood assets were hypothesised to influence poverty in western Kenya. These included: (1) human capital assets such as age, household headship, dependency ratio and education; (2) productive assets such as land, livestock and other farm assets; (3) financial capital such as access to credit, off-farm employment and cash crop production; (4) technology variables such as adoption of hybrid maize; (5) market access; (6) level of production risks such as *Striga* damage on maize yields; and (7) differences in agricultural production potentials among districts.

Outline of the report

This report presents empirical results from preliminary analyses for both Western and Nyanza provinces. Chapter one gives an introduction (background and methodology) to the study. Chapter two describes the characteristics of households and their livelihood assets. Land allocation to crops, their production and productivity, and gender roles in farming are discussed in chapter three. Chapter four dwells on the *Striga* problem and technologies available for its control. Chapter five presents livelihood outcomes including household income, poverty, vulnerability and anthropometric measurements of vulnerable groups. It also presents and discusses the results of the logit model of determinants of poverty, whereas maize production efficiency measures and determinants are presented in chapter six. Policies and issues on institutional arrangements are addressed in chapter seven using the farmers' perspectives. Chapter eight gives a summary of findings and draws recommendations.

Chapter 2

Socioeconomic Characteristics of Households and Livelihood Assets

Socioeconomic and demographic characteristics of households

Demographic and socioeconomic characteristics play a key role in determining the livelihoods of rural people. In this study, more male-headed households fell in the sample selected and they form an average of about 72%. There were more female-headed households in Nyanza province than in Western province. The highest number of female-headed households was found in Siaya district of Nyanza province, probably due to high incidence of HIV/AIDS and out-migration of youths. Although most household heads had attended school, the average number of years of schooling is low. It is even lower for female-headed households (3.5 years) compared to male-headed households (7 years). As expected, the dependency ratio shows that there is about an equal number of dependents (children below 15 years old and adults above 64 years old) compared to adults ($\geq$ 15 years and $\leq$ 64 years old) in the two provinces. Other socioeconomic characteristics of the respondents show that Nyanza was behind Western in many indicators (Table 2.1).

Table 2.1. Demographic and socioeconomic characteristics of the sample households

	All	Nyanza	Western
N	802	402	400
Male household head (%)	74.1	71.9	76.3
Age of household head (years)	51	51.8	50.1
Household size (number)	5.8	5.5	6.2
Dependency ratio	0.92	0.90	0.94
Attended school for household head (%)	83.0	79.9	86.5
Years of schooling of head	6	5.5	6.8
Years of schooling for household members	4.4	4.4	4.6

N = Number of respondents

Livelihood assets

The baseline study applies the sustainable rural livelihoods framework (SRLF) by considering five types of capitals upon which people build their livelihoods. These are natural, financial, physical, human and social. The benchmark indicators on the five capitals are described below.

Natural capital

Land is by far the major natural capital for smallholders in western Kenya. Holdings are very small in size, 1.3ha on average. The smallest farm size was found in Kisumu district (0.52ha) and the largest in Busia district (2ha). The major land tenure systems are private ownership and land with use right only for both the proportion of land (85%) and number of households (Table 2.2). In Western province, 11% of land was gifted land. The gender analysis of land use system shows that similar patterns in land acquisition modes were found for both male and female headed-households (Figure 2.1).

Table 2.2. Land tenure

	All	Nyanza	Western
Total farmland (ha)	1.31 (802)	1.25 (402)	1.37 (400)
Private (titled) land (% of total farmland)	52.8 (468)	58.9 (260)	46.9 (208)
Land with use right only (% of total farmland)	32.2 (281)	27.9 (123)	36.5 (158)
Rented in land (% of total farmland)	5.7 (96)	6.4 (52)	4.9 (44)
Sharecropped land (% of total farmland)	0.7 (17)	1.4 (16)	0.1 (1)
Borrowed land (% of total farmland)	2.5 (53)	4.4 (44)	0.6 (9)
Gifted land (% of total farmland)	6.1 (56)	1.0 (10)	11.0 (46)
Total percentage	100	100	100

Figures in brackets indicate number of valid entries in analysis

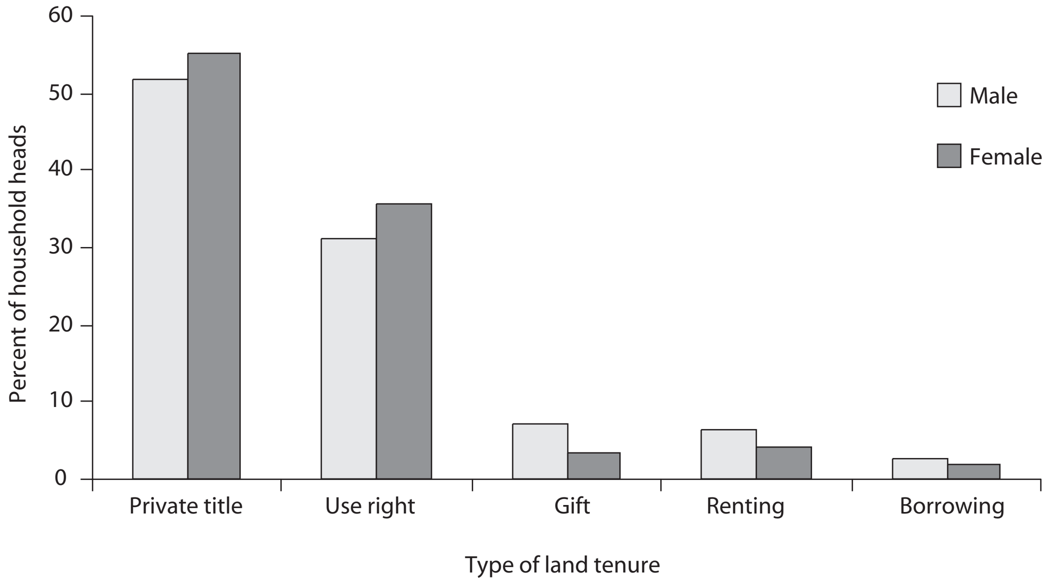

Figure 2.1. *Mode of land acquisition in western Kenya*

The analysis on land utilisation indicates that 68% of total farmland is allocated to annual crops (Table 2.3). 29.6% is allocated to perennial crops, grazing, fallow and rented/given out. Smallholders in Western province cultivate more perennial crops than the ones in Nyanza. In both provinces, fallow land is very small, which could lead to problems of soil fertility because of continuous cropping in the absence of soil fertility amendments. In fact, low soil fertility was ranked second as the major cause of food shortage in both provinces next to *Striga*.

Table 2.3. Land utilisation

	All	Nyanza	Western
Total farmland (ha)	1.31 (780)	1.25 (389)	1.37 (391)
Annual crops (% of total farmland)	68.0 (770)	70.5 (384)	66.0 (386)
Perennial crops (% of total farmland)	12.1 (366)	6.6 (95)	17.3 (271)
Grazing (% of total farmland)	8.9 (237)	11.6 (116)	6.0 (121)
Fallow (% of total farmland)	8.8 (230)	9.6 (107)	8.1 (123)
Rented/given out (% of total farmland)	2.2 (62)	1.7 (24)	2.6 (28)
Total percentage	100	100	100

Figures in brackets indicate number of valid entries in analysis

Financial capital

Financial capital includes cash and cash-related property. It is a form of asset that can contribute to both production and consumption in the household.

Remittances appear to be the commonest form of financial capital for the respondents, followed by informal credit and cash savings (Figure 2.2). Other forms of financial

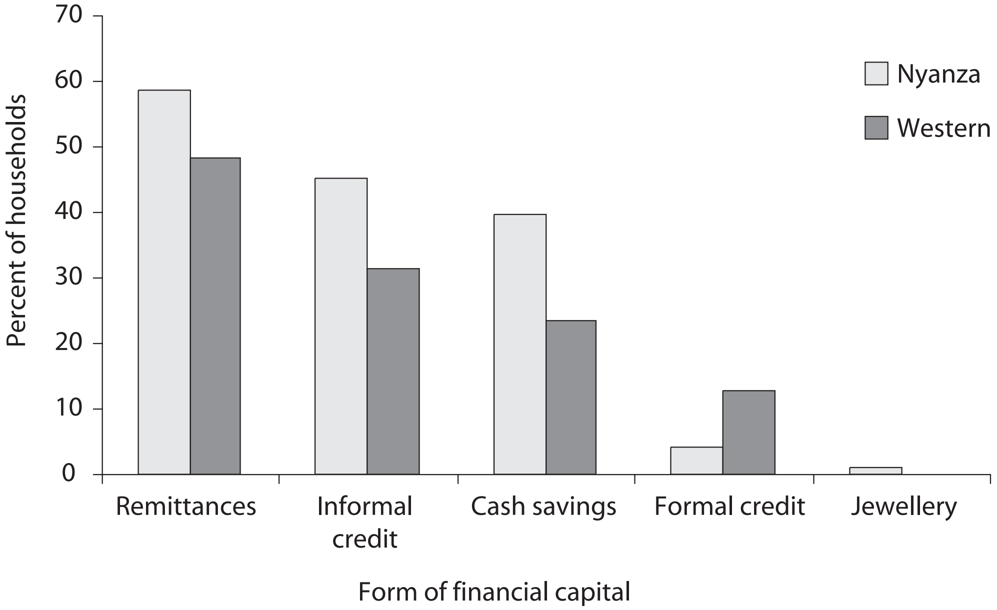

Figure 2.2. *Major forms of financial capital in two provinces of western Kenya*

capital, which are not very common in the area, are formal credit and sales of jewellery. In Bondo and Nyando districts no respondent kept financial capital in form of jewellery and less than 50% of respondents obtain remittances.

Smallholders often maintain stocks of animals they can rely on in periods of scarcity. These non-working livestock are life-supporting assets to the poor. They form part of the financial capital that enhances the quality of life as they have the potential to generate quick cash to owners when there is an urgent need for money; they can feed humans with meat/milk and add manure to the soil. They are also a source of security to the smallholders who depend heavily on such assets during periods of unexpected partial or total crop failure. In addition, they are symbols of social recognition.

The most common types of livestock assets are small ruminants and poultry (Table 2.4). In both provinces, results indicate that the number of non-working animals was higher in male than in female-headed households. Female-headed households are at risk since their safety nets are very limited.

Table 2.4. Financial capital – non-working livestock (means)

Type	Nyanza	Western
Goats	4.24 (232)	3.2 (187)
Sheep	4.78 (128)	2.3 (84)
Pigs	6.0 (2)	2.2 (36)
Poultry	11.32 (359)	12.9 (348)
Calves	1.98 (194)	1.7 (144)
Rabbits	5.33 (3)	7.3 (10)
Doves	7.18 (11)	10.5 (38)

Figures in brackets represent number of respondents

Physical capital

Physical capital comprises the basic infrastructure required to support livelihoods in a given environment (rural or urban). These basic infrastructure include adequate water supply, sanitation, environmentally friendly sources of energy, secure shelter, access to transportation and communication facilities.

The major sources of water in Nyanza are rain water (59.4% of households), borehole (36.1%), and unprotected wells/springs (23.1%). The proportion of households relying on rain water goes up to 86.7% of households in Kisumu district and 69% for Siaya in Nyanza. In contrast, the major source of water in Western is protected well/spring for 68% of households (with 99% in Vihiga district). Piped water is not common in all the villages surveyed (<10% of households). Toilet facilities include covered (44.3% of households for Nyanza and 70.6% for Western) and uncovered (31.2% of households for Nyanza and 23.9% for Western) pit latrines. About 25% of households in Nyanza and 5% in Western still use the bush as a toilet facility.

