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EXAMINING THE LINKS BETWEEN AGRICULTURE

AND CHILD MALNUTRITION IN MALI

presented by

Christopher L. Penders

has been accepted towards fulfillment
of the requirements for

M.S. degree in Agricultural Economics

John M. Staatz
Major professor

Date November 29, 1999

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EXAMINING THE LINKS BETWEEN AGRICULTURE AND CHILD MALNUTRITION IN MALI

BY

Christopher L. Penders

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Economics

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ABSTRACT

EXAMINING THE LINKS BETWEEN AGRICULTURE AND CHILD MALNUTRITION IN MALI

By

Christopher L. Penders

Although Mali has experienced modest growth in agriculture over the past decade, rates of preschool child malnutrition remain alarmingly high. This thesis examines the links between agricultural development and preschool child malnutrition in Mali. A review of recent agricultural trends in Mali concludes that extensification is occurring throughout much of the country, and intensification is occurring in the rice zone of the Segou region. The data also suggests that farm households in the Sikasso and Koulikoro regions are substituting some cotton production for the production of cereals.

This thesis examines four areas in which agriculture affects malnutrition: income; community infrastructure; staple food prices; and labor allocations. Overall, the findings of this study are inconclusive regarding the relationship between agricultural commercialization and child malnutrition. Parameter estimates obtained from econometric analysis of child weight-for-height and height-for-age are consistent with findings from previous studies but are not robust to model specification. However, the research indicates several mechanisms through which agriculture can affect malnutrition. The effects of agricultural development on income and infrastructure suggest certain policy implications that exploit these links and identify specific areas for future research.

To my financé and my parents; without their love and enduring support this endeavor would not have been possible.

ACKNOWLEDGEMENTS

There are numerous people and organizations responsible for contributing to and improving this research. First and foremost, I would like to thank the members of my committee, Bob Myers, John Strauss, Loraine Weatherspoon, and in particular my thesis advisor, John Staatz. Without their unending advice and assistance, this research would not have been possible. Jim Tefft has also been an excellent source of help and information. I would also like to acknowledge the help of Carl Eicher, Michael Weber, Valerie Kelly and Josie Keel in this research and throughout my studies, and to Arthur Goldsmith, a professor of mine from Washington and Lee University.

I owe a special debt of gratitude to the Institut du Sahel for their assistance and would also like to thank those involved with the Demographic and Health Survey in Mali, particularly the people at Macro International and the DNSI in Mali. I also wish to thank the U.S. Agency for International Development Mission in Mali and Michigan State University for their generous support of my studies and this research.

I am deeply indebted to my mother for her editorial assistance and to my fellow graduate students, especially Brady Deaton who spent considerable time improving this research. All remaining errors are the sole responsibility of the author.

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CDC

CERPO

CMDT

DHS I

DHS II

DNSI

EBC

EMCES

HAZ

IUGR

LBW

MSSPA

NCHS

OMA

OPAM

PRMC

UNICEF

WAZ

WHO

WHZ

LIST OF ABBREVIATIONS

CDC	Center for Disease Control
CERPOD	Centre de Recherche sur la Population pour le Developpement
CMDT	Compagnie Malienne pour le Developpement des Textiles
DHS I	Demographic and Health Survey, Mali, 1987
DHS II	Demographic and Health Survey, Mali, 1995-96
DNSI	la Direction Nationale de la Statistique et de l'Informatique
EBC	Enquete Budget-Consommation, 1988
EMCES	Enquete Malienne de Conjoncture Economique et Sociale
HAZ	Height-for-age Z score
IUGR	Intrauterine growth retardation
LBW	Low birthweight
MSSPA	Ministère de la Sante, de la Solidarite et des Personnes Ages
NCHS	National Center for Health Statistics
OMA	Observatoire du Marche Agricole
OPAM	Office des Produits Agricoles du Mali
PRMC	Programme de Restructuration des Marches Cerealiers
UNICEF	United Nations Children's Education Fund
WAZ	Weight-for-age Z score
WHO	World Health Organization
WHZ	Weight-for-height Z score

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CHAPTER I

INTRODUCTION

1.1 Problem Statement

This thesis examines the links between agricultural development and preschool child malnutrition in Mali. Although Mali has experienced modest growth in agriculture over the past decade, rates of preschool child malnutrition remain alarmingly high. The most recent Demographic and Health Survey (DHS II), conducted from November 1995 to May 1996, found that 30 percent of children surveyed under three years of age suffer from *stunting* (low height-for-age), as defined by the World Health Organization (WHO 1995) (see section 2.3). Furthermore, nearly one-quarter, 23 percent, of the children surveyed under age three suffer from *wasting* (low weight-for-height).

While the levels of preschool child malnutrition are disconcerting, these figures also represent a deterioration in nutritional status from earlier studies[1]. Since the first Demographic and Health Survey (DHS I), conducted in 1987, wasting more than doubled, rising from 11 percent of the children measured under three years of age to 23 percent. Stunting increased by one-quarter, from 24 percent to 30 percent, from the first to the second survey. However, the levels of stunting in Mali are not unusual, and are in fact lower than those reported in Southern and Eastern Africa. Table 1.1 reports the percentage of children classified as "stunted" according to Demographic and Health Surveys conducted throughout Africa by Macro International.

[1] It is not clear that these statistics are truly comparable; differences due to sample selection, sample size, lower mortality rates and seasonal variation in weight and height may bias the results of the second DHS upwards.

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Table 1.1: Percentage of Children Under 3 Years Classified as Stunted from Anthropometric Studies in Sub-Saharan Africa

Country	Year	% Stunted	Country	Year	% Stunted
Benin	1996	25%	Niger	1992	27%
Burkina Faso	1992	25%	Nigeria	1990	37%
Burundi	1987	47%	Rwanda	1992	41%
Cameroon	1991	21%	Senegal	1986	23%
Central African Rep.	1994	34%	Senegal	1992	19%
Cote d'Ivoire	1994	24%	Tanzania	1991	47%
Ghana	1988	29%	Tanzania	1996	43%
Ghana	1993	26%	Togo	1988	31%
Kenya	1993	31%	Uganda	1988	44%
Madagascar	1992	45%	Uganda	1995	38%
Malawi	1992	41%	Zambia	1992	37%
Mali	**1987**	**24%**	Zimbabwe	1988	30%
Mali	**1995**	**30%**	Zimbabwe	1994	21%
Namibia	1992	29%			

Source: Demographic and Health Surveys, Macro International, Inc.

Over time, agricultural growth and economic development are associated with rising standards of living and improvements in nutrition (von Braun 1994a). However, in the short run, this process of transformation may have adverse consequences as well. During the period of time that elapsed between the two studies, both the agricultural sector and the overall economy in Mali grew in real terms. From 1987 to 1995, per capita gross domestic product (GDP), measured in constant (1987) local currency, rose 9.3 percent, an average annual rate of growth per capita of 0.8 percent (Les Comptes Economique du Mali 1998). Over the same period, the value of agricultural production per capita increased nearly 17 percent, an average annual per capita growth rate of 1.5 percent (Les Comptes Economique du Mali 1998).

However, the rate of growth for the Malian economy fluctuated substantially from 1987 to 1995. Agriculture, which accounts for approximately half of the GDP in Mali, is primarily rain-fed and production can vary significantly from one year to the next, dependi

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depending on climatic conditions. Real per capita GDP declined in 1988, in 1990 and 1991, and again in 1993. The rate of growth for real per capita GDP in years when GDP increased was 10 percent in 1989, 6 percent in 1992 and 5 percent in 1995 (Les Comptes Economique du Mali 1998). Variation in the annual growth rates for agriculture is even greater. In 1989, the agricultural sector grew 14 percent, in 1992 11 percent and in 1995 6 percent. Agricultural production fell 2 percent in 1990, 5 percent in 1991 and 12 percent in 1993 (Les Comptes Economique du Mali 1998).

The problem of child malnutrition in Mali remains despite growth, albeit uneven. The purpose of this research is not to question the desirability of agricultural development as an integral part of economic growth. Following the work of T. W. Schultz (1964), this thesis assumes that farmers in developing countries are "poor but efficient," and that rural households allocate scarce resources according to economic incentives. Instead, this research endeavors to understand the effects of agricultural transformation on the determinants of poor nutrition in young children in Mali.

1.2 Research Objectives

The overall objective of this research is to analyze the potential effects of growth in agriculture, through gains in production and productivity, on the anthropometric outcomes of preschool children, and to distinguish between some of the factors that may affect immediate indicators of malnutrition from those which may affect malnutrition over a longer period of time. This distinction may help assist policy makers in designing interventions that can offset potential adverse effects or exploit unanticipated benefits.

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Specifically, the objectives of this research are to: (a) review the literature on the biological determinants of nutritional outcomes in children and potential connections to agricultural transformation, (b) examine the recent changes in agriculture in Mali, (c) develop a set of testable hypotheses which emphasize the links between agriculture and child health and nutrition, and (d) test these hypotheses and identify the short and long-run economic determinants of preschool child nutritional status.

The primary motivation for this study is to apply economic analysis of child malnutrition to data collected in Mali. Although Mali has had several recent studies collect data on child anthropometry and other socio-economic variables, no multivariate analysis has been published regarding the underlying determinants of child malnutrition. Other studies in West Africa have analyzed growth retardation in young children from an economic perspective, notably Côte d'Ivoire (Strauss 1990, Sahn 1990) and Ghana (Alderman 1990). However, there has been little economic analysis of malnutrition in the Sahelian countries[2], which have somewhat lower standards of living and face different climatic conditions, in particular a shorter rainy season.

Another impetus for this research is to empirically test potential adverse consequences associated with agricultural development on child nutrition. Von Braun and Kennedy (1994) provide a detailed but by no means exhaustive nor conclusive analysis of the effects of agricultural commercialization on child health and nutrition. Few of the case studies included in their review, with the notable exception of Zambia, explicitly analyze the effects of changing female labor allocations on malnutrition.

A third factor motivating this research is careful selection and interpretation of variables used to explain nutritional outcomes in children. An extensive array of

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literature exists on child nutrition in developing countries. Scientists in health and medical related professions often include a host of socio-economic, endogenous variables without clear directions of causality. By including potentially endogenous variables in their empirical specification, these studies are plagued by problems of simultaneity that may lead to biased and inconsistent parameter estimates. For example, Strassman (1997) estimates the effects of polygyny on child mortality in the Dogon Escarpment of Mali using a binary (logit) model. However, from an economic perspective, the number of wives in a household is clearly an endogenous variable. Many economists have attempted to estimate the effects of factors such as income, education, infrastructure, prices and birth spacing (see Behrman and Deolalikar 1988 for a review) on health and nutrition. Regression analysis by economists often tests the same model specification for low weight-for-height (an immediate indicator of malnutrition) and small height-for-age (a longer-term measure of nutritional status). This study will review the existing literature on child malnutrition from both health and economic perspectives in order to carefully select and interpret the variables used to analyze the underlying determinants of short and long run nutrition.

1.3 Thesis Organization

The thesis is organized in the following manner. The second chapter is a review of the literature regarding child malnutrition and agricultural development. The scientific literature on the biological and related behavioral determinants of nutritional outcomes comprises the bulk of the chapter. Emphasis is also given to the extensive literature on

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[2] In particular, Mauritania, Senegal, Mali, Niger, Burkina Faso and Chad.

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agricultural commercialization and its effects on rural populations in developing countries, particularly where it relates to nutrition and health-related outcomes.

Chapter three presents an analytical framework for analyzing the potential links between agriculture and child malnutrition. First, a general conceptual model is presented to identify the different levels at which the underlying determinants affect nutritional outcomes. Next, a static one period economic model of household behavior is developed, specifically incorporating the production of health. Then, the reduced form model of nutritional outcomes, which will be used later for analytical purposes in chapter six, is presented.

The fourth chapter is a descriptive analysis of existing, available data on the agricultural sector in Mali, focusing primarily on regional-level data covering production, yield and area under cultivation since 1985. This section analyzes the changes in farming systems associated with agricultural development that could effect nutritional outcomes in children. Particular attention is given to potential changes in agriculture through extensification and intensification.

The fifth chapter is a descriptive and comparative analysis of child malnutrition in Mali. This section utilizes several different sources of child nutritional data, which are discussed in detail. First, the results of the DHS II are thoroughly examined in order to identify particular trends, patterns and anomalies. Then, these results are compared statistically, where possible, across studies in order to identify important changes and emerging trends.

Utilizing the information from the literature review and an understanding of both the recent trends in agriculture and malnutrition in Mali, chapter six puts forth a model and several hypotheses to be tested regarding child malnutrition and agricultural development. The reduced-form economic model of the household, developed in chapter three, is used to test hypotheses regarding agricultural development and their anticipated effects on anthropometry. The model attempts to distinguish between the immediate impact and the medium-term effects of the growth in agriculture through changes in production and productivity on child malnutrition. These hypotheses are tested using econometric techniques, and robustness of results is judged across model specification. A discussion of the data used to test the hypotheses, such as issues of sample selection, accuracy of the data and representativeness of the sample, is also included in the chapter.

The final chapter is reserved for concluding remarks and policy recommendations, given the results of the preceding chapters. This chapter also specifies areas for further research and hypotheses to be formally tested.

1.4 Background Information

Mali is a land-locked country, located in the middle of Sub-Saharan West Africa between 10 and 25 degrees north latitude of the equator. The country is 1,241,300 square kilometers in size, roughly twice the size of the state of Texas (Poulton and ag Yousouf 1998). Mali has a heterogeneous population of approximately 10 million people (World Bank 1999). Most of these people inhabit the southern half of the country, as the Sahara desert occupies the northern portion of Mali. Consequently, the density of the population varies substantially by geographic area. Some regions may have as little as five or fewer people per square kilometer, while much of the Niger River delta have population densities greater than 20 people per km^2 (Raynaut et al. 1997).

Figure 1

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Figure 1.1 Political Map of the Republic of Mali

Climatic conditions in Mali are determined by two alternating aerial fluxes, the Harmattan, a hot and dry wind blowing dust and sand from the Sahara desert, and a flux of humid air. These fluxes are regulated by the Intertropical Front (ITF), which is a zone of separation that oscillates from the Gulf of Guinea in January north to the 25th parallel in Augu

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in August (Raynaut et al. 1997). It is the movement of the ITF that determines the length of the dry and rainy seasons throughout West Africa.

Mali is often classified according to isohyets that correspond to different amounts of annual rainfall. These vegetative bands, which progress southward, help distinguish between the different agricultural and pastoral practices and strategies adopted. The Sub-desert band receives less than 200 to 250mm of rainfall each year and has a dry season of 10 months. This area is inhospitable to agriculture and inhabitants are usually linked to transhumanance and nomadism (Raynaut et al. 1997). The Sahelian band lies just below the sub-desert, from a range of 200 or 250mm to 500 or 550mm of rain each year. In this zone, agriculture and pastoralism can coexist (Raynaut et al. 1997). The Sub-Sahelian area receives 500 or 550mm to 750mm of rain each year. The North Sudanese band ranges from 750mm to 1000mm isohyets. The Sudano-Guinean zone, along the southern most portion of Mali, receives between 1000 and 1500mm of rainfall annually. In the Sub-Sahelian, North Sudanese and Sudano-Guinean zones, agriculture becomes increasingly more diversified while the importance of livestock diminishes. All of these isoheyts, which vary in location from one year to the next, have been moving progressively southward over the past 30 years (Raynaut et al. 1997).

Different types of hardpan cover much of the arable land in Mali. These soils, classified as *tropical ferruginous*, are thin, do not reserve moisture well and are better suited for livestock than for agriculture (Raynaut et al. 1997). Due to the low fecundity of these soils, they require replenishment, either by manure, chemical fertilizer or through fallow. The traditional system of land management worked well in Mali; however, given the growth of the population and new agricultural techniques, soil fertility has decreased and th

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and the yields for crops in many areas are declining (Raynaut et al. 1997). In particular, animal traction has expanded agriculture onto new, marginal areas, which reduces fallow periods and accelerates soil degradation. Furthermore, the increase in the number of livestock has also contributed to the problem through overgrazing.

Approximately 80 percent of the population are involved in agriculture (Poulton and ag Youssouf 1998) which accounts for roughly half of the GDP in Mali. While many of these individuals are considered "farmers," the term is really a misnomer. "Part-time farmers" would be more accurate, as many farming households may earn as much as 50 percent of their income from off-farm sources (Reardon 1998). Typically, "farmers" are also employed as artisans, blacksmiths, carpenters, masons, laborers or engage in micro-enterprise activities. Families that are typically thought of as being pastoralists are also farmers, and likewise farming households keep livestock. In reality, all of these households are diversifying an asset portfolio in order to manage risk, primarily associated with climatic conditions.

The area known today as Mali has a rich history of various kingdoms dating back to the ancient empire of Ghana, at least as far as the eighth century, according to written record (Fage 1969). Timbuktu was once a great center of learning in the Moslem world and the library housed one of the most impressive collections of scholarly Islamic work (Fage 1969). In the latter part of the nineteenth century, the French took control of much of West Africa. Under the Brussels Conferences of 1885 and 1890, Africa was divided among the European powers, and not until 1960 did Mali gain independence from the French.

Major economic reforms were undertaken in the 1980s, at the behest of the international donor community, the World Bank and the International Monetary Fund, including much privatization of formerly state-run enterprises. Although structural adjustment programs have helped to reorganize the Malian economic system from a more state-managed to a more market-driven system, the actual structure of the economy has changed very little (World Bank 1996). The creation of the Program to Restructure the Cereals Market (PRMC) in March 1981, was the first step in the privatization of the grain trade. Today, the mandate of the Malian Agricultural Products Office (OPAM), the former government run grain marketing board, has devolved to managing the strategic grain reserve.

Economic reforms have continued throughout the 1990's. In January 1994, the currency, as part of the CFA franc zone, was devalued 50% against the French franc. This devaluation helped boost livestock exports and was also critical for restoring the profitability of the cotton subsector as well (Institut du Sahel 1998). Other reforms included a reduction in tariff charges, which were necessary under the previous overvaluation of the currency (World Bank 1996).

Today, Mali is a fledgling democracy. Since the 1991 overthrow of Moussa Traore, a dictator who came to power in 1968, Mali has adopted a new constitution and held two successive democratic presidential and legislative elections. In the rich African tradition of discussion, a series of national concertations were held throughout Mali over a period of three days (Poulton and ag Youssouf 1998). These discussions, led by various ministers, involved a wide audience of participants, including village chiefs. These meetings formed the basis for beginning the process of political decentralization and regi

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and regional integration, as well as reconciliation for those parties engaged in the conflict in Northern Mali.

Politically, the country is divided into nine different regions: Kayes, Koulikoro, Sikasso, Segou, Mopti, Timbuktu, Gao, Kidal and Bamako. Each of these regions is further divided into a sub-regional level, or "cercle," and these administrative bodies are divided into smaller political entities, called an "arrondisement." As part of the concertation process, Mali is in the process of decentralizing the government and devolving power to newly created "communes" (Poulton and ag Youssouf 1998). These communes are roughly the same size as the previous arrondisements, but will not simply replace the old political administrative unit. Instead, these entities will elect their own administrators who will be responsible for the management of various activities, including the allocation of funds from the government and local taxing authority.

With the exception of ongoing conflict and tension in the North, a situation that arose, in part, from French occupation and was aggravated under Moussa Traore's reign, Mali's diverse population has been relatively peaceful (Poulton and ag Youssouf 1998). The major ethnic groups in Mali include the Bambara, Fula, Dogon, Tuareg, Songrai, Bozo, Malinke, Senufo, Miniaka, and Sarakole. Inter-marriage among different ethnic groups is common in Mali. French is officially the national language; however, most ethnic groups speak their own language, in addition to one or more other languages. Bambara is by far the most predominant language spoken in Mali. Islam is the major religion in Mali, and approximately 80 percent of Malians are Moslem, although animism is still practiced in some of the more rural areas (Poulton and ag Youssouf 1998).

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Geography, climate, and environment help shape the political ecology of Mali. People's choices are constrained by these ecological factors and their set of choices is conditioned by historical and cultural norms. This complex web of relationships has a profound impact on the prevalence of child malnutrition. The physical quantity and quality of food produced by the household will affect a child's nutritional status as will taboos and norms of behavior regarding feeding practices and health care. It is within this context that changes in nutritional outcomes associated with agricultural development and economic growth must be viewed.

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CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Malnutrition is a complex problem resulting directly from inadequate nutrient intake, disease and the interaction of these two factors. This chapter summarizes the literature on the biological and behavioral determinants of malnutrition and the effects of agricultural commercialization on nutritional outcomes. First, the term "malnutrition" is discussed (section 2.2). Next, the major consequences of poor nutrition are identified (section 2.3). Section 2.4 reviews the major anthropometric measures of malnutrition. Section 2.5 summarizes the intermediate factors associated with malnutrition, focusing on prenatal growth retardation (2.5.1), the role of the caregiver (2.5.2), foods and feeding practices (2.5.3), education (2.5.4), fertility preferences (2.5.5) and the disease environment (2.5.6). The following section (2.6) discusses agricultural commercialization and the potential impact this process may have on health and nutrition for farmers in developing countries. Particular attention is given to the debate concerning cash cropping versus food cropping (2.6.1) and the distribution of resources among members of the household (2.6.2). The last section (2.7) offers a brief summary of the major points identified in the chapter.

2.2 Malnutrition in Preschool Children

Malnutrition is the direct result of an inadequate dietary intake, the presence of disease, or the interaction of both factors (WHO 1995). Growth retardation (or growth

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faltering) among children is commonly referred to as malnutrition. This leads to the conclusion that their diet is inadequate, either in quantity or quality. However, the weight of evidence unequivocally indicates that growth faltering is a non-specific response to a variety of factors (Mosley and Chen 1984). As Bradley and Keymer (1984) point out, it is virtually impossible to determine, in practice, whether children are malnourished due to the presence of parasites, or if the children harbor these parasites because they are undernourished. The maintenance of vital functions receives higher priority than growth; consequently, growth retardation is the result of a variety of complicating factors (Martorell 1995).

Numerous factors contribute to disease patterns and nutrient intake, such as the indigenous diet, feeding practices, the foods offered to children, in part a function of cultural norms, children's appetites when feeding does and does not occur, food and liquid contamination, and the sanitation of the environment (Martorell 1995). Engle (1995) notes that child growth and development is the continuous interaction between the child and the environment. Nutritional outcomes are determined by shifts in the child's ability to improve a system of self-regulation as the child ages, in addition to the constitution and vulnerability of the child, as well as household resources.

Martorell (1995) lists four reasons why children under the age of three are most affected by malnutrition. First, rates of growth for children are highest during infancy, thus there is a greater potential to retard growth. Second, young children have high nutritional requirements. Third, children have not been exposed to many diseases and are therefore more susceptible to illness. Fourth, children are more likely to suffer from inadequate caregiving behavior, because they are less capable of articulating needs.

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During the second year of a child's life, the incidence of infection and rates of malnutrition are highest (UNICEF 1993). It is during years two and three when the effects of family resources, both wealth and poverty, begin to manifest themselves (Engle 1995). At this point in a child's life, the development of motor skills exceeds that of his or her cognitive ability. Although the child may be capable of self-feeding, assuming that food is available, the child may not understand which foods should or should not be eaten (Engle 1995).

After three years of age children are better able to care for themselves. Cognitive and motor development allows these children to feed themselves and avoid harm. Many children at this age become part of a culture of children, where they may even become responsible for the care of younger siblings (Werner 1984, as cited in Engle 1995). At this point, children are capable of obtaining food and are wise enough to begin protecting themselves from their environment (Johnston, et al. 1980, as cited in Engle 1995).

2.3 Consequences of Malnutrition

Child malnutrition has three major effects: (1) increasing the probability of death, (2) growth retardation, and (3) poor scholastic achievement (Martorell 1995). The probability of death is heightened directly through starvation or indirectly by complicating and facilitating other health problems which result in death. The risk of dying from a disease is twice as high for mildly malnourished children, five times as high for moderately malnourished, and eight times greater for children classified as severely malnourished (UNICEF 1996). Vitamin A deficiency alone will increase the risk of death from measles and diarrhea by 33 to 50 percent (UNICEF 1996). Malnutrition is reported as

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reported as a complicating factor in more than half of all deaths in low income countries for children under five years of age (Gillis, Perkins, Roemer and Snodgrass 1987).

Malnutrition contributes both directly and indirectly to growth retardation as well. Growth faltering in early childhood is permanent and independent of growth occurring after five years of age (Downes et al. 1991). The result of growth retardation is smaller adult body size, which reduces the body's capacity to work, as measured by maximum oxygen consumption, and increases obstetric risk for women (Martorell 1995). Reduced capacity to work is particularly significant for agrarian societies; such an effect could facilitate a vicious cycle. Haddad and Bouis (1991) conclude from their study of The Philippines that adults primarily involved in agriculture and who are stunted as a result of growth retardation during childhood may earn substantially less income over their lifetimes.

Severe malnutrition is associated with retarded physical and mental development, and behavioral problems that remain throughout later years (Sigman et al. 1989). The effects of mild and moderate malnutrition in children are more ambiguous. Malnutrition is also associated with poor psychological test performance and low scholastic achievement (Pollitt 1988). In a study of children from Kenya, aged 18 to 30 months, Sigman et al. (1989) find that mild to moderate malnutrition is associated with lower cognitive, physical and motor development in children. However, the study also highlights the importance of other socioeconomic factors in determining these outcomes.

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2.4 Anthropometric Measures of Malnutrition

The three most commonly used anthropometric indices of malnutrition are weight-for-height (WHZ), height-for-age (HAZ), and weight-for-age (WAZ) (WHO 1995). Low weight-for-height, also referred to as *wasting*, is considered a short run or immediate indicator of malnutrition. Low height-for-age, also referred to as *stunting*, is a more medium-term proxy for poor nutrition. Low weight-for-age, also called *underweight*, identifies elements of both wasting and stunting, and can be used as an overall measure of a population's health. Each of these measures must reference a population mean, usually in the United States, where "Z" indicates the number of standard deviations from the mean or median of the reference population. If the child's measurement falls two or more standard deviations below the mean of the reference population, the child is considered to suffer from wasting, stunting or being underweight (WHO 1995). The Z score is calculated as follows:

$$\text{Z score} = \frac{\text{Observed value} - \text{Median value of the Reference Population}}{\text{Standard deviation of the Reference Population}}$$

The above anthropometric indices are regarded to be good indicators of the overall health of a child, and the benchmark of two standard deviations below the mean is a widely accepted criterion (Martorell 1995). However, these methods of measurement are not without controversy. The U.S. standards are derived from two different sources of data. The Fels Research Institute measured children under two years of age from 1929 to 1975, while the Center for Disease Control was responsible for measuring children aged 2 to 18 years from 1960 to 1975 (WHO 1995). Martorell (1995) notes that for certain ages, particularly 13 to 24 months, the absolute rate of growth is small relative to individual variation resulting from sweat loss, defecation, food consumption, water intake and the p

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and the precision of measurement instruments. Martorell (1995) also notes that, "growing bigger is better than big is better (p. 15)." The concern is that young children, whose poor growth may not yet be clearly observable, may be growing slowly, while older children, who are stunted as a result of past growth faltering, are currently growing at an acceptable rate.

Seckler (1982) purports the "small but healthy" hypothesis, whereby stunting is an adaptation to poor nutrition. Other critics support Seckler, noting that the recommended caloric standards for daily consumption are too high, although this may overlook the role of micronutrients. Sukhatme (1982, as cited in Mosley 1984) argues that growth faltering is the body's natural response, not a pathological one, to a reduced diet. This definition of malnutrition could have profound implications for public policy. For example, using Sukhatme's definition, in India the number of children classified as malnourished would decrease from 250 million to 50 million (Mosley 1984).

Mosley (1984) suggests that indicators of growth retardation should be combined with measures of mortality to create one single variable. This new variable could then be scaled across a population to represent the relative risk of mortality by various groups within the sample population. The risk of mortality in newborns appears to increase exponentially with subsequent deviations in Z scores (Federici and Terrenato 1980, as cited in Mosley 1984). Such a measure could not be used to compare countries, because different nations have distinct rates of mortality.

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2.5 Biological and Social Determinants of Child Malnutrition

Genetic differences in height for young children across ethnic groups in well-nourished populations are small. WHO (1995) reports that these differences result in a variation of approximately 1 cm difference in height for five year old children throughout the world. The largest source of variation in attained height and weight for preschool children is associated with socioeconomic status (WHO 1995).

The proximate determinants of wasting and stunting are inadequate dietary intake and disease (Martorell 1995, WHO 1995). The underlying socioeconomic factors, for example income, education and culture, affect the proximate determinants either directly or indirectly through various causal relationships (intermediate factors) (WHO 1995). For example, higher levels of income may enable households to purchase more (or less) nutritional foods or increase the usage of health facilities. Greater education may improve the manner in which households utilize available resources to improve health and nutrition. Improvements to infrastructure can reduce the opportunity cost of acquiring information and inputs into the production of health and nutrition. For a full description of the interaction between proximate, intermediate and distal factors that influence nutritional outcomes, see the conceptual model presented in chapter three, section 2.

2.5.1 Prenatal Growth Retardation

The single, most important factor associated with child survival is birth weight (Newman 1987). Overall, infants who suffer from intrauterine growth retardation (IUGR) have higher rates of morbidity and mortality (Villar, et al. 1984). Low-birth-wei

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weight (LBW) babies, defined as weighing less than 2.5 kilograms at birth (WHO 1995), are more likely to suffer from stunting and other illnesses than are other infants (UNICEF 1996). Martorell (1995) notes that maternal size, determined in part by past growth stunting and current nutritional status, and reproductive success are related. In a study of LBW infants in The Gambia, neither babies born pre-term nor full-term demonstrated any capacity to "catch-up" by growing faster than other infants born in the same village (Downes, et al. 1991).

Naeye and Peters (1982) show that the growth retardation of newborns in the U.S. is most severe when the mother works away from home during the last trimester after the twenty-eighth week of gestation. Furthermore, the study by Villa, et al. (1984) in Guatemala concludes that IUGR infants are more likely to be the result of maternal malnutrition during pregnancy and not genetic differences. These children, who came from the lowest strata of socioeconomic backgrounds, scored lowest on developmental tests. In addition to the negative impacts of maternal work on prenatal growth retardation, most evidence also shows that maternal work during the first two months of a child's life is negatively associated with nutritional status (Engle 1995).

2.5.2 Caregiver Interaction

Unfavorable childcare practices and unsynchronized patterns of interaction between the caregiver and the child in the early stages of development contribute to higher rates of growth retardation and sub-optimal behavioral development (Engle 1995). Although the child plays an important role in establishing the bond between caregiver and child, the initial responsibility rests with the caregiver (Wachs et al 1988, as cited in

Engle 1995). Engle (1995) remarks that caregivers who are more responsive to a child's needs are more capable of nurturing malnourished children back to a healthy status. Factors such as the educational attainment and nutritional status of the mother are associated with caregiving activities in low-income countries (Mosley 1984).

There is mounting evidence that poor nutritional and health status for the child, which manifests itself through behavior and physical appearance, may affect the way in which the mother or other primary caregivers react and respond to the child (Ricciuti 1981, as cited in Engle 1995). Other factors may include disabilities, gender, parentage and attractiveness. The behavior of malnourished children may further impair the bond between mother and child. Irritating cries, out-of-sync sleep patterns, and frequent illness can all contribute to weakening their relationship (Engle 1995).

Apart from the direct impact of breastfeeding on child nutrition, breastfeeding also affects future nutritional outcomes indirectly, through enhanced (or reduced) maternal-infant bonding (Huffman and Lamphere 1984). Factors that reduce the caregiver's ability to observe and react to the child's need, such as depression or overwork, will increase the risk of mortality. Research in the United States has focused on the links between low birth weight (or sickliness) with failure to thrive (FTT). Children that become FTT are typically low-birth-weight infants and children who are difficult to feed (Lozoff 1989, as cited in Engle 1995).

Throughout the world, the care of children is performed not just by mothers, but by other family members as well. Leslie's (1988) review of nearly 30 empirical studies shows no conclusive evidence that women's work should be expected to have a negative impact on the nutrition of young children. However, during infancy, poor nutritional r

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status is associated with mothers who work away from the home. This association is not apparent during the second and third years of a child's life. Engle (1995) notes that mothers working at home are generally less responsive to their child's needs, and also that children being cared for by older siblings and teenagers tend to eat less than other children.

2.5.3 Foods and Feeding Practices

The process of weaning a child, from the introduction of solid foods to the end of breastfeeding, is a critical element, if not the single most important factor, in determining the nutritional status of a child (Martorell 1995). Growth faltering is associated with the introduction solid foods too early or too late in a child's life, the types of solid foods introduced, how much supplemental breastfeeding occurs, and whether breastfeeding stops too early or too late. UNICEF (1996) recommends that all infants be exclusively breastfed until approximately 6 months of age, after which solid foods, in addition to breast milk, should be introduced into the diet. Children in Mali are often given water and other liquids, such as water, before 6 months of age, and the solid foods introduced into the diet are most often a watery millet or sorghum porridge (Dettwyler 1992). Many of the customs surrounding the process of weaning in low-income countries actually foster malnutrition, for example not offering meat to children (Engle 1995).

Engle (1995) reviewed a number of studies that report a variety of reasons why children were not eating all of the food offered. The main reasons were poor quality, low nutrient density, poor taste, illness and appetite loss, inappropriate timing, failure to assist the child and offering too much food initially. The studies show that better nutritional status, as measured by HAZ and WAZ, is associated with the frequency with which a child finishes its food. There is the problem of circularity created by illness, whereby a child who is ill is unable to consume as much food, thereby increasing malnutrition which in turn may worsen the severity of the illness.

Studies such as Dettwyler (1992) demonstrate a positive association between the child's nutritional status and the active role of caregivers in feeding. However, Bently et al. (1991), as cited in Engle (1995), note that caregivers are more likely to encourage children to eat when the child is ill, in which case maternal activity would appear unrelated to nutritional outcomes. In an earlier Dettwyler study (1991) of Mali, the cultural norm is the perception that children know how hungry they are; consequently, food is not forced upon them. Engle (1995) lists several problems with food availability as a poor measure of actual food consumption for children. The suggestion is that more data are needed on feeding time and frequency, food quality, nutrient and caloric density, child appetite and refusal, active feeding behaviors by the caregiver and beliefs and cultural norms regarding child feeding practices.

Studies of the intrahousehold distribution pattern of food and other resources in developing countries often show that age and gender affect how the food is distributed among family members (Rogers 1990). However, differences between children and other household members tend to even out when snacks and between-meal feeding is accounted for in the study (Engle 1995). Supplementary feeding, which usually starts during the first year of life, forms the basis for social interaction. Rogers (1995) cites a review of several studies in developing countries by Lipton (1983) which show women l

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and children usually receive equitable food shares in the household, but diarrheal disease is responsible for higher rates of child malnutrition.

A study of a rural village in The Gambia by Thompson and Rahman (1967) paints a picture very similar to the case studies presented by Dettwyler (1991, 1992) in Mali today. Thompson and Rahman (1967) observe that children were typically breastfed, on demand, for the first three to four months, at which time gruel made from rice and water was introduced into the diet. By one year of age, most children were eating small portions of the family's meal. Some children were fortunate enough to receive cow's milk regularly from a very early age on, while others received none at all. Supplemental breastfeeding did occur, as the child demanded; however, only one-third of the children in the survey were breastfed for a full two years. Once the decision was made to wean, children in this society were sent away to live with a relative to ease the weaning process.

2.5.4 Education

There is overwhelming evidence throughout the world that formal maternal education is associated with lower levels of child mortality. Women who have been to school have fewer children die than women who have not been to school (Ware 1984). However, it remains ambiguous how five or six years of schooling could substantially reduce these rates of mortality (Engle 1995). Most of the hypotheses relate education to levels of fertility, but little is known about how these effects actually occur.

Much of the economic literature on education and its impact on fertility follows Becker (1981), who argues that higher levels of education in women will increase the opportunity cost, through lost wages, of having children and hence reduce fertility.

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Furthermore, as the level of schooling in a country rises, the cost of educating a child becomes more expensive as well, further reducing the demand for children.

Behrman and Wolfe (1984) discuss four different impacts of women's education on the household. First, it will increase the wage rate paid to women and thus increase household income. Second, women may become more efficient in the production of non-market (home produced) goods and services. Third, education could be responsible for changing preferences (however, making tastes endogenous to the economic model of the household poses serious problems). Fourth, education could change the bargaining position of women in the household (this, too, presents difficulties to the standard economic model, as it implies a negation of the assumption of unified preferences). Behrman and Wolfe's (1984) study of nutrient demand in Nicaragua found women's schooling to be not only positive and significantly related to all seven nutrients measured, but also to have a larger impact in magnitude than either income or household size.

Traditional nutrition education programs in developing countries have been ineffective, primarily because the content is too theoretical, the use of food groups is out of context, and the suggestions are not economically feasible for the household (Cerqueira 1995). Many health and nutrition programs use mass media, such as television and radio, to broadcast messages to a large audience. These programs, which often invest significant amounts of capital, have very limited, if any, real impact on health and nutrition (Cerqueira 1995). One criticism is that these messages reflect the sender's concept of what is important. However, Cerqueira (1995) notes that nutrition education programs can have a positive impact on nutritional status if the participants are actively engaged in the project.

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2.5.5 Fertility Preferences

Birth intervals and the mother's age are also important determinants of child malnutrition. Shorter intervals between children increases child mortality, growth faltering and intrauterine growth retardation, independent of confounding factors, for both the younger and older siblings (Haaga 1995). Infants may be abruptly weaned when the new pregnancy is realized. In the study of The Gambia by Thompson and Rahman (1967), more than one-third of the women ranged from 6 weeks to 5 months pregnant when lactation ended for children under two years of age. Haaga (1995) also notes that infants of both younger and older mothers face a higher risk of mortality and growth retardation, and that children with six or more siblings are also more likely to die.

