Farm Household Allocative Efficiency

A Multi-Dimensional Perspective on Labour Use in Western Kenya

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ABSTRACT

Labour is an important resource for smallholder households. In this study, efficiency in labour use is examined from three perspectives that are relevant in smallholder farm households of western Kenya. A horizontal perspective was adopted in evaluating labour use efficiency within the farm. Outcomes of household behaviour in allocation of labour to various crops were examined while controlling for variability in bio-physical characteristics of the farm. The study revealed that efficiency in labour allocation within the farm can be improved and that mobility of labour is mainly inhibited by poor output markets.

The strong seasonality in agricultural production results in variability in the labour constraint over a cropping season. A vertical perspective to labour use on the farm was therefore adopted in which efficiency in labour use over the cropping season was examined. In order to capture variability in the labour constraint, labour use decisions were differentiated by stages in a cropping season and inferences made with regard to allocative efficiency of labour. On average, the marginal product of labour at the beginning of the season is not equalised to the marginal product of labour at weeding. Many households appear most labour constrained (i.e. show highest marginal labour product) at the beginning of the season.

Lastly, efficiency in labour allocation between the farm and off-farm activities was evaluated. There were large differences between returns to labour employed on farm and off the farm implying that household efficiency in allocation of family labour could be improved. Households which participate in labour markets as sellers or buyers are more productive and efficient in use of family labour on the farm.

While there is no single figure for the opportunity costs of labour in rural households, the study does provide indicators which may be used as guidelines in determining the opportunity cost of labour in farm households. Policy measures that would steer farm households towards more efficient use of their labour include measures which: i) reduce the marketing costs for food and cash crops, ii) increase labour market participation, and iii) improve the functioning of other rural markets like the markets for maize and credit.

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CHAPTER 1

INTRODUCTION

1.1 Research problem

Labour and land are the important resources of the poor and hence important component of development programs aimed at alleviating poverty. Labour in particular has characteristics that make it particularly attractive for management as well as policy level interventions. In the context of the developing world, a household's labour assets can be more easily integrated into the market than its land assets because compared with land: divisibility of labour is much higher because it can be sold and still made available for farm activities and household chores; it is highly mobile i.e. can be transported to different locations where needed; and it can be improved or re-trained. The effectiveness of labour as an entry point for change may however be constrained by immobility of labour. In fact most issues plaguing smallholder farm households like the lack of adoption of productivity enhancing technologies or cash crops or low productivity of labour on the farm or low incomes are partly due to immobility of labour. Apparently something withholds farm households from doing more or getting more from their resources like labour.

The first place to look for solutions to problems in smallholder farming is in their use of resources. Behavioural studies like efficiency studies have the potential to provide reliable indications of how well farm households use their resources. Efficiency measures how effectively production firms use variable resources for the purpose of profit maximization given the best production technology[1] available, the level of fixed factors and product and factors prices. Maximum efficiency is attained when the most efficient production function is used and when the marginal value product of each factor used in production is equal to its price. This concept of efficiency may be split into technical and allocative efficiency. Technical efficiency being the ability of a firm to avoid waste by producing as much output as input usage allows or using as little input as output production allows. It therefore compares the actual to the maximum attainable productivity (actual output/maximum output for a given

[1] Technology defines a frontier relationship between inputs and outputs while economic efficiency incorporates waste and misallocation relative to the frontier.

level of input). On the other hand, allocative efficiency is the ability of a firm to combine inputs and outputs in optimal proportions in light of the prevailing prices. Allocative efficiency therefore determines whether outputs are obtained and input used in accordance with their scarcity values. Efficient households are able to achieve more with the resources at hand than the inefficient ones because their expenditure is the minimum possible and their resources earn the maximum possible.

While technical efficiency is measured by the ratio of actual and potential output at given mix of inputs, allocative efficiency is measured by the ratio of optimal costs to the costs incurred at the technically efficient level. Here, costs are optimal when inputs would be used up to the point where their marginal products equal their prices or opportunity costs.

Not all farm households succeed in utilizing the minimum inputs required to produce the output given the technology at their disposal. In addition even if technically efficient not all producers succeed in allocating their inputs in a cost effective manner given the input prices faced. Variation from technical efficiency is attributed to variation in factors which are under the control of producers e.g. the biophysical environment. Variation from allocative efficiency on the other hand, is attributed to the divergence between expected and actual prices, satisficing behaviour amongst others.

Allocative efficiency reflects responsiveness to incentives like prices because factors of production easily move to activities where they are paid the maximum possible. The economic environment, especially markets[2], determines the relative prices of factors of production and outputs, the margin between farm gate and market prices for farm output, the off-farm opportunities and the costs of and access to financial services. Economists are therefore mainly interested in quantifying and explaining allocative inefficiency as opposed to technical efficiency because it informs policy makers on the effectiveness of the economic policies in place i.e. are they producing the desirable effects like encouraging households to make best use of their resources.

In a number of studies on farm households, both technical and allocative inefficiencies were found. Bravo-Ureta and Pinheiro (1997) found the allocative efficiency to be much less than the technical efficiency (44% and 70%, respectively). Shenggen Fan (1999) reports a 'plateau' to be reached for allocative efficiency of 75% and 91% for technical efficiency in Chinese rice farms, whereas Coelli et al. (2002), using the DEA technique, found for rice farmers in Bangladesh that allocative efficiency was better than technical efficiency (78%

[2] Others included in the economic environment are infrastructure and other institutions

against 66%). Allocative inefficiency is therefore an important source of inefficiency, often more important than technical inefficiency.

Earlier economists regarded farmers in developing countries as inefficient, but the position taken by Schultz in his book (1964) and repeated in his Nobel Lecture (1980) "poor but efficient[3]" revolutionarised these perceptions. According to Schultz, smallholder farmers fine tune their resource allocation in order to deal with their circumstances in terms of costs, returns and risks. In particular, Schultz indicated that "there are comparatively few significant inefficiencies in the allocation of the factors of production in traditional agriculture"(page 37) Modern economic theory therefore recognises that peasants are rational (Stiglitz 1989). This means that observed deviations from expected economic behaviour arise not from inefficiency but rather from different notions of the incentives facing households i.e. the relevant prices and from idiosyncrasies of various plots and/or households. Studies on allocative efficiency are therefore important for analysts because they are suggestive about the incentives or any disincentives farm households are faced with. Hence, allocative inefficiencies point to failures of the markets rather failures of the households themselves, if Schulz's hypothesis is maintained.

There are various reasons why households may not be allocative efficient but the most important one is market failure, a common phenomenon in developing economies (Stiglitz 1989). A market fails when the cost of a transaction through the market exchange causes a dis-utility which is greater than utility gain it produces, resulting to non use of the market. Where markets have failed, households may be observed to pursue goals and aspirations that are in conflict with expected economic behaviour (De Janvry, Fafchamps et al. 1991; Sadoulet and De Janvry 1995). For example, households are known to strive for self sufficiency in the factors or products for which markets has failed because the household values them differently from the market value[4]. Transaction costs and shallow markets are the main causes of market failure. Transaction costs are particularly high and market integration poor where infrastructural development is poor because it raises transportation costs and uncertainties. Following, is a discussion on other possible reasons why households may not be allocative efficient.

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[3] Prior to the 1964 publication of 'Transforming Traditional Agriculture', farm households in developing countries were generally considered unresponsive to economic incentives and driven, in allocation of their resources by culture or tradition.

[4] When the market is not used for transaction, the household behaves as if a market exists within it and the equilibrium of supply and demand within the h/hold determines a shadow price for the household which may be different from the market price (Sadoulet, DeJanvry, 1995).

Empirical studies on labour allocation are commonly based on the assumption that farm households view their farms as single units the premise being that there is efficiency within the household. It is now well established that there is significant heterogeneity[5] within smallholder farms (Tittonell, Vanlauwe et al. 2005a; Tittonell, Vanlauwe et al. 2005b). We suspect that farm households may be withheld from efficient use across various fields owned by the same household if the prices attached to farm output are different from the market prices. Moreover, plot specific idiosyncrasies like the distance from homesteads means that substantial time is used in travelling to fields located far from the homestead. Efficiency is questionable where resources are allocated along the gender line (Udry 1996). He and his colleagues found that a move to equal distribution of resources between men and women over the plots they cultivated could lead to over 10% increase in staple production (Alderman, Hoddinott et al. 1995). Schulz's efficiency hypothesis may therefore not hold once we take intra-household decision-making into account.

Empirical studies on labour allocation assume that production decisions and hence resource allocation are made simultaneously at the beginning of the cropping season. One price is used for labour throughout the season, and one marginal value product is calculated. If, however, demand for labour varies over the season, these assumptions may not hold. Under such circumstances we cannot assume efficiency will prevail across the season. Attainment of allocative efficiency over time may be particularly challenging where there is little flexibility in off-farm work such that labour hired-out cannot be recalled during peak periods, or when households cannot hire-in labour during peak periods. We therefore study intertemporal allocative efficiency in addition to the standard allocative efficiency. If intertemporal inefficiency is found, it shows the perceived differences in scarcities of labour and/or the gains that can be made by reallocating labour over the season.

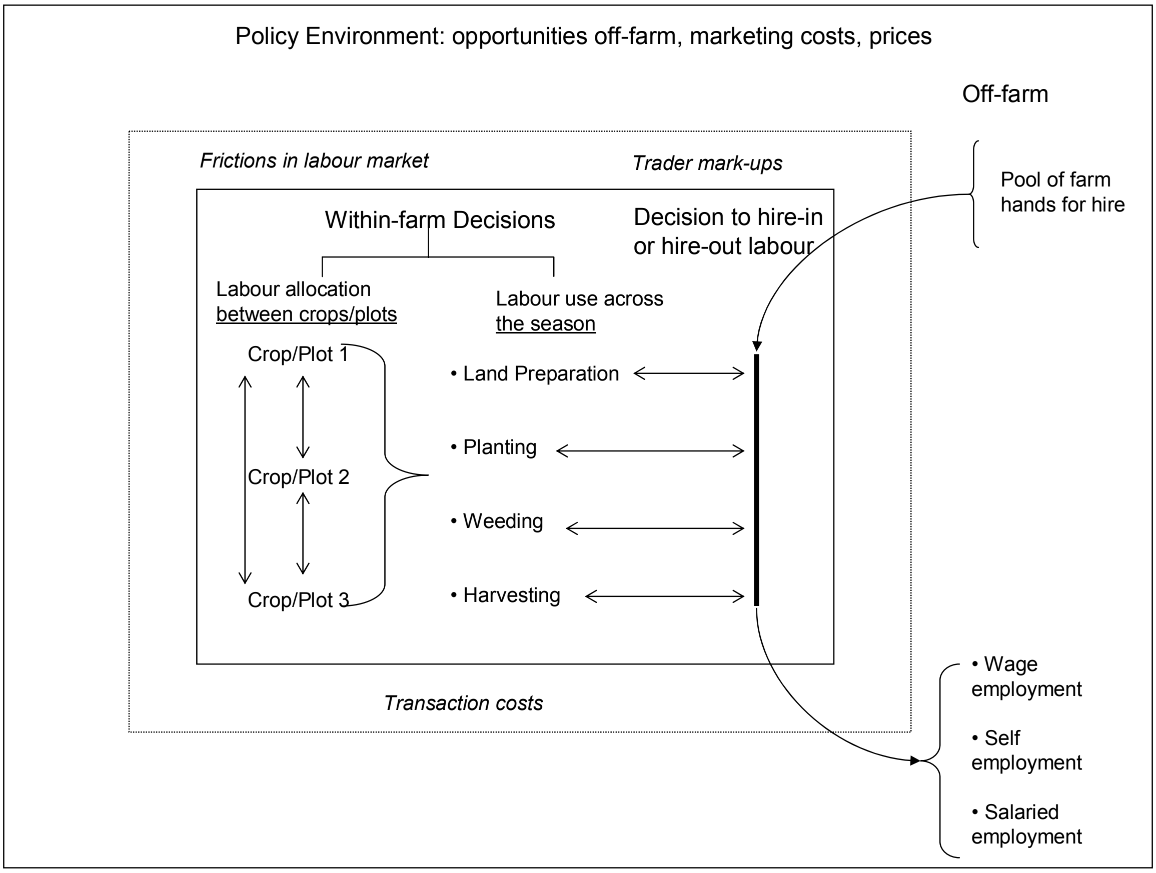
Members of farm households driven by the wage differential between farm and off-farm employment and the scope for alleviating the risk and credit constraint facing them often seek off-farm employment. This has the potential to increase efficiency in labour use on the farm because farm households may off-load excess labour into the labour market. The down side is that off-farm employment can reduce availability of labour for farm activities and harm production unless there is compensation (Romano 2001) e.g with hired labour or labour saving technologies.

[5] The term heterogeneity within smallholder farms is usually used in reference to the biophysical characteristics of a farm in terms of soil quality, position on the slope etc. In this thesis within farm heterogeneity refers to this biophysical variability as well as the spatial distribution of a variety of crops or crop combinations grown in small-holder farms.

While many households often succeed in securing off-farm employment, various studies shown that rural households' access to non-farm opportunities is constrained (Reardon 1997; Barrett 2001). Consequently, studies on the impact of diversification often show varied results. Access is determined by amongst others the agro-ecology and location. Differences in agricultural potential and characteristics of the farming sector, infrastructural development and access to urban areas or markets determine labour absorption capacity and transaction costs. Access is also determined by household level characteristics like skills, assets and income because they determine ability to meet employment or investment requirements (Woldehanna and Oskam 2001; Dercon 2001; Barrett, Sherlund et al. 2006). According to utility maximising behaviour, if not constrained, farm households are efficient in labour allocation between farm and off-farm activities. Efficient allocation of labour between farm and off-farm activities is however not achievable where access to off-farm employment is restricted.

Smallholder farm households provide a suitable environment for studying household allocative efficiency in its multi-dimensionality because: agricultural production is simultaneously carried out on more than one plot, agricultural production occurs in uncontrolled environments with strong seasonality and over 80% of the households sell their labour off-farm. Figure 1 shows the three dimensions of allocative efficiency in labour use in a farm household. The farm household operates within a policy environment which determines off-farm employment opportunities and costs of participation, prices and marketing costs of farm inputs and outputs. Within the farm the household allocates labour between the several crops grown and within each plot the household determines labour use across the season. The household also determines the timing and need to buy or sell its labour. The interaction between the farm household and the labour market is however curtailed by transaction costs and frictions in hiring-in and hiring out labour.

Figure 1.1: Multi-dimensionality of allocative efficiency in smallholder farm households



1.2 Objectives of study

The aim of this thesis is to contribute to the identification of barriers hindering farm households from benefiting from interventions by establishing whether farm households are efficient in allocation of labour and by identifying the constraints responsible for deviations from expected behaviour. The objective of the thesis is met by addressing three research questions:

1. Are farm households efficient in labour allocation within their farms and what are the factors influencing labour allocation within the farm?
2. Are farm households efficient over the cropping season? What are the factors influencing farm labour use across the season?
3. Are farm households efficient in allocation of labour between farm and off-farm activities? What are the factors influencing labour supply and demand and hence labour mobility between the farm and off-farm activities.

1.3 Contribution of the study

This study is linked to the NUANCES, now AfricaNUANCES "Exploring tradeoffs around farming livelihoods and the environment" whose aim is to examine trade-offs made in implementing a variety of soil fertility technologies (Giller, Rowe et al. 2006). The project identifies failure of past interventions in mitigating the challenges faced in soil fertility management and food production to the failure of addressing the complexity in the livelihoods of smallholder farm households. This study contributes to the NUANCES framework by addressing farm household labour use, a key issue in the uptake of soil fertility technologies by smallholder farmers. The study's contribution is a deeper understanding of farm household behaviour in labour allocation and the 'opportunity cost' of labour in smallholder farm households.

1.4 Methodology

1.4.1 Motivation of the methodological approach

Labour is an important resource for smallholder households in food production, off-farm activities and in most technological interventions. Understanding farm household behaviour in labour allocation is therefore an important consideration in formulation of policy interventions targeting this group of households. This section discusses views of previous studies in western Kenya regarding labour and its availability.

A high population density as reflected in government statistics (RoK) and the limited employment opportunities suggests abundant labour in Kakamega and Vihiga. Previous studies have also alluded to this, e.g. Salasya (2005) suggests that surplus labour is bottled up in the farms resulting to inefficiencies in labour use on the farm. Yet other studies have suggested that labour is scarce because it is a constraint, for example, in adoption of technologies on the farm (Place and Dewees 1999). Labour is frequently listed as one of the major constraints to the adoption of soil fertility management and soil conservation technologies (KARI 1998-2002). Low returns to labour and technologies being too labour demanding are the two major reasons given for lack of adoption.

The reasons given are surprising for a region with surplus labour (a high population density with few employment opportunities). In earlier studies, the opportunity costs of labour were equated to zero in such regions having surplus labour (Ranis and Fei 1961). Later studies have however shown that the opportunity of labour in peasant households is not zero (Sen 1966) and that the marginal productivity of labour has to be positive for the labour market to function (Jorgenson 1961; Jorgenson 1967; Lefeber 1968). If the shadow wage of labour is not zero, how does it compare to the market wage rate? We expect payment to labour on-farm and off-farm to be equalised if households are efficient.

In this study we hope to reveal the dynamics which lead to the observed contradictions in perceptions about labour and its value in smallholder farm households. These contradictions may arise from seasonality i.e. agricultural systems are characterised by periods of intense activity followed by low activity. They may also arise from household or plot specific idiosyncrasies.

While recognising the importance of biophysical conditions, previous studies which examine factors influencing household decisions (Salasya 2005) have been mainly at the farm household level. The argument is that allocation of labour and other resources is normally made at the household level. While recognising the importance of prices in decision making, these studies assume that decisions are made simultaneously or use a single price (wage rate). Such studies have shortcomings and may not adequately unravel the complexities that underlie household decisions.

It is widely recognised that household behaviour in use of its labour is normally influenced by conditions in the rural markets (De Janvry, Fafchamps et al. 1991; Sadoulet and De Janvry 1995). Plot idiosyncrasies may also alter household behaviour yet earlier studies on efficiency have mainly been at the farm level. We use plot level studies not only to control for these idiosyncrasies but also to reveal additional information regarding within farm dynamics that influence labour use. In Chapter 3 within farm efficiency in labour use is examined with a view to explaining farm household behaviour.

Although some previous studies suggest that seasonality may influence household behaviour (Kanwar 2004; White and Leavy 2004; White, Labarta et al. 2005), only a few (Fafchamps 1993; Elad and Houston 2002) have quantified this effect. The underlying assumption in most behavioural studies is that household decisions are made simultaneously at one point in time, probably at the beginning of the season. This would suggest that household decisions are based on a single wage which remains constant over the cropping season. In Chapter 4, the model applied incorporates the idea that labour use decisions over a cropping season are influenced by the information held at each stage and not by the information held at the beginning of the season (Fafchamps 1993). The model thus allows for a changing labour constraint and hence wage rate across the season.

Eighty percent of the farm households in the study area participate in both farm and off-farm activities. This suggests an interrelationship between decisions on labour use on and off the farm. Having understood household behaviour within the farm and over a season, this study would be incomplete without an understanding of labour allocation between farm and off- farm activities. This is examined in Chapter 5.

1.4.2 Analytical approach

A multi-dimensional approach to efficiency is adopted. To answer the first research question, a spatial perspective of allocative efficiency within the farm is adopted where crop specific production functions are estimated while controlling for within farm-heterogeneity by using plot level data. The parameters from the estimated production functions are used to calculated the marginal product of labour applied to each of the crops. In order to establish whether farm households are allocative efficient within the farm, these marginal products of labour are compared to each other and to the market wage rate. The factors driving labour allocation were established by creating an index which compares labour allocated to maize (the staple food) with labour allocated to other crops grown by the household. This index is related to farm and household characteristics which influence labour supply on and off the farm and farm characteristics which determine household decision price for mainly food but also marketed crops.

To address research question number two, a temporal perspective of allocative efficiency is adopted. Season specific marginal products of labour are estimated and compared in order to establish the allocative efficiency of farm households in the presence of variability in the opportunity cost of labour due to changes in labour demand occurring over a cropping season. Although farm household labour use is influenced by seasonality, economic theory does not provide information on the expected household behaviour i.e. to maximise profits. Our expectation is that households will allocate labour over the cropping season in a manner such that losses in output due to scarcity of labour are minimised. Moreover, the household will allocate labour so as to minimise the variability in the gap between labour demand and labour supply over the cropping season. The optimal labour allocation in the planting and weeding stages of a cropping season is derived using a sequential decision model (Antle 1983; Antle and Hatchett 1986) where decisions in the current stage are influenced by the outcomes from the previous stage and the expected optimal labour allocation in the later stages. A system comprising of two labour demand functions (planting and weeding stage labour) and a production function was estimated and the parameters used to generate stage specific (planting and weeding stages) marginal products of labour. Indexes are created from the marginal products and comparisons made within each household with an aim of establishing substitutability of labour between the stages and the allocative efficiency. Inefficiency in labour allocation between stages in a cropping season is expected to be related to farm and household characteristics which influence labour demand and labour supply to the farm and off-the farm. Seasonality, its implications on labour scarcity and households ability to cope with the changes occurring over the cropping season has far reaching consequences including the uptake of productivity enhancing technologies.

In addition to spatial and temporal perspectives adopted in allocative efficiency within the farm, farm household's efficiency in allocation of labour between farm and off-farm activities is relevant because: the environment within the farm and off-farm interact in ways that influence farm household labour use, farm households participation in off-farm activities has been shown to yield mixed effects on agricultural production (Shuyi 2006). Farm household supply of labour to the farm and off-farm and its demand for hired labour are examined. Theory suggests that efficient farm households allocate their labour such that payment to an extra hour of labour spent on-farm and payment to an extra hour labour spent off-farm is equalised. Moreover, the productivity of hired labour on-farm should equal the market wage for such hired labour. The outcomes of farm household behaviour in the presence of labour market imperfections may deviate from allocative efficiency. The presence of transactions and rationing in labour markets may result in market wages which are either inflated or discounted depending on the position of the household. Moreover, unequal distribution of assets and skills between households as well as within households suggest that the payment to labour may vary even within the household.

1.5 Outline of thesis

This thesis is organized as follows. **Chapter 1** introduces the problem addressed by the thesis, the objective of the thesis, the research questions. In **Chapter 2**, the data and study sites are presented together with the methodological approach.

Chapter 3 is about farm household efficiency in labour allocation within the farm and provides useful insights in resource mobility within the farm. Farm household behaviour in labour allocation to different crops within the farm is examined while controlling for variability in bio-physical characteristics of the farm. Factors influencing labour allocation within the farm are also determined.

In **Chapter 4** a vertical view point of labour allocative efficiency is adopted where allocation of labour over a cropping season is considered. The focus of the study is on the effects of variability in labour scarcity within a season. Analysis in this Chapter captures the sequential nature of farm household labour allocation decisions in derivation of optimal farm labour use at various stages within a cropping season. We apply the model to smallholder maize production to determine the impact of changes in the shadow wage during different stages within a season on production and to assess household efficiency in labour allocation.

The analysis undertaken in **Chapter 5** complements that of Chapter 3 and 4 because it examines household efficiency in labour allocation between farm and off-farm activities. The Chapter details the context within which decisions on labour supply and demand are made by exploring various scenarios and their possible effects on household choices. Factors influencing mobility of labour between farm and off-farm activities and substitutability between family and hired labour are identified.

In C**hapter 6** the findings from the three preceding (analytical) Chapters are synthesised giving the main conclusions that are derived from the study and recommendations for policy and further research.

1.6 Contribution to existing literature

This study contributes to the body of research in smallholder labour allocation in both the methodological approach and in the findings. The first methodological innovation is the multi-dimensional approach to farm household labour allocative efficiency. By analysing labour allocation within the farm, within a season and between farm and off-farm, this study deepens the understanding of farm household behaviour in labour use. The second methodological innovation is that the study exploits the heterogeneity which is shaped by smallholder livelihood strategies[6] in making its case. This heterogeneity can be observed within the farm due to diversity in plot characteristics and crops grown, within a season emanating from variability in the labour constraint and within a household due to variable payments to labour.

[6] An organized set of lifestyle choices

The study clearly shows that based on market prices for the products, farm households are not always efficient in allocation of labour within the farm, over the cropping season or even between farm and off-farm activities. To a limited extent, this could be attributed to different perceptions of the values of the products, as held by the household. The finding of the relative under-use of labour at planting stage shows that a household may feel more labour constrained during certain stages within a season while within the farm, labour is not availed equally to all crops or plots. It also shows that outside the farm, all household members may not enjoy similar access to employment opportunities the result being that some labour remains on the farm despite the low returns. Although the study comes short of providing a single figure indicating the opportunity cost of labour in rural households, it does provide indicators which can be used as guidelines in determining the opportunity cost of labour in a household.

Chapter 2

THE STUDY AREA

2.1 Introduction

The agricultural sector is the mainstay of the Kenyan economy. It provides 26% of the GDP, 27% through links with manufacturing, distribution and other service sub-sectors and 60% of the export earnings. It is the dominant employer of the work force particularly in the rural areas where 80% of the population derive their livelihood from agriculture. Smallholder farms are particularly important because they make the bulk (80%) of the producers. Despite the importance of agriculture, 80% of Kenya's poor are to be found in the rural areas. Moreover, smallholder households increasingly derive a significant proportion of their income outside the farm. Indeed one of the distinguishing characteristics of smallholder farm households is the diversity of activities they engage in. Typically, smallholder farm households grow a range of crops, raise livestock and engage in off-farm activities. Literature offers many reasons why households diversify (Ellis 1998; Barrett and Reardon 2001; Barrett Marenya et al. 2006). Households engage in a range of social and economic activities to balance their food and cash needs and/or to reduce risk. The chosen combination of households assets and activities is commonly referred to as a livelihood strategy. According to Brown et al. (2006) there are significant differences in outcomes between livelihood strategies and hence significant potential gains to be made by households moving from one livelihood strategy to another.

This thesis is concerned with farm household behaviour (choice) and the barriers to activities with higher outcomes. The options available to farm households vary with the region, household and personal characteristics. In this chapter the study area and the households in the sample are introduced, highlighting the diversity therein with a view to setting the stage for evaluation of household efficiency in the following chapters. The chapter proceeds as follows: Section 2.2 describes the dataset and sampling methods used; Section 2.3 describes the study area; and Section 2.4 provides the conclusion.

2.2 Data Source and data collection

The main data set used in this study comprises of household and plot level data collected from a random sample of farm households in sixteen villages in two districts of western Kenya namely, Kakamega, and Vihiga districts. The village is the smallest administration unit in Kenya however they differ in size and population. Western Province is one of the six provinces of Kenya. Like other parts of Kenya, the economy of western Kenya is mainly driven by the agricultural sector which mainly comprises of smallholder farmers. The two districts were selected because they represent the variability found in the highlands of western Kenya (Tittonell, Vanlauwe et al. 2005b). The two are also research sites of the soil fertility programme of the CGIAR institute, TSBF-CIAT.

A multi-stage sampling design was used to identify households to be included in survey. In the first stage, one division was selected to represent each of the two districts and then two locations were selected to represent each of the divisions. Selection of divisions and locations was partly guided by the need to include both research and non-research sites. Two sub-locations were randomly picked from each of the selected locations and lastly, four villages were randomly picked from each sub-location. The households to be included in the survey were randomly picked using informal sampling methods. The survey was executed in two phases with each phase corresponding to a growing season. The first survey in which data for 2003 short rain season (SR) were collected took place between February and March 2004. The second survey in which data for 2004 long rain season (LR) were collected took place between October and November 2004. Each household was therefore visited and interviewed twice. In the first survey, approximately twenty to twenty five households were interviewed in each village totalling to 327 (168 and 159 households in Kakamega and Vihiga districts respectively). In the second survey, fewer (317) households were interviewed either because some households could not be traced or due to death of the main respondent. Details on the villages and the precise number of households interviewed are given in Table A.1 in the appendix.

The working definition[7] of a household has been adapted from Ellis (1993). In many parts of Kenya, it is common for households to have some of their members working in distant locations away from home. The household in this study therefore includes household

[7] Definitions of households (Ellis); Usually the group is led by one person, the household head, who is the decision maker for the household.

1. A group of people who eat from the same pot
2. A group of people who live together and form an economic decision making unit
3. A group of people who live together and have common financial arrangements for their day to day living expenses
4. The group is usually led by one person who is the household head. He is normally the decision maker for the household.

members who do not always eat from the same pot but have a common financial arrangement and are part of the decision making unit. This definition allows for the inclusion of household heads and in few cases grown-up children who are not married[8] who have temporarily migrated in search of employment.

As is the case in farm household data collection in many developing countries, farmers recollection was relied upon to provide information. Data were collected at the end of each season thereby improving the accuracy of data due to the relatively shorter period of recollection. Furthermore, data were collected at the plot level[9] so as to increase accuracy and to capture the spatial variations within the farms. Prior to the survey, the enumerators who held the interviews with farmers and recorded data were trained on several aspects of data collection including but not limited to the art of questioning and recording data; units and measurement of quantities, weights, area and time. Outmost care was taken to collect "good data", this involved discussions with the farmer and visits to the farm for a visual appreciation of the farm layout.

Information on crop and farm management practices, land and labour allocation, input and output data was collected. Observable plot characteristics were recorded whilst perceptions on plot characteristics (soil fertility, position on slope etc) were elicited from the farmers. Other types of information collected from the household include livestock production, marketed farm produce, prices and wages, participation in labour markets, income sources and household demography. Some households did not have a market price for crops grown or for labour. In such cases the village level prices applied and where absent, prices from neighbouring major market were used. The rainfall received during the study period was slightly lower and later than the 5-year average for the area. The recorded prices and wage rates were however normal.

2.3 Description of study area

2.3.1 Location and farming systems

Much of the land in the two districts (Kakamega, and Vihiga) falls in the high to medium potential areas UM1 and the rainfall ranges from 1400 mm to 2000 mm (RoK

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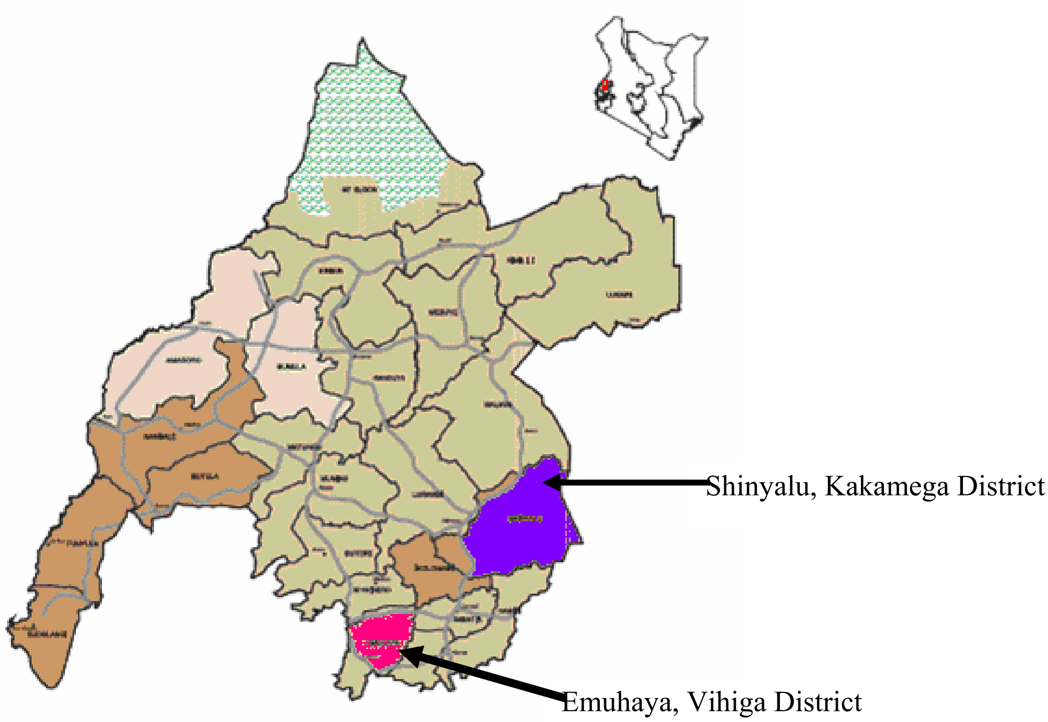
[8] A married couple is normally assigned their own plot and are expected to be independent.

[9] As opposed to farm level

2000). The rainfall pattern for western Kenya is bimodal whereby rainfall is received in two distinct seasons namely; the long rains (LR) which falls between March and July and the short rains (SR) which fall between August and October. The difference between the long and short rains is in the total amount of rainfall received, the length of the rainfall period and the variability in both amounts and length (Kenya Meteorological Station, Nairobi). The cropping seasons closely follow the rains where the long rains define the major season (long rain season) and the short rains define the minor season (short rain season). Tittonell (2005a) and Ojiem (2006) have an in-depth exposition of the bio-physical characteristics of the study area (see appendix 2.5).

Vihiga district is one of the most highly populated areas with a population density estimated at 978 persons per square km. Kakamega is less densely populated with a density of 461 persons per square km (RoK 2001). Consequently, farms are on average small (see Table 2.1) but are slightly larger in Kakamega district.

Figure 2.1: Map showing western province of Kenya



Source: Adapted from Kenya Poverty Atlas, Central Bureau of Statistics

Table 2.1: Distribution of farm sizes in hectares[a]

	Whole Sample	Kakamega	Vihiga
Average	0.79	0.97	0.58
Minimum	0.04	0.08	0.04
Maximum	3.43	3.43	2.02
Percentiles			
10	0.20	0.40	0.20
25	0.40	0.49	0.30
50	0.61	0.81	0.49
75	1.01	1.21	0.76

[a]1 ha = 2.475 acres;

The average farm size is 0.79 ha for the overall sample and 0.97 ha and 0.58 ha for Kakamega and Vihiga respectively. Fifty percent (50%) of the households own not more than 0.81 ha in Kakamega and 0.5 ha in Vihiga. These statistics compare well with government statistics for this area. As described in chapter one, it is very common for smallholder farmers to subdivide their farms into plots. The total number of distinct plots for each household ranges from one (1) to six (6) with most households having two (2) to four (4) plots. The plots are normally small and range from a minimum of 0.02 hectares to a maximum of 2.42 hectares with a mean of 0.24 hectares in Kakamega and 0.16 hectares in Vihiga.

In a typical farm, homesteads are located at the uppermost part of the farm near to the road or foot path which generally runs along the top of ridges in the village. The plot in which the homestead lies is normally not cropped but serves as a grazing plot for tethered animals (sheep, goats and cattle) and for receiving guests. The plots surrounding the homestead are small compared with the outer fields and are normally planted with bananas, chewing cane and vegetables. Plots planted with field crops follow and these may be planted in one or two plots depending on farm size. It is only in market-oriented farming that vegetables are planted in large plots away from the homestead. Trees are found within the homestead plot or in the furthest and steepest plots. On average farmers in Vihiga travel a shorter distance from the household to the farm (70 m) compared with households in Kakamega who travel for over 200 m to get to their plots. Although these plots are not located alarmingly far from the homesteads, farmers claim it is comparatively inconvenient to work or to ferry farm inputs and outputs from distant plots (Misiko 2007).

Farm households in the two areas mainly practice subsistence farming. In spite of the small farm sizes, households grow a wide range of crops mainly to satisfy their food needs. Maize and beans are the major crops planted. Other food crops like sweet potatoes and cassava are either intercropped with maize or planted in small portions along the edge of maize/bean plots. Cash crops like tea and sugar cane are also grown although to a limited extent.

Historically, the entire household food requirement for households in western Kenya was met during the long rain season so that the land was left fallow in the short rain season (KARI 1998-2002; Crowley and Carter 2000). The long rain season was regarded as best for maize production but too heavy for beans. During the short rain season beans were the main crop planted with minimal acreage put under maize. Due to a decline in farm sizes, farms are under pressure to produce[10] for the high population and hence the farms are more intensively cropped. In Vihiga where the farms are considerably small, farms are cropped intensively during both the long and short rain seasons. In Kakamega, the cropping intensity is lower in the short rain season (SR)[11] although this varies with farm size and hence between households. Generally, maize and beans dominate in both seasons, but fewer plots are planted with maize during the minor season. Compared with the major season, there are more plots planted with vegetables, Napier grass, indigenous crops, other legumes and cereals in the minor season. In addition, more plots are left fallow during the minor season. There are other factors that influence crop choice including farm characteristics, expected returns and household preferences.

2.3.2 Relative importance of various income sources

Farm households normally supplement their income with cash from sale of livestock products and live animals, off-farm employment and remittances. Table 2.2 indicates the contribution of various income sources to the total farm household income. As indicated in the previous section, agricultural production in the study area is primarily for subsistence. Appendix 2.4 shows that cash income from the farm contributes only eleven percent (11%) of the household income. However, when farm output is valued at the market price, the contribution of agricultural production to household income is close to thirty percent (29%). Eighteen percent (18%) of this income comes from crop production while the rest (11%) is derived from livestock products and sale of live animals.

Although off-farm income provide the largest proportion of household income (approx. 66%), 24% of the households do not have access to this kind of income. In contrast, all the households derive some income from the farm. Compared with other sources of

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[10] Inspite of the intensification, most households can meet their food needs for only one to two months in a season

[11] from this point used interchangeably in the text

income, livestock sales followed by non-labour income provide the lowest income to the farm households in the study area.

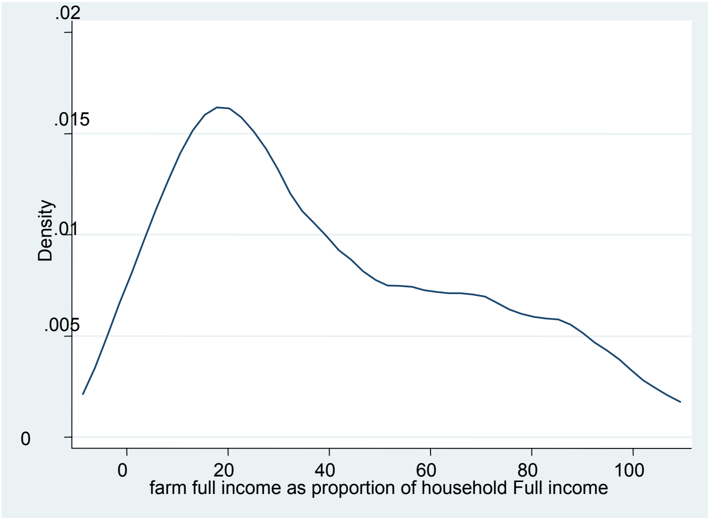
Table 2.2: Sources of income and their contribution to household income: Value of farm output[a], and non-farm income

Variable	Obs	Mean	Std. Dev.	Min	Max
Income (KSh[b]/yr)					
Household total	317	92,322	87,265	2,321	769,622
1. Value of farm output	317	26,648	27,295	1,013	307,878
• *Value of crop output*	317	16,671	12,732	548	78,246
• *Value of livestock products & animal sales*	317	7,624	20,797	0	273,600
• *Cash income from livestock sales*	317	2,353	4,585	0	30,000
2. Income earned off-farm	317	60,958	76,352	0	576,000
3. Non-labour income	317	4,716	10,833	0	123,700
As a proportion of total (%)					
1. Value of farm output	317	28.86	29.71	0.44	100.00
• *Value of crop output*	317	18.06	23.45	0.35	100.00
• *Value of livestock products*	317	8.25	14.43	0.00	71.76
• *Cash income from livestock sales*	317	2.55	8.15	0.00	58.97
2. Income earned off-farm	317	66.03	33.19	0.00	99.56
3. Non-labour income	317	5.10	13.64	0.00	84.18

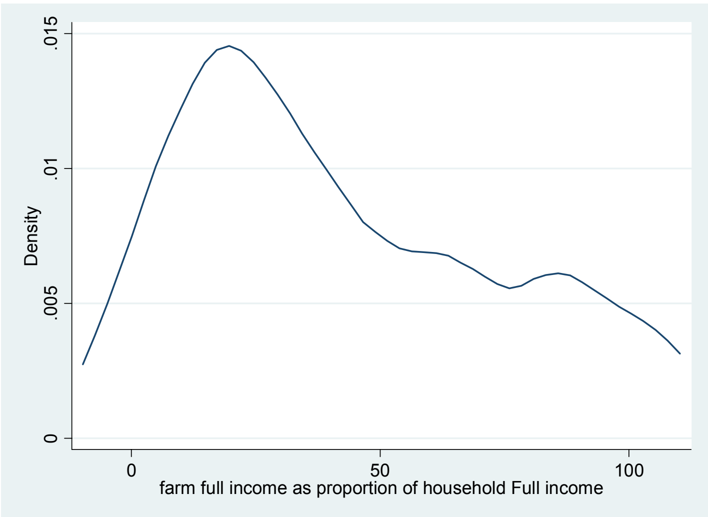
[a] includes sales and value of consumed output
[b] the mean exchange rate in the year 2004: KSh. 75.00 = 1USD

Appendix 2.4 shows that total household income in Kakamega is thirty percent higher than that in Vihiga which is due to the higher incomes derived from crop and livestock production as well as off-farm employment. The K-density plots in Figure 2.2 show the importance of farm income to the farm households in the study area. The table and figure shows similarities in the importance (contribution to household income) of agriculture and other sectors in the two study areas despite the differences observed in the bio-physical and socio-economic characteristics.

Figure 2.2: K-density plots showing farm income as a proportion of household income in farm households



Kakamega



Vihiga

2.3.3 Participation of farm households in various markets

Table 2.3 below describes the distances that farm households travel to markets and services. On average, households travel short distance (300 m – 400 m) to get to a motorable road, but the nearest stop for public means of transport (bus or matatu) is 1.7 km in Vihiga and 3.1 km in Kakamega. Bicycles (boda boda) are the most accessible mode of transport at an average distance of 1.2 km in Vihiga and 1.7 km in Kakamega. Their use is however restricted by the hilly terrain that characterises most parts of western Kenya. It costs an average of KSh. 20.00 to KSh. 25.00 per person to travel in a bus or matatu to a major market and Ksh. 30.00 to travel to the fertiliser market. The use of matatus and buses is however restricted by low levels of liquidity, poor roads and long hours of waiting.

Table 2.3: Distance (km) travelled to markets and services

Distance to …	Kakamega		Vihiga	
	Mean	Std. Dev.	Mean	Std. Dev.
A motorable road	0.3	0.3	0.4	0.5
A tarmac road	4.2	2.6	2.2	1.5
A bus stage	3.1	2.1	1.7	1.2
A boda boda stage	1.7	1.6	1.2	1.0
The nearest trading centre	2.0	1.5	1.4	1.0
The nearest major market	3.9	2.2	2.8	1.5
A posho mill	0.5	0.4	0.5	0.5
The fertiliser market	5.2	2.4	2.8	1.9
A telephone facility	1.9	1.2	2.0	1.2

Ninety five percent (95%) of the households in the areas of study prefer to walk. They walk to the market for their household and farm supplies, to sell farm output, and to access other essential services. On average, posho mills (where maize is ground) are located closest to homesteads at an average distance of 0.5 km while the nearest trading centre is located 1.4 km in Vihiga and 2.0 km in Kakamega. Major markets where traders from distant markets convene to buy and sell farm output and other supplies are located at an average distance of 2.8 km in Vihiga and 3.9 km in Kakamega. Farmers travel an average distance of 2.8 km in Vihiga and 5.2 km in Kakamega to purchase fertiliser. Telephone facilities are available at an average distance of 2.0 km from the homesteads.

Table 2.4: Households participation in food and input markets (percentage)

	Vihiga	Kakamega
Maize market		
Net Buyer	76	51
Net Seller	5	26
Self-sufficient	19	23
Input market		
Seed	57	75
Fertiliser	48	85

Maize is the main staple food and hence the most popular crop amongst the households in western Kenya. It is planted by over 90% of the households and occupies close to 70% of the farm during the Long rain season. Table 2.4 shows that majority of the households in western Kenya have a food deficit and are net buyers of maize. This finding is consistent with previous studies (RoK 2000; RoK 2002; Ojiem 2006) which show that maize production by most households is enough to feed the household for 1 to 2 months. Twenty six percent of the households in Kakamega sell maize but only 5 percent have surplus to sell in Vihiga. Nineteen percent and twenty three percent of the households in Vihiga and Kakamega respectively opt for self-sufficiency in maize which means that they neither sell nor buy any maize. The important question to ask with regard to households choice of enteprises is whether they are efficient i.e. choice lead to best outcome and if not the barriers they face.