Regarding modern sources of light, only 2% of households in Western and 1.3% in Nyanza have access to electricity. The major type of lighting is paraffin/kerosene (>98% of households). Firewood remains the major cooking fuel for all sampled households. Some of them combine firewood with charcoal (32% for Nyanza and 16% for Western). Other sources of cooking energy are marginal such as gas, electricity, biogas, solar and paraffin/kerosene. A large majority of households have access to health centres/hospital (84% for Nyanza and 94% for Western), own bicycles (61% for Nyanza and 56% for Western), own or have access to mobile phones (83% for Nyanza and 59% for Western). Very few have motor cycles (<1.5%) or own vehicles (<2%) in either province.

The other indicator of wealth under physical capital is the type of housing. Two types of house roofs were identified: iron sheets (78% for Nyanza and 63% for Western) and thatched (22% for Nyanza and 37% for Western). Other types of house roofs are not used at all such as asbestos, tiles, tin or cement. The house wall was made of mud and poles essentially (87% for Nyanza and 80% for Western). Burnt bricks were found in 6.5% of households in Nyanza and 9% in Western. The house floor was made of earth and cow dung for 80% of households in Nyanza and 74% in Western. 17% of households in Nyanza had cemented floor. This figure was slightly higher at 26% in Western.

Other physical capital recorded in the households include working animals (oxen/bulls, donkeys and cows) and agricultural tools (hoes, axes, slashers, machetes, wheel-barrows, ploughs, sprayers, accessorily carts and irrigation pumps). No tractors were recorded.

In summary, the analysis on physical capital, which are often used as social indicators of wealth, show that the sampled households are poor though households in Western seem to be less poor than those in Nyanza.

Human capital

In traditional agriculture such as the one common in western Kenya, household labour endowment is an important factor when a new technology is to be introduced into an area. Availability of labour is one of the determining factors if a household is going to participate in the testing/adoption of a new technology. In the absence of sufficient family labour, the cost of hiring labour or opportunity cost of labour can hinder adoption and promotion of new agricultural technologies.

The potential labour available during one agricultural year (254 days) is shown in Figure 2.3. It is based on the average number of adult equivalents. Western province

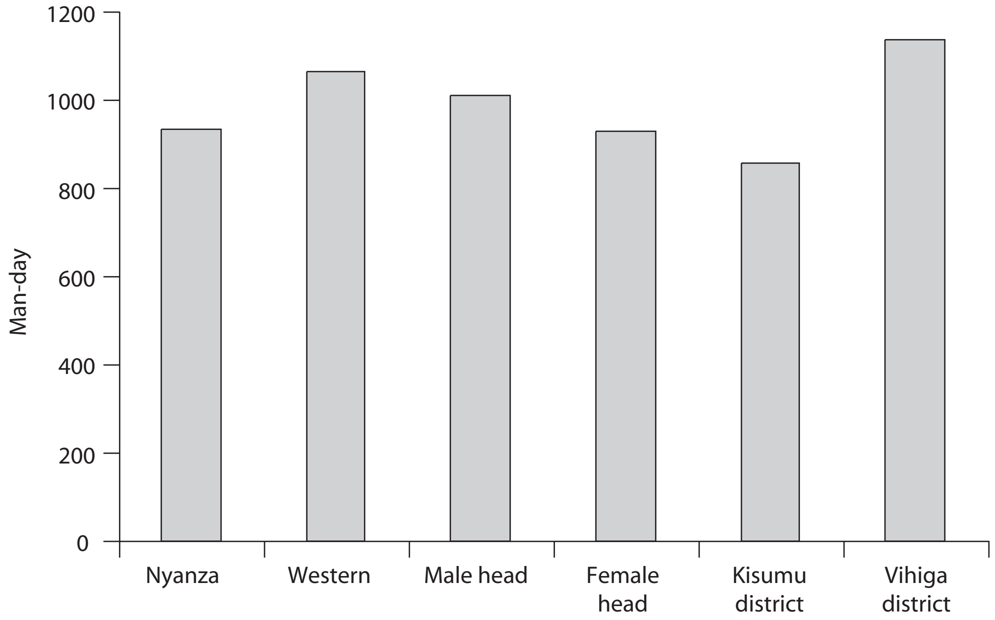

Figure 2.3. *Household labour endowment during one agricultural year*

has more labour available than Nyanza. Female-headed households are less endowed with family labour in both provinces. Across the eight districts, the number of adult equivalents was smallest in Kisumu district and highest in Vihiga.

Another interesting parameter on human capital is the education level of household members: the higher the level of education, the higher the probability of adopting new innovations. The level of education is low in western Kenya, though better in Western province compared to Nyanza province (Table 2.1).

Extension services play a major role in building the knowledge stock of farming communities. They help farmers to translate research results into improvement in livelihoods. Visits by extension agents to farmers and participation of the latter in field days, seminars or agricultural shows are cost effective ways of reaching out with the new agricultural practice or technology to a large number of farmers. About 25% of male-headed households declared receiving at least one visit by extension agents (Table 2.5). The proportion is lower for female-headed households because extension agents are often male and their first contact is with male farmers. The extension services in Nyanza seem to perform better than those in Western as the proportion of households visited by extension agents is higher.

Table 2.5. Human capital – extension visits (% of households)

	Male Headed Households			Female Headed Households		
	All	Nyanza	Western	All	Nyanza	Western
Extension visits	27.1 (587)	35.8 (285)	18.9 (301)	21.0 (205)	25.9 (112)	15.1 (93)
Attend field days/ seminars/agricultural shows and tours	25.9 (590)	28 (286)	20.1 (303)	14.8 (203)	13.5 (111)	16.3 (92)

Figures in brackets indicate number of valid entries in analysis

Social capital

Members of a community rely on a network of social relationships that provide safety nets to their livelihoods. For example it was shown how farmers rely on relatives to survive in rural areas through remittances.

In farming communities, membership in community associations offers tremendous opportunities to boost agricultural production by providing various forms of support to farmers. The respondents pointed out that they belong to diverse community associations. Some respondents belong to only one association while others belong to more than one association.

Overall, a large number of respondents belong to religious groups, women's groups and community development groups (Table 2.6). Membership into community development groups in Western province might be a response to the weakness of official extension services. Also in districts where most of the social indicators were poor, memberships in religious groups was found to be very high such as in Kisumu district (99% of households) and Siaya district (85%).

Table 2.6. Social capital – membership into community associations

	Nyanza	Western
N	375	400
Community development (%)	29.1	33.0
Cooperative association (%)	6.1	4.8
Religious group (%)	66.9	50.3
Credit and savings group (%)	4	5.7
Informal insurance (%)	3.2	1.5
Women groups (%)	52	37.8
AIDS groups (%)	1.9	2.7

N = Number of respondents

Chapter 3

Crop Production and Productivity

Land allocations to crops

Maize, beans and sorghum are popular in the cropping system of western Kenya. Maize was grown by more than 96% of respondents, beans by 56% and sorghum by about 51%. Others were cassava (37%), groundnut (13%), cowpea (8%), millet (6%) and soybean (5%). In terms of area cultivated, the major crops in their decreasing order of importance were maize, beans, sorghum, cassava, millet, groundnut, cowpea and soybean (Table 3.1).

Table 3.1. Land allocation to crops (ha)

	Long rains 2005			Short rains 2004		
	All	Nyanza	Western	All	Nyanza	Western
N	802	402	400	802	402	400
Local maize (sole)	0.08	0.10	0.06	0.07	0.08	0.05
Hybrid maize (sole)	0.03	0. 01	0.05	0.02	0.01	0.03
IR maize (sole)	0	0	0	0	0	0
Maize (sole)	0.11	0.11	0.11	0.09	0.09	0.08
Local maize (intercropped)	0.19	0.21	0.18	0.12	0.11	0.13
Hybrid maize (intercropped)	0.08	0.05	0.10	0.02	0.03	0.02
IR maize (intercropped)	0	0	0	0	0	0
Total maize (sole and intercropped)	0.38	0.37	0.39	0.23	0.23	0.23
Beans (sole)	0.01	0.01	0.01	0.09	0.04	0.14
Beans (intercropped)	0.11	0.07	0.15	0	0	0
Beans (total)	0.12	0.08	0.16	0.09	0.04	0.14
Cowpea	0.01	0.01	0.004	0.01	0.01	0.004
Soybean	0.01	0.04	0.01	0.003	0.002	0.004
Sorghum	0.15	0.26	0.04	0.01	0.004	0.01
Groundnut	0.02	0.02	0.02	0.04	0.004	0.003
Millet	0.02	0.002	0.04	0	0	0
Cassava	0.09	0.06	0.13	0.02	0.03	0.02
Total area	0.80	0.842	0.794	0.40	0.32	0.411

While all the crops are grown with the same relative importance in both provinces, sorghum is predominant in Nyanza. The same crops are also grown during the two cropping seasons: long rains and short rains (except for beans that were grown mostly during the long rains). However, the total area cultivated during the short rains is smaller than the average area during the long rains.

Maize, the main crop, occupies 0.38ha on average per household, or about 42% of the total area cultivated during the long rains. This proportion was higher during the short rains (71%). Farmers grow local varieties of maize and "hybrid" (improved varieties). The area cultivated to local varieties is larger.

The common cropping pattern is intercropping crops of different types. Intercropping represents 71% of area for maize and about 50% for beans.

The area cultivated to annual crops for female-headed households was about 20% less than that of the male-headed households. However, similar crops are found for both categories of household heads.

Intensification of agriculture

The analysis on intensification refers to the use of inputs (chemicals and seed) and power from family members and from animals within the farming system.

Fertiliser and pesticides

Farmers apply inorganic fertiliser and pesticides to their crops, especially maize. Results in Table 3.2 indicate that few respondents used inorganic fertiliser during the two growing seasons under study. In Nyanza province, only eight farmers reported on fertiliser application during the 2005 long rains. More farmers (25%) in Western province applied fertiliser to their maize. During the short rains, fewer farmers invest in inorganic fertiliser. The rates of fertiliser applied to maize are also very low: about one 50 kg-bag per ha for Nyanza and two 50-kg bags for Western during the long rains. These quantities would correspond to about 13kg N/ha for Nyanza and 26kg N/ha for Western for the most commonly commercialised compound fertiliser, Calcium Ammonium Nitrogen (CAN) in the ratio 26:0:0. Maize often requires rates of 90 to 120kg N/ha to expect good yields of about 4–6tonnes/ha. The quantities applied in western Kenya are just symbolic. The quantity of fertiliser applied to other crops is even worse than that of maize.

Table 3.2. Fertiliser and pesticide use in western Kenya

	Long rains 2005		Short rains 2004	
	Nyanza	Western	Nyanza	Western
Inorganic fertiliser in maize (kg/ha)	53.3 (8)	97.0 (109)	38.8 (4)	84.0 (61)
Inorganic fertiliser in other crops (kg/ha)	34.6 (8)	55.1 (22)	32.6 (10)	22.0 (10)
Pesticide in maize (l/ha)	3.7 (10)	0.9 (30)	0.9 (7)	0.2 (14)
Pesticide in other crops (l/ha)	1.4 (26)	2.3 (43)	1.2 (21)	3.1 (31)

Figures in brackets represent number of respondents

The proportion of farmers who applied pesticides in post harvest to protect the produce (such as Skana or Spinto dust against weevils in maize grains) is also minimal. In contrast to fertiliser rates for maize, the doses used for pesticides seem to be optimal (at least for the 2005 long rains), provided that the information given refers to the pure chemical before its dilution. In summary, there is little done to invest in external inputs for the purpose of the intensification of crop production.

Seed use

The results are shown for Nyanza province only (Table 3.3) since the patterns in seed use for Western province are similar. Quantity of seed used (kg/ha) does not often comply with the recommendations by extension services. For maize, the provincial average of 34kg/ha during the 2005 long rains is higher than 25kg/ha recommended for this crop. In Siaya, the quantities sown for maize were almost double the recommendations. In Kisumu, it was the opposite with less than 50% of recommendations. The comments made for maize also apply to other crops (Table 3.3). This shows that farmers do not sow the quantities of seed required to obtain an optimal occupation of the field by the crop. A lower density of plants does not pay back on the investments made to open up a new field and to optimise the utilisation of soil nutrients by crops. A higher density leads to overexploitation of natural resources and competition of crops. In both situations, the resulting crop productivity can only be low. The field management of a new crop technology (such as IR maize) is as important as the genetic material itself.