Large numbers of young children in a household could have a negative affect on nutritional outcomes through congestion, by increasing the risk of contracting a disease, or through competition, whereby fewer resources, either food or parental care, can be allocated to each child. In an economic sense, fertility, or household composition, is an endogenous variable. Becker (1981) puts forth an argument that the demand for children is based on a tradeoff between quantity and quality. As the cost of raising children increases, the number of children demanded will decrease. Furthermore, as incomes rise, households may not demand more children, but, through substitution effects, demand fewer, more well-educated (higher quality) children. Similar to the preceding section on education, as a woman's marginal physical product of labor rises, the opportunity cost of having children, operating through lost wages, increases the "price" of children and therefore reduces demand.

Singh (1988) lists a number of reasons why families choose to have children. Quoting T. W. Schultz, Singh emphasizes that, "children are, in a very important sense, the poor man's capital." Children provide important contributions to the household, through work and as "insurance" in old age. Because the cost of producing children is low in most developing countries, there is an incentive to have more children, and, consequently, to marry more wives. Singh (1988) also finds that livestock, used as a proxy for wealth, are positively correlated with the number of children in the household.

2.5.6 Water, Sanitation and Disease

Water, sanitation and disease all have tremendous effects on children's health and nutrition. Todaro (1989) notes that water-borne diseases such as cholera, typhoid fever and a variety of diarrheal diseases are responsible for 35 percent of all deaths of young children in Africa, Asia and Latin America. Evidence from around the world also shows that clean water and better sanitation are associated with decreased morbidity from diarrhea, ascariasis, shistosamiasis, guniea worm and trachoma, as well as lower rates of child mortality and better nutrition (Burger and Esrey 1995).

Access to clean water and proper waste disposal systems does reduce exposure to many diseases and the risk of diarrhea (UNICEF 1996). However, water collection can be a very time intensive activity for women in developing countries (UNICEF 1996), an effort that varies according to season. Although community water supplies may be clean, contamination, usually fecal, occurs sometime between collection and ingestion.

Intestinal parasites and diarrhea often result in growth retardation and contribute to malnutrition by diminishing the body's ability to absorb and retain nutrients and by increasing the body's requirements (UNICEF 1996). Measles are another debilitating childhood disease that plays a significant role in the malnutrition-infection cycle. Infectious diseases can also contribute indirectly to malnutrition by causing appetite loss (WHO 1995). Malaria is yet another tropical disease that is also associated with growth retadation in children (WHO 1995). It is very difficult to distinguish the causal relationship between parasites and malnutrition. Hosts may harbor parasites because they are malnourished or hosts may become malnourished because they harbor parasites (Bradley and Keymer 1984). Malnutrition may also increase the susceptibility to parasites already present in the host. Measles, malaria, dysentery, giardia, guinea worm, shistosamiasis, river blindness, yellow fever, hepatitis and other diseases and parasites are all present in Mali.

2.6 Agriculture and Malnutrition

According to Mebrahtu, et al., (1995) agricultural development can affect health and nutrition through the following intermediate pathways: (1) household income, (2) relative food prices, (3) time allocation, especially for the primary caregiver, (4) energy and nutrient expenditures, (5) changes in the nutrient composition of foods, and (6) exposure to disease caused by changes in the environment associated with input use, particularly water and sanitation, technological change and resettlement or other rural projects.

Mebrahatu, et al. (1995) then list four types of agriculture change: (1) agricultural research and technology, (2) commercialization, (3) rural development, and (4) pricing and marketing policies. It is difficult to isolate any one factor from the others, as many of

these changes are intimately related. In Mali, agricultural development has been sparked, to some extent, by cotton production. The cotton company, la Compagnie Malienne pour le Developpement des Textiles (CMDT) is the primary research and development organization for cotton through its parent company. Furthermore, CMDT is heavily involved in rural development projects, which are funded through its sales of cotton. Finally, through negotiation with the government and the union of cotton producers, SYCOV, CMDT sets producer prices for seed cotton.

Kurth (1989) studied child malnutrition in and outside of the Lilongwe Rural Development Project (LRDP) in Malawi. The study found that income was statistically significantly greater in the LRDP zone. However, levels of child malnutrition were not significantly different between the two areas, nor were levels of maternal education. Dewey (1981), in a study of a rural village in Mexico, finds a negative association between the share of land devoted to cash crops and the nutritional status of preschool children, despite the higher incomes of households producing more cash crops.

These findings underscore the need for precision in estimating income and price effects from growth in agriculture through changes in production and productivity. First, households must be identified as either net buyers or net sellers of staples. Then, due to the high marketing margins in most low-income countries, differences between producer prices and consumer prices must be determined as well in order to understand the full effects of cash cropping (Jayne 1994).

Fleuret and Fleuret (1980) emphasize the role of cultural practices in affecting nutritional outcomes. Many societies throughout the world, particularly those in developing countries, have encouraged equitable distribution of food among households.

However, cultural factors within these societies often encourage an inequitable distribution among household members. Several studies (Kolata 1978, Wilmsen 1978, and others, as cited in Fleuret and Fleuret 1980), report that throughout the world societies systematically deprive pregnant women, lactating women and children of proper nutrition in part, at least implicitly, to control fertility and population growth.

2.6.1 Cash Cropping versus Food Cropping

Von Braun and Kennedy (1994) review the results from International Food Policy Research Institute (IFPRI) studies of agricultural commercialization schemes in The Gambia, Guatemala, Kenya, The Philippines, and Rwanda, in addition to synthesizing the results from studies of Malawi, Papua New Guinea, and Sierra Leone. Von Braun (1994b), studying household income in cash-cropping projects, finds that income increased in cash-cropping schemes for six of the eight countries. Income fell in Papua New Guinea and Sierra Leone; however, in Sierra Leone the results are ambiguous because the commercial scheme is a tree crop, and due to the length of the study, the full returns to investment were not yet known. Furthermore, in the case of Papua New Guinea, the upstart company faced a series of financial setbacks, including a fire and a drought, which contributed to its failure. Given these results, the initial assumption that agricultural commercialization will increase household income seems reasonable.

Bouis (1994), using the same data as von Braun and Kennedy, studies the effects of the share of income on food expenditures. These results are also included in the following section. Total household expenditures were used as a proxy measure of income, following the permanent income hypothesis (Friedman 1957). In each of the

case studies, increases in income (total expenditures) led to greater absolute expenditures on food. Bouis concludes that, with the exception of Rwanda, neither the difference in the marginal propensities to consume for men and women nor the percentage of income earned from commercial crop production has a substantial effect on household food expenditures.

Table 2.1 presents a summary of the findings from von Braun (1994b), Bouis (1994) and Kennedy (1994) of the effects of agricultural commercialization on income, food consumption, food expenditures and health and nutrition. The results of von Braun's (1994b) regression analysis of income and sources of income on child nutrition, as measured by undernutrition (WAZ – an overall indicator of both short- and long-run malnutrition), are summarized below in Table 2.2 (page 34). Some of the results from Kennedy's (1994) Tobit analysis of child morbidity on selected variables are also included (most of the variables are not economic ones). Morbidity is a different proxy for health, which measures the incidence of illness among children.

The findings from the von Braun analysis are, to some extent, consistent with the hypothesis that higher levels of income will improve nutritional outcomes. However, although is positive and significantly related to weight-for-age Z scores, the absolute effects of income in the von Braun analysis are small in most of the countries studied. In four countries, a 10% increase in income was associated with a range of 1% to 2.5% increases in the child's WAZ score; in Kenya, the result was not statistically significant. Only in Malawi was the result substantial, at 5%. Furthermore, little explanation of the income-squared variable is given relative to the level of income. Essentially, the negative

Table 2.1: Effects of Agricultural Commercialization on Income, Food Expenditures, Caloric Consumption, Health and Nutrition

Country	Agriculture Project	Subsistence/ CashCrop	Subsistence Crop Prod.	Household Income	Food Expenditures	Caloric → Consumption	Impact of Inc. Source	Health and Nutrition →	Impact of Inc. Source
Kenya (a)	Sugar	Maize/ Sugarcane	No change	Increased Significantly	Increased for meats and fruits	Increased	Women's inc. beneficial; off-farm neg.	No change	No effect; sanitation most important
Kenya (b)	Irrigated Rice	Maize, Sorghum, Rice, Sugarcane	Decreased for some	Increased for some	Not Available	Increased for some	Women's income beneficial	Improved for nutrition, not for health	Diversity more important than inc.
Rwanda	Potatoes	Beans, Sweet Potatoes, Maize/ Potatoes, Tea	No change	Increased somewhat	Increased for meats, staples (potatoes)	Increased	Poor, female-headed families eat more staples	Improved for nutrition, effect on child is small	No source effect; higher income → ↑ health
Zambia	Maize – techno-logical change	Maize, Millet Sorghum/ Hybrid Maize	Not available	Increased by 25%	Not Available	Increased	Not Available	Improved for health, nutrition for child < 5 yrs.	Not available
Malawi	Maize and Tobacco	Maize, Legumes/ Maize, Tobacco	No change	Increased for some; wide variation	No increase	Increased	Women spend more than men on food 25% vs. 13%	No change	No source effect; higher income → ↑ health
Sierra Leone	Tree Crop	Vegetables, Rice, Roots/ Coffee, Cocoa	Decreased, but partially offset by higher yields	Decreased 12%; tree crop hasn't matured yet	Decreased	Increased	No effect	Children of comm. farmers worse off	Off-farm inc. raises, tree crop → ↓ health
The Gambia	Small-holder Rice	Millet, Rice Sorghum/Peanut Irrigated Rice	Increased; new technology raised yields	Increased	Increased for meats and fruits	Mixed results; higher incomes help	Lower women's share of rice reduced calories	Improved for women, kids in poor families	No source effect; higher income → ↑ health

Source: von Braun, Bouis and Kennedy, International Food Policy Research Institute, 1994.

Table 2.2: Results of von Braun (1994b) and Kennedy (1994) Regression Analysis

Variable	The Gambia	Guatemala	Kenya	Malawi	The Philippines	Rwanda
Von Braun: Regression of selected variables on underweight Z scores (WAZ) in children						
Income	Positive & significant	Positive & significant	Positive, not significant	Positive & significant	Positive & significant	Positive & significant
Income-squared	Negative & significant	Negative & significant	Negative, not significant	Negative & significant	Negative & significant	Negative & significant
Income share from cash crops	Positive, not significant	Positive, not significant	Positive & significant	Negative, not significant	Positive, not significant	Positive, not significant
Male off-farm income share	Negative & significant	Positive & significant	NA	Negative, not significant	NA	NA
Female income share	Negative & significant	Positive & significant	NA	Positive, not significant	NA	Negative, not significant
Kennedy: Tobit regression of selected variables and child morbidity						
Participate in cash crop	Positive, not significant	Negative & significant	Positive, not significant	Positive, not significant	Positive, not significant	Positive, not significant

results could be overwhelming the positive effects, particularly if measured in local currency, where $1 may equal 5000 local units.

The analysis by Kennedy regarding the effects of participation in cash cropping schemes on child morbidity tests, to some extent, the relationship between cash cropping and improvements to environmental conditions (infrastructure). Unfortunately, such a vague dummy variable may be accounting for other impacts as well, such as differences in infrastructure. The results are ambiguous; in five of the six countries, the coefficient is positive but not significant. In Guatemala, the variable was actually negative and significant. In the Von Braun analysis, the increasing shares of income from cash cropping was not significantly associated with better weight-for-age Z scores, although most coefficients were positive. Further analysis is necessary before any conclusions may be drawn.

Kumar and Siandwazi (1994), in a study of maize production in Zambia, examine the effects of seasonal factors, among others, on child nutrition. Although the number of stunted children is consistent throughout the study, which follows naturally given that stunting is a permanent condition, weight-for-height fluctuated according to the season. Weight-for-height Z scores in children under 5 years were worse during the month of February, when weeding was occurring in the fields. Women made up nearly two-thirds of the labor force in the valley where maize production was being studied during this period.

Other studies typically find no negative impacts on child anthropometry associated with cash cropping (commonly measured as the percentage of land devoted to cash crops). In a study of four Mexican communities, DeWalt, et al. (1990) find no statistically significant difference in the anthropometry of children between families that grew the traditional maize crop and those that had shifted to producing sorghum (the cash crop). Immink and Alarcon (1993) also find no negative effect on child nutrient consumption associated with agricultural commercialization in Guatemala. Von Braun and Immink (1994) report in a study of the same children in Guatemala that total expenditures increased by 38% on average for participating farmers and income gains were greatest for small farmers. Children in the study area were somewhat better off nutritionally than other children; however, the study area is near in proximity to the capital, which may represent the impact of better infrastructure.

Bouis and Haddad (1994) conclude from a study of households involved in sugarcane production in The Philippines that raising income is a necessary but not sufficient condition for improving child nutrition. Higher incomes in The Philippines stud

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study translated into greater expenditures on foods, particularly higher priced foods such as meats that children did not necessarily benefit from. However, farmers who lost access to land and choose not to farm sugarcane fared worse and their children are more likely to be stunted. Kennedy (1994a), in a study of sugarcane production in Kenya, finds that although income is higher for sugarcane farmers, there is no significant relationship between higher incomes and reduced levels of morbidity in children.

In a study of children in Rwanda, Blaken, von Braun and de Haen (1994) conclude that nutrition is largely related to health and sanitary conditions. However, the study does find that higher incomes through potato production increased caloric consumption for food deficit households that translated into small improvements in Z scores for children. Von Braun (1988) finds no negative or positive affect on child anthropometry associated with technological change in rice production in The Gambia. Sahn (1990a) concludes that children in households that grow crops for export do not have a higher probability of being malnourished than other children in Côte d'Ivoire. However, Sahn (1990b) finds significant negative effects of land holdings per capita on weight-for-height. Sahn concludes that households with more land under cultivation will likely require more participation from women, reducing the amount of time spent caring for children.

While agricultural growth may be a necessary condition for improving nutritional outcomes in the aggregate, it is clearly not sufficient. Cash cropping schemes are associated with higher incomes. However, the resulting increase in income is associated with only minor improvements in levels of malnutrition in children. Claims by critics that

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that cash cropping schemes would lead to a reduction in food availability at the household level and a worsening of nutrition appear unsubstantiated.

2.6.2 Intrahousehold Resource Allocation

The rules for allocating resources among household members may have a significant effect on nutritional outcomes in children, particularly if the preferences of family members differ substantially (Behrman 1995). Growing evidence suggests that income earned by family members, at least in developing countries, is not pooled (Bruce and Lloyd 1997). In a review of several empirical tests of the unified household model, Hoddinott, Alderman and Haddad (1997) conclude that econometric errors could not be responsible for all of the rejections of the hypothesis that income is pooled.

Men and women have different levels of access to various types of household resources in Mali. A study by De Groote and Coulibaly (1988) shows that access to land and to factors of production are affected by gender, age, ethnicity and marriage. Approximately half of the women in the study had access to private plots of land, while only 10% of the men had such access. However, men had much more access to animals than did women. These distinctions reflect, in part, different responsibilities among household members. In Mali, men are usually responsible for preparing the fields for cultivation, hence the need for animal traction, whereas women are often responsible for sowing the seeds and weeding.

The issue of intrahousehold resource allocation could have profound implications for development policy in low-income countries. Policy is often designed to target households within a given income strata or characterized by other distinguishable factors.

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However, with regard to nutrition, certain family members within the household may be malnourished while others are not, irrespective of income. Understanding the distribution of resources within the household may assist policy makers in more appropriately targeting at-risk individuals as opposed to at-risk households (Haddad 1994).

Intrahousehold resource allocation is a controversial topic among economists. The suggestions that income is not pooled and preferences may not be "unified" have serious implications for the standard neoclassical economic model of behavior. If, in fact, the control over household resources determines, in part, what goods and services are purchased, then the household may not attain a Pareto efficient allocation of resources (Doss 1996). Behrman (1995) notes that the assumption that households act "as if" to maximize a unified set of preferences is too strong; it is more likely that the allocation of household resources is the outcome of implicit and explicit bargaining among family members.

Thomas (1997) tests the unified household model with respect to the demand for numerous goods and services according to income ownership by male and female members of the household. This model is rejected, and Thomas (1997) shows that a greater share of the household budget in the hands of women is more likely to be spent on household services, health, education and certain leisure activities. Furthermore, calorie and nutrient consumption increase much faster through increases in women's income than for male's incomes within the household. The increase in nutrient and calorie consumption is also associated with positive effects on child nutritional status; raising won

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women's income within the household is more beneficial for children's anthropometric measures of weight-for-height and height-for-age.

2.7 Summary

Malnutrition is a complex problem, resulting directly from the interaction between nutrient intake and disease. Growth retardation, commonly referred to as malnutrition, represents a non-specific response to a variety of factors. The consequences of malnutrition are severe. Malnutrition is a significant determinant, both directly and indirectly, of child mortality. Malnourished children who survive are still at a disadvantage; they are more likely to have a smaller adult body size and are less likely to do well in school. Although measures of child anthropometry are not without controversy, weight-for-height, height-for-age and weight-for-age "Z scores" are widely accepted as useful indicators of poor health and nutrition.

Biological and socioeconomic factors affect malnutrition through various causal relationships. Intrauterine growth retardation, particularly low birth weight, is associated with increased child mortality and higher rates of morbidity. Much of a child's health status depends on the care received and the quantity, quality and timing of food provided. Children who are ill at an early age may have a more difficult time bonding with the primary caregiver, which can lead to a vicious cycle. For the most part, children in low-income countries are not weaned properly, which contributes to malnutrition. The level of the caregiver's education, after controlling for confounding variables, is associated with increased rates of child survival and better nutrition. Fertility choices, particularly short birth intervals, may also affect nutritional outcomes. Finally, water, sanitation and the (

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the disease environment are of paramount importance. A poor sanitary environment increases the risk of contracting diarrhea and other water-borne diseases. These diseases further complicate malnutrition and increase the risk of mortality.

The process of agricultural development is an integral component in the economic development of many low-income countries. Most studies of agricultural commercialization, through the substitution of cash crops for food crops, show no negative affect on household food security or nutrition. However, these studies also do not show strong, positive affects of this process on nutrition. Many researchers now look to the allocation of resources among household members in order to better understand how agricultural growth affects individuals, particularly women and children.

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CHAPTER III

ANALYTICAL FRAMEWORK

3.1 Introduction

This chapter develops the economic framework used to analyze child malnutrition throughout the thesis. First, a conceptual model of nutritional outcomes in children is specified in order to explain the causal mechanisms through which various factors affect nutrition. Once these causal pathways through which economic variables operate have been identified, a general economic model of household behavior is reviewed. A reduced form equation is then derived from the basic economic household model. The reduced form equation is used in chapter six to estimate the relationship between specific economic determinants and child malnutrition.

The following section (3.2) puts forth a general, static model of child nutrition, illustrating the various levels at which different factors affect nutrition. Section 3.3 reviews the economic agricultural household model and incorporates the production of health into the model. Section 3.4 explains the reduced form derivation of the economic model that is used in chapter six to model nutritional outcomes and discusses the variables incorporated into this model. The final section (3.5) summarizes the major points of the chapter and discusses how chapters four and five will be incorporated into the economic model.

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3.2 Conceptual Model of Malnutrition

Malnutrition is the immediate outcome from inadequate dietary intake, disease and the interaction of these two factors (WHO 1995). The nutritional quality of foods and the quantity of those foods consumed by children directly affect dietary intake. Dietary intake is also affected by the health status of the child in determining the body's ability to process the foods consumed. The health status of the child, or the presence of disease, is affected by exposure to disease, the susceptibility of contracting the disease and any care the child has or is currently receiving. The presence of one disease may impair the body's ability to fight off other diseases, increasing the susceptibility to illness. Dietary intake may also affect the body's susceptibility to illness. Socio-economic and ecological factors, such as income, prices, government policies and environmental conditions, underlie this process, and operate through the above mechanisms to affect child nutritional outcomes.

Figure 3.1 depicts the proximate, intermediate and underlying determinants of low weight-for-height and small height-for-age Z scores in children. The diagram is not meant to be an exact representation of all the processes at work in the determination of poor nutrition. However, the illustration does show through what channels and at what levels these factors must operate. The model is also static, and does not specifically address the temporal aspects of malnutrition. In particular, past periods of poor nutrition can affect the current health status of children, particularly growth retardation as measured by height-for-age Z scores.

The objective of this thesis is to analyze the manner in which agriculture, as an underlying determinant, affects the nutritional status of children. Agriculture operates

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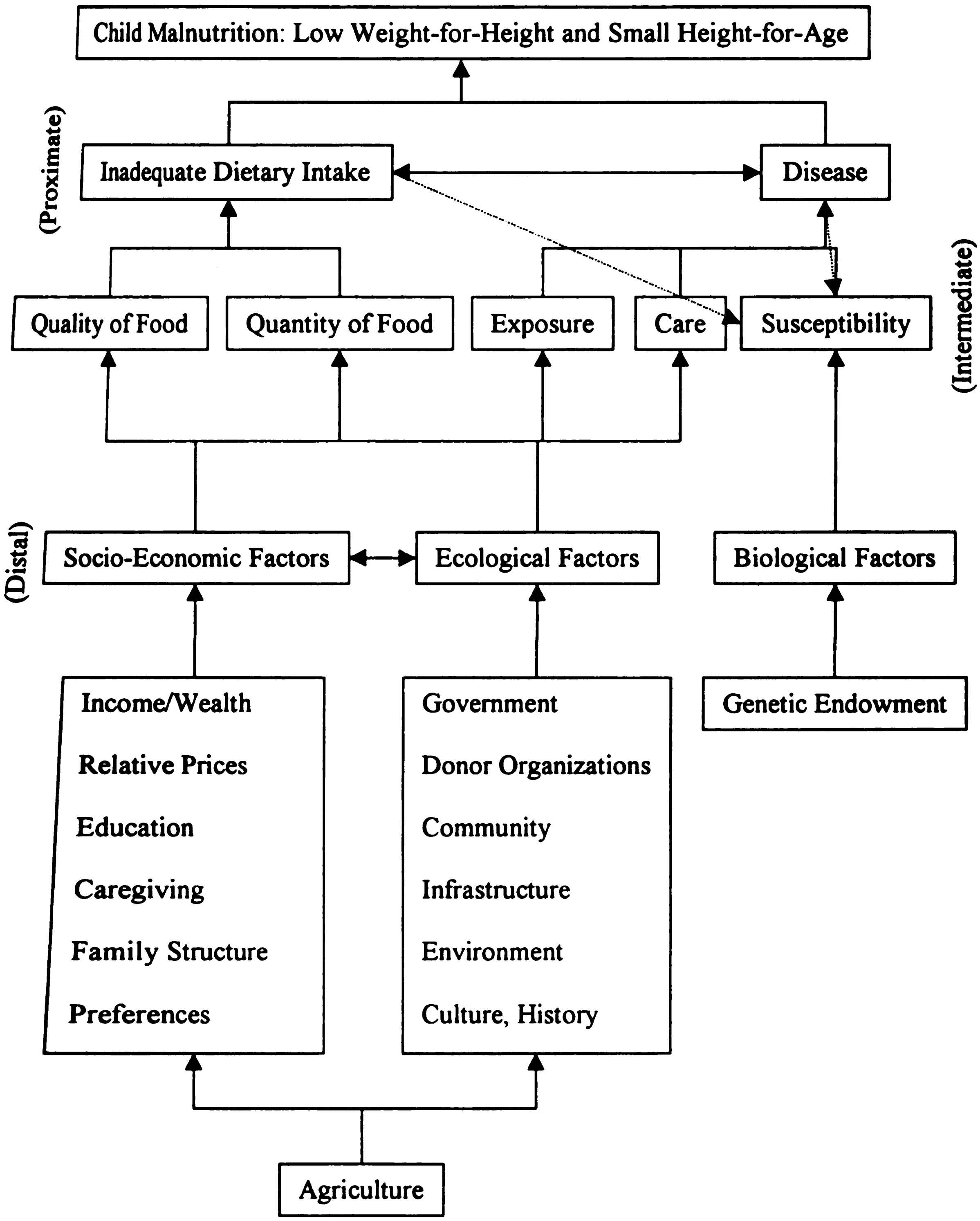
Figure 3.1: Static Causal Model of Child Malnutrition



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with and through other distal factors to affect the quantity and quality of food, exposure to disease and the care received by children. Agriculture can affect the quality and quantity of food and exposure to disease and care. Improved crop varieties can change the nutrient content of food and the amount of food produced, ceteris parabus. New crops may increase incomes or change time allocations of family members and may alter the status quo among household members. Pesticides and herbicides may contaminate the water supply. Government policies on subsidies and tariffs change relative prices and affect the profitability of different crops. Agricultural development projects may allow communities to build a health facility, improve grain storage capability or construct roads that facilitate commerce.

3.3 The Household Economic Model

Economic theory of individual behavior focuses on the household as the primary unit of observation. Consequently, economic theory views child nutritional outcomes as the product of household decisions. Thus, the economic model of child nutrition differs markedly from the conceptual model developed in section 3.2. The conceptual model is used to represent the processes by which different factors affect growth retardation. An economic model, however, presents child nutrition as the outcome of sets of choices made by households who are faced with a variety of constraints.

A single-person household model of economic behavior is put forth by Becker (see Becker 1981). This model has since been adapted for farm households, to include the joint consumption-production decision when markets are missing or incomplete (for example see Singh, Squire and Strauss 1986, Sadoulet and de Janvry 1995). There are two main types of economic household models that explicitly incorporate health: reduced form equations and health production functions (Rosenzweig and Schultz 1983, Pitt and Rosenzweig 1984, Behrman and Deolalikar 1988, Chernichovsky and Zangwill 1990, Strauss and Thomas 1995). In reduced form models, households respond to changes in exogenous factors, such as prices and income. Health production functions use a system of equations to incorporate a health production function and all of the relevant endogenous variables in the model. A brief explanation of a general agricultural household model including the production of health is discussed below; a discussion of the reduced form model used in this thesis is included in section 3.4.

Economic analysis of malnutrition is rooted in the behavioral theory of the household, which posits the notion that households maximize utility subject to a budget constraint. Samuelson (1956) argues that each family member's preferences can be aggregated into one household utility function, such that "the family can be said to act as if it maximizes such a group preference." From the utility function, demand for any commodity, such as health or nutrition, is derived. Thus, demand is a function of the household's tastes and preferences (assumed to be static), income, and the prices faced by the household (for example see Nicholson 1998).

Within this unified household framework, goods and services are disaggregated into market- and home-produced goods, where household production of goods and services is a function of labor and other purchased inputs. Households are constrained by "full-income," which states that the total amount of goods consumed, including the opportunity cost of leisure, can not exceed the total value of the household's time, profits from home produced goods (total value net of labor and input costs) and any endowments (Becker 1981).

However, agricultural households in developing countries are distinct from other households in that production and consumption decisions are made simultaneously (Singh, Squire and Strauss 1986). The basic model put forth by Singh, Squire and Strauss is very similar to the Becker model with one particular exception. Households in both models take prices as given and would be adversely affected by a rise in the price of a particular good. However, for agricultural households, an exogenous increase in the price of an agricultural commodity produced by that household will have a secondary effect, which raises their income. For example, an exogenous rise in grain prices will typically benefit the households who are net sellers, but adversely affect those who are net buyers.

Therefore, in a reduced form agricultural household model, the impacts of agricultural commercialization on child health must operate either through income, including endowments, or relative prices. The household responds to exogenous changes through the choice of consumption and the allocation of labor. Assuming well-behaved preferences, a static one period household model is defined as follows.

(1) $U = U(X_{mkt}, X_{ag}, X_{health}, L, \xi)$

(2) $T = N_{wage} + N_{ag} + N_{health} + L$

Equation 1 states that the household derives utility, U, from the consumption of market purchased goods and services, X_{mkt}, an agricultural good, X_{ag}, health, X_{health}, and leisure, L. The agricultural commodity is "home produced" and the explicit modeling of other home produced goods and services is omitted for the sake of convenience. The symbol "ξ" captures tastes and preferences, unobservable to the researcher. Equation 2 is the household's time constraint, which states that time, T, can be allocated to labor that earns market wages, N_{wage}, agricultural production, N_{ag}, health production, N_{health}, and leisure, L.

(3) $Q_{Ag} = a(N_{ag}, X_{input}, X_{health}, M, \delta)$

Equation 3 is a basic production function for the agricultural good. The production of an agricultural commodity is a function of the household time allocated to it's production, N_{ag}, purchased inputs, X_{inputs}, and land, M. Health may be an input into the production of agricultural commodities; consequently, X_{health} is also included in the production function. All other variables relevant to the production of the agricultural commodity are included in the matrix noted by "δ".

(4) $X_{health} = h(N_{health}, X_{mkt}, X_{input}, X_{ag}, C, HH, CG, \theta, \gamma)$

The consumption of health by the household is also constrained by a biological production function, specified in equation 4. Unfortunately, health can not be purchased in the marketplace; however, inputs into the production of health can. Health is a home-produced good that requires time, N_{health} – leisure in this instance may actually be a type of "labor" input into health production – and other inputs. These inputs include other consumption goods, X_{mkt}, such as fresh fruit or cigarettes, that may positively or negatively affect health, purchased inputs such as medicines, X_{input}, and the agricultural commodity, X_{ag}, which could be a staple food item. Health production is also a function of community (C), household (HH), caregiver (CG), and child (θ) characteristics. The symbol "γ" represents a matrix of all other inputs necessary in the production of health. Thus, the unified household model incorporates both the economic and biological factors that determine behavior, permitting households to make decisions based upon relative prices and full-income and physical constraints (Strauss and Thomas 1995).

$$(5) \qquad p_{mkt} \cdot X_{mkt} + p_{input} \cdot X_{input} \quad \leq \quad w \cdot N_{wage} + p_{ag} \cdot (Q_{ag} - X_{ag}) + E$$

Equation 5 is the household's budget constraint for market produced goods and services, where the value of goods consumed and purchased inputs, evaluated at market prices, p_{mkt} and p_{input}, cannot exceed income. Income is comprised of income from labor, N_{wage}, measured at the prevailing wage rate, w, the net value of all agricultural commodities produced and consumed, $p_{ag} \cdot (Q_{ag} - X_{ag})$, and any endowment net of transfers, E.

$$(6) \qquad p_{mkt} \cdot X_{mkt} + p_{ag} \cdot X_{ag} + w \cdot L \;\leq\; w \cdot T + (p_{ag} \cdot Q_{ag} - w \cdot N_{ag} - p_{input} \cdot X_{input}) - (w \cdot N_{health} + p_{input} \cdot X_{input}) + E$$

Equation 6 combines equations 2 through 5 into the full income constraint, which states that the value of consumption of market-produced goods and services, agricultural products and the opportunity cost of leisure cannot exceed the total value of household time, the value of agricultural production net of agricultural labor and purchased inputs, the opportunity cost of time spent producing health, the value of health inputs, and the initial endowment. Thus, in a one period model, the household, taking prices and wages as given, chooses an allocation for N_{wage}, N_{ag}, N_{health}, L, X_{mkt}, X_{input}, X_{ag} and X_{health} that maximizes utility subject to the full income constraint and the various physical constraints on production.

3.4 The Reduced Form Model

Reduced form equations for arguments contained in the utility function are derived from the solution to the constrained optimization problem faced by the household. While limited in scope, these reduced form equations provide a useful analytical tool for estimating the impact of income, prices and other exogenous arguments germane to production constraints on the consumption of a particular good or service. All variables in the reduced form equation are exogenous, and hence issues of simultaneity are avoided.

The reduced form equation for child nutrition used in this thesis, shown below in equation 7, relates the exogenous relative prices and income that a household faces when choosing to allocate scarce resources to the production of health. In addition to income and prices, community, household, mother and child characteristics are included in the reduced form equation for child nutrition. These characteristics are regarded as endowments which influence the production of health known to but not influenced by the family, and are not necessarily beneficial (Rosenzweig and Schultz 1983, Pitt and Rosenzweig 1984).

$$(7) \qquad C_{Nutrition} = f(E, p_{mkt}, p_{input}, p_{ag}, w, C, HH, CG, \theta, \varepsilon), \text{ where } \varepsilon \sim N(0,\sigma^2)$$

Equation 7 states that child nutrition, $C_{Nutrition}$ is a function of household exogenous wealth, E; prices for market-produced consumption goods and services, p_{mkt}; prices for various inputs into the production of health and the agricultural commodity, p_{input}; the price of the agricultural commodity, p_{ag}; the wage rate, w; community characteristics, C; household characteristics, HH; characteristics of the mother, CG; child characteristics, θ; and a random error term, ε.

In the community fixed effects models, dummy variables for each community are used to account for differences in relative prices and infrastructure between communities. The community covariates models incorporate the prices of coarse grains as well as information regarding community infrastructure in an attempt to understand their significance in determining child nutrition. Household wealth is approximated by the ownership of certain assets, including a radio, a bicycle, a motorcycle, a television, a refrigerator and a car. Child characteristics include the age of the child, measured by dummy variables according to 6 month intervals and whether the child is a twin. Household characteristics include the size of the household, the presence of flush toilets or latrines, the primary water source being piped water or obtained from a pump, the number of women between ages 15 and 49 which represents the number of potential caregivers. Maternal characteristics include a dummy variable for the age of the mother, measured in 5 year intervals, maternal anthropometry and maternal education. Maternal education is represented by the formal level of education received by the mother, measured in dummy variables, with the default being no education, the first dummy variable being some primary education or a separate dummy variable for secondary or higher education.

Econometric estimation of these models incorporates an error term in the estimation of the reduced form equation for several reasons. First, households have different tastes and preferences which are unobservable to the researcher. Thus, households with identical resources facing the same constraints will still make different consumption decisions. Second, households make mistakes in optimizing the allocation of scarce resources. Third, there are errors in the process of collecting and entering data. Consequently, the error term in the reduced form health equation must account for all of the variation resulting from the exclusion of endogenous variables and incorporate the errors associated with unobserved preferences, optimization and measurement.

The error term, assumed to be normally distributed with a mean of zero and variance of σ^2, is potentially heteroscedastic, particularly if the exogenous variables explain little of the variation in weight-for-height and height-for-age Z scores. If nutritional outcomes show little correlation with the exogenous variables, as many previous models demonstrate, then the variance of the error term may increase as anthropometric observations deviate further from the mean. The residual may also exhibit spatial autocorrelation if error terms are correlated with one another by geographical location.

A health production function approach is not used in this thesis. Such a function would incorporate numerous endogenous, or "choice" variables. Endogenous household decisions are excluded from the model, which, if included, would lead to problems of simultaneity and potentially biased and inconsistent results from regression analysis. For example, feeding practices are widely regarded to be of paramount importance in the determination of child health. However, variables that would capture the effects of feeding practices are excluded from reduced form economic models. For example, the current health of the child is unobservable to the researcher, but known to the primary caregiver. Thus, the caregiver may attempt to improve the diet of the sick child. To the researcher, information on the effects of feeding practices on malnutrition may appear negatively correlated, i.e. better foods and feeding practices lead to worse levels of child nutrition when, in fact, children may be more likely to receive better foods when they are ill. Correctly specifying a system of equations that would resolve problems of simultaneity is not possible, given the limited amount of available information.

3.5 Summary

This thesis utilizes a reduced form health equation employed by economists to empirically estimate the effects of certain exogenous variables on child nutrition in developing countries. To the extent that public policy can influence nutritional outcomes in children, the underlying determinants of malnutrition are of particular interest to policy makers and social scientists alike. While a conceptual model of nutrition examines the pathways of influence for these variables, an economic model regards child health as an outcome stemming from a set of choices made by the household. Since these decisions are interrelated, the necessary information needed to estimate all of the variables involved is daunting and well beyond the scope of this study. A reduced form equation can be used to estimate the impact of exogenous income, prices and certain environmental, household, maternal and child characteristics. However, many of the variables that may be of interest to policy makers, such as feeding practices, must be excluded from the model in order to estimate other parameters with any degree of reliability.

The following two chapters, chapters four and five, examine recent trends in agriculture and child malnutrition in Mali. Recent trends in agriculture can identify changing allocations of land, labor and capital that may affect child nutrition through a variety of underlying determinants. These changing allocations may point to particular geographical areas or certain strata of households that should be examined for potential changes, either positive or negative, in child nutrition. For example, rapid extensification through animal traction could necessitate an increase in the labor by women allotted to weeding and harvesting. The increase in time allocated to agricultural activities may come at the expense of time spent in food preparation or child caregiving activities.

Analysis of malnutrition and food expenditures helps to indicate the extent and type of malnutrition present through the quantity and quality of foods being consumed. Certain patterns may suggest specific causal links between malnutrition and specific socio-economic or ecological factors. For example, are small height-for-age Z scores unique to specific areas and income levels or are these low scores widespread throughout Mali? The household economic model will glean information from chapters four and five in an effort to identify the relationship, if any, between agriculture and child malnutrition.

CHAPTER IV

AGRICULTURAL PRODUCTION AND PRODUCTIVITY IN MALI, 1984 to 1996

4.1 Introduction

This chapter reviews recent statistics of agricultural production and productivity to determine whether extensification and intensification of major agricultural commodities are occurring in Mali. This chapter begins with a discussion the data and types of measures used to analyze agricultural production and productivity (section 4.2). Section 4.3 examines national agricultural statistics from 1984 to 1996, with specific attention given to trends in production (4.3.1), yield (4.3.2) and area cultivated (4.3.3) for major agricultural commodities. The next section (4.4) breaks down the aggregate statistics by analyzing trends in commodities by individual region, while section 4.5 looks at trends in the number of livestock, including cattle, sheep and goats, by region. Finally, section 4.6 summarizes the evidence regarding the extensification and intensification of agricultural commodities.