The other crops grown by households in the study area together with the prices fetched in the market are shown in Table 2.5. It is important to mention here that not all households participated in selling of crops and hence the prices presented in the table are those reported by households which sold the particular crop. Soya beans and groundnuts fetch the highest price followed by tomatoes and then dry beans. Maize, the most popular crop, fetches an average price of KSh. 13.00 and shows a wide fluctuation in price. The wide price range may be related to differences in the time of sale whereby maize (and indeed any crop) sold immediately after harvest fetches the lowest price whereas maize sold after two or three months after harvest fetch a high price. It is not uncommon in the study area for households to sell immediately after harvest to meet cash needs only to purchase at a high price later in the season. The crops showing little fluctuation in price were sold by few households compared to crops that show wide fluctuation.

Table 2.5: Crops grown and their selling prices[a] by season

Crop		Short Rain Season			Long Rain Season		
	Units	Mean	Min	Max	Mean	Min	Max
Maize	KSh/kg	13.11	1.11	26.67	13.58	1.11	22.22
Sorghum	KSh/kg	14.81	13.33	17.78	12.78	8.89	17.78
Arrowroots	KSh/kg	2.55	2.55	2.55	8.16	8.16	8.16
Cassava	KSh/kg	15.00	15.00	15.00	4.54	4.08	5.00
Sweet Potatoes	KSh/kg	4.07	1.53	7.65	5.96	2.04	10.20
Dry Beans	KSh/kg	25.21	6.67	53.33	23.74	8.89	35.56
Cowpeas	KSh/kg	22.22	22.22	22.22	-	-	-
Green grams	KSh/kg	8.89	8.89	8.89	-	-	-
Soya Beans	KSh/kg	41.43	20.00	70.00	39.29	20.00	70.00
Groundnuts	KSh/kg	41.45	36.36	47.27	43.64	43.64	43.64
Cabbage	KSh/kg	8.33	8.33	8.33	-	-	-
Cowpea leaves	KSh/kg	15.75	1.40	32.00	21.16	8.00	40.00
Indigenous Veges	KSh/kg	15.55	2.00	40.00	13.46	4.00	24.00
Onions	KSh/kg	16.67	16.67	16.67	-	-	-
Sukumawiki	KSh/kg	7.32	2.00	20.00	5.64	2.00	14.00
Tomatoes	KSh/kg	39.49	27.27	62.50	27.81	25.00	31.25
Napier Grass	KSh/kg	1.28	.57	2.86	1.71	.57	2.86
Bananas	KSh/kg	4.10	1.68	8.75	3.99	1.12	6.25
Eucalyptus[b]	KSh/tree	732.22	40.00	3000.00	502.86	100.00	2000.00
Gravellier	KSh/tree	-	-	-	2500.00	2500.00	2500.00
Tea	KSh/kg	8.82	5.00	15.00	8.58	7.00	15.00
Sugarcane	KSh/piece	6.09	2.00	20.00	8.14	4.00	10.00

[a] the mean exchange rate in 2004 was KSh. 75 = 1 USD
[b]the price range reflects the size and/or age of tree and not fluctuation of price

The data suggests that more households participate in the input market in Kakamega compared with households in Vihiga. Seventy five percent of the households in Kakamega purchased maize seed during the survey period compared to only fifty seven percent in Vihiga. Moreover, eighty five percent of the households in Kakamega purchased fertiliser for maize during the survey period compared to only forty eight percent in Kakamega. These results are consistent with findings in previous studies (Salasya, Mwangi et al. 1998) which show less farm intensification in Vihiga compared with Kakamega.

Although farming is one of the major economic activities for households in the study area, majority of the households are also active in the labour market as either sellers or buyers of labour. In this kind of setting, adult members of farm households will work on their farms, engage in business, sell their labour for wages or get salaried employment. Participation in various employments is expected to differ between households depending on their characteristics. Education level emerges (results presented in chapter 5) as an important determinant of occupation or source of employment. Persons without any formal education are likely to work for wages in the agricultural sector but not in the non agricultural sector. They are also self-employed in the farm or out of the farm by engaging in petty trade. Although persons with a wide range of education levels are likely to be found on the farm, persons with primary education or less are most likely to be employed on the farm. Some level of formal education is necessary for one to secure salaried employment.

Table 2.6 describes household participation in the off-farm labour market. We define participation as having at least one household member spending some or all his/her time working off the farm. Twenty five percent (25%) of the farm households in Vihiga did not participate in off-farm employment, however participation is higher in Kakamega especially during the long rain season where only 15 percent of households did not participate.

Table 2.6: Percentage of farm households participating in off-farm employment

	Vihiga		Kakamega	
	Short rain season	Long rain season	Short rain season	Long rain season
Casual wage in agriculture	41	39	32	33
Casual wage outside agriculture	18	16	9	13
Self-employment	34	38	26	39
Salaried employment	30	31	26	28
Not selling labour off-farm	26	24	21	15

Since casual wage employment in the agricultural sector is the most common, we investigate further casual labour exchange within the agricultural sector. Table 2.7 describes the overall casual labour exchange in the agricultural sector. While the farm households in the sample offer some employment for hired casual workers, their supply of the same kind of labour (casual workers in agriculture) is more than double their demand. In absolute numbers, there are far more hours of casual labour hired-out than hired-in. The study area is therefore a net supplier of agricultural casual labourers. The hours of labour hired-out do not differ between Kakamega and Vihiga, however, households in Vihiga hire-in more labour compared to households in Kakamega. The large difference between hours hire-in and hours hired-out suggests that the surplus casual labour in agriculture seeks employment outside the study area e.g. in sugar plantations in neighbouring districts. It could also be due to under reporting of hours of labour hired-in although there is no reason for us to suspect this.

Table 2.7: Hours of casual labour hired-in and hired-out of the agricultural sector in the study area

	Hours hired-out	Hours hired-in	Net hours hired out of study area
Vihiga	59,304	38,044	21,260
Kakamega	57,072	16,511	40,561
Total hours	116,376	54,555	61,821

In Table 2.8 we look within the farm and compare the hours spent working on the farm by family or hired labour and the hours of work spent in casual employment outside the farm. Generally, households in the study area mainly use family labour on their farms and also spend a considerable amount of time in casual employment outside their farms. Ojiem (2006) and Misiko (2007) show that households which do not hire-in labour or have members working for wages in agriculture are the poorer households. We found that these households spend more time in casual farm labour work than they do on their farms (Table 2.8). It was observed that households reduce the hours in casual employment by about 30% during the main planting season.

In this kind of scenario, there are bound to be differences in labour availability between households in the study area especially if for some reason, the labour constraint is binding. According to farmers in the area, they are experiencing labour shortages because the social system has changed i.e. school going children no longer supplement family labour, social labour groups are no longer active and community members increasingly demand for payment, majority of farm households sell their labour to meet cash needs and the high incidence of diseases (HIV & malaria) puts a strain on household labour and the cash needs (Ojiem 2006).

Off-farm employment opportunities are available in local trading centres, major markets and towns. Casual employment opportunities are mainly available in masonry, jua kali (fabrication and repairs) and in provision of transport services. A whole range of businesses (self employment) offering a wide range of services are to be found in the area of study. The most common business is trade in agricultural goods followed by trade in non-agricultural goods. Other common businesses include shops, local brewing, posho mills and pottery. Shamba-boy[12], guard and house-help and clerical work are the most common in salaried employment. Others are in the medical and teaching profession. The returns to labour are higher off-farm compared with returns to labour on-farm. There is also a wide variation in returns to labour employed off the farm. According to our estimations, the average returns to labour during the long rain season was KSh. 7.00 in casual employment in agriculture, KSh. 17.00 in casual employment outside agriculture, KSh. 23.00 in self employment and KSh. 28.00 in salaried employment.

In a series of articles, Tittonell et al. (2005a, 2005b, 2006, 2007) explore the diversity of crop and soil management in this region. They indicate a very large diversity in soil conditions and management both within the farm and between households. Within the farms, they show large differences in plot management by distance, with nearby fields being better supplied with nutrients and other inputs. These fields are also planted earlier and with greater plant density. The differences by distance diminish however if the resources of the household are larger. Our study takes this point a step further by investigating if the marginal use of labour on the various plots obeys the optimality conditions, i.e. if marginal reallocation of labour would lead to better outcomes.

Between the farms, Tittonell and his colleagues find that the degree of involvement of farm households in the off-farm labour market, and their land endowments profoundly affect their land management strategies. In particular, off-farm employment is taken up by both rich households (with educated members) and poor households (with little land). Their land management differs as a consequence of differential access to cash income, and land. In chapter 5 of our study, we explore how the degree of involvement in the labour market affects the *marginal* efficiency of labour use, i.e. whether the household finds itself in an equilibrium as to its labour allocation

[12] Farm hands

Table 2.8: A comparison of the average time (hours of labour) spent on-farm and in casual employment

	Overall sample		Households which hiring-in labour		Households which do not hire-in labour		Households with members working for wages in agriculture		Households without members working for wages in agriculture	
	Short rain	Long rain	Short rain	Long rain	Short rain	Long rain	Short rain	Long rain	Short rain	Long rain
Hours of family labour on-farm	258	291	252	263	262	313	269	340	250	263
Hours of hired labour on-farm	81	96	185	225	0	0	37	46	108	124
Hours in casual employment in agric	229	150	123	80	312	202	606	407	0	0
Hours in casual employment outside agric	99	115	49	90	138	132	113	156	91	91

2.4 Conclusion

In this chapter the study area was introduced the study area describing it's location, farming systems, sources of household income, distances travelled to access markets and services and participation of households in the food and labour markets. The study was carried out in western Kenya which is well endowed with adequate rainfall and a deep soil is classified as an area with high to medium agricultural potential. The households in this region are mainly small-scale farmers growing a wide range of crops to meet their food needs. Some of the households generate cash from farming. Agricultural productivity in the region has been declining in spite of the existence of solutions for many of the technical constraints. This and the small farms mean that the number of households with a food deficit is high especially in Vihiga.

Non-farm activities are an important livelihood strategy for the farm households where over 65% of the household total income and 80% of its cash income is earned. The farm households have adopted different strategies in both the food and labour markets. Most are net buyers of food, some sellers while others opt for self sufficiency. Many of the households participate in the labour market as sellers or buyers although some households opt for self sufficiency. Opportunities in the labour market are mainly in the casual labour market, specifically in the agricultural sector.

Labour is the main input on the farm and in off-farm activities. It's allocation is therefore important since it determines the households ability in meeting its food and cash needs. The diversity within smallholder farms as well as the seasonality in agricultural production also influences household behaviour in labour use. The previous chapter elaborated on the contradictions in labour in western Kenya and its availability for *inter alia* the implementation of agricultural technologies. Some of these contradictions may arise from the multi-dimensionality of labour allocation in smallholder farm households. Within-farm heterogeneity, seasonality and possible rationing in labour markets may influence labour use and hence should be investigated in behavioural studies. This study will combine these three aspects to shed more light on labour and its availability.

Appendices

Appendix 2.1: Description of sampling frame and sampling methods

Emuhaya and Shinyalu divisions where selected as the sites where soil fertility management research work has at some point been carried out by any of the institutions that are involved in soil fertility research, namely K.A.R.I/TSBF/ICRAF. A total of sixteen villages formed the sampling frame. These included villages which hosted the soil fertility research sites, namely Mukhombe, Mwironje villages in Emuhaya division and Muhonje and Mondulu villages in Shinyalu division. The rest of the villages were randomly picked from the neighbouring sub-locations.

Informal Survey

The aim of the survey was to familiarise myself with the study area and to collect useful background information. During this visit, contact was made with potential facilitators of my work for example the K.A.R.I – Kakamega Centre Director and the socio-economists. Informal discussions were also held with Key informants in research and in the ministry of agriculture. In addition, a review of research work and adoption of soil fertility management technologies in western Kenya was carried out.

Farm visits were made to familiarise with farming systems in the area as well as there soil fertility management practices. Informal discussions were held with farmers regarding farming activities, buying and selling as well as non-farm and off-farm employment opportunities.

Data Collection Tool (Questionnaire)

The initial plan was to collect household data for the year 2003 at one go. However this idea was abandoned because of the following two reasons. First the questionnaire was too long due to the detailed data being collected and would therefore have taken too much of the farmers time to fill out. Secondly the recollection period (two seasons or twelve months) was long and likely to affect the quality of data collected. The final tool was therefore designed to elicit data for the short season only which was assumed to fall in the period august 2003 to January 2004. The final tool was a 36 page document covering all aspects of a farm household farming activities, labour allocation, income sources and consumption. Also included were their assets, land improvements, markets, marketed products and prices. The tool was extensively coded for ease of data entry and analysis. This tool was adapted for data collection at the end of the long rain season.

<u>Identification and Training of Enumerators/Pre-testing the Questionnaire</u>

Six enumerators were hired to assist in data collection. Three of them were drawn from RRC Kakamega, K.A.R.I, two were fresh university graduates and come from the region and one, a young graduate with some experience in data collection for agricultural economists. Most of the trained enumerators dropped out during the second survey and so we had to hire new enumerators.

Two nine day training workshops were held in Kakamega each corresponding to the survey period. The emphasis was on; clear understanding of each question and the information being sought; weights and measures common in the region; estimation of area and weights; introduction of self to farmer; how to ask questions. Other important aspects of training included the identification of households to interview and how to handle skips due to absent farmers or turn downs. The group also helped in further refinement of the questionnaire.

On the eighth and ninth day we went out to pre-test the tool in real farm situations. The enumerators were paired and each one of them was able to interview and fill one questionnaire. The groups later met to discuss their experiences and to suggest changes on the questionnaire. By the end of the second day of pre-test, the questionnaire was declared good enough to collect data.

<u>Sampling Data Collection</u>

The households included in the survey were randomly picked using the following approach. Using a local guide, a central location in a village was identified and using the **Y sign,** three directions were identified. Three teams, each comprising of two enumerators were formed so that each team followed one of the directions indicated by the **Y** sign picking every fifth household.

The task for each enumerator was to interview a minimum of two households each day and only one or two enumerators would interview three households in a day. At the end of each day, the research assistant and I went through each and every completed questionnaire to ensure that all questions have been asked and that farmer responses were recorded in the appropriate rows or columns. In addition we checked for coding mistakes. Revisits to make corrections were made the next day before embarking on the day's task.

During the short rain season a total of 327 households were interviewed. In Shinyalu Division of Kakamega district where we began our survey, 168 households were interviewed whilst in Emuhaya Division of Vihiga district 159 households were interviewed. 317 households were interviewed during the long rain season. The initial plan was to interview 25 households in each village was abandoned after discovering that villages were smaller than we had anticipated. This number was however reduced to 20 households or less. The Appendix 22 shows villages where the survey was carried out and the number of households interviewed.

Appendix 2.2: Sampling frame and number of households sampled

Village name	Number of households		Sub-location	Location	Division	District
Villages in Kakamega	SR	LR				
Bukusi-musingu	19	18	Mugomari	Ilesi	Shinyalu	Kakamega
Wimaria	19	19	Mugomari	Ilesi	Shinyalu	Kakamega
Muhonje	20	20	Muhonje	Ilesi	Shinyalu	Kakamega
Musulwa	20	20	Muhonje	Ilesi	Shinyalu	Kakamega
Mondulu	20	20	Shidodo	Khaega	Shinyalu	Kakamega
Isoroso	20	20	Shidodo	Khaega	Shinyalu	Kakamega
Mutsolio	25	24	Lugose	Khaega	Shinyalu	Kakamega
Shieywe	25	19	Lugose	Khaega	Shinyalu	Kakamega
	168	160				
Villages in Vihiga						
Mukhombe	20	20	Ebusiloli	N.E. Bunyore	Emuhaya	Vihiga
Mwironje	20	20	Ebusiloli	N.E. Bunyore	Emuhaya	Vihiga
Emuminchia	20	20	Ebunangwe	N.E. Bunyore	Emuhaya	Vihiga
Ebunyonje	20	20	Ebunangwe	N.E. Bunyore	Emuhaya	Vihiga
Misitinyi	20	20	Ebubayi	S. Bunyore	Emuhaya	Vihiga
Wadiye	20	20	Ebubayi	S. Bunyore	Emuhaya	Vihiga
Esirabe	19	18	Esirabe	S. Bunyore	Emuhaya	Vihiga
Mulukhambi	20	19	Esirabe	S. Bunyore	Emuhaya	Vihiga
	159	157				

Appendix 2.3: Sources of cash income and the contribution to household income: Non-farm income and revenue from sale of farm output[a]

	Mean	Std. Dev.	Min	Max
<u>Income (KSh)</u>				
Household total	74,222	78,592	100	578,501
Gross cash income from farm	8,548	11,197	0	78,486
Gross income from sale of crops	3,537	6,689	0	56,600
Gross income from sale of livestock products.	2,657	6,322	0	52,800
Gross income from sale of livestock	2,353	4,585	0	30,000
Income earned off-farm	60,958	76,352	0	576,000
Non-labour income	4,716	10,833	0	123,700
<u>As a proportion of total (%)</u>				
Cash income from farm	11.51	29.41	0	100
1. Cash income from crop sales	4.76	18.35	0	100
2. Cash income from sale of livestock products.	3.57	14.91	0	100
3. Cash income from sale of livestock	3.17	15.40	0	100
Income earned off-farm	82.13	36.16	0	100
Non-labour income	6.35	23.10	0	100

[a] includes only revenue from sales of farm produce
[b] the exchange mean exchange rate in the year 2004: KSh. 75.00 = 1USD
N=317

Appendix 2.4: Sources of income and their contribution to household income: Value of farm output and non-farm income for Kakamega and Vihiga

Variable	Total sample	Kakamega	Vihiga
<u>Income (KSh[b]/yr)</u>			
Household total	92,322	106,654.10	76,764.00
4. Value of farm output	26,648	28,643.63	19,574.68
• *Value of crop output*	16,671	20,146.22	12,899.46
• *Value of livestock products & animal sales*	7,624	8,497.41	6,675.217
5. Income earned off-farm	60,958	70,759.26	50,318.71
6. Non-labour income	4,716	4,681.00	4,753.93
<u>As a proportion of total (%)</u>			
4. Value of farm output	28.86	26.85	25.49
• *Value of crop output*	18.06	18.88	16.80
• *Value of livestock products*	8.25	7.96	8.69

Appendix 2.5: Bio-physical and Socio-economic Characteristics Some of the Study Sites of the NUANCES Project
Source: P, Titonell et al. 2005a

Variable	Unit	Emuhaya	Shinyalu
Bio-physical characteristics			
Altitude	m	1640	1820
Annual mean temperature	°C	20.4	20.8
Total annual rainfall[a]	mm	1850	2145
Long rains (66% probability)	mm	800	1094
Short rains (66% probability)	mm	660	727
Rain distribution			
Long rains		begin mar to mid-jul	march to mid jul
Short rains		end jul to begin dec	jul to begin dec
Topography		moderately undulating (slopes 2-15%)	very undulating (slopes upto 45%)
Dominant soil type (FAO)		nito-humic ferralsol & dystro-mollic nitosol	humic nitosols & dystro-mollic nitosol
Socio-economic	Ha	0.69	1.25
Average farm size	Inhabitants	930	650
Population density	Km^{-2}	7.2	6.8
Family size		Munyore	Isukha
Ethnic group			
Agricultural Production			
Food crops		Maize/beans	Maize/beans
Cash crops		Tea, Napeir grass, fruits and vegetables	Tea, sugarcane, fruits and vegetables
Livestock		Local zebu with low population of exotic breeds	Local zebu with low population of exotic breeds

[a] average over 26 in Emuhaya and 14 years in Shinyalu

CHAPTER 3

ALLOCATIVE EFFICIENCY WITHIN THE FARM

3.1 Introduction

Economic efficiency measures are frequently used by economists to gauge how effectively production firms use scarce resources for the purpose of profit maximization given the technology and the level of fixed factors. In a competitive environment, resources move freely to where they are paid an equivalent of their market price. Allocative efficiency studies in developing countries are of interest because they provide information on whether resources are employed where they could earn their market value. The factors which inhibit free movement of resources can also be identified.

Most efforts investigating farm household behaviour in resource use have been at the farm level. These studies are based on the assumption that farm households view their farms as single units. When the farm is modelled as a single unit the premise is that there is efficiency within the household yet evidence of the heterogeneity within smallholder farms suggests that efficiency of the outcomes of household behaviour within the farm is not obvious but an empirical question. Heterogeneity within smallholder farms is usually used in reference to the variability in biophysical characteristics of a farm in terms of soil quality, position on the slope etc. Bio-physical discontinuities: topography, soil types, soil texture and long term management practices: intensity of land degradation, history of parcel use contribute variedly to the bio-physical variability observed on farms (Carter and Murwira 1995; Mapfumo and Giller 2001; Tittonell, Vanlauwe et al. 2005a; Tittonell and Leffelaar 2006). For example, scarcity of both organic and inorganic nutrients further reinforces farm heterogeneity creating strong fertility gradients even within the smallest of farm. The heterogeneity in small holder farms is significant enough to influence the productivity of factors of production. In western Kenya, Tittonell (2005b) found differences in intensity of input application in plots with different soil fertility status and up to 30% difference in maize yields between plots (Tittonell, Vanlauwe et al. 2005b).

Heterogeneity may also refer to the diversity in crops grown, crop combinations and their spatial distribution within a farm. Smallholder households in western Kenya are subsistence farmers and the crops grown in smallholder farms reflect the diet of the population within which households belong. Farms in western Kenya are small and virgin land is generally unavailable making it unfeasible for farm households to increase production by opening up fallow or fresh land. Expansion of production by hiring-in of land is out of the question since this is only possible in the minor season and is discouraged by insecurity and the fact that only the poor plots are hired-out (personal communication with farmers). This means that farm households have to meet their needs from the small parcels of land and therefore commonly have more than 5 different crops planted on one farm. Tittonell (2005a) found that soil fertility indicators and nutrient concentrations varied quite consistently between land quality classes according to farmers criteria. This implies that farmers are often aware of the heterogeneity within their farms (TSBF-CIAT 2003; Vanlauwe, Tittonell et al. 2006). Given this heterogeneity and the need to grow a wide range of crops, farmers may practice what is known as "niche matching"[13] (Carter and Murwira 1995) where different patches of land within a farm are selectively allocated to particular use or crops.

Farmers normally delineate their farms by use of live hedges, terraces, ditches, paths or permanent crops to map out this heterogeneity. The distinction and easy identification of plots within small-holder farms suggests that farmers view and hence manage the plots individually. Agricultural production in smallholder farms can therefore be said to be simultaneously carried out on several units (from this point onward referred to as plots) a fact which we exploit in studying allocative efficiency within the farm. In western Africa, control of plots is determined on the basis of gender (Udry 1996), but there is no evidence of a role of gender in control of plots in western Kenya.

Few studies have looked at the economic efficiency of the outcomes of resource allocation within smallholder farms. Udry (1996) found differential application of inputs (labour and fertiliser) in plots controlled by the household on the basis of gender. Male controlled plots received more of all inputs and had greater yield (30% more). This mis-allocation resulted in a loss of 6% of output. His approach focused on who is in control and the ensuing consequences for efficiency. Our approach is different in that the issue of control is not there. Under centralized control over all plots, the allocation of labour over the plots would be efficient if no gains could be made from shifting some labour from one plot to the other. In other words, the marginal value product of labour on all plots should be the same.

A fair starting point in the study of farmer's behaviour in resource allocation within the farm is to assume they are profit maximisers. A necessary condition for profit

[13] different land qualities within the farm make plots best suited or not suited to production of some crops

maximisation is that factors of production should be allocated efficiently to the various production activities of the household (Udry 1996). This also holds if farm households are not perfectly integrated in the market. In the case of imperfect labour markets, we may find differences between the marginal value product of labour on the farm and the ruling wage rate off-farm. But the allocation of on-farm labour over various activities and plots, in order to be efficient, should still display equal returns to every allocation. This is what we test at the level of the farm household. Aggregate farm level production functions assume an average production function and hence average elasticities for the farm. Plot level or crop specific production functions, however, allow for variations within the farm and therefore yield better estimates and are the basis for the assessment of equality of marginal value products of labour.

3.2 Theoretical framework

The farm household is represented as a single decision-making unit in production and consumption decisions. In a perfect market setting, farm household decisions may be viewed as occurring in two separate stages. In the first stage, decisions are made on the level of farm inputs that maximize profits without any regard for household preferences in consumption or leisure whilst in the second stage household decisions on consumption level are made based on the farm profits, prices and wages. This kind of model is commonly referred to as a separable farm household model where the market prices are the decision prices and production decisions influence consumption only through the income effect. The model requires that strong assumptions are made regarding the functioning of rural markets i.e. perfect markets. Previous studies have shown that modelling phenomena in the developing world should incorporate the incomplete nature of rural markets. Under such circumstances, production decisions are linked to consumption decisions (De Janvry, Fafchamps et al. 1991; Sadoulet and De Janvry 1995) which makes the relevant model for studying farm household behaviour one that simultaneously utilizes the production and consumption theory.

The farm household model is adopted in analysis of the farm household behaviour in factor allocation since it incorporates the production, consumption and labour supply behaviour of households (Singh, Squire et al. 1986). This model is also highly adaptable to different farm types from commercial to subsistence farms (Nakajima 1986).

3.2.1 The farm household model

The farm household's problem is to maximize its utility of consumption and leisure defined as;

$$\text{Max } U(c, fd, L_f^l; z_u) \quad 3.1$$

Where c is a vector of non-food market goods consumed, fd is a vector of food (maize and others) which is either purchased or produced on the farm, L_f^l is leisure which is the total time (T) minus time spent on economic activities (Burger 1994). z_u is a vector of household preference shifters that include age, education level and family size. The utility function is continuous and non-decreasing in consumption and leisure. The maximum utility that households can attain is restricted by the production technology used, endowment in land, the available time, the budget and availability of off-farm work. These constraints are defined next.

In the *production technology constraint* we distinguish two crops that are grown on predetermined plots of land. While the allocation of land is an important decision of the household, we focus the research on the subsequent allocation of labour to the plots. For the explanation of the approach two plots (and therefore two crops) are sufficient. The production technology is therefore given by two production functions:

$$q_j = f^j(A_j, L_j; z_j), \text{ where } j=1,2 \quad 3.2$$

Here A_j is the area of the plot devoted to crop j, and L_j is the labour (hired and family) used on that plot; z_j are characteristics of the plot like soil quality that influence productivity of factors of production.

The households time constraint is defined as:

$$T = \sum_{j=1}^{2} L_j^f + L_f^o + L_f^l \quad 3.3$$

Here, the household's time endowment is spent on the two farm plots (L_j^f) doing actual farm work; in off-farm work (L_f^o) or on leisure (L_f^l) which includes family maintenance and sleeping.

Household cash needs for purchasing food items, non-food items and farm inputs including hiring labour are met from sales of crop output, sale of labour off-farm and from remittances. So the budget constraint facing the household is defined as follows:

$$\sum_{j=1}^{2} (p_j q_j - w_h L_j^h) + w_o L_f^o + R - C - p_f fd \geq 0 \qquad 3.4$$

Where, p_j is the farm-gate selling price for crop *j*, p_f is the farm-gate buying price for food, w_h is the wage rate for hired labour L_j^h, including the value of food and other favours extended to hired labour. Off-farm wage is w_o, here taken to be net of travelling and other costs. *R* is non-labour income including remittances and C is the cost of non-food market goods.

Limited off-farm employment opportunities and barriers to entry in the form of skills, education or experience suggest that some households maybe rationed for off-farm work. This constraint is expressed as:

$$L_f^o \leq H_f^o \qquad 3.5$$

Which means that some farm households are faced with a situation where labour supply off-farm (L_f^o) is less than it would be willing to supply.

The household may produce its own food. If we set crop 1 equal to the food crop, we typically have that p_f equals the selling price p_1 in case the household is a net seller, and p_1 equals the (higher) buying price p_f in case the household is a net buyer. In between, the household is self sufficient and its shadow price lies between the buying and selling price. In practice, households may sell at the low price p_1 after harvest, and still buy later at the higher price p_f, (but save on storage costs).

The Lagrangian for this maximization problem is thus defined as;

$$U(c, fd, l_f^l; z_u) + \sum_{j=1}^{2} \delta_j \left[q_j - f^j(A_j, L_j; z_j) \right] + \lambda \left[T - \sum_{j=1}^{2} L_j^f + L_f^o + L_f^l \right]$$
$$+ \tau \left[\sum_{j=1}^{2} (p_j q_j - w_h L_j^h) + w_o L_f^o + R - C - p_f fd \right] + \eta \left[H_f^o - L_f^o \right] \qquad 3.6$$

The Lagrange multipliers represent the marginal utility derived by the household when the constraints facing it are relaxed. They represent the incremental change of the objective function resulting from an incremental change in the constraint. Delta (δ) is the marginal utility derived from greater crop output due to a technological change; lambda (λ) is the marginal utility derived from relaxation of time constraint, it represents the marginal value of the household's time; tau (τ) is the marginal utility derived from relaxation of the budget constraint and represents the marginal value of cash in the household and eta (η) is the marginal utility derived by a household when off-farm employment increases by one hour and is therefore the marginal value of extra off-farm employment.

From the first-order conditions of the Lagrangian function we can derive the conditions that must hold for optimal factor allocation within the farm.

Labour allocation of hired labour

$$p_j \frac{\partial f^j}{\partial L_j^h} - w_h = 0 \text{ for } j=1,2 \qquad 3.7$$

Labour allocation of family labour

$$\tau p_j \frac{\partial f^j}{\partial L_j^f} - \lambda = 0, \text{ for } j=1,2 \qquad 3.8$$

where λ/τ is the marginal value of the household's time endowment

Here, λ/τ may take on various values. It may equal w_0 in case off-farm work is the alternative open to the household, or w_h in case hired labour is the only alternative, and family labour and hired labour are complete substitutes, or some shadow value specific to the household in case off-farm work is restricted and no hired labour is used. The optimal level of labour allocation is at the point where the marginal value product (MVP_L) of labour on crop *j* is equal to the marginal value of the household time and is equalized between all crops grown by the household.

Important is that the expressions are the same for both crops. Even if the relevant wage rate for hired labour differs from one household to the other (for example due to distance), the MVP of hired labour for crop 1 should equal the MVP for crop 2. And even if the shadow value of household time differs from one household to the other, the equality of the MVPs of family labour of the two crops should hold. As the marginal value products of both hired and family labour must be the same for the two crops, this should also hold for the MVP of the total time allocation to each crop. In the case of perfect markets, the MVPs should be equal to the market wages for either the family labour or hired labour. This provides another test on the efficient functioning of the labour market. But the internal efficiency of the labour allocation within the household is the focus of our research. A test on the efficient allocation of labour within the household is based on the ratio of the two marginal value products

$$c = \frac{MVP_1}{MVP_2} = \frac{p_1(\partial f^1 / \partial L_1)}{p_2(\partial f^2 / \partial L_2)} \qquad 3.9$$

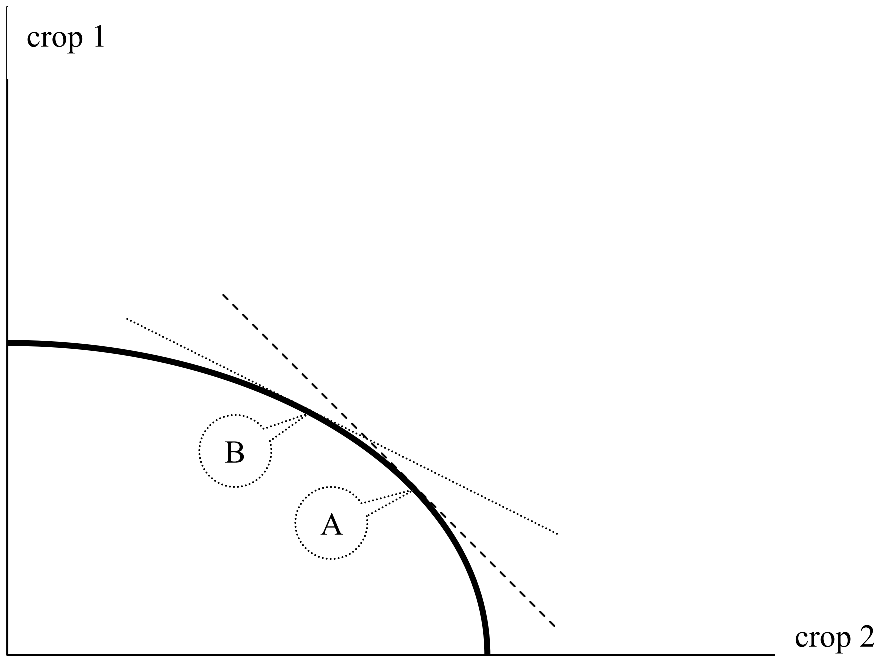
If *c=1* the allocation is efficient. The expression shows the influence of the two prices. The first-order conditions for labour allocation include the prices of the two crops. These may differ from one household to the other and the two prices may not be affected in the same way. If crop 1 is a food crop, also consumed by the household, and crop 2 is not, distance to the market likely affects the relevant prices differentially for the two crops. When the food market cannot be used, farm households will choose to produce their own food which implies that factor allocation will not only be determined by profit motivation but also by household preferences. For observations on the same (food) crop, but grown on different plots, the two prices would obviously be the same. This provides us with an even stronger statistic to measure efficiency of labour allocation.

3.2.2 Allocative efficiency over crops

If a household grows two crops, efficient labour allocation occurs when the MVP of both allocations are the same. At given areas of land of the two plots, the household faces a production frontier as shown in Figure 3.1. The household can produce crops 1 and 2 and at given prices the combination at point A is optimal. The slope of the tangent line in A is the ratio of the two MVPs. At these prices, a combination as in point B would be inefficient. If the household would perceive the product prices as different and have combination B as its optimal point, this would make point B the efficient allocation, and point A inefficient.

Hence, the efficiency measure of the ratio of the marginal value products is an indicator of the combined effect of actual inefficiency within the household and differences in optimal allocations due to differences of price perceptions. A household that has more labour at its disposal, for example because alternative employment for the family members is lacking, may choose to grow more of both crops, and particularly more of the labour intensive crop. This need not affect the ratio of MVPs however, and the measure of allocative efficiency is still relevant.

Figure 3.1: Within-Farm Allocative Efficiency



3.3 Methodology

We confront the theory with data to establish whether indeed farm households in western Kenya are efficient in allocation of labour within their farms and to explore the possible factors which can explain farm household deviation from profit maximizing behaviour. The concept of efficiency suggests that if markets are working well, the value of the marginal product (MVP) of a production factor will be equal to the market price of the factor. The MVP measures the incremental value of output resulting from an additional unit of input. The MVP of factor *m* is calculated from the marginal effects derived from crop specific production functions by taking the first derivative of the production function. The general form of a Cobb-Douglas production function written in logarithms is:

$$\ln q_j = a + \sum_m \beta_{jm} \ln x_{jm} + e_j \qquad 3.10$$

The coefficients (β_{jm}) are directly interpreted as elasticities (ε_{jm}) and indicate the percentage change in output of crop *j* resulting from a percentage change in an input x_m.

$$\varepsilon_{jm} = \frac{\%\Delta q_j}{\%\Delta x_{jm}} = \frac{1}{AP_{jm}} MP_{jm} \qquad 3.11$$

where

$\%\Delta$ is the percentage change

MP_{jm} is the marginal product of the input *m* in crop *j*.

AP_{jm} is the average product of the input *m* in crop *j*.

Crop/intercrop specific marginal product for each factor of production is calculated as;

$$MP_{jm} = \varepsilon_{jm} AP_{jm} \qquad 3.12$$

The marginal value product then follows from

$$MVP_{jm} = MP_{jm} p_j \qquad 3.13$$

On the basis of these measures, we can compare MVPs between households and crops. In the perfect model all the MVPs of a single production factor should be the same. If some households are less well integrated into the labour market than other households, the MVPs of labour will be different between the households, but should still be the same within the household. If, however, the households that are less well integrated in the labour market are also at a disadvantage as to the output markets, MVPs can differ within the households (and between crops therefore) and between the households.

We use the analysis of variance analysis (ANOVA) to test the null hypothesis (H_0) that the marginal products of labour (MVP_L) applied to different crops/intercrops on the same farm are equal. We also test the null hypothesis that there is equality in MVP of labour (MVP_L) applied to the same crop but on different plots within the same farm. A significant F-statistic leads to rejection of the null hypothesis.

The extent of inequality within the farm maybe obtained by comparing the deviation of MVP_L for each crop from the household-specific average marginal value product which is defined as:

$$\overline{MVP_L} = \tfrac{1}{N}\sum_{1}^{N} MVP_{Lj} \qquad 3.14$$

where MVP_{Lj} is the marginal value product of labour in crop j and N is the number of crops planted by the household. When all the MVP_{Lj}'s are equalised then, $\overline{MVP_L} = MVP_{Lj}$.

Our interest is not only to test for equality of marginal products but also to determine the factors influencing household behaviour in factor allocation. From the theoretical model we have seen how the decision price of a household is influenced by the conditions in the factor and output markets and the liquidity position of a household. Imperfections in the output markets prevent free movement of factors of production within the farm and also between farm and non-farm activities. Imperfections in the output market result in an inflated price for food[14] such that the household decision price is an internal price which is higher than the market price. Imperfect output markets result in discounted prices for non-food crops so that farmers rellocate factors of production away from such crops to food crops which have higher (internal) prices. This implies that whilst we observe the market price $\overline{p_m}$, the household decision price is $\tilde{p}_{im}$ and the marginal product of labour is equalised to this internal price. The effect of imperfect markets on the factor allocation within the farm is therefore an overuse of resources on plots planted with food crops and under use of resources on plots planted with non-food crops.

We create a household specific index *c*, indicating within-household inefficiency. The index compares the MVP_L in other crops on the farm to the MVP_L in maize plots. It is calculated as the ratio of the MVP_L of other crops in the household ($MVP_{Lothers}$) except maize to the MVP_L for maize (average if household has more than one plot of maize).

$$c = \frac{MVP_{Lothers}}{MVP_{Lmaize}} \qquad 3.15$$

[14] In the study site, most households are net buyers of maize which is the staple in the study area

where,

$$MVP_{Lothers} = \tfrac{1}{N-N_m} \sum_{j \neq maize} MVP_{Lj} \qquad 3.16$$

N_m is the number of maize plots

The index can give an indication of how much more or less the household internal price of a crop is, compared with its market price. Market failure is specific to households (De Janvry, Fafchamps et al. 1991), so the *c*'s can be shown to vary with household and farm characteristics.

If the MVP_L of crop 1 within the same household are not equalized we test the hypothesis that the differences result from intra-farm heterogeneity. We exploit the repeated observations (plot level) within the same farm households to estimate a household-fixed-effects model. Essentially a fixed-effects model will explain the variation in observations within a household. The dataset used has a relatively rich description of the variability within the farm including the position on the slope, soil type and texture, farmer's perception on soil fertility status as well as the distance of the plot from the homestead. Table A3.1 in the appendix compares plot characteristics and input use across the fertility gradient in smallholder farms. Nutrient imbalances in the soil do impact on input output relationships (Zingore and Manyame 2005; Vanlauwe and Giller 2006; Vanlauwe, Tittonell et al. 2006). In this study we are interested in the effects of the interactions between land, labour and soil amendments with plot characteristics like slope and soil fertility status. Previous studies which have reported poor response to land improvements have attributed this poor response to household specific constraints (Place and Hazell 1993). Controlling for household effects, however, yields significant effects for soil and water improvements (Adegbidi, Oostendorp et al. 2001). We control for the observable and unobservable household characteristics using the household-fixed-effects model in order to determine the impacts of within farm heterogeneity on returns to labour.

The fixed effects estimator is unbiased only if the explanatory variables are uncorrelated with the error term or unobserved sources of variation. Provided the explanatory variables are strictly exogenous, any autocorrelation in error terms between observations does not result in inconsistent estimators (Verbeek 2000) because the constant term captures all autocorrelation between observations i.e. all observable and unobservable variability is captured by the constant and thus eliminated from the error term. Consequently it eliminates all these endogeneity problems.

3.4 Estimation and discussion of results

3.4.1 Crop specific production functions

Mono-cropping is rarely[15] practiced in the study area so the first task was to identify predominant intercrops or practices. The six distinct crops or intercrops outlined below were identified as the most common cropping practices in the area of study.

1) Maize-based intercrop; Maize intercropped with beans is the most predominant cropping practice. With declining farm sizes it is common to find maize/bean intercrops with a third or fourth crop. Maize intercrops that include bananas have been left out of this group. In the long rain season a few households plant maize in a pure crop.

2) Banana-based intercrop; This cropping practice includes all plots planted with bananas. Bananas normally occupy relatively small and permanent plots near the homestead. These plots are valued for their high organic matter content formed by the gradual transfer of nutrients from other parts of the farm (manure, ash, household refuse). Bananas are normally intercropped with other crops especially vegetables, chewing cane and with maize and beans.

3) Bean monocrop; Comprises of a pure crop of beans rarely intercropped with other crops. This practice is not dominant and is only be observed during the short rain season.

4) Napier monocrop; This refers to a pure crop of Napier[16] grass. Napier grass is used as a supplementary livestock feed during. Poor households who do not own cattle plant Napier as a cash crop while the Napier grass grown by wealthier households is consumed by their own animals. It is more common to plant Napier grass planted along the contour lines for erosion control and to delineate plots within the farm.

[15] The most common practice is the planting two or more crops in the same plot in an intercrop. With the exception of plots that were left fallow, 94% of the plots were planted with a second crop, 50% with a third crop and 20% with a fourth crop. Only 4% had a fifth crop.

[16] Napier grass (*Pennisetum purpureum*) is one of the most important forages producing high herbage yield per unit area of land and is thus the most popular and widely grown forage by smallholders in East Africa (Orodho, 1990; Lukuyu *et al*., 1990). Orodho (2005) indicates that Napier grass forms up to 40 percent of the dry matter in the diet of smallholder dairy cattle (the rest coming from other cultivated grasses, fodders, crop by-products, crop residues and purchased concentrates). Napier is a tall, predominantly vegetatively propagated, perennial indigenous to sub-Saharan Africa which can produce biomass of 20-30 tons of dry matter/ha/year with good agronomic and management practices. Productivity of Napier grass starts declining after a number of years, especially if proper management is not used. In conventional methods Napier grass stem cuttings or root splits are planted 15-20 cm deep in well prepared land, using organic or inorganic fertilizers, at a spacing of 60 cm x 60 cm, 90 cm x 60 cm or 90 cm x 90 cm depending on the amount of rainfall received. The higher the rainfall the closer the spacing. Output price of Napier grass is based on sales of green Napier grass.

5) Vegetable monocrop; This refers to a pure crop of vegetables mainly grown for the market. It is a common practice to plant vegetables in plots adjacent to the banana/homestead plot in very tiny patches but that system is not included here.

6) Other; Comprises other crops like sweet potatoes, cassava and other cereals that do not fall into any one of the above mentioned systems.

When the cropping system is predominantly an intercropping system measurement of crop output is a challenge to the analyst. Next we discuss measurement of crop output in situations where; intercropping is the norm, the crops included in the "intercrop" differ between households, the crop is harvested in both its green and dry states and there is lack of reliable information of area covered by each crop.

As mentioned, the most common cropping practice is the maize/bean intercrop, however variations in this system are common where a third, fourth or fifth crop maybe included. This implies that the range of crops grown in a plot may vary between households depending on preferences. The first challenge was that we could not get reliable estimates of the proportion of plot area of each of the crops planted in a plot. Moreover attribution of input to output is difficult where inputs directed at one crop benefit other crops planted in the same plot. Under these circumstances it made sense to take a systems view and not a crops approach. All inputs applied to the plot were therefore aggregated.

The second challenge was that due to the wide variety of crops grown in smallholder farms, output is only comparable in value terms and not physical units (weight) of output. Crop value may be captured in terms of the food value (calorie or protein content) or by the market price. We adopt the latter approach whereby the output of each crop in the plot was valued using the selling price.