Table 3.3. Seed use in Nyanza

	Long rains 2005					Short rains 2004				
	All	Bondo	Kisumu	Siaya	Nyando	All	Bondo	Kisumu	Siaya	Nyando
Maize seed (kg/ha)	34.3 (367)	29.5 (99)	25.5 (87)	50.8 (96)	30.1 (85)	30.5 (135)	31.6 (42)	11.8 (32)	40.2 (55)	33.3 (6)
Bean seed (kg/ha)	11.8 (4)	0	18.3 (2)	5.6 (1)	5 (1)	4 (1)	0	0	4 (1)	0
Sorghum seed (kg/ha)	16.1 (200)	12.4 (73)	8.7 (21)	24 (67)	13.5 (39)	5.3 (6)	2 (1)	3 (2)	8 (3)	0
Millet seed (kg/ha)	0	0	0	0	0	0	0	0	0	0
Soybean seed (kg/ha)	0	0	0	0	0	6.7 (5)	0	0	6.7 (5)	0
Ground-nut seed (kg/ha)	27.1 (3)	39.4 (2)	0	0	2.5 (1)	8 (3)	0	6 (2)	12 (1)	0
Cowpea seed (kg/ha)	10 (2)	0	0	0	10 (2)	4.5 (6)	0	2 (1)	5.3 (4)	4 (1)

Figures in brackets represent number of respondents

Labour use

Family labour represents the major source of power in the studied systems. Occasionally, farmers make use of oxen power input (Table 3.4). There was no much difference in the use of oxen input between the two provinces in the two seasons. Family labour use in maize as well as in other annual crops was also similar between the two provinces during the long rains. The difference in the use of family labour was noticeable only for the short rains season, where households in Western used more labour. This could be because of differences in the duration of the short rains between the two provinces. The short rains season is longer in Western (a highland belt) than Nyanza.

Table 3.4. Labour use in western Kenya

	Long rains 2005		Short rains 2004	
	Nyanza	Western	Nyanza	Western
Labour input in maize (MD/ha)	57 (337)	61 (328)	40 (217)	59 (243)
Oxen power input in maize (Oxen-days/ha)	13 (95)	9 (163)	7 (87)	6 (85)
Labour input in other annual crops (MD/ha)	56 (348)	69 (304)	37 (250)	58 (292)
Oxen power input in other annual crops (Oxen-days/ha)	10 (279)	10 (163)	7 (173)	7 (130)
Labour input in perennial crops (MD/ha)		0	63 (52)	64 (64)

Figures in parentheses represent number of respondents, MD = Man-day

Crop productivity

Smallholders cultivate several crops in their systems. The productivity of the different crops is shown in Table 3.5 for the short rains in 2004 and the long rains in 2005.

In general, the productivity of all crops was higher in Western compared to Nyanza, and in the long rains season compared to the short rains season. Hybrid maize yielded higher returns to land compared to local maize. Fitting maize in the farmers' scale of *Striga* infestation on maize, the calculated average maize yields would correspond to a moderate level of *Striga* infestation. Unexpected are the very low yields for cassava of less than 3tonnes/ha while this crop could yield up to 10tonnes/ha in the study region. The reasons could be in the high incidence of pest and diseases in the sampled villages and low stands of cassava in the intercropping of maize/cassava. The other reason could be that cassava is not harvested at once as it is often done for cereals and grain legumes.

Table 3.5. Crop productivity (kg/ha)

Crop	Long rains 2005			Short rains 2004		
	All	Nyanza	Western	All	Nyanza	Western
Local maize	777.4 (573)	632.3 (295)	931.3 (278)	648.3 (430)	599.5 (189)	686.5 (2410)
Hybrid maize	1271.4 (151)	681.9 (43)	1506.1 (108)	829.7 (63)	780.5 (19)	850.9 (44)
Beans	567.7 (14)	281.3 (04)	682.3 (10)	499.4 (62)	236.4 (02)	508.2 (60)
Sorghum	705.3 (308)	665.7 (215)	796.8 (93)	496.8 (19)	589.4 (04)	472.2 (15)
Millet	506.4 (47)		506.4 (47)			
Soybean	478.1 (32)	314.6 (06)	515.8 (26)	400.8 (11)	183.3 (03)	482.3 (08)
Groundnut	748.8 (92)	947.9 (24)	678.4 (68)	1780.4 (45)		1780.4 (45)
Sunflower	358.1 (03)		358.1 (04)	460.3 (08)		460.3 (08)
Cassava	1894.8 (113)	2990.0 (17)	1700.9 (96)	2692.3. (20)	2233.1 (12)	3381.9 (08)
Sweet potatoes	2801.7 (131)	1991.0 (18)	2930.9 (113)	2471.8 (163)	1784.7 (46)	2741.9 (117)

Figures in brackets indicate number of valid entries in analysis

Gender roles in household decision making

Documenting gender roles in the household decision making process is important in a baseline study before a new technology is deployed in a rural area. An understanding of the role of household members in making decisions about the utilisation of resources could guide the design of appropriate strategies for the introduction of a new technology. How household members decide on the disposal of benefits from agriculture is important as well in order to predict who among the household members the new technology would benefit most.

About the utilisation of resources, questions were related to choices of crops to bring into the family system, selection of crop varieties to grow, planting of a new crop, purchase of improved seed, and allocation of family labour to crops. On the disposal of benefits, issues were related to decisions on selling maize, control over income from maize, and control over income from other sources.

Results on the control over resources appear in Table 3.6. The household head plays a critical role in the utilisation of the five parameters considered for the household decision making process. That role is stronger in Western province than in Nyanza province. Of the five parameters, the weak position of the household head could be found in the allocation of labour from the household members. In this case, some type of negotiation would be required for the head to get cooperation from other members of the household.

For the female-headed households, the role of the head is even more pre-eminent, often above 85% of responses. Children seem not to be involved (according to the respondents) about the utilisation of the household resources. One would expect their role to be important in the female-headed households. However, the number of responses in favour of children in that type of households reached a maximum of 2.1%.

Table 3.6. Gender roles in decision making on the control over resources (% of respondents)

	Crops to plant		Variety to grow		Planting of a new crop		Purchase of improved seed		Allocation of family labour	
	Ny	We	Ny	We	Ny	We	Ny	We	Ny	We
N	402	400	399	400	398	400	398	400	400	400
Head alone	46.4	64.5	47.4	65.4	49.5	65.8	52.8	71.2	46.3	56
Spouse alone	14.8	13.0	15.5	11.8	15.1	12.7	14.6	9.8	15.3	19.5
Jointly (head and spouse)	38.6	22.5	36.8	22.8	34.9	21.2	32.2	18.5	38.3	24
Children	0.3	0	0.3	0	0.5	0.3	0.5	0.5	0.3	0.5

N = Number of respondents; Ny = Nyanza, We = Western

Results on the control of benefits appear in Table 3.7. The role of the household head has been reduced tremendously. The spouse has increased in importance about the disposal of benefits, probably because women are often in charge of sale of the farm products. This is confirmed for female-headed households where the head alone decides (more than 90% of respondents). Children are not involved by their parents on the utilisation of benefits.

Table 3.7. Gender roles in decision making on the control of benefits (% of respondents)

	Selling of maize		Use of income from maize		Use of other incomes	
	Nyanza	Western	Nyanza	Western	Nyanza	Western
N	330	400	326	400	237	400
Head alone	38.8	50.3	43.3	50.9	52.7	51.4
Spouse alone	25.5	27.8	20.9	26.3	24.9	31.7
Jointly (head and spouse)	35.5	21.9	35.6	22.4	21.9	16.6
Children	0.3	0	0.3	0.4	0.4	0.4

N = Number of respondents

Chapter 4

Striga and *Striga* Control Technologies

Maize production and post harvest constraints

Farmers in western Kenya are faced with a number of constraints in the production of maize. These include *Striga*, stalk borer, storage insects, low and erratic rainfall, low soil fertility and inadequate input supply (Table 4.1a). *Striga* was cited by almost all the households, followed by low soil fertility, low and erratic rainfall, stalk borer

Table 4.1a. Maize production and post harvest constraints (% of respondents)

	All N = 802	Nyanza N = 402	Western N = 400
Striga (%)	93.3	93.7	93.0
Stalk borer (%)	72.6	80.3	64.8
Storage insects (%)	69.3	60.9	77.6
Low and erratic rainfall (%)	85.1	98.2	71.8
Low soil fertility (%)	86.5	85.8	87.2
Inadequate input supply (%)	51.5	59.4	42.4

N = Number of respondents

and inadequate input supply. In terms of severity, both male and female-headed households (more than 50%) ranked *Striga* as the major constraint to maize production (Table 4.1b). The second most severe problem was low and erratic rainfall, whereas the third was inadequate input supply. There were differences in ranking per province.

Table 4.1b. Rank 1 of maize production and post harvest constraints

	Male headed households			Female headed households		
	All	Nyanza	Western	All	Nyanza	Western
Striga (%)	52.3 (560)	33.3 (273)	70.5 (288)	51.3 (189)	34.0 (106)	72.6 (84)
Stalk borer (%)	2.3 (428)	3.4 (232)	1.0 9 (197)	2.6 (151)	2.2 (91)	3.3 (60)
Storage insects, eg Osama (%)	3.8 (420)	2.2 (181)	5.0 (240)	3.0 (134)	3.0 (67)	2.9 (68)
Low and erratic rainfall (%)	27.3 (480)	42.1 (278)	6.9 (203)	28.0 (186)	43.1 (109)	6.5 (77)
Low soil fertility (%)	11.1 (512)	3.7 (246)	18.0 (267)	12.1 (174)	5.3 (94)	20.0 (80)
Inadequate input supply (%)	12.2 (288)	11.0 (173)	13.9 (115)	8.6 (93)	6.3 (64)	16.7(30)

Figures in brackets indicate number of valid entries in analysis

Striga was still the number one constraint for Western province while for Nyanza it was low and erratic rainfall. Probably, the reason for the high ranking of this climatic factor in Nyanza was because the survey was conducted at the period when there was a severe drought in some districts of Nyanza. Soil fertility was the second major constraint in Western, and consequently the inadequacy of input supply was also important in Western.

Perception of *Striga* as a problem to households

The perception of *Striga* as a problem to households can be addressed through its depressive effects on maize yields. Respondents had the correct perception about the damage *Striga* could cause to maize yield. In maize fields that are not infested by *Striga*, farmers would expect an average maize yield of 1,482kg/ha in Nyanza. In fields moderately infested by *Striga*, the expected yield is about 750kg/ha, and only 317kg/ha in situations where there is high *Striga* infestation. The corresponding figures for Western are 1,788kg/ha, 891kg/ha and 425kg/ha respectively. In general, farmers in Western expect to achieve higher maize yields compared to those in Nyanza. These patterns are similar for both male and female-headed households (Table 4.2). The female respondents gave higher figures of maize yields compared to the male respondents. Female farmers are often in charge of the harvesting of crops, therefore, their perception of effects of *Striga* on maize yield could be more accurate than that of their male counterparts.

Table 4.2. Effects of *Striga* on maize yield (kg/ha)

	Male headed households			Female headed households		
	All	Nyanza	Western	All	Nyanza	Western
No *Striga* infestation	1566.4 (562)	1434.9 (278)	1697.8 (283)	1819.3 (197)	1606.6 (106)	2067.0 (91)
Moderate *Striga* infestation	796.2 (557)	726.1 (275)	866.8 (281)	883.03 (194)	811.9 (105)	966.9 (89)
Very high *Striga* infestation	355.04 (483)	299.6 (242)	411.9 (240)	410.4 (174)	362.9 (94)	466.2 (80)

Figures in brackets indicate number of valid entries in analysis

Striga has become a major scourge to farmers' livelihoods in the last three decades (Table 4.3). Farmers could not give a plausible explanation on why the witch weed has become so harmful to their livelihoods in recent years. It could be that a change in the environment has contributed to this increased severity of *Striga* or that maize varieties grown have shown little adaptation to the weed. These speculations need to be confirmed or rejected by more indepth studies.