4.2 Data and Methods

The analysis contained in this chapter uses information on population, production and area cultivated for major agricultural commodities in Mali from 1984 to 1996 to develop measures of partial factor productivity for labor and land. The source for all agricultural data is the Malian statistical office, the Direction National de la Statistique et de l'Informatique (DNSI). The DNSI designs stratified random samples to be representative at the regional level. The Ministry of Rural Development and Water published this data in March, 1998. The population data are unpublished, collected from the most recent Malian census taken in 1997. In total, three estimates of the Malian population, in 1987, 1991 and 1996, generate the two population growth rates (pre and post 1991) used in this chapter to calculate annual per capita changes in agricultural production and area cultivated. The source for all livestock statistics is the Malian Office of Livestock and Meat, the Office Malien du Betail et de la Viande, OMBEVI, and is also published by the Ministry of Rural Development.

Per capita production is one measure of the partial factor productivity of labor. This approach implicitly assumes that labor from a growing population is consistently allocated to agricultural production (Kelly et al. 1995). To the extent that intra-regional variation is small, per capita production may be a useful indicator of trends over time within a specific location. However, different geographical regions may allocate more or less labor, according to the relative rates of return; thus a comparison of trends in per capita production across regions may be inappropriate.

Yield, measured by output per unit of land, is a commonly used indicator of the partial factor productivity of land. National and regional statistics, which average across land that is of varying quality, receiving different amounts of labor, capital inputs and rainfall, may inaccurately measure the productivity of land (Kelly et al. 1995). Moreover, the extent to which inter-cropping occurs understates the productivity of land.

It is very difficult to draw conclusions concerning agricultural productivity without data on the allocation of labor. With the 1994 devaluation of the currency, horticultural products are much more attractive for export, both in Europe and West Africa, and this sector of the economy has been expanding rapidly. Consequently, households that shift resources away from staple crops to horticultural products, or any other good for that matter, will understate the productivity of agriculture, as measured by the production of "major" commodities. On the other hand, population growth rates may account for rural to urban migration; however, the failure of population data to capture out-migration of labor from cities to rural areas in peak work seasons will overstate agricultural labor productivity.

Regional analysis of livestock trends is also problematic. Livestock are associated with transhumanant behavior. Cattle are herded further and further south as the dry season progresses. While the owner may inhabit one particular region, to speak of cattle in a regional context is clearly inappropriate. It would be more useful to collect livestock statistics based on primary use – for example, by recording the number of bulls a household maintains for farming versus the size of a herd intended for slaughter.

4.3 National Trends for Major Agricultural Commodities

Malian farmers must contend with three major sets of constraints: environmental conditions, limited resources and political policies. Agriculture in Mali is primarily rain-fed; consequently, annual production (and yield) will depend significantly on the amount, timing and duration of rainfall. Even irrigated agriculture depends on rainfall; river levels will influence the costs of pumping water. Other factors that influence agriculture are the quality of the land being cultivated, the amount of labor employed, particularly in weeding, and the use of other inputs (capital) into the production process.

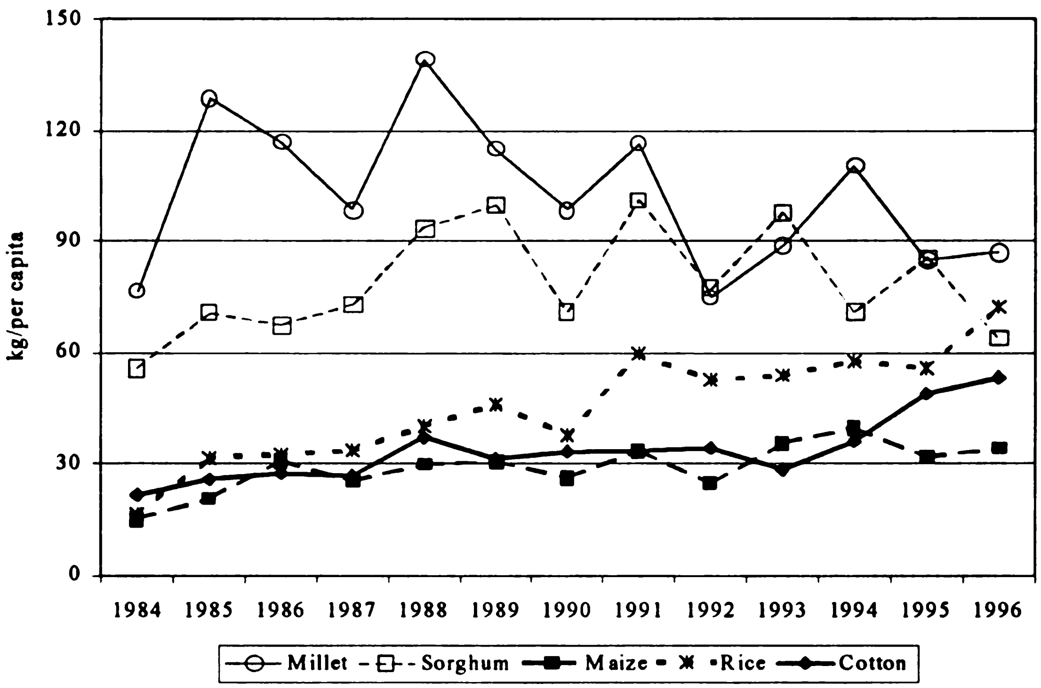
In an effort to improve economic performance, particularly in agriculture, major political reforms were undertaken in the 1980's, including much privatization of formerly state-run enterprises. The creation of the Program to Restructure the Cereals Market (PRMC) in March, 1981, was the first step in the privatization of the grain trade. Initially, the PRMC opened trade to private merchants, a practice which had been occurring illegally for some time (Sall 1989). The role of the Office of Malian Agricultural Products (OPAM) was reduced to assuring respect for a floor price (Sall 1989). Bumper harvests in the late 1980's brought OPAM to the brink of insolvency; consequently, in 1989, the second phase of the PRMC further diminished the role of OPAM to that of a buyer and seller of last resort. Finally, with the third phase of the PRMC in 1994, OPAM's mandate devolved to managing the strategic grain reserve. The reforms were undertaken with the expectation that private trade and removal of official prices would increase producer prices, stimulate investment in cereals and reduce marketing margins (Dembélé and Staatz 1999).

In January 1994, the common currency of the CFA franc zone, which includes Mali, was devalued 50 percent relative to the French franc, with which it maintains a fixed exchange rate. This devaluation helped boost livestock exports by 58 percent that year (Institut du Sahel 1998) and was also critical for reviving the cotton subsector as well. Falling world prices for cotton in the early 1990's were challenging the profitability of the industry. The devaluation allowed CMDT to increase the fixed price paid to producers for seed cotton less than the rate of the devaluation. This relative decrease in the producer price and the subsequent rise in world prices have restored new life to the cotton industry (Institut du Sahel 1998).

4.3.1 Production

Millet and sorghum production was marked by substantial volatility from 1984 to 1996. Figure 4.1 follows per capita production of major agricultural commodities from 1984 to 1996. Per capita millet production, peaking at 139 kilograms in 1988, demonstrated a slight downward trend, ending at 87 kilograms in 1996. Sorghum production, which appeared to rise progressively from 1984 to 1989, fluctuated back and forth from 1989 onward. Production of sorghum was typically lower than millet

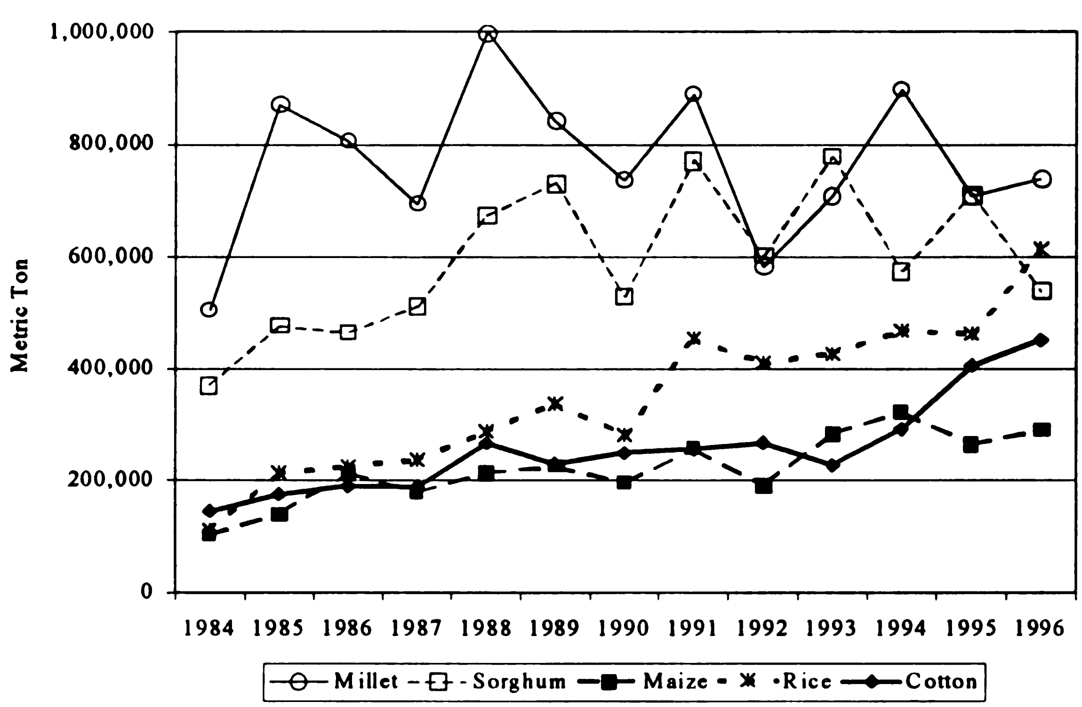
Figure 4.1: Per Capita Production of Selected Agricultural Commodities, 1984 to 1996



production, with the exception of 1992 and 1993. Rice, cotton and maize production showed much more stability and demonstrated a clear upward trend in per capita production. Rice production rose from 16 kilograms per capita in 1984 to 72 kilograms in 1996. Over the same period, cotton production increased from 22 to 53 kilograms per capita and maize production increased from 15 to 34 kilograms per capita.

Figure 4.2 shows total production for major agricultural commodities. The increasing importance of rice, cotton and maize is more evident, as is the relative decline

Figure 4.2 Total Production of Selected Agricultural Commodities, 1984 to 1996

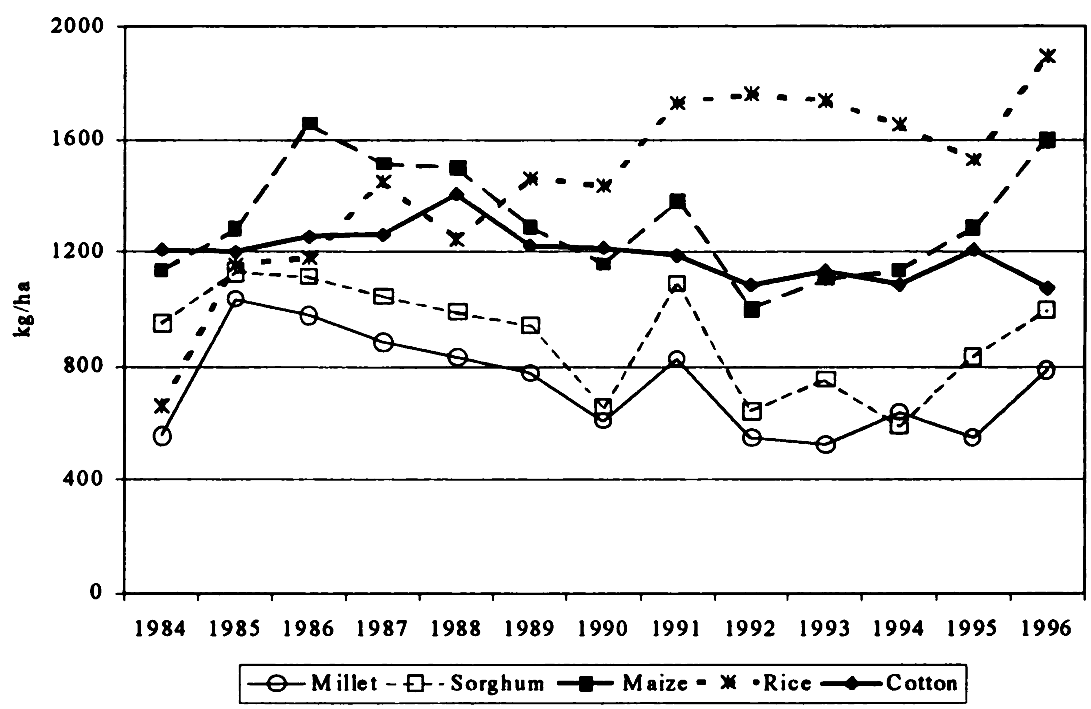


of millet and sorghum to household production. These results beg the question of how labor is being reallocated among these two sets of commodities.

4.3.2 Yield

Yields for many of the major agricultural commodities demonstrated periods of substantial variation. Rice was the one commodity where yields demonstrated a consistent upward trend from 1984 to 1996. In 1984, rice yields were approximately 660 kilograms per hectare, but by 1996 this figure rose to almost 1,900 kilograms. Yields for

Figure 4.3: Yield for Selected Agricultural Commodities, 1984 to 1996



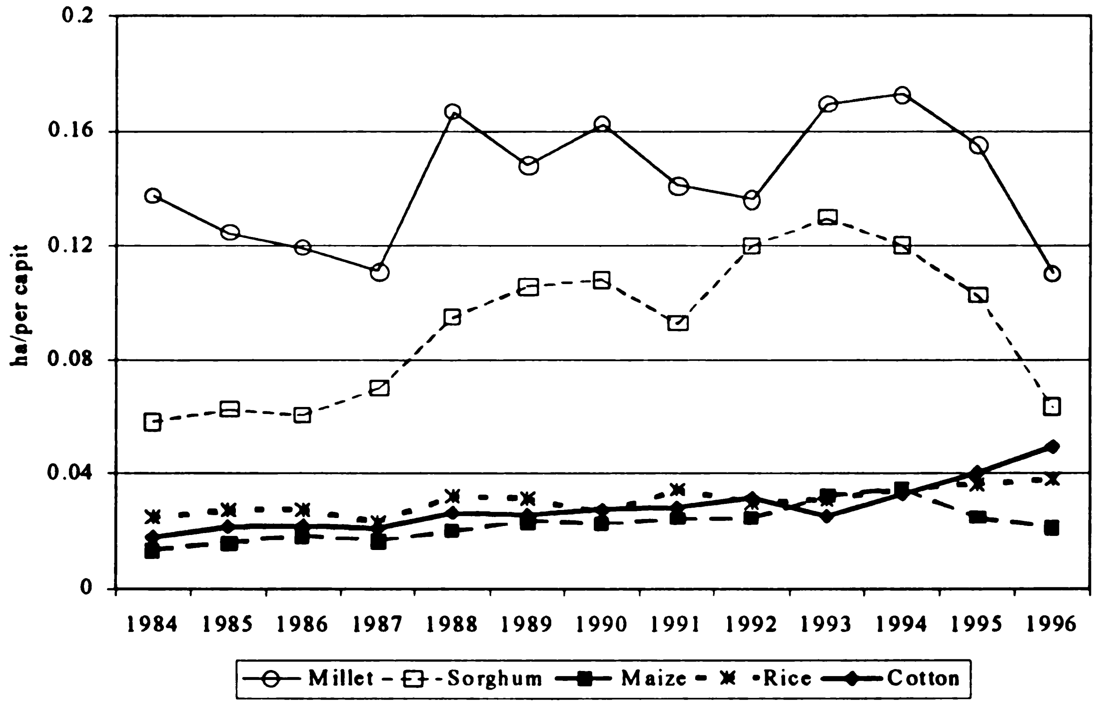
millet and sorghum tended to decline from 1984 to 1996, with yields for millet typically lower, on average, than yields for sorghum. Yields for maize declined for much of the period as well, but then began to rise from 1992 through 1996. In 1986, maize yields reached a high of 1,655 kilograms per hectare, before falling to a low of approximately 1,000 kilograms in 1992, and then climbing back to nearly 1,600 kilograms per hectare in

1996. The decline in maize yield follows the suspension of OPAM to defend official prices in 1986. CMDT had been buying maize at official prices on behalf of OPAM, and was pushing an intensive maize production system along with cotton in the Sikasso region. Once official prices ended, CMDT stopped promoting intensification, and farmers reduced capital inputs due to lack of profitability (Dembélé and Staatz 1999). Yields for cotton showed a gradual downward trend. Yields per hectare peaked at 1,408 kilograms in 1988 and declined to 1,075 kilograms in 1996.

4.3.3 Area Cultivated

The area cultivated for millet and sorghum production varied substantially from 1984 to 1996. Figure 4.4 shows area cultivated, measured in hectares per capita, for major agricultural commodities from 1984 to 1996. Overall, millet received more land for cultivation than sorghum, ranging from a low of 0.11 hectares per capita in 1987 to a maximum of 0.17 hectares in 1994. The area cultivated for sorghum showed a rising trend from 1984 to 1993, before falling off significantly after 1993. In 1984, the area allocated to sorghum was just 0.06 hectares per capita. By 1993, the area doubled to 0.13 hectares, before falling back to 0.06 hectares in 1996. The area cultivated for rice, cotton and maize, while small relative to millet and sorghum, demonstrated a clear upward trend. The area allocated to these crops was also much less volatile than for the traditional coarse grain crops. Cotton cultivation increased from 0.02 hectares to 0.05 hectares per capita and rice cultivation rose from 0.03 hectares to 0.04 hectares per capita. The drop in sorghum production, and to some extent millet, may be associated with the expansion of cotton. Maize cultivation went from 0.01 hectares to a high of 0.03 hectares, before tapering off to 0.02 hectares per capita in 1996.

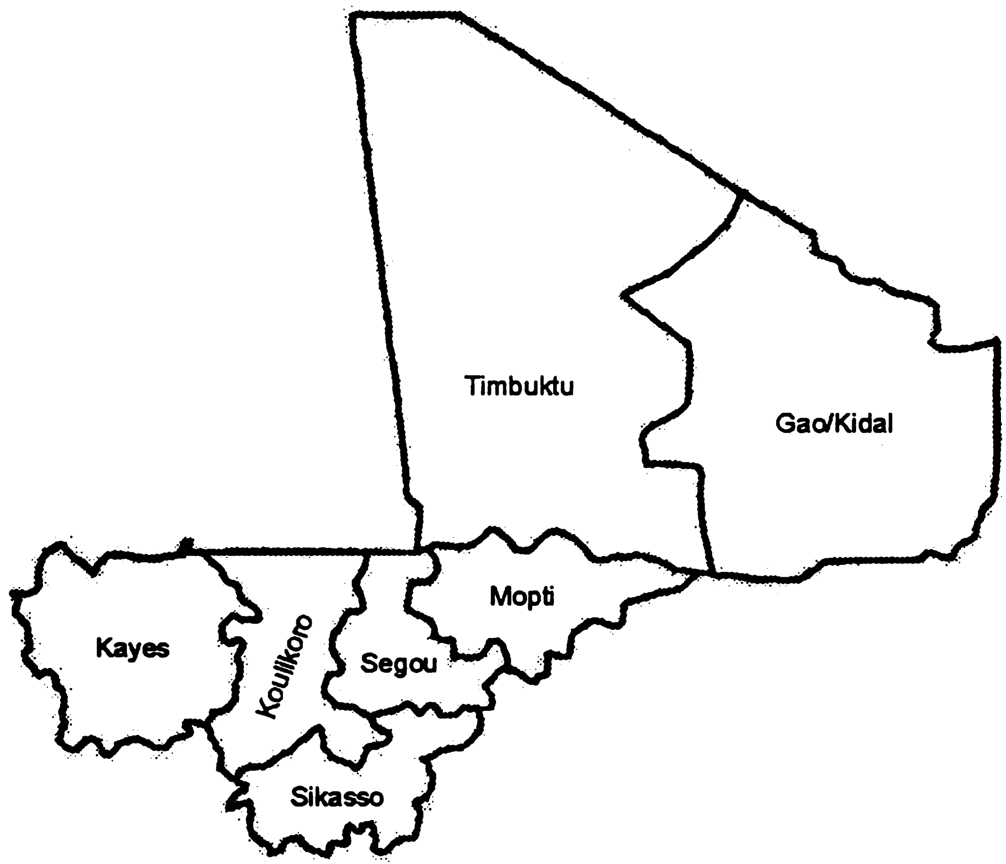
Figure 4.4: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



4.4 Regional Variation in Agriculture

Regional variation in agriculture is largely associated with changing climate and geography. The Sikasso region, the southern portion of the Koulikoro region, and the area near Kita in the Kayes region lie in the Sudano-Guinean zone which, on average, receives between 1000 and 1500 mm of rainfall annually. These areas are hospitable to crops such as sorghum, maize and cotton, which require greater amounts of rainfall. The Segou region is marked by floodplains along the Niger River delta, which are well suited for growing rice and recession agriculture. Livestock, important to many of the small-

Figure 4.5: Political Map of the Republic of Mali



holder farming systems of the south, becomes even more significant to the northern regions of Mali as a means of livelihood. The Mopti region, located in the Sub-Sahelian zone, typically receives 500 to 750mm of rainfall each year. Consequently, production shifts towards commodities such as millet, which demand less rain and are more responsive to dry conditions but generally have a lower yield than sorghum. Livestock, associated with transhumanance, is a dominant aspect of life in the Timbuktu, Gao and Kidal regions of Mali, where agriculture can be a tenuous proposition. Individual charts for production, yield and area cultivated from 1984 to 1996 for each of the regions are included in Appendix I. Figure 4.5 is a political map detailing regional boundaries.

4.4.1 Kayes Region

Production of sorghum varied substantially in the Kayes region from 1984 to 1996. In six of the growing campaigns, 1987, 1988, 1989, 1992, 1993 and 1995, per capita production was well above 100 kilograms, while in 1986, 1990 and 1994, sorghum production fell below 50 kilograms per capita. Maize and millet production were less volatile but much lower than sorghum. Maize peaked at 37 kilograms and millet at 31 kilograms per capita in 1987. Levels of rice production were low throughout this period. Cotton was not introduced into the Kayes region until 1994, when the area around Kita began cultivating cotton for CMDT.

Yields for most commodities appear highly volatile. Maize yields went from 461 kilograms per hectare in 1985 to 2,431 kilograms in 1987 and back down to 545 kilograms in 1990. However, the variation in maize yields does stabilize somewhat from 1991 to 1996. The yields for other commodities were also highly variable, particularly for rice and sorghum, and for millet to some extent as well.

The area cultivated for sorghum demonstrated a substantial trend upward from 1984 to 1994, but then fell significantly in 1995 and again in 1996. In 1984, approximately 0.07 hectares of land, per capita, were cultivated for sorghum; in 1994, more than 0.2 hectares of sorghum were cultivated. However, by 1996 this figure dropped to under 0.1 hectares per capita. The other major agricultural commodities displayed some fluctuation over this period, but only varied from 0.01 to 0.03 hectares per capita.

The dramatic rise in the area cultivated for sorghum, unaccompanied by any offsetting change in the area cultivated to other major agricultural commodities, is evidence that extensification is occurring in the Kayes region. Furthermore, yields for sorghum are trending downward. Although yield is the complex outcome of a variety of factors, this is consistent with the notion that extensification moves farmers onto marginal lands, decreasing average yields.

4.4.2 Koulikoro Region

Sorghum production showed substantial variability, particularly from 1987 to 1993, when per capita production was at or near 175 kilograms in 1989, 1991 and 1993, but fell to around 100 kilograms per capita in 1987, 1990 and 1992. Millet production kept pace with sorghum production until 1989 when per capita millet production dropped significantly below levels of sorghum production. Maize production was much less volatile than millet or sorghum, but levels never reached more than 50 kilograms per capita. Per capita cotton production rose to 70 kilograms in 1988, then declined steadily to 26 kilograms in 1992 before rising to a high of 83 kilograms in 1996. Rice production remained relatively flat, increasing somewhat from 1990 to 1996, when production peaked at 20 kilograms per capita.

The yields for all commodities fluctuated widely from 1984 to 1996 and showed markedly similar patterns. Yields for sorghum, measured in kilograms per hectare, ranged from nearly 2,000 to nearly as low as 500 kilograms. Millet yields were, for the most part, somewhat lower than sorghum. All of the yields, except for rice, appear to exhibit a slight downward trend.

The area cultivated for sorghum displayed a dramatic upward trend from 1984 to 1993, but then tapered off rapidly in 1994, 1995 and 1996, from 0.2 hectares per capita to 0.11 hectares. During the last three years, the area cultivated for cotton began to rise more substantially, from 0.04 hectares per capita in 1993 to 0.08 hectares in 1996.

The significant increase in the area cultivated for sorghum and millet from 1984 to 1993 is evidence of agricultural extensification. While extensification is often attributed to the use of animal traction, the proximity of the Koulikoro region to Bamako could result in some urban-to-rural migration during the rainy season, increasing the amount of labor available. The area allocated to sorghum and rice cultivation fell from 1994 to 1996, while at the same time the area of land under cotton cultivation increased significantly. This pattern suggests that farm households are substituting, to some extent, cash crops for food crops.

4.4.3 Sikasso Region

Maize and sorghum production varied from year to year in the Sikasso region. Cotton production, which also fluctuated from year to year, clearly had an upward trend, reaching 183 kilograms per capita in 1996. Rice production also trended upward, although absolute levels of production remained under 50 kilograms. Millet production, on the other hand, declined throughout most of this period.

Yields for all commodities fluctuated substantially from year to year. Millet and sorghum yields were nearly identical for many of the growing seasons. Yields for cotton remained stagnant and showed a slight decline. The trend for rice, however, appeared to move upward from 1984 to 1996, and maize also demonstrated a slight upward trend.

The area cultivated for maize, millet and sorghum followed similar patterns. The area cultivated for these crops rose from 1984 to 1989, then fell in 1990 and 1991, increased in 1993, 1993 and 1994, and the fell again in 1995 and 1996. Area cultivated for cotton rose steadily, with one small drop in 1993, from 0.07 hectares per capita in 1984 to 0.16 hectares per capita in 1994. Meanwhile, rice cultivation remained low but clearly trended upwards.

The rise in area cultivated for nearly all major commodities from 1984 to 1989 implies that extensification was occurring in the Sikasso region. After 1994, there is a sharp rise in land under cotton production and a general downward trend in the area allocated to the cultivation of other commodities. Again, this suggests that households in the cotton region are beginning, to some extent, to substitute cash crops for food crops.

4.4.4 Segou Region

Millet production fluctuated substantially during this period. In 1985, 1986 and 1992, per capita production of millet exceeded 300 kilograms; yet in 1984, 1987, 1992 and 1995, this level was much closer to 150 kilograms. Sorghum production increased from a low of 19 kilograms per capita in 1984 to a high of 172 kilograms in 1991, then declining rapidly to 51 kilograms in 1996. Per capita rice production rose steadily, from 70 kilograms in 1984 to 200 kilograms in 1996, overtaking millet production in 1995. Production of maize and cotton in this region was very low and remained flat throughout this period.

The yield for all major commodities, except rice, varied substantially over this period. Rice yields rose significantly, from 1,222 kilograms per hectare in 1984 to nearly 3,600 kilograms in 1996. Although little cotton is grown in the region, yields for this crop remained stagnant.

The area cultivated for rice production remained relatively flat. Much more millet is grown than sorghum, in part because this crop is better suited to the lower levels of rainfall received in this portion of Mali. The area cultivated for sorghum rose steadily from 1984 to 1991, reaching a level of 0.13 hectares per capita, before falling to 0.05 hectares in 1996.

The steady climb in rice production and yield from 1984 to 1996, coupled with little change in the area cultivated, indicate that the significant gains in production were the result of agricultural intensification. Although gains could be attributed to improved rice varieties, they are more likely the result of intensification by farmers in the irrigated rice zones of the Office du Niger in the Niono area of Segou. Reforms in the rice processing sector in the late 1980's increased profitability to farmers in this region (Dembélé and Staatz 1999). There is no clear evidence of extensification occurring for other crops in this region.

4.4.5 Mopti Region

Millet production showed a clear trend upward, but varied substantially from one year to the next. In 1986, millet production was approximately 100 kilograms per capita. By 1988, production rose to nearly 250 kilograms, but then fell back to 100 kilograms per capita in 1989, before reaching 157 kilograms in 1996. Rice production, considerably less volatile than millet, also demonstrated a rising trend from 1984 to 1996. Cotton is not grown in the Mopti region, due to climatic conditions, and very little sorghum and maize are produced.

Yields for millet were relatively flat from 1989 onward, hovering near 500 kilograms per hectare. Rice yields were less stable than millet. The area cultivated for millet fluctuated, but showed an upward trend throughout much of the period; however, the area cultivated fell from a high of 0.33 hectares per capita in 1994 to 0.23 hectares in 1996. Rice production showed some variation, but remained relatively stable, fluctuating from 0.05 hectares per capita to 0.08 hectares over the period of study.

The rising trend in area cultivated for millet indicates that extensification of millet is occurring in the Mopti region. No significant changes occurred in the production of other commodities.

4.4.6 Timbuktu Region

Much less agricultural production occurs in the regions north of Mopti. In Timbuktu, sorghum production rose dramatically in 1989 to nearly 150 kilograms per capita, but then fell to very low levels following that year. Millet production also peaked in 1989, at 85 kilograms per capita, but then fell to levels below 50 kilograms per capita and remained there until rising toward 75 kilograms per capita in 1994 and 1996. Rice production, which fluctuated substantially, demonstrated a rising trend from 1984 to 1996, reaching nearly 125 kilograms per capita in 1996.

Rice yields were extremely volatile for much of the period, and appeared to decrease on average. In 1985, rice yields were 1,525 kilograms per hectare. Yields then jumped to 2,774 kilograms in 1986 and then fell to 1,373 kilograms the following year. The period from 1993 to 1996 also showed similar volatility. There was also a substantial variation in sorghum yields from 1984 to 1989 and again from 1993 to 1996. Millet yields were less variable, and remained low throughout the entire period.

The area cultivated for millet rose dramatically from 1988 to 1989, from 0.10 hectares to 0.26 hectares per capita, peaking in 1990 at 0.29 hectares. Then, in 1991, the area cultivated fell back and remained at or 0 .15 hectares per capita – an increase from the pre-1989 levels of millet cultivation, which were at or below 0.10 hectares. Meanwhile, rice production rose steadily from 1984 to 1991, then fell in 1992, 1993 and 1994, before rising slightly in 1995 and 1996. Sorghum production also rose dramatically from 1988 to 1989, but then fell significantly in 1990.

The dramatic increase in area cultivated for millet and sorghum appears to be more of an anomaly than part of any trend. Moreover, the 1989 growing season received higher than normal amounts of rainfall. There may be some substitution between rice and coarse grain production (millet and sorghum), but the area cultivated does not follow a particular trend.

4.4.7 Gao and Kidal Regions

Production levels for most agricultural commodities in the Gao and Kidal regions were minimal, at least in the aggregate. Rice production did peak in 1989 at 83 kilograms per capita, but then declined steadily throughout the rest of the study period, reaching a low of 13 kilograms in 1995. Yields, which were extremely volatile, are difficult to interpret due to the low levels of production. The area devoted to rice cultivation was greater than any other commodity, but only exceeded 0.05 hectares per capita twice, in 1985 and again in 1989. Little agricultural production occurs in these regions, and there is no evidence of agricultural extensification or intensification.

4.5 Trends in Livestock

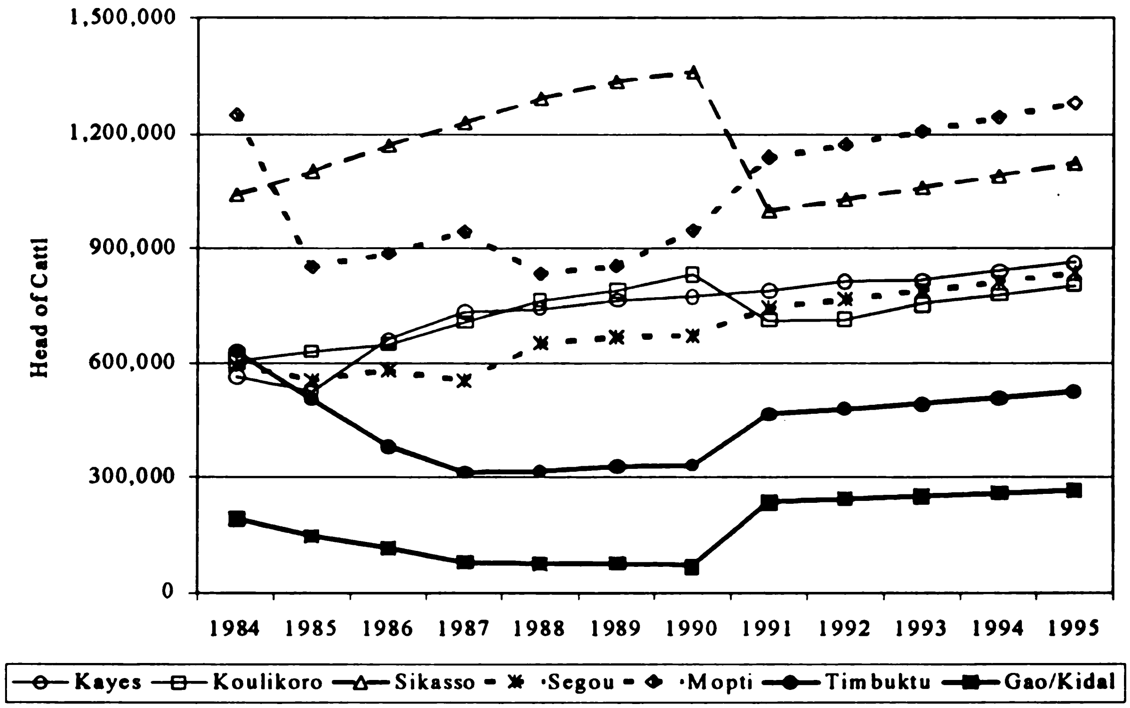
Livestock represent many things in Mali: a way of life for some, a store of wealth, an asset, a tool for managing risk, an input into production, and a status symbol. Droughts have a severe impact on livestock. While agricultural commodities may be lost for the year, herds of animals that represent years of work can be decimated all at once. After the Sahelian drought of the early 1970's, the numbers of livestock fell in half. These herds recovered somewhat, until the drought of the mid 1980's caused further damage. The livestock sector did benefit greatly from the currency devaluation in 1994. Due in part to the overvaluation, cattle in Mali could not compete with subsidized meat imported from Europe to major markets in West Africa such as Abidjan (Yade, et al. 1998).

4.5.1 Cattle

Figure 4.6 shows total head of cattle by region from 1984 to 1995. Trends in the number of head of cattle per capita in the Timbuktu and Gao/Kidal regions are similar, but at different levels. The pattern demonstrates a substantial decline in the number of head, roughly half, from 1984 to 1990, followed by a significant rise to levels near 1984 totals. Mopti now has the largest number of cattle for any region, nearly 1.3 million in

1995. However, this level is only slightly higher than the number of cattle recorded in 1984, which then fell significantly in 1985. In Sikasso, the number of cattle climbed

Figure 4.6: Regional Totals for Cattle, 1984 to 1995

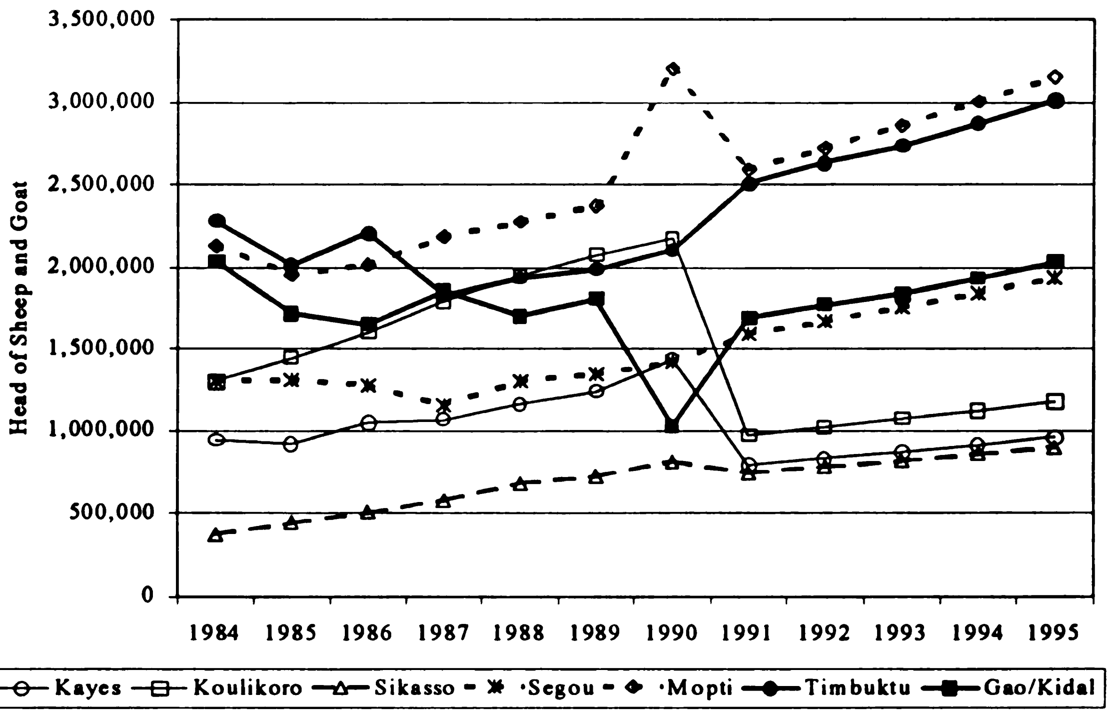


dramatically, by roughly 300,000 head, during the declines in numbers in the more northern regions. The Kayes, Koulikoro and Segou all follow gradual upward trends in the number of head of cattle, from approximately 600,000 to 850,000 head. The trends for Mopti, Timbuktu and Gao and Kidal may be driven, in part, by poor rainfall in the mid 1980's, forcing herds to move southward or be sold to purchase food.