The third challenge was the definition of the "harvested" crop. In western Kenya, maize and beans may be harvested in the green or/and in the dry state. Previous studies in Kenya (Hassan 1998) have ignored the green harvest because it forms but a small component of the total harvest. If adopted for western Kenya, this approach would return zero output observations for many households because consumption of green maize is common especially in households with small farm sizes and during the short rain season. In this study we have valued both the green and dry harvest. Finally, not all households had a price for all or any of the crops grown. In such cases the village level prices were used and where absent market level prices were used. Total crop value was computed as a sum of the value of all crops harvested from a plot in a season.

The sample of households over which crop or intercrop specific production functions can be estimated is essentially truncated as production data is only reported by those households who planted a crop or intercrop. If crops are not randomly picked, then the error in the crop choice equation and that in the production function are related in some way. Ignoring this non-random nature of the sub-samples introduces a selectivity bias in the production functions and in the inferences made (Trost and Lee 1984). To get consistent estimates of the parameters (if there is selection bias) from production functions of specific crops/combination given that they are chosen, the disturbance term μ in the production function should be replaced by the conditional expected value obtained from the binary choice estimations. In the case of a multinomial logit the bias correction term λ is similar to the inverse Mills ratio (IMR) and is given by;

$$\lambda_j = \frac{\phi(\Phi^{-1}(P_j))}{P_j} \text{ for j=1, 2, …} \qquad 3.17$$

Here, ɸ(.) and Φ(.) are the standard normal density an the distribution functions respectively.

In this study we have corrected for possible selection bias in selection of crops or intercrop by adopting the approach proposed by Heckman (1979) whereby the inverse Mills ratio is included in the OLS estimation. The predicted probabilities used in the construction of the selection bias correction term λ_j were obtained from the logit model.

A Cobb-Douglas[17] functional form is adopted because the number of observations for some crops is small and does not allow estimation of models with squared and interaction terms. Moreover, preliminary analysis using more flexible functional forms like the translog that include squared and interaction terms did not improve the model and yielded coefficients that were not statistically significant. Despite its limitations, it is parsimonious in parameters, easy to estimate and interpret. The estimated models are specified in the logarithmic form as;

$$\begin{aligned} lpcropval_{ji} = \alpha_j + \beta_{1j} ltotalL_{ji} + \beta_{2j} lplotsize_{ji} + \beta_{3j} l\exp_{ji} + D_{1j} fertile1_{ji} + D_{2j} fertile2_{ji} \\ + D_{3j} fysr2002_{ji} + D_{4j} division_{ji} + D_{5j} iffert_{ji} + \lambda_j IMR_{ji} + \varepsilon_{ji} \end{aligned} \qquad 3.18$$

Here, *i* refers to the observation (plot), *j* is the crop, *lpcropval* is the log of value of output, *ltotalL* is the log of total labour used, *lplotsize* is the log of plot size, *l*exp is the log of

[17] a modified Cobb-Douglas with interaction terms included to capture interaction between the factors of production did not yield better results.

fertilizer expenditure, *fertile1* and *fertile2* are dummies for high and moderate fertility status respectively, *fysr2002* is a dummy indicating manure use in the year 2002, *division* is a dummy for Kakamega district and *iffert* is a correction term for the large number of zeros in fertilizer use. λ is the correction term for selectivity bias and ε_i is an error term that summarises the effects of unobserved variables. Unlike farm level production functions the aggregation level for crop or intercrop production functions is the plot (i).

Fertiliser is included in the model as the total expenditure on inorganic fertilizers (*lexp*) which takes care of the variety in fertilizer types. In the area of study, inorganic fertiliser is applied to maize. The other crops may benefit from organic fertilisers depending on ownership of livestock and the commonly used organic fertilisers are farm-yard manure and compost. The variable *lexp* was therefore included in production functions for maize but left out in the production functions for the other crops.

Table 3.1: Descriptive statistics of variables included in the production functions

Variable	Maize	Bean	Vegetables	Banana	Napier	Tea	Sugarcane	Other
SR season								
N	414	72	33	122	68	5	2	52
Crop value	2649	1654	2831	2893	1936	3520	1438	1069
Adjusted crop value	3266	1981	3707	3261	1988	3788	5818	1195
Plot size	0.48	0.55	0.42	0.53	0.39	0.27	0.20	0.39
Total labour	175	149	61	93	60	562	69	79
Manday /acre	56	39	29	26	25	508	54	30
Fertilizer expenditure	272	45	91	55	113	1420	0	50
Fertiliser intensity KSh[a]/acre	492	75	417	75	117	7466	0	99
LR season								
N	619	1	25	102	78	10	2	21
Crop value	4651		2625	1908	2277	4073	1499	1857
Adjusted crop value	5459		3178	2083	2386	4273	127	2168
Plot size	0.55		0.46	0.51	0.34	0.66	0.20	0.47
Total labour	176		51	44	43	319	24	111
Manday /acre	55		22	15	21	104	22	38
Fertilizer expenditure	255		42	12	5.6	1648	0	4.8
Fert KSh[a]/acre	508		153	22	22	2553	0	19

[a] the mean exchange rate in the year 2004: KSh. 75 = 1 USD

Due to the variation in the quality and measurement of organic fertilisers we use instead a dummy variable to indicate use or non-use of organic fertilisers. We lag manure use by one year since organic nutrients added are often not immediately available to the plants and the positive effects of these inputs are observed in subsequent seasons. Lagging manure use also solves potential problems in estimation where current year application of manure is considered to be endogenous. Tables 3.1 and 3.2 provide the descriptive statistics for variables included in the production functions.

Table 3.2: Average distance (metres) from the household of plots planted with specific crops/intercrop

	Maize intercrop	Bean Mono crop	Vegetables Mono crop	Banana intercrop	Napier Mono crop	Tea Mono crop	Sugarcane Mono crop	Other
Vihiga (SR)	52	26	3	4	96	23	12	179
Vihiga (LR)	55		6	4	41	23	12	25
Kakamega (SR)	120	90	14	8	90	111	31	26
Kakamega (LR)	346		15	8	100	111	29	94

SR = short rain season; LR = Long rain season

Plot size and output are expected to be positively related given that land is one of the important inputs into production. Plot characteristics like soil fertility status, slope and distance from the homestead have been shown to influence input-output relationships. We suspect that plot characteristics like fertility status may interact with some of the inputs to influence output. We therefore include interaction terms for fertility status with the fertiliser use dummy and the manure use dummy in the model. These were however found not to be significant and not adding value to the estimation and so were also left out of the final model. Plot characteristics without interaction were retained.

In this study we include only indicators of the soil fertility status since other plot characteristics like position on slope and distance from homestead did not improve our estimates. The dummy for plots with poor fertility is left out for comparison. Distance of the plot from the homestead is excluded from the model since it is expected to be correlated to labour and to manure use. In any case its effect on output is through its influence on labour use.

Ideally the plot characteristics should be instrumented in order to obtain consistent estimates of the fertility[18] differential. It was however not possible to get a variable that is highly correlated with fertility status of the plot but uncorrelated with the unobserved variation in the plot. A dummy representing the district is included to capture the effect of differences in amounts and variability in rainfall between Kakamega and Vihiga districts.

[18] Fertility status of a plot may be considered endogenous since farmer practices contribute to the enhancement or detriment of the fertility status

Results for crop specific production functions

Table 3.3 shows the results from the production function for the most common crops and intercrops found in the study area. The fact that maize is planted by virtually all households made it possible to estimate separate production functions for Kakamega and Vihiga districts. The observations for the other crops are few and so we differentiated the production functions by season only. We do not expect this to influence our results since the technology for these crops is largely the same in the two study areas.

We estimate production functions for planned and not realized output. This is valid when the assumption is that farmers allocate their resources prior to shocks like drought and pest attack so that harvesting labour is the only resource allocated in response to the shocks. In this case the inputs are not endogenously determined. In contrast, if the realized output is the dependent variable i.e. assuming that the farmer allocated his factors of production in response to the shock the inputs would be endogenously determined. The planned crop value was determined by inflating the reported crop output with the reported crop damage[19] attributed to shocks.

The results show that labour is a limiting factor in maize production in both Kakamega and Vihiga districts in both seasons. The response to labour is also shown to be relatively the same. One percent change in hours of labour spent on maize production yields an increase of over half a percent in maize output. It is only during the long rain season that maize production increases with plot size. This is consistent with the relative importance of the two rainy seasons in crop production where the land is relatively more intensively cropped during the long rain season. This response is higher in Kakamega where a one percent increase in plot size yields an increase of 0.45% in maize output whereas in Vihiga it yields 0.19%. Lower productivity of land in Vihiga maybe explained by relatively tired[20] soils compared with Kakamega.

[19] One could also instrument the labour with crop damage and use realised output as output
[20] Relatively smaller farm sizes in Vihiga such that land is hardly ever left fallow.

Table 3.3: Plot level production functions for maize specified by season and district

	Vihiga Short rain Season	Kakamega Short rain Season	Vihiga Long rain Season	Kakamega Long rain Season
Dependent Variable = log of planned output				
Log of total labour	0.57***	0.59***	0.52***	0.51***
Log of plot size	0.01	0.06	0.19**	0.45***
Log of fertiliser expenditure	0.15	0.18*	0.16	0.13*
Dummy for fertile plots	1.04***	0.64**	0.19	0.17
Dummy for moderately fertile plots	0.82***	0.88***	0.24*	0.13
Dummy for manure application in short rain season of 2002	0.33***	0.14	0.06	0.20*
Dummy =1 if no fertiliser and 0 if fertiliser was used	0.68	0.37	0.62	0.37
constant	3.16***	3.35***	4.59***	5.31***
N	250	135	271	324
F	18.99	15.43	14	46
Adj. R^2	0.34	0.43	0.25	0.50

legend: * P<0.1; ** P<0.05; *** P<0.01

The response to fertilizer is only weakly significant at 10% in Kakamega and 15% in Vihiga. The effects of differences in soil fertility status are mainly noticeable during the short rain season. Plots of high or moderate fertility have higher production compared with plots of poor fertility maybe because poorer plots are relatively less intensively cropped during the short rain season whereas during the long rain season all plots are intensively cropped such that the differences in output are not significant.

Amongst the other crops (Tables 3.4 & 3.5) labour is the limiting factor except for Napier grass during the long rain season and other crops in the short rain season. The effect of increasing plot size has a positive effect although not significantly different from zero while in some cases it was negative. This surprising response maybe attributed to biases due to measurement error in the plot size. This kind of error biases the estimates downwards towards zero. Instrumenting plot size with farm size did not improve the result which suggests that the poor response may be due to other reasons. Other possible reasons for the poor response to land include; lower cropping densities in larger plots as compared with smaller plots; labour may limit response to land because small plots are better managed than large plots i.e. larger plots are more prone to labour management problems; larger plots are normally located further from the homestead and hence have a fixed travelling[21] cost on labour which may not have been accounted for; there is unobserved variation in land quality in bigger plots; in small

[21] Although the distances may not be too prohibitive as compared with those in West Africa, the hilly terrain that characterises the study area makes the visit such fields inconvenient M Misiko, "Fertile Ground? Soil Fertility Management and the African Smallholder" (PhD Dissertation, Wageningen, 2007)..

holder farm fertilizer may not be used at all and where used it is more limiting in larger than in smaller plots; and lastly field pests like rodents may also limit response to land.

The soil fertility status dummies generally have positive coefficients which signify higher output in more fertile plots, the coefficient for fertility status dummy is however only significant for Napier grass and vegetables. The coefficient for fertile soils is larger than that for moderate fertility suggesting that farmer's perception on fertility status serves as a good indicator for soil fertility status. The effect of manure is mixed and this can be attributed to the difference in quality of manure applied and in the plot characteristics. The insignificant selectivity correction terms indicate that there is no serious selection problem.

Table 3.4: Plot level production functions for bananas and Napier grass specified by season

	Banana Short rain Season	Napier Short rain Season	Banana Long rain Season	Napier Long Season
Dependent Variable = log of planned output				
Log of total labour	0.54***	0.37**	0.62***	0.26*
Dummy for fertile plots	0.26	2.54**	0.09	0.32
Dummy for moderately fertile plots	0.13	1.54***	0.20	-0.07
Dummy for manure application in SR 2002	0.01	0.30	0.41***	-0.76***
Division	0.48**	-0.48	-0.31	-0.54*
IMR of the crop	1.19	-3.73	-2.87	4.35
Constant	4.24***	7.13***	6.98***	3.72
N	117	45	93	61
F	8.41	4.40	13.34	2.71
Adj. R^2	0.28	0.34	0.45	0.15

Table 3.5: Plot level production functions for beans, vegetables and other crops specified by season

	Bean Season 1	Vegetables Season 1	Other Season 2
Dependent Variable = log of planned output			
Log of total labour	0.67***	1.31***	0.33
Dummy for fertile plots	0.08	1.57*	0.91
Dummy for moderately fertile plots	-0.10	0.83	0.52
Dummy for manure application in SR 2002	0.03	-0.004	0.57
Division	0.55	-0.14	0.16
IMR of the crop	3.65	3.42	-2.05
Constant	1.05	-1.39	6.25
N	59	31	35
F	4.05	5.16	1.26
Adj. R^2	0.24	0.45	0.05

Legend for Tables 3.4 & 3.5: * p<.1; ** p<.05; *** p<.01: IMR = inverse Mills ratio

3.4.2 Within-farm allocative efficiency

On the average, the marginal value product of labour differs between the crops/intercrops and the market wage rate. A days work in western Kenya starts at 7.00 a.m until 2.00 p.m. which makes it seven (7) hours a day (excludes traveling and break time). The daily market wage for farm labour during the survey period was between KSh 50.00 - 60.00 when meals are included or KSh 100.00 – 120.00 where meals are not included. This translates to an hourly wage rate of KSh 8.00 with meals and KSh 16.00 without meals respectively.

Table 3.6 below gives the MVP_L specified by crop/intercrop and season. As indicated earlier, the MVP of an input measures the incremental value of output resulting from an additional unit of input spent on a crop. The unit of measure for land, labour and fertilizer is acre, hour and KSh respectively. The indications are that the MVP of labour varies between the various crops/intercrops and with season for the same crop/intercrop. The MVP_L is lowest in plots planted with other crops and highest in plots planted with vegetables and banana.

Table 3.6: Marginal value product of labour and fertiliser applied to specific crops/intercrop

	Maize Vihiga	Maize Kakamega	Banana	Napier	Vegetables	Beans	Other
MVP of Labour in SR (KSh/hr)	12.74	16.90	36.17	21.23	48.70	10.81	2.80
MVP of Labour in LR (KSh/hr)	14.94	19.49	47.47	31.07			
MVP of Fertiliser in SR (KSh/KSh)	2.93	3.22					
MVP of Fertiliser in LR (KSh/KSh)	4.82	2.53					

SR = short rain season; LR = long rain season

In the short rain season, the MVP_L is above the market wage rate except in plots of maize, beans and indigenous crops. The MVP_L for bean and maize plots is close to the market wage rate while that of Napier, bananas and vegetables is higher than the market wage rate. This suggests that farm households would increase their profits in the short rain season by increasing labour in crops/intercrops that have a higher than wage rate MVP_L while reducing labour applied in plots with a lower than market wage rate. The MVP_L for vegetables and even bananas is exceptionally high suggesting constraints in the economic environment which prevents an increase in labour in these plots.

In the long rain season, the MVP_L is exceptionally high in banana and Napier plots. The MVP_L in Vihiga maize plots is very close to the market rate while that of Kakamega maize plots is higher than market rate. This implies that farm households can increase their profits by increasing labour in plots of bananas, Napier and maize in Kakamega. Generally the MVP_L is higher during the long rain season suggesting that the labour constraint in stronger during the long rain season.

The MVP of fertilizer is calculated for maize plots only. It is generally higher than the market price in both Kakamega and Vihiga. In Kakamega, the MVP is highest during the short rain season whilst in Vihiga it is highest during the long rain season. These results suggest that farm households in both Kakamega and Vihiga would increase profits by increasing fertilizer application to maize.

Next we look at how these plot level resource allocations manifest themselves at the farm level. For the purpose of comparison, we provide in Table 3.7 below, farm level estimates of the MVP of land labour and fertilizer. They indicate the marginal productivity of factors employed in agricultural production by season.

Table 3.7: Farm level marginal* value products (MVP) of factors of production

	Vihiga Short rain Season	Vihiga Long rain season	Kakamega Short rain season	Kakamega Long rain season
MVP of labour (KSh/hr)	10.80	14.07	14.10	21.44
MVP of fertiliser (KSh/KSh)	5.05	2.30	2.50	1.17
MVP of land (KSh/acre)	-	2050	-	2415

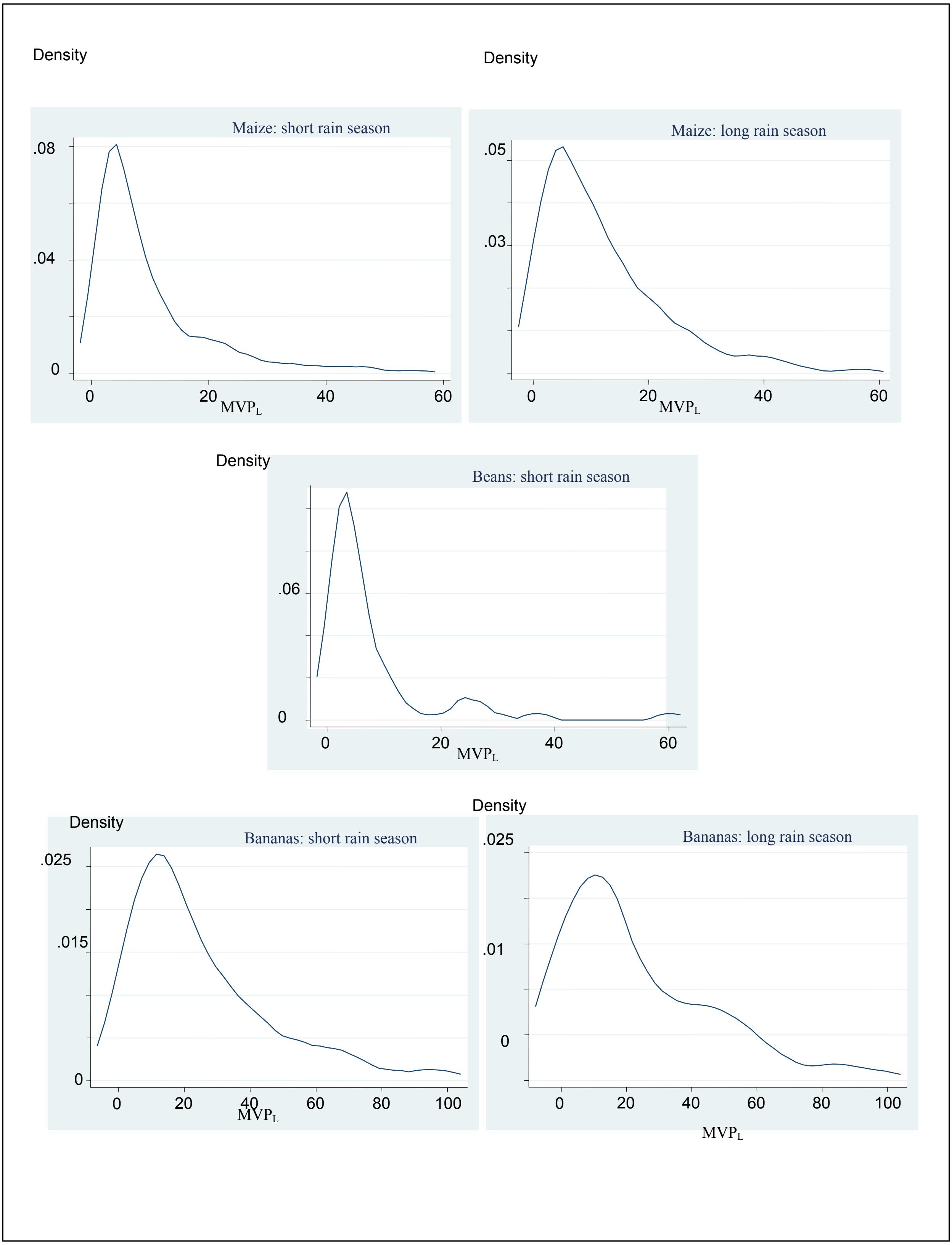
*from OLS estimates

The farm level marginal products of labour generally seem to reflect the marginal product of labour in maize plots. Compared with plot level estimates they are lower during the short rain season and higher in Kakamega during the long rain season. With the exception of Vihiga during the short rain season, farm level estimates of the marginal product of fertiliser are generally below the values obtained from plot level estimates. The smaller MVP of fertiliser at the farm level can be attributed to the fact that fertiliser is only applied to some plots and not to the whole farm. The results therefore suggest that farm level functions production functions are unsuitable for estimating returns to fertiliser in areas where fertiliser use varies within the farm.

Further exploration of the variation in MVP of labour

We explore further the intra-farm behaviour of farm households by examining the variation of the MVP_L between and within crops/intercrops. We have restricted ourselves to MVP of less than 100 to reduce the error due to outliers. The Kernel density plots (K-density) in Figure 3.2 below show the distribution of MVP of the labour in each crop or intercrop among the households who planted the crop. The distribution shows there is variation in MVP of labour between plots and that the distribution depends on the crop or intercrop.

Figure 3.2: K-density plots of Marginal Value Product (MVP) of labour by crop and season



There was significant variation in MVP_L in plots planted with different crops/intercrops (Table 3.8). The variation (S.D.) between crops/intercrops (within farms) is smaller than the variation within crops/intercrops (between farms).

It is common to find farm households in western Kenya planting more than one plot with maize. We explore whether households equalize the MVP of labour between plots planted with the same crop. Our interest is in the variation in MVP of labour within the household. The results show that there is some variation between plots of maize belonging to the same household and even more so than between plots of different households.

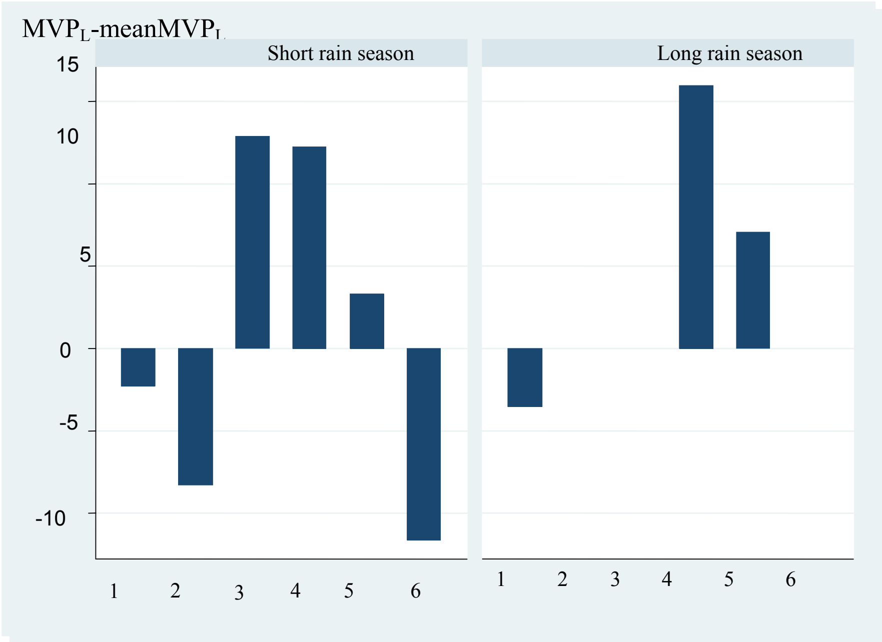
Table 3.8: ANOVA results showing the variation in MVP of labour between crops and within the household

Source of Variation in MVP_L	F	Prob>F	Std. Dev. Between plots Within farms	Std. Dev. Within crops, Between farms
Variation between Crops/Intercrop (SR)	48.88	0.000	0.74	1.06
Variation between Crops/Intercrop (LR)	47.87	0.000	0.53	0.94
Variation between maize plots (SR)	2.12	0.000	0.81	0.63
Variation between maize plots (LR)	2.74	0.000	0.67	0.60

The hypothesis that households in Kakamega and Vihiga allocate labour so as to equalise the MVP of labour in different crops is rejected. Moreover, the results lead to rejection of the hypothesis that the variation in MVP of labour found within the farm is only between crops/intercrops.

We said earlier that the extent of inequality in MVP_L within a farm household maybe indicated by the difference between crop/intercrop specific MVP_L and the household mean. If households are efficient then we expect no deviation of MVP_L from the household mean. The bar charts in Figure 3.3 show the deviation of crop/intercrop specific MVP_L from the household mean. The MVP_L in vegetable, banana and Napier is higher than the household mean whilst MVP_L in plots planted with food crops (maize, beans & indigenous crops) have an MVP_L lower than the household mean. For higher profits, farm households must reduce the labour applied to plots with maize, beans and other crops while increasing labour applied to plots planted with vegetable, banana and Napier.

Figure 3.3: Deviation of crop specific MVP_L (KSh) from the household mean MVP_L



Legend: 1 = maize; 2 = beans; 3 = vegetables; 4 = bananas; 5 = Napier grass; 6 =other

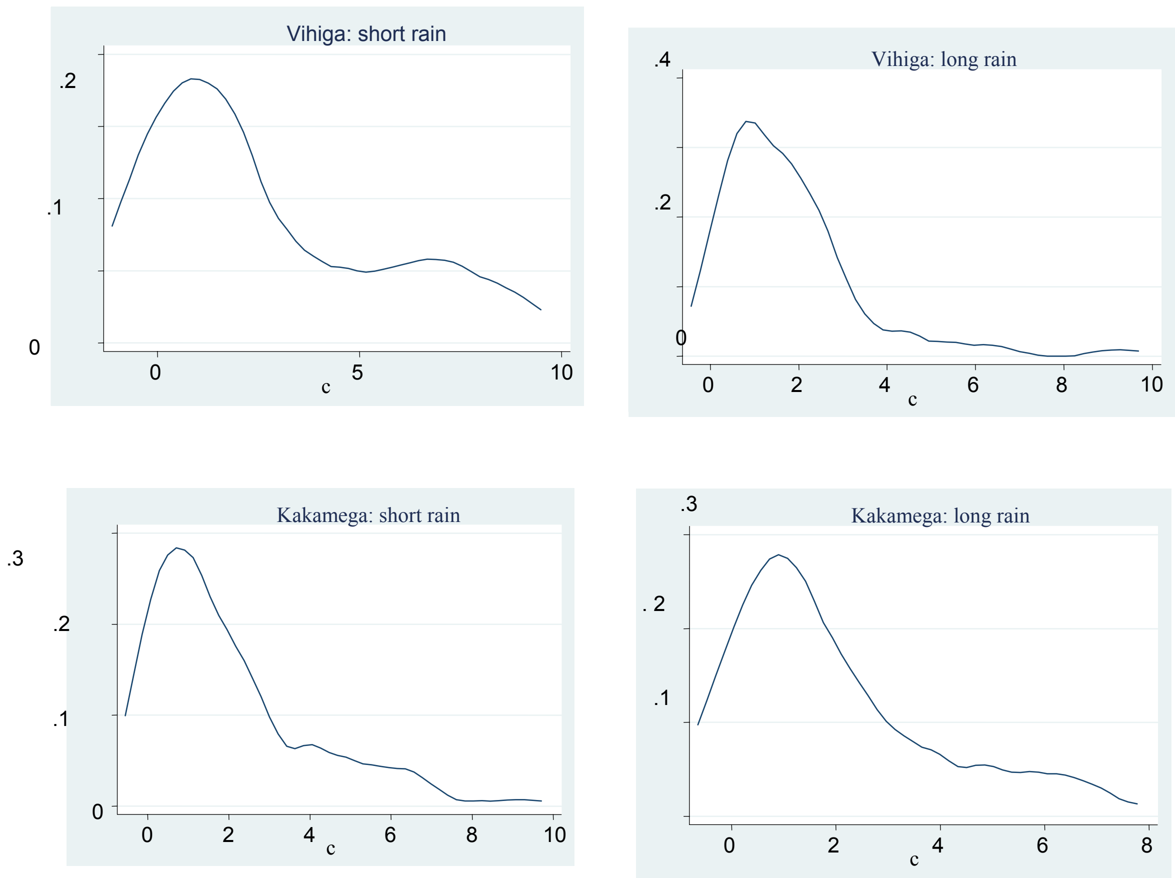
As noted earlier, maize is the staple and main crop in smallholder farms in the study area which suggests that resource allocation behaviour of smallholder farm households is greatly influenced by factor allocation in maize. The MVP_L in maize plots is generally lower than the household mean which means it is generally lower than that of other crops planted by the same household. More labour is likely to be applied to maize than other crops (vegetables, banana or Napier) if household value of maize is higher than the price used in our analysis (market price) or if the household value of other crops is lower than market price. Rationing in the labour market would matter only if labour is not uniformly restricted for all types of workers, thus affecting some crops more than others. Both household and farm characteristics are therefore important determinants of labour allocation. The variation observed between plots of maize within the same household suggests that within-farm differences (i.e. price of various crops and plot characteristics) do play a major role in determining labour allocation.

3.4.3 Factors determining inequality between MVP_L within the farm

Maize is the main staple food for households in western Kenya and is planted by all households. From the theoretical model we established that imperfections in the output markets may prevent the free movement of factors of production within the farm. In this section we determine the factors influencing the variation in MVP_L by regressing household and farm characteristics against the index *c*.

The kernel density plots in Figure 3.4 below shows the distribution of the *c*. We have restricted the following analysis to households who planted maize and other food crops and to a *c* of between 0 -10. Although maize has been undervalued (*c* <1) or overvalued (*c* >1) in some households, for most households the *c* is around 1 (Fig. 3.4). The interpretation of these results is that households with a *c* greater than one (1) have a MVP_L in maize which is lower than MVP_L in other crops because either they value an extra unit of maize higher than market price or value an extra unit of other crops lower than the market price. Households with a *c* less than one (1) have a MVP_L in maize which is higher than MVP_L in other crops because they value an extra unit of maize lower than market price.

Figure 3.4: Distribution of *c* by district and season



Generally a relatively higher value is given to maize (food) where high transaction and transportation costs and risk/uncertainty associated with whether and at what costs households can access the maize (food) even when readily available in the market. Other than output prices, the functioning of the labour market may also influence labour use.

We test the hypothesis that *c* is determined by market and household characteristics. Factors that increase a household's access to the market are expected to reduce *c* whilst factors that increase a households labour capacity are expected to increase the *c*. Results are provided in Table 3.9. The significance of F-statistic means that collectively, the variables included in the model explain the variation in *c*.

The household's labour capacity emerges as the strongest determinant of labour use within the farm. An increase in the number of adults in a household by one increases the labour applied on maize plots relative to the labour applied to other crops and hence the increase in *c* by 0.66. This means that in western Kenya, a larger labour capacity translates into deterioration in labour use efficiency as households attempt to increase its food production where food markets do not function well. It also reflects the presence of barriers to alternative crop enterprises e.g. the lack of confidence by households in markets for alternative crops. Households with a head in salaried employment have less labour available for farming and hence lower *c* (-1.0) compared with households without a head in salaried employment. They may also have more access to financial resources which enables them to pursue alternative crop enterprises other than maize.

Table 3.9: Factors determining c_i

Variables in Model	*Coefficients for overall sample*	*Coefficients for Kakamega*	*Coefficients for Vihiga*
Dependent Variable = c			
Distance to the tarmac road	-0.23*	-0.26	-0.03
Distance to a motorable road	0.71	-0.64	0.90
If head has salaried employment	-1.09*	-0.70	-0.17*
Non labour income ('000)	-0.08**	-0.06	-0.17**
Age of head	0.05**	0.05	0.05*
If head is male	-0.14	0.07	0.57
Family size	-0.24	-0.15	-0.28
Number of adults	0.66***	0.47*	1.07***
Farm size	-0.43	-0.58	-0.51
constant	1.01	0.68	-0.95
N	239	112	127
F (9, 272)	3.46	1.24	2.83
Adj R^2	0.09	0.01	0.12

legend: * p<.1; ** p<.05; *** p<.01

Households with an older head of household are likely to have a larger labour capacity or are less likely to pursue alternative crop enterprises. They therefore apply relatively more labour to maize and hence a higher *c*. Non labour income in the household reduces the *c* probably because it eases the cash constraint thereby reducing the household decision price. Presence of a salaried head of household is likely to ease the cash constraint and thereby lower the *c*. The reduction in *c* means that households without a liquidity constraint (external sources of financial support) are less likely to have an internal price that is different from the market price.

When the distance to a motorable road increases by 1 km the *c* increases by 0.71 (not significant). This means that households allocate more labour to food crops and less to marketed crops when they anticipate transportation problems which increase the effective price of food and reduce the effective price of marketed crops. The negative sign of the coefficient for distance to the tarmac road is not expected. A larger farm size leads to a reduction in the *c* (not significant) probably because less labour is available as farm size increases. The household characteristics that emerge as most important in determining labour allocation within the farm are the labour capacity and the liquidity status. There are mixed signals on the effect of farm characteristics on labour allocation in the farm. This may be because the variation in distance to a motorable road is not large and that the presence of tarmac roads has not reduced the costs of transportation making the households prefer to walk. The distance to tarmac may therefore be picking up a different effect.

But what can these results tell us about the diversity of households in the study area? To interpret the meaning of the relationship between c_i and explanatory factors to different households, we have simulated the expected change in c_i due to change in household characteristics that were significant in explaining c_i (Table 3.10). Increasing the number of adults in the household makes maize dearer in the household relative to other crops grown in the farm and hence the household will respond by applying more labour to maize production. This leads to marginal value product of labour in maize production becoming smaller (0.66 for each additional adult) relative to that of labour in other crops For the same number of adults in a household, maize is 55% more dear (relative to other crops) in Vihiga compared with Kakamega.

Table 3.10: Impact on the marginal product of maize relative to other crops (c) due to a change in labour capacity and liquidity

Change in Variable	Overall Sample	Kakamega	Vihiga
Number of adults			
1	0.66	0.47	1.07
Non-labour income			
1000	-0.08	-	-0.16
2000	-0.16	-	-0.33
3000	-0.24	-	-0.50
5000	-0.40	-	-0.84
Salaried Employment			
Yes	-1.09	-	-1.75

Because maize is a staple food, the results reflect the internal value that households put on an additional mouth (adult) to feed. Because farm households in Vihiga are mainly net buyers, the larger c_i reflects not only the inefficiencies in food markets but also the value of money. Unlike the effect of more adults in household, an increase in non-labour income makes maize less dear compared to other crops grown by household. The impacts are however smaller. For example, an increase in non-labour income by KSh. 5,000.00 would result in only a 0.4 reduction in the value of maize relative to other crops. This factor is significant only in Vihiga. Salaried employment for household head reduces the value of maize relative to other crops. This effect is not significant in Kakamega but is high and significant in Vihiga emphasizing the importance of cash and may be security for these net buyers of maize.

3.4.4. Estimation of returns to factors of production given within farm heterogeneity using the household-fixed-effects model

Earlier results show variability not only between crops/intercrops but also between maize plots owned by the same household. We test the hypothesis that the response of maize output to factors of production is conditioned by plot characteristics. Plot characteristics are interacted with the most common inputs into small-holder farms namely land, labour, manure, inorganic fertilizer and soil conservation features in order to determine their effect on output. The effect of soil conservation structures is obtained from the interaction of plot size, fertiliser and labour with the dummy for presence of conservation structures in a plot. Because the cropping intensity differs between the two seasons, the functions estimated are season specific.

Table 3.11 below show the variability in plots planted with maize in terms of fertility status and position on the slope and land improvement. We determine whether within the same household, the variability in bio-physical characteristics of the plots planted maize is significant. The F-statistic for variability in both fertility status and slope is large and significant which means we cannot reject the null hypothesis. The variation in fertility status is larger within the household. This intra-farm heterogeneity in smallholder farms condition factor productivity (Vanlauwe and Giller 2006) yet most behavioural studies carried out on productivity of soil amendments have been at the farm level (Salasya 2005). We exploit the repeated observations (plot level) within the same farm households and estimate a household-fixed-effects model. The model is estimated only for maize because it is common for households to have more than one plot of maize but not so for other crops. The results of the household-fixed-effects model for each season are presented in Table 3.12.

Table 3.11: Frequency of occurrence of plots with specified characteristics

Plot characteristic	Frequency
Position on Slope	
Steep to very steep	210
Gently undulating	341
Plain	57
Valley bottom	10
Sub-total	618
Fertility Status	
Very fertile	81
Moderately fertile	419
Poor fertility	93
Sub-total	593
Soil Conservation	
None	334
Terraces	222
Ridges	25
Cut-off drain	31
Sub-total	619

The results generally show that response to factors of production vary in direction, magnitude and significance between the Kakamega and Vihiga on the one hand and between the two seasons on the other hand. Specifically, the results show that the response to a unit increase in expenditure on inorganic fertilizer is higher (5%) on plots with a gentle slope compared with the response on steep slopes. The difference is significant only in Kakamega during the long rain season. The response to an additional unit in fertilizer expenditure is higher in plots with good (55%) and moderate (65%) soil fertility compared with plots with poor soil fertility in Kakamega during the short rain season.

The response to an increase in manure application is also higher in plots with good (20%) to moderate (9 – 13%) fertility compared with plots with poor fertility. The higher response to manure is only observed in Vihiga maybe because there is much higher manure application compared with Kakamega (Vanlauwe, Tittonell et al 2006). The response to an increase in land on a plain is lower (89%) than the response to an increase in land on steep slopes. This maybe due to problems of water logging which is common in land on the plains. Response to fertilizer applied to plots on gentle slopes is higher (5%) than the response to fertilizer applied on plots with a steep slope maybe because there is more run-off in plots with steep slopes.

Table 3.12: Results of household fixed effects model of maize production

	Vihiga short rain season	Vihiga long rain season	Kakamega short rain season	Kakamega long rain season
Dependent Variable = value of output from maize based intercrop				
Log of fertiliser expenditure	0.07	0.01	-0.58**	0.07
Log of total Labour	0.34**	0.60***	1.07**	0.57***
Log of plot size	0.58*	0.53**	1.15*	0.18
Log of fert expend* dummy for good soil fertility	-0.015	0.11	0.55**	0.01
Log of fert expend* dummy for moderate soil fert	-0.14	0.00	0.65***	-0.06
Log of quantity of manure* dummy good soil fertility	0.20*	0.15	0.23	-0.01
Log of quantity of manure* dummy moderate soil f	0.09***	0.13***	-0.05	0.04
Log of hours total labour * dummy good soil fertility	0.09	-0.12	-0.41	0.01
Log of hours total labour* dummy moderate soil f	0.09	-0.12	-0.56**	0.05
Log of plot size* dummy for good soil fertility	-0.35	-0.06	-0.48	-0.06
Log of plot size* dummy for moderate soil fertility	-0.23	-0.08	-0.75	0.09
Log of total labour* dummy for conservation	0.09	-0.06	0.37	-0.02
Log of plot size*dummy for conservation	0.11	-0.31	-0.51	-0.06
Log of plot size* dummy for no slope (plain)	-0.41	-0.89*	-0.81	0.04
Log of plot size* dummy for gentle slope	-0.08	0.01	0.27	0.11
Log of fert expend* dummy for no slope (plain)	0.11	0.03	0.02	0.04
Log of fert expend* dummy for gentle slope	0.07	0.05	0.05	0.05*
Dummy for soil conservation*dummy for steep slope	-0.15	0.45	-2.20	0.05
Constant	4.44***	5.24***	4.70**	5.27***
N	259	281	136	330
F	5.62	4.25	2.36	7.79
R^2 *within*	0.51	0.39	0.59	0.48
R^2 *between*	0.23	0.14	0.004	0.49
R^2 *overall*	0.31	0.19	0.02	0.50

Although the results do not provide a clear cut indication of the effects of plot characteristics they do show that plot characteristics do matter in determination of maize output. The mixed effects of plot characteristics on response to factors of production may be due to the variations in cultural practices between regions or/and seasons.

3.5 Conclusions

On the average farm households in western Kenya are not efficient in labour allocation within the farm. However, some households are more efficient than others as is evident from the kernel density plots, we therefore rephrase our hypothesis to read that not all households are efficient in labour allocation within their farms. The inequality in marginal value of labour within the farm is partly due to household decision price being different from the market price. This may be due to poor infrastructural development, bottling up of labour on the farms due to lack of opportunities and barriers in off-farm employment and liquidity constraints. This leads to comparatively higher labour allocated to maize plots,.

The inequality in MVP_L within the farm may also stems from within-farm heterogeneity the evidence of which is the variation in MVP_L of plots planted with maize within the same farm. The results from the household-fixed-effects model suggest that plot characteristics like soil fertility status and slope of a plot influence the marginal effects of factors of production. However the results do not provide a clear cut indication of the effects of plot characteristics since the effects seem to differ by region or/and by season.

Within farm efficiency analysis adds value to smallholder farm efficiency studies because it provides more precise information for re-allocation of labour in smallholder households. The analysis identifies the crops in which labour could be increased or reduced. For example, farm level analysis may suggest that farmers could increase profits by either increasing or reducing labour on the farm. Instead of increasing or reducing labour uniformly across the farm and seasons, within-farm analysis identifies the crop/season/plot where an increment or reduction in labour leads to the desired result. More importantly, the study shows that increasing the number of adults in the household makes maize dearer to the household relative to other crops grown in the farm whereas increasing a households liquidity position (salaried employment and non-labour income) makes maize less dear compared to other crops grown by household.

Appendices

Appendix 3.1: Measurement Errors

Data Collection

The data used in this study is survey data collected in a farm household survey where enumerators recorded data provided by the farmers during formal interviews. Prior to the survey, the enumerators were trained on several aspects of data collection including but not limited to the art of questioning and recording data; units and measurement of quantities, weights, area and time. Utmost care was taken to collect "good data" In the actual survey this involved discussions with the farmer and visits to the farm for a visual appreciation of the farm and plots.

Problem of measurement error in regressors

There are situations where the condition $E\{\varepsilon_t x_t\} = 0$ cannot be imposed thus making the OLS estimator inconsistent. One such situation is when there is measurement error in one of the regressors as shown in Verbeek (2000).

If a dependent variable is explained by a variable *w*, a relationship expressed in the following equation:

$$y = \beta_1 + \beta_2 w + v \qquad \text{(A1.1)}$$

where v is the error term and v ~(N,σ_v^2) and $E\{v|w\} = 0$, so that the model describes the expected value of y given w i.e. $E\{y|w\} = \beta_1 + \beta_2 w$.

If the regressor *w* cannot be measured accurately either because of misreporting of the crude methods of; estimation, the measure value of *w* can be denoted by *x* which equals the true *w* and the measurement error;

$$x = w + u \qquad \text{(A1.2)}$$

If we make normal assumptions i.e. u ~(N,σ_v^2), *u* is independent of *v* and that *u* is independent of the true value of *w* and by substituting eqn 2 into equation 1 we express our model in terms of the observables i.e *y* and *x* and the error term *v*.

$$y = \beta_1 + \beta_2 x + e \qquad \text{(A1.3)}$$

where $e = v - \beta_2 u$

OLS estimates from this model with x which has a measurement error are biased because x and e are both depend on u. The necessary conditions for consistent β is violated because $E\{\varepsilon_t x_t\} \neq 0$. Actually when β is negative, e and x are negatively correlated because e has the component $-\beta_2 u$ and x has a positive u and the two are positively correlated when β is positive making the OLS estimates inconsistent!

The estimator of β_2 is;

$$b_2 = \frac{\sum (x-\bar{x})(y-\bar{y})}{(x-\bar{x})^2} \tag{A1.4a}$$

and substituting equation 3

$$b_2 = \beta_2 + \frac{(1/N)\sum (x-\bar{x})(e-\bar{e})}{(1/N)\sum \ (x-\bar{x})^2} \tag{A1.4b}$$

At the limit;

$$b_2 = \beta_2 + \frac{p\lim(1/N)\sum (x-\bar{x})(e-\bar{e})}{p\lim(1/N)\sum \ (x-\bar{x})^2} \tag{A1.4c}$$

or

$$b_2 = \beta_2 + \frac{E\{xe\}}{V\{x\}} \tag{A1.4d}$$

The last term is not equal to 0 because $E\{\varepsilon x\} \neq 0$

$$E\{\varepsilon \ x_t\} = E\{(w+u)(v-\beta_2 u)\} = -\beta_2 \sigma_u^2 \tag{A1.5}$$

Moreover variance of x is not constant as shown below.

$$V\{x\} = V\{(w+u) = \sigma_w^2 + \sigma_u^2 \tag{A1.6}$$

so that at the limit

$$b_2 = \beta_2 (1 - \frac{\sigma_u^2}{\sigma_w^2 + \sigma_u^2}) \tag{A1.7}$$

OLS estimate is consistent if σ_u^2=0. When the variance of the measurement error is positive and large relative to the variance of the true variable w, it biases the estimate towards 0. If in fact the ratio of σ_u^2/σ_w^2 is large the bias in OLS estimate is large and vice versa. This shows us that a measurement error will lead to underestimation of the effect of the regressor on the phenomenon being studied.