Table 4.3. Perception on increase in *Striga* as a problem to households

	Nyanza	Western
N	402	400
2001 and beyond	23.3	29.7
1976 – 2000	46.5	63.8
1951 – 1975	8.1	6.2
1926 – 1950	2.4	0.0
1900 – 1925	0.4	0.3

N = Number of respondents

Traditional methods of *Striga* control

There are three traditional methods of *Striga* control in western Kenya: uprooting of *Striga* plants, burning of dry *Striga* plants and manuring (Table 4.4). Uprooting of *Striga* appears to be the most common (more than 80% of respondents). Manuring is second while burning appears to be an uncommon control method.

Striga causes damage to the crop when still underground. Uprooting the plant when it is visible above ground would not prevent any depletion of maize yield. If done consistently and before flowering, uprooting could contribute to reducing the *Striga* seed bank in the soil. Unfortunately, this operation of uprooting is not done by all the farmers and in a consistent manner. Therefore, it is not efficient for the control of *Striga*. Manuring increases the nutrients in the soil for a crop to grow well. A well-fed crop has more resistance to biotic and abiotic stresses. However, manuring of a soil does not reduce the *Striga* seed bank, therefore, it is not an efficient method to control *Striga*. Burning of *Striga* has similar effects like uprooting, thus an inefficient method. In summary, the traditional methods are inefficient for sustainable control of *Striga*.

Table 4.4. Traditional methods of *Striga* control

	Nyanza	Western
N	402	400
Uprooting (%)	82.3	86.0
Burning (%)	8.2	12.3
Manuring (%)	15.7	35.5

N = Number of respondents

Awareness of modern *Striga* control technologies

There are several modern technologies available for the control of *Striga*. The most prominent being made available to farming communities in western Kenya are: the push-pull (or maize–Desmodium strip cropping), intercropping of legumes followed by cassava intercropped with Desmodium, *Striga* resistant maize with legumes intercropped, and *Striga* resistant maize without legumes intercropped. Results showed that only few respondents are aware of the various *Striga* control technologies. In the entire western Kenya and for both male and female headed households, less than 5% of respondents (except for the push-pull technology with a higher percentage but still below 10%) were aware of these technologies (Table 4.5).

The results in Table 4.5 show that this baseline study is timely before the large deployment of IR maize in western Kenya.

Table 4.5. Awareness of *Striga* control modern technologies

	Male headed households			Female headed households		
	All	Nyanza	Western	All	Nyanza	Western
IR maize variety (*Ua Kayongo*)	1.9 (593)	2.1 (288)	1.6 (304)	1.0 (208)	0.0 (113)	0.0 (113)
Striga resistant maize with legumes	3.9 (594)	3.5 (288)	4.3 (305)	2.4 (203)	1.8 (113)	1.8 (111)
Striga resistant maize without legumes	2.5 (593)	2.4 (287)	2.6 (305)	0.0 (208)	0.0 (112)	0.0 (112)
Intercropping of legumes followed by cassava/Desmodium	3.9 (593)	5.6 (287)	2.3 (305)	2.9 (208)	4.4 (108)	4.4 (113)
Push-pull (maize-Desmodium strip cropping)	4.9 (591)	3.1 (286)	6.6 (304)	2.9 (208)	0.9 (112)	0.9 (112)

Figures in brackets indicate number of valid entries in analysis

For those farmers in the sample who have had a previous experience with an improved technology for the control of *Striga*, maize yields were high (Table 4.6).

Table 4.6. Average yield of maize under different *Striga* control technologies (kg/ha)

	Nyanza	Western
IR maize variety (*Ua Kayongo*)	2250.0 (1)	2250.0 (1)
Striga resistant maize with legumes	1181.3 (4)	2229.5 (11)
Striga resistant maize without legumes	1800.0 (1)	2250.0 (2)
Intercropping of legumes followed by cassava/Desmodium	686.3 (10)	1650.0 (3)
Push-pull (maize–Desmodium strip cropping)	0.0 (0)	825.0 (3)

Figures in brackets represent number of respondents

Current use status of modern *Striga* control technologies

Awareness of technologies and their potential is a crucial stage towards making adoption decisions by farmers. Consequently, the low level of awareness on modern *Striga* control technologies has implications for the level of usage of the technologies. Because awareness is low, the level of usage for all the modern *Striga* control technologies available in the area is also low (Table 4.7).

Table 4.7. Current use status of modern *Striga* control technologies

	Nyanza			Western		
N	402			400		
	1*	2*	3*	1*	2*	3*
IR maize variety, *Ua Kayongo* (%)	0.2	0	1.2	0.3	0	1.5
Striga resistant maize with legumes (%)	1	0.2	2	2.0	0	1.5
Striga resistant maize without legumes (%)	0.2	0	1.7	1.3	0.8	0.3
Intercropping of legumes followed by cassava/ Desmodium (%)	2.5	0.2	2.5	1.0	0	1.5
Push-pull, maize–Desmodium strip cropping (%)	0	0	2.7	0.3	0.3	5.8

1* = Currently using, 2* = Abandoned, 3* = Never adopted, *N* = Number of respondents

Sources of information on modern *Striga* control technologies

In Nyanza province several media have been useful in promoting the awareness of modern *Striga* control technologies available to farmers, although the level of success is not very high. The results in Table 4.8 show patterns for Western province that are similar to those of Nyanza province.

Little has been done to promote the IR maize technology. Table 4.8 below shows the source of information on IR maize among the farmers in the two provinces.

Table 4.8. Sources of information on IR maize (% of respondents)

	Nyanza	Western
N	402	400
Farmers in the village	0.2	0.3
Farmers in other villages	0	0.3
Mass media	0.7	0.8
Extension agents	0.5	0
Local NGOs	0	0.5
International Research Institutes	0	0
National Research Institutes	0	0
Others	0	0

N = Number of respondents

Sources of seed and knowledge of management practices for modern *Striga* control technologies

Apart from having access to information about a new technology, one other crucial stage in the technology adoption pathway is the possibility of testing (validating) the technology and its potential. Potential adopters would require the hardware component (for example seed) and the software component (for example management practices) in order to be able to pass through the validation stage successfully.

The respondents indicated poor access to seed in spite of the fact that some of the modern *Striga* control technologies have been available in the region for some time. The scenario flows logically from a situation of low level of awareness through low level of information dissemination to the stage of poor access to the required seed and knowledge about crop management practices.

Concerning IR maize, farmer-to-farmer diffusion channel represented 0.2% of the sources of seed. The percentages were 0.5% for extension agents and 0.7% for national research institutes (KARI) in Nyanza. For Western province, KARI and CIMMYT were major sources of seed (Table 4.9). For the sustainable adoption of IR maize, seed companies need to be engaged in the dissemination of this technology.

Table 4.9. Sources of seed and knowledge of management practice for IR maize

	Nyanza	Western
N	402	400
Farmers in the village (%)	0.2	0
Farmers in other villages (%)	0	0.3
Extension agents (%)	0.5	0
Local NGOs (%)	0	0
International Research Institutes (%)	0	0.5
National Research Institutes (%)	0.7	0.8
Others (%)	0	0

N = Number of respondents

Reasons for non-adoption of modern *Striga* control technologies

Several factors can hinder the adoption of a new technology. Some of these can be technology-specific or household-specific reasons such as socio-economic characteristics. In Nyanza province, the main reason for non-adoption was lack of awareness. The few respondents who knew about the new *Striga* control technologies but had refused to adopt it gave household-specific reasons.

Results presented in Table 4.10 indicated that a majority (>90%) of farmers did not adopt because they are not aware of the technology. Some respondents were still gathering more information about the new *Striga* control technologies while some pointed out that their reason is lack of cash to buy the new *Striga* tolerant seed, and resistance to change under the cover that traditional control practice is better.

Table 4.10. Reasons for non-adoption of modern *Striga* control technologies

Reason	Nyanza	Western
N	402	400
Not aware (%)	96.6	92.2
Gathering more information about the technology (%)	1.7	4.3
Too risky to adopt (%)	0.0	0.0
Lack of improved seeds (SR varieties) (%)	1.0	0.0
Traditional control practice is better (%)	0.2	0.0
Cash constraints to buy seeds and other inputs (%)	0.5	3.5
Others (%)	0.0	0.0

N = Number of respondents

Chapter 5

Livelihood Strategies and Outcomes

Livelihood strategies: Rural non-farm activities

Farmers diversify their livelihoods by engaging in non-farm activities. This appears to be one of the most common strategies to hedge risk and reduce the negative impacts of shocks, trends and seasonality in agricultural production. Respondents in western Kenya were involved in about 15 non-farm income activities for both male and female headed households (Table 5.1). A high proportion of households were found engaged in petty trading, followed by agricultural wage employment, and non-agricultural wage employment. Other non-farm income generating activities that were of importance are selling fuel wood and charcoal, handicraft, food for work, selling prepared food/drinks and professional work. All age groups were involved in non-farm activities: adult males, adult females and youths. The number of households involved in these activities was higher in Nyanza province compared to Western province.

Table 5.1. Involvement of household members in non-farm income sources (% of respondents)

	Male headed households			Female headed households		
	All (594)	Nyanza (289)	Western (305)	All (208)	Nyanza (113)	Western (95)
Honey production	1.0	1.7	0.3	0.0	0.0	0.0
Agricultural wage employment	26.2	32.9	19.7	32.7	38.9	25.3
Non-agricultural wage employment	27.4	28.7	26.2	18.8	21.2	15.8
Food for work	10.4	13.5	7.5	17.8	17.7	17.9
Petty trading	39.8	49.1	31.1	38.5	44.2	31.6
Handicraft	10.4	18.7	2.6	11.5	21.2	0.0
Transport service	5.0	4.2	5.9	1.0	0.0	2.1
Grain mills	1.2	0.3	2.0	1.0	0.9	1.1
Fishing	1.0	1.7	0.3	0.0	0.0	0.0
Hunting and gathering of wild food	1.3	1.7	1.0	1.0	0.9	1.1
Selling fuel wood and charcoal	14.1	20.8	7.9	17.8	26.5	7.4
Selling prepared food/drinks	7.9	13.1	3.0	10.1	16.8	2.1
Professional work	18.5	17.0	20.0	5.3	5.3	5.3
Traditional medicine	1.7	1.7	1.6	2.4	4.4	0.0
Rent income	2.9	2.8	3.0	0.5	0.0	1.1

Figures in brackets indicate number of respondents

Household income and poverty

The annual income was calculated at an average of Ksh 52,678 per household, with the income in Western a bit higher than that in Nyanza (Table 5.2). Off-farm income was the major source of income, followed by farm income. Maize income represented about 27% of cash income and about 48% of value of gross income from crop production, confirming the importance of maize not only as a food crop but also as a cash crop in western Kenya. The proportion of maize income in the farm income was higher in Nyanza compared to Western. The per capita household income corresponded to about US$ 0.34/day for Nyanza and US$ 0.36/day for Western, which is far below the World Bank poverty line of US$ 1/day/person used in international poverty comparisons.