4.5.2 Sheep and Goats

Figure 4.7 shows the total number of sheep and goats by region from 1984 to 1995. There is a sharp decline of nearly 50% in the numbers of sheep and goats in the Kayes and Koulikoro regions in 1991. Mopti and Timbuktu have the largest numbers of

Figure 4.7: Regional Totals for Sheep and Goats, 1984 to 1995



sheep and goats. Gao and Kidal and the Segou region have roughly two-thirds the number of sheep and goats as Mopti, and the other regions have approximately one-third as many sheep and goats. All regions experience a linear rise in total numbers from 1991 onward, which calls into question the reliability of these statistics.

4.6 Summary

The measures of partial land and labor productivity indicate that agricultural extensification and intensification may be occurring in selected areas of Mali. The Kayes, Koulikoro, Sikasso and Mopti regions all demonstrate significant increases in area cultivated per capita that can be associated with extensification. In the Kayes region, the rise in area of sorghum cultivation is accompanied by a marked decrease in yield, consistent with the notion that farmers would be moving onto more fragile lands. In the Koulikoro region, extensification may be occurring through the use of animal traction, although the proximity to the capital city of Bamako may also allow for some urban-to-rural migration during the peak work season. The area under cultivation rose significantly in Sikasso until 1990 and 1991, when numbers of livestock fell substantially in the region. In Mopti, the area cultivated for millet also demonstrated a clear upward trend until 1994.

The rice zone of the Segou region is the only area in Mali where agricultural intensification appears evident. Production and yields of rice have skyrocketed, while the area under cultivation remains stable. The northern regions of Timbuktu, Gao and Kidal show no evidence of either extensification or intensification. Agriculture in these regions is clearly limited by environmental constraints, and livestock are an integral part of a household's livelihood. The data on number of cattle do not suggest any particular trend or change from 1984 to 1996.

There is also some evidence that households in the cotton zone may be substituting cotton for food crops. The cotton zone, occupying the southern portion of Mali, has recently expanded, in part due to the construction of new ginning facilities. In

Koulikoro, the area allocated to sorghum and rice cultivation fell from 1994 to 1996, and at the same time the area of land under cotton cultivation increased significantly, suggesting that farm households may be diversifying crops and substituting cash crops for food crops. In the Sikasso region, there is a similar downward trend in the area allocated to the cultivation of other commodities and a sharp rise in land under cotton tenancy after 1994. Again, this suggests that households in the cotton zone are diversifying their crops and may also be substituting cash crops for food crops.

CHAPTER V

CHILD MALNUTRITION AND FOOD EXPENDITURES IN MALI

5.1 Introduction

Engel's law states that as incomes rise, household expenditures on food, as a percentage of total expenditures, will decline. A variation of Engel's law, Bennet's law states that as incomes rise, households will spend a smaller percentage of their food budget on basic staple foods and spend a greater share of the food budget on meats, fresh fruits, vegetables, and more processed foods. Although the link between Engel's and Bennet's Laws and nutrition is evident, it is not immediate. While these laws hold in the aggregate over time and across countries, it is not clear that a relatively small variation in income and the resulting food expenditure patterns will positively affect nutrition in the short run.

The trends in weight-for-height and height-for-age Z scores by age of the child (see Figure 5.1, p.78) unequivocally demonstrate that certain factors are operating to increase illness and reduce nutrient intake during the first three years of life. This chapter analyzes malnutrition and factors associated with malnutrition over time. Measures of child anthropometry are examined from three separate surveys. Food expenditures, household consumption, maternal education and asset ownership are compared across different studies as well. The next chapter incorporates the results of this univariate analysis into an appropriate multivariate economic framework.

The following section (5.2) discusses the anthropometric and expenditure data used in the analysis and the appropriate methods for statistical comparison. Section 5.3

analyzes weight-for-height and height-for-age Z scores from the Demographic and Health Survey conducted in 1995-96, focusing on differences associated with the environment, household variables and feeding practices. A 1987 Demographic and Health Survey is reviewed in section 5.4, with particular emphasis on maternal education and statistical differences between the first and second studies. Section 5.5 examines information regarding child anthropometry, elasticities of demand for food items, household expenditures and food consumption collected from the Enquete Budget-Consommation, or Budget-Consumption Study, conducted in 1988-89. Section 5.6 reviews the 1994 Enquete Malienne de Conjuncture Economique et Sociale, the "Malian Study of Socio-Economic Circumstances", and explores differences in household expenditures between the study and the earlier Budget-Consumption study, as well as the changes in household asset ownership across all four studies. The final section (5.7) summarizes the major points discussed in the chapter.

5.2 Data and Methods

Raw data were available only for the Demographic and Health Surveys. Data in tabular format for the Enquete Budget-Consommation and the Enquete Malienne de Conjuncture Economique et Sociale are available from the National Statistical Office. Descriptive statistics are used to compare mean scores of child anthropometry across a variety of factors. Statistical comparisons use the Student's t distribution to compare the mean values for weight-for-height and height-for-age Z scores for the Demographic and Health Surveys (1987 and 1995-96). The Demographic and Health Survey (DHS) is administered in numerous developing countries throughout the world by Macro

International, Inc[1]. These surveys collect information on individuals regarding such issues as health, fertility, family planning, AIDS awareness and mortality, as well as community infrastructure.

There have been two DHS studies conducted in Mali; DHS I was conducted in 1987 and DHS II from 1995 to 1996. The first study was undertaken in collaboration with the Ministry of Public Health and Social Affairs (le Ministère de la Santé Publique et des Affaires Sociales) and the Center for the Study and Research on the Population for Development (le Centre d'Etudes et de Recherches sur la Population pour le Développement), financed by the United States Agency for International Development (USAID). The second study, also financed by USAID, involved the Ministry of Health, Solidarity and Aged Persons (le Ministère de la Santé, de la Solidarité et des Personnes Âgées) and the National Statistical Office (la Direction Nationale de la Statistique et de l'Informatique) [DNSI].

The first DHS study, conducted from March to August, 1987, surveyed 3,200 women, 970 men and 1,538 children throughout Mali. The second DHS was much larger, collecting information from 9,704 women, 2,474 men and 6,019 children in 8,716 households, carried out throughout Mali between November, 1995 and May, 1996. In both studies, the age of the women surveyed ranged from 15 to 49 years of age and the children from 3 to 36 months. In the first study, the men interviewed were from 20 to 55 years of age, while the second DHS surveyed men from 15 to 59 years of age.

Both the first and second DHS studies used stratified random sampling to identify households to be surveyed. DHS I selected 151 clusters to represent both urban and rural milieu, as well as the rural areas of the Kayes, Koulikoro, Sikasso, Segou and Mopti

[1] At the time of the first DHS, Macro International was known as the Institute for Resource Development.

regions. DHS II was designed to be representative of 13 strata: the urban areas of Bamako, Timbuktu and Gao and Kidal[2], and both the rural and urban areas of the Kayes, Koulikoro, Sikasso, Segou and Mopti regions. Three hundred clusters, usually representing more than one village, were drawn to represent the 13 strata. The first DHS study utilized three questionnaires: (1) household, (2) individual female and (3) individual male. The second survey added a fourth questionnaire to survey community services. Each questionnaire was field tested and translated into the three major local languages, Bambara, Fula and Sonrai.

The Budget-Consumption Study (EBC) was conducted by the DNSI, in collaboration with the United Nations Development Program and the Ministry of Finance and the Economy (le Ministère de l'Economie des Finances et du Plan) from June, 1988 to May, 1989. Stratified random sampling was used to select 434 sampling units, designed to represent both urban and rural areas in each of the eight regions. In total, 2,816 "eating units" were surveyed. "Eating units" correspond to the manner in which food is prepared and shared across households. An eating unit may comprise more than one household if, for example, two or more households, which may or may not be located in the same concession, share in the preparation of food. Three different questionnaires were used: (1) food supply, (2) household budget, and (3) food consumption and health, which included child anthropometry. Direct measurement was used for the alimentation questionnaire. Children included in the anthropometric survey ranged from 0 to 10 years of age.

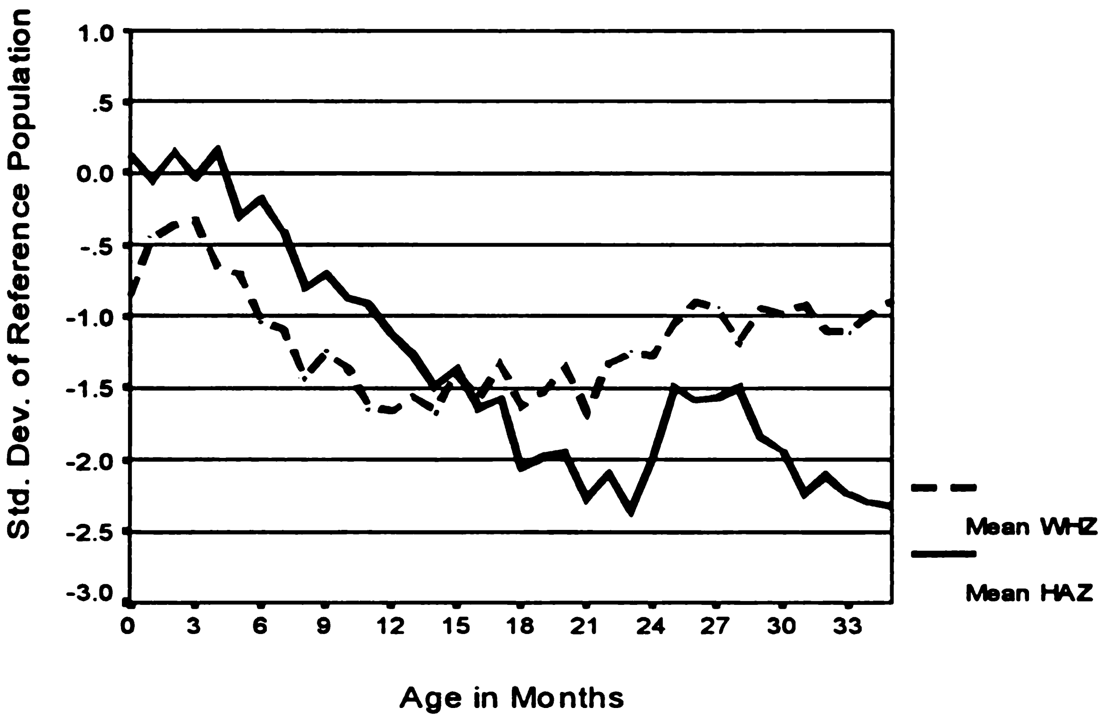
[2] Today, Gao and Kidal are separate administrative units; however, at the time of DHS II they were considered one region.

No documentation is available for the Malian Study of Socio-Economic Circumstances (EMCES). This study, which took place in 1994, was funded by the World Bank in collaboration with the DNSI. The study was designed to be representative of urban and southwest, riverine and off-river rural populations. It appears that 9,496 households were surveyed in Mali, and the study excluded the region of Gao. The survey includes information on household expenditures, agriculture, unemployment and migration, the situation of women in Mali, and child health and anthropometry. The children surveyed ranged from 0 to 59 months of age.

5.3 Demographic and Health Survey, 1995-96

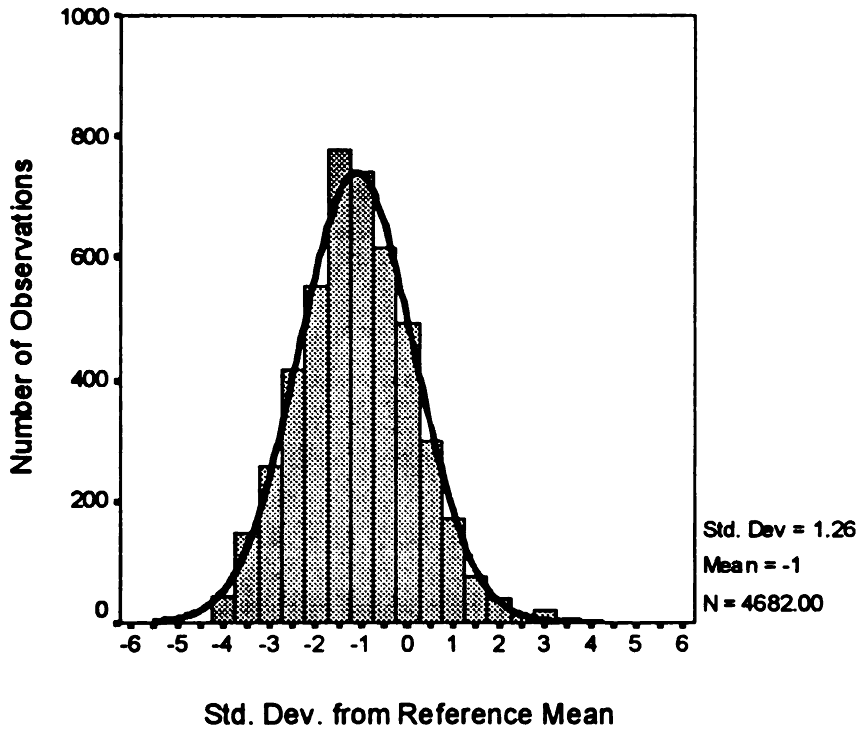
For the Malian sample, both weight-for-height and height-for-age Z scores vary

Figure 5.1: WHZ and HAZ Scores by Age of Child, 1995-96



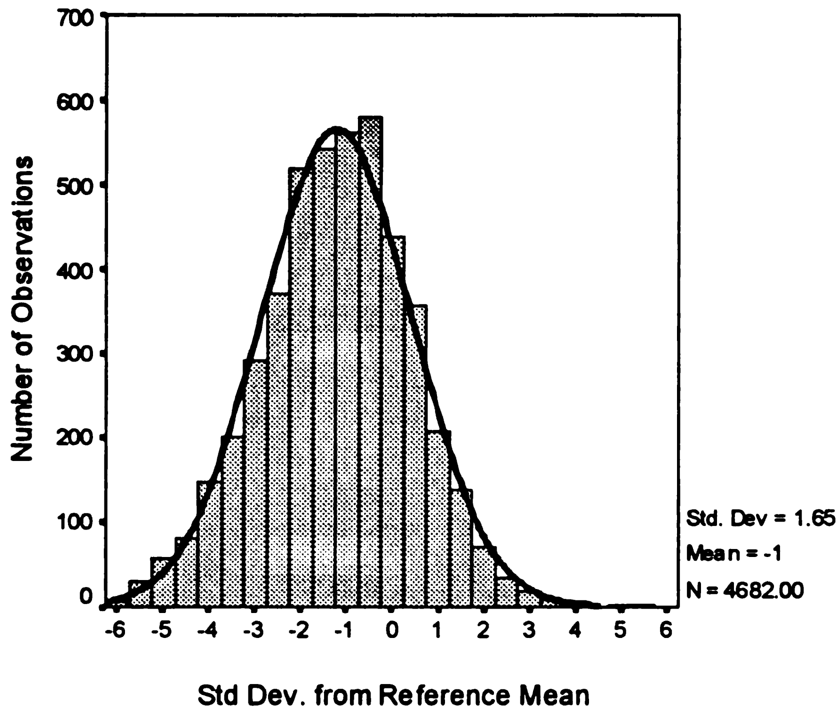
Source: Demographic and Health Survey, 1995/96 substantially relative to the standard with the age of the child. The average weight-for-height Z score declines throughout the first year of life, remains low during the second year and then improves somewhat during the third year of age. Height-for-age decreases markedly in the first two years of life, improving somewhat during the first half of year three before falling again. This pattern, shown above in Figure 5.1, strongly suggests that certain factors are affecting disease and nutrient intake throughout the child's early years. Figures 5.2 and 5.3 present the distribution of weight-for-height and height-for-age Z scores for all children measured in the Demographic and Health Survey II.

Figure 5.2: Histogram of WHZ Scores



Child malnutrition, as measured by anthropometry, is pervasive in Mali. Table 5.1 contains mean Z scores for wasting (weight-for-height) and stunting (height-for-age) by a variety factors, including the age of the child, sex, region, urban or rural locale, ethnicity, mother's educational attainment and household assets. Wasting, an immediate measure, and stunting, a more medium term measure, are widely accepted indicators of

Figure 5.3: Histogram of HAZ Scores



the overall health of children (Martorell 1995). All of the mean scores reported in table 5.1, excluding mothers with post secondary education (the sample size, n = 7, is insufficient), are statistically below zero ($p < 0.001$).

From Table 5.1, it is clear that the sex of the child has no substantive affect on weight-for-height and height-for-age Z scores. Although significant differences may exist in other parts of the world, such as South Asia, this finding is consistent with the literature on child malnutrition in Africa (see, for example, Svedberg 1990).

Table 5.1: Mean Z Scores for Wasting and Stunting

	WHZ Score – Wasting		HAZ Score – Stunting	
	Mean	Sample Size	Mean	Sample Size
Total	-1.11	4708	-1.22	4682
Age of Child:				
0 to 11 months	-0.88	1854	-0.30	1848
12 to 23 months	-1.51	1418	-1.70	1417
24 to 35 months	-1.02	1436	-1.94	1417
Sex of Child:				
Male	-1.12	2311	-1.25	2295
Female	-1.11	2397	-1.19	2387
Region:				
Kayes	-0.97	691	-1.36	691
Koulikoro	-1.09	885	-1.30	882
Sikasso	-1.15	890	-1.40	877
Segou	-1.05	782	-1.30	779
Mopti	-1.27	516	-0.97	516
Timbuktu	-1.44	238	-1.22	236
Gao/Kidal	-0.97	250	-1.24	250
Bamako	-1.14	456	-0.65	451
Location:				
Urban	-1.11	1459	-0.97	1451
Rural	-1.12	3249	-1.33	3231
Ethnicity:				
Bambara	-1.10	1376	-1.25	1364
Fulani	-1.24	627	-1.31	625
Dogon	-1.15	291	-0.98	291
Tuareg	-1.45	205	-1.40	204
Songrai	-1.08	282	-1.25	281
Malinke	-0.85	361	-1.17	361
Sarakole/Soninke	-1.06	512	-1.21	509
Senufo/Minianka	-1.09	424	-1.32	422
Mother's Education:				
None	-1.15	3935	-1.28	3911
Incomplete Primary	-0.91	488	-1.01	487
Complete Primary	-0.96	60	-1.20	59
Incomplete Secondary	-0.96	218	-0.72	218
Higher	-0.21	7	0.29	7
Household Owns:				
Radio	-1.04	3049	-1.15	3035
Bicycle	-1.07	2050	-1.31	2037
Motorcycle	-0.94	1003	-1.04	997
Television	-1.00	412	-0.75	410
Refrigerator	-0.78	161	-0.78	160
Car	-0.92	154	-0.52	153

Source: Demographic and Health Survey, Mali, 1995-96

While there is no significant difference between urban and rural scores of short-term malnutrition, there is a substantial and statistically significant difference between the long-term measure of malnutrition ($p < 0.001$). However, this difference in the long-term measure may be partially accounting for differences in maternal education. Women in urban areas receive more education on average than women in rural areas; women living in urban areas studied in DHS II were more likely to have some primary education, 16 percent, and some secondary education, 11 percent. Levels of some primary education were 8 percent for women in rural locations and some secondary schooling just 1 percent in the survey.

Regional differences for many of the mean Z scores for weight-for-height and height-for-age are statistically significant, particularly between the top two or three and bottom two or three. Perhaps more interesting is the change in the relative ranking of regions between the two measures. Regions that have worse mean scores for the short-term measure of malnutrition have relatively better average scores for the medium-term measure. The Kayes region, which had one of the better average weight-for-height Z scores among regions, has one of the worst average height-for-age scores. Bamako and Mopti, which fared poorly relative to other regions in the immediate measure of malnutrition, have higher scores for the medium-term measure of malnutrition. However, Bamako is an urban location and only urban areas within the Timbuktu region were surveyed. Moreover, the age distribution of children within these regions is also of significance. Mopti has many more children less than 1 year old, 48 percent, than other regions. Bamako has relatively more young children, 38 percent, in its sample as well. Rates of stunting are much lower for these children than for 1 and 2 year olds.

Consequently, it is not clear that these differences among regions reflect different disease and nutrient intake, or simply different samples.

There are also statistically significant differences among ethnic groups in weight-for-height and height-for-age Z scores. The Tuareg, who mostly inhabit the Timbuktu, Gao and Kidal regions, have children lower anthropometric scores than other ethnic groups in both the short and medium-term measures of malnutrition. Unlike the regional variation, changes in the relative ranking of various ethnic groups are not substantial, with the exception of the Dogon, who inhabit the Escarpment of the Mopti region.

Maternal education appears to have little association with weight-for-height Z scores; however, this correlation is much more pronounced on height-for-age. Differences in the medium-term measure between mothers with no schooling and some primary education, and between some primary and some secondary education are statistically different at the 0.001 level of significance[3]. Higher education appears to have substantial effects on both short and medium-term measures of malnutrition; however, the sample size is insufficient (n = 7) to draw any conclusions. The sample sizes for weight-for-height (n = 60) and height-for-age (n = 59) child Z scores by women who have completed primary school are also too small, such that the differences in means between no schooling and completed primary education are not statistically significant.

Because weight-for-height reflects more immediate health and nutritional problems, maternal education should have less of an impact on this indicator. Clearly education could affect the manner in which a caregiver responds to illness, but it is unclear how a few years of schooling could have such dramatic impacts on malnutrition

[3] Primary education is defined as the first six years of education, secondary education as years seven through nine and higher education as any schooling beyond nine years.

(Engle 1995), particularly in the short run. Rather, the effects of education would likely accumulate over time, and thus be more recognizable in measures such as height-for-age.

Similar to maternal education, the effects of household wealth, as measured by asset ownership, are more highly correlated with the medium-term measure of malnutrition, particularly as those assets increase in value. DHS II included ownership of the following assets in the survey: radios, bicycles, motorcycles, televisions, refrigerators and cars. Although fewer households own a bicycle than a radio, owning a bicycle is much more important for rural than for urban households. In DHS II sample, 54 percent of rural households own a bicycle compared to just 15 percent of urban households.

The mean scores for weight-for-height do not vary considerably except for those households owning a refrigerator. The mean values for weight-for-height do decrease somewhat as asset ownership, in terms of value, rises, from owning a radio or a bicycle to ownership of a television, motorcycle or car. However, these differences are not statistically significant. The average WHZ score for families with a refrigerator is statistically significantly lower than for ownership of a television at the .05 level.

Wealth, as measured by household assets, is associated with much greater differences in the medium-term measure of malnutrition. The mean value for height-for-age is statistically significantly less for ownership of a radio than for ownership of a bicycle. Whether the difference between urban and rural average Z scores is due to wealth or some other factor remains to be investigated. Owning a motorcycle is also associated with better height-for-age Z scores ($p < 0.001$). Household ownership of televisions and refrigerators was, in turn, significantly related to higher HAZ scores than households owning motorcycles ($p < 0.05$). Finally, ownership of a car is associated with the highest mean height-for-age Z score. The small percentage of households owning cars, 3 percent in DHS II, leads to a smaller sample size (n = 154), which limits the significance of the results ($p < .10$).

It is logical that household wealth have a greater impact on medium-term than immediate indicators of malnutrition. If wealth is correlated with income, then higher levels of wealth will increase the ability of the household to produce and consume health-related goods and services. Elasticities of demand for certain food products, such as meat, are typically high in developing countries. Bennet's Law states that as income levels rise, households demand less staple foods and greater quantities of meats, fresh fruits and vegetables. These factors should lead to higher levels of nutrition within the household over time. Yet, in the short run, the effects of diarrhea or malaria may overwhelm the benefits afforded by greater income. The effects of a refrigerator could be more significant in the short run because it can serve as an input into the production of health-related goods and services.

The incidence of illness, size at birth and feeding practices are reported in the literature as significant factors in determining the health status of a child. Table 5.2 examines weight-for-height and height-for-age Z scores by the presence of disease, maternal anthropometry, prenatal and antenatal health care, and feeding practices.

Women reporting that their children had recently suffered from diarrhea and fever are associated with lower average Z scores for both WHZ and HAZ ($p < 0.001$)[4]. The effects of diarrhea on the immediate measure of malnutrition are clear; the significance of diarrhea on stunting may be serving as a proxy for maternal care. Children with recent

[4] Mothers were asked at the time of the interview whether their children had suffered from different illnesses within the past two weeks; children who were ill at the time of the interview were not measured.

episodes of diarrhea may be more likely to suffer from illness in general. Consequently, these children will have lower HAZ scores. The impact of fever is also significantly associated with stunting and wasting. However, it is impossible to discern whether the fever is a symptom of a mild flu or a much more serious disease, such as malaria. The

Table 5.2: WHZ and HAZ Scores by Health, Care and Feeding Practices

	WHZ Score – Wasting		HAZ Score – Stunting	
	Mean	Sample Size	Mean	Sample Size
Total	-1.11	4708	-1.22	4682
Illness:				
Diarrhea	-1.41	1250	-1.55	1245
Fever	-1.30	1974	-1.37	1965
Cough	-1.21	1435	-1.24	1427
Maternal BMI[5]:				
1st Quartile	-1.36	1172	-1.43	1165
2nd Quartile	-1.20	1157	-1.23	1150
3rd Quartile	-1.00	1169	-1.25	1163
4th Quartile	-0.90	1156	-0.98	1150
Prenatal Visit:				
None	-1.21	2325	-1.38	2310
Some Care	-1.02	2380	-1.06	2369
Antenatal Visit:				
None	-1.21	2325	-1.38	2310
1 or More	-1.02	2374	-1.06	2363
Feeding Practices:				
Under 7 Months				
Total	-0.61	1135		
No Other Liquids	-0.78	85		
Water	-0.60	1026		
Fresh Milk	-1.06	53		
Cereals	-1.19	58		
Eggs, Fish & Poultry	-0.88	15		
Meats	-0.71	8		
7 Months and Over				
Total	-1.28	3573	-1.60	3550
Eggs, Fish & Poultry	-1.21	1232	-1.61	1224
Meats	-1.21	1206	-1.65	1198

Source: Demographic and Health Survey, 1995-96

[5] Body Mass Index (BMI) is a commonly used indicator of adult anthropometry, measured by weight in kilograms divided by height in meters, which are then squared (WHO 1995).

effects of incidence of fever on stunting may again be serving as a proxy for maternal care, while the effects on wasting could operate through a loss in appetite or increased risk to other diseases and pathogens in the environment.

Maternal anthropometry is positively correlated with birth weight, one of the best predictors of child survival (Newman 1987). Infants who suffer from low birth weight and intrauterine growth retardation are more likely to be wasted and stunted (UNICEF 1996). Maternal anthropometry will account for a variety of factors, including household resources, endowments and environmental factors. Mean weight-for-height Z scores follow a clear upward trend with maternal body mass index (BMI) across the four quartiles (the fourth being the highest) and are statistically significantly different from each other ($p < 0.001$). Maternal BMI follows a similar pattern with height-for-age; however, there is no significant difference between the second and third quartiles.

Prenatal and antenatal care have similar affects on mean WHZ and HAZ scores. Nearly all of the respondents reporting prenatal care also reported antenatal care, hence there is no substantive difference between the two samples. There is a significant difference ($p < 0.001$) between those reporting having sought care versus those who did not in both mean WHZ and HAZ scores.

UNICEF (1996) recommends that all children be exclusively breastfed for the first six months. Although there appears to be some difference in the average weight-for-age Z score between children under 7 months and those being fed cereals, only 5 percent of the children in the survey were being weaned inappropriately. Children receiving foods rich in proteins, such as meat, poultry, eggs and fish, demonstrated no substantively better scores for height-for-age. While foods and feeding practices may be very important to the health and growth of a child, the method used in DHS II survey, in which respondents were asked which foods (read from a list) had been fed to children within the past 24 hours and over the past week, may collect inaccurate information.

5.4 Demographic and Health Survey, 1987

In nearly every category, average weight-for-height and height-for-age Z scores have decreased from the first DHS study, in 1987, to the second DHS study, conducted in

Table 5.3: Mean Z Scores for Wasting and Stunting

	WHZ 1987 Mean	WHZ 1995-96 Mean	$\mu_{1987} - \mu_{1995\text{-}96}$ Significance	HAZ 1987 Mean	HAZ 1995-96 Mean	$\mu_{1987} - \mu_{1995\text{-}96}$ Significance
Total	-0.85	-1.11	***	-1.05	-1.22	***
Age of Child:						
0 to 11 months	-0.64	-0.88	***	-0.62	-0.30	***
12 to 23 months	-1.12	-1.51	***	-1.28	-1.70	***
24 to 35 months	-0.80	-1.02	***	-1.40	-1.94	***
Sex of Child:						
Male	-0.89	-1.12	***	-1.06	-1.25	**
Female	-0.81	-1.11	***	-1.03	-1.19	**
Region:						
Kayes	-0.97	-0.97	NS	-1.14	-1.36	NS
Koulikoro	-0.80	-1.09	***	-0.88	-1.30	***
Sikasso	-0.78	-1.15	***	-1.25	-1.40	NS
Segou	-0.86	-1.05	**	-0.98	-1.30	**
Mopti	-1.07	-1.27	**	-1.28	-0.97	**
Timbuktu	-1.03	-1.44	NS	-1.19	-1.22	NS
Gao/Kidal	-1.05	-0.97	NS	-0.88	-1.24	NS
Bamako	-0.67	-1.14	***	-0.78	-0.65	NS
Location:						
Urban	-0.82	-1.11	***	-0.92	-0.97	NS
Rural	-0.88	-1.12	***	-1.18	-1.33	*

* indicates given H_0: $\mu_{1987} - \mu_{1995\text{-}96} = 0$; prob $|t| \leq 0.10$
** indicates given H_0: $\mu_{1987} - \mu_{1995\text{-}96} = 0$; prob $|t| \leq 0.05$
*** indicates given H_0: $\mu_{1987} - \mu_{1995\text{-}96} = 0$; prob $|t| \leq 0.01$
NS indicates not statistically significant

Source: Demographic and Health Surveys, Mali, 1987 and 1995-96

1995 and 1996. These results do not necessarily indicate that child health and nutrition is worsening in Mali because the two studies may simply represent different samples of the population. What these results do suggest is that the prevalence of low weight-for-height and height-for-age is a cause for concern. Table 5.3 reports the average WHZ and HAZ scores for the first and second DHS studies, as well as a significance test of the difference in means.

The mean Z score for weight-for-height and height-for-age is lower in the DHS II study and statistically significantly different from DHS I at the .01 level of significance. Likewise, the average WHZ and HAZ scores by age of the child in DHS II are all lower, with the exception of height-for-age for children under one year, and statistically significantly different at the .01 level. Average WHZ and HAZ scores have also deteriorated in the Koulikoro ($p < .01$) and in the Segou and Mopti regions ($p < .05$). The sample sizes for Timbuktu and the Gao and Kidal regions are very small, thus the means for WHZ and HAZ scores are not statistically different across studies.

Table 5.4: Maternal Education for Urban and Rural Households

	Urban		Rural	
Maternal Education:	DHS I 1987	DHS II 1995-96	DHS I 1987	DHS II 1995-96
None	67%	70%	92%	91%
Some Primary (1-5 years)	13%	15%	6%	7%
Complete Primary (6 years)	6%	3%	1%	1%
Some Secondary (7-8 years)	6%	7%	1%	1%
Completed Secondary (9 years)	5%	3%	0%	0%
Higher (10 or more years)	4%	1%	0%	0%

Source: Demographic and Health Surveys, Mali, 1987 and 1995-96

Maternal education is widely reported in other studies to be an important factor associated with better child nutrition and lower rates of mortality. One potential explanation of the differences in mean Z scores for weight-for-height and height-for-age could be levels of schooling. Higher levels of schooling are correlated with better WHZ and HAZ scores in both studies. Table 5.4 summarizes the maternal education for women with children measured in the two studies.

Overall, there is very little difference in maternal schooling for rural households. There is evidence that urban households in the first DHS study may have received more education than their counterparts in DHS II. Furthermore, 40 percent of the children in the first DHS study live in rural areas, compared to just 30 percent of children in DHS II. Although the differences in maternal education will likely contribute to lower WHZ and HAZ scores in the more recent study, they are not substantial enough to account entirely for the drop in mean Z scores. It is unlikely that female schooling rates would be declining over time, given the recent emphasis on women in development. Thus, the variation in maternal education for the two studies may simply be the result of different samples.

Another important consideration is differences in levels of reported illness across the two studies. The first DHS was conducted from March to August, while DHS II occurred between November and May. Disease is directly related to environmental conditions, which vary substantially according to the season. The rainy season generally begins in June, depending on the region, and lasts through September or October. Water and sanitary conditions vary substantially with the season, and hosts that transmit disease, for example malaria, may be more prevalent during certain periods of the year. Table 5.5

summarizes the differences in reported illnesses for children by the month of the interview.

Multiple responses were not permitted for the incidence of diarrhea in the first DHS study. The child can either have been ill in the last 24 hours or the last two weeks, but not both. For purposes of comparison with DHS II, these two responses can simply be added together, which results in much higher rates of women reporting children with diarrhea in DHS I.

Table 5.5: Incidence of Illness by Month of Interview

	DHS I – 1987				DHS II 1995-96		
	Diarrhea last:		Fever last:	Cough last:	Diarrhea last:	Fever last:	Cough last:
Month:	24 hrs.	2 weeks	4 weeks	Unspecified	2 weeks	2 weeks	2 weeks
January					31%	45%	28%
February					28%	42%	29%
March	17%	19%	34%	10%	24%	40%	27%
April	26%	22%	62%	6%	24%	41%	32%
May*					30%	35%	45%
June	28%	16%	36%	5%			
July	28%	19%	37%	5%			
August**	26%	3%	18%	3%			
September							
October							
November					23%	43%	38%
December					27%	40%	32%
Total	26%	18%	37%	6%	27%	42%	30%

*n = 20
**n = 34
Source: Demographic and Health Surveys, Mali, 1987 and 1995-96

It is difficult to compare the results of the two studies because different questions were posed to respondents. Furthermore, the months in which the interviews took place vary according to region, and regional differences will also affect the incidence of disease. The number of women reporting their child having a cough recently is much lower in DHS I than DHS II even for the two months which overlap. The incidence of fever within the last 4 weeks in the DHS I is particularly high during April, 62 percent.

5.5 Enquete Budget-Consommation, 1988-89

The incidence of malnutrition in children, as measured by the Enquete Budget-Consommation (EBC), is generally higher or as high as those reported in the first DHS study, but somewhat lower than DHS II. Children whose weight-for-height Z scores 2 or more standard deviations below the reference mean are classified as "wasted". Similarly, children with height-for-age Z scores 2 or more standard deviations below the reference mean are classified as "stunted". Table 5.6 summarizes the incidence of wasted and stunted children by age group for the three studies. Means and standard deviations are not available to make statistical comparisons between the EBC and the two DHS studies.

Table 5.6: Percentage of Children with WHZ and HAZ Scores ≤ -2 S.D. Below the Mean

	Wasted: % ≤ -2 S.D Below the Mean			**Stunted: % ≤ -2 S.D Below the Mean**		
Age of Child:	EBC 1988-89	DHS I 1987	DHS II 1995-96	EBC 1988-89	DHS I 1987	DHS II 1995-96
0 to 11 Months	18.8%	9.1%	19.6%	9.3%	12.4%	9.5%
12 to 23 Months	20.2%	15.6%	34.1%	28.3%	30.0%	40.7%
24 to 35 Months	15.1%	7.2%	18.9%	35.6%	30.5%	47.7%

Source: Enquete Budget-Consommation, 1988-89 and Demographic and Health Surveys, 1987, 1995-96.

The EBC study reports a higher percentage of wasted children among the three age groups of children than DHS I study conducted in 1987. However, the number of children classified as stunted are slightly less but similar for less than 1 and 1 year old children, and somewhat higher for 2 year olds. Although the percentage of children classified as wasted and stunted are nearly identical in the first year of life between the

EBC and DHS II, these rates rise much more dramatically in the second and third years for DHS II sample. It is still difficult to conclude whether rates of malnutrition are worsening across time, or if these differences are due to sample selection.