The suggested solution for this problem is use of an instrument variable.

Appendix 3.2: Estimation of crop value at the plot level

Data collected on crop output differentiates between dry harvest and green harvest. The unshelled grain was converted to grain using 33% as the conversion rate. The formulas used in calculation of crop value are as follows;

i. dryhvt*kgcondry*shlconD*price, for maize and other grains harvested dry
ii. greenhvt x kgcongrn x shlconG x price, for maize other grains harvested green
iii. greenhvt x kgcongrn x price, for crops harvested green

where;
dryhvt = units of output harvested dry
greenhvt = units of output harvest green
kgcondry = conversion of units of dry harvest into kg
kgcongrn = conversion of units of green harvest into kg
shlconD = conversion of dry unshelled maize or beans into kg
shlconG = conversion of green unshelled maize or beans into kg

Crop value was obtained by multiplying output of each crop with the village average price and then aggregating the value at the plot level. Village level prices are average prices reported by households in a village. Average market prices were used where prices were missing which was common for minor crops.

Appendix 3.3 Within farm heterogeneity and crop choice

Table A1 shows the distribution of crops given the variation within smallholder farms. It shows that most plots are allocated to maize based intercrop and most plots do not have soil conservation features. Terraces are the most common soil conservation feature whereas ridging and cut-off drains. Most plots were ranked as moderate in fertility. Bananas and vegetables are planted closest to the homestead. From Table A3.1 we see that plots of poorest soil fertility are not located furthest from the homestead which suggests that distance from the homestead may not be the best indicator for fertility status. This finding differs from earlier findings by Tittonell (2005) and may be due to the fact that they differentiated between households by wealth. Farms of poor households are smaller than those of the wealthier such that the distances in small farms are shorter as compared with those in larger farms. The results show that plot sizes do not differ between soil fertility status. Compared with poor plots, the most fertile plots receive more of all the inputs, produce highest output and suffer the least crop damage (mainly due to drought and weeds.

Table A3.1: Comparison of inputs and outputs[22] by soil fertility status

		Soil Fertility Status[23]		
		Very fertile	Moderate fertility	Poor fertility
Distance from homestead (metres)	Kakamega Vihiga Overall sample	57.7 17.9 40.5	113.9 48.8 82.1	46.3 19.7 37.5
Crop (hectare)	Kakamega Vihiga Overall sample	0.20 0.12 0.16	0.24 0.12 0.20	0.16 0.08 0.12
Manure (kg)	Kakamega Vihiga Overall sample	94.4 102.7 98.1	53.2 80.0 66.3	37.4 68.5 48.2
Expenditure on fertilizer (KSh[a])	Kakamega Vihiga Overall sample	381.1 85.0 250.4	405.7 55.6 234.5	266.8 110.0 212.4
Planting Labour (mandays)	Kakamega Vihiga Overall sample	3.4 3.6 3.5	3.4 3.6 3.5	2.3 4.2 3.0
Weeding labour (mandays)	Kakamega Vihiga Overall sample	7.7 5.7 6.8	9.2 3.9 6.6	7.1 3.6 5.9
Output (kg) use crop value instead	Kakamega Vihiga Overall sample	253.5 80.5 177.2	278.5 89.4 186.0	168.4 77.1 136.8
Crop Damage (% crop loss[b])	Kakamega Vihiga Overall sample	16.2 17.8 16.9	22.2 25.7 24.0	26.8 26.1 26.5

[a] 1 USD = 75 KSh; [b] crop loss based on expected harvest

[22] refers to maize/bean (12) intercrop only

[23] Farmers perception

CHAPTER 4

ALLOCATIVE EFFICIENCY WITH SEQUENTIAL LABOUR ALLOCATION DECISIONS

4.1 Introduction

The major factors of production in peasant farm households are land and labour with little use (if any) of modern agricultural inputs or technology. The choices made by farm households regarding farm and off-farm work, technology adoption, schooling or migration, amongst others have to do with the opportunity cost of their time. Moreover, design and prior evaluation of yield increasing and land augmenting technologies which increase labour demand require an understanding of the determinants of labour demand and supply decisions of households (Skoufias 1993). While analysing farm household behaviour in labour use, it is important to take into account that the opportunity cost[24] of time is not constant (Sen 1966) but closely follows the cropping calendar which is characterized by periods of intense farm activity followed by slack periods.

Agricultural production decisions follow a sequence and are determined by seasonality (Antle 1983). Smallholder agricultural systems that are mainly rain-fed are subject to many shocks including the timing and amount of rainfall received, weeds, pests and diseases which make agricultural production a highly stochastic process. Farm households in this kind of environment may attempt to control the stochastic variability in crop growth by varying the labour effort (Fafchamps 1993) during different stages of growth. This suggests that variable production inputs such as labour are not chosen from a single decision but in a series of consecutive decisions made in response to the revealed information as well as the expected states of nature. Moreover, productivity of variable inputs like labour depends on the amounts used and also the timing of application (Antle 1983; Skoufias 1993). This suggests that changes in exogenous variables like wage rates have varied effects on labour demand at different stages within a season (Skoufias 1993).

Single stage static models commonly used in production studies fail to recognize the effects of seasonality and stochastic processes which determine farm labour use. Previous studies (Skoufias 1993) found varying response to changes in wages at different stages of a

[24] We define opportunity cost of time as the payment forgone when labour is employed elsewhere.

season. This suggests that estimates of elasticities from static single-equation models which do not account for seasonality of farming activities and the stochastic nature of agricultural production in explaining farm labour use in smallholder farms may be misleading (Antle and Hatchett 1986). Farm labour use decisions are therefore better represented as multi-period dynamic optimisation problem (Antle 1983) that allows farmers to continually update the information used in decision making and allows uncertainty in later stages to influence optimal farm labour allocation.

In Chapter 3 the spatial variability within smallholder farms and its impact on farm labour use is discussed. In this chapter the focus is on effects of the variability arising from changes occurring within a season on allocative efficiency of labour over the cropping season. Using a sequential model approach, optimal levels of labour use and output at each stage within a cropping season are derived. The model, comprising of two labour functions (planting and weeding stage labour) and a production function is applied to a maize based intercrop in smallholder farms of western Kenya. The 3SLS technique is used in estimation. The estimated elasticities are used in a simulation of the effects of across season changes in a household's labour constraint on the shadow value of time. Allocative efficiency is evaluated by comparing this shadow value of time at the beginning of the season with the shadow value of time at the weeding stage. Inefficiency is next explained by farm and household characteristics.

4.2 Theoretical model

4.2.1 Conceptual framework: Intra-season sequential decision making

Optimal solutions in sequential decision problems differ from those from single period solutions by the information utilised by the decision maker in choice of inputs (Antle 1983). Farmers decisions within a season maybe stylized on time steps that follow the stages of crop growth i.e. "planting", "weeding" and "harvesting". In the course of a cropping season, the farmer decides on the intensity of planting, weeding and harvesting labour. The actual time that labour is applied may vary and is therefore a decision variable, however in modeling it may be considered fixed (given) depending on data availability. Decisions regarding acreage, draught power and capital[25] inputs are made right at the beginning of the season and may therefore be considered as pre-determined inputs.

As a cropping season progresses, farmers revise the decisions made earlier in the season as more information becomes available. The states of the crop at each stage Q_1, Q_2, and Q_3 when normalized, capture the information available to farmers during the first, second and third stages respectively (Fafchamps 1993). The labour applied at harvesting stage (L_3) is directly related to the standing crop Q_2 with some error. At weeding stage (stage-2), the farmer makes decisions on labour effort (L_2) having observed Q_1 which captures the state of the crop (i.e. the health (vigour) of plants that result from planting and replanting), the amount of weeds and the rains. At the land preparation and planting stage (stage-1), the farmer may try to influence Q_1 through timeliness and the effort applied (L_1) however decisions at this stage are made with uncertainty regarding timing or onset of rains, the persistence and quantity of rains i.e. shocks in later stages.

In summary, in a sequential model information about the shocks and state of crop is revealed progressively over the season with farmers continuously updating the information held. At every stage the farmer maximizes his objective based on the present information rather than information previously held about states of nature. In contrast, single stage models assume labour applied at each stage is dependent on the information held at the beginning of the season which implies that farmers continue with the errors made in earlier stages of cropping season.

As the farmer updates his information, sequential decisions may allow for correction of mistakes or errors made in earlier stages rather than continuing with the same error. For example errors that occur at the beginning of the season may be corrected by increasing effort in the weeding stage by way of more careful weeding, double or triple weeding. The farmer is assumed to know the bio-physical limitations in the effectiveness of labour in influencing outcomes at different stages of plant growth.

4.2.2 Derivation of optimal levels of stage specific labour

A household's problem at each stage in a cropping season is defined as one of choosing the level of effort which maximizes expected profit subject to the information held.

[25] Fertiliser is normally applied once mainly determined by availability of cash at beginning of season. Application may be regarded as pre-determined. There is however spatial heterogeneity in application of fertiliser. This will be tackled later.

The general form of production functions for each of the three stages may be represented as follows:

$$Q_1 = f(X, L_1, \varepsilon_1)$$
$$Q_2 = f(Q_1, L_2) \qquad 4.1$$
$$Q_3 = f(Q_2, \varepsilon_3)$$

Where:

Q_t is the output at stage t of production, X is a vector of pre-determined factors of production, L_t is the labour applied at each stage and ε_t is the distribution of the error. The production functions are increasing functions of all the arguments in the function. The labour effort applied at each stage given information available to the farmer is optimal (Fafchamps 1993).

Only L_1, L_2, L_3, X, Q_3 are known for estimation of structural parameters in these functions. Recursively substituting the output functions into the input functions gives sequentially dependent optimal input and output choice functions. We derived for each stage in a cropping season, the optimal level of labour and output. The Cobb-Douglas functional form is adopted because: it has been used in similar studies (Antle 1983; Antle and Hatchett 1986; Skoufias 1993), it allows explicit derivation of optimal input decision rules for each stage, recursive substitution yields a composite production function which is also Cobb-Douglas, and it is simple to estimate and interpret. These advantages compensate for the technological restrictions imposed by this functional form (Skoufias 1993).

Stage-3 (harvest period)

The harvested crop (Q_3) is the standing crop output from the previous period (stage-2) with some uncertainty. Uncertainty at this stage emanates from possible losses due to too much moisture or bird damage at this stage. Hence we have the expression:

$$\ln Q_3 = \ln Q_2 + \varepsilon_3 \qquad 4.2$$

The expected output for stage-3, E[$Q_3|Q_2$], is therefore proportional to Q_2, with a multiplicative constant of $e^{\frac{1}{2}\sigma^2}$, with σ_3 the standard deviation of ε_3.

Labour at this stage is determined by the output but not the other way round i.e. harvesting labour contributes little to state of the harvested crop. This assumption defines the departure of this study from previous studies (Antle 1983; Antle and Hatchett 1986; Fafchamps 1993; Skoufias 1993; Elad and Houston 2002) which include harvest labour as an important determinant in agricultural production. The optimal level of labour is therefore directly proportional to the harvested crop.

$$L_3 = b_3 Q_3 \quad (4.3)$$

Stage-2 (weeding period)

At the beginning of stage-2, the farmer knows the state of the crop in the previous stage (Q_1). The output from this stage is therefore given by:

$$Q_2 = a_2 Q_1^{\alpha_2} L_2^{\beta_2} \quad (4.4)$$

Output at this stage is a function of the state of the crop from previous stage and the effort. The next stage after this is the harvest stage i.e. after the weeding stage there are no other activities undertaken to influence output. This implies then that stage-2 output is the expected[26] harvest.

In stage-2, the farmer's problem is to maximise expected profits at harvest period given the information held at that time.

$$\max_{L_2} Ep_3 Q_3 - w_3 L_3 - w_2 L_2 \quad (4.5)$$

which can also can be written as:

$$\begin{aligned}
&\max_{L_2} E(p_3 - w_3 b_3) Q_3 - w_2 L_2 \\
&\max_{L_2} (p_3 - w_3 b_3) e^{\frac{1}{2}\sigma_3^2} Q_2 - w_2 L_2 \\
&or \\
&\max_{L_2} (p_3 - w_3 b_3) e^{\frac{1}{2}\sigma_3^2} a_2 Q_1^{\alpha_2} L_2^{\beta_2} - w_2 L_2 \\
&let \\
&p_2 = (p_3 - w_3 b_3) e^{\frac{1}{2}\sigma_3^2}
\end{aligned} \quad (4.6)$$

[26] This explains omission of the error term in stage 2

From the first order conditions for this problem we derive the optimal level of labour at weeding (L_2^*) as:

$$L_2^* = \left[\frac{w_2}{\beta_2 p_2 a_2 Q_1^{\alpha_2}} \right]^{\frac{1}{\beta_2 - 1}} \qquad 4.7$$

Optimal labour in stage-2 (weeding) decreases with the wage rate in stage-2 and increases with the state of the crop from stage-1 (planting period) and the output price. The state of crop from stage-1 is expected to increase[27] with labour at planting and to decrease with uncertainty. Consequently, weeding labour will increase with planting labour and decrease with the error in stage-1.The optimal profit is given by:

$$\pi_2^* = (1-\beta_2)(p_2 a_2 Q_1^{\alpha_2})^{\frac{1}{1-\beta_2}} (\frac{w_2}{\beta_2})^{\frac{-\beta_2}{1-\beta_2}} \qquad 4.8$$

Stage-1 (planting period)

In stage-1, the farmer maximises the expected profits in period 2 given the information available to him i.e. rainfall etc. The problem in this stage is:

$$\max_{L_1} \pi_2 \text{ subject to } Q_1 = a_1 A^{\gamma_1} L_1^{\beta_1} e^{\varepsilon_1} \qquad 4.9$$

Optimal profits in stage-1 are therefore given by:

$$\pi_1^* = \mathrm{E}\xi A^{\frac{\alpha_2\gamma_1}{1-\beta_2}} L_1^{\frac{\alpha_2\beta_1}{1-\beta_2}} e^{\frac{\alpha_2\varepsilon_1}{1-\beta_2}} - w_1 L_1 \qquad 4.10$$

where:

$$\xi = (1-\beta_2)(p_2 a_2 a_1^{\alpha_2})^{\frac{1}{1-\beta_2}} (\frac{w_2}{\beta_2})^{\frac{-\beta_2}{1-\beta_2}} \qquad 4.11$$

The optimal labour in this period is obtained from the first order condition.

[27]observed as improvement of crop

$$L_1^* = \left[\frac{w_1(1-\beta_2)}{\xi A^{\frac{\alpha_2\gamma_1}{1-\beta_2}} \alpha_2 \beta_1 \eta} \right]^{\frac{1-\beta_2}{\alpha_2\beta_1-(1-\beta_2)}} \qquad 4.12$$

Where η is the expected error which is, for normally distributed error with zero mean and constant variance,

$$\eta \equiv \mathrm{E}e^{\alpha_2 \varepsilon} = e^{\frac{1}{2}\alpha_2\sigma^2} \qquad 4.13$$

Optimal labour in stage-1 reduces with the wage rate at both planting (w_1) and weeding (w_2) stages, and with increased uncertainty (σ^2). It increases with acreage and with output price. The optimal output from stage-1 (Q_1) is therefore:

$$Q_1 = a_1 \left[\frac{w_1(1-\beta_2)}{\xi A^{\frac{\alpha_2\gamma_1}{1-\beta_2}} \alpha_2 \beta_1 \eta} \right]^{\frac{\beta_1(1-\beta_2)}{\alpha_2\beta_1-(1-\beta_2)}} A^{\gamma_1} e^{\varepsilon_1} \qquad 4.14$$

It increases with acreage, output price and decreases with the wage rate at planting (w_1).

Note how pre-determined variables such as acreage from the first stage appear in every equation in the system because of recursive substitution of the known inputs into the unknown intermediate outputs.

4.3 Econometric model

4.3.1 Specification of the model

The econometric model derived from the theory is a system consisting of two labour equations (stage-1 and stage-2) and a production function for the harvest stage. Recursive substitution of optimal labour functions into the production functions results in nonlinear functions. However, logarithmic transformation allows for linear estimation of the model and simplifies interpretation of model parameters. The specification of the log-linear model is as follows:

(1) Labour function for stage-,

We can derive from (4.12)

$$\ln L_1 = c_0 + c_1 \ln(w_1) + c_2 \ln(w_2) + c_3 \ln(p_2) + c_4 \ln A + \lambda_1$$

where;

$$c_1 = \frac{1-\beta_2}{\alpha_2\beta_1 - (1-\beta_2)}$$

$$c_2 = \frac{\beta_2}{\alpha_2\beta_1 - (1-\beta_2)} \qquad 4.15$$

$$c_3 = \frac{1}{\alpha_2\beta_2 - (1-\beta_2)}$$

$$c_4 = \frac{-\alpha_2\gamma_1}{\alpha_2\beta_2 - (1-\beta_2)}$$

And the constant term captures the constant of the original model.

Production level of the intermediate stage is given by

$$\ln Q_1 = \ln a_1 + \beta_1 \ln L_1^* + \gamma_1 \ln A + \varepsilon_1 \qquad 4.16$$

(2) Labour function for stage-2

From (4,7) follows for optimal labour input in stage 2

$$\ln L_2 = c_2 + \frac{1}{\beta_2 - 1}\ln w_2 + \frac{1}{1-\beta_2}\ln p_2 + \frac{\alpha_2}{1-\beta_2}\ln Q_1 \qquad 4.17$$

Substituting for Q_1 with the optimal labour in stage-1 (L_1^*) we get:

$$\ln L_2 = c_5 + c_6 \ln w_2 + c_7 \ln L_1^* + c_8 \ln A + c_9 \ln p_2 + \lambda_2$$

where

$$c_6 = \frac{1}{\beta_2 - 1}$$

$$c_7 = \frac{\alpha_2\beta_1}{1-\beta_2} \qquad 4.18$$

$$c_8 = \gamma_1$$

$$c_9 = -\frac{1}{\beta_2 - 1}$$

Here, the constant c_5 captures the constant terms.

(3) Production function in stage-3

$$\ln Q_3 = \ln a_2 + \alpha_2 \ln Q_1 + \beta_2 \ln L_2^* + \varepsilon_3 \qquad 4.19$$

Substituting for Q_1, we get:

$$\ln Q_3 = c_{10} + \alpha_2\beta_1 \ln L_1^* + \alpha_2\gamma_1 \ln A + \beta_2 \ln L_2^* + \lambda_3 \qquad 4.20$$

c_{10} captures the constants and λ_3 the various error terms.

In summary, the three equations that can be estimated given the observations are:

1) $\ln L_1 = c_0 + c_1 \ln(w_1) + c_2 \ln(w_2) + c_3 \ln(p_2) + c_4 \ln A + \lambda_1$ 4.21

2) $\ln L_2 = c_5 + c_6 \ln w_2 + c_7 \ln L_1^* + c_8 \ln A + c_9 \ln p_2 + \lambda_2$ 4.22

3) $\ln Q_3 = c_{10} + \alpha_2\beta_1 \ln L_1^* + \alpha_2\gamma_1 \ln A + \beta_2 \ln L_2^* + \lambda_3$ 4.23

λ_1 , λ_2 and λ_3 represent the errors in the three functions.

Imposition of cross-equation restrictions implied by the underlying technology is constrained by lack of information on intermediate outputs. Moreover, due to non-observability of the intermediate output (Q_1), it is not possible to recover β_1 which is the planting labour (L_1) elasticity of output in stage-1 (Q_1) and α_2 which is stage-1 output (Q_1) elasticity of the intermediate output in stage-2 (Q_2). This being the case we proceed by interpreting the parameters as they appear in the model. For example, the elasticity of stage-1 labour on final output (Q_3) is given by $\alpha_2\beta_1$ which means that the coefficient obtained comprises of the direct response of Q_1 to L_1 and the response of Q_2 to a marginal increase in Q_1.

4.3.2 Effects of changes in the shadow wage

As the season progresses and more information revealed, there are bound to be changes in demand for labour and hence in a household's labour constraint. The effort applied at each stage in a cropping season largely depends on the labour constraint in a household because tightening of the labour constraint increases the shadow value of the household's time and vice versa. In this section we derive the effects of changes in the labour constraint on output.

The response of stage specific labour (L_t) to a change in the corresponding wage rate (w_t) i.e. wage elasticity, is given by the first derivative of the labour function with respect to the wage rate (w_t) which according to our theoretical model is the coefficient of w_t. In a Cobb-

Douglas specification, wage elasticity of planting (stage-1) labour (L_1) i.e. response to a change in stage-1 wage rate (w_1) is given by the coefficient c_1 in equation (4.21) and the response at stage 1 to the wage rate of stage 2 is the coefficient c_2, or:

$$\frac{\partial \ln L_1}{\partial \ln w_1} = \frac{1-\beta_2}{\alpha_2\beta_1-(1-\beta_2)}; \quad \frac{\partial \ln L_1}{\partial \ln w_2} = \frac{\beta_2}{\alpha_2\beta_1-(1-\beta_2)} \qquad 4.24$$

The response of weeding (stage-2) labour (L_2) to a change in the wage rate of the first stage depends on how L_2 responds to Q_1, and thus implicitly to L_1, and is given by the coefficient c_7 in (4.22), multiplied by how w_1 affects L_1, i.e. by c_1 in (4.21). Similarly L_2's response to a change in w_2 consist of a direct effect, c_6 in (4.22), and an indirect effect through L_1. The total response is given $c_6 + c_7*c_2$. This leads to

$$\frac{\partial \ln L_2}{\partial \ln w_1} = \frac{\alpha_2\beta_1}{\alpha_2\beta_1-(1-\beta_2)}; \quad \frac{\partial \ln L_2}{\partial \ln w_2} = \frac{1-\alpha_2\beta_1}{\alpha_2\beta_1-(1-\beta_2)} \qquad 4.25$$

In the previous section, equation (4.23), the harvest stage production function shows that eventual production Q_3 responds to L_1 and L_2, and thereby responds to the wages rates prevailing in the two periods. The response coefficients are the sum of the responses of L_1 and L_2, each multiplied by their elasticities in (4.23):

$$\frac{\partial \ln Q}{\partial \ln w_1} = \frac{\alpha_2\beta_1(1-\beta_2)}{\alpha_2\beta_1-(1-\beta_2)} + \frac{\alpha_2\beta_1\beta_2}{\alpha_2\beta_1-(1-\beta_2)} = \frac{\alpha_2\beta_1}{\alpha_2\beta_1-(1-\beta_2)} \qquad 4.26$$

and

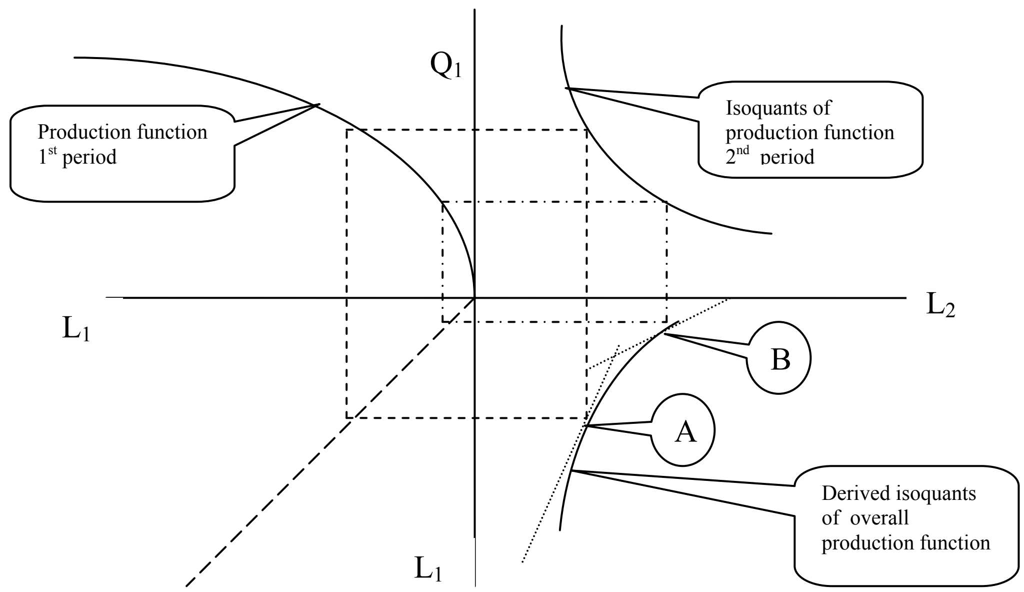
$$\frac{\partial \ln Q}{\partial \ln w_2} = \frac{\alpha_2\beta_1\beta_2}{\alpha_2\beta_1-(1-\beta_2)} + \frac{(1-\alpha_2\beta_1)\beta_2}{\alpha_2\beta_1-(1-\beta_2)} = \frac{\beta_2}{\alpha_2\beta_1-(1-\beta_2)} \qquad 4.27$$

Substitutability of labour over stages

The net effect on output due to changes in wage rates at planting and at weeding stage depends on the flexibility in the production process. A production process may be considered flexible if the penalty of delayed action is low and not flexible if the penalty is high (Epstein 1978). In the context of this study, if the negative effect of a higher shadow wage in stage-1 cannot be corrected in a later stage, then the flexibility in the production process may be considered to be low. Flexibility in a production process is therefore directly proportional to the degree of substitutability between the labour applied at different stages within the season (Fafchamps 1993).

According to production theory, an increase in the cost of labour (wage rate) will result in a reduction in its use. In Figure 4.1, points A and B show the optimal levels of L_1 and L_2 which is at the point of tangency between the derived isoquant and the isocosts. An isocost line shows the level of inputs which satisfy the household's budget. The slope of an isocost gives the relative cost of the two inputs. A change in the relative cost of L_1 and L_2 will change the slope of the isocost. The tangent points show the levels of inputs at the point where the marginal product of L_1 and L_2 equals their respective wage rates.

Figure 4.1: Optimal labour use in a sequential decision framework



According to the Figure, a higher wage rate at the beginning of the season (w_1), such as shown in point B, will result in a lower labour input at the beginning of the season, lower level of Q_1 and, therefore, also lower demand for labour during the weeding stage. At the optimal level of labour use, a reduction in labour use leads to a reduction in the output level. The question is how well the farm household can adjust to this situation during stage 2 and still arrive at the same output level? Figure 4.1 suggests that households which can lower the wage rate during weeding (w_2) so that more effort is applied are able to circumvent a fall in output that is due to a higher wage rate at the beginning of the season. Equivalently, the price as perceived by the household may increase as a consequence of low levels of Q_1. Such low levels are acting as a warning of low harvests.

Equation 4.28 defines the condition under which the negative effect of a higher wage rate at planting on output Q_3 can be neutralised i.e. the weeding-stage labour perfectly substitutes for planting-stage labour.

$$d \ln w_2 = \frac{-\beta_2}{\alpha_2 \beta_1} d \ln w_1 \qquad 4.28$$

As wage rates reflect scarcities, the interpretation of the above formula in a non-market context is that any change in circumstances that make labour more scarce in the first stage, needs compensation in the second stage if production levels are to be maintained. A change in technology, such as row planting, that requires more labour at planting stage, but less labour at weeding stage, could fit into this pattern: it makes labour scarcer in the first stage but less scarce in the second stage. To maintain levels of production at par, one would need fairly large changes in stage-2 scarcity. With typical sizes of 0.5 for all parameters, the ratio in (4.28) equals -2 so that stage-2 changes in (shadow) price need to be twice those of stage 1.

Time-related allocative efficiency

The ability of households to adjust the labour input so that the same output level is achieved may vary. Moreover, this may be technically infeasible in some cases i.e. to correct for the negative effects of a reduction in labour in the earlier stages of a production cycle. A rational household however, is expected to maximise its profits by allocating its labour efficiently. In a time related context, a profit maximising household will be observed to maximise returns to labour applied at each stage of a cropping cycle. We proceed to define the condition under which allocative efficiency in a time related context prevails.

In a one input case, allocative efficiency prevails when the marginal value of the input divided by the input price is unity. In our definition, crop output is a function of amongst others, two inputs namely, labour applied at the beginning of the season (L_1) and labour applied at weeding (L_2). In the case of two inputs, allocative efficiency prevails when the marginal products of the two inputs equal the ratio of the price of the inputs. This means that the two inputs should be used at the point where the returns to each input are equal and at a rate which satisfies the budget constraint.

$$\frac{MVP_{L1}}{MVP_{L2}} = \frac{w_1}{w_2} \qquad 4.29$$

Equation 4.29 says that allocative efficiency over the cropping season therefore prevails when the ratio between the marginal products of labour applied in the two periods (L_1 and L_2) are equal to the ratio of prevailing wage rates in the two stages. In absence of stage-specific market wage rates[28], we follow Jacoby (1993), Skoufias (1994) and Abdulai (2000) and take the estimated marginal product of labour at each stage of a cropping cycle to be the corresponding shadow wage.

Variation in the marginal products of labour between the two stages would suggest that the household is more labour constrained during some stages compared with the others. Since there is no economic rationale for a household to maintain a labour use regime where returns to labour are high during some periods and low during others, it is more likely that farm households strive to maintain a constant marginal product of labour (shadow value of its time) across the season unless constrained e.g. by non-functional markets (especially labour). Our test for allocative efficiency in a time-related context is therefore, equality in the marginal products of labour applied at the beginning of the season and labour applied at weeding (see appendix 4.1).

Constant returns to labour across a cropping season may be achieved by employing elsewhere, surplus labour during the relatively slack periods and employing additional labour during the peak season. Where food and labour markets are functioning, farm households can make even the labour constraint across the season by: offloading the surplus labour to the labour market or to other crops during the slack period; increasing labour applied to maize during the peak periods by withdrawing labour employed in other crops, withdrawing labour from off-farm employment or by hiring-in labour.

[28] Two meals are provided as part of the payment for casual labour employed on the farm. Variations in the wage rate may therefore be observed as a sharp increases in the price of maize during the hunger period.

4.4 Empirical model

4.4.1 Discussion of the considerations made in estimation

There are challenges in estimating the econometric model as given in equations 4.21 to 4.23. In the following section we discuss these challenges and the considerations made in estimation.

Endogeneity

The econometric model has several unknowns including α_2, β_1, β_2 and three endogenous variables (L_1, L_2, Q_3). Estimation of this model is plagued by possible endogeneity of L_1 in estimation of L_2. Firstly, L_1 does influence the decisions underlying quantities of L_2 which means there is a problem of simultaneity and hence a correlation between the regressors and the error term which makes OLS estimates of the single equations biased and inconsistent (Murkherjee, White et al. 1998; Verbeek 2000). Secondly, because the household determines the levels of labour applied in both periods, there is a probable correlation in their measurement e.g. exaggeration in measurement of labour affects both L_1 and L_2. We are likely to have spurious correlation between the two. We adjust for these problems by resorting to instrumental variable estimation, 3SLS method in particular and include instruments like the number of adults for L_1.

Contemporaneous correlation

In addition to simultaneity, there is a possibility of a correlation between the error terms in the different equations in the model. When the error terms in different equations in a recursive model are correlated, the estimates are biased and inconsistent. We have minimised the possibility of this correlation by controlling for biophysical characteristics which influence not only the output but also labour use during both stages.

When only cross-correlation between error terms is the problem, the seemingly unrelated regression (SUR) estimation technique gives consistent estimates. However when simultaneity and cross-correlation between error terms occur together then three stage least squares (3SLS) is the most appropriate estimation technique (Verbeek 2000).

Identification

The appropriateness of 3SLS technique for estimating an equation in a simultaneous system depends on the identification status of the equation. When not identified the parameters of an equation can not be estimated. An equation is identified when the numbers of exogenous variables not appearing elsewhere in the system are as many as the number of endogenous variables in that equation. There are three endogenous variables appearing in the system, one in the planting labour equation, two in the weeding labour equation and three in the production function.

Missing variables

According to the econometric model, farm labour use at each stage in a cropping season is influenced by amongst others, the prevailing wage rate at each stage i.e. w_1 and w_2. Payments to casual labour in the area of study normally include in-kind payments like meals, payment to labour may therefore vary across the season with the movement of food prices. In-kind payments are difficult to quantify and hence only a constant wage rate (w) was observed. This is a classic example where attempts to confront economic theory with empirical data is hampered by paucity of data either because it is unavailable or unobservable. In such cases proxy[29] variables may be used in the regression to substitute for the missing variable (Krasker and Pratt).

Under conditions of imperfect markets, the decision price for farm labour allocation may not be the prevailing market wage rate but an internal price (shadow wage). Therefore, in the place of the market wage rate, we can use an internal price (shadow wage) that is household and stage specific. A household's internal price is determined by amongst others, the prevailing wage rate and a household's value of its time where the household's value of its time depends on the labour capacity, labour constraint and transaction costs. Because a households labour constraint varies across the season so will its internal price.

4.4.2 The Estimated model

The estimated model consisting of two labour functions and a production function was specified to contain the major production factors labour (stage specific) and area, joined by other variables reflecting the farm and the household characteristics. We have the following

[29] The proxy is chosen such that the difference between the 'proxy' regression and the 'true' regression and the direction of influence must be as theory suggests.

variables: dependent variables are the log of value of planned output and, as an alternative, the log of the value of realised output; the log of hours of labour applied at the beginning of the season which includes land preparation, planting and in some cases fertilizer application; the log of hours of total labour applied at weeding stage.

As independent variables we have the log of the plot size and the log of fertilizer expenditure at the plot, with a correction dummy to account for zero-observations. In addition we use information on the fertility status of the plot, whether soil conservation measures are taken, or manure is used and slope of the plot.

At farm level, we have the log of farm size owned, non labour income, the prime age adults, prime age male adults and prime age female adults respectively, *educle* and *age* represent the highest education level and age of the household head respectively and *draught* a predicted variable for use of draught power.

Location variables refer to: the distance from a major market, the distance from a tarmac road, the distance from a motorable road and the distance of a plot from the homestead. In addition we use the village wage rate, a dummy for the district (Kakamega = 1). λ is an error term summarising the effects of unobserved variables and uncertainties. The unit of analysis is the plot carrying a maize based intercrop. The maize based intercrop is defined in Chapter 3 as a cropping practice that is predominantly maize intercropped with beans but with declining farm sizes it is common to find maize/bean intercrops with a third or fourth crop.

The numbers of prime age adults in a household represent a household's labour capacity. The preference for work may vary between household members. We differentiated the adults by gender in the labour equation for the weeding stage only because the tasks at the beginning of the season (land preparation and planting) are intensive and normally involve all adults in the household. Direct measures of a households labour constraint e.g. labour demand on the farm were avoided because: firstly, labour use is endogenous and secondly, crop labour demand in a peasant farm is directly proportional to labour used on maize[30]. The proxies used for labour demand are: education level of household head because it increases productivity on the farm and determines the chances of securing off-farm employment; location variables like distance to major markets or tarmac road because they determine the off-farm employment opportunities and transaction costs in the labour market; non labour income which determines the households use of it's labour in alleviating the liquidity problem; and age of household head because it determines the opportunities for employment.

[30] maize is the main crop grown

The biophysical characteristics of a plot are likely to influence the returns to labour and hence household behaviour in labour use. We expect households to apply more labour in plots with higher returns. However labour could be used as a substitute for capital or technology in the poorer plots. Maize output is determined by labour applied at the beginning of the season and at weeding, purchased inputs like fertiliser and plot characteristics.

While there are several pre-determined variables appearing in the system, the land preparation and planting labour equation is identified by the number of adults in the household and the variable indicating use of draught power. The weeding labour equation is identified by the number of females and male adults in the household whilst the production function equation is identified by manure use in previous year, the location dummy variable and fertiliser expenditure. Fertiliser expenditure although endogenous may be considered as a pre-determined variable since fertiliser use is determined before the season begins. The system is therefore fully identified and the parameters can be estimated.

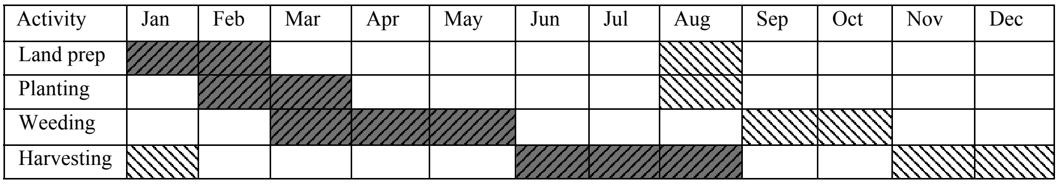
The optimal level of labour is influenced by the information used in decision making. We have incorporated this idea by using two different measures of output in the production function namely planned and realized output. Realized output is the actual output whereas planned output which is the output the farmer expected at the beginning of the season and is calculated as actual output plus the reported crop damage due to vagaries of weather or pests. Planned output indicates that farm households do not update information held about the state of the crop etc but applied labour according to the information held at the beginning of the season. On the other hand realized output indicates that farm households update information held as the season progresses. In the model where realized output is used, labour applied at each stage reflects household response to the states of nature and any other information held at that stage. In the model where planned output is used, the information held at the beginning of the season determines the labour applied at each stage.

4.5 Results and discussion

4.5.1 Data used

Cropping activities in Kakamega and Vihiga districts follow the calendar year as shown in the Figure 4.2. The long rain season starts in January/February ending in August and immediately gives way to the short rain season which end in December/January. Unlike in Chapter 3 where we dealt with a wide range of crops grown in both seasons, in this chapter the focus is on labour use in maize production during the long rain season. The long rain season is the main season especially for maize production. The unit of analysis is still at the plot level.

Figure 4.2: Agricultural Activity Calendar for Western Kenya



Activity Calendar for western Kenya: source Salasya et al, 1998
Key; shaded up-lines = LR; none shaded down-lines = SR

A description of the variables included in the empirical model is given in Table 4.1. Table 4.2 provides the labour intensities during the various stages in a cropping season. The first stage or beginning of the season (land preparation and planting) is most labour demanding as shown by the high labour intensity. It is followed by harvesting stage and then the weeding stage.

Table 4.1: Descriptive statistics for inputs in a maize based intercrop

1USD = 75 KSh.

Variable	*Mean*	*Std. Dev.*
Realised[a] Crop Value (KSh)	4,651	5,225
Planned[b] Crop Value (KSh)	5,459	6,023
Farm size (ha)	0.79	0.57
Plot size (ha)	0.20	0.19
Dummy for good soil fertility	0.13	0.34
Dummy for moderate soil fertility	0.68	0.47
Dummy for poor soil fertility	0.16	0.36
Dummy for steep slope	0.33	0.47
Dumy for gentle slope	0.56	0.49
Dummy for plain slope	0.08	0.28
Dummy for soil conservation	0.41	0.49
Dummy for draught power	0.01	0.98
Dummy for manure use	0.48	0.49
Village wage rate (KSh/hr)	9.62	1.77
Total Labour (hours of family plus hired labour)	176	131
Land preparation and planting Labour (hours of family plus hired labour)	61	23
Weeding Labour (hours of family plus hired labour)	54	60
Fertiliser Expenditure (KSh)	256	489
Fertiliser Expenditure (users only)	451	578
Number of adults in a household	3.9	3.9
Number of adult males in a household	2.0	2.0
Number of adult females in a household	1.9	1.9
Non-labour income (KSh. yr^{-1}.)	5,406	12,243
Non-labour income (KSh. yr^{-1}.) (recipients only)	10,285	15,337
Distance to the tarmac road (km)	3.3	2.4
Distance to the nearest major market (km)	3.6	2.3
Distance to a motorable road (km)	0.35	0.4
Age of household head (yr)	52	14
Education level of head;1 upto 4 where 1 = none & 4 = secondary finished)	1.8	1.3

[a] the value of the crop that was actually realised i.e. it excludes any crop loss due to drought or pests.

[b] the value of the crop which was planned for at the beginning of the season. It was obtained by adding the value of crop loss as reported by the farmers.

Table 4.2: Distribution and intensity of labour applied at different stages in a cropping season

Labour	Mean (hr)	Proportion of total	Labour intensity (hr/acre)
Total	176	100	
Land preparation & planting	61	35	165
Weeding	54	31	123
Harvesting	60	34	153

4.5.2 Determination of factors influencing farm labour use at different stages within a cropping season

Table 4.3: Factors determining[31] farm labour use: A 3SLS estimation

Variables in Model	*Land preparation & planting labour*	*weeding labour*
Dependent Variable = Log of labour (hr)		
Log of village wage rate (KSh)	0.02	-0.32*
Predicted value for the likelihood of using draught power at the beginning of the season	-1.47*	
Number of female adults		-0.06*
Number of male adults		-0.02
Number of adults	-0.01	
Log of land preparation and planting labour (hr)		1.29***
Log of plot size (acre)	0.48***	0.02
Log of farm size (acre)	0.05	-0.11
Log of non-labour income (KSh)	0.02*	0.005
Distance to the tarmac road (km)	0.03	-0.02
Distance to the nearest major market (km)	-0.01	0.06***
Distance to a motorable road (km)	0.02	-0.09
Education level of household head; None, primary, secondary, post secondary	-0.05**	
Age of household head (yr)	-0.001	
Dummy for good soil fertility	0.34***	-0.40***
Dummy for moderate soil fertility	-0.02	-0.21***
Dummy for soil conservation; 1=yes	-0.02	-0.23***
Dummy for plot on gentle slope	0.16**	-0.07
Dummy for plot on a plain	-0.01	-0.02
Dummy for division (1=Kakamega; 0=Vihiga)	-0.42***	0.92***
Log of distance to the homestead (km)	-0.01	-0.08
constant	4.40***	-0.75
Number of observations	404	404
''R-sq''	0.27	0.51
Chi Square	149	445
P	0.000	0.0000

[31] Does not vary with assumption i.e. planned vs. realised output

Table 4.3 provides the elasticities for the various variables hypothesised to influence farm labour use at the beginning of the season and at weeding. The adjusted R-squared for function for labour use at the beginning of the season is 0.27 which is considered reasonable for cross-sectional data. The adjusted R-squared for the weeding labour function is 0.51 indicating a good fit. The coefficients for continuous variables are interpreted as elasticities and are interpreted as the percentage change in labour use at the beginning of the season resulting from a one percent (1%) change in the variable. The coefficients for dummy variables are interpreted as the percentage difference in labour relative to the comparison group. The coefficient for categorical variables is interpreted as the percentage difference in labour due to a change in the categorical variable by one level.

The strongest influence on labour use at the beginning of the season is use of draught power. Increasing the probability of using draught power at the beginning of the season by 1% results in a 1.5% decrease in labour applied. Labour use at the beginning of the season also increases with plot size (0.48**). The strongest influence of labour use at the weeding stage is the labour applied at the beginning of the season. A 1% increase in labour applied induces a 1.2% increase in labour use at the weeding stage. We refer to this as the indirect effect of labour at the beginning of the season on weeding labour. At the first glance, labour use at the weeding stage appears not to be sensitive to an increase in plot size. This is because the coefficient of plot size only gives the direct effect on weeding but excludes the indirect effect which is induced by increased labour use at the beginning of the season.

Labour at the beginning of the season is wage inelastic (not significant) whilst weeding labour is wage elastic (-0.32*). The non-responsiveness of labour at the beginning of the season may be because the wage effect is overshadowed by the effect of draught power. The use of draught power is common where high wage rates prevail and vice versa which would make the direction of effect of draught power the same as that of the wage rate. This hypothesis is however rejected because we find no difference in response to wage rate when the variable draught power is dropped from the model. We also find no difference in labour applied at the beginning of the season between households which use draught power and those which do not. The more plausible explanation for this non-responsiveness is that the labour constraint at the beginning of the season is greater than the market wage rate suggests.