Table 5.2. Household income in both seasons

	All	Nyanza	Western
N	802	402	400
Farm income (Ksh)	17,389.8	9,337.7	25,482.3
Remittances (Ksh)	1,968.9	2,492.9	1,442.3
Off-farm income (Ksh)	33,319	36,056	30,569.5
Total household income (Ksh)	52,678	47,887	57,494
Per capita household income (Ksh)	9,082	8,706	9,273.2
Per capita per day household income (US$)	0.355	0.340	0.358

N = Number of respondents

Following the World Bank's approach to local poverty assessment (for example World Bank, 1996), total household income, which is composed of farm income, off-farm income and transfer incomes, was used to set a relative poverty line equivalent to two-thirds of the mean per capita income (Ksh 18/day/person). The results are presented in Figure 5.1 and they show that about 58% of the sample farmers are poor. Poverty is slightly higher in Western (60%) than in Nyanza (57%) and is more pervasive among female-headed households (64%) than male-headed households (57%). The analysis of poverty by district is even more revealing than that by province or by household headship. Poverty differentials across provinces mask a lot of variation across districts, even within the same province. The level of poverty varies from 48% in Teso to 82% in Vihiga district, all in Western province. Bondo has the second highest (69%) prevalence of poverty, whereas Siaya has the second lowest (49%), all in Nyanza province. The results confirm how inappropriate it would be to make generalisations about poverty based on broader geographical classifications. This is because poverty is a result of complex socio-economic, agro-ecological, and institutional and policy variables.

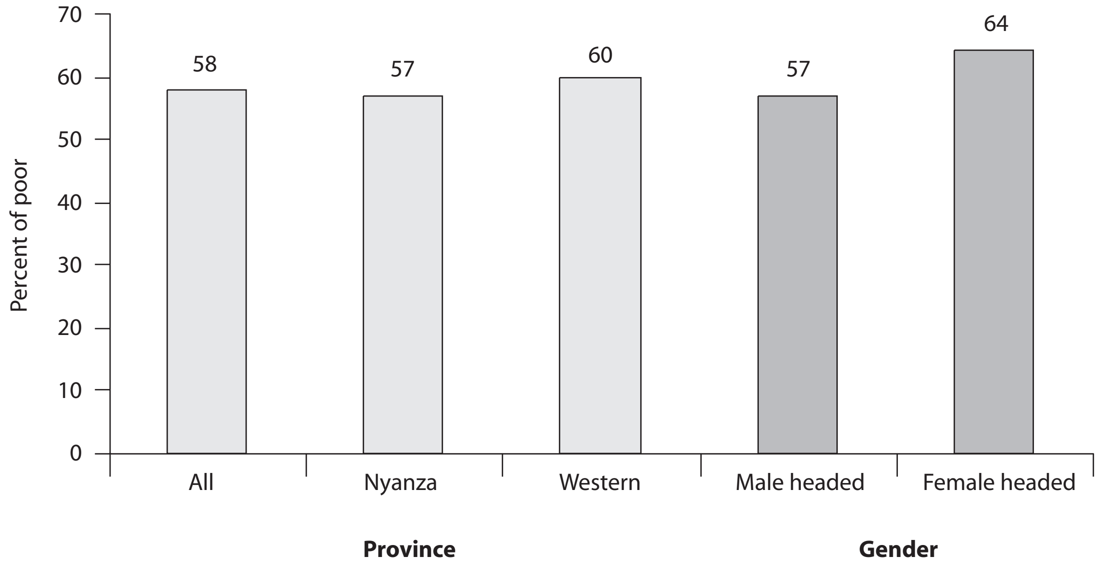

Figure 5.1. *Poverty by province and by gender (change -v)*

Determinants and correlates of poverty

A logistic regression model of determinants of poverty was estimated to examine the determinants and correlates of poverty. The logit maximum likelihood estimates and the marginal effects are presented in Table 5.3. The model fits the data well as indicated by the highly significant chi-squared model test statistics (Hosmer-Lemeshow and Likelihood Ratio) and 74% correct prediction. All the coefficients of the variables have the expected signs, as it will be shown latter in this section. The marginal effects from the logit model provide interesting insights into the potential effects of technology and policy interventions on household poverty. The marginal effects essentially constitute results of a policy simulation. The marginal effects were computed only for significant variables and converted into percentage changes in the probability of being poor associated with a unit change in the value of an explanatory variable, holding all other factors constant.

Striga infestation, in terms of the number of years it has been on the maize farm, has the expected positive and significant influence on household poverty, implying that the longer *Striga* stays on a maize farm, the more likely the household is to be poor. Perceived *Striga* damage on maize yields, weighted by the share of maize in total household income, has a very significant positive influence on household poverty, indicating that *Striga* damage has been more severe among households who derive much of their income from maize production. On the other hand, households that adopt integrated *Striga* control methods, involving uprooting and burning, tend to have 15% lower probability of being poor.

The results show that an additional child to a household, holding other factors constant, raises the probability of being poor by 12%, implying that 10 additional children will almost certainly make an average household slide into poverty. The probability of being poor increases with age, at the rate of 0.3% per year. An additional year of schooling for household heads reduces a household's probability of being poor by 1.3%, implying that a household headed by a farmer with 10 more years of education than the average level of education (4.4 years) of an average household is 13% less likely to be poor.

Table 5.3. Logit model estimates of the determinants of poverty in western Kenya

Variables	Estimate	T-ratio	Marginal effect	% change in probability of being poor
Constant	2.245**	2.110		
***Striga* damage (risk)**				
Years since *Striga* infested the maize farm	0.018**	2.200	0.004	0.4
Yield loss (%) × maize share in household income	0.065***	7.300	0.016	1.6
***Striga* control (mitigation)**				
Uprooting and burning (yes = 1)	-0.552*	1.850	-0.136	-13.6
Human and social capital				
Dependency ratio (child/adult)	0.498***	3.990	0.120	12.0
Gender (male headed = 1)	-0.045	-0.210		
Age (years)	0.012*	1.650	0.003	0.3
Education of household head (years)	-0.054**	-2.030	-0.013	-1.3
Natural capital				
Land per capita (ha)	-1.862***	-4.360	-0.447	-45.0
Physical capital				
Livestock ownership per capita (TLU)	-0.142	-0.131		
Log of value of farm assets (Ksh)	-0.300*	-2.440	-0.0722	-7.2
Financial capital				
Off-farm income share in total income	-1.395**	-2.210	-0.335	-33.5
Land under cash crop (ha)	-1.168**	-2.330	-0.280	-28.0
Credit (Yes = 1)	0.862**	1.970	0.197	19.7
Technology and market access				
Hybrid maize (adopter = 1)	-0.987***	-3.700	-0.241	-24.0
Distance to market (km)	0.007	0.130		
Location (relative to Bondo)				
Kisumu	-0.398	-0.960		
Siaya	-0.500	-1.380		
Nyando	-0.060	-0.160		
Busia	-0.329	-0.830		
Teso	-0.342	-0.810		
Vihiga	0.448	1.080	0.102	
Bungoma	-0.624*	-1.620	-0.154	-15.4
Goodness of fit tests				
Hosmer-Lemeshow chi-squared (765) = 880***				
Likelihood ratio chi-squared (20) = 244***				
Pseudo R-squared = 0.23				
% of correct prediction = 74				

*** Significant at 0.01 level; ** Significant at 0.05 level; * Significant at 0.10 level

One of the most significant results is the relationship between poverty and access to land. An additional hectare of land per capita reduces a household's probability of being poor by 45%. This result is consistent with the expectation that rural household poverty is associated with poor access to land and hence that further fragmentation of land due to increasing population pressure like that in western Kenya will worsen poverty and calls for sustainable intensification through adoption of modern technologies such as hybrid maize, fertiliser and other improved cultural practices. The effect of limited access to land can be further aggravated by production constraints such as *Striga* unless appropriate and affordable technologies are made available to farmers. Other farm assets, including farm tools and equipment, constitute an important capital in farming. The results show households owning more farm assets have a lower probability of being poor.

Households who diversify their income sources into off-farm activities are less likely to be poor, implying that the poorer households are those who depend largely or solely on farm income for their livelihoods. A 10% increase in the share of off-farm income in total income reduces a household's probability of being poor by about 34%. This implies that poverty reduction strategies must consider income-earning opportunities for rural households beyond farming and provide the needed access to capital to enhance rural households' access to these opportunities. Diversification of farm income into cash crops production is yet another avenue within farming itself that could help reduce rural poverty. The results show that an additional hectare of land under cash crops reduces a household's probability of being poor by over 28%.

The result relating to the positive relationship between credit and poverty confirms that causality runs from poverty to credit. Informal credit was indicated by the sample households as one of their coping strategies in times of food shortage and shocks. Informal credit is part of a larger inter-household cash as well as in kind borrowing and transfers that is used by the poor to maintain their productive capacity (that is human capital). Poverty reduction strategies should consider strengthening such social and financial capital assets of the poor.

Agricultural technologies play a key role in poverty reduction. As expected, adoption of hybrid maize is significantly and negatively related to the dependent variable, implying that households adopting hybrid maize are more likely to come out of poverty. The results show that adopter households of hybrid maize have a 24% lower probability of being poor than non-adopter households. However, increasing input-output price ratios following liberalisation have had a negative influence on adoption of improved agricultural technologies. While increased input-output market liberalisation has lowered food prices, input prices have increased due to the marginal effect of increased competition on marketing costs relative to the effect of exchange rate devaluations and other reforms. The role of increased competition through private sector involvement in improving market efficiency and in reducing input prices for producers and output prices for consumers has been undermined by the lack of public infrastructural development and support services such as credit and extension. Strategies have yet to be developed on how to make improved technologies such as hybrid maize more profitable for farmers to ensure sustainable technology adoption under the current food price dilemma of what level of food prices would make food more accessible to the poor without compromising producer incentives and hence food supply.

With regard to location effects on poverty, households in all districts except Vihiga district have lower probability of being poor than those in Bondo, the district of reference in this analysis. The econometric results thus lend strong support to the descriptive result showing that Vihiga (82%) and Bondo (69%) have the highest level of poverty. Poverty analysis shows the proportion or households below the threshold of the two-third of average income per capita as a whole. Results for all the districts were computed on that overall average of income per capita. The results further show that only households in Bungoma have a significantly lower probability of poverty compared with those in the reference Bondo district. This implies that poverty is less pervasive in Bungoma than in other districts, confirming its greater agricultural production potential.

Household vulnerability

Vulnerability was assessed from two perspectives. The first considered the perception by respondents of their vulnerability. Two parameters from the qualitative analysis were considered: number of households affected by food shortages and frequency of food shortages during the year. The second perspective used a neutral assessment of nutritional poverty (as opposed to farmer perceptions). Two parameters on vulnerable groups of household members were used for this quantitative analysis: the anthropometric Z scores of children aged six years and below and the body mass index (BMI) of women.

Food shortages

A large proportion of farmers declared experiencing food shortages in their households (Figure 5.2a). The proportion of food insecure households was highest in Bondo (96%) for Nyanza and in Busia (76%) for Western. These percentages are high, probably because households expected some favour from the survey team by showing high levels of distress. However, they are a good indication of food insecurity in the region because a high proportion of households that claim experiencing food shortages is an indication of vulnerability. Majority (81% for Nyanza and 76% for Western) of the respondents pointed out that they experience food shortage every year (Table 5.4). All the three parameters on food shortage indicate a high level of household vulnerability in western Kenya.