Table 5.7: Differences in Maternal Education by Urban and Rural Location, DHS I and II

	DHS I								DHS II			
	WHZ				HAZ				WHZ & HAZ			
	% No Educ.		Sample		% No Educ.		Sample		% No Educ.		Sample	
Age of Mother	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur	Urb	Rur
15 to 19	48%	90%	26%	74%	45%	91%	31%	69%	69%	92%	29%	71%
% of sample			8%	11%			8%	13%			12%	10%
20 to 24	59%	91%	30%	70%	54%	90%	40%	60%	66%	91%	27%	73%
% of sample			18%	21%			19%	20%			24%	22%
25 to 29	60%	87%	34%	66%	58%	84%	44%	56%	68%	91%	26%	74%
% of sample			27%	26%			29%	26%			24%	24%
30 to 34	63%	91%	35%	65%	54%	89%	42%	58%	72%	91%	24%	76%
% of sample			22%	21%			20%	20%			20%	21%
35 to 39	90%	97%	41%	59%	92%	95%	50%	51%	69%	93%	23%	77%
% of sample			19%	14%			18%	15%			13%	16%
40 to 44	92%	98%	30%	70%	90%	96%	40%	61%	88%	90%	27%	73%
% of sample			6%	7%			6%	6%			7%	6%
45 to 49	100	88%	24%	77%	100	100	33%	67%	80%	96%	14%	86%
% of sample			1%	2%			1%	1%			1%	2%
Same Age Cohorts:												
15-19 & 23-27	48%	90%	26%	74%	45%	91%	31%	69%	68%	92%	26%	74%
% of sample			8%	12%			8%	13%			34%	31%
20-24 & 28-32	59%	91%	30%	70%	54%	90%	40%	60%	68%	90%	24%	76%
% of sample			19%	23%			20%	22%			31%	32%
25-29 & 33-37	60%	87%	34%	66%	58%	84%	44%	56%	71%	92%	24%	76%
% of sample			29%	29%			31%	28%			21%	22%
30-34 & 38-42	63%	91%	35%	65%	54%	89%	42%	58%	82%	91%	26%	74%
% of sample			24%	22%			21%	22%			12%	11%
35-39 & 43-47	90%	97%	41%	59%	92%	95%	50%	51%	85%	94%	17%	83%
% of sample			20%	15%			20%	15%			2%	4%

Source: Demographic and Health Surveys, 1987 and 1995-96.

Table 5.7 details the differences in the percent of mothers with no formal education by urban and rural areas for the two Demographic and Health Surveys. Comparisons are made by specific age cohorts of mothers in the two studies and also for age cohorts of women eight years older in DHS II (roughly the time between the first and second study). It is clear from this table that the urban women selected for DHS I are more educated than the women studied in the second survey. Consequently, direct comparison of weight-for-height and height-for-age Z scores between the two studies may be inappropriate; the samples from two DHS studies appear to represent different populations.

The EBC study calculated elasticities of demand, based on household expenditures, for numerous food products. Under the assumption that household expenditures closely reflect income, elasticities based on expenditures represent the income elasticity for demand. The income elasticity of demand for a particular commodity indicates the percent change in the quantity demanded of a particular good for a one unit change in income (Mansfield 1970). Table 5.8 reports the elasticities by average expenditure for various food products.

The estimates of expenditure elasticities on food is consistent with other findings. Subramanian and Deaton (1996) estimate .75 for their study in rural India. Overall, the elasticities for individual foods calculated by the EBC study are higher for rural than for urban consumers. Food is clearly more of a priority for rural households than for urban dwellers. This may indicate lower average incomes for rural households or different preferences. The income elasticity of demand for meat is high among both urban households and rural consumers, 1.36 for urban households and 1.43 for rural, although

Table 5.8: Demand Elasticities by Food Products for Urban and Rural Households

Expenditure Elasticities:	Urban	Rural
Total Food	.75	.88
Cereals	.22	.49
Tubers	.67	.80
Vegetables	.38	.62
Legumes	.39	.43
Fruits	.92	1.23
Grains and Oils	.45	.97
Meat	1.36	1.43
Poultry	.98	1.23
Fish	.25	.56
Oils and Fats	.76	1.58
Milk and Eggs	.84	.78
Sugar and Sugar Products	.68	1.54
Drinks, Tobacco	.95	1.33
Other	1.07	.97

Source: Enquete Budget-Consommation, 1988-89.

consumption may still be low. Cereals, however, have elasticities well below unity. The demand elasticity for cereals is .22 for urban consumers and .49 for rural consumers. The expenditure elasticities for cereals, fish, vegetables, legumes, and grains and oils are all less than .5 for urban consumers. While the only elasticities that exceed unity for urban consumers are meat and other foods, fruits, meat, poultry, oils and fats, sugar and sugar products, and drinks and tobacco are all greater than one for rural consumers.

The expenditure elasticities are also reported according to expenditure category by the EBC study. Table 5.9 summarizes the demand elasticities and the average share of the household budget by category for urban and rural consumers. For urban households, food is the only category substantially below 1.0; lodging is near 1.0 and all the other categories are well above unity. Rural households are similar, although the demand elasticity for food is greater and for lodging smaller. Since food accounts for such a large percentage of the household budget, the greater than unitary increase in the consumption

Table 5.9: Demand Elasticities by Expenditure Category for Urban and Rural Households

	Urban		Rural	
Expenditure Category:	Elasticity	% of Budget	Elasticity	% of Budget
Food	.75	47%	.88	57%
Clothes	1.65	16%	1.24	14%
Lodging, Energy	.97	13%	.81	10%
Household Goods	1.36	4%	1.26	5%
Health	1.37	4%	1.43	3%
Transportation, Communication	1.68	6%	1.45	4%
Education, Leisure	1.53	2%	1.56	1%
Other	1.11	7%	1.21	6%

Source: Enquete Budget-Consommation, 1988-89.

of many goods and services is permissible, to some extent, by the relative decrease in food expenditures.

There is substantial variation in the types of foods consumed by households in different geographical areas of Mali. Table 5.10 reports per capita consumption, in kilograms, of selected food categories and the food share of the total household budget by region. Millet and rice are much more important to the northern area of the country, while sorghum and maize are an important part of diets in the south. Bamako and Gao, predominately urban for the purposes of the study, consume much fewer cereals, on average, than the rest of the country. However, men in urban areas are more likely to eat meals away from home (Reardon et al. 1998). Although the EBC has accounted for this by distinguishing people who do not eat all of their meals at home, the estimates of per capita cereal consumption may still be understated, as would the share of expenditures on food. Bamako does consume more vegetables per capita than any other region. All of these figures will vary according to climatic conditions and the ensuing success or failure of crops among the different regions.

Table 5.10: Annual Per Capita Consumption (kg.) of Selected Foods by Region

Product:	Kayes	Koulikoro	Sikasso	Segou	Mopti	Timbuktu	Gao/Kidal	Bamako
Cereals	190.1	233.4	221.3	197.3	227.0	198.8	155.8	137.8
Millet	22.7	99.2	82.7	114.3	147.9	69.2	42.4	22.4
Sorghum	107.7	92.7	50.7	27.3	24.9	46.2	15.4	42.1
Rice	21.2	19.7	12.0	34.4	47.6	69.9	68.8	59.7
Maize	34.7	20.2	73.7	17.3	5.6	7.1	21.6	7.8
Legumes	22.0	10.0	4.8	13.1	3.8	0.7	0.6	9.0
Meat/Poultry	13.0	7.7	4.4	8.1	3.1	8.1	16.6	14.0
Fish	2.9	4.2	2.4	7.1	10.0	12.0	13.0	5.1
Milk & Eggs	8.9	7.5	4.8	6.3	6.6	20.2	16.6	3.6
Vegetables	16.7	15.8	15.2	14.1	5.1	10.9	5.0	28.7
Green Leafs	13.1	7.3	3.6	4.3	7.3	4.1	3.1	6.2
Fruits	1.2	3.0	1.2	1.6	1.8	0.6	0.4	2.2
Food Share of Budget	64%	51%	54%	55%	66%	77%	76%	54%

Source: Enquete Budget-Consommation, 1988-89.

5.6 Enquete Malienne de Conjuncture Economique et Sociale, 1994

The Enquete Malienne de Conjuncture Economique et Sociale (EMCES) studied a wide variety of socio-economic factors in Mali, including child anthropometry. However, the children measured ranged from 0 to 5 years old. No breakdown of these measures by age is available; thus the percent of children classified as stunted and wasted is not comparable to the other studies.

The EMCES did examine household budgets by expenditure. Table 5.11 summarizes the percent of expenditures allocated to different categories between the EMCES study in 1994 and the EBC study in 1988-89. Comparing the results from the EMCES study with the EBC study in 1988-89 shows substantial change in expenditures on food. Urban consumers allocated 15 percent more and rural consumers 20 percent more of the household budget on food between the 1994 and the 1988-89 study. Much of this increase is accounted for by the rise in the share of the household budget spent on

Table 5.11: Expenditures by Category as a Percent of Total Expenditures

Expenditure Category:	Urban EBC 1988-89	Urban EMCES 1994	Rural EBC 1988-89	Rural EMCES 1994
Food	47%	62%	57%	77%
Cereals	14%	23%	23%	42%
Meat/Poultry	7%	11%	4%	9%
Clothing	16%	6%	14%	6%
Lodging	13%	11%	10%	4%
Household Goods	4%	NA	5%	NA
Health Care	4%	3%	3%	3%
Transportation	6%	15%	4%	7%
Leisure/Education	2%	1%	1%	0%
Other	7%	2%	6%	3%

Source: Enquete Malienne de Conjuncture Economique et Sociale, 1994 and Enquete Budget-Consommation, 1988-89.

cereals. Urban households spend 9 percent more on cereals in the EMCES study and rural households spend 19 percent more, almost double the share of expenditures devoted to cereals in the EBC study. Both urban and rural consumers also devoted a larger share of their budget to meat and poultry in the more recent study. The reason for the change in expenditures is difficult to interpret. Clothing expenditures, as a share of total expenditures, did fall substantially for both urban and rural households in the EMCES study. The increase in food expenditures could be due to falling real incomes in Mali. Moreover, the devaluation of the currency in 1994 and the resulting rapid increase in prices could have made consumers more cautious, lowering the consumption of non-essentials. However, the differences in the two studies may also represent different samples or different methods of data collection.

The EMCES study also reported asset ownership of various items. Table 5.12 summarizes the percent of urban and rural households owning different assets across the four studies. The EBC study reported the lowest percentage of assets owned by urban households. The percent of urban households owning all assets except televisions was highest in DHS I study. For rural households, the pattern is similar, but not as stark. Asset ownership was generally lowest among rural households in the EBS survey. Rural households in DHS I and II studies were more likely to own bicycles and radios than in the other studies.

All of these assets are durable goods, although they will depreciate over time. Nevertheless, one would expect to find asset ownership increasing over time. There is some evidence of such an increase in the three most recent studies, the EBC survey in

Table 5.12: Asset Ownership by Urban and Rural Households

	Urban				Rural			
	DHS I	EBC	EMCES	DHS II	DHS I	EBC	EMCES	DHS II
Asset:	1987	1988-89	1994	1995-96	1987	1988-89	1994	1995-96
Radio	81%	60%	69%	73%	45%	37%	49%	60%
Bicycle	21%	19%	19%	17%	55%	38%	39%	55%
Motorcycle	47%	21%	29%	30%	21%	6%	13%	17%
Television	10%	10%	25%	22%	0%	0%	3%	3%
Refrigerator	11%	8%	12%	10%	0%	1%	1%	0%
Car	12%	7%	15%	9%	0%	1%	2%	1%

Source: Enquete Malienne de Conjuncture Economique et Sociale, 1994 and Enquete Budget-Consommation, 1988-89, Demographic and Health Surveys, 1987 and 1995-96.

1988-89, the EMCES in 1994 and DHS II in 1995-96. However, the differences in asset ownership may also represent differences in the samples, particularly for the dramatic decrease in asset ownership between DHS I study in 1987 and the EBC study just two years later. This suggests that the DHS I selected wealthier urban households than the other three surveys.

5.7 Summary

Child malnutrition in Mali is pervasive. The pattern of low weight-for-height and height-for-age Z scores clearly indicates that a set of factors is contributing to diminishing the nutrient intake during the first three years of life. It is possible that these factors are consistently present and biological changes in the child accelerate growth retardation at different stages in life. As the child ages, the manner in which households respond and adjust behavior may also contribute to lower levels of nutritional status.

There is a substantial amount of variation across different factors, such as region, ethnicity, education and wealth, in weight-for-height and height-for-age Z scores. Maternal anthropometry, health and health care are also correlated with better nutrition. However, other factors widely reported as being influential, notably feeding practices, are more ambiguous. Measures of child anthropometry declined overall between the first and second DHS studies, and in nearly every case when disaggregated by various factors, including age of the child, region, and location. Levels of maternal education in rural households remained constant, although for urban households this figure may have decreased slightly.

Estimates of elasticities of demand, based on household expenditures, reveal higher demand elasticities for rural households than urban consumers for nearly all types of foods. The demand elasticity for cereals is particularly low in urban areas, .22, while it is estimated at .49 for rural households. Similarly, rural consumers allocate a larger share of the household budget to food than urban residents, 57 percent versus 47 percent. However, these estimates of the share of the total budget spent on food is substantially less than a more recent study in 1994, in which 62 percent of the urban budget and 77 percent of rural expenditures were spent on food. The high elasticities of demand for food and the large portion of expenditures allocated to food for many of the households offers some evidence that people are not eating as well as they would like to be.

Wealth, as measured by the ownership of various durable goods, reveals substantial differences between some of the surveys analyzed in the chapter. It is unlikely that wealth would fluctuate so remarkably over such a short time period. Instead, it is more likely that the different studies are representative of different samples in Mali. Consequently, the analysis in the following chapter must control for many of these factors in order to analyze the determinants of malnutrition and explain the apparent deterioration of child health.

CHAPTER VI

UNDERLYING DETERMINANTS OF CHILD MALNUTRITION

6.1 Introduction

This chapter examines the underlying determinants of child malnutrition through an economic model of household behavior, developed in Chapter 3, with specific attention to the role of agricultural production and productivity. Econometric analysis is used to estimate the effects of certain key variables, notably income, education, prices and infrastructure, on weight-for-height and height-for-age Z scores in children aged 6 to 35 months. Community fixed effects and community covariate models are compared across different samples, urban, rural and pooled, for both Demographic and Health Surveys from 1987 and 1995-96. The results of these parameter estimates are then compared for robustness across model specification.

The following section (6.2) discusses the data and methods used in the analysis. Section 6.3 presents the results of the community fixed effects models on weight-for-height (6.3.1) and height-for-age (6.3.2) for children from both the DHS I and DHS II studies. Section 6.4 includes data on staple food prices and community infrastructure with information from DHS II into community covariate models to study their impact on wieght-for-height (6.4.1) and height-for-age (6.4.2) Z scores for children. The following section, (6.5) incorporates information learned from other studies and the analysis of agriculture contained in Chapter 4 in order to test the potential affects of agriculture on child malnutrition. The final section (6.6) summarizes the major points discovered in the analysis of the underlying determinants on child malnutrition.

6.2 Data and Methods

Data from the two Demographic and Health Surveys, 1987 and 1995/96, are used for the analysis in this chapter. Details of the sampling method for the households included in the surveys are discussed in section 5.2. There are some important differences between the children measured in the first and second DHS studies. Notably, more children measured were from urban areas in the first survey than in the second, roughly 40% in DHS I versus 30% in DHS II. Moreover, the mothers of children living in urban areas in DHS I have higher levels of education, on average, than the mothers of children in urban areas in DHS II. While regression analysis will control for some of the variables that influence these differences, it is clear that the two studies are representative of different populations. Consequently, the results of the economic models are presented separately for DHS I and II. The regression models were also run separately for the urban and rural subsets of the population, in addition to the pooled sample for each DHS study.

A larger percentage of the children surveyed in the first DHS study were not measured anthropometrically than were measured in DHS II. Children who were not at home, were sick or refused were not measured for either study. All other living children[1] were weighed and measured for height[2]. Thus a weight-for-height Z score has been calculated for these children. Any WHZ score falling below 4 or above 4 standard deviations from the reference mean is excluded. Essentially, children are unlikely to survive if their WHZ score is below 4 standard deviations; consequently, such a score is

[1] Birth histories are recorded for all children born, living or dead, within the past five years.
[2] Height is measured as recumbent height for children under two years and measured standing up for children two years and older.

more likely to represent measurement error than an actual valid observation. A score 4 standard deviations above the mean is typically not encountered in developing countries.

For children whose birth month and birth year is unknown by the mother, height-for-age Z scores are not calculated. This is not a factor in DHS II; year and month of birth were known by all respondents. However, in DHS I, 563 children had weight-for-height Z scores without height-for-age Z scores. The birth of the child has been imputed from other events in the child's life by the interviewer. For example, the year of birth is known but not the month, or the month is known but the birth year is not specified. In some cases, neither the month nor the year of birth is known. The number of children with a known birth month but an unspecified year of birth is quite large relative to the size of the sample, 243 children in addition to the 948 children measured. Consequently, HAZ scores, using the CDC/NCHS reference data (WHO 1978) have been calculated for these children by the researcher. These children are, on average, predominately from rural areas, have less educated mothers and lower HAZ scores. Due to the sensitivity of HAZ scores to the age of the child in months, HAZ scores are calculated only for children whose month of birth, but not year, is known. It is assumed that the year is likely to be specified correctly, and if it were not correct, the HAZ score would likely fall outside the acceptable range of values, 6 standard deviations above or below the mean reference score.

Least squares regression was used to estimate the models in this chapter. The Breusch-Pagan test for heteroscedasticity rejected the null hypothesis of homoscedasticity for all but one iteration of the community fixed effects models at a significance level of .05. Heteroscedasticity occurs when the variance of the error term is not constant across observations, which can lead to biased and inconsistent estimates of the standard errors of model parameters. Consequently, estimates of the standard errors, robust to both heteroscedasticity and auto-correlation, were calculated using the Newey-West correction. The null hypothesis of homoscedasticity was also rejected at the .05 level of significance for the community covariates models. For these models, robust estimates of standard errors were also calculated using the Newey-West method. Weighted least squares[3] were initially used to compute more efficient estimates of the standard errors; however, estimates of standard errors did not differ substantively between the two methods. The Newey-West correction was chosen for convenience.

The price data on coarse grains are collected by the Agricultural Market Information Service (OMA) in Mali, part of the Permanent Assembly of the Malian Chamber of Agriculture (APCAM). Producer and consumer prices are collected on a weekly basis in 80 different markets throughout the country. Prices for millet, sorghum, maize and rice reflect a monthly average of the available number of observations for each market. In the models of children's weight-for-height, the monthly average price corresponds to the month in which the interview was conducted. In the height-for-age models, the November price was used as an indicator of prices for the rest of the year. This month was selected because large quantities of grain are traded following the harvest; consequently, markets are less susceptible to imperfect competition. If the price of a commodity is less in 1994 than in 1995, it is expected that the price of this commodity will, on average, remain lower throughout 1994 than in 1995. The November

[3] The weighting variable for each observation is the inverse of the predicted value obtained from a regression of the squared residuals on all the variables in the model, including the dependent variable. The squared residuals were estimated using ordinary least squares regression of dependent variable on the explanatory variables in the model.

prices were averaged corresponding to the age of the child. For instance, if the child was between two and three years of age, prices of coarse grains from November 1993, November 1994 and November 1995 were averaged. If the child was under one year of age, only the November 1995 price is included. For commodities in markets where price information was not available, average regional prices are substituted. To account for average prices representing commodities not actually being traded, a dummy variable is used to represent markets with missing prices for absent commodities. However, the exact interpretation of the effect of the dummy variable on the corresponding grain price is unclear.

The information concerning community infrastructure is contained in DHS II. This data are collected for each cluster point in the DHS II and include information on schools, health centers, markets and other community endowments. Because the information is collected at the cluster level, households within that cluster may reside in different villages. This questionnaire was usually administered to largest village within the cluster point. Consequently, variables such as the distance to the nearest health facility only relate to the main village. Many of the households in the same cluster actually inhabit nearby villages. However, the presence of infrastructure within the central village may still serve as a useful proxy for the availability of various facilities to households from outlying areas.

Tables of means, standard deviations, minimums and maximums for all the variables used in the weight-for-height and height-for-age regression models are included in Appendix II. Appendix III contains the parameter estimates for all variations of the models used in this chapter including variables that control for maternal age, household size, the number of women, the type of toilet facility and the type of water source. Some discussion on the influence of water source and toilet facility is included in section 6.5, particularly as these variables relate to rural development projects associated with agriculture in Mali. These variables are suppressed in the following analysis contained in sections 6.3 and 6.4 to avoid any conflict with biased results from possible endogenous variables. The coefficients on dummy variables controlling for community variability in the community fixed effects model are not reported.

6.3 Community Fixed Effects Determinants of Malnutrition

The reduced form community fixed effects models of the underlying determinants of weight-for-height and height-for-age Z scores in children aged 6 to 35 months yield ambiguous results. These models analyze intra-community variation in child health and nutrition, controlling for differences across communities. Most of the parameter estimates are not robust across model specification. Asset ownership, used as a proxy variable for household income, is typically positively associated with the Z scores, and several of the parameter estimates are significant or jointly significant at conventional levels. The effects of maternal schooling are mixed; education is positive and significantly associated with better WHZ scores, but is not significantly related to better HAZ scores, a somewhat counter-intuitive result. One might expect to find that, over the long run, children with more educated mothers would fare better, or that this result might at least be more pronounced.

6.3.1 Weight-for-Height

The effects of income on weight-for-height Z scores in children, approximated by the ownership of various assets, are generally positive but not robust across model specification. Table 6.1 presents the results of OLS regression of selected variables on weight-for-height Z scores for children ages 6 to 35 months. In the first DHS study, the signs of the coefficients on the dummy variables for wealth are positive in the pooled sample, negative in the urban area and positive in the rural sample. In the DHS II sample, all the coefficients are positive, and ownership of two and three or more assets are both significant at the .05 level of significance.

The effects of education on weight-for-height Z scores are fairly consistent across model specification. The parameter estimates are positive for the DHS I samples, and range from .16 to .34. Thus, the children of women with some primary or secondary or higher education are expected to have a WHZ score that is approximately .25 standard deviations greater than women with no education. Both the parameter estimates for the pooled sample are significant at the .10 level. The effects of education in DHS II are somewhat less clear, but are generally positive. Primary education is positive and significant for both the pooled and for the urban samples ($p < .01$), with magnitudes somewhat greater than the DHS I model. Only for the rural sample is the coefficient negative and, given the very small number of rural mothers with secondary or higher education, probably associated with other unobserved factors for these few households. The dummy variables used to control for the age of the child indicate that understanding the factors associated with age will help explain much of what is occurring that results in low weight-for-height. The effects of the child aging from 6 to 11 months to 12 to 17

Table 6.1: Regression of Selected Variables on WHZ Scores of Children 6 to 35 months

	DHS I			DHS II		
Variable[†]	**Pooled**	**Urban**	**Rural**	**Pooled**	**Urban**	**Rural**
Constant[‡]	-0.6934 (3.2289)***	-0.6903 (2.4181)**	-0.7238 (3.3335)***	-1.5474 (6.1490)***	-1.5484 (5.9004)***	-0.8439 (4.7876)***
Wealth (1 asset)	0.0491 (0.5933)	-0.0521 (0.3258)	0.0991 (1.0447)	0.0958 (1.6808)*	0.1077 (1.0769)	0.0884 (1.2736)
Wealth (2 assets)	0.0603 (0.6656)	-0.0349 (0.2363)	0.1052 (0.8730)	0.1338 (2.1724)**	0.1354 (1.0907)	0.1246 (1.7494)*
Wealth (3 + assets)	0.0373 (0.3777)	-0.1063 (0.6290)	0.1836 (1.4393)	0.1707 (2.2172)**	0.2327 (1.7202)*	0.1256 (1.3297)
Primary Education	0.1999 (1.9406)*	0.1570 (1.0391)	0.2291 (1.6203)	0.2332 (3.1269)***	0.3223 (2.7962)***	0.1623 (1.6448)
Secondary Education	0.2120 (2.0648)**	0.1967 (1.6315)	0.3399 (1.7159)*	0.1411 (1.4055)	0.2214 (1.8353)*	-0.0848 (0.4258)
Mother's HAZ	Not Available	Not Available	Not Available	0.0405 (1.9930)**	0.0343 (0.8800)	0.0423 (1.7743)*
Child's Age 12-17 months	-0.3033 (3.6406)***	-0.3476 (2.4129)**	-0.2765 (2.7840)***	-0.2753 (4.6258)***	-0.2219 (1.9317)*	-0.3058 (4.3772)***
Child's Age 18-23 months	-0.1904 (2.1795)**	-0.3273 (2.3553)**	-0.0806 (0.7164)	-0.2095 (3.1862)***	-0.1846 (1.4431)	-0.2279 (2.9660)***
Child's Age 24-29 months	-0.0830 (0.9352)	-0.2469 (1.6986)*	0.0408 (0.3627)	0.2429 (3.9279)***	0.2134 (1.7744)*	0.2550 (3.5350)***
Child's Age 30-35 months	0.1073 (1.2747)	0.0316 (0.2183)	0.1540 (1.5185)	0.2926 (4.8723)***	0.2566 (2.2478)**	0.3030 (4.2983)***
Child is Twin	-0.2267 (1.7675)*	-0.3074 (1.5541)	-0.1665 (0.9618)	-0.1672 (2.0493)**	0.0506 (0.4081)	-0.2768 (2.6928)***
Joint Significance: Wealth (2 & 3+ assets)	F(2,1162) 0.2475	F(2,480) 0.2448	F(2,661) 1.0188	F(2,3364) 3.2078**	F(2,973) 1.6513	F(2,2369) 1.6410
Primary & Secondary Ed.	3.7412**		2.3125*	4.2780***		1.6278
Breush-Pagan X^2 (n – k d.f.)[§]	232.0***	93.7**	145.4***	624.9***	227.9***	402.6***
F Test Statistic	1.6360***	1.4753**	1.6726***	2.2303***	1.9790***	2.3122***
R-Squared	0.1747	0.1670	0.1896	0.1695	0.2044	0.1565
R-Squared Adjusted	0.0679	0.0538	0.0762	0.0935	0.1011	0.0888
Sample Size	1328	561	767	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

months on WHZ scores are negative and significant for all of the models, ranging from a decrease of .22 to .30 standard deviations. These effects occur after the child has been weaned, and could be associated, in part, with the quality of foods being fed to the child. Positive improvements in WHZ scores, relative to 6 to 11 month old children, begin to occur as the child moves into the second year of life. Many of the effects of the child's age are highly significant ($p < .01$) in the DHS II, particularly for the rural and pooled samples.

Many of the parameter estimates of the variables used to explain the variation in weight-for-height Z scores of children are not robust across model specification. The effects of education are somewhat consistent across models; wealth is more ambiguous. Much of the explanatory power of the model is attributable to dummy variables controlling for the age of the child and the individual communities. A very low percentage of variation in the dependent variable explained by the explanatory variables in sample is not uncommon in studies of weight-for-height, and, according to some researchers, is to be expected given the nature of this phenomenon (von Braun et. al 1994b).

6.3.2 Height-for-Age

All of the dummy variables used to control for the age of the child are negative and highly significantly related to height-for-age Z scores in children 6 to 35 months. Table 6.2 reports the results of OLS regression for selected variables on height-for-age Z scores for children ages 6 to 35 months. The extent of this relationship suggests that small height-for-age accumulates over time. To a large extent, the age dummy variables

Table 6.2: Regression of Selected Variables on HAZ Scores of Children 6 to 35 months

Variable[†]	**DHS I Pooled**	**Urban**	**Rural**	**DHS II Pooled**	**Urban**	**Rural**
Constant[‡]	-0.7918 (1.1975)	-0.3493 (0.6762)	-0.6893 (1.0461)	-0.5110 (1.3090)	-0.6277 (1.5615)	-0.3776 (1.4407)
Wealth (1 asset)	-0.0163 (0.1004)	0.2520 (1.0646)	-0.1576 (0.7284)	0.0283 (0.4110)	0.1429 (1.1631)	-0.0268 (0.3215)
Wealth (2 assets)	0.3614 (2.2216)**	0.5244 (2.3537)**	0.3674 (1.5542)	0.0341 (0.4511)	0.2694 (1.7519)*	-0.0450 (0.5205)
Wealth (3 + assets)	0.3376 (1.7057)*	0.7595 (2.6898)***	-0.1514 (0.5424)	0.1276 (1.4086)*	0.3013 (2.0121)**	0.0503 (0.4366)
Primary Education	0.1012 (0.5569)	-0.0750 (0.3296)	0.3453 (1.2437)	0.0862 (1.0572)	0.0690 (0.5469)	0.0968 (0.9041)
Secondary Education	0.2024 (1.2966)	0.1707 (0.9510)	-0.1134 (0.3273)	0.1113 (1.0252)	0.0601 (0.4562)	0.1985 (1.0096)
Mother's HAZ	Not Available	Not Available	Not Available	0.2526 (9.8747)***	0.2140 (4.6680)***	0.2680 (8.7031)***
Child's Age 12-17 months	-0.6284 (4.3436)***	-0.5454 (2.5441)**	-0.6631 (3.4207)***	-0.7819 (11.128)***	-1.0013 (8.0902)***	-0.6874 (8.1087)***
Child's Age 18-23 months	-0.7563 (4.9401)***	-0.5918 (3.0581)***	-0.9203 (3.9718)***	-1.5134 (20.121)***	-1.4190 (10.029)***	-1.5501 (17.413)***
Child's Age 24-29 months	-0.9587 (6.0785)***	-0.7898 (3.8055)***	-1.1571 (4.7266)***	-1.1224 (15.227)***	-0.9443 (6.7818)***	-1.2021 (13.818)***
Child's Age 30-35 months	-0.9646 (6.5462)***	-0.5864 (2.8937)***	-1.2874 (6.1089)***	-1.5762 (20.619)***	-1.4892 (10.550)***	-1.6124 (17.728)***
Child is Twin	-0.0188 (0.0999)	-0.2725 (1.0888)	0.3930 (1.4501)	-0.3678 (4.1020)***	-0.4196 (2.8764)***	-0.3391 (3.0002)***
Joint Significance: Wealth (2 & 3+ assets)	F(2,877) 2.6947*	F(2,393) 4.3357**	F(2,463) 2.3102	F(2,3364) 1.0022	F(2,973) 2.3230*	F(2,2369) 0.4679
Primary & Secondary Ed.	0.7746	0.7250	0.7543	1.6143	0.1915	0.6397
Breush-Pagan X^2 **(n – k d.f.)**[¶]	211.0***	75.3	130.6***	1020.5***	306.3***	699.2***
F Test Statistic	1.5084***	1.1640	1.5222***	4.1824***	2.9175***	4.6523***
R-Squared	0.2027	0.1591	0.2300	0.2768	0.2747	0.2719
R-Squared Adjusted	0.0683	0.0224	0.0789	0.2106	0.1805	0.2134
Sample Size	1041	473	568	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[¶]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

and the dummy variables controlling for unobserved heterogeneity among communities are accounting for most of the in sample variation explained by the explanatory variables. However, other information on certain key variables can still be gleaned from the results of the regression analysis.

Wealth, as proxy for income, is positively associated with child height-for-age Z scores in the majority of the model specifications. The relationship is statistically significant for the first DHS study for ownership of 2 ($p < .05$) and 3 or more ($p < .01$) assets in the urban sample. The urban sample in the DHS II is similar, but results are somewhat less significant. These results carry over to the pooled sample, but magnitudes and significance decrease. Parameter estimates for the rural samples are more puzzling, as several of the coefficients are negative, although not significant. These results, particularly for rural households, appear troubling on the surface; however, much of the variation in wealth across communities is accounted for by the community dummy variables. Consequently, these measures of wealth represent variations within households, and it is unlikely that ownership of one or two assets represents substantially higher levels of income.

Although estimates of the effects of maternal education on child HAZ scores are generally positive, none of these estimates are statistically significant. F tests on the joint significance of primary and secondary schooling are also not significant. Maternal HAZ scores, as a predictor of child HAZ scores, are statistically significant ($p < .01$); however, this data is only available in the second DHS study. A one standard deviation increase in maternal anthropometry is associated with a .25 standard deviation increase in the child's anthropometric measurement. Maternal anthropometry is commonly interpreted to represent the influence of unobservable family background characteristics, both genetic and socio-economic (see for example Strauss 1990). Children with twin siblings in the DHS II are associated with lower HAZ scores, a statistically significant relationship, which is generally negative but not significant in the DHS I.

6.4 Community Covariate Determinants of Malnutrition

Reduced form community covariate models of the underlying determinants of weight-for-height and height-for-age Z scores for children ages 6 to 35 months, studied in the second Demographic and Health Survey from 1995-96, are fairly consistent with the results obtained in the community fixed effects models of those same children. These models explain less of the variation in Z scores associated with the explanatory variables in sample primarily because dummy variables are no longer used to control for variation across communities. Instead, different ecological variables, in particular infrastructure and staple food prices, are included in the model to account for some of this variation.

Asset ownership, used as a proxy variable for household income, becomes increasingly significant in its relationship with higher Z scores, while primary and secondary maternal education becomes less significant in the community covariate models. Controlling for specific community infrastructure allows for more specific analysis of the differences among communities regarding health and educational facilities, but also yields some confounding results. Distance from facilities is only relative to the largest village within the cluster sample point, and outlying villages within the cluster can vary substantially in proximity. Unfortunately, there is no way to account for differences in the quality of health care provided. One question in the DHS II study did ask what medicines were available from these facilities; however, this question was posed to the chief of the village and does not reflect direct observation. Consequently, many of the respondents simply answered "yes" to all the medicines listed.

The effects of the presence of community infrastructure, treated as exogenous to the household, appear more straightforward for height-for-age Z scores than for weight-for-height. This result is consistent with the types of poor health and nutrition represented by the two dependent variables. Low weight-for-height may reflect a sudden illness, such as diarrhea, that is not necessarily preventable simply by living near a health facility. However, over time, it is expected that the frequencies of these incidents would decrease and in this case height-for-age would be more significantly related to infrastructure. The parameter estimates of prices for basic staples commodities, millet, sorghum, maize and rice, are difficult to interpret due to inadequate information. Households that are net sellers of grain may benefit from the income effect of higher prices, while those families who are net buyers will be negatively affected by the standard price effect.

6.4.1 Weight-for-Height

The results of the regression of selected variables on weight-for-height Z scores for children ages 6 to 35 months are included in Table 6.3. The parameter estimates of the variables common to both the community covariate and community fixed effects models remain fairly consistent to model specification with a few exceptions. One difference is the statistical strength of the relationship between wealth, measured by the ownership of various assets as a proxy for household income, and weight-for-height Z scores. The magnitudes for all of the coefficients increase; moreover, the effects of wealth are more likely to be statistically significant in the community covariate models than in the fixed effects models, particularly for rural households. Ownership of 1, 2 and 3 or more assets for rural households is significant at the .05 level for both the rural and pooled samples. One possible explanation for this change is that many of the dummy variables controlling for community differences in the fixed effects models were also accounting for some of the differences in wealth across communities as well, thus reducing the parameter estimates.

A priori, it is expected that the presence of various health and educational facilities will be associated with positive effects on weight-for-height Z scores. The default for all of the community infrastructure dummy variables is that no facility is available within 15 kilometers. The effects of community infrastructure variables on weight-for-height Z scores in children ages 6 to 35 months are mixed and not robust across pooled, urban and rural samples. For example, the presence of a secondary school is positively associated with WHZ scores for the rural and urban samples, and significant ($p < .05$) within the urban sample, but the parameter estimate turns negative and significant ($p < .05$) within the pooled sample. The sign on the coefficient for the presence of a center for adult literacy, although not significant, is negative in the pooled and urban samples while positive and significant ($p < .10$) in the rural sample. This may reflect, in part, the large emphasis on community literacy programs for rural areas that have been incorporated with the expansion of cotton by CMDT.