An increase in the number of adults in the household does not change the labour applied at the beginning of the season. However, when the number of males in the household reduce (due to an increase in the number of females in the household), there is a decline in the labour applied at weeding. This suggests that a general increase in labour capacity in the household will not necessarily increase labour use on the farm, but a change in the number of males in the household (by increasing the number of females) induces a reduction in the labour used on-farm. The lack of response to a larger labour capacity may be due to market imperfections (financial, insurance) i.e. any extra family labour is used to alleviate such constraints. The lack of response also suggests that the farm to worker ratio maybe low so that labour needs to be off-loaded to the off-farm labour market. Increasing the number of females in the household does not increase labour on-farm probably because it may be easier for them to get employment off-farm (e.g. domestic workers). Households with higher non-labour income (remittances) apply more labour at the beginning of the season.

At the beginning of the season, more labour (34%) is used in plots with better fertility compared with plots with poor fertility. Similarly, plots with a lower slope are allocated 16% more labour at the beginning of the season than plots with a steep slope. Since it was shown that increasing labour at the beginning of the season induces increased labour at the weeding stage, we expect that the higher labour applied to the "good" plots at the beginning of the season induces increased labour at weeding. However, the results show that plots with good characteristics (fertility and slope) receive less labour at the weeding stage compared with the poorer plots. We however cannot conclude that less labour is applied to the better plots at the weeding stage because the coefficient of L_1 in the weeding labour function suggests that a 1.29% increase in weeding labour is induced by increasing labour at the beginning of the season by 1%. This is what we refer to as an indirect effect of labour at the beginning of the season on weeding labour. As expected, labour at both the beginning of the season and weeding stages declines with increased distance from the homestead.

In Kakamega labour at the beginning of the season is less (42%) than that in Vihiga suggesting that the labour constraint is higher in Kakamega. On the contrary, much more weeding labour (92%) is used in Kakamega partly because the higher rainfall translates to more weeds.

The validity of the assumption made about labour at the harvest stage i.e. $L_3 = b_3 Q_3$ is tested by regressing harvest labour against the actual crop output. Because actual output is endogenous, the predicted[32] output was used to instrument actual output. We first estimated a production function in which labour applied at the harvest stage (L_3) was not included as an explanatory variable. A predicted value of crop output was then obtained from the estimated

[32] Predicted from a production function where harvest labour (L3) is not included as an explanatory variable.

function. The high F-statistic (633), adjusted R-square (0.32) and large coefficient (b_3) for crop output (0.94) suggests that harvest labour is indeed determined by realised output.

4.5.3 Factors influencing output in the maize based intercrop

Table 4.4: Production function estimates for a maize based intercrop: results from a 3SLS estimation

Variables in Model	*Model with realised[a] output as the dependent variable*	*Model with planned[b] output as the dependent variable*
Dependent Variable = Log of value of output (KSh)		
Log of land prep. & planting labour (hr)	0.31	0.31
Log of weeding labour (hr)	0.41*	0.31
Log of plot size (acre)	0.23*	0.28**
Log of fertiliser expenditure (KSh)	0.19**	0.22**
Dummy for fertiliser use = 1 if no and 0 if yes	0.70	0.83*
Dummy for good soil fertility	0.23	0.19
Dummy for moderate soil fertility	0.23**	0.21*
Dummy for soil conservation; 1=yes	-0.02	-0.001
Dummy for plot on gentle slope	0.08	0.09
Dummy for plot on a plain	0.24	0.28*
Dummy for Kakamega District	-0.02	0.02
Dummy for manure use in previous year; 1 = yes	0.04	0.03
constant	4.41***	4.82***
Number of observations	404	404
''R-sq''	0.38	0.40
Chi square	295	285
P	0.0000	0.0000

[a] the value of the crop that was actually realised i.e. it excludes any crop loss due to drought or pests.

[b] the value of the crop which was planned for at the beginning of the season. It was obtained by adding the value of losses due to crop damage as reported by the farmers.

We provide results of two production functions namely, the planned and realized outputs because they generate useful information. When planned output is the dependent variable, the weeding stage labour elasticity is small and not significant. Conversely, when realised output is the dependent variable, the weeding stage labour elasticity is larger and significant. This shows that the assumption that as the season progresses, farmers labour use is based on updated information is valid. We therefore report results for the first regression i.e. with realised output as the dependent variable. Table 4.4 gives the elasticities for the various factors hypothesised to influence production in a maize based intercrop. An adjusted R-squared of 0.38 to 0.40 for cross-sectional data shows the estimated model has a good fit.

The results show that realized output may be slightly more responsive to weeding labour (labour elasticity is 0.41) and less to labour at the beginning of the season (elasticity is 0.31) and that only the response to weeding labour is significant. Land and fertilizers also influence output where land elasticity is 0.23 while that of fertilizer is 0.19. This confirms findings of previous studies (Salasya, Mwangi et al. 1998; Salasya 2005). Output from plots with good fertility is higher than that from plots with poor fertility by 23% and there is however, no difference in output between plots with good and moderate fertility, apart from the effects through the labour variables. Plots with a small slope have higher output compared with plots with a high slope. The difference is especially high (24%) when the slope is very small; a finding which confirms findings by previous studies that soil erosion is a problem in the area (Place, Barrett et al. 2003). These results show that the fertility status influences labour use which in turn influences the output obtained. The small negative and insignificant coefficient of the dummy for plots with soil conservation and the strong negative effect on labour especially weeding labour suggests that soil conservation affects output indirectly through its effect on labour use.

4.5.4 Effects of a change in the wage rate

Tightening of the labour the constraint in a household increases the shadow value of its time thereby reducing the labour applied. Our estimation results have shown that when the labour constraint at either stage is relaxed it results in a higher maize output. Conversely, a higher labour constraint would lead to application of less labour resulting in lower maize output. Equation 4.82 gives the condition under which the effects of a higher shadow value of time would be neutralised. Our calculations (Table 4.5) show that, at the current levels of labour constraint in the study area, this negative effect is neutralised only when the change in the shadow value of time at the beginning of the season ($dMVP_{L_1}$) is at least 80% less than the shadow value of time at weeding ($dMVP_{L_2}$). When a negative shock like crop damage is expected, the negative effect is neutralised only when there is no labour constraint at the beginning of the season (the shadow value of labour is close to zero).

Table 4.5: Labour elasticities and change in wage rate necessary to neutralise negative effect of a high shadow wage at the beginning of the season

	Land preparation & planting labourP[a]	*Land preparation & planting labourR[b]*
Stage Specific Elasticities		
Labour Stage 1	0.31	0.31
Labour stage 2	0.31	0.41
Change in wage rate (dlnw1)*	-0.80	-1.08

*the change in stage 1 wage rate (dlnw1) given a 1% change in stage 2 wage rate; [a] planned output i.e. no negative shock like crop damage factored in; [b] Realised output with the negative shock factored in.

4.5.5 Stage-Specific Marginal Value Products of labour

We use the results of the estimated model to estimate the changes in stage-specific marginal products of labour. While the change in the marginal product of labour at weeding was obtained directly, estimation of the change in the marginal product of labour applied at the beginning of the season is complicated by the fact that when more labour is applied in stage-1 (beginning of the season), it induces more labour use in stage-2 (see Table 4.3). We therefore used the estimated model to simulate the effects of a 5% increase in labour at the beginning of the season. The marginal product of stage-1 labour was therefore calculated as the sum of the marginal product of labour at the beginning of the season (stage-1) and the marginal product of the induced labour at weeding (stage-2). The marginal products were calculated at the plot level for each household in order to control for plot and household specific idiosyncrasies and adjusted to standardize these to effects of a single unit change of labour (see Appendix 4.1)

K-density plots in Figure 4.3 – 4.5 show the distribution of the estimated MVP of labour applied to maize plots at the beginning of the season and at weeding stage. The MVP captures the marginal change in realised output given a marginal change in stage specific labour with all other variables held constant.

Figure 4.3: Frequency distribution of stage specific marginal product of labour without the effects of induced labour

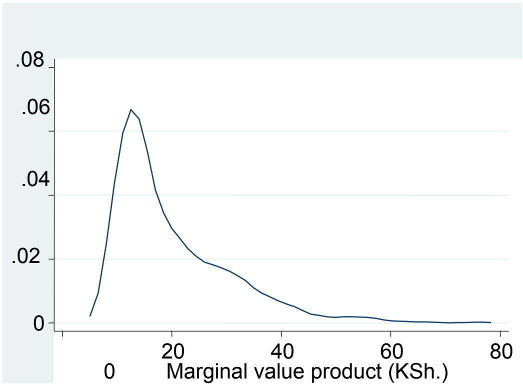


Figure 4.4: Frequency distribution of the marginal product of stage-1 labour with the effects of induced labour

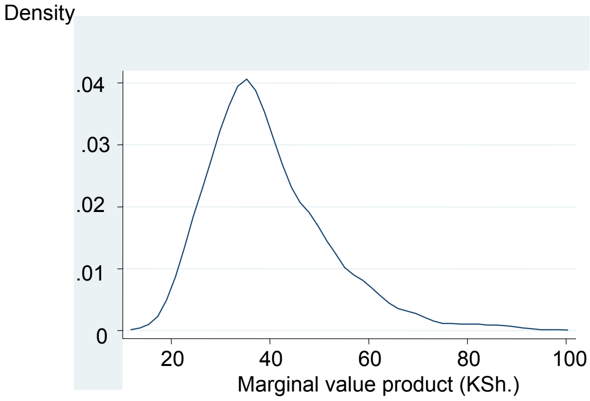
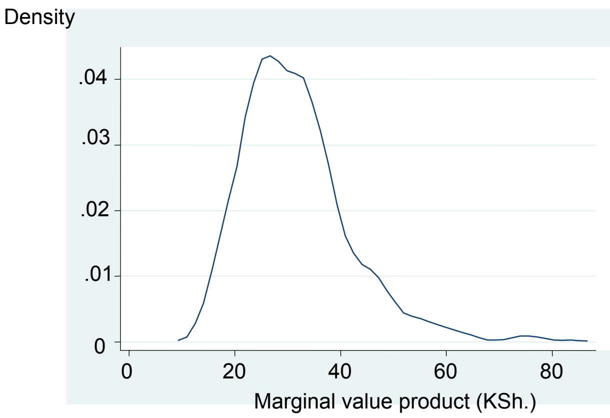


Figure 4.5: Distribution of the marginal product of stage-2 labour



The distribution of MVP of labour in stage-1 when only the direct effect of stage-1 labour is included is shown in Figures 4.3. The distribution of MVP of stage-1 labour when both the direct and induced effect are included is shown in Figures 4.4. Figure 4.5 shows the distribution of MVP of stage-2 labour. The mean MVP for stage-1 labour is around KSh. 20.00 when effect of induced labour is excluded and KSh. 40.00 when induced labour is included. The mean MVP for stage-2 (weeding) labour is around KSh. 30.00 (Table 4.6). The MVP for stage-2 (weeding) labour is larger than that for stage-1 (at the beginning of the season) only when the effect induced by an increase in stage-1 labour is not included. This means that on average, households in western Kenya perceive the labour constraint at the beginning of the season to be larger than the constraint at weeding (see also Appendix 4.3). The table also shows that on average, the MVP of labour differs between the different stages within a cropping season but not between seasons or locations.

Table 4.6: Comparison of stage specific marginal value product (average) of labour

	Average MVP (KSh/hr) stage-1		**Average MVP (KSh/hr) stage-2**
	Includes effects of induced labour	*Excludes effects of induced labour*	
LR season	39.32	18.32	31.16
SR season	40.07	21.17	32.02
Vihiga	39.77	13.44	32.70
Kakamega	39.77	27.77	30.47

1USD = 75 KSh

Optimal efficiency prevails when the ratio of the marginal products of labour at the beginning of the season and the marginal product of labour at weeding stage equal the ratio of the price of labour during the two stages. In the absence of stage specific market wages, the ratio between the two marginal products i.e. is indicative of the ratio between the shadow value of time during the two stages. At the optimal point, this ratio also gives the marginal rate of substitution (MRS_{21}) i.e. the rate at which labour at weeding can substitute for labour at the beginning of the season because at that point, the MRS equals the price ratio between the two inputs.

Figure 4.6: Distribution of the ratio "MVP1:MVP2"

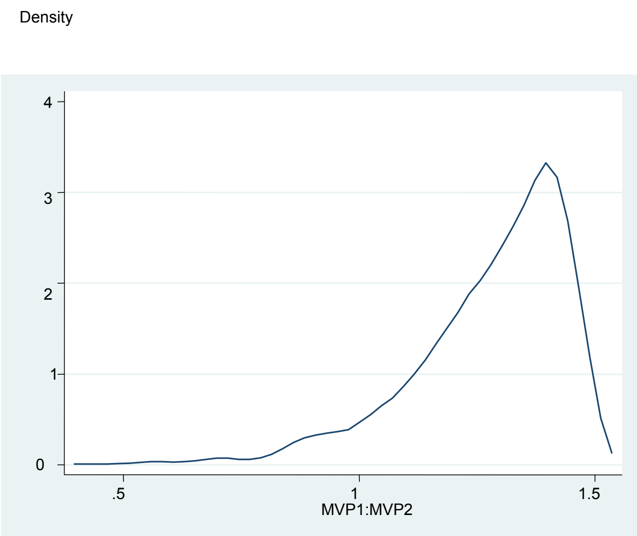


Figure 4.6 shows that most households have a ratio greater than one, indicating that for most households, the shadow value of time at the beginning of the season is greater than that at weeding. There are also a few households with a ratio less than one indicating that for some households the shadow value of time at the beginning of the season is lower than that at the weeding stage. These results imply that the labour constraint is not uniform across the season and the stage at which the household is most constrained varies with most households being more constrained at the beginning of the season.

Previous studies (Fafchamps 1993) have alluded to the possibilities of substitutability of labour between different stages in a cropping season. We estimated the rate at which labour at the beginning of the season may substitute for labour at weeding or vice versa. For households with a ratio (MVP_1 / MVP_2) smaller than one, it is cheaper when labour at the beginning of the season substitutes for labour at weeding. For households with a ratio larger than one, it is cheaper when weeding stage labour substitutes for labour at the beginning of the season. The applicability of this concept of substitutability of labour is for example where more careful land preparation or planting a larger acreage compensates for less weeding. Alternatively, more intensive/careful weeding results in higher yield per hectare thereby compensating for a smaller acreage under the crop resulting from less labour used at the beginning of the season. These findings also inform us about adoption of labour demanding technologies. Households with a higher constraint at the beginning of the season will demand technologies which save labour at that stage e.g. draught animals and tractors or even zero tillage. Households that are constrained at the weeding stage will demand technologies which save labour at that stage e.g. herbicides. Farm households may re-allocate family labour or hire-in labour to reduce the labour constraint. This however depends on whether the labour constraint is binding.

4.5.6 Factors influencing household allocative efficiency

According to Schultz (1964), farmers, given their circumstances adjust factor allocation to serve their interests. Deviations from the expected household behaviour are therefore attributable to household specific idiosyncrasies. We explain the within-season differences in marginal products by regressing the difference in stage specific marginal products (MVP1 - MVP2) against plot, farm and household characteristics. Given that MVP1 exceeds MVP2, a decline in this difference is interpreted as an improvement in allocative efficiency and an increase in the difference is interpreted as a deterioration in allocative efficiency. The results are given in Table 4.7.

Table 4.7: Factors influencing extent of allocative inefficiency

Variables Included	*Coefficient for overall sample*	*Coefficient for Kakamega*	*Coefficient for Vihiga*
Dependent Variable: MVP1 – MVP2			
Dummy for whether household sells labour off-farm	0.117	0.125	-0.173
Gender of household head	-0.018	0.240	-0.178
Dummy for head with no education	-1.120**	-0.431**	-1.852**
Dummy with head with unfinished primary level education	-0.717*	-0.061	-1.496**
Dummy with head with primary level education	0.236	1.202***	-0.957
Dummy for draught power	-6.366***	-6.672***	
Log of value of farm equipment (kSh.)	0.389**	-0.001	0.841***
Log of non-labour income	0.0009	-0.0004*	0.0001
Family size	-0.117	-0.260**	0.021
Number of adult females in household	0.495***	0.769***	0.159
Number of adult males in household	-0.292**	-0.187	-0.454*
Distance to a major market (km)	-0.123*	-0.271***	0.121
Age of household head (yrs)	0.015	-0.021	0.031
Dummy for location	1.539***		
Log of farm size (acre)	0.573***	1.926***	-0.301
Log of distance to homestead (km)	1.908***	1.825***	4.298***
Dummy for soil conservation structures	-0.173	-0.545	-0.174
Dummy for good soil fertility	2.044***	2.162***	2.496***
Dummy for moderate soil fertility	2.344***	2.547***	2.221***
Dummy for steep slope	2.202***	2.051***	1.491
Dummy for gentle slope	0.819***	0.677	0.661
Constant	*6.214****	*8.900****	*5.916****
Number of observations	*766*	*401*	*371*
"R-sq"	*0.18*	*0.34*	*0.10*
F	*9.18*	*10.14*	*2.21*

The use of draught power at the beginning of the season results in improved labour use efficiency within the season. Households in Kakamega have greater efficiency compared to those in Vihiga suggesting that the labour constraint is higher in Kakamega. An increase in farm size leads to a greater difference which is suggestive of constraints in the labour market. Plot characteristics also have an important influence on labour allocation over the cropping season. The location of the plot in relation to the homestead is an important determinant. Allocative efficiency deteriorates with greater distance from the homestead which emphasises the inconvenience of working on distant plots (Misiko 2007). Contrary to our expectations, there is less efficiency on the better plots. The other surprising finding is that efficiency deteriorates with increasing value of farm equipment. This may be because greater value of farm equipment[33] translates to an increased demand for labour.

Increasing the family size improves allocative efficiency but not significantly. However, the family composition is an important determinant of labour allocation within a cropping season. Allocative efficiency improves with the number of adult males in the household but deteriorates with the number of females. This may be because the tasks undertaken in the first and second stages are gender specific. For example, increasing the number of females may not reduce the labour constraint in the first stage but increasing the number of males may. Households selling labour off-farm are less efficient (not significant), it is therefore not surprising that greater distance from the major markets (and less likely to sell labour off-farm) results in improved within season allocative efficiency. Households headed by persons who have less than basic level of education are more efficient than those headed buy persons with higher education probably because of differences in labour availability as the season progresses. The off-farm jobs taken by persons with low education have more flexibility compared with the salaried jobs taken up by persons with higher education level.

What does an increase in one of the factors translate to in terms of the labour constraint during different periods within a season? What is the effect in monetary terms? Table 4.8 shows the magnitude of the change in the difference between marginal product of labour at the beginning of the season ($MVPL_1$) and that at weeding ($MVPL_2$). Our earlier results showed that $MVPL_1$ is greater than $MVPL_2$ for 90% of the households. For these households we interpret the results of Table 4.8 as follows. A negative means that $MVPL_1$ declines while a positive indicates an increase in $MVPL_1$. The greatest reduction is due to

[33] Mainly comprises of jembes & machetes

draught power (KSh. 62.00), however this is only applicable in Kakamega where it is used. The $MVPL_1$ in households headed by persons with less than secondary education is lower by KSh. 10.00 - 13.00. We have also shown how the marginal product increases when the plots are located further from the homestead. A 1 km increase in distance of a plot from the homestead results in the largest increase in the marginal product at the beginning of the season and this effect is larger in Vihiga (KSh. 30.00) compared with Kakamega (KSh. 17.00).The effect of an increase in farm size is also large. An increase in farm size in Kakamega by 1 acre induces an increase of KSh.17.00 in the marginal product of labour at the beginning of the season. The effect is much larger as the farm size increases. At the beginning of the season, labour in Kakamega is more expensive (by KSh. 12.55) compared with labour in Vihiga which is consistent with the higher population density found in Vihiga. The results indicate that labour employed in plots with different characteristics have a different cost (as perceived by the household) at the beginning of the season. In Vihiga, labour applied to plots with better fertility at the beginning of the season 'costs' KSh. 15.00 to 17.00 more than labour applied to poorer plots. This difference is much larger in Kakamega. The reduction in the difference between $MVPL_1$ and $MVPL_2$ due to an increase in males or females in the household is comparatively small. However, we note that the increase in difference of the marginal products due to an increase in the number of females in larger than the reduction which results from an increase in males. It seems like 1.5 males would be required to correct for the effect of an extra female. The other kind of questions that could be asked with these results is, how many males can compensate the increase in marginal product due to an increase in farm size or an increase in distance from the homestead. It would seem more efficient to use draught power to reduce the inefficiencies caused by increases in size or distance.

Table 4.8: Change in $MVP_1 - MVPL_2$ (KSh[a]) due to a change in farm and household characteristics

	Overall Sample				Kakamega				Vihiga			
Magnitude of change[c]	100%	1	2	3	100%	1	2	3	100%	1	2	3
No education[b]	-9.14	-	-	-	-	-	-	-	-13.09	-	-	-
Unfinished primary education[b]	-5.85	-	-	-	-	-	-	-	-10.57	-	-	-
Primary education finished[b]	-	-	-	-	11.17	-	-	-	-	-	-	-
Draught power[b]	-51.95	-	-	-	-62.04	-	-	-	-	-	-	-
Value of farm equipment		-	-	-	-	-	-	-		0.84	1.68	2.52
Family size		-	-	-	-	-0.26	-0.52	-0.78	-	-	-	-
Number of females (number)		0.40	0.99	1.48	-	0.76	1.53	2.30	-	-	-	-
Number of males (number)		-0.29	-0.58	-0.87	-	-	-	-	-	-0.45	-0.90	-1.35
Distance to major market (km)		-0.12	-0.25	-0.37	-	-0.27	-0.54	-0.81	-	-	-	-
Farm size (acre)		4.67	9.35	14.00	-	17.90	35.80	53.70	-	-	-	-
Distance from homestead (km)		17.74	35.48	53.23	-	16.97	33.94	50.91	-	30.38	60.77	91.16
Good soil fertility[b]	16.67	-	-	-	20.10	-	-	-	17.64	-	-	-
Moderate soil fertility[b]	19.12	-	-	-	23.68	-	-	-	15.70	-	-	-
Steep slope[b]	17.96	-	-	-	19.07	-	-	-	-	-	-	-
Gentle slope[b]	6.68	-	-	-	-	-	-	-	-	-	-	-
Location = Kakamega[b]	12.55	-	-	-	-	-	-	-	-	-	-	-

[a]Exchange rate at time of survey 1USD = KSh 75.00

[b]dummy variables:

[c] indicates 100% change for dummy variables whereas 1,2,3 indicate a unit increase for the other variables

4.6 Conclusions

The seasonality and uncertainty in rain-fed agricultural production means that farm households are normally faced by variable labour demand over the cropping season. A higher wage rate at the beginning of the season may give rise to lower labour input at the beginning of the season and also lower demand for labour during the weeding stage. To prevent a drop in the level of output, a household would have to apply more effort during the weeding stage. This may be achieved by lowering the wage rate at that stage. The ability of households to adjust labour supply so that the same output level is achieved may vary. This notwithstanding, an efficient farm household will allocate its labour such that the returns to labour (the marginal products of labour) are equalised across the season.

In this study, the within-season allocative efficiency of farm households was evaluated. The study has captured within-season variability by differentiating labour use decisions during main periods in a cropping season. Returns to labour were estimated for the planting and weeding stages with the model showing that increasing labour demand at the beginning of the season impacts not only on the returns to labour applied at beginning of the season but also on the returns to labour applied at the weeding stage. For over 90% of the farm households the marginal product of labour applied at the beginning of the season, including its induced effect on weeding labour, was larger than the marginal product of labour applied at weeding. This suggests that households are most labour constrained at the beginning of the season. There are a few households that are more labour constrained at weeding or maintain constant returns to labour across the season.

Efficiency improves significantly when the labour capacity, specifically adult males, increases and where labour saving technologies like draught power are used. There is improved efficiency in households headed by persons with less than the basic education may be due to increased flexibility in labour employed off-farm. Households located further from major markets have greater efficiency probably due to inaccessibility of off-farm employment opportunities. Efficiency improves with increased non-labour income probably because it eases the labour constraint. Conversely, efficiency deteriorates when demand for labour within the household increases e.g. with increased farm size, with greater distance from the homestead and when there are more adult females in the household. The latter finding that increasing the number of males improves efficiency whilst increasing the number of females reduces efficiency is interesting. This makes sense when tasks performed during some stages within a season are gender specific. If the tasks at the beginning of the season are mainly done by men, households endowed with more males will have a lower labour constraint at that stage compared with households that are endowed with fewer male adults. Moreover in the study area, the number of female adults in a household is negatively correlated with the number of male adults.

One of the main causes of inefficiency in labour use is failure in labour markets. When households are faced with a failed labour market, an increase in labour demand increases the internal price of labour to reflect the severity of the constraint. In the study area, the costs of hiring-in labour may be prohibitive. The peak periods normally coincide with high food prices[34] yet households must provide 2 meals for a days work. Moreover, shirking increases costs by increasing supervision time. Labour markets will also not work where the labour market is shallow i.e. all households demanding hired labour during the same period. Lack of secondary markets like credit can also contribute to the failure of the labour market. The households' labour constraint may be reduced by encouraging use of draught power by lowering the cost of draught power and/or provision of credit. Where draught power cannot be used, reduction in the transaction costs and frictions in the labour market would encourage farm households to supplement or substitute for family labour wherever necessary. Reduced marketing costs and greater market integration will ensure food prices remain low through out the season thereby encouraging use of hired labour.

The results have implications on evaluation of interventions. One of the criteria used in evaluation of agricultural technologies is its impact on total labour use. This study however suggests that the impact of new interventions on stage specific labour demand gives a better indication of how households evaluate interventions. The results suggest that, technologies with the greatest potential to be adopted are those which ease the labour constraint at the beginning of the season.

While the model used adequately explains within-season farm labour use in smallholder farms, the limitations are that the Cobb-Douglas functional form assumes, a unitary elasticity of substitution between labour at the beginning of the season and weeding stages irrespective of the labour effort applied at the beginning of the season. However, including an interaction term between labour at the beginning of the season and weeding labour did not improve our results and this term was dropped.

[34] during the "hunger" season

Appendices

Appendix 4.1: Marginal product of stage specific labour

$$q = f(L_1, L_2)$$
$$L_2 = g(L_1)$$
$$\frac{dq}{dL_1} = \left[\frac{\partial f}{\partial L_1} + \frac{\partial f}{\partial L_2}\frac{\partial L_2}{\partial L_1}\right] / \left[1 + \frac{\partial L_2}{\partial L_1}\right]$$
$$\frac{\partial q}{\partial L_2} = \frac{\partial f}{\partial L_2}$$

A4.1

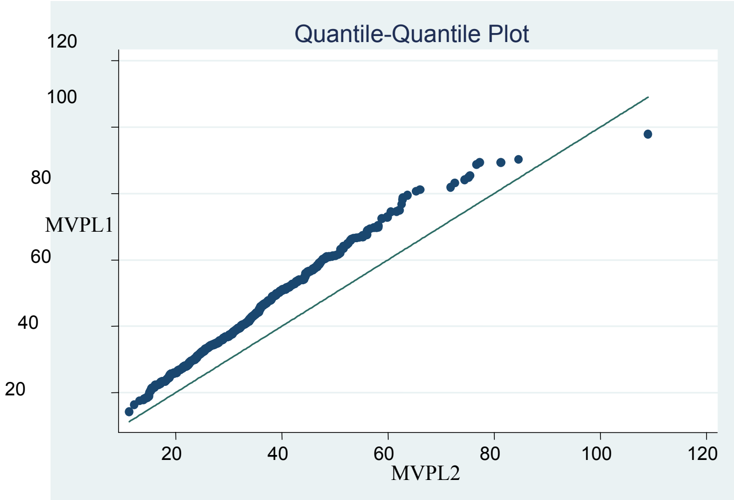
The marginal increase in output due to a unit increase in labour at the beginning of the season (MVP_{L1}) is the sum of two effects namely, the direct and indirect effect. The direct effect is the increment due to labour at the beginning of the season per se and the indirect effect is the increment due to the induced labour at weeding. The labour cost of this increment therefore includes not only the increase in labour at the beginning of the season but also the induced labour at weeding. The estimate for the inclusive effect of a change in L_1 is adjusted for the induced change in L_2 as shown by the denominator in the formula. Without this adjustment, we would actually measure the effect of one unit change of labour in stage 1 plus the induced change of labour in period 2. Now we have the effect of one unit change of labour, distributed over stage 1 and stage 2, according to the induced effect.

Appendix 4.2: Testing validity of the assumption that labour at harvest is determined by the realised output.

Dependent Variable = log of hours of labour applied at harvesting	*Estimated coefficient*
Log of predicted value of realised output (KSh)	0.94
Constant	-3.90
Number of observations	1305
''R-sq''	0.32
F	633
P	0.0000

[a] the value of the crop that was actually realised i.e. it excludes any crop loss due to drought or pests.

Appendix 4.3: QQplot showing the relationship between MVP1 & MVP2



The figure shows a positive relationship between MVPL1 and MVPL2 and that MVPL1 is higher than MVPL2 for all quintiles.

CHAPTER 5

ALLOCATIVE EFFICIENCY BETWEEN FARM AND OFF-FARM WORK

5.1 Introduction

The labour market in western Kenya can be described as active with farm households showing preference for different labour market participation strategies. Although active, the labour market is not without imperfections and these imperfections affect farm household behaviour (De Janvry, Fafchamps et al. 1991). Little is known about the efficiency of farm households in labour allocation between farm and off-farm activities, efficiency in use of hired labour or the effect of changes in exogenous factors on labour supply or demand by farm households in western Kenya. This study complements the work in Chapters 3 and 4 by examining allocative efficiency in labour use, of farm households which interact with the labour market and the factors influencing household labour supply and demand. In addition to informing us whether farm households are making the best of their resources, this study will provide useful information regarding the mobility of labour between the farm and off-farm activities. Where mobility is a problem, it is important to know whether the problem is systematic i.e. is resource immobility a problem in specific groups of households e.g. households targeted by policy makers in their efforts to alleviate poverty?

In studying farm household labour supply and demand, we are often constrained by non-observability of wages for households which do not participate in labour markets. There are several ways of going around the problem: One, the problem could be modelled as a problem of censoring or selectivity. Two, wage rates imputed from households which participate in labour markets could be assigned to non-participating households. The problem with the first approach is that information from non-participating households is lost. In the second approach separability in production and consumption decisions is assumed. When separability is assumed, household decisions are modelled as if occurring in two stages. In the first stage, the amount of farm labour which maximizes profits is determined without regard for preferences in consumption or leisure. In the second stage the household decides on consumption and labour supply based on the farm profits, prices and wages. In this kind of farm household model, the market wage rate provides the measure for family labour and production decisions influence consumption only through the income effect.

Farm household production and consumption decisions can only be modelled as separable under the assumption of perfect input and output markets, perfect substitutability between family and hired labour in farm production and where no dis-utility is associated with working off the farm (Jacoby 1993; Woldehanna 2000). Rural conditions in the developing world suggest that these assumptions are highly restrictive. Any of the following conditions will prevent separability in production and consumption decisions of a farm household: constraints in off-farm employment are binding such that there is incomplete adjustment in the labour market (Singh, Squire et al. 1986; Singh I. 1986; Benjamin 1992), family and hired labour are not perfectly substitutable (Jacoby 1993; Skoufias 1994), household members have preference for farm work (Lopez 1984), credit rationing or level of interest depends on household characteristics (Singh I. 1986), households are risk averse and expected utility of profit is maximized (Roe and Graham-Tomasi 1986). The presence of market imperfections means that households production decisions are linked to its consumption decisions (De Janvry, Fafchamps et al 1991).

In this study we have followed Jacoby (1993) who solved the problem of non-observability without assuming separability. In this approach household specific shadow wages are estimated from structural non-separable farm household models.

In previous Chapters we restricted ourselves to the farm by examining within-farm and across-season efficiency. In this study however, we examine household efficiency in allocation of family labour between the farm and off-farm activities, use of hired labour and the factors influencing labour supply and demand. We build on the analysis from Chapter 3 in which household specific internal price of labour were estimated.

5.2 Theoretical framework

When separability cannot be assumed, the relevant model is one which simultaneously utilizes the production and consumption theory. In this section we discuss the farm household model which provides the background for the expected household behaviour in terms of choices made between farm and off-farm work. The farm household model is represented as a single decision making unit and incorporates the production, consumption and labour supply behaviour of households (Singh, Squire et al. 1986). It easily incorporates partial or incomplete nature of rural markets and is highly adaptable to different farm types from commercial to subsistence farms (Nakajima 1970; Nakajima 1986). In this model we do not differentiate between male and female workers or between family and hired labour thereby imposing perfect substitutability. This assumption was imposed because firstly, the data is not differentiated by gender. Secondly, for households hiring-in labour, the MVP of labour on the farm is assumed to be equal to the market wage. Not differentiating labour meets the interest of this study which is to determine productivity of labour applied in crop production.

The farm household's problem is defined as maximization of its utility of consumption and leisure:

$$\text{Max } U(X_m, L_l; z_u) \tag{5.1}$$

Where X_m is a sum of all goods consumed by the household, L_l is pure leisure which is the total time minus time spent on economic activities $T - L_s$ and z_u is a vector of household characteristics (size of the household and its composition) that determine the household's preferences. The utility function is continuous and non-decreasing in its arguments. The maximum utility that households can attain is restricted by a budget constraint, time constraint, home production technology and the constraint in off-farm employment.

The household is faced by a budget constraint shown below which says that the profit plus earnings from off-farm employment plus non-labour income must be equal or greater than the value of purchased goods.

$$\Gamma(L_F, A; z_q) - w_{hm}L_h - w_{hk}L_h + w_oL_o - w_{om}L_o + R - X_m \geq 0 \tag{5.2}$$

Where L_F comprises family (L_f) and hired labour (L_h) i.e. $L_F = L_f + L_h$ 5.3

Γ is a function that specifies the production function for the agricultural commodity produced by the household, w_{hm} is the monetary component of the wage rate for hired labour whilst w_{hk} is any in-kind payment to hired labour including food and other favours. Payment to off-farm labour is denoted w_o while the travelling and search costs associated with off-farm labour are denoted as w_{om}. R is non-labour income including remittances. The production technology is a closed and bounded possibility set defined as:

$$\Gamma(l_F, A; z_q) \geq 0 \tag{5.4}$$

The farm household produces an agricultural good using labour (L_F) and land (A). z_q are farm characteristics like soil quality that influence productivity of factors of production. The inequality means that households may or may not be using the variable and fixed inputs to produce the maximum output possible (i.e. at the boundary of the set).

The time constraint is defined as:

$$T = L_f + L_O + L_l + L_h \sup + L_O tc \qquad 5.5$$

T is the households time endowment which is spent on the work at the farm doing actual farm work (L_f) or supervising hired labour ($L_h \sup$), off the farm working (L_O), or searching and travelling ($L_O tc$). Time spent not working is leisure time (L_l) which includes social activities and resting time.

The household may also be rationed for off-farm work due to few employment opportunities and barriers to entry in the form of skills, education or experience so that it supplies less labour off-farm (L_O) than it would be willing to supply (M_O). This constraint is expressed as:

$$L_O \leq M_O \qquad 5.6$$

The Lagrange function G for this maximization problem is defined as follows:

$$\begin{aligned} G = {} & U(X_m, L_l; z_u) + \lambda(T - (L_l + L_f + L_O + L_h * \sup + L_O * tc)) + \eta[M_O - L_O] \\ & + \tau[\Gamma(L_F, A; z_u) - w_{hm} L_h - w_{hk} L_h + w_o L_O - w_{om} L_O + R - X_m] \end{aligned} \qquad 5.7$$

The Lagrange multipliers namely lambda (λ), tau (τ) and eta (η) are the time, cash and off-farm labour market constraints facing the household. They represent the marginal utility derived by the household when the constraint is relaxed. Specifically, lambda (λ) is the marginal utility derived when the household time is relaxed by one unit, tau (τ) is the marginal utility derived when the budget constraint is relaxed and represents the marginal value of cash in the household and eta (η) is the marginal utility derived when off-farm employment increases by one hour, it is therefore the marginal value of off-farm employment.

Maximising the Lagrange function with respect to L_F, L_f, L_h, L_O, L_l, and X_m yields the first-order conditions which spell out the necessary conditions for maximising household utility.

$$\frac{\partial G}{\partial X_m} = U_{C_m} - \tau = 0 \quad , \qquad U_{C_m} = \tau \tag{5.8}$$

The marginal utility of consumption of an extra unit of a market good is equal to the value of cash in the household i.e. it depends on the cash constraint in the household.

$$\frac{\partial G}{\partial L_l} = U_{L_l} - \lambda = 0 \quad , \qquad U_{L_l} = \lambda \tag{5.9}$$

The marginal utility of leisure is equal to the marginal utility of household time.

$$\frac{\partial G}{\partial L_f} = -\lambda + \tau[\partial\Gamma / \partial L_f] = 0 \qquad \tau MVP_{L_f} = \lambda \tag{5.10}$$

At the optimal point, the marginal product of family labour on the farm will be equalized to the value of household time (λ/τ). The value of household time increases with the cash constraint (τ), implying that the marginal product may vary with household characteristics.

$$\frac{\partial G}{\partial L_h} = \tau\frac{\partial\Gamma}{\partial L_h} - \tau(w_{hm} + w_{hk}) - \lambda \ * \sup = 0$$

$$\frac{\partial\Gamma}{\partial L_h} - \lambda / \tau * (\sup) = w_{hm} + w_{hk} \tag{5.11}$$

$$MVP_{L_h} = w + \lambda / \tau * (\sup)$$

At the optimum, the marginal productivity of hired labour on the farm should be equal to the wage rate for hired labour (both cash and kind) plus the value of household time spent supervising the hired labour. If supervision costs are negligible, then the marginal productivity of hired labour is equal to the market wage rate for hired labour.

Family and hired labour are perfectly substitutable when the value of household time is equal to the market wage rate.

$$\frac{\partial G}{\partial L_O} = -\lambda(1+tc) + \tau(w_o - w_{om}) - \eta = 0$$
$$\lambda = \frac{\tau(w_o + w_{om}) - \eta}{1+tc} \qquad 5.12$$

At the optimal point, the value of household time will be equalized to the wage rate only if there are no transaction or travelling costs in the labour market or rationing. The magnitude by which the value of household time is greater than payment in off-farm work depends on transportation and transaction costs involved or the cash constraint. Rationing in labour market causes a reduction in the value of time.

The optimal solution to a households labour allocation problem is conditional on the labour market participation strategy. Given the prevailing wage rate and household preferences, some households may prefer not to work off-farm in which case labour is allocated to the farm and leisure only. By definition, the optimal point for such households is where the shadow wage is equal to the marginal value of labour on the farm (Skoufias 1994). For households that sell labour off-farm, time is allocated to leisure, farm and off-farm activities in which case the optimal labour allocation is at the point where the marginal value of an extra unit of time on the farm is equal to the market wage rate and we have seen how frictions in the labour market or a liquidity constraint will affect this rule.

The solution to the households labour allocation problem (optimal demand and supply functions) is obtained by simultaneously solving the first order conditions. Although the solution in a non-separable model may not be tractable, the implications derived from it are testable (Sadoulet and De Janvry 1995).

The budget constraint for households which do not participate in labour markets is nonlinear due to strict concavity of the production technology. This means that we cannot use the traditional demand theory (Woldehanna 2000). This problem is circumvented by linearising the budget constraint (Jacoby 1993; Skoufias 1994; Woldehanna 2000) at the point of tangency with the households indifference curve so that households arrive at the same optimal choices. The slope of the linearised budget line is the shadow wage rate W^* and the shadow income of the household (V*) is a function of shadow profit:

$$\pi_F^*(W^*, W_h, A) \quad 5.13$$

Shadow income is therefore defined as:

$$V^* = \pi_F^*(W^*, W_h, A) + V \quad 5.14$$

where:

$$\pi_F^* = \Gamma(L_F; A) - W_h L_h - W^* L_f \quad 5.15$$

V is the income earned off-farm plus non-labour income which is mainly remittances.

So we now maximize the household problem:

$$\text{Max } U(C, L_l; z_u) \quad 5.16$$

Subject to the constraints:

$$C = X_m \quad 5.17$$

$$X_m + W^* L_l = V^* + W^* T \quad 5.18$$

$$L_l^* = T - L_s^* \quad 5.19$$

$$L_S^* = T - L_l^* = L_f^* + L_o^* \quad 5.20$$

Substituting the non-linear budget constraint with the linear one gives the following Lagrange function:

$$\begin{aligned} &U(X_m, (T - L_f - L_O); z_u) \\ &+ \tau\left[X_m + W^* L_l - V^* - W^* T\right] \end{aligned} \quad 5.21$$

The solution to this problem provides the structural equations for labour supply and demand as shown below:

$$L_S^* = l_s(W^*, V^*; Z) \text{ for labour supply} \quad 5.22$$

$$L_f^* = l_f(W^*, V^*; Z) \text{ for farm labour supply} \quad 5.23$$

$$L_F^* = l_F(W^*, V^*; Z) \text{ for farm labour demand} \quad 5.24$$

$$L_o^* = l_o(W^*, V^*; Z) \text{ for off-farm labour supply} \qquad 5.25$$

In the optimal labour supply and demand functions for non-participating households, the shadow wage replaces the market wage. For these households, labour allocation is a function of shadow wage, shadow income and household characteristics. The supply and demand functions derived in this framework differ from those derived using the market wage because W^* and V^* are endogenous i.e. they are jointly determined with labour supply. They depend on the constraints facing a household for example time and rationing in off-farm employment. Changes in exogenous factors which relax or tighten such constraints result in different levels of W^* and V^*. Moreover, the estimated marginal productivity of labour depends on the levels of labour applied which means that W^* and V^* are correlated with the error term which summarises the effects of unobserved variables.

Previous studies (Jacoby 1993; Abdulai and Regmi 2000), have used instrumental variables to control for simultaneity between labour supply shadow wage and shadow income. The shadow wage approach is applicable irrespective of whether a household has some of its members working off-the farm (Skoufias 1994). Under the assumption of utility maximization, the effective wage rate earned by family members working off the farm should equal their marginal productivity on the farm. When hired labour cannot perfectly substitute for family labour or households cannot sell labour due to high transaction costs, the labour demand and supply functions can be estimated by substituting the marginal product of labour applied on the farm for the corresponding shadow wage (Jacoby 1993; Skoufias 1994; Abdulai and Regmi 2000).

5.3 Returns to labour on and off-farm

5.3.1 Description of labour market

All households in the sample engage in farming as an economic activity and the family is the main source of labour. A few households however, do hiring-in labour from neighbouring[35] villages to supplement family labour. Employment opportunities available for farm households in the area of study have been categorised into 4 categories namely: self-

[35] Many households reported having hired labour from neighbouring villages due to what Mango calls social rules. It is easier for household to enforce contractual arrangements with hired workers when such workers are not close relatives or neighbours.

employment on own farm, self-employment or casual employment (for wages) off the farm or salaried employment. Table 5.1 shows both the household and individual participation in the various off-farm employment opportunities where off-farm employment refers to casual employment, salaried and self employment. Approximately eighty percent (80%) of the farm households have at least one member working off-farm. Over forty percent (43%) of the farm households have at least one member working in casual employment. The rest of the farm households have at least one member in salaried employment (31%) or self-employment (35%). The Table also shows that the most important source of employment outside ones own farm is casual employment which employs forty five percent of all persons working off-farm. Self employment is second in importance followed by salaried employment. The level of participation by household or individuals is slightly higher in Kakamega but not significantly different from that in Vihiga.

Table 5.1: Participation in off-farm employment (percentage of total)

Percentage of households with members working off-farm

	Casual wages	Salaried employment	Self-employed	Total off-farm
Kakamega	44	34	37	82
Vihiga	42	29	32	75
Total	43	31	35	79

Number and (percentage)of persons engaged in off-farm employment

	Casual wages	Salaried employment	Self-employed	Total off-farm
Kakamega	200 (45)	106 (24)	138 (31)	464 (100)
Vihiga	144 (44)	76 (23)	107 (33)	227 (100)
Total	344 (45)	182 (24)	245 (32)	771 (100)

Shown in Table 5.2 and 5.3 are the range of employment possibilities outside self employment in their own farm and their importance in terms of the number of persons employed. Opportunities in casual employment are available in both the agricultural and non-agricultural sectors, however, the agricultural sector provides the bulk of these opportunities (70% in Kakamega and 80% in Vihiga). It is also the single largest source of employment providing 33% of the total off-farm opportunities. Since there are no large commercial farms in the study area, casual employment in the agricultural sector is mainly available in neighbouring farms and villages. The other types of employment are available in local trading centres, major markets and towns.