Table 5.4. Frequency of food shortage by province (% of respondents)

	Nyanza	Western
N	390	400
Every year	81.0	76.0
Once in 2 years	14.4	17.0
Once in 3 years	3.3	4.7
Once in 4 years	0.5	0.9
Once in 5 years	0.8	1.4

N = Number of respondents

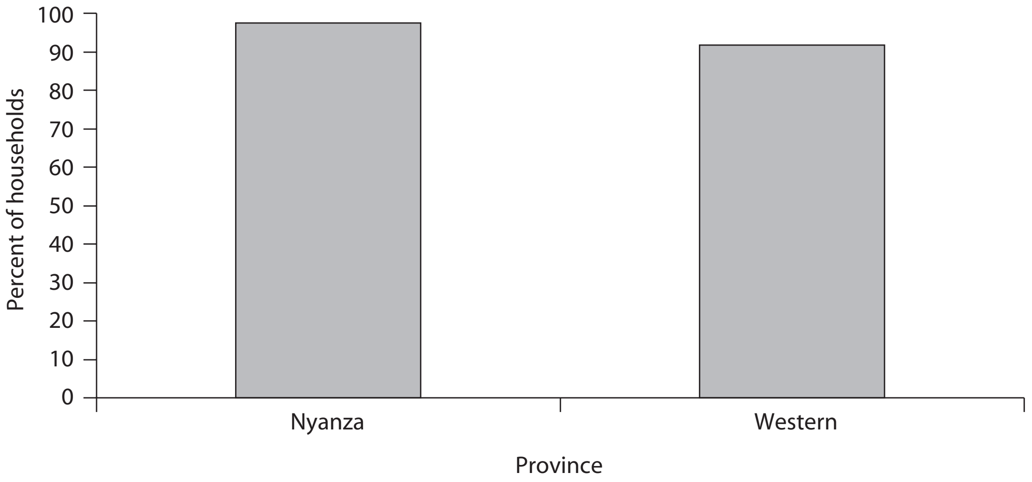

Figure 5.2a. *Households experiencing food shortages in western Kenya (n= 402 for Nyanza and 400 for Western)*

Frequency of food shortages in the households is another good indicator for measuring household vulnerability. It projects the extent to which households are exposed to other risks such as the need to dispose assets as a coping strategy. The frequency of food shortages during the year is given by the number of months that farmers experience food shortages. It is beyond a quarter for each province, higher in Nyanza compared to Western (Figure 5.2b).

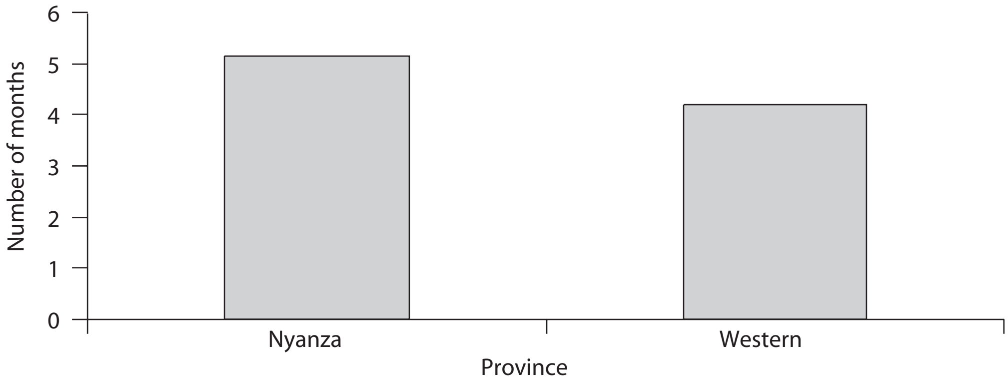

Figure 5.2b. *Frequency of food shortages in western Kenya (months)*

Causes of food shortages

Respondents ranked *Striga* infestation and drought as the foremost causes of food shortages, this is followed by low soil fertility, land shortage, pest infestation and conflict (Table 5.5). There was no discrepancy in the ranks provided to the possible causes of food shortages by both male-headed and female-headed households.

Table 5.5. Rank of major causes of food shortages in western Kenya

	Nyanza	Western
N	390	400
Striga infestation	1st	1st
Drought	1st	3rd
Pest infestation	5th	6th
Low soil fertility	2nd	2nd
Land shortage	3rd	4th
Labour shortage	4th	5th
Conflict	7th	7th

N = Number of respondents

Strategies to mitigate food shortages

Households evolve coping strategies to grapple with risk and uncertainty as well as to put undesirable situations under control. Different strategies employed by the households to tackle food shortages are shown in Table 5.6. Results obtained pointed to the fact that households relied on petty trading, short-term off-farm employment, informal safety nets (such as remittances) and disposal of household assets. Most of them said that these strategies were not effective.

Table 5.6. Strategies to mitigate food shortages

	Nyanza	Western
N	402	400
Managing to survive on little food (%)	4.2	2.3
Formal credit (%)	2.0	3.8
Informal credit (%)	8.2	19.0
Formal safety net (%)	10.0	9.3
Informal safety net (%)	41.0	33.0
Off-farm wage employment (%)	43.5	41.3
Sell land/other assets (%)	21.9	1.8
Business/petty trading (%)	61.7	38.5

N = Number of respondents

Anthropometric measurements on vulnerable groups

Anthropometric information on children

A number of anthropometric measurements are useful for the assessment of the quality of life/livelihoods of a group of people. Most common indicators for the assessment of the nutritional status of children are Z-scores on weight-for-height (wasting) or ZWFH, weight-for-age (underweight) or ZWFA, and height-for-age (stunting) or ZHFA. These measurements were made for children aged six years old and below in the two provinces. The Z values used in the classification of children were as follows: Z > –1.00 is normal; –1.00 >Z> –2.00 is mild malnutrition; –2.00 >Z> –3.00 is moderate malnutrition and; Z < –3.00 is severe malnutrition.

There were a total of 767 children aged six years old and below (46.7% were male). Overall, the nutritional status of children falls under the normal category for the three Z scores. However, two indices fall under mild malnutrition on ZWFA for male-headed households in Western province and for ZHFA for male-headed households in Nyanza province and female-headed households in Western province (Table 5.7).

Table 5.7. Anthropometric indices on children

Z score	Male headed households			Female headed households		
	All	Nyanza	Western	All	Nyanza	Western
Weight-for-height	–0.02 (628)	0.3 (276)	–0.2 (352)	0.5 (91)	–0.7 (50)	1.8 (41)
Weight-for-age	–0.8 (661)	–0.5 (292)	–1.1 (369)	–0.3 (97)	–0.7 (53)	0.1 (44)
Height-for-age	1.4 (648)	–1.1 (285)	1.6 (363)	–0.9 (94)	0.2 (51)	–2.3 (43)

Figures in brackets indicate number of valid entries in analysis

However, the above averages hide many differences. For Nyanza, the proportion of children experiencing wasting was as high as 30% (Table 5.8). Almost 50% of children were underweight as a consequence of short-time exposure to food insecurity. Also a large number (48%) of children were stunted. Children were suffering not only from a scarcity of food but their long-term development was also affected by the chronic exposure to food shortages. This situation of generalised malnutrition of children in regions not affected by civil conflicts is frightening.

Table 5.8. Nutritional status of children in Nyanza province

	Weight-for-height	Weight-for-age	Height-for-age
N	327	346	338
Normal (%)	70.3	50.6	52.1
Mild malnutrition (%)	11.9	18.5	18.9
Moderate malnutrition (%)	7.0	10.4	10.7
Severe malnutrition (%)	10.7	20.5	17.8

N = Number of children

A similar analysis done for Western province shows 35% of children suffer from wasting; 59% are underweight; and 58% are stunted (Table 5.9). The comparison of the nutritional status of children also shows that food insecurity is higher in Nyanza for wasting and in Western for underweight and stunting. The proportion of children who experience a severe malnutrition was higher in Western compared to Nyanza.

Table 5.9. Nutritional status of children in Western province

	Weight-for-height	Weight-for-age	Height-for-age
N	404	413	408
Normal (%)	65.1	40.9	41.7
Mild malnutrition (%)	13.1	16.5	17.2
Moderate malnutrition (%)	7.7	15.5	15.7
Severe malnutrition (%)	14.1	27.1	25.5

N = Number of children

Body Mass Index of mothers

The Body Mass Index (BMI) is a measurement of the nutritional status that is based on height and weight (BMI = weight/height^2). It is used to compare and determine the health effects of body weight on human beings. A BMI score between 22 and 24 is considered normal. Below the lower limit, the individual is underweight; and above the upper limit, the individual is overweight or obese.

For western Kenya, the average BMI score indicates a normal situation for both Nyanza and Western provinces (Table 5.10). However, a breakdown into BMI classes indicates that only 46% of mothers were in a normal category of BMI, 36% were underweight and about 18% were overweight in Nyanza. In Western province, 61% of mothers were in a normal category of BMI, 27% were underweight and about 12% were overweight. The results show that more mothers were undernourished in Nyanza than in Western province.

Table 5.10. Body Mass Index and BMI groupings of mothers

	Nyanza	Western
N	364	461
BMI (average)	21.54	21.9
Normal (%)	45.9	60.7
Underweight (%)	36.3	27.3
Overweight (%)	17.9	11.9

N = Number of mothers

Chapter 6

Empirical Analysis of Maize Production Efficiency in Western Kenya

Stochastic production frontier estimates

The maximum likelihood estimates of the parameters of the translog stochastic frontier and inefficiency model were obtained using FRONTIER 4.1 (Coelli, 1996) (Table 6.1). The choice of the empirical frontier production function was made based on the generalised likelihood ratio test following Coelli and Battese (1996), without having to impose any functional form. The functional form of the stochastic production frontier and inefficiency model was thus determined by testing the adequacy of the Cobb-Douglas model against the more flexible translog model. The null hypothesis that the Cobb-Douglas model is an appropriate representation of the data, given the specifications of the translog, was highly rejected (Table 6.2), indicating that the Cobb-Douglas model was actually not appropriate. Therefore, the translog stochastic frontier and inefficiency model was used as the preferred model for the analysis of maize production efficiency in western Kenya.

Table 6.1. Maximum likelihood estimates of the translog stochastic frontier and inefficiency model for maize production in western Kenya

Variable	Parameter	ML estimates	*T-ratios*	Elasticities
Stochastic frontier				
Constant	β_0	5.601***	8.800	
Land	β_1	0.877***	2.730	0.479***
Labour	β_2	0.107	0.392	0.201***
Fertiliser	β_3	–0.140	–0.894	0.036***
Oxen	β_4	–0.040	–0.180	0.278***
Land × Land	β_{11}	–0.050	–0.770	
Labour × Labour	β_{22}	–0.079**	–1.973	
Fertiliser × Fertiliser	β_{33}	–0.057	–1.013	
Oxen × Oxen	β_{44}	0.119	1.404	
Land × Labour	β_{12}	–0.011	–0.385	
Land × Fertiliser	β_{13}	0.091*	1.846	
Variable	Parameter	ML estimates	*T-ratios*	Elasticities
Land × Oxen	β_{14}	–0.004	–0.065	
Labour × Fertiliser	β_{23}	–0.017	–0.740	
Labour × Oxen	β_{24}	0.132***	2.718	
Fertiliser × Oxen	β_{34}	–0.122	–1.572	
Hybrid maize	α_0	0.405***	5.340	
Striga control	α_1	0.194**	2.376	
Gender (male headed = 1)	α_3	0.100*	1.651	
Kisumu	λ_1	–0.443***	–4.001	
Siaya	λ_2	0.455***	4.678	
Nyando	λ_3	–0.432***	–4.267	
Busia	λ_4	0.386**	3.423	
Teso	λ_5	0.270***	2.526	
Vihiga	λ_6	0.637***	5.916	
Bungoma	λ_7	0.711***	6.645	
Inefficiency model				
Constant	δ_0	0.577	0.551	
Age	δ_1	–0.040	–1.126	
Age-squared	δ_2	0.001	1.233	
Education	δ_3	–0.128***	–3.640	
Farm size	δ_4	–0.704***	–3.052	
Farm size-squared	δ_5	0.014***	3.069	
Off-farm employment	δ_6	0.535	1.465	
Efficiency parameters				
	γ	0.855***	20.235	
	σ^2	1.619***	5.295	
Log-Likelihood Function	LLF	–795		

*** Significant at 0.01 level; ** Significant at 0.05 level; * Significant at 0.10 level

Table 6.2. Generalised likelihood ratio tests of hypotheses involving the parameters of the stochastic frontier and inefficiency model

Null hypothesis	Statistic	*Critical value* (χ^2)	Decision
$H_0 : \beta_{kj} = 0$	16*	15.98	Reject H_0
$H_0 : \gamma = \delta_0 = \delta_1 = \ldots = \delta_7 = 0$	78***	19.38 [a]	Reject H_0
$H_0 : \delta_1 = \delta_2 = \ldots = \delta_7 = 0$	28***	18.48	Reject H_0

*** Significant at 0.01 level; * Significant at 0.1 level; [a] The critical value for the test γ=0 is obtained from Table 1 of Kodde and Palm (1986)

The results indicate that maize output increases with land, labour, fertiliser and oxen power. The sizes of the elasticities of frontier output with respect to the inputs show the relative importance of the various factors of maize production. In this regard, maize output is most responsive to land and least responsive to fertiliser. The low production elasticity of fertiliser confirms the observation that only 15% of the sample farmers used fertiliser. Moreover, most of these farmers (70%) applied fertiliser below recommended rates. Low adoption and intensity of use of fertiliser could be associated with the increasing prices of fertiliser relative to maize. On the other hand, the high production elasticity of land is consistent with the fact that land is a critical factor of production for smallholders, especially in western Kenya where there is a growing population pressure on land.