Basic health centers are defined as either community health centers or clinics, while advanced health centers represent either hospitals or health centers. The presence

Table 6.3: Regression of Selected Variables on WHZ Scores of Children 6 to 35 months

Variable[†]	DHS II Community Covariates			DHS II Community Fixed Effects		
	Pooled	Urban	Rural	Pooled	Urban	Rural
Constant[‡]	-2.0155 (6.4069)***	-1.2733 (1.7975)*	-2.7298 (6.8946)***	-1.5474 (6.1490)***	-1.5484 (5.9004)***	-0.8439 (4.7876)***
Wealth (1 asset)	0.1320 (2.4342)**	0.1126 (1.1277)	0.1329 (2.0559)**	0.0958 (1.6808)*	0.1077 (1.0769)	0.0884 (1.2736)
Wealth (2 assets)	0.1947 (3.3645)***	0.1397 (1.1870)	0.1663 (2.5024)**	0.1338 (2.1724)**	0.1354 (1.0907)	0.1246 (1.7494)*
Wealth (3 + assets)	0.2522 (3.5534)***	0.2961 (2.3294)**	0.2163 (2.4716)**	0.1707 (2.2172)**	0.2327 (1.7202)*	0.1256 (1.3297)
Primary Education	0.2085 (2.0628)**	0.2119 (0.6236)	0.1849 (1.6919)*	0.2332 (3.1269)***	0.3223 (2.7962)***	0.1623 (1.6448)
Secondary Education	0.1191 (0.8742)	0.0764 (0.2119)	0.0917 (0.4616)	0.1411 (1.4055)	0.2214 (1.8353)*	-0.0848 (0.4258)
Mother's HAZ	0.0461 (2.4353)**	0.0460 (1.2338)	0.0454 (2.0735)**	0.0405 (1.9930)**	0.0343 (0.8800)	0.0423 (1.7743)*
Child's Age 12-17 months	-0.2605 (4.5037)***	-0.2348 (2.1068)**	-0.2840 (4.2051)***	-0.2753 (4.6258)***	-0.2219 (1.9317)*	-0.3058 (4.3772)***
Child's Age 18-23 months	-0.1998 (3.1309)***	-0.1461 (1.1937)	-0.2325 (3.1107)***	-0.2095 (3.1862)***	-0.1846 (1.4431)	-0.2279 (2.9660)***
Child's Age 24-29 months	0.2058 (3.4366)***	0.1442 (1.2601)	0.2341 (3.3306)***	0.2429 (3.9279)***	0.2134 (1.7744)*	0.2550 (3.5350)***
Child's Age 30-35 months	0.2899 (4.9501)***	0.2829 (2.5671)**	0.2864 (4.1552)***	0.2926 (4.8723)***	0.2566 (2.2478)**	0.3030 (4.2983)***
Child is Twin	-0.1806 (2.4839)**	0.0423 (0.3452)	-0.2985 (3.3929)***	-0.1672 (2.0493)**	0.0506 (0.4081)	-0.2768 (2.6928)***
Center for Adult Literacy	-0.0177 (0.4165)	-0.0210 (0.2420)	0.0963 (1.7543)*			
Primary School < 2km	0.0882 (1.5546)	-0.1634 (0.3866)	0.0689 (1.1603)			
Secondary School < 2km	-0.1461 (2.1991)**	0.4466 (2.0395)**	0.1011 (1.1081)			
Basic Health Facility < 2km	-0.0084 (0.1338)	0.0343 (0.2597)	-0.0330 (0.3921)			
Basic Health < 15km	0.1396 (2.4380)**	0.2144 (1.1268)	0.0743 (1.1688)			
Advan. Health Fac. < 2km	-0.0002 (0.0027)	-0.3053 (0.9265)	0.0305 (0.3113)			
Advan. Health Fac. < 15km	-0.0539 (1.0944)	-0.6839 (2.0561)**	-0.0513 (0.9695)			
Health Agent Provides ORT	0.0341 (0.7325)	0.0756 (0.7521)	0.0871 (1.5698)			
Mom's w/ Ed. &Health <2km	0.0783 (0.6232)	0.1420 (0.4054)	-0.0384 (0.2038)			

(Table 6.3 Con't)

Variable:	DHS II Community Covariates Pooled	Urban	Rural
Price of Millet (Month of interview)	-0.0001 (0.2283)	-0.0017 (0.3761)	0.0005 (0.6865)
Price of Sorghum (Month of interview)	0.0058 (3.6307)***	0.0009 (0.1632)	0.0081 (3.4998)***
Price of Maize (Month of interview)	-0.0020 (1.6080)	-0.0051 (2.7549)***	0.0012 (0.5478)
Price of Rice (Month of interview)	0.0005 (0.4245)	0.0022 (0.7608)	0.0004 (0.2780)
Millet Not Available In Market	0.0676 (1.1523)	-0.1538 (0.6605)	0.0299 (0.4787)
Sorghum Not Available In Market	0.0757 (1.2552)	0.2107 (1.0265)	0.1155 (1.6783)*
Maize Not Available In Market	0.0486 (0.8694)	-0.1889 (1.1990)	0.1198 (1.6875)*
Rice Not Available In Market	0.1369 (2.1496)**	0.4352 (1.3768)	0.0679 (0.9872)
Breush-Pagan ~ X^2 (k d.f.)[§]	205.0***	86.4***	187.9***
F Test Statistic	7.6921***	3.2594***	7.1570***
R-Squared	0.0556	0.0775	0.0730
R-Squared Adjusted	0.0484	0.0537	0.0628
Sample Size	3687	1115	2572
Joint Significance of:	F(2,3645)	F(2,1073)	F(2,2532)
Primary and Secondary School < 2km	2.7455*	1.6140	1.7055
Basic Health < 2km and < 15 km	3.0046**	0.6480	0.8019
Advanced Health < 2km and < 15km	0.0789	5.9787***	0.6370
Price of Millet & Sorghum	6.8728***	0.0816	7.0696***
Price of Millet, Sorghum, Maize and Rice - F(4,n-k)	3.6583***	1.7927	9.3572***

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

of a health facility in or near to the central village within the cluster was negatively associated, although insignificant, with WHZ scores for the pooled and rural samples.

The relationship between advanced health facilities within 2 km and weight-for-height is generally negative, although not significant, with one exception. In the urban samples, nearby basic health facilities and advanced health facilities are negatively related with WHZ scores (both estimates are insignificant). The negative coefficients on parameter estimates of the impact of advanced health centers less than 15 km may suggest that these facilities are too far and may not be geared to improving child nutrition.

Only the presence of a basic health facility less than 15 kilometers from the central village and a government health agent promoting oral rehydration therapy are consistently positively related to weight-for-height in pooled, urban and rural samples. Basic health facilities less than 15 km are significantly positively related to better nutrition for the pooled sample ($p < .05$); the relationship is not significant for government health agents.

The effects of formal maternal education on child WHZ scores decreased in the community covariate models. In order to examine the interaction between maternal education and access to health care, a dummy variable was used to denote women who had received some education and communities where a basic health facility was less than 2 kilometers from the main village. The parameter estimates for this interactive effect were positive and not significant for the pooled and urban samples and negative and not significant for the rural sample. Due to the small number of women in rural areas with any formal education, this variable may be accounting for other unobservable household characteristics.

For the pooled and rural samples, the positive association between maternal anthropometry and child WHZ scores is statistically more significant in the community covariate model. Again, some of the variation across communities in household characteristics, including wealth, which maternal anthropometry is, at least in part, interpreted to represent (Strauss 1990), may previously have been accounted for by the dummy variables in the fixed effects models.

Dummy variables accounting for the age of the child remained highly significant in the covariate models. These parameters have a negative effect for children ages 12 to 17 months and 18 to 23 months, versus 6 to 11 months, and a positive impact on children ages 24 to 29 months and 30 to 35 months, versus 6 to 11 months. These coefficients continue to indicate that low weight-for-height, independent of the household economic and community factors controlled for in the model, is associated with other phenomena, such as breast feeding and the process of weaning, that are intimately related to the chronological changes in child development.

The parameter estimates on the prices of all coarse grains are positively related to weight-for-height Z scores for rural households. The coefficients on the price of rice and sorghum are also positively related to WHZ scores for all samples, and the effects are significant ($p < .01$) for the price of sorghum in the rural and pooled samples. The estimates of the relationship between the prices of millet and maize are negative for the urban and pooled samples, and the effects of maize prices are significant for the rural ($p < .01$) sample.

The effects of staple food prices on nutrition are difficult to sort out, particularly given the limited amount of information available. First, it is important to distinguish between net buyers and net sellers of these commodities, as price effects should work in opposite directions for these two types of households. Secondly, although prices relate to the month of the interview, it is not clear whether households are actively buying and selling grains during this period. Some families may face liquidity constraints and sell grain stocks while others decide to store. It is expected that most urban households would be net buyers of coarse grains; however, the price effects are not consistently negative across the urban sample, and only the price of maize is significantly (negatively) related to WHZ scores ($p < .01$). Moreover, it is difficult to understand why the price of rice, a grain that is favored by urban households, would be positively, although not significantly, related to nutrition. There may be substitution effects occurring, unobservable to the model, which are driving these ambiguities. For example, higher rice and sorghum prices may induce urban households to substitute consumption of millet and maize. The weakly positive relationship between millet, maize and rice prices for rural households could represent a larger number of net sellers than net buyers represented in the study. The strong positive effects of sorghum prices for rural households may then account for not just income effects for net sellers, but substitution effects for net buyers as well.

The parameter estimates for the unavailability of millet, sorghum, maize and rice in the various markets at the time of the interview are difficult to interpret in relation to their effects on WHZ scores. These dummy variables may be accounting for unobservable differences between communities in addition to substitution effects among different commodities. Furthermore, the absence of certain grains in a cereal market does not preclude households from having previously purchased and storing the grain.

6.4.2 Height-for-Age

The results of the regression of selected variables on height-for-age Z scores for children ages 6 to 35 months are reported in Table 6.4. Many of the parameters estimated in the community covariate models of children's height-for-age Z scores remain consistent with the coefficients from the community fixed effects models. Ownership of three or more assets is associated with a larger expected increase in HAZ scores in the community covariate models, and this relationship is significant ($p < .05$) for all three samples. All of the coefficients on wealth increased in magnitude for the covariate models, and ownership of 1 and 2 assets is significant for the urban ($p < .05$) and the pooled ($p < .10$) samples.

The presence of community infrastructure in health and education is expected, more than in the weight-for-height model, to have positive and significant impacts on better nutrition in children over the long run. Consequently, height-for-age Z scores should improve in areas with better access to health and education. Overall, most of the parameter estimates in the community covariate models confirm this expectation, although there are some puzzling results. The presence of a primary school in the central village is negatively associated, but not significantly, with height-for-age. This result may simply result from the fact that primary school education has little impact in communities on reducing disease and improving dietary intake. However, the presence of a secondary school is positively and significantly associated with improved HAZ scores ($p < .01$) for the rural and pooled samples. Centers for adult literacy do not have a significant effect on child HAZ scores, and the parameter estimates on the presence of this facility are negative for all samples.

Basic health facilities, such as clinics and community health centers, less than 2 and between 2 and 15 kilometers, are positively associated with better HAZ scores in children. This relationship is significant ($p < .01$) for facilities within 15 kilometers of the main village being surveyed in pooled and rural samples and for the urban sample ($p < .10$) as well. Advanced health facilities, including hospitals and health centers, within 2 kilometers are positively, but not significantly, related to improved height-for-age in the pooled and urban samples. However, advanced health facilities within a 15 kilometer radius are negatively associated with HAZ scores in all three samples. Since the distance categories are mutually exclusive, the negative coefficient may indicate that these facilities are too far away to be of any use to the outlying villages they serve. It is also ambiguous which health facilities are more appropriate for improving poor nutrition in children. Basic health facilities may be better suited to deal with the underlying causes of malnutrition whereas advanced health facilities are necessary for other serious medical problems, such as accidents or cerebral malaria.

Primary and secondary maternal education is not significantly associated with height-for-age Z scores. In fact, the parameter estimates for both primary and secondary education in the urban sample are negative. The coefficient on the dummy variable used to indicate the interaction between mothers with some formal education and basic health facilities within 2 kilometers is positive but not statistically significant. Maternal anthropometry is positively and significantly ($p < .01$) related to better height-for-age Z scores in children.

Table 6.4: Regression of Selected Variables on HAZ Scores of Children 6 to 35 months

	DHS II Community Covariates			DHS II Community Fixed Effects		
Variable[†]	Pooled	Urban	Rural	Pooled	Urban	Rural
Constant[‡]	0.7299 (1.3376)	-2.4234 (2.0551)**	1.4321 (2.0745)**	-0.5110 (1.3090)	-0.6277 (1.5615)	-0.3776 (1.4407)
Wealth (1 asset)	0.0949 (1.4202)	0.2103 (1.7596)*	0.0319 (0.3924)	0.0283 (0.4110)	0.1429 (1.1631)	-0.0268 (0.3215)
Wealth (2 assets)	0.1122 (1.6062)	0.3448 (2.3934)**	0.0163 (0.2009)	0.0341 (0.4511)	0.2694 (1.7519)*	-0.0450 (0.5205)
Wealth (3 + assets)	0.2584 (3.0854)***	0.4312 (3.0120)***	0.1342 (1.2484)	0.1276 (1.4086)*	0.3013 (2.0121)**	0.0503 (0.4366)
Primary Education	0.0930 (0.8460)	-0.2681 (0.6626)	0.0983 (0.8233)	0.0862 (1.0572)	0.0690 (0.5469)	0.0968 (0.9041)
Secondary Education	0.0796 (0.5563)	-0.3315 (0.7748)	0.2258 (1.1419)	0.1113 (1.0252)	0.0601 (0.4562)	0.1985 (1.0096)
Mother's HAZ	0.2265 (9.4139)***	0.1979 (4.4777)***	0.2367 (8.2064)***	0.2526 (9.8747)***	0.2140 (4.6680)***	0.2680 (8.7031)***
Child's Age 12-17 months	-0.9011 (9.9278)***	-0.8063 (4.4936)***	-0.8871 (7.9134)***	-0.7819 (11.128)***	-1.0013 (8.0902)***	-0.6874 (8.1087)***
Child's Age 18-23 months	-1.6482 (17.663)***	-1.2303 (6.3971)***	-1.7776 (15.671)***	-1.5134 (20.121)***	-1.4190 (10.029)***	-1.5501 (17.413)***
Child's Age 24-29 months	-1.3651 (10.829)***	-0.6213 (2.4427)**	-1.6234 (10.386)***	-1.1224 (15.227)***	-0.9443 (6.7818)***	-1.2021 (13.818)***
Child's Age 30-35 months	-1.8288 (14.389)***	-1.1477 (4.5273)***	-2.0482 (12.979)***	-1.5762 (20.619)***	-1.4892 (10.550)***	-1.6124 (17.728)***
Child is Twin	-0.4263 (4.7716)***	-0.5057 (3.2378)***	-0.3689 (3.4843)***	-0.3678 (4.1020)***	-0.4196 (2.8764)***	-0.3391 (3.0002)***
Center for Adult Literacy	-0.0510 (0.9717)	-0.0138 (0.1457)	-0.0415 (0.5976)			
Primary School < 2km	-0.0402 (0.5615)	0.5889 (1.0106)	-0.0442 (0.5841)			
Secondary School < 2km	0.3795 (4.3909)***	0.5354 (1.8871)*	0.3905 (3.3176)***			
Basic Health Facility < 2km	0.1412 (1.8873)*	-0.1412 (0.9460)	0.1030 (0.9648)			
Basic Health < 15km	0.3199 (4.3838)***	0.3051 (1.7132)*	0.3721 (4.4685)***			
Advan. Health Fac. < 2km	0.0996 (1.2037)	-0.0447 (0.0931)	0.1951 (1.7974)*			
Advan. Health Fac. < 15km	-0.0321 (0.5325)	-0.0843 (0.1798)	-0.0675 (1.0532)			
Health Agent Provides ORT	0.0111 (0.2035)	-0.0668 (0.7378)	0.0220 (0.2989)			
Mom's w/ Ed. &Health <2km	0.0523 (0.3834)	0.3830 (0.9179)	0.0916 (0.4461)			

(Table 6.4 Con't)

Test Statistic	DHS II Community Covariates Pooled	Urban	Rural
Price of Millet (Nov. avg. by child's age)	-0.0020 (0.8753)	0.0069 (1.1871)	0.0041 (1.5209)
Price of Sorghum (Nov. avg. by child's age)	-0.0058 (2.2930)**	-0.0121 (1.9618)**	-0.0044 (1.3201)
Price of Maize (Nov. avg. by child's age)	0.0023 (1.1221)	0.0191 (3.7810)***	-0.0050 (1.7481)*
Price of Rice (Nov. avg. by child's age)	-0.0053 (2.8130)***	-0.0017 (0.5070)	-0.0065 (2.6632)***
Millet Not Available in Market	0.2220 (2.4118)**	0.9661 (3.2383)***	0.1212 (1.2026)
Sorghum Not Available in Market	-0.1528 (1.4913)	-0.3063 (0.6984)	-0.1830 (1.6843)*
Maize Not Available in Market	-0.0331 (0.5358)	0.0022 (0.0169)	0.0629 (0.7046)
Rice Not Available in Market	-0.0528 (0.7180)	-0.5253 (2.1305)**	-0.0224 (0.2669)
Breush-Pagan Test $\sim X^2(n-k\ d.f.)$[ƒ]	729.8***	226.8***	512.5***
F Test Statistic	32.8374***	10.2033***	22.9230***
R-Squared	0.2009	0.2083	0.2015
R-Squared Adjusted	0.1947	0.1879	0.1927
Sample Size	3687	1115	2572
Joint Significance of:	F(2,3645)	F(2,1073)	F(2,2532)
Primary and Secondary School < 2km	8.0725***	1.5803	4.3940**
Basic Health < 2km and < 15 km	11.5586***	0.6644	8.0538***
Advanced Health < 2km and < 15km	1.1384	0.0921	2.4185*
Price of Millet & Sorghum	0.2840	0.4161	0.9568
Price of Millet, Sorghum, Maize and Rice - F(4,n-k)	1.1259	1.6346	1.7425

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[ƒ]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

The age of the child continues to be highly negatively associated with height-for-age. Moreover, the magnitude of these coefficients increases with age, with a small exception for children 24 to 29 months. This relationship underscores the fact that past growth retardation is permanent, and that growth faltering is continuing throughout the first three years of life for the children measured in this survey. The magnitude and significance of these variables, coupled with the low percentage of variation in the HAZ scores explained by variation in the explanatory variables, continues to indicate that other behavioral factors outside the model, perhaps associated with the age of the child, are determining nutritional outcomes.

The price of sorghum and rice is consistently negative and, in many cases, significantly associated with height-for-age Z scores. Millet is also negatively related to HAZ scores for children in the pooled sample but positive for the rural and urban samples. The price of maize, on the other hand, is positively related to HAZ scores for the pooled and urban samples, significant ($p < .01$) in the urban sample of children, but negatively associated with the rural sample ($p < .10$). Given the previous concerns raised in section 6.4.1 regarding net buyers and net sellers and the prices households actually face when sales and purchases are made, interpreting the parameter estimates on prices is tenuous. November prices are used to represent a general indication of where prices will be higher and lower throughout the year. The November 1995 price is averaged with November prices in 1994 and 1993 as the child moves from the first year to the second and third years of life. Whether these averages accurately reflect differential price levels across time and space is also difficult to judge. The weak negative relationship between most coarse grains and height-for-age probably reflects the wide range of factors that can counteract one another.

The absence of coarse grains in various markets is also difficult to interpret. Because of the spatial aspect of missing certain types of grains, these dummy variables may be accounting for other unobservable differences between the communities. The absence of millet and maize from markets are positively, but not significantly associated with HAZ scores, while sorghum and rice are negatively related to nutrition. The negative effect of sorghum being unavailable in markets is significant for the pooled ($p < .05$) and rural ($p < .10$) samples.

6.5 Agriculture and Malnutrition

The analysis in chapter 4 suggests that agricultural extensification has occurred between 1984 and 1996 in the Kayes, Koulikoro, Sikasso and Mopti regions, while intensification of rice production has occurred in the Segou region. Furthermore, there is also evidence that supports households substituting cotton for food crop production in the Koulikoro and Sikasso regions in recent years. Agricultural extensification, in addition to income and price effects, is likely to change labor allocations among household members. To understand the impact of agriculture on child malnutrition, it is important to determine if the reallocation of labor has nutritional consequences for children, and whether any potential negative effects resulting from this reallocation are more than offset by changes in income and relative prices. Substituting cash crops for food crops may result in different labor allocations and will likely affect income and potentially the distribution of resources among household members.

Little information on agriculture is available from the Demographic and Health Surveys. Consequently, the only comparisons available are based on geographical location and chronology of the agricultural calendar. One hypothesis is that young children receive less care from the primary caregiver during peak work periods for agriculture. Specifically, agricultural extensification may increase the amount of labor women must devote to agriculture at the expense of other activities, such as care giving. Increased energy expenditure can also affect breast feeding and meal preparation. Older siblings, who may be entrusted with the care of younger children, may not be capable of providing adequate care for their brothers and sisters.

Stunted growth in children is permanent; consequently, cross sectional data collected at one point in time cannot distinguish between different periods of growth retardation. Intrauterine growth retardation (IUGR) is also permanent. Women involved in agricultural activities during the harvest may retard the growth of the fetus, particularly during the third trimester. The harvest occurs throughout the months of October, November and into December, depending on the type of crop and the geographical location. Consequently, children born following the start of the harvest, December January or February, could be smaller in stature for their age if pregnant women are involved in the harvest. Thus, evidence of additional growth stunting among children born during these months could indicate potential seasonal effects of agriculture on child nutrition.

The price effects of staple agricultural commodities on child nutrition are difficult to interpret due to unobservable differences among households, such as those who are net buyers versus those who are net sellers, and when these households execute buying and selling in the market. The most difficult time for many households is the hungry season, which occurs when last year's food stocks have been depleted but the current year's crops have not matured. Typically, the months of July, August and September are the most difficult and grain prices climb steeply, peaking just before the harvest begins. Children in the third trimester of gestation are also at high risk of intrauterine growth retardation during this period. Therefore, children born during September, October and November suffering IUGR could indicate additional problems of consumption smoothing to accommodate for seasonal shortages in food stocks.

Table 6.5 reports the results of including additional dummy variables to control for any effects of children born during the hungry season and children born during the harvest season on height-for-age Z scores for three different locations: rural south, where agricultural extensification is the most pronounced; all children in rural areas; and, all children in the study. If the phenomenon is related to agricultural extensification, children in the southern rural areas will be most affected. However, if these effects plague all children in agricultural households, the coefficients will increase in significance in the dummy variables for all rural children. Conversely, if these variables are merely adding additional variation from age-related affects to the model, the coefficients on the estimates for all children will likely be more significant than for the other two samples, and may be positive rather than negative. The community fixed effects model was used to estimate the coefficients for these variables. The other parameter estimates are excluded for the sake of convenience, and these parameter estimates remain consistent with the initial model specification. Each dummy variable was run separately and then estimated jointly in the same model.

Table 6.5: Examining Third Trimester Gestation during the Hungry and Harvest Seasons

	DHS II Community Fixed Effects Model:		
Gestation Period‡:	Southern Rural	All Rural	All Children
3rd trimester during hungry season†	0.1652 (1.6119)	0.1412 (1.8930)*	0.1429 (2.2929)**
3rd trimester during harvest season†	-0.0158 (0.1591)	0.0342 (0.4648)	-0.0187 (0.2956)
3rd trimester during hungry season††	0.1817 (1.6741)*	0.1834 (2.2688)**	0.1651 (2.4087)**
3rd trimester during harvest season††	0.0454 (0.4302)	0.1045 (1.3097)	0.0495 (0.7328)

‡T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.
†Parameters are estimated separately in different models.
††Parameters are jointly estimated in the same model.
* denotes significance at $p < 0.10$.
** denotes significance at $p < 0.05$.
*** denotes significance at $p < 0.01$.

It is clear from the results of the parameter estimates presented in table 6.6 that the dummy variables used to control for intrauterine growth retardation during the hungry and harvest seasons are not an adequate test of the above hypotheses concerning seasonal factors that may influence poor nutrition. The generally positive associations suggest that other factors, such as the presence of certain illnesses during specific times of the year, may more than offset any negative impacts from IUGR. Kumar and Siandwazi (1994), in a study of children in Zambia, find a significant negative association between the weeding season and child weight-for-height, and significantly positive associations later in the year, but no significant relationships between seasons and height-for-age Z scores.

Similar tests were run for children of women in the Segou region where rice intensification appears to be occurring. It is likely that increased fertilizer usage will increase the amount of time spent weeding and require more labor for harvest. These are typically women's responsibilities in Mali, therefore it is reasonable to expect that the labor allocated by women to agriculture will increase. Results similar to those presented in table 6.5 were obtained and are not reported. Understanding the effects of seasonal labor allocations on child malnutrition is clearly an area that warrants future research.

The results presented in table 6.5 are by no means a conclusive test of the relationship between maternal labor allocations and the potential ramifications on child nutritional status. Moreover, diseases associated with seasonal factors during the periods not tested may outweigh any negative effects from maternal labor during the hungry and harvest seasons, hence the positive parameter estimates. If child anthropometry had been collected during the hungry and harvest seasons, tests of the same dummy variables on weight-for-height would serve as an interesting point of comparison.

The seasonal effects may be more appropriately analyzed in a model containing birth weight as the dependent variable rather than height-for-age. The number of rural children with known birth weights is too small in the DHS II, and birth weights were not collected in the first DHS study. Babies are weighed at the time of birth and given a birth card if the mother takes the child to a health facility. Such a method of collecting information is inherently biased by self-selection, and these children are more likely to come from households with different attitudes and behaviors concerning health care and may not accurately represent the overall population in Mali.

Another potential pathway between agriculture and malnutrition is the effect of agriculture on community infrastructure. The development of the cotton sector has necessitated the formation of village associations throughout the cotton zone of Mali. Due to the profit-sharing arrangements between the cotton company, CMDT, and the growers, large sums of money, over and above the fixed price paid to farmers, may be returned in any given year. It is often argued that these profits allow communities, through the village associations, to build infrastructure that otherwise would not have been possible. Infrastructure is positively associated with height-for-age, the longer-term indicator of health and nutrition. Although this relationship is not so evident with weight-for-height, the immediate nature of this problem makes such a relationship less likely, particularly when measured in a cross-sectional study. However, to the extent that better infrastructure can reduce short-term health and nutritional problems, weight-for-height Z scores should improve over time in these areas.

CMDT, as a formerly quasi-public institution, has and still is responsible for various rural development projects, notably literacy and numeracy training and installing and repairing pumps and wells. The coefficients on adult literacy centers are mixed, and often have a negative, although not significant, association. This negative relationship may simply represent other unobservable community characteristics. Furthermore, it is not clear how a basic literacy and numeracy training program, apart from potentially increasing income, would improve child nutrition.

Improved water and sanitation should have significant affects on both weight-for-height and height-for-age by reducing the number of many types of illnesses. Parameter estimates on water source and toilet facilities are contained in Appendix III. The coefficients on the use of a pump by households are also inconsistent and rarely significant. Moreover, simply having access to cleaner water does not improve sanitary conditions in the household. Much of the contamination of the water supply occurs between the time the water is collected and the time it is consumed, either for cooking or for drinking. If households do not actively use soap to wash their hands, then clean water may have little impact on improving health and nutrition.

The effects of better sanitation, approximated by improved toilet facilities, and safer water on children's weight-for-height are mixed. All of the coefficients estimated are positive in the DHS II samples but insignificant, although the joint effects are significant for improved sanitation ($p < .10$) and safer water ($p < .05$) for the pooled sample. However, most of the parameter estimates on these variables are negative for the DHS I samples. The negative sign on piped water is significant ($p < .05$) for households in both the pooled and urban samples.

The parameter estimates of the effects of cleaner water and sanitation on child height-for-age are also ambiguous. Flush toilets are positively and significantly related to better Z scores in the DHS I samples, but negative (not significant) in the DHS II study. In fact, the magnitude of having a flush toilet in the first DHS study is expected to increase child Z scores by more than 2 standard deviations. Such effects may be accounting for a variety of unobserved characteristics, particularly income, that are responsible for increasing height-for-age.

6.6 Summary

There are many causal pathways in which agriculture can affect child nutrition. In particular, changes in agricultural production and productivity may result in new allocations of labor among household members. Much of the agricultural development in Mali is associated with cotton, and the cotton corporation, CMDT, is entrusted with many rural development projects. Moreover, profits from cotton, which are returned in lump sums, have enabled many village associations to undertake improvements in infrastructure. Child nutrition is, to some extent, affected by these relationships. The econometric models developed in this thesis attempt, in part, to determine the magnitude and significance of these relationships.

Attempts to model the effects of these relationships on child malnutrition have not yielded consistent parameter estimates. Furthermore, the effects of variables such as wealth and maternal education on child nutrition, which are well-documented in studies of developing countries, provide mixed results as well. The only truly robust parameter estimates are dummy variables controlling for the age of the child, particularly in height-for-age, and maternal anthropometry. Neither of these variables is useful in terms of policy tools or for explanatory purposes. Ultimately, the dummy variables used to represent child age signify that the reduced form model does a poor job of explaining the underlying determinants of small height-for-age and low weight-for-height.

Due to the limited information available, prices of staple commodities, often of interest to policy makers, are extremely difficult to interpret. The sign of the coefficient may have one effect for a net seller of the commodity and the opposite effect for a net buyer. Furthermore, it is not known when households actually execute buying and selling decisions in the market. Since grain prices fluctuate substantially throughout the year, the timing of this decision will have an enormous impact on the actual price confronting the household.

The hypotheses concerning changing labor allocations among household members remains an area for further analysis. The attempt in this thesis to model such effects was unsuccessful, although other studies indicate that seasonal affects do occur. It is essential that data on health and nutrition be collected throughout the year, in a manner that allows the researcher to distinguish between changes in exposure to illness that are associated with seasonal variation and behavioral changes that reflect, at least implicitly, household decisions.

CHAPTER VII

CONCLUSIONS

7.1 Summary of Key Findings

The objective of this research is to analyze the links between agricultural development and preschool child malnutrition in Mali. Overall, the findings of this study are inconclusive concerning the relationship between agricultural commercialization and child malnutrition. However, the research indicates several mechanisms through which agriculture can affect malnutrition. The effects of agricultural development on income and infrastructure suggest certain policy implications that exploit these links and identify specific areas for future research.

There have been no published results of multivariate analysis from recent anthropometric surveys in Mali and little empirical research on countries in the Sahel. The application of a reduced form economic model of health outcomes offers limited explanation of the variation in child anthropometry, a result that is consistent with other studies of conducted by economists in developing countries (Behrman and Deolalikar 1988). Few studies have attempted to look at the effects of changing labor allocations among household members, particularly for women, on child health and nutrition. The findings from this analysis do not suggest any deleterious consequences associated with increased participation in agriculture; however, these tests do not represent a conclusive test of this relationship. This research, distinguishing between factors that affect nutrition in the short run from those which influence nutrition in the long run[1], finds a logical

[1] Weight-for-height is an indicator of the child's short-run or current nutritional status; height-for-age measures long-run nutrition.

relationship with income and infrastructure but seemingly counterintuitive results with respect to maternal education.

Child malnutrition is omnipresent in Mali, irrespective of maternal education, household wealth, geographic region, urban or rural location and season. Although anthropometric measures of child nutrition are not truly comparable between a 1987 and a 1995-96 study, the percentage of children classified as wasted and stunted remains high despite overall economic and agricultural growth. The review of recent agricultural trends in Mali concludes that extensification is occurring throughout much of the country, and intensification is occurring in the rice zone of the Segou region. The data also suggests that farm households in the Sikasso and Koulikoro regions are substituting some cotton production for the production of cereals.

This thesis examines four areas in which agriculture affects malnutrition: income; community infrastructure; staple food prices; and labor allocations. Parameter estimates obtained from econometric analysis of child weight-for-height and height-for-age are consistent with findings from previous studies but are not robust to model specification. Wealth, used as a proxy for income, is generally positively correlated with better nutrition. This result is somewhat stronger for weight-for-height than height-for-age Z scores. Maternal education, widely reported in other studies to be of particular importance for better growth, is, in some cases, significantly correlated with weight-for-height but not with height-for-age. This result is counterintuitive to the extent that weight-for-height reflects immediate conditions for disease and dietary intake, while height-for-age represents health and nutrition throughout the early years of child development.

The parameter estimates of various community infrastructure on height-for-age indicate generally positive effects. In particular, the presence of a nearby secondary school and basic health facilities within 15 kilometers are significantly related to better HAZ scores between .3 and .5 standard deviations. However, weight-for-height does not have a strong positive correlation with proximity to schools and health facilities. This result is consistent with the nature of the two measures of malnutrition. Transitory shocks to the health and nutrition of a child are probably not preventable simply by the presence of certain infrastructure. Nevertheless, infrastructure should, over time, reduce the incidence of these events and improve overall care. To the extent that agricultural commercialization encourages the development of community infrastructure, this is a potentially positive link between agriculture and nutrition.

Parameter estimates for sorghum and rice prices yield a positive association with weight-for-height and a negative relationship with height-for-age. Indeed, nearly all of the signs are the inverse of one another from the WHZ to the HAZ model. The effects of food prices on child nutritional outcomes are difficult to interpret due to unobservable heterogeneity among households. Prices affect net sellers and net buyers of staple commodities in opposite directions. Even under the assumption that all urban households are net buyers, the parameter estimates are still ambiguous. Furthermore, it is not evident when households execute buying and selling decisions in the market. Consequently, given the large annual fluctuation in prices, the actual price households respond to varies significantly.

The process of agricultural extensification raises concerns regarding the relationship between changing labor allocations among household members and the potential nutritional consequences for children. One particular concern is the hypothesis that increasing the amount of time women devote to agriculture will increase the likelihood of intrauterine growth retardation. Low birthweight babies, resulting from prenatal growth retardation, are more likely to suffer growth retardation and are more likely to die during childhood. Increasing the time women devote to agricultural activities may also cause mothers to reduce the amount of time spent in caregiving activities or reallocate these responsibilities to younger siblings. Moreover, the time spent preparing food may also decrease or again be redirected to other family members, which may reduce dietary quality. The tests of hypotheses concerning prenatal growth retardation occurring during peak agricultural work periods do not demonstrate any negative effects on long term malnutrition. However, these results do not represent a conclusive test of the hypotheses regarding changing labor allocations for women.

7.2 Policy Implications

This research emphasizes the links between wealth, access to infrastructure and, to some extent, maternal education to account for differences in the nutritional levels of the children studied. These results do not suggest any relationship between agricultural commercialization and the persistence of high rates of child malnutrition. Wealth is associated with better nutrition in children. Consequently, increasing income through agricultural development should, over time, be associated with higher levels of nutrition in children. However, these effects are very small and may be moderated and potentially overwhelmed by other factors associated with agricultural commercialization that inhibit improved health and nutrition.

Proponents for the expansion of cotton production through the CMDT model often point to the empowerment of village associations to make improvements to infrastructure from profit sharing arrangements. To the extent that cotton and other agricultural development projects result in new investments or improvements in infrastructure that would not have occurred otherwise, these claims appear to have merit. Nearby health facilities and secondary schools are positively associated with better nutrition over the long run. These affects do not manifest themselves in the short run; consequently, strategies should be designed to help people take advantage of existing health and educational infrastructure to decrease the incidence of factors resulting in low weight-for-height among children.

Maternal education is generally regarded to be of significant importance to child nutrition. This study suggests that children benefit in the short run from mothers with at least some primary education. Many view female education, ipso facto, as one goal for development. Although it is not evident how a few years of primary education result in better nutrition, children may increasingly benefit from maternal education, especially to the extent that the links between a mother's education and health and nutrition can be more fully exploited. Many development projects, usually through school curricula, already endeavor to foster this relationship.

7.3 Directions for Future Research

Policy implications will depend on the ability of future research to explain in greater detail the manner in which agriculture affects nutrition and other underlying determinants. The low explanatory power of the reduced form equation questions the appropriateness of such a model for understanding and estimating the effects of underlying determinants on measures of child anthropometry. These results are consistent with the explanatory power obtained from other models of nutritional status in developing countries (Behrman and Deolalikar 1988). In fact, the only parameter estimates truly robust to model specification were dummy variables controlling for the age of the child. Sahn (1990) and Alderman (1990) show similar results in studies of Cote d'Ivoire and Ghana. While child age variables offer little explanation of nutritional phenomena and are of no use for policy makers, they do indicate an important relationship between the development of the child and household behavior.

Economists are quick to emphasize that reduced form health equations still provide useful insights into nutritional outcomes for policy makers. Behrman and Deolalikar (1988) state, "the critical question is not what is the proportion of explained variance, but whether there are biases in the relevant estimates due to specification errors, simultaneity or omitted variables," (p. 660). Clearly their concerns are well-founded; biased parameter estimates are a potential source of misinformation. However, without specifying a system of equations, it is difficult to interpret whether the variables in the reduced form equations are accounting for some of the variation in other, omitted relevant variables. For example, income and education could be correlated with birth spacing. Furthermore, by explaining such a low proportion of the variance in sample, it is difficult to inform policy makers who are faced with decisions regarding the allocation scarce public resources among competing alternatives. It would seem more appropriate that researchers seek to identify the underlying factors that determine the variation in nutritional outcomes. Then policies can be formulated to target key variables.

Consequently, it may be more useful to model nutritional outcomes in children as part of a system of equations, which include the specification of a health production function. Apart from the estimation issues that arise, a health production function approach to modeling child nutrition requires a substantial amount of information. Furthermore, understanding how household labor allocations, particularly for women, are changing as a result of agricultural extensification necessitates more individual data from farm households. Farm households not only experience price effects from staple commodities, but income effects as well. Consequently, prices are another important component to understanding malnutrition that requires greater observation at the household level than simply noting current market prices.

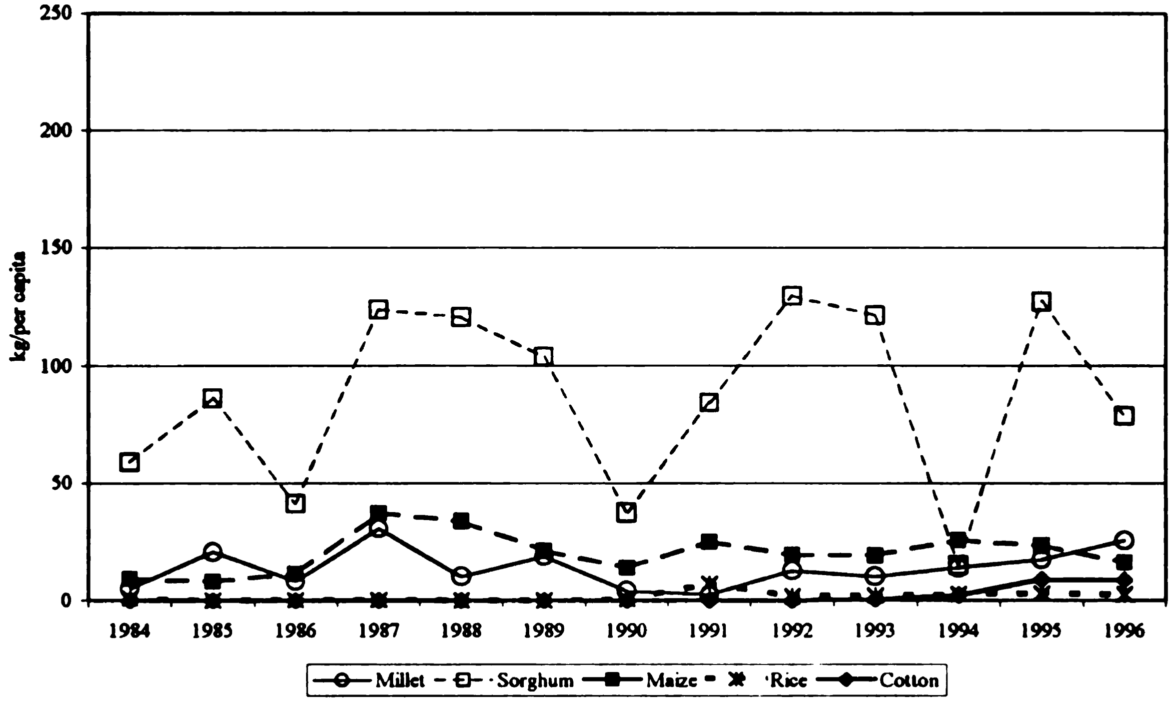
Recommending the commission of new studies to investigate various aspects of behavior, particularly when many of these households already suffer from survey fatigue, is impractical. There already exist a number of past, ongoing and future studies, each collecting important data but none gathering all of the essential information to present a holistic view of life in Mali. For example, the Budget-Consumption Study in 1988-89 contains detailed information on household expenditures, particularly for food, as well as child anthropometry, but lacks information on sources of income and labor allocations. The Demographic and Health Studies from 1987 and 1995-96 contain a large amount of information on health, fertility and nutrition but no information on income or labor allocations. Ongoing farming systems research in southern Mali, conducted by the Institute Economie Rurale (IER), or Rural Economic Institute, contains a large amount of information on agriculture, including labor allocation by gender, but no information on household expenditures or nutrition.