Table 5.2: Range and importance (by number of persons employed) of off-farm activities in Kakamega and Vihiga Districts

Off-farm employment possibilities	Number of persons employed in self employment		Number of persons employed in casual employment	
	Kakamega	Vihiga	Kakamega	Vihiga
Casual labour in agriculture	-	-	140	116
Jua-Kali (fabrication & repair)	1	-	19	10
Posho mill	7	3	-	-
Carpentry	5	6	-	-
Tailoring	2	3	-	-
Local Brewing	14	1	-	-
Brick Making	2	1	1	-
Butchery	3	-	-	-
Pottery	3	4	4	-
Masonry	2	3	22	18
Photography	-	1	-	-
Sand mining	-	4	1	-
Traditional Doctor/chemist	1	1	-	-
Bird trapping	-	1	-	-
Watch/phone repair	3	-	-	-
Timber harvesting	1		4	2
Basketry	-	1	-	-
Bicycle repair	-	2	-	-
Cobbler	3	3	-	-
Ploughing		-	-	-
Barber	4	-	-	-
Transportation/boda-boda[a]	4	-	11	4
Trading agricultural goods	47	42	-	-
Trading non-agricultural goods	19	21	-	-
Trading animals		1	-	-
Selling clothes	2	1	-	-
Selling grass	1	-	-	-
Selling timber	1	-		-
Selling spare parts	1	-	-	-
Hotel/kiosk	1	2	-	-
Shop	11	8	-	-
Total	138	107	200	144

[a] bodaboda refers to provision of transportation services using bicycles

A whole range of businesses (self employment) offering a wide range of services are to be found in the area of study. The most common business is trade in agricultural goods followed by trade in non-agricultural goods. Other common businesses include shops, local brewing, posho mills and pottery. Masonry, jua kali (fabrication) and transportation businesses are the most frequently mentioned as employers of casual workers. Surprisingly, these are not the main self employment activities suggesting that opportunities for casual employment are mostly found outside the area of study and the self employment activities in the area are small businesses that employ one person or mainly employ family members. Shamba boy[36], guard

[36] Farm hand

and house-help, clerical work are the most common salaried employment. Others are in the medical and teaching profession.

Table 5.3: Range of salaried employment and number of persons employed in Kakamega and Vihiga

Type of salaried employment	Number of persons employed Kakamega	Number of persons employed Vihiga
Teacher	7	7
Nurse/community health	5	-
Doctor/clinical officer/pharmacist	9	2
Guard	13	13
Policeman	3	-
Driver	7	3
Tout	2	-
Clerk/cashier/administrator	12	5
Shamba boy/cowboy	21	8
House girl/boy	12	12
Preacher/catechist	2	5
Cook/waiter	6	5
Driller/plumber	2	-
Sales	1	-
Carpenter	1	5
Engineer	-	1
Mason	-	1
Tailoring	-	5
Messenger	2	1
Mechanic	1	2
Electrician	-	1
Total in salaried employment	106	76

Table 5.4 provides a comparison of mean wage rates in various labour employment opportunities which are broadly categorised into four namely: casual employment in agriculture and outside agriculture, self employment and salaried employment. N indicates the number of households participating and hence an indicator of the importance of each employment category in the area of study. During the short rain season, casual employment in agriculture emerges as the most important and casual employment outside agriculture emerges as the least important. Salaried and self employments are almost equally important. During the long rain season, self-employment is the most important. Apart from self-employment, the number of households participating in the other employments does not change.

The wage rate in casual employment is directly calculated as the mean of the wage received divided by the number of hours worked. The payment to labour in self employment is the marginal product of labour in self-employment which is estimated from a revenue function (see appendix 5.5). The wage rate equivalent for salaried employment is calculated as the total salary earned divided by the total number of hours in salaried employment. Hours in salaried employment are based on number of months in salaried employment while the hours in a month are calculated based on a 20 working days in a month and 8 hours in a day. Table 5.4 shows that there is a wide variation in payment to labour employed off the farm. In both seasons, the wage rate in casual employment in agriculture is much lower than the wage rates in other employment categories while payment to labour in salaried employment is the highest. The wage rate earned in casual employment outside agriculture is not very different from the marginal product of labour in self-employment, however, there is a larger spread in the returns to labour in self employment. The standard deviation shows the spread in returns to labour in the sample and the figures suggest wide variation within each employment except casual employment in agriculture. This variation is highest in self and salaried employment. Appendices 5.2 and 5.3 show the education level of persons of at least 15 years in the area of study, employed in the various categories of off-farm employment. Since the level of education[37] seems to determine the kind of employment secured off-farm, the high standard deviation suggests that although both skilled and unskilled workers work off-farm, they attract markedly different wages.

Table 5.4 Wage rate earned (KSh[b] per hour) in various off-farm labour markets

Wage rate	Short rain season			Long rain season		
	N[a]	Mean	S.D.	N[a]	Mean	S.D.
1. Casual employment in agriculture	114	5.4	3.6	113	7.0	2.0
2. Casual employment outside agriculture	43	18.4	16.0	46	17.0	9.5
3. Self employment	94	19.0	36.0	119	23.0	23.0
4. Salaried employment	96	30.0	29.0	97	28.0	26.0

[a] the sample size representing the number of households with members working in a particular labour market.

[b]1USD = 75 KSh

Exploration of the wage rates earned within casual work outside agriculture revealed that wage rates decrease with the number of hours worked but not the length of engagement (see Appendix 5.4).

5.3.2 Farm household efficiency in labour allocation

Our evaluation of household efficiency in labour allocation between farm and off-farm is based on the condition that a farm household will allocate its labour such that it is not possible to reallocate its labour without making the household worse off. This means that where there

[37] A test of the difference of means of the education level by employment showed that the education level of persons working for wages in the agriculture sector is lower than that of persons working for wages outside the agriculture sector.

are off-farm opportunities the household will allocate its labour between the two such that marginal payment to labour on and off-farm is equalised. When payment on-farm is lower than off-farm employment, this implies that no family labour will be allocated on-farm unless household invests in technology thereby raising payment to labour on-farm. Hired labour (which is less costly) can substitute for family labour then. In the case where labour is hired-in, the condition for efficiency is that the marginal product of labour on the farm must equal the market wage rate for hired labour.

Appendices 5.6 - 5.8 show the distribution of returns to labour on-farm, off-farm and the market wage rate for hired labour. The correlation between off farm wage and the marginal value product of labour was found to be positive but not significant. A significant correlation was expected because persons with high productivity on farm are likely to get high paying off-farm jobs. Moreover, proceeds from off-farm employment when ploughed back on-farm normally increase productivity of labour on-farm. Quartile plots of the gap between returns on-farm and off-farm (not shown here) show that: returns to labour on-farm are lower than returns off-farm for the first, second and part of the third quartiles and higher than returns off-farm for the fourth quartile; returns on-farm for the first three quartiles are lower than the market wage rate and greater than the market wage rate for the third quartile.

In Table 5.5, the means of returns to labour employed on-farm and off the farm are differentiated by farm household labour market participation strategy and season. The village wage rate for hired labour is also included for comparison. The number of households in each labour market participation strategy is given by N. The largest group comprises households which hire-out their labour but do not hire-in maybe because they may have relatively smaller farms compared with others. The other large group comprises farm households which hire-in and also hire-out labour. For these households, hired labour maybe substituting for family labour employed off-farm. The households which only hire-in labour are lowest in number indicating that this is not a common or popular practice. Farm households that neither sell nor buy labour are classified as self sufficient which means that household members are only employed on the farm and only use family labour on the farm.

The Table generally shows that there are large differences in returns to labour employed on and off the farm. Results of the tests show that returns to labour employed off-farm are much higher than returns to labour employed on the farm. This suggests inefficiency in labour allocation between the farm and off-farm. This maybe attributed to either one of the following: one, households are unable to sell as much labour as they wish due to lack of employment opportunities which leads to bottling up of labour on-farm. This has been alluded to in previous studies (Salasya 2005); two, the presence of a kind of selection effect where only skilled labour gets employment off-farm while unskilled labour remains on-farm. Thus the margin between farm and off-farm wage rate reflects the difference in earning potential of household members due to differentiation in skills or education level. The off-farm wage rate for farm households which are involved in both hiring-in and hiring-out labour is higher compared with that for households which only hire-out labour. For households hiring-in and hiring-out, hired labour with a wage rate w_h plus transaction costs substitutes for family labour working off-farm for a higher wage rate w_o minus transaction costs.

Table 5.5: Test of equality of the shadow wage to off-farm wage and wage for hired labour by households labour market participation strategy

		Payment to labour (KSh.[f] Per hour)		Ttest: Difference: Wmeanwageoff [c] – meanWMVPL[a] Difference: vwagea[e] – meanWMVPL[a] Ho: mean(diff) = 0		
				Pr(|T| > |t|)		
	N[b]	Mean	SD	Ha: mean(diff)<0	Ha: mean(diff)≠0	Ha: mean(diff)>0
Households hiring-in & hiring-out						
Off-farm wage rate	200	25.00	31.0	1.00	0.000	0.000
Shadow wage[a]	202	8.30	8.50			
Village wage for hired labour	202	9.50	1.80	0.97	0.04	0.02
Households hiring-out only						
Off-farm wage rate	274	16.40	16.60	1.00	0.000	0.000
Shadow wage[a]	281	10.10	11.00			
Village wage rate for hired labour	281	9.60	1.80	0.20	0.41	0.79
Households hiring-in only						
Shadow wage[a]	64	9.70	20.10			
Village wage rate for hired labour	64	9.50	1.70	0.47	0.94	0.53
Self sufficient households						
Shadow wage[a]	67	6.70	6.00			
Village wage rate for hired labour	67	9.70	1.70	0.99	0.000	0.000

[a] MVP of labour employed on-farm. It was calculated in Chapter 3 as the weighted mean of the marginal product of labour employed in the different plots.

[b] represents the number of households adopting a particular labour market participation strategy

[c] weighted mean wage rate received off-farm; [e] village average wage rate for hired labour

[f] 1USD = 75 KSh

Households participating in the labour market can be considered more productive because they have a shadow wage higher than that for households which do not participate in labour markets (self-sufficient in labour). Moreover, these households can be considered efficient in labour use on the farm because the shadow wage is not to be significantly different from the village wage rate for hired labour. However, for households which both hire-in and hire-out labour, the wage rate for hired labour is shown to be higher than the shadow wage (although on a lower confidence level). This suggests that such households may have some difficulty in getting the right balance of hired-in and hired-out labour probably due to frictions in the labour market.

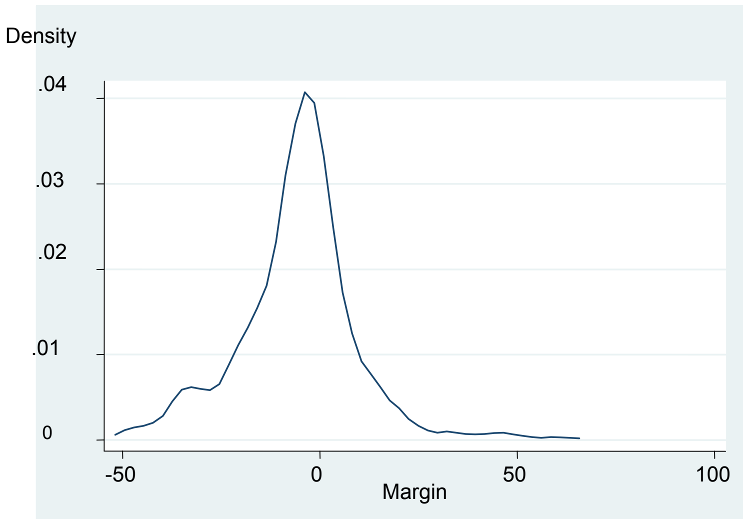
On the contrary, farm households which do not participate in labour markets (self-sufficient) have the lowest shadow wage and are inefficient because the difference between the prevailing wage rate for hired labour and the shadow wage is highly significant.

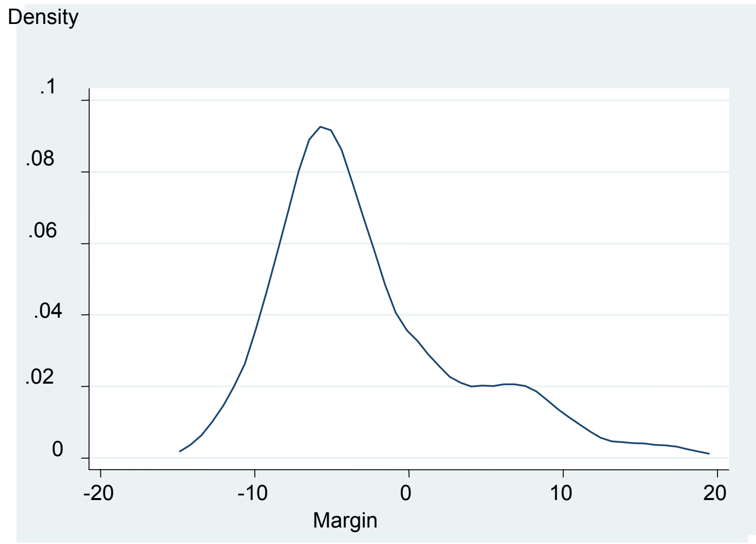
Since the characteristics of farm households in the study area differ (Salasya 2005; Tittonell, Vanlauwe et al. 2005a; Ojiem 2006), so do the constraints they face. We therefore expect labour allocation behaviour to vary, even between households with a similar labour market participation strategy. The deviation of wage rate received off-farm and wage rate paid to hired labour from the shadow wage amongst households is used to evaluate household specific allocative efficiency. The k-density plots in Figure 5.1 show the deviation of wage rate received off-farm and wage rate paid to hired labour from the shadow wage. The k-density plot in Figure 5.1a shows that for most households selling labour off-farm, the deviation of household shadow wage from the wage rate earned off-farm is close to zero. However, there are as many households with a shadow wage greater than off-farm wage rate as there are with shadow wage less than the off-farm wage rate. For farm households with a shadow wage lower than off-farm wage rate, this would mean that there is bottling up of labour in the farm may be due to lack of off-farm opportunities (Salasya 2005) or there is a selection effect. For farm households with a shadow wage higher than off-farm wage rate, one or more of the following conditions are true: farm households are faced with liquidity constraints, hired labour is not a perfect substitute for family labour, frictions in hiring-in labour. These results confirm that labour markets fail for individual households (Sadoulet and De Janvry 1995).

For farm households which hire-in labour, the k-density plot in Figure 5.1b show that for most farm households the shadow wage is lower than the wage rate for hired labour by a small margin of KSh. 5.00. However, there are as many households with a greater shadow wage than wage rate for hired labour as there are with a lower shadow wage. Where the shadow wage is higher than wage rate for hired labour it means that there are frictions in hiring-in labour. The only possible explanation for a shadow wage lower than the wage rate paid to hired labour is that in some households labour maybe fixed to the farm but not a good substitute for hired labour. Of course, the large variances suggest that it can also be attributed to measurement errors.

Farm households may fail to attain allocative efficiency when one or more of the following conditions prevail: market prices are different from effective prices due to transaction costs; hired labour is not a perfect substitute for family labour due to shirking, moral hazard and other frictions which inflate payment to hired labour; when there is rationing in the off-farm market such that households cannot supply as much labour as they would wish to; when there is lack of market information. The rest of this chapter is devoted to identifying the factors which influence farm household labour supply and demand and hence allocative efficiency of farm households in western Kenya.

Figure 5.1: K-density plots showing the distribution of deviations (margin) of shadow wage from; a) wage rate received off-farm; b) wage rate paid to hired labour




Density
.1
.08
.06
.04
.02
0
-20
-10
0
10
20
Margin

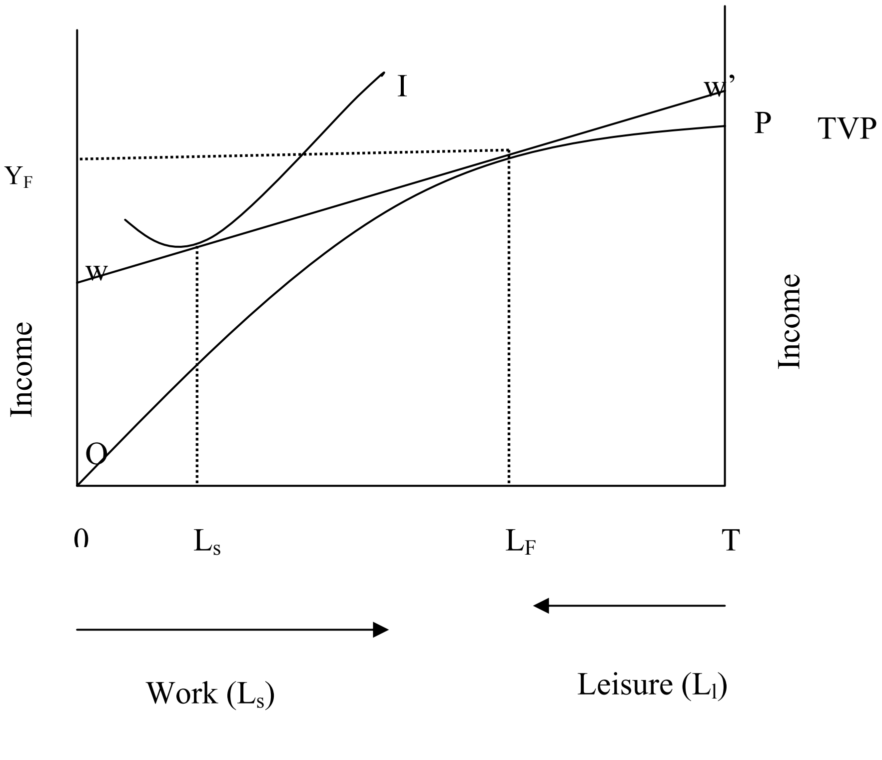
5.4 Considerations in analysis of farm household behaviour in labour use

Economic theory says that labour supply is a function of the wage rate, income and household characteristics. In our assumption of utility maximizing behaviour, the wages earned off-farm should be equalized to the marginal productivity of labour employed on the farm in environments where there is perfect substitutability between farm and off-farm. This would imply that the shadow wage approach is applicable to all cases irrespective of their labour market participation strategy. However, we are faced with a situation where households are not efficient in labour use on the farm and payments to labour on and off the farm differ markedly. Moreover, households may have more than one wage for labour employed off the farm. In this section we compare household behaviour in labour use under different market conditions, explore the situations under which multiple payments to household time may arise and discuss the implications on household behaviour. Lastly the estimation procedure is expounded.

5.4.1 Decision wage for family labour

We start by re-visiting the expected household behaviour in a situation of perfect labour markets as illustrated by Ellis (1993). In Figure 5.2 the production function is indicated by the curve OP. Household labour supply is shown on the x-axis where movement from the right to the left indicates reduction in labour supplied and an increase in consumption of leisure.

Figure 5.2: Decision wage for households hiring-in labour



At T there is no leisure consumed while at 0 the household consumes only leisure with no labour supplied. The Y-axis indicates the household income where TVP is the maximum revenue earned from farming. The line ww' is the income possibility line which is the wage rate. I is the households indifference curve showing the combination of consumption goods for which the household is indifferent. It can lie anywhere along the income line so its positioning depends on a households preferences. The optimal labour demand on the farm (L_F) is at the point where the wage rate denoted by the line ww' is tangent to the production function (P). Optimal labour supply (L_s) is determined by the households characteristics and is at the point where the indifference curve I is tangent to the wage rate. In the case depicted in Figure 5.2, the household labour supply L_s is less than labour demand L_F which implies that the households will hire-in labour to meet the demand. Labour is hired-in at the wage ww' which is the marginal product of labour on the farm.

Figure 5.3: Decision wage for households hiring-out labour

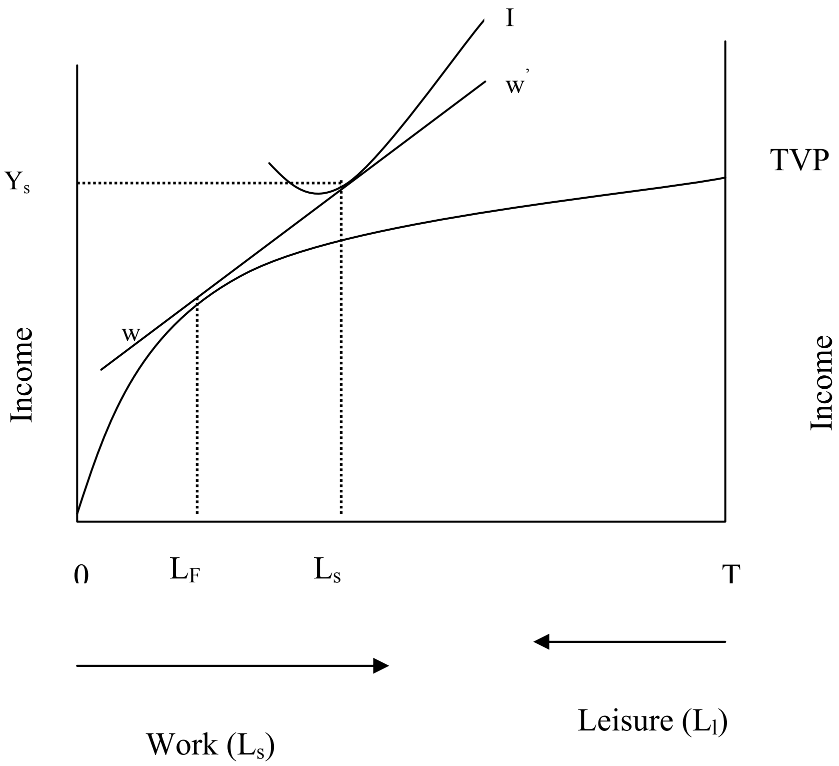


Figure 5.3 depicts a household whose preferences are such that the optimal labour supply is more than the optimal labour demand on the farm. In this case the household sells its excess labour off the farm. Figure 5.3 suggests that farm and off-farm labour are perfectly substitutable so that the household sells its surplus labour at the wage rate ww' which is equal to the marginal product of labour on the farm.

In Kakamega and Vihiga districts, the wage earned off-farm is higher than the payment to labour on the farm (see Table 5.4). Figure 5.4 depicts a stylised situation of a farm household where some members have an off-farm wage w^1w' higher than its shadow wage ww'. In this situation the household income is higher which means that less labour is likely to be supplied (L_{s1}) than when a lower wage ww' is the decision wage. Labour allocation decisions in this situation are based on both the shadow wage and the wage received off-farm.

When the payment to household labour off-farm is such that the amount of labour the household is willing to supply is less than that required on the farm (L_F), we expect the households to hire-in labour to compensate for the shortfall. Table 5.4 showed that labour is hired-in at a lower wage rate than the wage rate earned off-farm.

Figure 5.4: Decision wage for households hiring-out labour at a higher wage rate

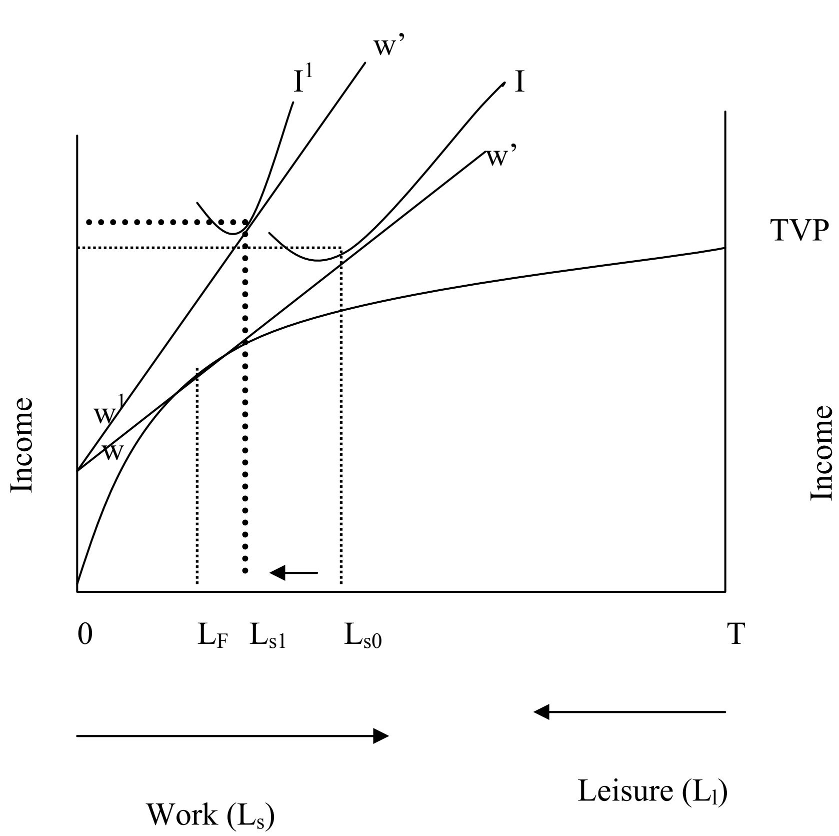
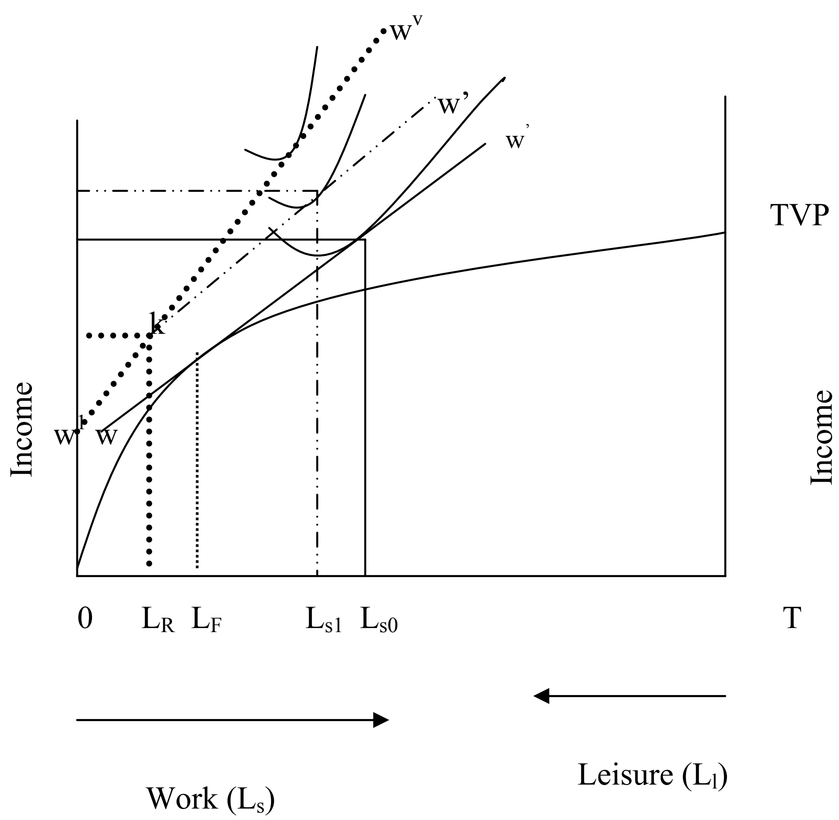


Figure 5.5 shows the case when a household is rationed in off-farm labour supply. The stylised Figure depicts a household that is restricted in the amount of labour which it can supply i.e. it cannot supply as much labour as it would like to in the off-farm market. The line at the wage rate w^1w^v represents the virtual income that the household

could earn when supply is unrestricted. When labour supply is restricted at L_R, the actual income possibility line (wage rate) is w^1kw' and is lower than the virtual income possibility line when the household is not rationed. It is therefore clear that the position of the income possibility line depends on the constraint in off-farm employment and is expected to differ between households. This suggests that such a household is forced to supply more labour L_{s1} and at a wage rate lower than it would without rationing. The actual wage rate and amount of labour supplied depends on the magnitude of the constraint in off-farm employment. It is however bounded from above by the virtual wage rate and from below by the shadow wage.

Figure 5.5: Decision wage for households whose off-farm labour supply is rationed



Which shadow wage?

Estimates of the shadow wage could be obtained either from the marginal product of labour in agricultural production or from the marginal product of labour in home production . In this study the indicator of the shadow wage is the productivity of labour on the farm. Chapter 3 of this thesis provides details of how plot level estimates of farm labour productivity were obtained. Plot level estimates of the marginal product are preferred because they minimize the concern for omitted relevant variables bias that is endemic to many estimates of production functions . It is a common practice in the study area for the different plots to be planted with different crops.

Under the assumption of profit maximization, households' optimal allocation of labour is at the point where the marginal product of labour is equalised between the different plots. The results of Chapter 3 however showed that farm households do not equalise labour productivity between the plots[38]. We are therefore confronted with a situation where we have two to three different marginal productivities of labour for a single household. Udry (1996) attributes this to intra-farm non-cooperative allocation of labour while Barrett, Sherlund et al. (2005) attribute this inequality to inefficiency which he attributes to variable qualities of labour applied on the different plots as a result of exogenous shocks like prices. In our case difference in MVP_L may be due to the relative prices for the different crops planted and/or the imperfections in the output markets.

For estimation of supply and demand functions we need a single indicator of the households shadow wage yet we have more than one for each household. In this case a choice has to be made regarding which marginal product best indicates a household's shadow wage? The first impulse is to take the household mean MVP_L as the indicator for farm level labour productivity. However, in an environment with several market imperfections, it is also possible that the better indicator of the constraints facing each farm household is the maximum and not the average marginal product. In absence of a theoretical rationale on which to base our choice of MVPL in estimation of labour supply it may be interesting to compare estimations using both the maximum and the mean marginal value products of labour. In this study however, the household mean weighted by the number of hours spent in each crop/plot is used as the shadow wage.

Which off-farm wage?

Households that participate in off-farm activities may have their members engaging in one or more of the employment options available in off-farm. The various options available to farm households in the area of study have been classified into casual wage employment in agriculture, casual wage employment outside agriculture, self-employment or salaried employment. We saw in Table 5.4 that payment to labour (w) varies between the various employment options. The wage earned off-farm may vary[39] within a household if household

[38] note: the crop specific estimates of the marginal value product were weighted with total labour used.

[39] This variation occurs where skills cannot be freely acquired due to differentiation between households in terms of wealth or external linkages or where there is differentiation in the relative position of members within

members engage in different off-farm activities. Where household members engage in only one of the off-farm options, the labour allocation decision is based on the marginal product of labour on the farm and the payment to labour off-farm. Where household members engage in diverse off-farm activities, then we have a situation where a household has more than one off-farm wage. This is in agreement with Low (1990). The economic theory however does not provide us with suggestions on which wage could be the decision wage in this case i.e. is it the mean or maximum? Like Low (1990) this study recognizes that each household member has two wage rates i.e. the shadow wage which reflects returns to labour employed on the farm and the potential wage rate which could be earned off-farm. He suggests that labour allocation is a process where by persons are allocated to the activity where they have a comparative advantage in terms of potential earnings. We are however constrained in using his method because of labour market imperfections. For example, is the potential wage rate of a skilled member working on the farm zero if he or she cannot get employment off-farm due to rationing or lack of opportunities? This makes it difficult apriori to allocate a potential off-farm wage rate to members who do not work off-farm. In this study we use the households average wage calculated as the mean wage weighted by the time spent in each activity in as the decision wage.

5.5 Econometric estimation

A two stage estimation procedure is adopted. In the first stage, plot level production functions are estimated and the shadow wages calculated using the estimated labour elasticities. In the second stage labour supply and demand functions are estimated. Estimation of the supply and demand equations was performed in two steps. Because the shadow wage (W*) and shadow income (V*) are determined together with labour supply, household labour supply was estimated as a function of instrumented shadow income (V*) and shadow wages (W*).

The first step was therefore to regress the shadow wage against a set of instrumental variables. Variables that describe the household size and composition, characteristics of individuals in the household (age, age squared, education, married), household assets (value of buildings, consumer durables, land, farm implements, financial assets, livestock owned),

households on the basis of age, gender or disability. If household wealth is determined by its position in its life cycle, then it is possible that persons of different age groups within a household have different skills.

location specific variables such as remoteness or average rainfall are all potential instrumental variables. The shadow wage and shadow income were regressed against all exogenous variables in the system. These include; individual characteristics (education level, age, gender of household head), household characteristics (family size, composition of household, farm size, type of housing and value of assets), and location characteristics (division, distance to major market, tarmac and motorable road).

Since individual, household characteristics and location characteristics are in the Z vector in the labour supply and demand functions, the identifying instruments are the value of type of building materials, initial cost of building, value of capital assets and sub-location dummies. In the second step, the predicted shadow wage and predicted shadow income are included as regressors in the supply and demand functions. The t-ratios are based on White's standard errors which account for the heteroskedasticity that is induced by this two-step procedure (Skoufias 1994).

From the theoretical model we saw that the shadow income is the full income augmented with restricted farm profits plus non-labour income. The restricted farm profit is calculated as crop value less expenditures on hired labour, fertilizers and value of family labour. Full income is the value of the households labour endowment where labour endowment is the total time available for work. Total time was calculated as the time for all adults between the age of 14 - 65 years minus the time spent away from home plus free time (school holidays) for household members attending school.

The value time depends on employment options available to the household. For households which do not sell labour, household time was valued at the shadow wage which is the mean marginal product of labour weighted by the time spent on each crop/plot. For the households with members working off-farm, household time was valued at the mean of off-farm wage rate weighted by the hours spent in each employment.

Based on the arguments in the preceding sections the behaviour of households is expected to depend on the decision wage. However, the shadow wage alone or the market wage alone may not explain labour allocation behaviour of a household with imperfect substitutability between farm and off-farm, between family and hired labour. Moreover, a single wage rate can also not explain behaviour of a household faced with more than one wage rate. In this regard estimating the households total labour supply function cannot yield useful information because the results would reflect the average household response to an average wage rate.

More insight into farm household labour allocation behaviour will be gained by exploiting the heterogeneity observed in employment of labour within a household. We estimated a farm labour supply function, off-farm labour supply function and hired labour demand function. It is expected that behaviour of farm households depends on their labour market participation strategy. Two farm labour supply functions were estimated, one for all households in the sample and the other for households supplying labour off-farm. Only the shadow wage is included in the supply function for all households while both the shadow wage and the off-farm wage rate are included in the farm labour supply function for households selling labour off-farm. The same approach is adopted in estimation of demand functions for hired labour. The wage rate for hired labour and the shadow wage were included in the demand functions for all households hiring-in labour whilst the shadow wage, the wage rate for hired labour and off-farm wage rate were included in demand functions for households hiring-in and also hiring-out labour. For off-farm labour supply, the shadow wage and the off-farm market wage are included in the function.

5.6 Determinants of household behaviour in labour use

5.6.1 Factors influencing labour supply

The simple Cobb-Douglas functional form is adopted to explain labour supply. The functions are estimated in their log-linear form which is specified as follows.

$$\log L_{ji} = \alpha_j + \beta_{1j} \log w^*{}_{1i} + \beta_{2j} \log w^*{}_{2i} + \gamma_j \log V_i^* + \varphi_j Z_i + \varepsilon_{ji}\,, \qquad 5.26$$

where:

The dependent variable L is the number of hours supplied per day[40] differentiated by season t, j represents the activity (1 = farm work and 2 = off-farm work) and i is the household. The regressands are the instrumented shadow wage (w_1*), shadow income (V*), off-farm wage ($w*_2$) and Z, a vector of individual, household and farm characteristics which influence labour supply while α is the constant, *β, γ* and φ are the parameters to be estimated. ε_i is the error

[40] The total number of hours supplied per day was obtained by dividing the total hours supplied by the total number of working days in a season. Total hours supplied was calculated as the sum of total hours in salaried employment, total hours in self employment, total hours in wage employment in agriculture, total hours in wage employment outside agriculture, and total hors in crop production. The total number of working days in a season was obtained by assuming there are 24 working days in a month and one season has six months. Hours supplied to the farm are given by hours in crop production whilst hours supplied off-farm is the total labour supplied less labour on the farm.

term which summarises all unobservable variables influencing labour supply. A selectivity correction term is included in the off-farm supply function for households selling their labour.

Table 5.6: Description, means and standard deviation of variables included in estimation

Variable	Mean	Std. Dev.
Total labour on crop production (hr)	369	306
Family time on crop production (hr)	276	245
Family time in crop production in SR (hr per day)	1.8	1.6
Family time in crop production in LR (hr per day)	2.0	1.8
Hired labour on crop production (hr)	205	225
Total time in off-farm (hr)	1163	1028
Family time in off-farm in SR (hr per day)	8.7	7.7
Family time in off-farm in LR (hr per day)	7.5	6.4
Time in casual employment in agriculture (hr)	512	546
Time in casual employment outside agriculture (hr)	742	611
Time in self employment (hr)	887	895
Time in salaried employment (hr)	972	634
Mean MVP_L (KSh)	6.34	2.79
Maximum MVP_L (KSh)	22.34	5.67
Shadow Income (KSh)	22,491	13,792
Farm Size (ha)	0.7	1.36
Total Livestock Units	0.79	0.59
Value of capital assets (KSh)	60,776	184,549
Value of farm equipment (KSh)	1,111	1,455
Distance to a motorable road (km)	0.35	0.45
Distance to the nearest major market (km)	3.48	2.37
Dummy for gender of household head: 0 = female, 1= male	0.86	0.35
Dummy for head with no education	0.16	0.37
Dummy for head with primary level not finished	0.33	0.47
Dummy for head with primary level finished	0.27	0.44
Dummy for head with secondary level and above		
Family size	6.30	2.76
Number of household members under 6 yrs	0.96	1.01
Number of household members between 6 and 14 yrs	1.55	1.40
Number of household members between 15 and 20 yrs	1.03	1.12
Number of household members between 21 and 54 yrs	2.16	1.35
Number of household members between 55 and 65 yrs	0.35	0.57
Number of household members over 65 yrs	0.24	0.50
Initial cost of house (KSh)	32,096	122,908
Materials used for building wall[a]	1.15	0.53
Materials used for building floor[a]	1.92	0.51
Materials used for building roof[a]	2.72	0.60
Dummy for location: 0 = Vihiga, 1 = Kakamega	0.52	0.50
Categorical variable for season: 1= SR, 2 = LR	1.50	0.50

[a] Building Material Code for walls: 1=mud wall; 2=mud wall plastered with cement; 3=brick wall; 4=stone wall;
[b] Building Material Code for floor: 1=earth floor; 2=earth floor plastered with cow dung; 3 = floor plastered with cement
[c] Building Material Code for roof: 1=grass thatched; 2=used iron sheets; 3=new iron sheets
1USD = 75 KSh

Table 5.6 gives a descriptive summary of the variables included in estimation. The statistics show that on average, the demand for labour is equivalent to just two months in a season (6 months). On average, the family spends an equivalent of only 1.5 months in crop production in a season which is about 24% of the time it spends on off-farm work. The statistics show that the demand for hired labour is the equivalent of just one month for households hiring-in labour. The time spent off-farm is quite substantial for households that hire-out their labour.

On average the farm households spend an equivalent of 3, 4, 5 and 6 months in a season in casual employment in agriculture, casual outside agriculture, self-employment and salaried employment respectively. The amount of time spent in each activity is indicative of the availability of employment or the nature of the employment. For example, casual wage employment in agriculture is not available through out the season but is available only during peak periods. On the other hand, salaried employment provides a steady employment through out the season. The large standard deviation suggests a large variation between households in the time spent on and off-farm the farm. The average farm size is 0.7 ha supporting a family of 6.3 persons. The low value of farm equipment is illustrative of the low level of capital investment in smallholder agricultural production. The average distance to a motor-able road is about 400 m whilst the average distance from a major market is 3.5 km. Transportation is unreliable and when available is costly, for this reasons most people prefer to walk to the market place.

An increase in the shadow wage has two effects namely, the income and substitution effects. The shadow income will decrease as increased costs of family labour erode the shadow profits (see equation 5.16). The income effect is therefore positive as households with lower income labour supply more labour to the farm. As the family labour becomes more expensive, the household substitutes hired labour for family labour. The substitution effect on farm labour supply is therefore negative. The overall effect of a higher shadow wage on farm labour supply is therefore ambiguous because it depends on the relative strength of the two effects. The income and substitution effect of an increase in shadow wage on off-farm labour supply is unambiguously positive.

The expected effect of a higher off-farm wage on labour supply off-farm is ambiguous due to the opposing forces; i.e. a positive substitution effect and a negative income effect. Households supply more labour as payment increases but the effect of an increased income from higher wages is negative i.e. households will consume more leisure. The effect of a higher off-farm wage on farm labour supply is negative firstly because the higher income means more leisure is consumed and also because increased labour supply off-farm means that less labour is available for farm work. The effect of a higher income is expected to be negative i.e. less labour supplied on and off the farm as households consume more leisure[41].

The cropped area and the labour capacity are important determinants of labour supply both on and off-farm. The farm size is included as the indicator of the cropped area and the larger the farm size the heavier the labour demand. The effect of farm size on family labour is therefore expected to be positive, since farm work is predominantly carried out by family labour. The effect on labour supply off-farm is negative (Kanwar 1998). The labour capacity is captured by the family size and the household composition. Labour supply both on and off the farm is expected to increase as the needs (family size) increase. The positive effect on supply off-farm is further reinforced by the small farm size. When the family farm is too small to employ all the family labour we expect more labour to be supplied off-farm. We decompose the labour force into six age groups describing the household demography. The first group captures the number of infants who do not provide any labour, the second the number of children aged 6 – 14 years who are normally in school, the third the young adults aged between 15 – 20 who may be in school or have dropped out, the fourth adults of the age 21 – 54, the fifth retired adults of age between 55 - 65 years and the sixth the number of senior citizens (over 65 years). Households with a larger number of prime age adults are expected to supply more labour both on and off the farm compared with households with more dependants (infants or senior citizens). The young adults may supply more labour off the farm whilst seniors may only work on the farm.

Individual characteristics like the education level and age of the household head are also important determinants of household labour supply. Education level of the household head is an important determinant of off-farm employment as it captures a household's endowment with skills to increase farm productivity on the farm and skills for off-farm employment. Education also shapes a household's attitude towards wage employment (Kanwar 1998). Households are placed into four groups (no education, primary unfinished, primary level finished and secondary level finished) based on the highest education level attained by the head. The effect of education level is ambiguous. It may increase supply off-farm if off-farm jobs available require skills or if farm employment is considered to be

[41] Leisure is considered to be a normal good. While many studies show that leisure is a normal good this may not always be the case for example where there are market imperfections. In environments where credit and insurance markets are absent or have failed, households can purchase desired market goods only when they have higher incomes. Moreover, where there is rationing, households with low incomes may be observed to supply less labour only because off-farm opportunities are lacking.

inferior to off-farm. The age of head of household and a household's life cycle are also expected to influence labour supply decisions.

The location of the farm determines the opportunities available and the frictions in the labour market and hence is an important determinant of off-farm labour supply. The variables included to capture this effect are the sub-location[42] dummies and the distance from major markets. These variables capture the local economic conditions that determine differences in off-farm employment opportunities and hiring frictions. The district dummy captures differences in agricultural productivity between Kakamega and Vihiga districts.

Factors influencing farm labour supply

As stated earlier, we estimated two functions for farm labour supply. Table 5.7 summarises the results of the estimates of farm labour supply function for all households in the sample and the estimates of farm labour supply by households that sold labour off-farm. The results show that farm labour supply is mainly influenced by the shadow income, the family size and composition, the location, farm size and season. The shadow income elasticity is -0.74 for all households which means that an increase in the shadow income by 1% induces a 0.74% reduction in labour supply. This implies that leisure is a normal good. An increase in the family size by 1% induces an increase in labour supply by 0.38%. An increase in the number of prime age adults in a household induces an increase in labour supply. Increasing adults of the age between 55-65 years by one induces the highest increase in farm labour supply (28%) whilst increasing adults of the age between 21-54 years by one induces a 15% increase in farm labour supply. An increase in adults of between 15-20 years only leads to a 9% increase in farm labour supply. The differences in supply response between the age groups reflects the relative availability of the different age groups for farm work where persons of the age 55-65 are at home having retired from off-farm activities and persons of the age 15-20 are still in school. Where the change in household composition leads to changes in the family size, the effect of an increase in the prime age adult includes also the effect through a larger household size.