The coefficients of the variables representing adoption of hybrid maize and *Striga* control technologies are both positive and significant, indicating that adoption of these technologies increased frontier maize output. Adoption of hybrid maize and *Striga* control practices increased maize production among the efficient farmers. The positive effect of hybrid maize adoption is consistent with the survey result that adopters obtained average yields of about 1.3tonnes/ha compared with non-adopters who obtained only 0.8tonnes/ha. Similarly, the positive influence of *Striga* control on frontier maize output is consistent with the result that maize farmers who used integrated *Striga* control practices obtained average maize yields over 1tonne/ha compared with the average 0.8tonnes/ha for farmers who did not adopt this practice. Indeed, in western Kenya where *Striga* damage on maize yield could be as high as 75–100%, the marginal benefit of a control practice is high. The coefficient of the household headship variable is positive and significant at 10% level, indicating that male headed households had higher frontier maize output than female headed households. A separate model, constructed by interacting gender with all other variables, was estimated to test whether the same technology was available to male and female heads of households. None of the interaction terms was significant, and a generalised likelihood ratio test could not reject the null hypothesis that the interaction terms are jointly equal to zero. This demonstrates that male and female headed households actually have a homogenous production technology, implying that if their respective frontiers were to be estimated separately, they would have the same S-curve shape usually found in adoption studies of new crop varieities. This is consistent, for instance, with the observation that both female headed (12%) and male headed (20%) households adopted hybrid maize. Higher frontier output among male headed households implies an intercept shift in the frontier and hence a change in its placement. Significant gender differentials in maize output were found from a separate conventional production function analysis using the same data set and this was consistent with the observed average maize yield differences between male headed (957kg/ha) and female headed (750kg/ha) households. However, the results from the frontier analysis reported here do not necessarily imply that male headed households produced more maize on average than female headed households. Rather, it implies that male headed households are more likely to produce at the frontier than female headed households and hence that the position of the maize production frontier is determined by male headed households. In either case, though, there is evidence of maize productivity differentials between male and female headed households.

All coefficients of the district dummy variables are highly significant, indicating substantial maize productivity differentials across locations in western Kenya. Kisumu and Nyando districts have significantly lower maize productivity relative to Bondo district. But Siaya district has significantly higher maize productivity than Bondo district. The results show that from the four districts in Nyanza, Siaya has greater maize productivity potential. All districts in Western are more productive than Bondo in Nyanza, with Bungoma having the highest maize productivity followed by Vihiga, Teso and Busia. Siaya in Nyanza compares well with Vihiga and Bungoma in Western in terms of maize production potential.

Factors influencing maize production efficiency

The estimate of the variance parameter, γ, associated with the variability of technical inefficiency of maize production, is close to the maximum value of one and is significantly different from zero. In Table 6.2, the significance of γ is shown by the high asymptotic *t*-ratio of 20. A generalised likelihood ratio test of the significance of the inefficiency effects was also conducted and the results are presented in Table 6.3. The null hypothesis, $H_0 : \gamma = \delta_0 = \delta_1 = \ldots = \delta_7 = 0$, tests whether the traditional average production function is appropriate as opposed to a frontier production function. As this is clearly rejected, the test results confirm that the traditional response function is not an adequate representation of maize production in western Kenya, given the specifications of the translog stochastic frontier and inefficiency model. In other words, the inefficiency effects are significant in determining the level and variability of maize production in western Kenya. Furthermore, the null hypothesis, $H_0 : \delta_1 = \delta_2 = \ldots = \delta_7 = 0$ tests whether the explanatory variables in the model for the technical inefficiency effects have zero coefficients. This is again rejected, implying that, taken together, the explanatory variables have a significant impact on technical efficiency of maize production in western Kenya.

Inefficiency decreases significantly with education but increases, although insignificantly, with off-farm work, whereas it has non-linear relationships with age and farm size. Education of the household head has the expected significant and negative coefficient, indicating that acquiring more years of schooling reduces technical inefficiency of maize production. There is adequate empirical evidence supporting the critical role of education in enhancing farmer efficiency in developing countries. For example Belbase and Grabowski (1985), for rice production in Nepal; Kalirajan and Flinn (1983), for rice production in the Philippines; Kalirajan and Shand (1986) and Coelli and Battese (1996), for rice and whole farm production, respectively, in India, Ali and Flinn (1989), for rice production in Pakistan, and Alene and Hassan (2003) for maize production in western Ethiopia obtained a positive and significant influence of education on technical efficiency.

The relationship between age and technical inefficiency was non-linear. That is, young farmers tend to become more efficient as they gain experience, but after a certain age, their inefficiency begins to increase with age. However, the non-linear effect of age on technical inefficiency is not significant. Farm size had a similar and even significant effect on farmer inefficiency. That is, as farm size increases from smaller landholdings, technical inefficiency declines, but after a certain land size, inefficiency begins to increase with farm size. It can thus be concluded that the relationship between farm size and technical efficiency exhibits an inverted U shape. A lot of empirical work has been carried out to test the inverse farm size-efficiency hypothesis, but such a non-linear relationship has not been explored. Rather, a linear relationship has been assumed and results have been mixed. For instance while Squires and Tabor (1991) and Llewelyn and Williams (1996) found no significant association between farm size and technical efficiency in the Java area of Indonesia, Daryanto et al. (2002) found a negative and significant relationship between farm size and technical efficiency. In Indian agriculture, while Huang and Bagi (1984), Ray (1985) and Kalirajan (1991) obtained no significant association between farm size and technical efficiency, Coelli and Battese (1996) obtained a positive and significant influence of farm size on technical efficiency.

Technical efficiency estimates

Tables 6.3–6.5 present the summary statistics of technical efficiency predictions by province, district and gender. The results show that the sampled farmers achieved an average technical efficiency of 62%, indicating substantial inefficiencies of maize production in western Kenya. There are only slight gender and location differentials in technical efficiency. Male headed households have an average technical efficiency of 63%, whereas female headed households achieved 60% efficiency. This variation is more apparent in Nyanza (64% vs. 58%) than in Western (64% vs. 62%). While the sample maize producers in Nyanza achieved 61% efficiency, those in Western achieved an average technical efficiency of 63%, confirming the higher maize productivity of farmers in Western. Technical efficiency variations across districts are more apparent than variations across provinces. Average efficiency estimates range from 55% for

Kisumu in Nyanza to 66% for Bungoma in Western. The sampled maize farmers in Bungoma and Busia are relatively more efficient than those in the other districts in western Kenya.

Table 6.3. Technical efficiency distributions by province and gender (% households)

Technical efficiency (%)	Province			Gender	
	All	Nyanza	Western	Male headed	Female headed
≤25	5	7	3	4	9
25–50	19	20	18	19	17
50–75	51	47	55	50	53
75–100	25	26	24	27	21
Mean	62	61	63	63	60
Minimum	4	4	4	6	4
Maximum	92	92	90	90	92

Table 6.4. Technical efficiency distributions by province and gender (% households)

Technical efficiency (%)	Nyanza		Western	
	Male headed	Female headed	Male headed	Female headed
≤25	5	13	3	4
25–50	21	56	18	18
50–75	45	53	54	54
75–100	29	18	25	24
Mean	62	58	64	62
Minimum	4	6	4	9
Maximum	92	85	89	90

Table 6.5. Technical efficiency distributions by district (% households)

Technical efficiency (%)	Nyanza				Western			
	Bondo	Kisumu	Nyando	Siaya	Busia	Teso	Vihiga	Bungoma
≤25	5	12	4	7	4	2	3	3
25–50	21	28	17	15	12	28	22	11
50–75	45	39	55	50	54	44	61	58
75–90	29	21	24	28	30	26	14	28
Mean	62	55	62	63	65	60	61	66
Minimum	7	4	11	17	9	16	10	4
Maximum	89	92	88	88	85	89	88	90

The finding that maize farmers in western Kenya exhibit high levels of inefficiency is consistent with the fact that there is a lag between farmers' attempts to adjust their production decisions to keep pace with changes in the production and economic environment and achieving the ultimate efficient use of their resources. Deviations of farmers' practices from technical recommendations coupled with production as well as system constraints always lead to technical inefficiencies among farmers. Knowledge of the extent of such inefficiencies and the underlying farm-level as well as system-level constraints will help guide policy makers to increase agricultural production through interventions that counteract major farming constraints. The results in this study point to the existence of a considerable potential for increasing maize production in western Kenya. Current levels of maize production are low due to under-utilisation of this potential. The sampled maize producers could increase production by an average 38% if they were fully technically efficient. In other words, if the production practices adopted by the best practice farmers in the sample were equally used, much of the maize production potential could have been exploited, all translating to more maize output. In this study, improved technologies such as hybrid maize and innovative local practices such as integrated *Striga* control have been shown to increase frontier maize output. This means that greater adoption of these practices and other alternative practices could increase maize production. AATF's technological intervention for *Striga* control using IR maize thus holds a lot of promise towards unlocking the maize production potential and enhancing maize productivity in western Kenya.

Chapter 7

Policy and Institutional Issues

Policies and institutional arrangements play a key role in the development of the agricultural sector. During the focus group discussion conducted during the survey, villagers were asked to provide information on services received from governmental and non-governmental organisations (NGOs) and to assess the effectiveness of government policies on agriculture and livelihoods.

Awareness about governmental and non-governmental organisations and their activities

Many villages were not aware of the activities of governmental and non-governmental organisations in their immediate environment. Out of 16 villages of Nyanza province, only five were aware of the presence of government and non-government projects in their immediate environment. The awareness was better in Kisumu district compared to other districts. For Western, less than half of the communities that participated in the village level survey indicated that they were aware of the presence of governmental and non-governmental organisations in their immediate environment through the activities of their agencies (Figure 7.1).

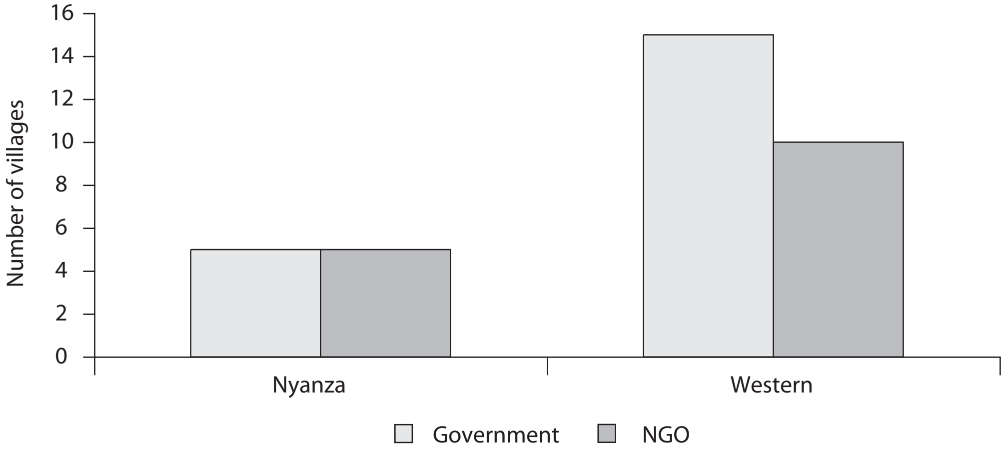

Figure 7.1. *Number of villages with government and non-governmental projects in western Kenya*

The types of programmes/services provided by the government appear in Table 7.1. Rural communities easily associate the government interventions to the construction of roads, supply of drinking water and agricultural projects. Unfortunately, these needed programmes/services are reaching out to only few rural communities. In Kisumu where access to water is a major bottleneck and drought an important farming constraint, there was no recorded programme on the supply of drinking or irrigation water in the sampled villages.