Prudence dictates that the different agencies, organizations and disciplines collaborate on research in order to improve everyone's understanding of malnutrition in Mali. Sharing subsets of samples from past, ongoing and future research is the most pragmatic solution to compiling comprehensive information on child nutrition. Policy makers, often confronted with conflicting advice from disparate sources, need consistent, cross-disciplinary recommendations to effectively address this crisis. There is an unequivocal moral imperative that supercedes methodological disputes in order to understand the behavioral phenomena that underlie child malnutrition.

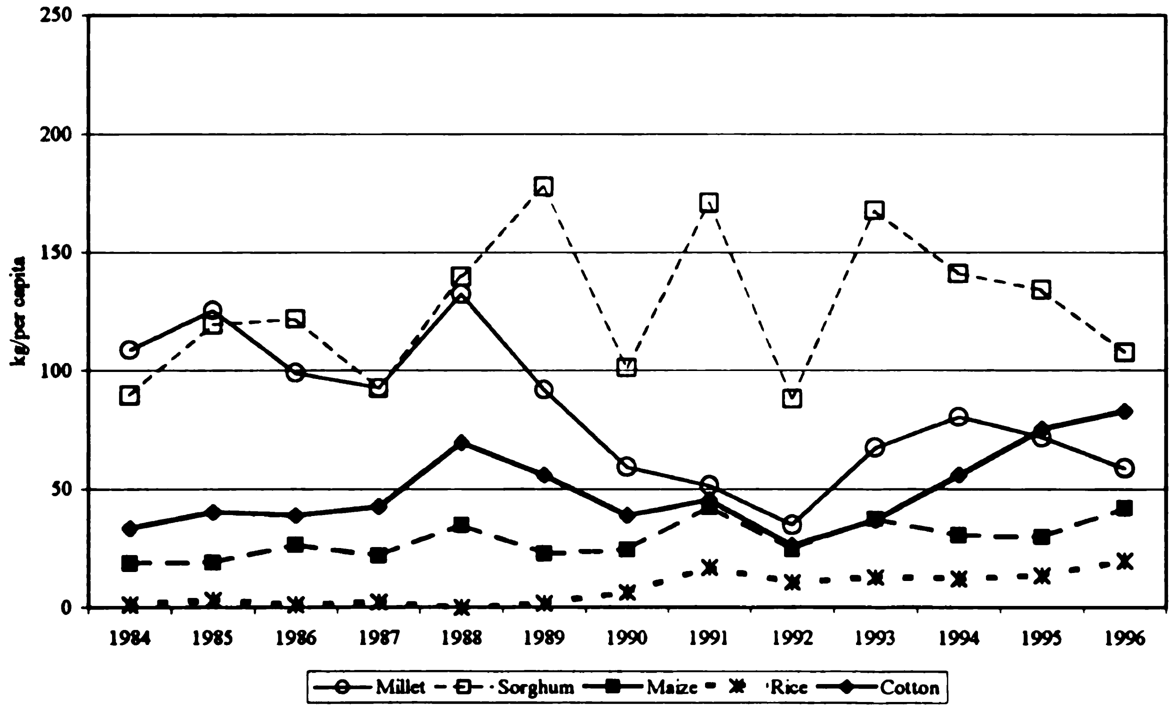
APPENDIX I

REGIONAL TRENDS IN AGRICULTURAL PRODUCTION, YIELD AND AREA

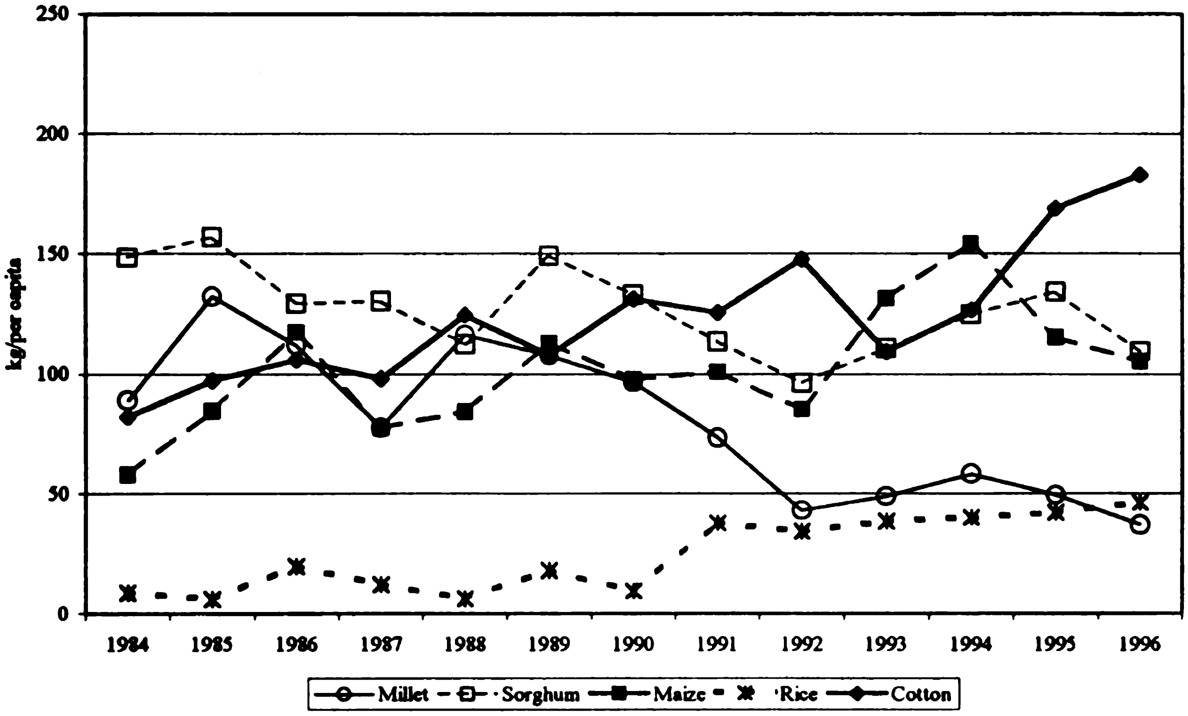
Kayes: Production of Selected Agricultural Commodities, 1984 to 1996



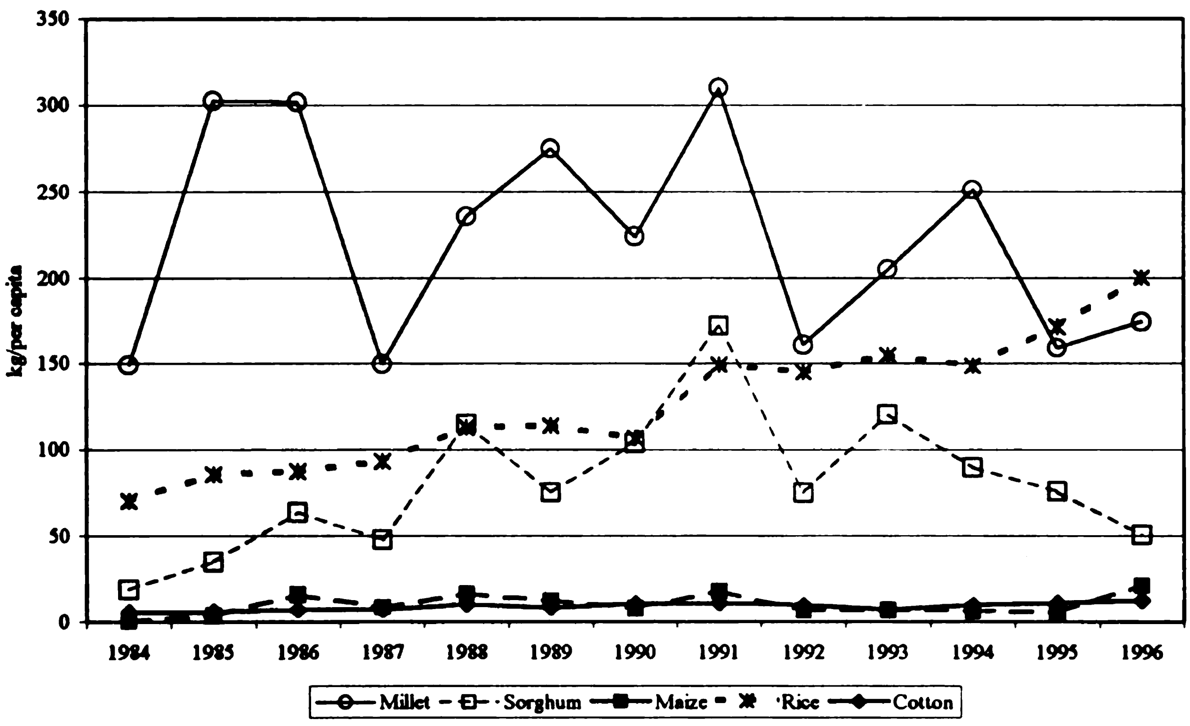
Koulikoro: Production of Selected Agricultural Commodities, 1984 to 1996



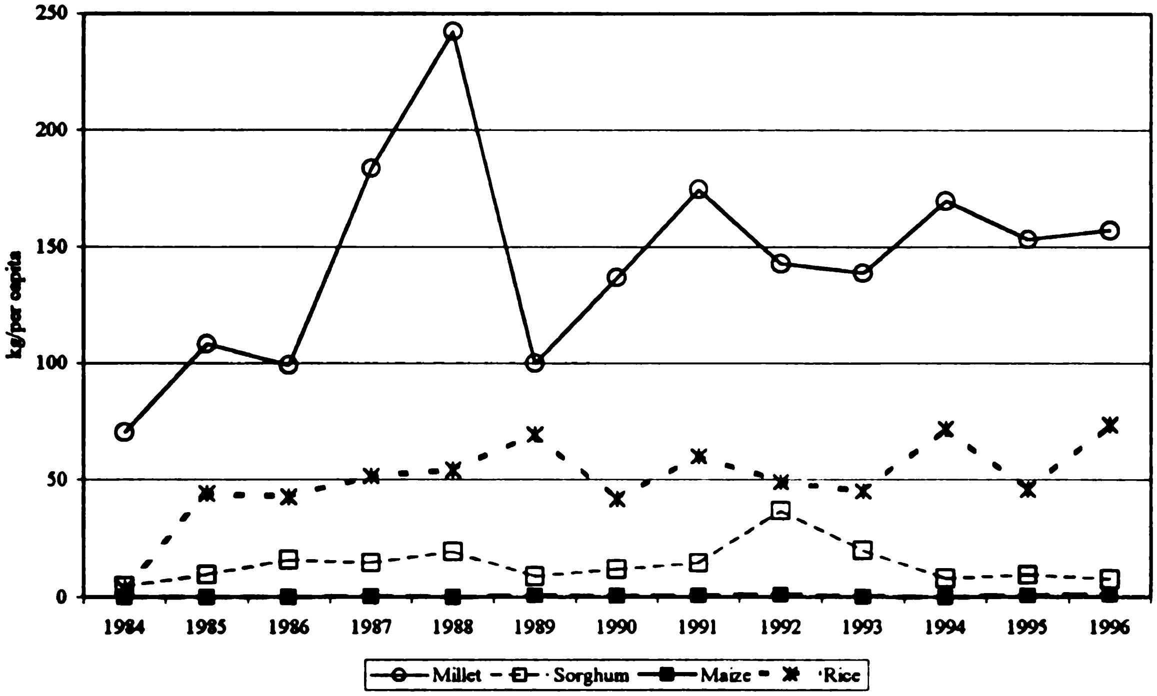
Sikasso: Production of Selected Agricultural Commodities, 1984 to 1996



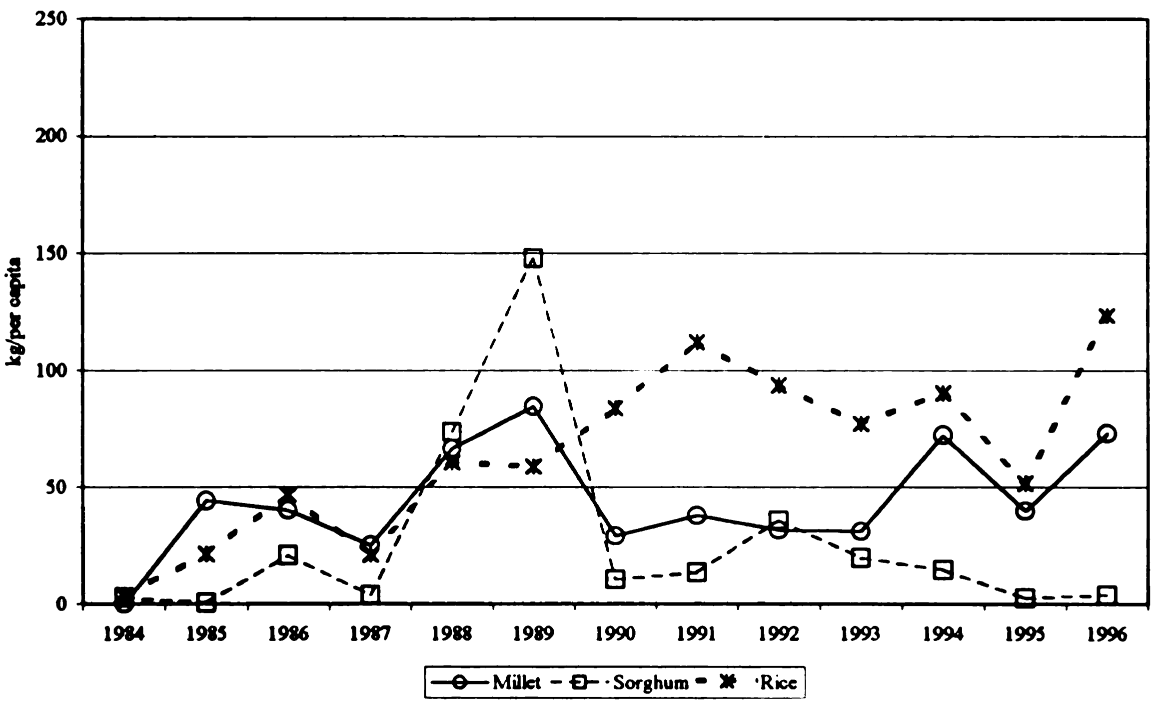
Segou: Production of Selected Agricultural Commodities, 1984 to 1996



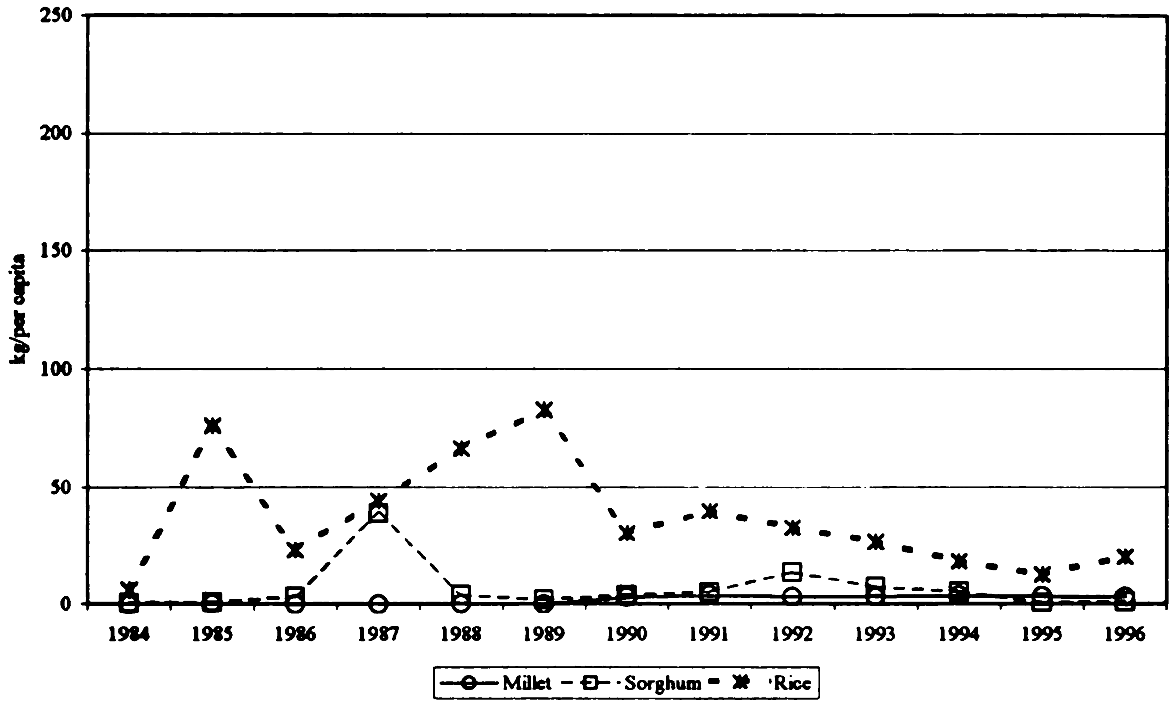
Mopti: Production of Selected Agricultural Commodities, 1984 to 1996



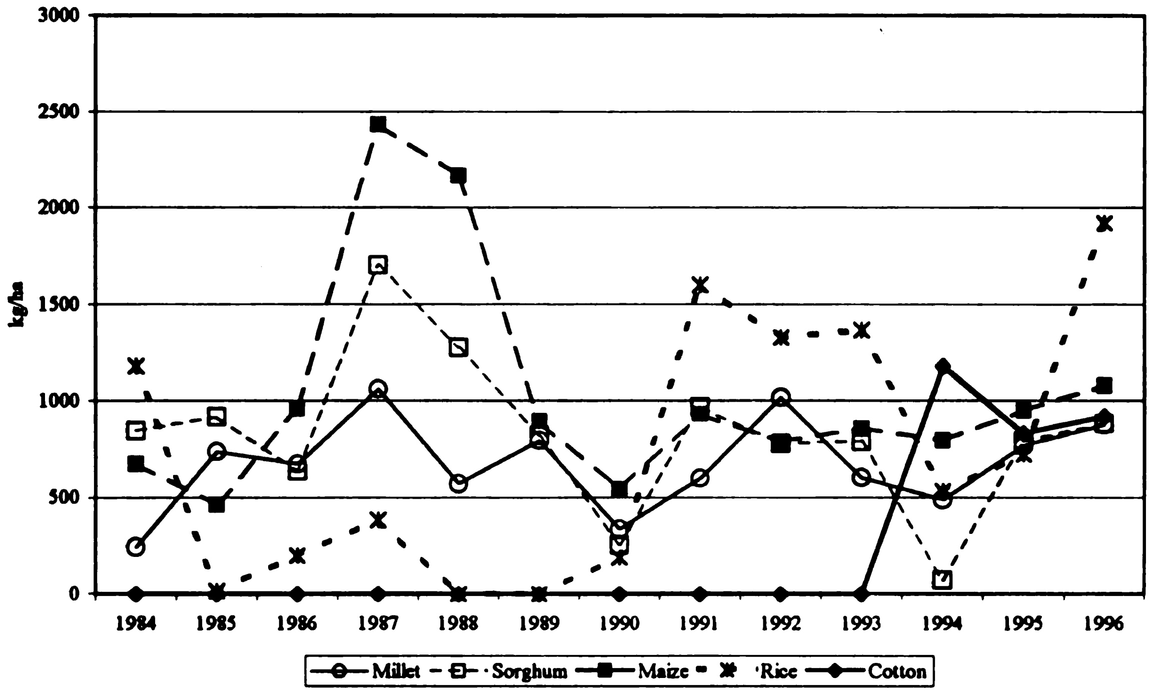
Timbuktu: Production of Selected Agricultural Commodities, 1984 to 1996



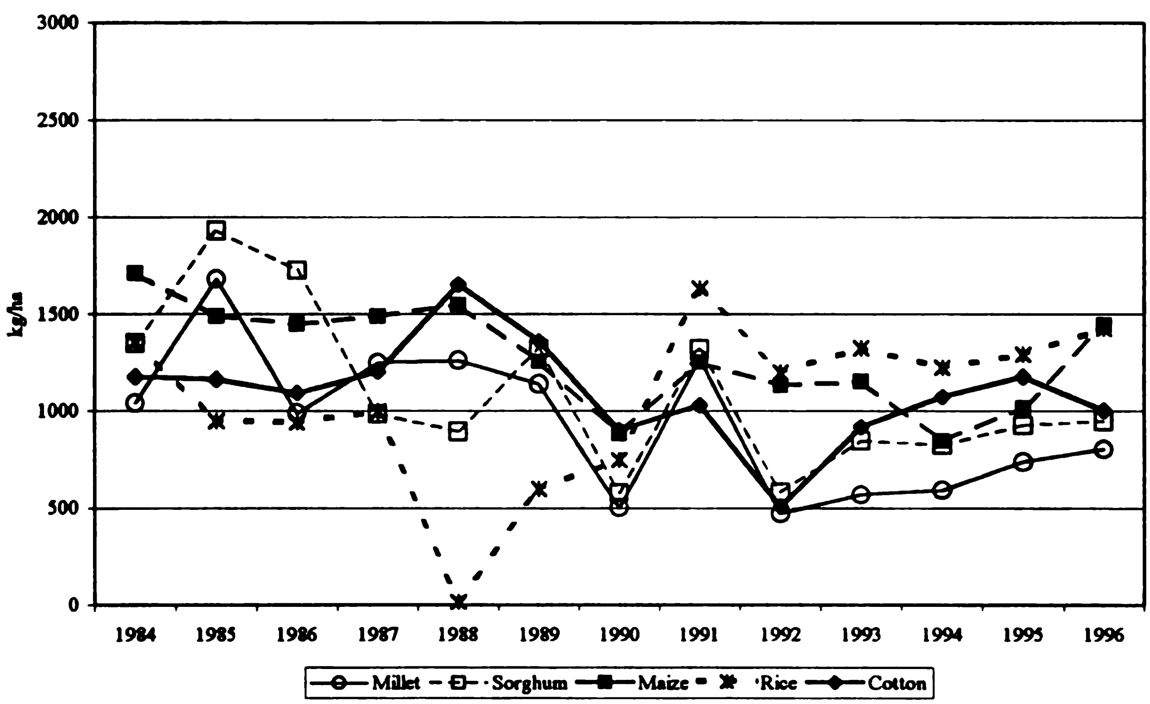
Gao/Kidal: Production of Selected Agricultural Commodities, 1984 to 1996



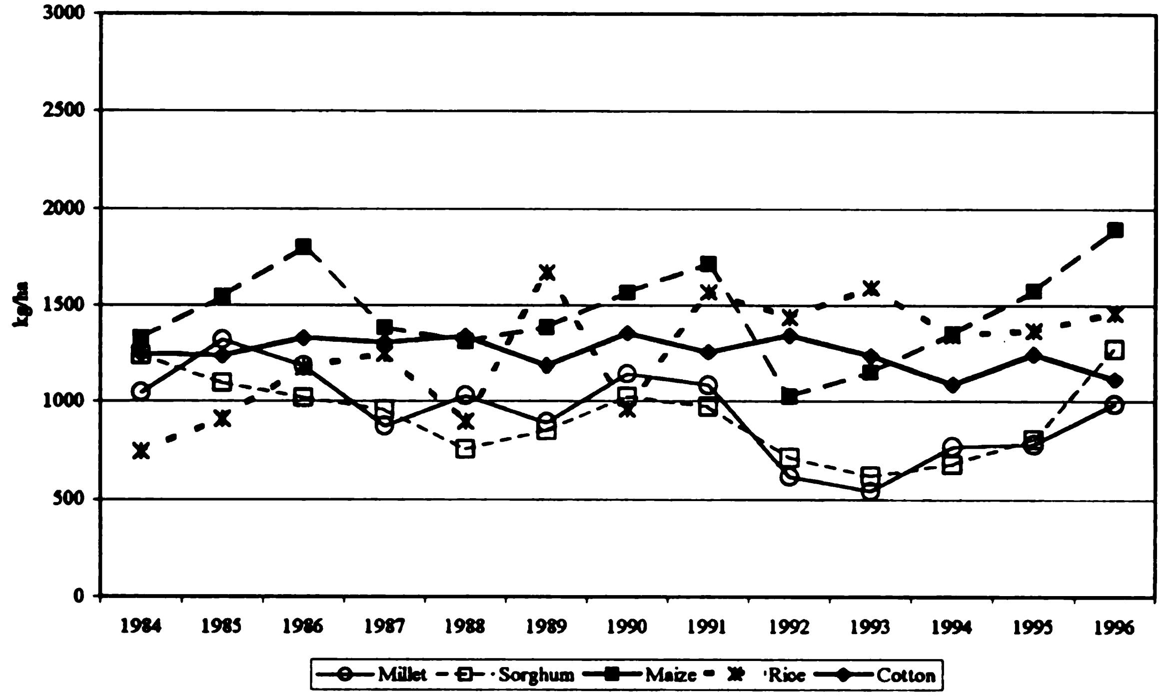
Kayes: Yield for Selected Agricultural Commodities, 1984 to 1996



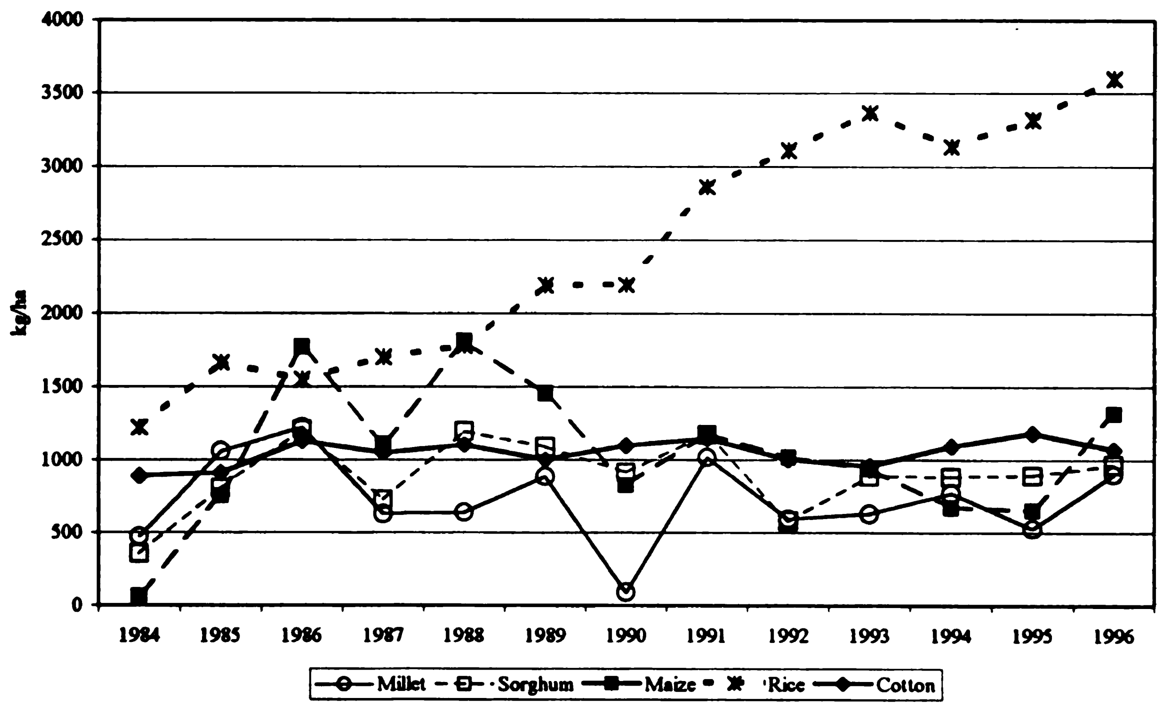
Koulikoro: Yield for Selected Agricultural Commodities, 1984 to 1996



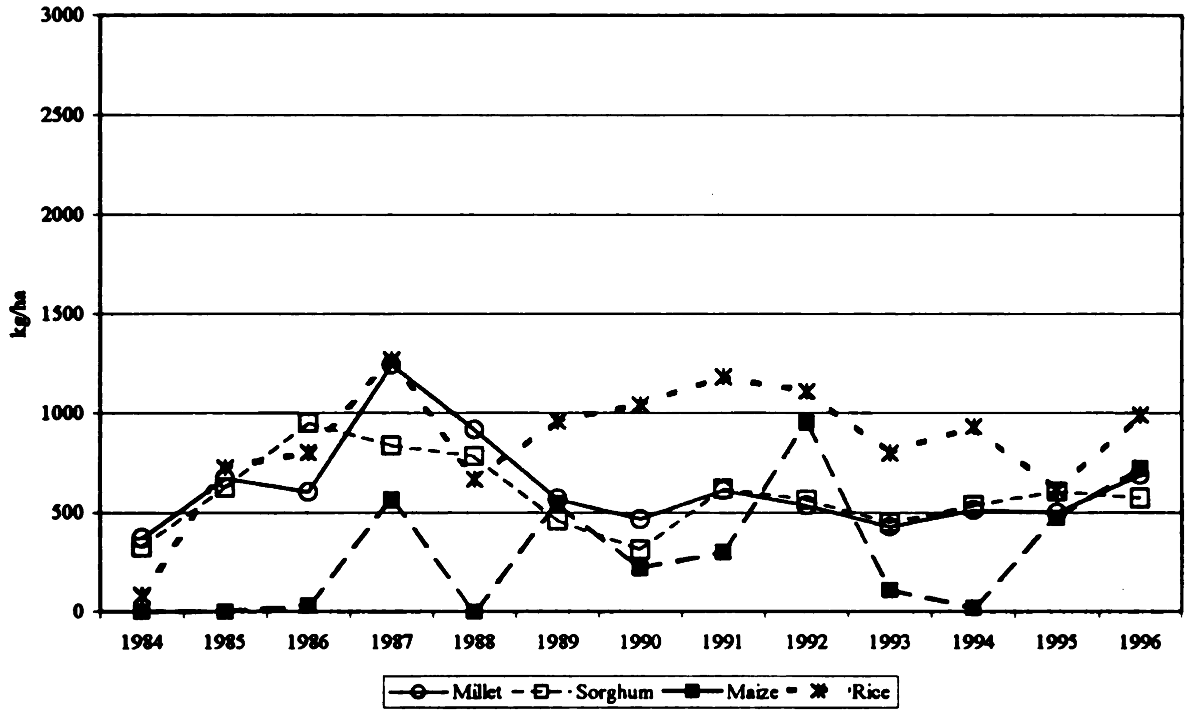
Sikasso: Yield for Selected Agricultural Commodities, 1984 to 1996



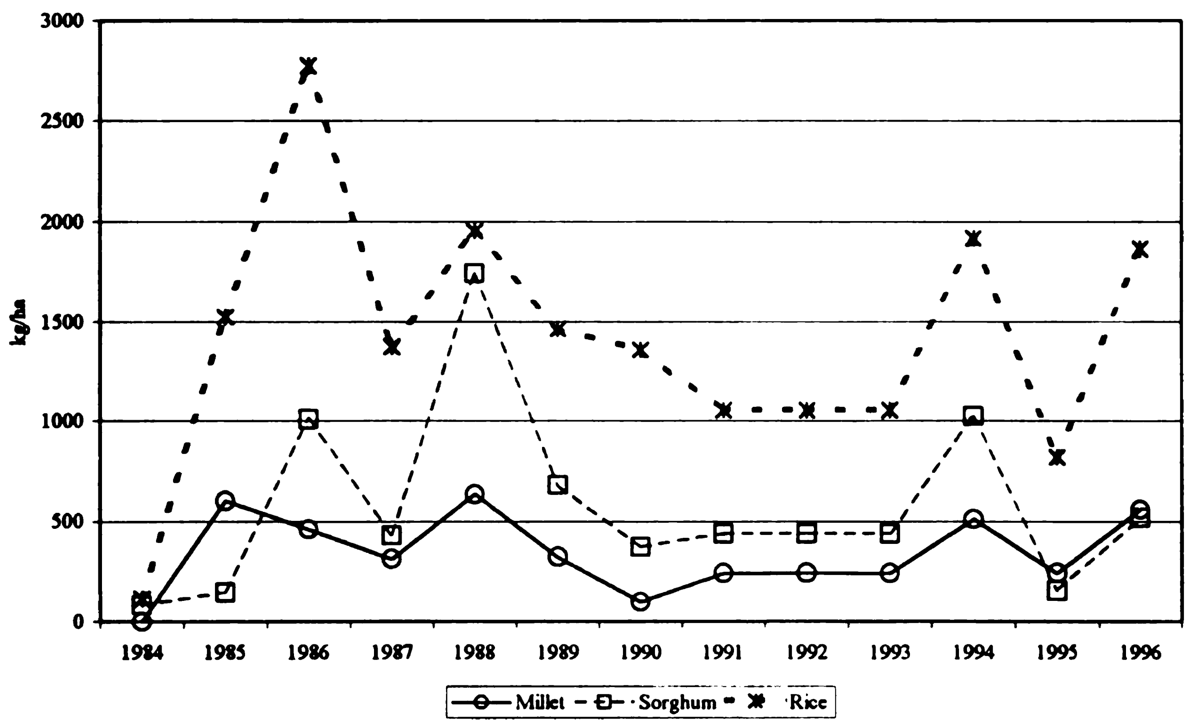
Segou: Yield for Selected Agricultural Commodities, 1984 to 1996



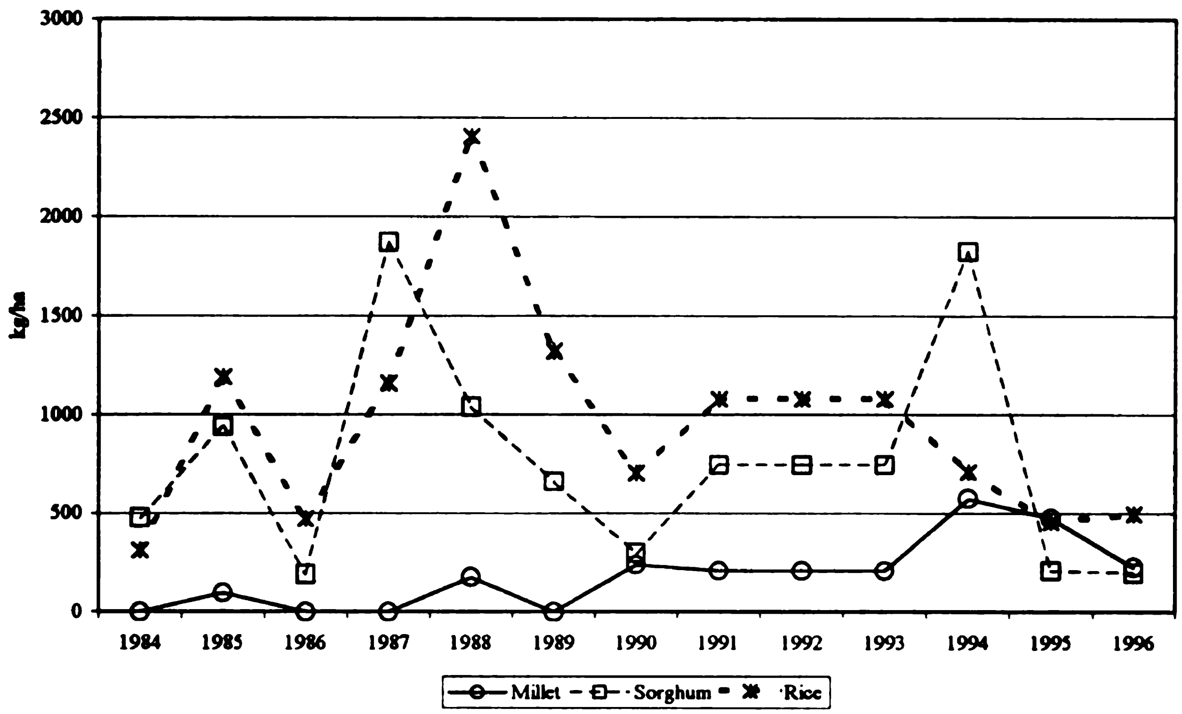
Mopti: Yield for Selected Agricultural Commodities, 1984 to 1996