The differences in sign and significance of some dummy coefficients for sub-location indicate variations in supply based on location. A larger farm size and change in season (from the short rain season to the long rain season) induced increased supply indicating that households are able to respond to changes in farm labour demand. Households supply is up to

[42] The sub-location is the second to last administration level. The lowest is the village. It comprises of several villages.

50% more labour in the long rain season compared with the short rain season which confirms that the short rain season is indeed a slack season.

Table 5.7: Factors influencing farm labour supply

	Farm Labour All Households	*Farm Labour Hholds that hired out labour*
Dependent variable is log of hours per day		
Log of shadow wage	-0.20	-0.48
Log of wage rate off-farm (hhold mean)		-0.08
Log of shadow income	-0.74***	-0.80**
Dummy for head with no education	-0.26	-0.51*
Dummy for primary level not finished	-0.20	-0.33
Dummy for primary level finished	-0.23	-0.41**
Log of age of household head	4.52	-5.02
Log of age of household head squared	-0.61	0.75
Dummy for gender of head: 0 = female, 1 = male	-0.02	0.08
Log of family size	0.38***	0.30
Number of households members over 65 yrs	0.08	-0.08
Number of households members between (55- 65)	0.28**	0.26*
Number of households members between 21-54 yrs	0.15***	0.11
Number of households members between 15-20 yrs	0.09*	0.09
Dummy for sub-location 1		-0.06
Dummy for sub-location 2	-0.19	-0.14
Dummy for sub-location 3	-0.10	-0.07
Dummy for sub-location 4	0.14	
Dummy for sub-location 5	-0.25*	-0.21
Dummy for sub-location 6	0.41***	0.46**
Dummy for location: 0 = Vihiga, 1 = Kakamega	-0.30	-0.18
Log of farm size	0.38***	0.30**
Log of distance to major market	-0.05	0.08
Categorical variable for season: 1 = SR, 2= LR	0.50***	0.62***
IMRworkoff		-3.20
Constant	-2.35	16.51
N	488	375
F	6.78	6.36
Adj. R^2	0.25	0.30

legend: * P<.1, ** P<.05, *** P<.01

Although not significant, households with a head having less than secondary level education supply less labour on the farm. This may be due to the fact that these households may be engaged in activities that are more labour demanding.

These results are compared with those of households which sell labour off-farm. The most notable difference is that family size does not influence labour supply for households that sell labour. Moreover, an increase in adults in a household does not induce a significant increase in supply except when the increase is in the number of adults between 55-65 years which is understandable given that these are senior adults who may not have other employment options in the area of study. As expected the shadow income elasticity is higher for households which sell labour off-farm probably because they earn more wage income. A

1% increase in the shadow income induces a higher (0.80%) reduction in labour supply. The reduction in labour supply due to a higher shadow wage is higher by 0.28% because the income effect is higher for these households which sell their labour. It also suggests that households which do not sell labour off-farm are constrained in their response.

The poor response to off-farm wage rate may be because the households respond to either the maximum wage or the wage paid in the most reliable off-farm job. According to Low (1989), household labour allocation is determined through a process where costs of production, cost of purchase and potential wage rates off-farm are compared. Labour is then allocated where it has the greatest comparative advantage.

We find that some factors like season, farm size influencing supply have the same direction of influence but a different magnitude. The larger season coefficient (0.62) suggests that households that sell labour off-farm are better able to respond to changes in labour demand on the farm whereas the smaller coefficient (0.30) for farm size suggests that given the small farm sizes in the study area, households selling labour off-farm are able to achieve higher farm to worker ratios. The effect of education level is greater and significant which means that households that sell labour off the farm supply less labour on the farm. The difference in education level coefficients between the two supply functions gives the reduction in supply due to labour supply off-farm.

Factors influencing off-farm labour supply

In this section we estimate the farm household labour supply function for off-farm labour. Off-farm labour includes labour engaged in casual wage employment, self employment[43] and salaried employment. Zero observation[44] for hours of labour supplied off-labour destroys the assumption of a linear budget constraint (Jacoby 1993; Skoufias 1994; Woldehanna 2000). Moreover the problem of truncation renders ordinary least squares (OLS) estimates inconsistent due to the potential problem of selectivity. We solve for the two problems by following Heckman's two stage approach where we include a correction term (inverse mills ratio (IMR)) in the OLS estimates for labour supply while restricting the sample to the households that sell labour. The IMR is calculated from the first-stage probit equation in which the decision to participate as a seller in the labour market is made.

[43] Includes petty trade which household members engage in after working on the farm
[44] Not all households sell labour off-farm

Participation in off-farm employment

The factors influencing farm household participation in the labour market are not expected to differ from those influencing labour supply. We have however included the wealth status which is expected to influence a household's labour supply and non-labour income which influences households liquidity status and hence the decision to participate. The sub-location dummies were left out in the decision to participate, however, the distance from a major market was included as the indicator of location.

The results in Table 5.8 show that the decision to participate in off-farm employment is mainly determined by the stage in the life cycle of a household, the family size and the location of the farm. The older the head of the household, the greater is the probability that the household will sell its labour off-farm. This increase is however curtailed at older ages probably as the probability of securing off-farm employment declines. Households with larger family sizes are more likely to sell labour off-farm whilst greater distance from a major market leads to a lower probability that a household will sell labour off-farm. Households in Kakamega are more likely to sell labour off-farm compared with households in Vihiga. Surprisingly, the education level of the head of household does not influence the decision to sell labour off-farm probably due to rationing in off-farm employment. The difference in likelihood of participation between the two seasons is not significantly different.

Off-farm labour supply

The supply of labour off-farm is mainly determined by the education level of the household head, the family size and composition and the sub-location (Table 5.8). The coefficients for the shadow wage, the wage rate off-farm and the shadow income have the expected sign i.e. a positive response to an increase in both the shadow wage and the off-farm wage rate and a negative response to increased income (although not significant). Supply of labour off-farm is higher for households whose education level is lower than secondary level education and is highest (87% more than households whose head has at least tertiary level education) when the household head has no formal education. A 1% increase in family size induces an increase of 0.6% in labour supply off-farm.

Table 5.8: Factors influencing off-farm labour supply

	Decision to Supply Labour	*Off-farm Labour Supply*
Dependent Variable in log of hours per day		
Non-labour income	0.03	
Categorical variable for wealth group	-0.05	
Log predicted shadow wage		0.62
Log of wage rate off-farm (hhold mean)		0.58
Log predicted augmented full income		-0.03
Dummy for head with no education	0.39	0.87***
Dummy for primary level not finished	-0.03	0.43*
Dummy for primary level finished	0.24	0.51***
Log of age of household head	9.9*	0.54
Log of age of household head squared	-1.41*	-0.22
Dummy for gender of head: 0 = female, 1 = male	0.21	-0.32
Log of family size	0.40**	0.59**
Number of households members over 65 yrs	0.27	-0.34
Number of households members between (55- 65)	0.07	-0.05
Number of households members between 21-54 yrs	0.02	0.25***
Number of households members between 15-20 yrs	0.03	0.15**
Number of household members between 6-14 yrs	-0.00	
Dummy for sub-location 2		0.30*
Dummy for sub-location 3		0.42
Dummy for sub-location 4		0.07
Dummy for sub-location 5		0.15
Dummy for sub-location 6		-0.06
Dummy for location: 0 = Vihiga, 1 = Kakamega	0.28*	-0.43
Log of farm size	-0.04	0.11
Log of distance to major market	-0.39***	-0.14
Categorical variable for season: 1 = SR, 2= LR	0.13	-0.24
IMR		10.51***
Constant	-15.99	-4.40
N	586	369
F	90	3.43
Adj. R^2	0.15	0.19

legend: * P<.1, ** P<.05, *** P<.01

Households with more adults supply more labour than households with more dependants (children or senior adults). An increase in the number of prime age adults i.e. between 15 to 54 years induces an increase in labour supply. The older the adults the larger the response i.e. supply increases by 0.25% when the increase is of adults between 21-54 years and 0.15% when the increase is in the number of adults of the age 15-20 years. This finding reinforces the argument that farm sizes in the area of study may be too small to fully employ a large labour capacity.

Although households in Kakamega district are more likely to participate in off-farm employment, they supply less labour (0.43%) compared with households in Vihiga District. The positive and negative coefficients for the sub-location dummy variables suggest differences in employment opportunities and/or frictions in the labour market. These findings emphasise the effect of differences in off-farm opportunities and farm sizes between the districts and the sub-locations. An increase in the distance from a major market induces a decline in labour supply (not significant). The influence of remoteness however has a stronger influence on the decision to participate than on labour supply. The coefficients of the season suggest that although households are more likely to sell labour during the long rain season, the amount of labour supplied is less than that supplied during the short rain season.

5.6.2 Factors influencing demand for hired labour

Crop production in western Kenya is typically carried out by members of the household. However, forty four percent (44%) of the households hire-in labour. According to the statistics in Table 5.6 the hours of hired labour are equivalent to one (1) month in a cropping season. The simple Cobb-Douglas functional form is adopted to explain demand for hired labour. The functions are estimated in their log-linear form and are specified as follows.

$$\log L_{it} = \alpha + \beta_1 \log w^*{}_{1i} + \beta_2 \log w^*{}_{2i} + \beta_3 \log w_{3i} + \gamma \log V_i^* + \varphi Z_i + \varepsilon_i, \qquad 5.27$$

where:

The dependent variable L_{it} is the total hours of hired labour differentiated by season. Predicted shadow wage (w_1*), predicted off-farm wage (w_2^*), village level wage rate for hired labour (w_3), predicted shadow income (V*), and Z a vector of individual, household and farm characteristics hypothesised to influence demand for hired labour are the regressands. *i* is the household, *t* represents the season, alpha is the constant, β_1, β_2, β_3, γ and φ are the parameters to be estimated and ε_i is the error term which summarises all unobservable variables influencing demand. In Table 5.6, a descriptive summary of the variables included in estimation of the labour supply functions is given.

Labour is normally hired-in during the peak periods normally at planting, weeding and harvesting stages. The optimal demand for hired labour is expected to be influenced by the market wage rate, household income and demand factors like rainfall, farm size and the season. The cost of hiring-in labour is proxied by market wage rate since we do not have quantitative information regarding other costs associated with hiring of labour. An increase in the market wage makes hired labour more expensive, hence a negative response is expected.

In markets where there is perfect substitutability between family and hired labour and between farm and off-farm the wage rate would be equalised. However, the realities in the area of study lead us to suspect that there are frictions in hiring-in of labour and rationing in the off-farm labour market. We therefore include the shadow wage to represent payment to labour on the farm. The coefficient for the shadow wage measures the substitutability between hired and family labour where a positive coefficient implies hired labour substitutes family labour whereas a negative coefficient suggests that hired labour does not substitute for family labour. Demand for hired labour is expected to increase as the shadow wage increases i.e. as family time becomes more expensive. In the same vein, imperfect substitutability between farm and off-farm work lead us to expect demand for hired labour to be influenced not only by the cost of hiring labour but also payment to family labour off-farm for households that participate as sellers and buyers in the labour market. The coefficient for off-farm wage measures the substitutability of hired labour for family labour working off-farm and is expected to be positive.

The influence of the shadow income is expected to be positive i.e. as the household income increases, households are expected to consume more leisure and hence supply less labour which increases their demand for hired labour.

The influence of household characteristics like family size and composition is expected to differ between households. Demand for hired labour is expected to be lower for households with larger family size and for households with a larger number of prime age adults. However, participation in the off-farm labour market is expected to influence this response. For example, family size and composition are not expected to influence demand for labour in households that are not rationed in off-farm employment.

Demand for hired labour is expected to be influenced by education because it determines the probability of securing off-farm employment and it also influences the wage earned off-farm. The effect of education level is an empirical question because it depends on the type of off-farm opportunities available in the area of study. Farm characteristics like size, season and location are obvious demand factors.

Decision to hire-in labour

The fact that the sub-sample of households that hire-in labour is not randomly drawn leads us to suspect selection bias. This bias will arise because the probability that a household hires labour is itself dependent on the demand for hired labour. We estimate demand for hired labour using Heckman's two stage approach where a selectivity correction term (IMRhire) is included in the OLS estimations while restricting the sample to households that hired labour. The IMRhire is calculated from first stage probit estimates for the household decision to hire-in labour.

Results in Table 5.9 show that households in Kakamega are more likely to hire-in labour compared with households in Vihiga district. Probability to hire-in increases with the farm size, wealth, livestock owned, distance from a major market and non-labour income. It is lower in households with a larger number of prime age adults.

Demand for hired labour

Two demand functions were estimated, the first one includes all households that hire-in labour and the second is restricted to households that sell labour off-farm. A selectivity correction term for hiring-in is included in the demand function for all households that hire-in labour. For households that hire-in and hire-out labour we included two selectivity terms where the first one corrects for hiring-in while the second corrects for the bias in hiring-out labour (Table 5.9).

The large coefficients for age and age squared suggest that demand for hired labour is mainly determined by the life cycle of a family. Demand also increases with shadow income which is in line with households consuming more leisure as income increases. It increases with farm size and contrary to our expectation demand for hired labour is higher in households where the head has no education.

The poor response to the wage rate for casual labour suggests two things: 1) lack of variation in the village wage rate; and 2) the wage rate used (monetary payment) does not reflect the actual cost of hired labour i.e. households consider other costs not reflected in the monetary payment e.g. supervision and in kind payments like food. The negative sign for shadow wage suggests that hired labour does not substitute for family labour working on the farm.

For households that hire and sell labour the greatest influence is the age of head and the stage in a family life cycle. Demand is higher in the long rain season compared with the short rain season. This coefficient is larger and significant compared with the coefficient in the first estimate suggesting that these households are better able to respond to changes in labour demand. The coefficients for family size and composition have the expected signs i.e. a large labour capacity does reduce demand for hired labour. The sign for off-farm wage rate is also as expected (+) suggesting that hired labour does substitute for family labour working off-farm. The effect of distance to market is much smaller for households that sell labour which confirms earlier findings that labour supply is influenced by distance to market.

Table 5.9: Factors influencing demand for hired labour

	Decision to hire labour	*Demand for all hholds*	*Demand for hholds selling labour*
Dependent variable is log of hours per day			
Wealth:1=low,2=medium, 3=high	0.24***		
Log non labour income ‘000	0.04**		
Log of wage rate for hired labour (village mean)		0.55	0.73
Log of shadow wage		-0.04	-0.09
Log of wage rate off-farm			0.50
Log of shadow income		0.64**	0.41
Dummy for head with no education	-0.11	0.68*	0.85
Dummy for head with primary level not finished	-0.11	0.41	0.54
Dummy for primary level finished	0.21	0.30	0.51
Log of age of head	-2.98	17.43**	34.68***
Log of age squared	0.36	-2.31**	-4.77***
Dummy for gender of head: 0 = female, 1 = male	0.12	0.36	-0.00
Log of family size	-0.01	-0.29	0.26
Number of households members over 65 yrs	0.20	-0.05	0.45
Number households members between 55-65 yrs	-0.17	0.01	0.14
Number of household members between yrs21-54 yrs	-0.14**	-0.01	0.05
Number of households members between 15-20 yrs	-0.10	-0.10	-0.04
Number of households members between 6-14 yrs	-0.02		
Dummy for Kakamega District	0.27*	-0.48	-0.33
Log of farm size	0.52***	0.25**	0.25
tlu	0.38***		
Log of distance to major market	0.21**	0.28	0.06
Season	-0.06	0.19	0.49**
IMRhire		-2.51***	-2.23
IMRoffwork			4.67
Constant	4.77	-8.01	-66.90***
N	573	206	159
F	144	5.06	4.06
Adj. R^2	0.18	0.28	0.35

legend: * P<.1, ** P<.05, *** P<.01

The highly significant IMRhire implies that households that hire-in labour are distinctly different from those that do not. It emphasizes the importance of including the selectivity correction term in estimation of demand for hired labour.

5.7 Impact of increases in farm size, family size, household income and education level on labour use

From the results from our estimations of the supply and demand functions, we found that farm size, family size, income and education level are important factors influencing household behaviour. Policy makers may therefore use these factors to influence household behaviour towards greater efficiency in labour use. In order to get the desired effect it is important to first understand how households are likely to respond to changes in the factors in question. This section elaborates on the results obtained so far in an attempt to present a clear picture of the estimated effects. Using the estimated elasticities, we predict the expected change in household labour supply and demand due to changes in the key factors. We proceed by carrying out simulations on the estimated equations. First we use the estimated model to obtain the base farm labour supply, off-farm labour supply and demand for hired labour. Thereafter, we predict the changes in farm labour supply, off-farm labour supply and demand for hired labour due to a ten percent (10%) change in each key variable while holding the others constant. We also predict the change due to a hundred percent (100%) change in the education level of the head of household while holding other variables constant. Table 5.10 presents the impact of the changes on key variables.

From the results, it appears like the education level of the household head has the highest impact on household behaviour on labour use. However, when we consider that this impact is due to 100% increase in education level, then it turns out to be much smaller compared to the impact caused by a 10% change in the other variables. In this case compared to effects of other variables; a change in the household income has the largest impact on farm labour supply, a change in family size has the largest impact on off-farm labour supply whilst a change in the age of household head has the largest impact on demand for hired labour.

An increase in the shadow income causes a reduction (-6.8%) in labour supply to the farm especially for households selling labour off-farm (-7.4%). The increase in income causes an increase (+6.3%) in the demand for hired labour. It appears that the reduction in labour supply to the farm is compensated for by hiring-in labour.

An increase in the family size has its largest impact on off-farm labour supply (+5.8%). It also induces an increase in farm labour supply (+3.7%). A higher family size generally reduces demand for hired labour (-2.7%) but it increases demand in the households which sell labour off-farm (2.5%). An increase in the farm size increases the supply of labour to the farm in the same magnitude as that due to a change in the family size (+3.69%). The increase in farm labour supply is however smaller (+2.9%) for households which sell labour off-farm. Increasing the farm size also increases the demand for hired labour (+2.4%).

Change in the age of household head has the largest influence on farm household demand for hired labour. A change in age of household head causes a massive increase in demand for hired labour especially in households which sell their labour off-farm. The impact of a change in age of head on demand for hired labour is however much lower and negative in households with much older heads. These results confirm that household demand for hired labour follows the family's life cycle where younger and growing households have increasing consumption whereas the older households have diminishing consumption needs.

Farm households respond variedly to higher education depending on the current level of education of the household head. An increase in the education level of a household head who previously had no education to some primary level education results in: an increase in farm labour supply of households which sell labour off-farm (1.97%), a general decline in demand for hired labour (-2.3%) and a decline in off-farm labour supply (-3.19%). An increase in the education level of a household head that previously had some primary level education to complete primary level education results in: an increase (1.46%) in off-farm labour supply. Increasing the education level of household head from primary level to secondary level education and above results in an increase (+5%) in farm labour supply in households which sell labour and a decrease (-3.65) in off-farm labour supply.

The observed impact to higher education suggests that there is unavailability or rationing in off-farm jobs for some categories of skilled labour. For example, moving from complete illiteracy to a level where the head has some basic skills results in less off-farm labour supply probably because there are fewer opportunities for persons with basic skills compared to opportunities available for illiterate persons. In addition, persons who have completed primary education are more likely to get off-farm opportunities than those who have not. As a result, this category of households sells more labour. Off-farm employment opportunities are least available for persons with secondary and above secondary education because moving from just primary education to secondary or above results in a big drop in labour supplied off-farm. The results show that when off-farm opportunities are unavailable, the labour gets absorbed into the farm and hence the observed inefficiency in farm labour use in households which do not participate in off-farm employment.

Table 5.10: Percent change in farm labour supply, off-farm labour supply and demand for hired labour as a result of a 10% change in family size, farm size, household income and age of household head and a 100% change in the education level of the household head

Variables	% change in farm labour supply for all households	% change in farm labour supply for households selling labour	% change in off-farm labour supply	% change in demand for hired labour for all households	% change in demand for hired labour for households selling labour
1. 10% increase in family size	3.69*	2.9	5.78*	-2.7	2.5
2. 10% increase in farm size	3.69*	2.9*	-	2.4*	2.4
3. 10% increase in shadow income	-6.8*	-7.34*	-0.29	6.3*	4.0
4. 10% increase in age of head	-	-	-	427.0*	2625.0*
5. 10% increase in age of head squared	-	-	-	-20.0*	-36.5*
6. 100% increase in education level:					
• From no education to some primary level education	6.2	19.7*	-31.9*	-23.7*	-26.5
• From some primary level to full primary education	-3.0	-7.69	14.6*	-10.4	-3.0
• From primary level to secondary level education	25.9	50.0*	-36.5*	-25.9	-40

* coefficient was significant in the estimated function

5.8 Conclusions

Differences in returns to labour between farm and off-farm employment were found to be large and significant implying that households are inefficient in use of family labour. However, households which participate in labour markets as sellers or buyers were found to be more productive on the farm and efficient in use of family labour on the farm. Households which do not participate in the labour markets were found to be less productive and not efficient in labour use on the farm because returns to labour on-farm are lower than the market wage rate for hired labour. Examination of labour use in individual households revealed that efficiency is curtailed for some households. There are as many households with off-farm wage rates higher than shadow wage as there are with a lower off-farm wage rate. There are also as many households with a shadow wage greater than the rate for hired labour as there are with a lower shadow wage. For farm households with a shadow wage lower than off-farm wage rate, this would mean that there is bottling up of labour in the farm may be due to lack of off-farm opportunities (Salasya 2005) or there is a selection effect. For farm households with a shadow wage higher than off-farm wage rate, one or more of the following conditions are true: farm households are faced with liquidity constraints, hired labour is not a perfect substitute for family labour, or there are frictions in hiring-in labour. Where the shadow wage is higher than wage rate for hired labour it means that there are frictions in hiring-in labour. The only possible explanation for a shadow wage lower than the wage rate paid to hired labour is that in some households labour may be fixed to the farm but not a good substitute for hired labour. These results confirm what was found in previous studies (Sadoulet and De Janvry 1995) that markets fail for individual households.

In the farm household modelling framework, determination of the household decision price is key in understanding behaviour in resource allocation. We found great heterogeneity within the farm household in returns to labour employed on-farm (Chapter 3) and off the farm. So, unlike previous studies where the household is assumed to base its decisions on a single wage, this study allowed household decisions to be influenced by multiple wage rates namely; the shadow wage, off-farm wage and the market wage rate for hired labour.

Returns to labour were found to vary within farms and the wages earned in different off-farm jobs were also found to vary. In this kind of scenario, members of the same households may face wages which vary considerably because the job opportunities available or earning potential differ by skill/education as well as by gender (Low 1990). This heterogeneity in returns to labour on-farm and returns to labour off-arm was exploited in generating a shadow wage and off-farm wage rate for each household.

The poor response to the shadow wage, off-farm wage rate and wage rate for hired labour emphasises the difficulty in identifying the "right" decision wage for a farm household on the basis of the cross-sectional data as we have. It also suggests that the household decision wage may not be captured by the average wage rate because households may consider factors like the characteristics of the household member working off-farm. For example, household decisions on labour allocation may be made through a process in which the allocations are based on each members comparative advantage in productive activities off the farm (Low 1990).

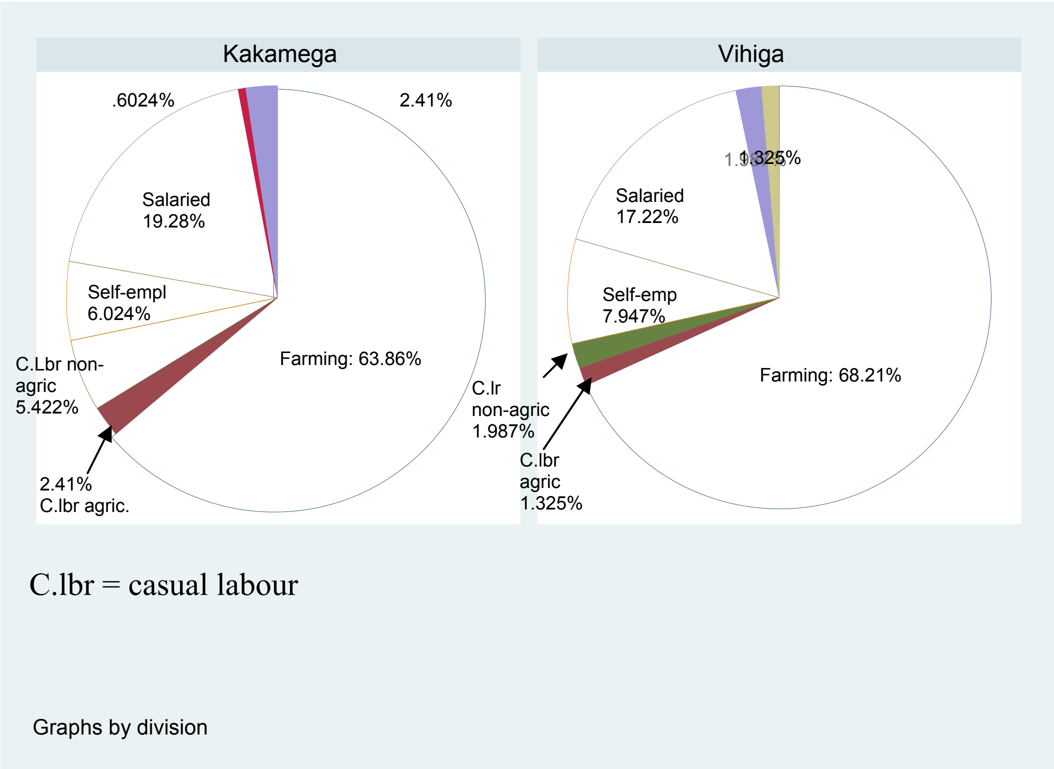
The study has provided evidence that farm labour supply is influenced by the market participation strategy because even though family size and labour capacity play a major role in determining labour supply, these considerations are of lesser importance for households selling labour. For such households, farm labour supply mainly depends on the income, education level, location and season. Labour supply off-farm depends on the education level of household head and the labour capacity of the household. The importance of distance to market in the decision to sell labour off-farm is indicative of transaction costs and lack of off-farm opportunities.

The demand for hired labour mainly follows the family's life cycle. Demand increases as the household consumption needs grow and falls as household consumption needs fall with age. The increase in demand is especially high for households which sell labour off-farm indicating that such households must buy labour to offset the short fall in family labour. An increase in the farm size, household income and education level of the head also increase demand for hired labour. Demand for hired labour is less dependent on household characteristics like family size and composition which supports the finding that these households are relatively efficient in labour allocation. The importance of non labour income in the decision to hire-in labour suggests that farm households are likely to have a liquidity constraint, restricting their use of hired labour.

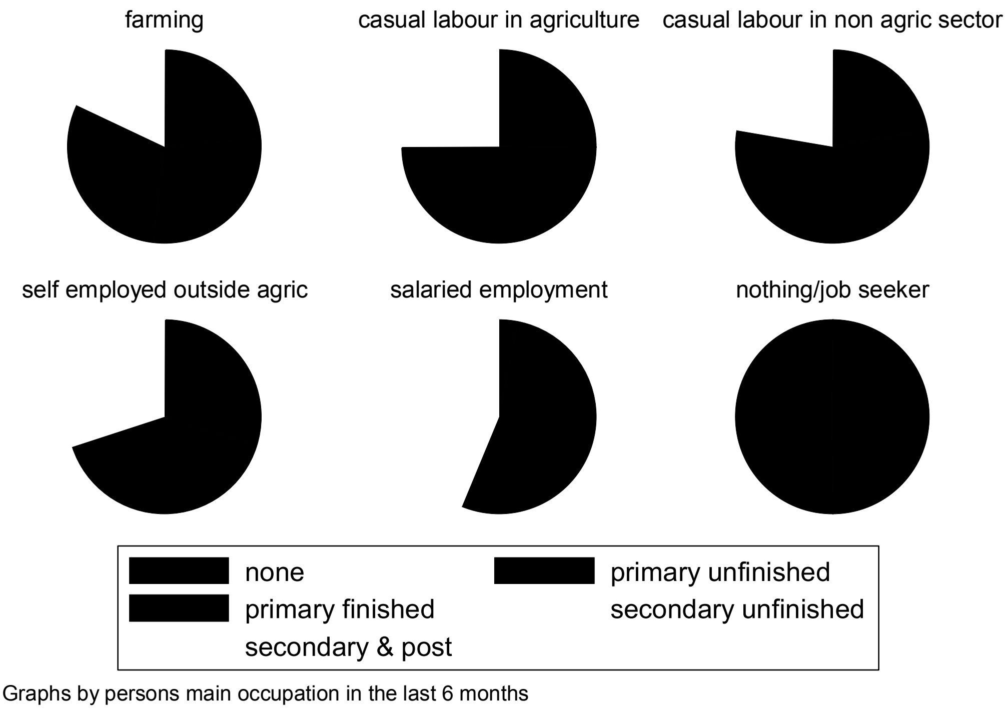
The results from the simulations show that increasing household income will result in increased consumption of leisure as households reduce farm labour supply on the farm. This reduction is however compensated with increased demand for hired labour. The largest increase in supply of labour to the farm may be achieved through an increase in farm sizes which results in greater supply of family labour and greater demand in hired labour. The observed impact of higher education suggests that there is unavailability or rationing in off-farm jobs for some categories of skilled labour like for persons with incomplete primary level education and above secondary level education. The results also show that when off-farm opportunities are unavailable, the labour gets absorbed into the farm and hence the observed inefficiency in farm labour use in households which do not participate in off-farm employment.

Appendices

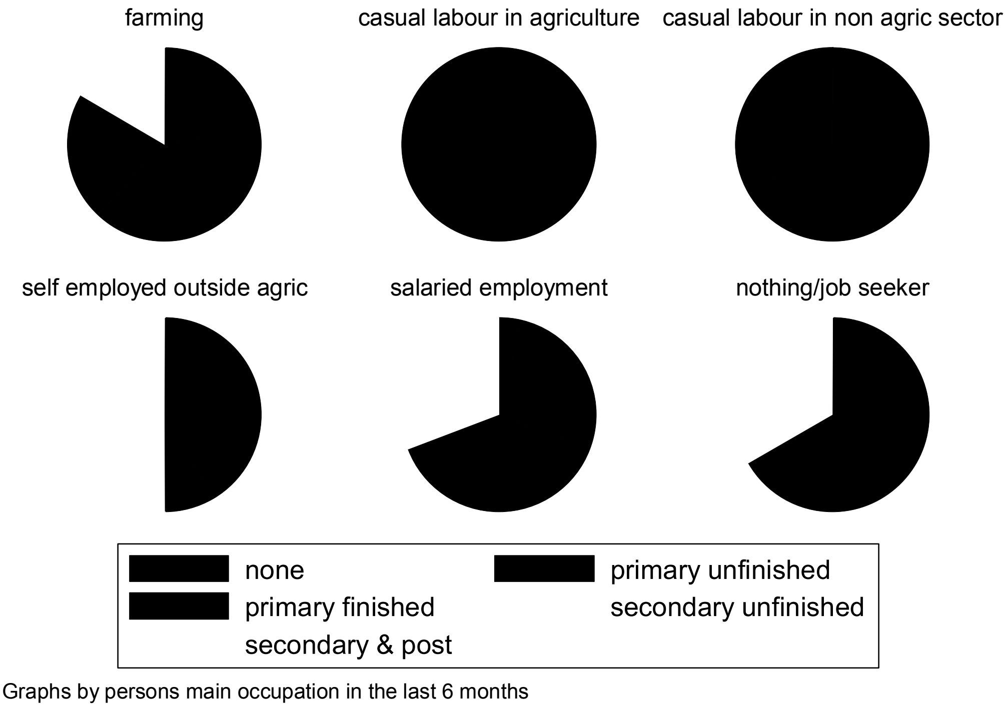
A5.1: Main occupation of household heads in Kakamega and Vihiga districts



A 5.2: Education level of persons by main occupation in Kakamega



A 5.3: Education level of persons by main occupation in Vihiga



Education level emerges as an important determinant of occupation or source of employment. Persons without any formal education are likely to work for wages in the agricultural sector but not in the non agricultural sector. They are also self-employed in the farm or out of the farm by engaging in petty trade. Although persons with a wide range of education levels are likely to be found on the farm, persons with primary education or less are most likely to be employed on the farm. Some level of formal education is necessary for one to secure salaried employment.

A5.4: Description of the wage rate, hours worked and number of days in wage employment outside agriculture

	N	Minimum	Maximum	Mean	Std. Deviation
Activity: Bodaboda					
Wage rate (KSh[a]/hr)	8	8.33	25.00	16.05	6.49
number of hours worked per day	8	4.00	12.00	7.13	2.35
number of days employed in the last six months	8	30.00	181.00	114.50	58.47
Activity: Fabrication					
Wage rate (KSh[a]/hr)	19	10.00	41.67	22.18	9.55
number of hours worked per day	19	4.00	14.00	8.00	2.49
number of days employed in the last six months	19	2.00	180.00	81.31	60.23
Activity: Masonry					
wage rate (KSh[a]/hr)	24	6.25	120.00	21.14	23.02
number of hours worked per day	24	6.00	10.00	8.29	1.04
number of days employed in the last six months	24	1.00	178.00	63.50	56.91

[a]1USD = 75 KSh

A5.5: Estimation of the returns to labour in self employment

A revenue function was estimated relating labour and other inputs to earnings in self employment. We expect the revenue earned in self employment to be influenced by the labour and capital employed as well as the distance from a major market. The distance from the market is expected to influence the input and output prices and hence the returns. The log of capital assets owned by the household was used to proxy the capital input in self employment. A simple Cobb-Douglas production function was estimated in its log-linear form specified as follows:

$$\log R_i = \alpha + \beta \log L_i + \gamma Z_i + \varepsilon_i$$

Where R is the gross revenue from self employment activities, L_i is the labour input (total hours) in self employment, Z_i represents farm and household characteristics that influence the revenue earned from self employment, ε is the error term summarizing the effects of all unobserved variables, α is a constant while β and γ are the elasticities to be estimated. The factors included in Z are household characteristics which influence the kind of business a household engages in and the costs incurred in the business. The results are shown below. Table shows mean wage rate is lowest in boda boda and about the same in jua-kali fabrication and masonry. The hours spent on the jobs do not differ between the different activities but the length of appointment (as shown by the number of days in employment) does.

Factors Influencing the Revenue Earned in Self Employment

The following are the variables included in estimation

- The dependent variable the log of the gross revenue earned from self employment
- lhourse is the log of labour hours in self employment
- ldistmkt is the log of the distance to the market
- lvalucass is the log of value of capital assets owned by the household
- educlenon is the dummy for head with no education
- primary1 is the dummy for head who did not finish primary level education
- primary2 is the dummy for head who has finished primary level education
- season is the dummy for the long rain season
- divisn is the dummy for Kakamega district

Factors influencing the revenue earned in self-employment: OLS regression

	Decision to Supply Labour
Dependent Variable in log of revenue earned in self employment	
Log of hours in self employment	0.862***
Log of distance to major market	-0.058
Log of value of capital assets	0.004
Log of value of farm equipment	0.061
Dummy for head with no education	-0.45**
Dummy for primary level not finished	-0.382**
Dummy for primary level finished	-0.315
Dummy for season: 1 = SR, 2= LR	0.432***
Dummy for location: 0 = Vihiga, 1 = Kakamega	0.282*
Constant	2.691
N	206
F	31
Adj. R^2	0.57

legend: * P<.1, ** P<.05, *** P<.01

The results show that revenue earned from self employment is highly responsive to the hours of labour. An increase in labour by 1% results in a 0.86% increase in revenue earned. It increases in the long rain season by 43% and is higher in Kakamega by 28%. Revenue from self employment increases with the education level of the household head. Households with a head with no education, not finished primary and just finished primary level earn upto 43%, 38% and 31% less respectively than households whose head has secondary level education.

The labour elasticity was used to calculated the marginal value of labour in self employment as follows:

$$MVP_{li} = \beta_i * AP_{li}$$

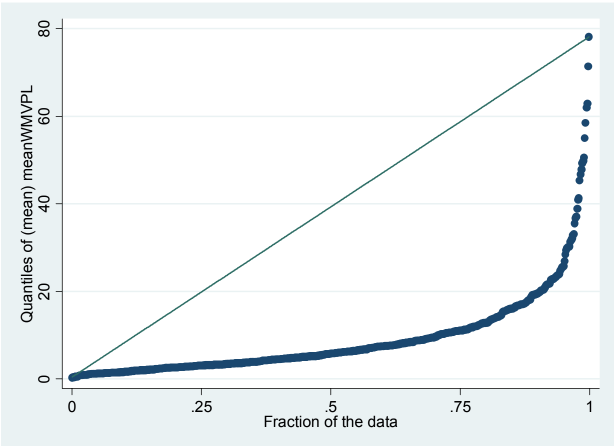
where:

MVP_{li} is the marginal product of labour in self employment which is specific to household i

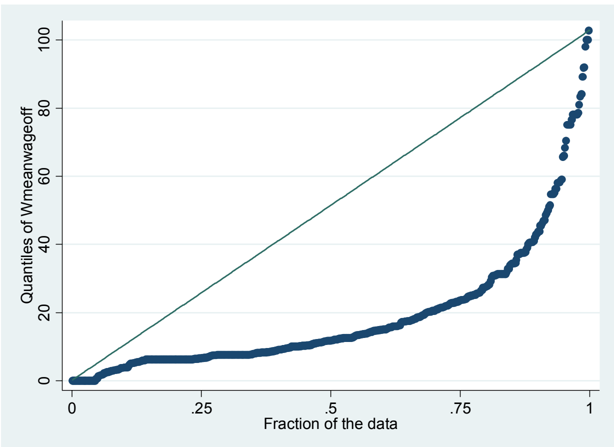
β_i is the labour elasticity

AP_{li} is the average product of labour in self employment.

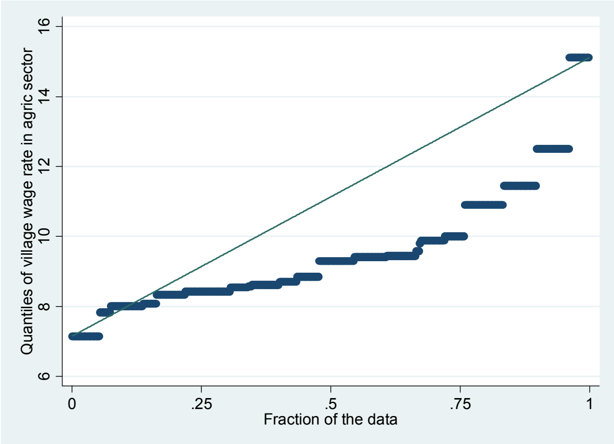
A5.6: Distribution of returns to labour on-farm (MVPL)



A5.7: Distribution of returns to labour off-farm



A5.8: Distribution of market wage rate for hired labour



Appendix 5.9: Farm labour demand by labour market participation strategy

	Short rain season			Long rain season		
	N	Mean	S.D.	N	Mean	S.D.
Hours of family labour on farm if hiring-in	135	252	245	131	263	282
Hours of family labour on farm if hiring-out	93	263	239	97	322	243
Hours of family labour on farm if hiring-in & hiring-out	41	283	229	36	337	308
Hours of family labour on farm if self sufficient in labour	79	260	211	79	300	217
Hours of hired labour	135	185	213	131	225	237
Hours of hired labour if hiring-in & hiring-out	41	145	166	36	171	135

Appendix 5.9: Characteristics of farms and households disaggregated by their labour market participation strategy

The Tables below show that the preference of most households in Kakamega is to hiring-out labour and hiring-in labour. Labour is most probably hired at at a lower wage than the wage these households command off-farm. The group of households with a preference to only sell their labour is also substantial. Households preferring to remain self-sufficient in labour are the minority. In Vihiga, a great majority of households prefer to sell their labour without hiring-in. This group is followed by households that hires-in and hires-out labour. The number of households hiring-in only is comparable to that in Kakamega but the self-sufficient households are much more.

In both districts, households hiring-in labour are the wealthiest gauging by the livestock owned. In Vihiga, self-sufficient households are the poorest whilst in Kakamega, households hiring-out labour seem to be less endowed with livestock or farm equipment. All households have access to non-labour income but the quantity differs between the groups. The households which only hire-out have the lowest income whereas households that hire-in have highest income. One similarity between Kakamega and Vihiga is that households which only hire-in have the smallest family size. Heads of households that hire-in only are oldest and also lease educated whereas households hiring-in and out are most educated in both Kakamega and Vihiga.In Kakamega, households with greatest number of adults or male adults are likely to remain self sufficient whilst in Vihiga they hire-out labour emphasising the differences in farm size. Households that hire-out labour are closest to roads or major markets whilst those hiring-in or remaining self-sufficient are furthest from roads and/or major markets.

a) Kakamega District

	Hire-out Only (N = 122)		**Hire-in & Hire-out (N = 136)**		**Hire-in Only (N = 31)**		**Self-Sufficient (N = 25)**	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Farm size	1.62	1.20	2.60	1.74	2.58	1.41	2.01	1.11
Tropical livestock units	0.60	0.54	0.98	0.66	0.96	0.73	0.68	0.65
Value of farm equipment	1,238.48	1,272.51	1,427.45	2,189.64	892.58	663.12	1,343.20	1,248.52
Non-labour income	2,815.16	57.83	6,586.33	13,696.35	7,907.61	10,263.75	3,364.00	7,005.28
Family size	6.81	2.65	6.87	3.13	4.96	2.75	6.36	3.10
Age of head	44.40	11.96	47.92	14.21	58.25	15.85	56.08	13.36
Gender of head	0.90	0.29	0.89	0.30	0.90	0.30	0.88	0.33
Education level of head	1.77	1.25	1.98	1.28	1.45	1.36	1.64	1.41
Number of adults	3.56	1.92	3.67	2.56	2.41	1.83	3.84	2.51
Number of female adults	1.85	1.08	2.06	1.57	2.03	1.31	2.00	1.25
Number of male adults	2.01	1.29	1.95	1.23	1.42	1.12	2.55	1.79
Distance to a motorable road	0.30	0.28	0.35	0.41	0.47	0.33	0.27	0.32
Distance to a tarmac road	4.06	2.78	4.06	2.42	4.66	2.64	4.27	1.78
Distance to a major market	3.71	2.11	4.03	2.31	5.11	4.43	4.72	4.70
If used drought power	0.07	0.26	0.26	0.44	0.22	0.42	0.04	0.20

b) Vihiga District

	Hire-out Only (N = 159)		**Hire-in & Hire-out (N = 64)**		**Hire-in Only (N = 33)**		**Self-Sufficient (N = 42)**	
	mean	std dev	mean	std dev	mean	std dev	mean	std dev
Farm size	1.08	0.86	1.71	1.19	1.75	0.85	1.23	0.87
Tropical livestock units	0.71	0.51	0.93	0.58	1.05	0.6	0.625	0.39
Value of farm equipment	984.75	1,306.40	737.98	601.3	854.22	818.94	835.46	503.3
Non-labour income	3,293.88	5,523.67	7,910.11	21,469.5	5,629.09	7,789.94	4,287.14	6,262.99
Family size	6.05	2.55	6.14	1.78	5.33	3.07	5.57	2.71
Age of head	51.49	13.68	51.54	15.5	63.87	12.89	58.09	15.98
Gender of head	0.83	0.37	0.87	0.33	0.66	0.47	0.73	0.44
Education level of head	1.52	1.20	2.07	1.37	1.51	1.17	1.59	1.23
Number of adults	3.36	1.83	3.06	1.48	2.57	1.63	2.59	2.1
Number of female adults	1.77	0.97	1.66	0.69	1.93	1.13	1.64	0.91
Number of male adults	2.09	1.17	1.93	1.1	1.77	0.92	1.84	1.08
Distance to a motorable road	0.37	0.46	0.41	0.63	0.47	0.76	0.24	0.27
Distance to a tarmac road	1.95	1.33	2.06	1.4	2.46	1.88	2.93	1.91
Distance to a major market	2.50	1.36	2.99	1.42	2.93	1.39	3.5	1.73
If used drought power	0.00	0.00	0	0	0	0	0.02	0.15

CHAPTER 6

DISCUSSION AND CONCLUSIONS

6.1 Introduction

The economy in western Kenya, like most of the other regions in Kenya is based on agriculture. The agricultural sector provides food, employment and cash income to the smallholder farm households who form the bulk of the households in this region. Despite its high agricultural potential, the region is characterised by low productivity and according to recent government statistics, over 57% of the households live below the poverty line RoK 2003). The causes of these problems and possible solutions can be traced to the government policies and livelihood strategies of households. Diversification is a common livelihood strategy of smallholder households in developing countries (Reardon 1997; Van den Berg 2001; Woldehanna and Oskam 2001). Most of these households diversify the crops grown to meet their food and/or cash needs or as dictated by the biophysical characteristics of the farm. In addition, a significant part of the income in smallholder farm households is earned outside the farm mainly from wage employment, self employment, salaried employment or from remittances.