Table 7.1. Types of development programmes/services sponsored by government (number of villages)

	All	Nyanza	Western
N	32	16	16
Supply of drinking water	7	3	4
Irrigation water	1	1	0
Roads	9	3	6
Electricity	2	0	2
Agricultural projects	7	1	6
Build schools/educational infrastructure	4	1	3
Pit latrines	0	0	0
Health and sanitation	1	1	0
Community capacity building for development	2	0	2

N = Total number of villages

NGOs are expected to complement the government in supplying services to its population. Results in Table 7.2, however, show that NGOs do not do better than the government because the number of villages serviced is still very small. The beneficial effects of NGOs are felt essentially in the agricultural sector. Many NGOs are involved in capacity building and community development. However, respondents could not easily single out this service provided by NGOs, probably because it is often embedded into the agricultural projects.

Table 7.2. Types of development programmes/services sponsored by non-governmental organisations (number of villages)

	All	Nyanza	Western
N	32	16	16
Supply of drinking water	5	1	4
Irrigation water	0	0	0
Roads	0	0	0
Electricity	1	0	1
Agricultural projects	9	4	5
Build schools/educational infrastructure	0	0	0
Pit latrines	2	0	2
Health and sanitation	3	0	3
Community capacity building for development	0	0	0

N = Total number of villages

In Western province, the ranking can be done on the districts that benefit from programmes sponsored by both governmental and non-governmental organisations in that decreasing number of villages: Vihiga (12), Bungoma (11), Busia (6) and Teso (6). The same analysis made for Nyanza resulted in the following decreasing ranking of districts: Kisumu (5), Siaya (4), Bondo (3) and Nyando (3).

The above analysis shows that the coverage of development programmes/services is better in Western than in Nyanza. This difference in the coverage is likely to induce a bias in the development of the two provinces. Nyanza must attract NGOs and more government programmes in the future than what it has been able to achieve in the past.

Level of awareness of government policies on agriculture and livelihoods

The assessment of government policies considered the perceptions of rural communities about the positive effects of those policies. Rural communities also listed what they considered as failures by the government policies. On the positive side, villagers recognised that government policies have contributed to the development of basic infrastructure (roads, water supply and electricity), development of market and ease of access to the markets. Other government policies that are generating positive effects include adequate extension services and accessorily availability of improved agricultural technologies (Table 7.3). On the negative side, major complaints were related to high costs of farm inputs, poor market prices, high taxes/tariffs on farm products, and lack of formal credit (Table 7.4).

Table 7.3. Level of awareness of the positive effects of government policies on agriculture and livelihoods (number of villages)

	All	Nyanza	Western
N	32	16	16
Development of basic infrastructure, eg roads, water supply and electricity	20	11	9
Market development/easy access to market	15	9	6
Provision of free/subsidised inputs (seeds, fertiliser, chemicals)	3	3	0
Health and sanitation improvement	2	2	0
Market liberalisation	7	2	5
Improved agricultural technologies/seeds	5	1	4
Crime control	2	1	1
Adequate extension services	11	2	9
Availability of rural non-agricultural employment	3	3	0

N = Total number of villages

Table 7.4. Level of awareness of the negative effects of government policies on agriculture and livelihoods (number of villages)

	All	Nyanza	Western
N	32	16	16
Inadequate extension services	5	4	1
Lack of information on improved technologies/seeds	1	1	0
Lack of information on climate/weather	1	1	0
High cost of farm inputs	21	8	13
High taxes/tariffs on farm products	13	3	10
Lack of subsidies on inputs and agric services	2	0	2
Land tenure problems	3	2	1
Lack of rural non-agricultural employment	5	3	2
Lack of formal credit facilities	8	4	4
Lack of informal credit facilities	0	0	0
Government cannot stabilise market prices of farm produce	1	1	0
Poor market prices	16	8	8
Views and priorities of local people not considered	1	1	0
Poor state of roads	4	2	2
Too frequent transfer of extension workers	2	2	0

N = Total number of villages

The following summary can be made about the perception of villagers on major effects of government policies: high cost of farm inputs (21–), development of basic infrastructure (20+), poor market prices (16–), market development/easy access to market (15+), high taxes/tariffs on farm products (13–), and adequate extension services (11+).

Chapter 8

Conclusions and Recommendations

The summary of the major findings from the baseline survey conducted in two provinces of western Kenya, namely Nyanza and Western is as follows.

1. Households are small in size and the dependency ratio is high. There were about 26% of households headed by females. The level of education was low for the heads of households and all members of farm families. Households are endowed with a multitude of assets for their livelihoods. However, the level of assets was found to be low or of very poor quality. The natural capital is made essentially of smallholdings and land of poor soil fertility. The financial assets are limited. These benchmark indicators would be useful in assessing the changes that would be brought about through the promotion of IR maize and other complementary *Striga* control technologies.

2. Land is allocated essentially to annual crops, mainly maize, beans, sorghum, cassava and sweet potato. Maize is the major food crop and a source of cash income. Farmers grow both local and improved (hybrid) maize varieties, but the productivity of maize is low. There is a considerable gap between potential and actual maize yields. Major factors constraining crop production include *Striga* infestation on maize, low soil fertility, drought and erratic rainfall. Intercropping is the predominant cropping practice where perennial crops are also cultivated within the systems.

3. *Striga* is by far the major threat to livelihoods of smallholders because of its negative impact on maize, the major commodity. According to respondents, the economic importance of *Striga* has increased over the past three decades. Traditional methods of *Striga* control include uprooting, burning and manuring, which have proved to be ineffective. Alternative modern technologies exist but they have not been adopted and used as they should be because the level of awareness is still very low. As far as the new IR maize is concerned, this baseline study was timely because this technology is still unknown to a majority of farmers. Respondents did not list the private seed industries among the major suppliers of improved seed to farmers. For sustainability, the seed industry must be involved in the deployment of IR maize.

4. Household incomes are low and the per capita annual income (US$ 0.36) falls far below the World Bank poverty line of US$ 1/day. Using a relative poverty line of two-third mean income per capita per day, it was revealed that about 58% of the sampled households are poor. Poverty is slightly higher in Western (60%) than in Nyanza (57%) and is more pervasive among female-headed households (64%) than male-headed households (57%). The level of poverty varies from 48% in Teso to 82% in Vihiga, all in Western province. Bondo has the second highest (69%) prevalence of poverty, whereas Siaya has the second lowest (49%), all in Nyanza province. The results confirm how inappropriate it would be to make generalisations about poverty based on agro-ecological zones or other broader geographical classifications.

5. Analysis of the determinants of poverty revealed that the poverty status of a household in western Kenya is significantly related to *Striga* damage, *Striga* control, dependency ratio, age, education, technology adoption, land per capita, farm assets, off-farm work, credit, cash crop production and location. While it was observed that *Striga* inflicted almost equally high damage on maize yields across districts and households, the results showed that its impact on poverty is the greatest among households, which depend heavily on maize for their livelihoods. Households with the following characteristics are more likely to be poor: *Striga* has been on the farm for long; high perceived yield loss to *Striga* while depending heavily on maize for household income; lack integrated *Striga* control; high dependency ratio; headed by older farmers; low educational attainment; non-adopters of technology; poor access to land and farm assets, depend on credit; no off-farm work; no cash crops; and live in environments with characteristics similar to those of Bondo and Vihiga districts.

6. Food shortage can last as long as five months in a year and it occurs every year for more than 70% of households. Coping strategies include off-farm short-term jobs, disposal of assets, and informal safety nets especially through remittances received from relatives. The above findings on household vulnerability were gathered from respondents' perceptions. The results from this qualitative assessment were confirmed by those from quantitative analyses on the anthropometric indices on children and women. The Z scores calculated on children indicate that about 30% were wasting, 50% were underweight and 48% were stunted. Therefore, the identified vulnerability is reflected in both indicators of short term exposure to food insecurity (underweight) and those on long-term exposure to food insecurity (stunting). The magnitude of the malnutrition on children is beyond any prediction in a country at peace. Similarly, the results on BMI on women showed that 36% were underweight while 18% were overweight. One would expect only cases of underweight for food insecure households. However, the presence of cases of obesity in that environment is not strange to nutritionists. They characterise this contrasting situation as nutrition in transition (Sanusi et al., 2005). It is typical of poor households but it is also common in wealthy countries. For households that depend on agriculture for their livelihoods, the only approach to break the above vulnerability is to increase the production and productivity of crops. For western Kenya, interventions should target maize. There is also need to look into additional strategies through the diversification of farming enterprises.

7. A translog stochastic frontier production function incorporating a model for technical inefficiency effects was used to analyse the technical efficiency of maize farmers in western Kenya. The results showed both gender and location differentials in maize productivity. Gender differentials in productivity were more apparent in Nyanza than in Western province. Adoption of hybrid maize and traditional *Striga* control increased maize production. The sampled maize farmers achieved an average technical efficiency of 62%, indicating a considerable potential (38%) for increasing maize production through improved efficiency and better practices such as integrated *Striga* control. An examination of the relationship between efficiency and socioeconomic attributes revealed that while technical efficiency increased with educational attainment, it has turned out to have a non-linear relationship with age and farm size. Technical efficiency first increases with age and farm size but eventually declines with age and farm size. The result relating to the direct farm size-efficiency relationship for smaller holdings coupled with the fact that most farmers cultivate tiny plots of land suggests that re-allocation of more land to maize would enhance farmer efficiency. Increased efficiency could be achieved through, for instance, more optimal application of inputs and greater intensity of adoption of improved maize varieties. Therefore, efforts must be made to enhance adoption of both hybrid maize (and hence fertiliser) and *Striga* control technologies to help increase maize production. Maize yields in Kenya have continued to decline despite increased use of new maize varieties, largely because of lack of effective *Striga* control technologies. Promoting both high-yielding varieties and *Striga* control technologies should thus be an important goal for research and extension in Kenya. In this regard, AATF's IR maize technological intervention for *Striga* control holds considerable promise for unlocking the maize production potential and enhancing maize productivity in western Kenya.

8. Farmers interviewed had a clear perception about positive government policies. They also made a major input by highlighting weaknesses in current policies. The weaknesses highlighted about high cost of farm inputs and poor market prices of products are interrelated. The devolvement of governments in the pricing policies needs to be accompanied by other measures such as easy flow of market information to allow economic agents to adjust their investments. Often smallholders are not fully aware of the requirements of a liberalised market because they have little or no access to market information. Therefore, they become victims of market liberalisation instead of benefiting from it. Market information should include type, quality and volume of products/inputs; prices; and timing required for the commercial operation to be initiated and completed. Farmers united are stronger than when they operate in isolation. Smallholders should be encouraged to form functional groups to deal with issues related to the marketing of products and inputs.

The findings from this study also showed the prime role the government must play in building infrastructure. Studies from Asia show that returns to investments in infrastructure are always high. In the absence of good infrastructure (for example roads, health and communication), the development of agriculture would never occur. Other policy interventions needed include efficient extension services, and revision of taxes and tariffs on farm products.

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