Labour is an important resource for smallholder households because it is the main input in food production, off-farm activities and in most technological interventions. Yet few studies have attempted to study the behaviour of smallholder farm households in its use of labour, given the wide portfolio of economic activities they engage in. Previous studies have mainly examined the pros and cons of diversification in terms of employment, income effects, consumption effect or lost labour effect (Stiglitz 1989; Reardon 1997; Van den Berg 2001). Knowledge about farm household behaviour in allocation of labour given this wide portfolio deepens our understanding of factors affecting farm household labour use and hence the responsiveness of poor households to economic and other market related incentives.

Previous studies in the study region have suggested that labour is a constraint in adoption of labour demanding technologies (Place and Dewees 1999). For example, labour is one of the most frequently listed constraints to the adoption of soil fertility management technologies (KARI 1998-2002). The two major reasons given for lack of adoption are low returns to labour and technologies being too labour demanding. The reasons given are surprising given that the area has a high population density with few employment opportunities off-farm suggesting that there is surplus labour in the region. In earlier studies, the opportunity cost of labour in regions with surplus labour was equated to zero. Later studies have however shown that the opportunity cost of labour in peasant households is not zero (Sen 1966). Even if the opportunity cost of labour is not zero, it may vary within the farm, and with seasonality. It is also not clear how it compares to returns to labour employed off the farm. This study has shed some light on the underlying household environment which leads to contradictions in perceptions about labour and its value in smallholder farm households.

In the context of the developing world, a household's labour assets are more easily integrated into the market than its land assets. The divisibility of land and transferability between different activities is limited. Labour on the other hand: is highly divisible i.e. it can be applied in varying amounts, can be sold and still made available for chores in the farm or household: is highly mobile i.e. can be transported to different locations where needed: and it can be improved or re-trained. These characteristics make labour attractive for technical as well as policy interventions. The effectiveness of labour as an entry point for change may however be constrained because the success of interventions depends on its mobility within farms, across time as well as between activities on the farm and off the farm.

Efficiency studies provide reliable indications about the mobility of factors of production in an economy. When households are efficient in allocation of factors of production it means that they are responsive to incentives i.e. factors of production easily move to activities where they earn the highest returns. Households operating in perfect markets are expected to be allocative efficient because they can easily move their resources to where the returns are highest (Singh, Squire et al. 1986; Hoff and Stiglitz 1993; Sadoulet and De Janvry 1995). In developing countries however, household resource allocation is highly influenced by their circumstances (Shultz 1980; Sadoulet and De Janvry 1995). Deviations from utility maximising behaviour would therefore suggest that there are barriers to free movement of resources. The consequences of non-optimal resource allocation are that households benefit less from their resources or from economic or policy interventions designed for them. The subject of this thesis is household behaviour in allocating the most important resource owned by the poor, namely labour.

Studies on allocative efficiency are mainly carried out at the household level with the assumption that allocative efficiency prevails within the household. Such an assumption although convenient ignores the effects on labour use of seasonality, heterogeneity within farms and the uncertainty in uncontrolled environments. Where these situations prevail, within household efficiency cannot be assumed. For example, farm households normally sub-divide their land into independent units either due to the heterogeneity in biophysical conditions and/or the wide range of is crops grown so as to meet food and cash needs. When agricultural production is simultaneously carried out in such semi-autonomous units, allocative efficiency may be at stake. The second situation where within household allocative efficiency may be questioned is where household resources are allocated on the basis of gender. Udry (1996) found inefficiency within households in western Africa where plots of land are owned along the gender line. Plots owned by the women received less resources compared to plots owned by men. The third situation where within household allocative efficiency cannot be assumed is where there is strong seasonality in production activities or where there is uncertainty because agricultural production occurs in uncontrolled environments. In such cases where labour demand varies over the season, efficiency in labour allocation cannot be assumed.

The assumption of most behavioural studies is that households are faced with a single price in decision making which under perfect markets is the market wage rate (Van den Berg 2001). For households not participating in labour markets, the appropriate price for labour is given by the returns to labour employed on own farm i.e. the shadow price (Jacoby 1993). There are situations however where households maybe faced by more than one payment to labour. For example, where households cannot sell as much labour as they would wish because of rationing in the labour market or where financial or insurance markets fail. In this case, labour allocation between farm and off-farm activities is influenced by the prevailing conditions on the farm as well as off the farm.

To understand household behaviour in labour use better, a holistic approach was adopted in assessing allocative efficiency. Various models were used to investigate allocative efficiency in the context of three aspects, namely: within farm heterogeneity, seasonality and the presence of multiple payments to labour. Efficiency within the household was assessed by examining labour allocation within farm and across the season. So, in the first model, marginal products of labour were generated for the different plots within a farm and compared. The second model, a sequential decision model, was applied in generating stage specific marginal products of labour. These were then compared to gauge efficiency in labour allocation over the season. Efficiency in labour allocation between farm and off-farm activities was assessed by combining information generated in Chapter 3 regarding returns to labour within the farm with information generated in Chapter 5 regarding returns to labour off the farm. Farm households in western Kenya show more than one marginal product of labour on the farm and report off-farm wages that are different from the marginal product on the farm. Behavioural studies normally pick one of these payments to labour as the decision price. In this study however, we do not choose a particular wage but allow the household to demonstrate how the payments to labour on the farm, off-farm and village wage rates influence its decisions on labour use.

Using indices of inefficiency we have demonstrated the factors which lead to the observed inefficiencies and provided explanations for the choices which households make (2nd best). The results we have show that when households are are linked to markets, not only do incomes increase but household internal efficiency also improves.

The analysis was based on cross-sectional data collected from households in two districts of western[45] Kenya namely Kakamega, and Vihiga districts. The study was guided by three research questions where each question addresses one of three dimensions of farm household labour allocation. The rest of this chapter proceeds as follows: Section 6.2 discusses the key debates and findings. The policy implications are then discussed in section 6.3. Finally, the innovativeness and limitations of the study are outlined in section 6.4.

6.2 Key debates and main findings

6.2.1 Are farm households efficient in allocating labour within their farms

Efficiency was then evaluated by comparing returns to labour applied to various crops within the farm. Efficient households are expected to allocate their labour such that returns to labour (the marginal products of labour) applied are equalised across the crops. Farm households can improve efficiency in allocation of labour within the farm because, within-farm marginal value of labour varies between crops and between plots planted with the same crop. Seventy five percent (75%) of the households have a deviation (from the household mean) of less than KSh. 5.00 while the rest (25%) have a deviation greater than KSh. 5.00. The study also shows that farm households tend to allocate more labour to food crops like maize and beans compared with other crops that are more market oriented. Relatively more efficient outcomes in labour allocation – at least at the ruling market prices - within the farm would be achieved by reducing the labour applied on food crops like maize and increasing labour applied on market oriented crops like bananas and vegetables.

[45] The districts are the research sites of KARI-Kakamega and the soil fertility programme of the CGIAR institute, TSBF-CIAT.

This study shows that the labour applied to maize relative to other crops increases with the household's labour capacity and with remoteness but reduces when the liquidity position of a household improves. These results may be explained by the failure of one or more markets, notably the food market, which biases household decisions on labour use.

First, the widening of the difference between the market price and farm gate price of farm output causes market failure because it makes the utility derived from using the market to be lower. In such a case households choose not to use the market because compared with the market price, its internal price for food crops is higher whilst that for marketed crops is highly discounted. This drives the household towards self-sufficiency in food thereby applying comparatively more labour to maize plots than to those with bananas or vegetables.

This difference in prices widens with higher marketing costs i.e. transportation costs, trader mark-ups, and transaction costs. Because poor roads increase marketing costs, they are a major contributor to failed markets for farm output. It is therefore not surprising that the labour use in food crops increase with increased distance from the road. Poor roads also increase the marketing costs of inputs (fertiliser and labour) and manufactured goods that are consumed by the households.

Increasing the number of adults in the household makes maize dearer in the household relative to other crops grown in the farm whereas increasing households liquidity position (salaried employment and non-labour income) makes maize less dear compared to other crops grown by household. A liquidity constraint in a household may lead to a rise in the internal price of food. This compels the household to apply comparatively more labour to food crops. Reducing the liquidity constraint was shown to result in a reduction of labour from food production. Increasing cash in the household reduces the internal price and allows the household to purchase food thereby releasing labour from food crops to other crops. Depending on a household's characteristics, it may be that relaxing a liquidity constraint encourages the household to hire-in labour or withdraw the labour employed off-farm (possibly in casual employment) and employ it in cash crop production.

The variation within the farm of the marginal value products of labour on plots planted with maize suggests that plot characteristics like soil fertility status and position on slope determine the marginal effects of factors of production like labour. However, the study does not provide a clear indication of the influence of plot characteristics because the effects differ by region or/and by season. Farm households may lack information or the means to uniformly improve the productivity of their land.

6.2.2 Are farm households efficient in labour allocation over the cropping season?

Variability in the labour constraint across the cropping season was captured by differentiating labour use decisions between stages in a cropping season. Efficiency was then evaluated by comparing returns to labour applied during the planting and weeding stages. Efficient households are expected to allocate their labour such that returns to labour (the marginal products of labour) applied during the two stages are equalised. Significant differences between the marginal products were found and the stage at which the household is most labour constrained (highest marginal product) and the magnitude of the constraint varying between households. For over 90% of the households, the marginal product of labour applied at the beginning of the season was found to be larger than the marginal product of labour at weeding. 50% have a deviation in stage specific marginal products of between KSh. 5.00 -10.00, 10% have a deviation of KSh. 5.00 or less, and 22% a deviation of between KSh. 10.00 – 20.00.

According to the study, efficiency improves significantly when the labour capacity, specifically adult males, increases and where labour saving technologies like draught power are used. There is improved efficiency in households headed by persons with less than the basic education may be due to increased flexibility in labour employed off-farm. Households located further from major markets have greater efficiency probably due to inaccessibility to off-farm employment opportunities. Efficiency improves with increased non-labour income probably because it eases the labour constraint. Conversely, efficiency deteriorates when demand for labour within the household increases e.g. with increased farm size, with greater distance from the homestead and when there are more adult females in the household. The latter finding that increasing the number of males improves efficiency whilst increasing the number of females reduces efficiency is interesting. This makes sense when tasks performed during some stages within a season are gender specific. If the tasks at the beginning of the season are male oriented, households endowed with more males will have a lower labour constraint at that stage compared with households that are endowed with fewer male adults. Moreover in the study area, increasing the number of female adults in a household reduces the number of male adults.

These results suggest that the main cause of allocative inefficiency within the season are imperfections in the labour markets since households are unable to lower the wage rate when faced with increased labour demand. In the study area, the costs of hiring-in labour may be prohibitive because the peak periods normally coincide with high food prices, especially at the beginning of a season, yet food is part of the payment for labour. Shirking may also increase costs of supervision. Labour markets will also not work where the labour market is shallow i.e. where all households demand hired labour during the same period. The lack of secondary markets like credit can also contribute to the failure of the labour market.

6.2.3 Are households efficient in labour allocation between farm and off-farm activities?

Differences in returns to labour between farm and off-farm employment are large and significant implying that household efficiency in allocation of family labour can be improved. Households which participate in labour markets as sellers or buyers are more productive on the farm and more efficient in use of family labour on the farm. Households which do not participate in the labour markets are less productive and less efficient in labour use on the farm because returns to labour on-farm are lower than the market wage rate for hired labour. Examination of labour use in individual households revealed that there households (25%) with off-farm wage rates higher than shadow wage and others (60%) with a lower off-farm wage rate. About 25% of the households have a shadow wage greater than the rate for hired labour and a little over 60% of the households have a lower shadow wage. For farm households with a shadow wage lower than off-farm wage rate, this would mean that there is bottling up of labour in the farm may be due to lack of off-farm opportunities or there is a selection effect. For farm households with a shadow wage higher than off-farm wage rate, one or more of the following conditions are true: farm households are faced with liquidity constraints, hired labour is not a perfect substitute for family labour, or there are frictions in hiring-in labour. Where the shadow wage is higher than wage rate for hired labour it means that there are frictions in hiring-in labour. The explanation for a shadow wage lower than the wage rate paid to hired labour is that in some households labour maybe fixed to the farm but not a good substitute for hired labour.

Farm labour supply is influenced by the market participation strategy because even though family size and labour capacity play a major role in determining labour supply, these considerations are of lesser importance for households selling labour. For such households, farm labour supply mainly depends on the income, education level, location and season. Labour supply off-farm depends on the education level of household head and the labour capacity of the household. The importance of distance to market in the decision to sell labour off-farm indicates the presence of transaction costs. Demand for hired labour mainly follows the family's life cycle. It increases as the household consumption needs grow and falls as household consumption needs fall with age. The response is especially high for households which sell labour off-farm indicating that such households must buy labour to offset the short fall in family labour. An increase in the farm size, household income and education level of the head also increase demand for hired labour. Demand for hired labour is less dependent on household characteristics like family size and composition which supports the finding that these households are relatively efficient in labour allocation. The importance of non labour income in the decision to hire-in labour suggests that farm households are likely to have a liquidity constraint which restricts their use of hired labour.

Interventions that increase household income will result in increased consumption of leisure as households reduce labour supply to the farm. This reduction is however compensated with increased demand for hired labour. The largest increase in supply of labour to the farm can only be achieved through an increase in farm size which would result in greater supply of family labour and greater demand for hired labour. There is unavailability or rationing in off-farm jobs for some categories of skilled labour. And when off-farm opportunities are unavailable, the labour gets absorbed into the farm and hence the observed inefficiency in farm labour use.

6.2.4 What is the relevance of our results given the wide diversity of households in the study area?

Previous studies in western Kenya have highlighted differences between household resources and the outcomes which are taken as a sign of diversity. However, the differences observed between households do not prove that they do not emanate from the same model. Our approach was to parameterise household behaviour where the model was defined by objectives of the household and the constraints facing it. The model was then applied to different groups by extrapolating the impacts on households with different characteristics. This study has captured the diversity found in the area of study with the variables included in the models. The low values of R-squared however suggest that a lot of the variability remains unexplained emphasizing the difficulty in capturing variability or diversity in a model. Despite this setback, the findings are in line with theoretical considerations i.e. they are as good as can be expected in this kind of situation. Secondly, the study has demonstrated the implications for the different situations that are to be found in farm households of Western Kenya. By doing so, the study shows how the model applies in environments characterized by diversity. We have gone further than providing abstract results by applying coefficients generated by the model on real life situations e.g. on the value of maize and on the value of labour to the households faced by different circumstances. There is however always room for improvement e.g. future research should capture the diversity in soils etc with more sophisticated tools that map the suitability of soils to specific crops.

6.3 Policy implications

In this section we stipulate the policy implications of the research findings by suggesting policy measures that would steer farm households towards more efficient use of their resources, especially labour. The commonly cited explanations for allocative inefficiency are missing or imperfect markets and the results from this study suggest the same. From the results of this study, policies that will result in increased allocative efficiency can be formulated.

The first policy implication is that efforts should be made to reduce the marketing costs for food crops and cash crops. These measures include: improvement of the infrastructure in the rural areas, enhancing competitiveness of traders, making available relevant, correct and timely market information. Increase funding for infrastructural development especially the upgrading of rural roads to all-weather status. Such infrastructural development should go hand in hand with the institutional development e.g. farmer groups through which information, inputs and outputs may be channelled. These measures will at the same time reduce the marketing costs for farm inputs and manufactured goods consumed by rural households.

The second policy implication is to increase labour market participation. This can be achieved by: creating off-farm employment opportunities in the rural areas so that surplus labour may be absorbed off-farm. Efforts must be made to deepen the currently shallow rural labour market and to reduce the synchronicity in labour use. This may be achieved through commercialisation of agriculture and through the increase of off-farm employment opportunities. The economy of western Kenya is agriculture based, so value addition of agricultural produce would be the first obvious off-farm activities which could be promoted. Others include art and craft, provision of service like repairs and maintenance, supply of inputs, transportation services and information technology. This drive should be specifically target the population with a higher than the basic level of education. This group could be provided with opportunities to acquire skills that make them employable or equipped for self-employment. Direct injection of cash into the rural areas through for example the popular Constituency Development Fund (CDF) and/or the Youth Development Fund (YDF) are steps in the right direction and should be boosted. Reducing frictions in hiring-in labour would encourage farm households to supplement or substitute for family labour wherever necessary. Reduced marketing costs and greater market integration will ensure that food prices remain stable throughout the season. Through standardisation of services and a code of conduct, supervision costs can be reduced.

The functioning of other markets contribute to failure of the food market, therefore the third policy implication is to improve other rural markets. A well functioning credit and insurance market would reduce the internal price of food thereby encouraging farm households to meet their food needs through the market. A functional credit market would also encourage farm households to hire in labour where necessary. Policies that encourage innovative ways of providing financial services in rural areas and to the poor should be encouraged.

The results of this study have implications on evaluation of interventions. The effect of a new intervention on total labour use is normally the criterion used to evaluate agricultural technologies. This study however suggests that the effect of new interventions on stage specific labour demand is a better reflection of how households evaluate interventions. The results suggest that technologies with greatest potential to be adopted are those which ease the labour constraint during peak periods. Draught power eases the labour demand at the beginning of the season. Innovative ways of increasing use of draught power include lowering the cost of draught power and provision of credit. Where draught power cannot be used, reduction in the transaction costs in the labour market would encourage farm households to supplement or substitute for family labour wherever necessary.

Given the situation in western Kenya, there are other incentives that would encourage farm households to use their labour more efficiently. Firstly, increasing productivity in food production would release resources from food to cash crop production. Shifting emphasis from general farm level messages to more targeted plot level solutions to technical constraints would address the heterogeneity within smallholder farms for increased productivity. Secondly, easily available and low priced non-farm market goods have the potential to increase production of market oriented crops because they encourage households to increase their incomes.

6.4 Innovativeness and suggestions for further research

The data, data collection methods and empirical analysis used in this study have some limitations which provide opportunities for further research. Similar studies would benefit from data collection methods which are likely to deliver more accurate data on household labour use. The use of such methods which entails frequent visits to households is normally limited by available resources. Future studies would also benefit from data collection methods which allow corroboration of analytical results with information collected using informal methods that allow in depth discussions with households. Use of panel data where possible would take care of problems like identification of parameters in the presence of endogenous regressors or measurement error. With panel data the problem of distinguishing spurious and true dependence will also be resolved because individual characteristics can be included in the model.

Despite challenges in data used, this study has contributed to the body of knowledge in smallholder behaviour in labour allocation both in the methodological approach as well as in the findings. The multi-dimensional approach to efficiency (within farm, within a season and between farm and off-farm activities) has deepened our understanding of smallholder farm household behaviour in labour allocation. Moreover, the study exploits the diversity that is shaped by the household's livelihood strategy in making its case. There is diversity; within the farm due to crop diversification, over a cropping season emanating from variability in labour demand and within a household due to interactions between a household's labour endowment and the labour market.

The study provides insight regarding availability of labour in smallholder households. It shows why a household may feel more labour constrained during some periods or in some activities compared with others and why labour remains on the farm despite the low returns. The study has shown that within the farm, labour is not availed equally to all crops or plots making some crops/plots to be more labour constrained compared with others. Within the season, some stages are more labour constrained than the others. Outside the farm, all household members may not enjoy similar access to employment opportunities. Although the study comes short of providing a single figure indicating the opportunity cost of labour in rural households, it does provide indicators which can be used as guidelines in determining the opportunity cost of labour in a household. E.g. the return to labour on the farm is almost always lower compared with payment off-farm; the return is almost always lower on labour spent on food crops like maize compared to other crops; and on average the labour cost is highest at the beginning of the season.

Are the results from this study surprising? Not really! What is new is that we have introduced an approach for quantifying outcomes of farm household behaviour in labour allocation and provide explanatory factors for deviations from allocations with more rewarding outcomes.

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SUMMARY

The economy in western Kenya, like most of the other regions in Kenya is agriculture based with smallholder farm households forming the bulk of the population. While all smallholder households engage in agricultural production to meet their food and cash needs, income earned outside the farm forms a significant component of household income. For these households, labour is the main input in both farm and off-farm activities. This study was motivated by three reasons: Firstly, there are contradicting perceptions regarding availability of labour in smallholder farm households of western Kenya. One view point suggests abundant labour due to the high population density and few employment opportunities. On the other hand, poor uptake of labour intensive agricultural technologies is frequently attributed to lack of labour and/or poor returns thereby suggesting scarcity of labour in the households. Secondly, previous studies mainly focus on the pros and cons of diversification in terms of employment, income effects, consumption effect or lost labour effect. Few however, have studied the efficiency or outcomes of household behaviour given the wide portfolio of economic activities they engage in. Thirdly, there are significant differences in outcomes between livelihood strategies and significant gains to be made by shifting between strategies. Labour has desirable characteristics, such as its versatility, divisibility and mobility, which make it attractive for technical and policy interventions targeting poor households. However, labour as an entry point for change may become an ineffective where its mobility is constrained.

The aim of this thesis was to identify barriers that hinder farm households from benefiting from interventions targeting them. Efficiency studies provide an indication of how well households use their resources and the mobility of factors of production in the household. Where households are efficient, it means that factors of production easily move to activities with highest returns. The aim of this study was therefore achieved by establishing whether farm households are efficient in allocation of labour and by identifying the factors responsible for deviations from expected behaviour. The study contributes to the AfricaNUANCES project "Exploring tradeoffs around farming livelihoods and the environment" by illuminating the dynamics which lead to varied perceptions about the opportunity cost of labour and its availability in smallholder farm households. Most studies on allocative efficiency are mainly carried out at the household level with the assumption that allocative efficiency prevails within the household. Such an assumption although convenient

ignores the effects on labour use of; seasonality, heterogeneity within farms and the uncertainty in uncontrolled environments. Where these situations prevail, within household efficiency cannot be assumed. For example, farm households normally sub-divide their land into independent units either due to the heterogeneity in biophysical conditions and/or the wide range of crops grown so as to meet food and cash needs. When agricultural production is simultaneously carried out in such semi-autonomous units, allocative efficiency may be at stake. The second situation where within household allocative efficiency may be questioned is where household resources are allocated on the basis of gender. The third situation where within household allocative efficiency cannot be assumed is where there is strong seasonality in production activities or where there is uncertainty because agricultural production occurs in uncontrolled environments. In such cases where labour demand varies over the season, efficiency in labour allocation cannot be assumed.

The assumption of most behavioural studies is that households are faced with a single price in decision making which under perfect markets is the market wage rate. There are situations however where households may experience more than one wage rate for their labour. For example, where households cannot sell as much labour as they would wish because of rationing in the labour market or where financial or insurance markets have failed. In this case, labour allocation between farm and off-farm activities is influenced by the prevailing conditions on the farm as well as off the farm.

A holistic approach to allocative efficiency was adopted by addressing three research questions namely: whether farm households are efficient within their farms i.e. whether marginal reallocation of labour would lead to better outcomes on the farm, whether farm households are efficient over the cropping season and lastly whether farm households are efficient in labour allocation between farm and off-farm activities i.e. whether their involvement in labour markets affects the marginal efficiency of labour use. The study combined one and two-step production functions, and labour supply and demand functions in addressing these questions.

In **Chapter 2**, the data used and the characteristics of the study area are described. In addition the diversity of household strategies in terms of labour use and incomes sources is described and comparisons made to highlight the relative importance. The dataset used comprises of household and plot level data collected from a random sample of farm households in Kakamega, and Vihiga districts of western Kenya. Like other parts of Kenya, the economy in western Kenya is mainly driven by an agricultural sector which mainly comprises of smallholder farmers. Much of the land in the two districts (Kakamega, and

Vihiga) falls in the high to medium potential areas where the rainfall ranges from 1400mm to 2000mm. Farms are on average small. The average farm size is 0.97 ha and 0.58 ha for Kakamega and Shinyalu respectively and fifty percent (50%) of the households own not more than 0.81 ha in Kakamega and 0.5 ha in Vihiga. It is a common practice for smallholder farmers to subdivide their farms into distinct plots. The plots are normal small with a mean of 0.24 hectares in Kakamega and 0.16 hectares in Vihiga.

In spite of the small farm sizes, farming is the main economic activity for households in the study area and the family is the main source of labour. Nutrient mining, soil erosion and little use of fertilisers characterise the farming landscape in the two districts. Consequently, majority of the households experience food deficits and earn little from their farms. Household income is normally supplemented with cash from sale of livestock products and live animals, off-farm employment and remittances. Majority of the households have at least one member working off-farm. The poverty incidence in western Kenya is however high with 57% falling below the poverty line.

In **Chapter 3**, a horizontal view point of labour use was adopted whereby within farm allocative efficiency was examined. The total number of distinct plots for each household range from one to six with most households having two to four plots. The outcomes of household behaviour in labour allocation to various crops was examined while controlling for variability in bio-physical characteristics of the farm. An index indicating the extent of inefficiency within the farm was created from model parameters and the factors influencing this inefficiency determined. The study reveals that there is room for improvement in efficiency of labour allocation within the farm. It shows that farm households tend to allocate more labour to food crops like maize and beans compared with other crops that are more market oriented. The labour applied to maize relative to other crops increases with the household's labour capacity and with remoteness but reduces when the liquidity position of a household improves. These results may be explained by the different perception of output prices by the household when there are imperfections in output markets.

A vertical perspective of labour use was adopted in **Chapter 4**. Seasonality and uncertainties in agricultural production result in a varying labour constraint over the season. A model which captures the sequential nature of farm household decisions over the cropping season was adopted in deriving optimal levels of stage-specific labour input and output. The resultant econometric model of two labour functions and a production function was applied to maize production and household's allocative efficiency of labour use over the season evaluated. Efficiency was evaluated by comparing returns to labour applied at the beginning of the season and at weeding. For over 90% of the farm households the marginal product of labour applied at the beginning of the season was larger than the marginal product of labour applied at weeding. This suggests that households in western Kenya are most labour constrained at the beginning of the season. There are a few households that are more labour constrained at weeding or maintain constant returns to labour across the season. The results are suggestive of imperfections in the labour market. An index of inefficiency was created and related to various farm and household characteristics. Simulations using model coefficients show how the model results can be interpreted for farm households with different characteristics. The change in the relative value of labour (due to changing farm and household characterstics) was expressed in monetary terms to demonstrate the application of model results to real life situations.

In **Chapter 5** we examine household efficiency in labour allocation between farm and off-farm activities and the determinants of labour supply and demand. Efficiency was evaluated by comparing information generated in chapter 3 regarding returns to labour within the farm with information generated in chapter 5 regarding returns to labour off the farm. In determination of factors influencing household behaviour, we did not choose a particular wage but allowed the household to demonstrate how the payments to labour on the farm, off-farm and village wage rates influence its decisions. On average differences in returns to labour between farm and off-farm employment are large and significant implying that efficiency in use of family labour can be improved. However, households which participate in labour markets as sellers or buyers are more productive on the farm and efficient in use of family labour on the farm. There is unavailability or rationing in off-farm jobs for some categories of skilled labour. Distance to market is an important determinant in the decision to sell labour off-farm. We simulated the expected farm household response to changes of 10% in the key factors influencing supply and demand namely; farm size, family size, income and education level. Increasing household income results in increased consumption of leisure as households reduce farm labour supply by 6.8%. This reduction in farm labour supply is however compensated with an increase (6.3%) in demand for hired labour. Households with a higher labour capacity supply more labour on-farm (3.7%) and off-farm (5.8%). Such households generally demand less hired labour (2.7%) with the exception of those that sell labour off-farm where a 2.5% increase in demand for hired labour was observed. The largest increase in supply of labour to the farm may be achieved through an increase in farm size which results in 3.7% increase in supply of labour and a 2.4% increase in demand for hired labour.

Moving from complete illiteracy to a level where the head has some basic skills resulted in reduced off-farm labour supply probably because there are few opportunities for persons with basic skills compared to opportunities available for illiterate persons. Off-farm employment opportunities are least available for persons with secondary and above secondary education because moving from just primary education to secondary or above results in a big drop in labour supplied off-farm. The simulations also showed that when off-farm opportunities are unavailable, more labour is employed on the farm.

In **Chapter 6** we conclude the study by revisiting the key issues addressed and discussing the key findings. Household inefficiency in labour allocation has been attributed to market imperfections particularly output and labour markets. These imperfections hinder labour mobility within the farm, across the season and between farm and off-farm activities. Policy measures that would steer farm households towards more efficient use of labour include reducing marketing costs for farm output, increasing participation in labour market and improving the functioning of other rural markets. This study quantified the degree of efficiency of the allocation of labour in the household. It did so for the allocation over crops, over time, and between on and off-farm employment. In this way the study contributes new measures of the effects that the varying degrees of integration in the markets have on the allocation of the household's most important production factor, their labour.

SAMENVATTING

Hoe efficiënt is de inzet van arbeid van landbouwhuishoudens in Westelijk Kenia? Een meerdimensionale analyse.

Net als in de meeste andere regio's van Kenia, vormt landbouw de basis van de economie in westelijk Kenia. Gezinsbedrijven vormen de hoofdmoot van de boerderijen. Hoewel al deze gezinsbedrijven landbouw bedrijven om in hun eigen behoeften te voorzien, is het inkomen dat buitenshuis wordt verdiend vaak nog belangrijker. Voor alle huishoudens is arbeid de belangrijkste factor, zowel op als buiten het bedrijf. Er zijn drie redenen voor deze studie naar de efficiëntie van de arbeidsinzet. Ten eerste zijn er tegenstrijdige opvattingen over de beschikbaarheid van arbeid in deze gezinsbedrijven; een visie is dat er een overvloed aan arbeid beschikbaar is gezien de bevolkingsdichtheid en het gebrek aan werkgelegenheid, maar anderzijds wordt het geringe gebruik van arbeidsintensieve technologieën toegeschreven aan schaarste aan arbeid in het boerenhuishouden. Ten tweede wijzen weliswaar veel studies op de wenselijkheid van diversificatie van inkomensbronnen, maar slechts weinige op de (in)efficiëntie van de huidige verdeling van arbeid over de vele activiteiten die zij thans ondernemen. Ten derde is arbeid door zijn flexibiliteit en mobiliteit bij uitstek gevoelig voor sturing door technische en beleidsinterventies ter bestrijding van armoede; als arbeid echter niet zo flexibel is als gedacht, vormt hij een minder geschikt aangrijpingspunt voor het beleid.

Het doel van dit proefschrift is de hindernissen te identificeren waardoor huishoudens niet kunnen profiteren van beleidsmaatregelen. Een studie naar de efficiëntie kan aangeven hoe gemakkelijk huishoudens de inzet van arbeid kunnen variëren en aanpassen aan veranderde mogelijkheden. Hoe efficiënter de inzet, hoe flexibeler deze kennelijk is. Het doel van dit onderzoek wordt derhalve bereikt door te bepalen óf huishoudens efficiënt zijn in hun arbeidsinzet, en welke factoren van invloed zijn op afwijkingen van optimale inzet van arbeid. Het onderzoek vormt een onderdeel van het AfricaNUANCES project *Exploring tradeoffs around farming livelihoods and the environment*. Onze bijdrage ligt in het aangeven van de redenen voor verschillen in de impliciete prijs van arbeid op de gezinsbedrijven.

De meeste studies naar de efficiëntie van arbeidstoedeling kijken naar het huishouden als geheel, en nemen aan dat daarbinnen de toedeling wel efficiënt is. Dit veronachtzaamt echter de effecten op arbeid van de loop der seizoenen, heterogeniteit binnen het huishouden en onzekerheid in de natuurlijke omstandigheden. De bedrijven hebben normaliter verschillende percelen, hetzij vanwege verschillen in biofysische omstandigheden, hetzij omdat verschillende gewassen worden gekozen. Wanneer daar landbouwproductie gelijktijdig wordt bedreven, is de efficiënte toedeling van arbeid in het geding. De tweede situatie doet zich voor waar hulpmiddelen van huishouden seksespecifiek worden verdeeld. Het derde geval waarin een efficiënte toedeling niet kan worden aangenomen is waar productieactiviteiten een sterk seizoenmatig patroon kennen of er onzekerheid bestaat vanwege omstandigheden buiten hun macht. Efficiënte toedeling van arbeid kan dan niet zonder meer worden aangenomen.

De meeste gedragstudies nemen een enkele prijs aan als waardering van de arbeid; in het geval van perfecte markten is dit de marktloonvoet. Er zijn echter situaties waarin huishoudens meer dan een loonvoet ervaren, bijvoorbeeld wanneer zij niet zoveel arbeid kunnen uithuren als zij willen (rantsoenering), of wanneer financiële of verzekeringsmarkten falen. In dergelijke gevallen wordt de toedeling van arbeid niet alleen door de loonvoet, maar ook door omstandigheden binnen het bedrijf bepaald.

Een holistische benadering van het vraagstuk van efficiëntie van toedeling van arbeid is gevolgd door drie vragen te beantwoorden. Zijn huishoudens efficiënt in de toedeling over verschillende activiteiten binnen het bedrijf, d.w.z. kan een kleine verschuiving hierin tot hogere winst leiden? Zijn zij efficiënt bij de toedeling binnen het groeiseizoen, en tenslotte, is de toedeling binnen en buiten het bedrijf efficiënt? Het onderzoek gebruikt productiefuncties, soms gestapeld, en arbeidsaanbod- en -vraagfuncties ter beantwoording van de vragen.

In **Hoofdstuk 2** komen de data en de locaties aan bod. De diversiteit in strategieën van de huishoudens waar het hun arbeidsaanwending betreft wordt hier beschreven en het belang ervan door onderlinge vergelijking aangegeven. De dataverzameling bevat huishoudens- en perceelsgegevens van een aselecte steekproef van 327 boerenhuishoudens in de districten Kakamega en Vihiga in westelijk Kenya. Veel van het land in deze gebieden behoort tot middel- en hoogproductieve grond, met een neerslag van 1400 tot 2000 mm. Bedrijven zijn klein. Het gemiddelde bedrijf is maar 0,97 ha in Kakamega en 0,58 ha in Vihiga, met mediane waarden van 0,81 ha en 0,5 ha respectievelijk. Het is gebruikelijk voor kleine bedrijven hun land nog verder te verdelen in percelen, die gemiddeld 0,24 ha groot zijn in Kakamega en 0,16 ha in Vihiga. Hoewel de bedrijven klein zijn is landbouw de hoofdactiviteit waarvoor in hoofdzaak gezinsarbeid wordt aangewend. De landbouw wordt gekenmerkt door bodemuitputting, erosie en gering gebruik van kunstmest in beide districten. Veel huishoudens lijden dientengevolge onder voedseltekorten en lage opbrengsten van hun bedrijf. Het huishoudinkomen wordt aangevuld met de geldopbrengsten uit verkoop van vee en veeproducten, werk buitenshuis en geldzendingen van familieleden. In meerderheid hebben de huishoudens tenminste eren gezinslid buitenshuis werken. Armoede komt veel voor in westelijk Kenia; 57% van de huishoudens valt onder de armoedegrens.

In **Hoofdstuk 3** wordt als het ware een horizontale kijk genomen op de toedeling van de arbeid en de efficiëntie ervan. Zoals eerder vermeld, zijn de bedrijven vaak verder onderverdeeld in percelen die in aantal uiteenlopen van 1 tot 6, met in de meeste gevallen 2 tot 4 stuks. De efficiëntie van de toedeling van arbeid over deze percelen is geschat, rekening houdend met de biofysische eigenschappen van de grond. Een index per huishouden is gemaakt om die efficiëntie uit te drukken. Vervolgens is nagegaan welke factoren die efficiëntie bepalen. Het onderzoek laat zien dat de efficiëntie van de toedeling beter kan. Huishoudens wijzen meer (te veel) arbeid toe aan voedselgewassen in vergelijking met marktgewassen en deze tendens wordt versterkt door aanwezigheid van veel arbeidskrachten in het huishouden of door grote afstand tot de markt, en vermindert als de liquiditeitspositie verbetert. De resultaten wijzen op falende markten voor de producten die de perceptie van de prijzen per huishouden doen verschillen.

In **Hoofdstuk 4** wordt een verticale kijk op toewijzingsefficiëntie gepresenteerd. Het gaat hier om de toedeling over verschillende tijdsperioden binnen het seizoen. Onzekerheid en de loop van het seizoen stellen wisselende eisen aan arbeid. Een model is gehanteerd dat het volgtijdelijke karakter van beslissingen van boerenhuishoudens beschrijft. Hiermee werd de optimale inzet van arbeid in beide tijdsspannen afgeleid. Het resulterende econometrische model bestaande uit twee arbeidsfuncties en een productiefunctie is toegepast op de verbouw van maïs. De efficiëntie van de toewijzing aan beide perioden (grondbewerking en zaaien; wieden) is geëvalueerd door de twee scores voor de marginale arbeidsproductiviteit te vergelijken. Voor meer dan 90% van de bedrijven was die productiviteit in het begin van het seizoen hoger dan tijdens de wiedperiode. Dit wijst erop dat arbeid in West-Kenia in de eerste periode meer als beperkende factor wordt ervaren, hoewel er enkele huishoudens zijn die hogere uitkomsten geven in de tweede periode. De uitkomsten wijzen op de aanwezigheid van imperfecties in de arbeidsmarkt. Een index van de inefficiëntie (uitgedrukt in geld) is geconstrueerd en vervolgens gerelateerd aan mogelijk verklarende variabelen, waaronder de karakteristieken van bedrijf en huishouden.

In **Hoofdstuk 5** onderzoeken we de efficiëntie van de toedeling van arbeid tussen het eigen bedrijf en daarbuiten, alsmede de bepalende factoren van de vraag naar en het aanbod van arbeid. De efficiëntie werd afgemeten aan het verschil in marginale beloning van arbeidsinzet binnen het bedrijf, zoals in hoofdstuk 3 gemeten, en die van de arbeid die buiten het bedrijf wordt ingezet. Hierbij hebben wij de beslissingen van het huishouden laten afhangen, niet van een enkele loonvoet, maar van de marginale productiviteit binnen het bedrijf, buten het bedrijf en van de waargenomen loonvoet in het dorp. Gemiddeld genomen zijn de verschillen tussen de arbeidsopbrengsten binnen en buiten het bedrijf erg groot, hetgeen erop wijst dat efficiëntie kan worden verbeterd. De huishoudens echter die actief zijn op de arbeidsmarkt (als werknemer of als werkgever) vertonen hogere marginale productiviteit op het eigen bedrijf, en zijn ook efficiënter. Er is slechts beperkte werkgelegenheid voor enkele categorieën geschoolde arbeid. De afstand tot de markt blijkt een belangrijke hinderpaal voor het aanbieden van arbeid buitenshuis. We hebben enkele simulaties gemaakt voor het gemiddelde huishouden van het effect van verandering van sommige sleutelvariabelen. Een hoger (10%) inkomen van huishouden leidt tot minder aanbod van eigen arbeid (6,8%), en een toename in ingehuurde arbeid van 6.3%. Huishoudens met meer (10%) arbeidskrachten bieden meer arbeid aan op het eigen bedrijf (3,7%) en erbuiten (+5,8%), terwijl zij minder arbeid inhuren (-2,7%), tenzij zij veel arbeid uithuren. In dat laatste geval neemt de vraag naar arbeid toe met 2,5%. De grootste toename in arbeidsaanbod volgt op een toename (10%) van de bedrijfsgrootte. Dan wordt 3,7% meer gezinsarbeid aangeboden, en 2,4% meer arbeid ingehuurd.

Een verschuiving van ongeletterdheid van het hoofd van het huishouden naar enige basisopleiding leidt tot een vermindering van het arbeidsaanbod buitenshuis, waarschijnlijk omdat de vraag ernaar tekortschiet, vergeleken met de vraag naar ongeletterde personen. Het minst is werkgelegenheid voorhanden voor personen met secundair of hoger onderwijs. Bij afwezigheid van dergelijke werkgelegenheid wordt extra arbeid op het eigen bedrijf ingezet.

In **Hoofdstuk 6** sluiten wij de studie af met een discussie van de belangrijkste bevindingen. De inefficiëntie van huishoudens bij de toewijzing van arbeid kan worden toegeschreven aan falende markten voor producten en arbeid. Deze imperfecties belemmeren de mobiliteit van arbeid binnen het bedrijf, binnen de seizoen en tussen het bedrijf en daarbuiten. Beleidsmaatregelen die huishoudens wat dichter bij efficiënte oplossingen zouden brengen dienen gericht te zijn op verlaging van de kosten van verkoop en aankoop van producten, toeneming van arbeidsmarktparticipatie en verbetering van het functioneren van de rurale markten. Deze studie heeft de mate van efficiëntie van de toewijzing van arbeid per huishouden gekwantificeerd, ingedeeld naar toewijzing over gewassen, toewijzing in de tijd, en toewijzing binnen en buiten het bedrijf. Zodoende heeft de studie nieuwe maatstaven geleverd voor de invloed die de uiteenlopende integratie in de verschillende markten heeft op de interne allocatie van de belangrijkste productiefactor van de huishoudens, hun arbeid.

TRAINING AND SUPERVISION PLAN

Description	Institute/Department	Year	Credits[a]
General Courses			
Mansholt Introduction Course	Mansholt Graduate School	2002	1
PE&RC Introduction Course	School of Ecology and Resource Conservation (PE&RC)	2003	0.75
Information Literacy	Wageningen Graduate Schools	2005	0.4
Techniques for Writing and Presenting a Scientific Paper	Wageningen Graduate Schools	2006	1
Discipline Specific Courses			
Facilitating change and Up-scaling of Participatory approaches: Building Personal Mastery and Organisational Capacities	CERES- Research School for Resource Studies for Development	2003	2
Quantitative Analysis of Cropping and Grassland Systems	Wageningen University	2003	4
Farm Household Economics	Wageningen University	2003	3
Economic Models	Wageningen University	2003	4
Econometrics II	Wageningen University	2003	4
Current Issues in Development Economics	Netherlands Network of Economics (NAKE)	2003	2
Theory and Practice of Efficiency & Productivity: Parametric Approaches	Mansholt Graduate School	2006	1.5
Presentations at Conferences and Workshops			3
Seminar on final PhD Proposal	PE&RC, Wageningen University	2003	
Mansholt Graduate School PhD-day	Mansholt Graduate School, Wageningen University	2006	
4th Development Economics PhD Seminar, European Network of PhD Students in Development Economics	University of Namur, Belgium	2006	
106th EAAE Seminar in Montpellier, France, 25-27 October 2007	European Association of Agricultural Economists (EAAE)	2007	
Total (min 20 credits)			**26.5**

[a] 1 credit represents 40 hours of coursework

CURRICULUM VITAE

Mercy Wanjiku Kamau was born in Nairobi, Kenya on 12th February 1965. Her career as a researcher began in 1988 soon after graduating from the University of Nairobi where she earned a Bachelor of Science degree in Agriculture. She joined the research division of the Ministry of Agriculture, now Kenya Agricultural Research Institute (KARI) as an assistant researcher and was posted to the National Horticultural Research Station in Thika. Two years later she re-joined the University of Nairobi for further studies and in 1994, graduated with a Master of Science degree in Agricultural Economics. Mercy returned to her duty station in Thika and continued providing socio-economic support to various projects. She played a key role in the first programme level priority setting initiative at KARI. In 1999, Mercy joined Tegemeo Institute of Agricultural Policy and Development as a research fellow. Her tasks were to investigate the effects of national, regional and international policies on the agricultural sector. During her tenure at Tegemeo, she investigated topical issues in the horticultural sub-sector (export-market-oriented and domestic-market-oriented) and the maize seed industry. Mercy also played a key role in developing a monitoring and evaluation tool for the KARI's Agricultural Technologies and Information Resources Initiative (ATIRI) and managed the testing and application of a tool for assessing the poverty levels of the clients of micro-finance institutions. Mercy always wanted to pursue a doctoral degree. In September, 2002 she obtained funding from the Rockefeller Foundation to pursue a PhD degree at Wageningen University.