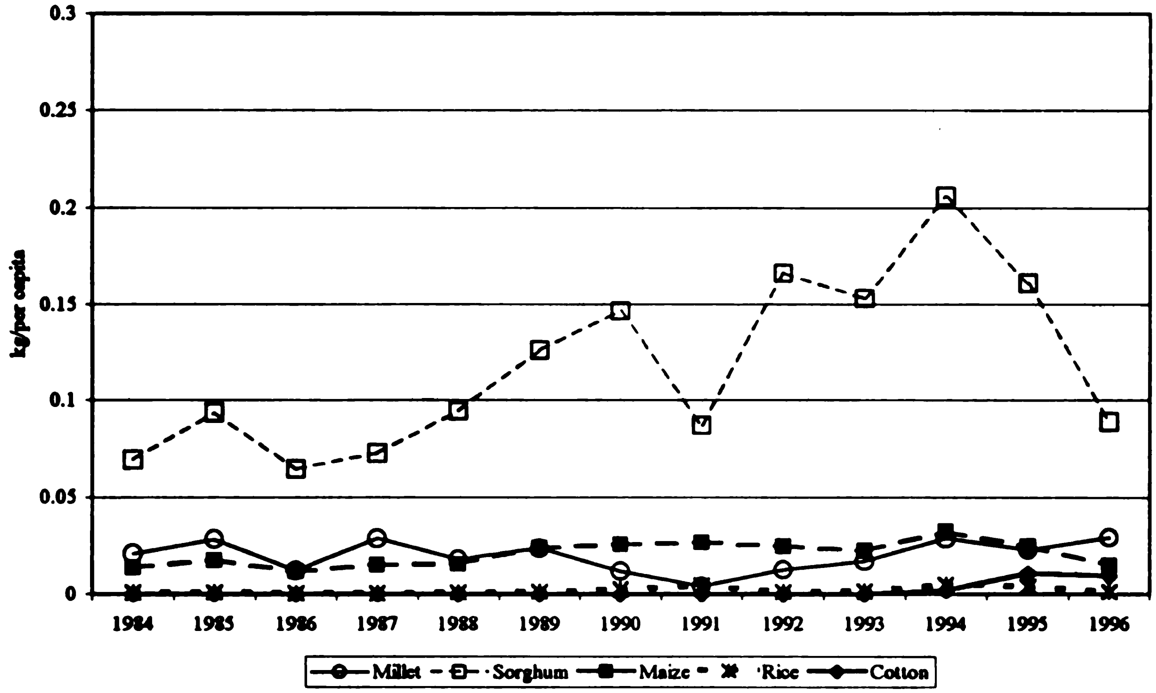
Timbuktu: Yield for Selected Agricultural Commodities, 1984 to 1996



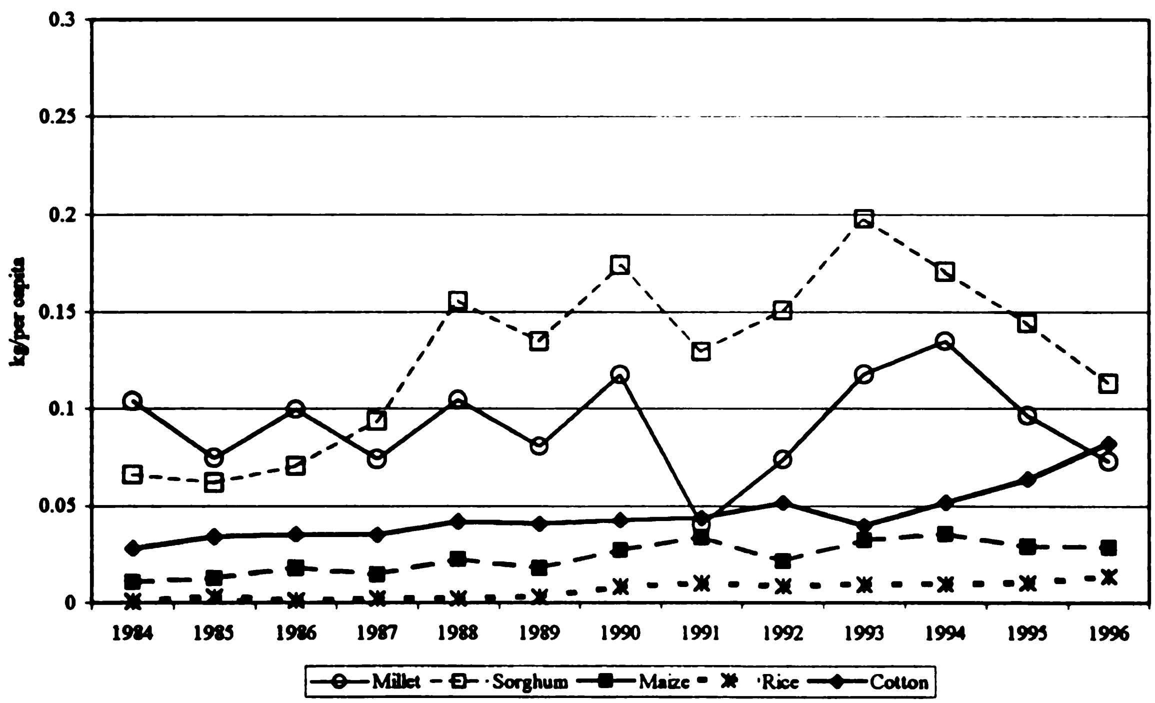
Gao/Kidal: Yield for Selected Agricultural Commodities, 1984 to 1996



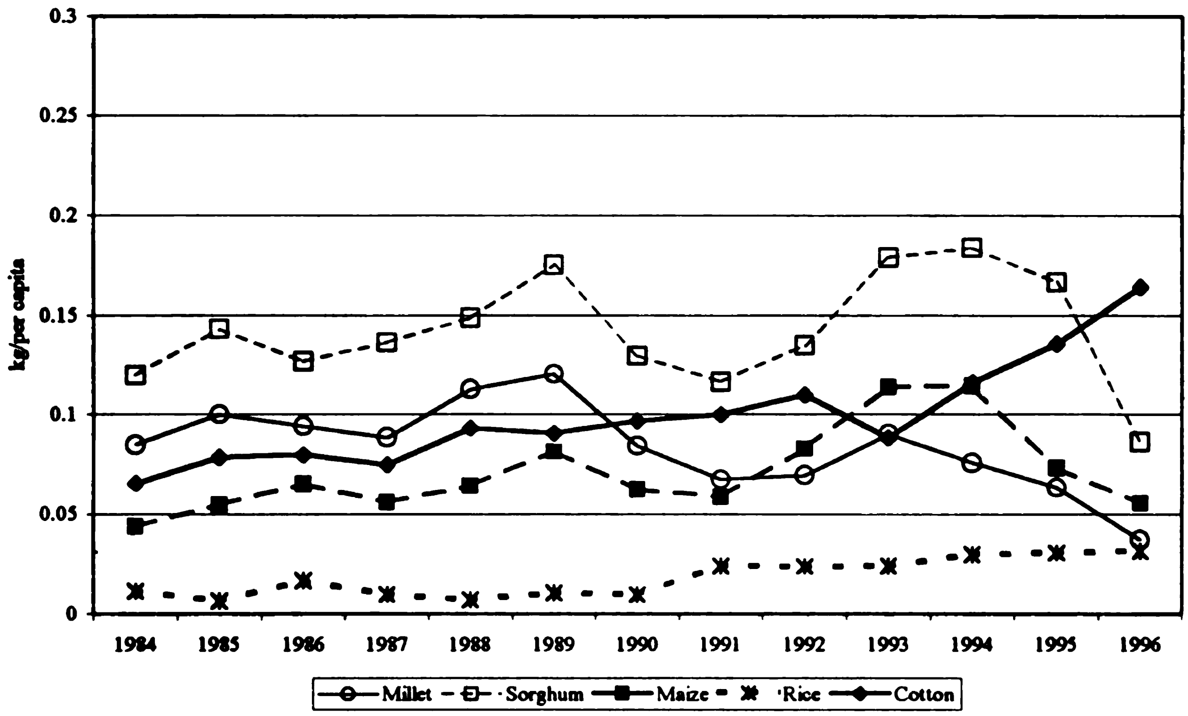
Kayes: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



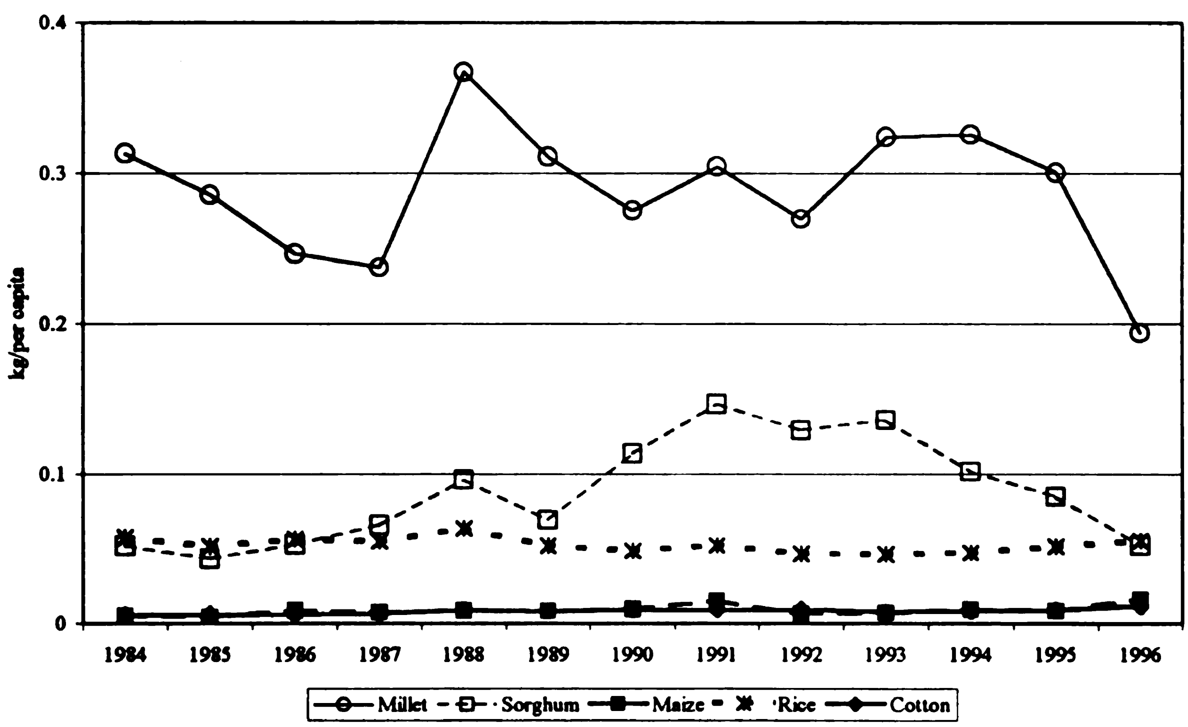
Koulikoro: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



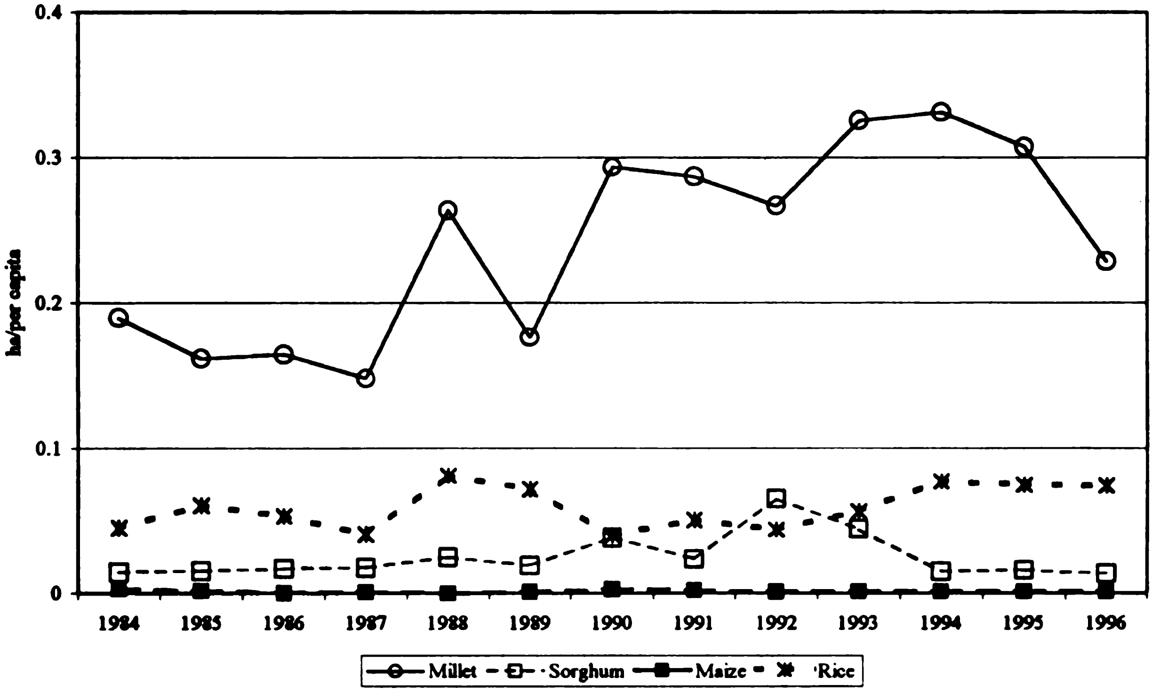
Sikasso: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



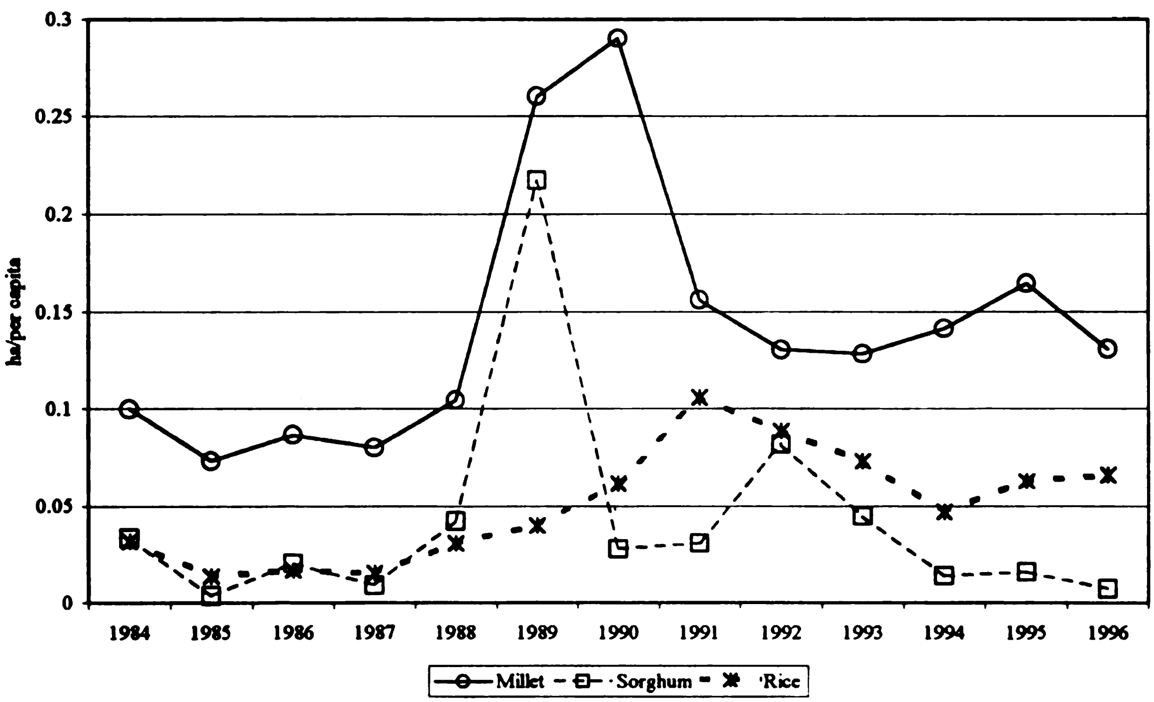
Segou: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



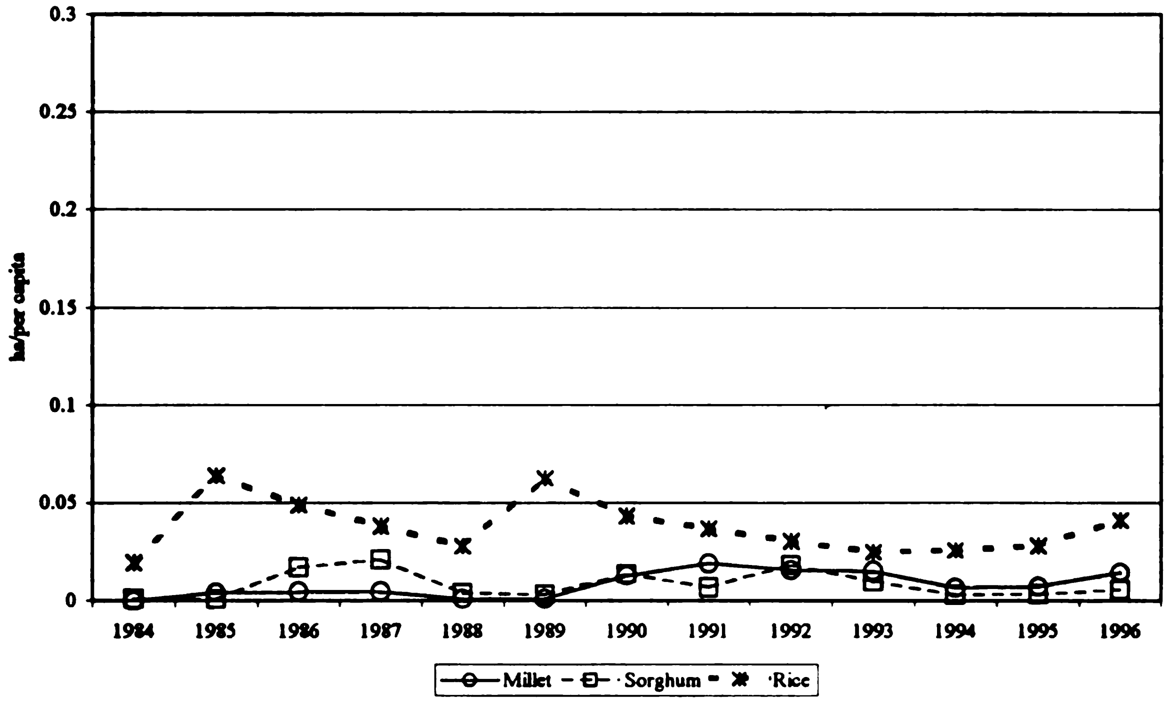
Mopti: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



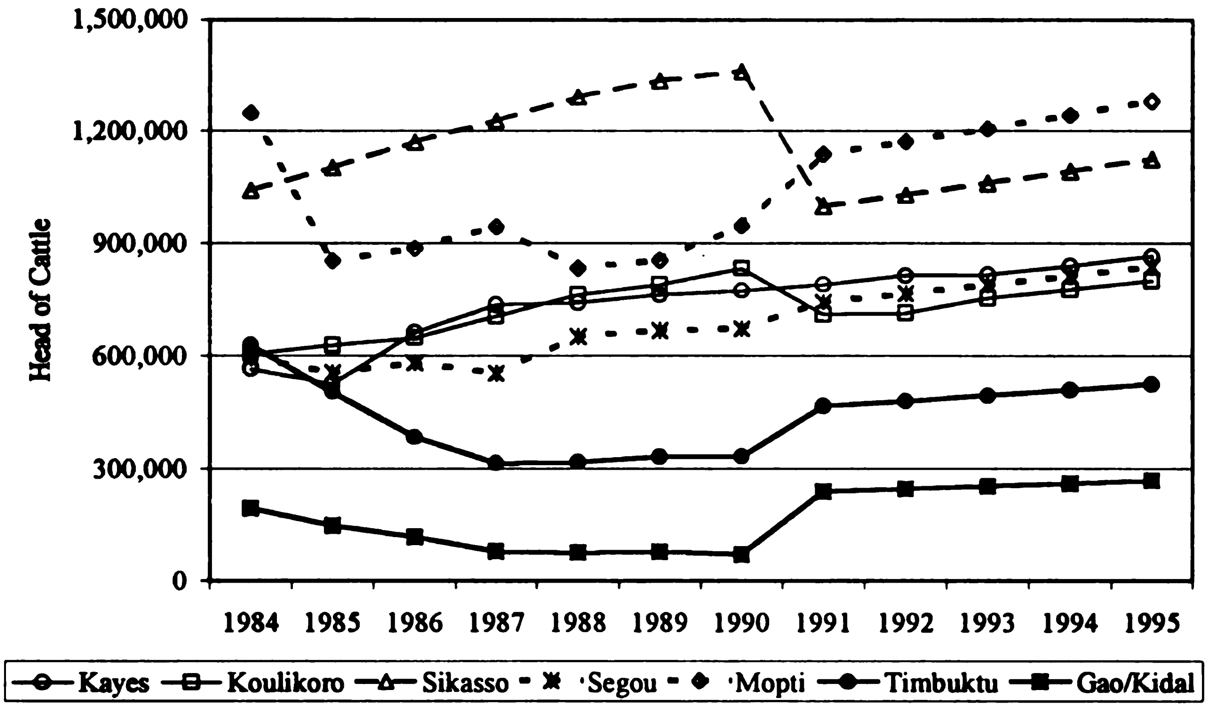
Timbuktu: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



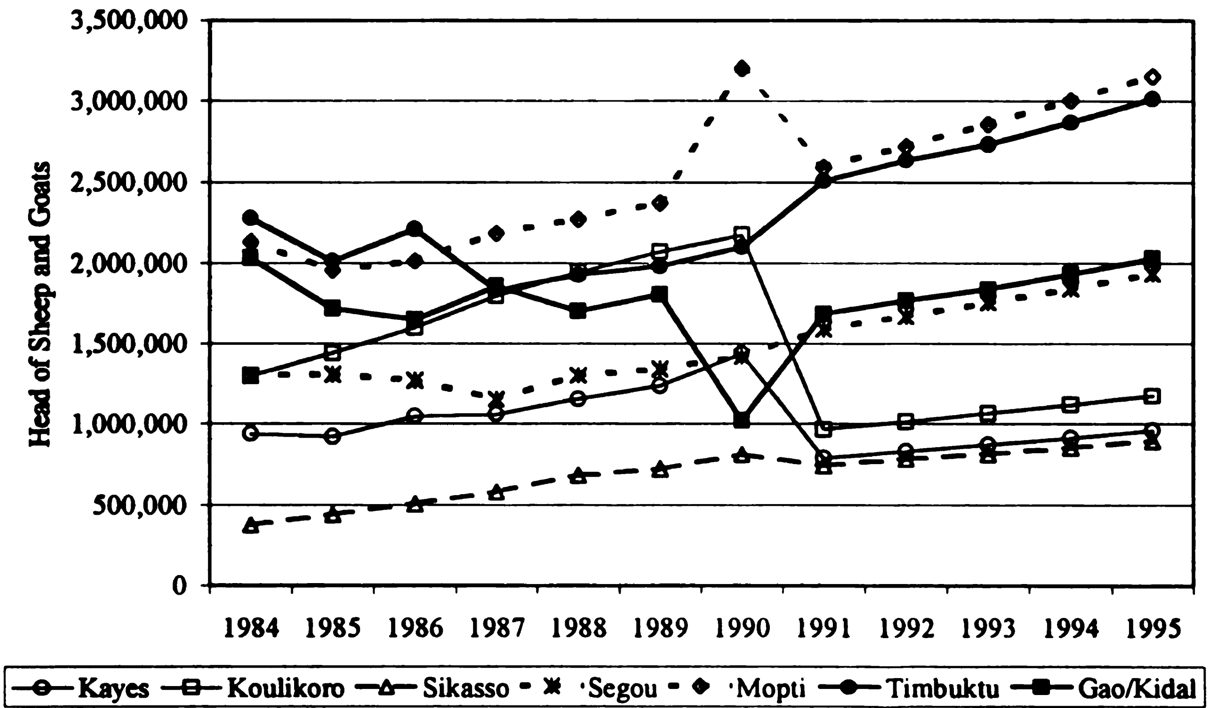
Gao/Kidal: Area Cultivated for Selected Agricultural Commodities, 1984 to 1996



Head of Cattle, 1984 to 1995



Sheep and Goats, 1984 to 1995



APPENDIX II

SUMMARY STATISTICS FOR MODEL VARIABLES

Table 1: Summary Statistics for the Fixed Effects Model of WHZ, DHS I Pooled Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-0.933117	0.964902	-3.98	2.78
Wealth (1)	0.295181	0.456296	0	1
Wealth (2)	0.292169	0.454931	0	1
Wealth (3)	0.170934	0.376593	0	1
Primary Education	0.091867	0.288948	0	1
Secondary Education	0.111446	0.314802	0	1
Child's Age 12 – 17	0.204819	0.403722	0	1
Child's Age 18 – 23	0.189759	0.392258	0	1
Child's Age 24 – 29	0.165663	0.371918	0	1
Child's Age 30 – 35	0.179970	0.384307	0	1
Child is a Twin	0.027108	0.217930	0	1

Table 2: Summary Statistics for the Fixed Effects Model of WHZ, DHS I Urban Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-0.907398	1.005904	-3.98	2.63
Wealth (1)	0.283422	0.451062	0	1
Wealth (2)	0.340463	0.474288	0	1
Wealth (3)	0.233512	0.423442	0	1
Primary Education	0.126560	0.332776	0	1
Secondary Education	0.228164	0.420023	0	1
Child's Age 12 – 17	0.199643	0.400089	0	1
Child's Age 18 – 23	0.196078	0.397383	0	1
Child's Age 24 – 29	0.185383	0.388955	0	1
Child's Age 30 – 35	0.176471	0.381560	0	1
Child is a Twin	0.032086	0.236879	0	1

Table 3: Summary Statistics for the Fixed Effects Model of WHZ, DHS I Rural Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-0.951930	0.933991	-3.76	2.78
Wealth (1)	0.303781	0.460189	0	1
Wealth (2)	0.256845	0.437178	0	1
Wealth (3)	0.125163	0.331120	0	1
Primary Education	0.066493	0.249304	0	1
Secondary Education	0.026076	0.159464	0	1
Child's Age 12 – 17	0.208605	0.406576	0	1
Child's Age 18 – 23	0.185137	0.388662	0	1
Child's Age 24 – 29	0.151239	0.358515	0	1
Child's Age 30 – 35	0.182529	0.386532	0	1
Child is a Twin	0.023468	0.203037	0	1

Table 4: Summary Statistics for the Fixed Effects Model of HAZ, DHS I Pooled Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
HAZ	-1.340763	1.547474	-5.91	4.36
Wealth (1)	0.285303	0.451775	0	1
Wealth (2)	0.300672	0.458771	0	1
Wealth (3)	0.173871	0.379181	0	1
Primary Education	0.098943	0.298729	0	1
Secondary Education	0.135447	0.342365	0	1
Child's Age 12 – 17	0.208453	0.406398	0	1
Child's Age 18 – 23	0.184438	0.388027	0	1
Child's Age 24 – 29	0.162344	0.368943	0	1
Child's Age 30 – 35	0.176753	0.381643	0	1
Child is a Twin	0.033622	0.243814	0	1

Table 5: Summary Statistics for the Fixed Effects Model of HAZ, DHS I Urban Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
HAZ	-1.103931	1.381390	-5.66	4.36
Wealth (1)	0.268499	0.443648	0	1
Wealth (2)	0.357294	0.479710	0	1
Wealth (3)	0.238901	0.426863	0	1
Primary Education	0.131078	0.337843	0	1
Secondary Education	0.262156	0.440273	0	1
Child's Age 12 – 17	0.196617	0.397861	0	1
Child's Age 18 – 23	0.188161	0.391254	0	1
Child's Age 24 – 29	0.186047	0.389556	0	1
Child's Age 30 – 35	0.175476	0.380776	0	1
Child is a Twin	0.038055	0.257576	0	1

Table 6: Summary Statistics for the Fixed Effects Model of HAZ, DHS I Rural Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
HAZ	-1.537984	1.648659	-5.91	3.62
Wealth (1)	0.299296	0.458353	0	1
Wealth (2)	0.253521	0.435410	0	1
Wealth (3)	0.119718	0.324918	0	1
Primary Education	0.072183	0.259019	0	1
Secondary Education	0.029930	0.170543	0	1
Child's Age 12 – 17	0.218310	0.413463	0	1
Child's Age 18 – 23	0.181338	0.385638	0	1
Child's Age 24 – 29	0.142606	0.349978	0	1
Child's Age 30 – 35	0.177817	0.382696	0	1
Child is a Twin	0.029930	0.231897	0	1

Table 7: Summary Statistics for Fixed Effects/Covariate Models, DHS II Pooled Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-1.265497	1.192583	-4.00	4.56
HAZ	-1.534020	1.583541	-5.95	5.89
Wealth (1)	0.333605	0.471564	0	1
Wealth (2)	0.301329	0.458898	0	1
Wealth (3)	0.150258	0.357372	0	1
Primary Education	0.088690	0.284334	0	1
Secondary Education	0.061025	0.239409	0	1
Mother's HAZ	-0.346640	1.010096	-4.51	3.35
Child's Age 12 – 17	0.214266	0.410368	0	1
Child's Age 18 – 23	0.165445	0.371633	0	1
Child's Age 24 – 29	0.183347	0.387003	0	1
Child's Age 30 – 35	0.196366	0.397302	0	1
Child is a Twin	0.038785	0.259101	0	1
Center for Adult Literacy	0.630865	0.482636	0	1
Primary School < 2km	0.564416	0.495901	0	1
Secondary School < 2km	0.349607	0.476910	0	1
Basic Health Facility < 2km	0.188500	0.391164	0	1
Basic Health Facility < 15km	0.158666	0.365414	0	1
Advanced Health Facility < 2km	0.319230	0.466241	0	1
Advanced Health Facility < 15km	0.307025	0.461322	0	1
Health Agent Provides ORT	0.509900	0.499970	0	1
Mom's Ed./Health Facility Interact	0.105777	0.307594	0	1
Current Price of Millet	115.359153	32.26006	65.00	631.25
Current Price of Sorghum	108.247322	18.887962	65.50	150.00
Current Price of Maize	117.244310	23.536101	72.50	193.00
Current Price of Rice	250.731571	21.718377	194.05	306.25
Millet not currently available	0.166802	0.372850	0	1
Sorghum not currently available	0.197993	0.398541	0	1
Maize not currently available	0.668836	0.470696	0	1
Rice not currently available	0.125305	0.331109	0	1
November Average Millet Price	93.634142	23.595207	47.84	175.00
November Average Sorghum Price	89.075262	21.103281	52.25	133.63
November Average Maize Price	83.136213	18.186469	42.58	130.56
November Average Rice Price	234.513821	22.287956	166.53	306.25
Millet missing from market	0.119881	0.324866	0	1
Sorghum missing from market	0.090046	0.286287	0	1
Maize missing from market	0.408462	0.491616	0	1
Rice missing from market	0.154055	0.361050	0	1

Table 8: Summary Statistics for Fixed Effects/Covariate Models, DHS II Urban Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-1.312332	1.199819	-3.97	4.56
HAZ	-1.281704	1.499707	-5.79	5.89
Wealth (1)	0.373094	0.483844	0	1
Wealth (2)	0.194619	0.396085	0	1
Wealth (3)	0.224215	0.417252	0	1
Primary Education	0.136323	0.343285	0	1
Secondary Education	0.161435	0.368097	0	1
Mother's HAZ	-0.213067	0.985084	-4.51	3.07
Child's Age 12 – 17	0.216143	0.411798	0	1
Child's Age 18 – 23	0.171300	0.376940	0	1
Child's Age 24 – 29	0.204484	0.403505	0	1
Child's Age 30 – 35	0.189238	0.391873	0	1
Child is a Twin	0.044843	0.277456	0	1
Center for Adult Literacy	0.586547	0.492674	0	1
Primary School < 2km	0.968610	0.174448	0	1
Secondary School < 2km	0.948879	0.220343	0	1
Basic Health Facility < 2km	0.412556	0.492515	0	1
Basic Health Facility < 15km	0.067265	0.250592	0	1
Advanced Health Facility < 2km	0.838565	0.368097	0	1
Advanced Health Facility < 15km	0.125561	0.331502	0	1
Health Agent Provides ORT	0.763229	0.425292	0	1
Mom's Ed./Health Facility Interact	0.290583	0.454235	0	1
Current Price of Millet	125.112819	19.245522	73.50	175.00
Current Price of Sorghum	120.571533	13.647567	65.50	150.00
Current Price of Maize	124.727225	23.445239	80.26	193.00
Current Price of Rice	247.797000	20.830454	194.05	300.00
Millet not currently available	0.023318	0.150980	0	1
Sorghum not currently available	0.187444	0.390433	0	1
Maize not currently available	0.578475	0.494025	0	1
Rice not currently available	0.016143	0.126084	0	1
November Average Millet Price	104.378329	20.215334	54.58	175.00
November Average Sorghum Price	102.543848	19.658633	53.96	133.63
November Average Maize Price	86.369277	16.279007	54.26	125.00
November Average Rice Price	232.850827	22.281707	166.53	301.25
Millet missing from market	0.023318	0.150980	0	1
Sorghum missing from market	0.007175	0.084438	0	1
Maize missing from market	0.327354	0.469458	0	1
Rice missing from market	0.052915	0.223964	0	1

Table 9: Summary Statistics for Fixed Effects/Covariate Models, DHS II Rural Sample

Variable	Mean	Std. Dev.	Minimum	Maximum
WHZ	-1.245167	1.189093	-4.00	3.54
HAZ	-1.643402	1.606548	-5.95	5.10
Wealth (1)	0.316485	0.465195	0	1
Wealth (2)	0.347589	0.476297	0	1
Wealth (3)	0.118196	0.322903	0	1
Primary Education	0.068040	0.251864	0	1
Secondary Education	0.017496	0.131136	0	1
Mother's HAZ	-0.404545	1.015491	-4.09	3.35
Child's Age 12 – 17	0.213453	0.409824	0	1
Child's Age 18 – 23	0.162908	0.369354	0	1
Child's Age 24 – 29	0.174184	0.379341	0	1
Child's Age 30 – 35	0.199456	0.399669	0	1
Child is a Twin	0.036159	0.250738	0	1
Center for Adult Literacy	0.650078	0.477038	0	1
Primary School < 2km	0.389191	0.487662	0	1
Secondary School < 2km	0.089813	0.285970	0	1
Basic Health Facility < 2km	0.091369	0.288189	0	1
Basic Health Facility < 15km	0.198289	0.398789	0	1
Advanced Health Facility < 2km	0.094090	0.292011	0	1
Advanced Health Facility < 15km	0.385692	0.486853	0	1
Health Agent Provides ORT	0.400078	0.490009	0	1
Mom's Ed./Health Facility Interact	0.025661	0.158152	0	1
Current Price of Millet	111.130794	35.670909	65.00	631.25
Current Price of Sorghum	102.904595	18.339678	65.50	150.00
Current Price of Maize	114.000356	18.211135	72.50	168.75
Current Price of Rice	252.003749	21.974700	194.05	306.25
Millet not currently available	0.229005	0.420274	0	1
Sorghum not currently available	0.202566	0.401990	0	1
Maize not currently available	0.708009	0.454766	0	1
Rice not currently available	0.172628	0.377999	0	1
November Average Millet Price	88.976378	23.438078	47.84	175.00
November Average Sorghum Price	83.236430	18.927766	52.25	130.56
November Average Maize Price	81.734632	18.784659	42.58	130.56
November Average Rice Price	235.234753	22.256405	166.53	306.25
Millet missing from market	0.161742	0.368285	0	1
Sorghum missing from market	0.125972	0.331882	0	1
Maize missing from market	0.443624	0.496908	0	1
Rice missing from market	0.197900	0.398494	0	1

APPENDIX III

REGRESSION RESULTS FOR MODELS CONTAINING MATERNAL AND HOUSEHOLD CHARACTERISTICS

Table 1: Regression of Selected Variables on WHZ Scores of Children 6 to 35 months

	DHS I			DHS II		
Variable[†]	**Pooled**	**Urban**	**Rural**	**Pooled**	**Urban**	**Rural**
Constant[‡]	-0.6564 (2.7415)***	-0.7183 (1.8454)*	-0.6676 (2.6578)***	-1.4492 (5.4982)***	-1.2982 (4.4117)***	-0.8255 (4.1935)***
Wealth (1 asset)	0.0571 (0.6814)	-0.0673 (0.4118)	0.1158 (1.2053)	0.0934 (1.6317)	0.1303 (1.2789)	0.0852 (1.2206)
Wealth (2 assets)	0.0702 (0.7524)	-0.0450 (0.2833)	0.1017 (0.8324)	0.1259 (2.0159)**	0.1508 (1.1960)	0.1177 (1.6191)
Wealth (3 + assets)	0.0985 (0.9720)	-0.0555 (0.3096)	0.2238 (1.7085)*	0.1619 (2.0247)**	0.2593 (1.8339)*	0.1217 (1.2318)
Size of Household	-0.0084 (0.7077)	0.0052 (0.2838)	-0.0182 (1.0833)	0.0018 (0.2198)	-0.0020 (0.1398)	-0.0004 (0.0354)
Number of Women 15-49	-0.0180 (0.3514)	-0.0507 (0.6973)	-0.0067 (0.0881)	-0.0142 (0.4352)	-0.0148 (0.2995)	0.0023 (0.0485)
Mom's Age 20-24	0.1005 (0.9597)	0.1582 (0.8951)	0.0711 (0.5340)	-0.0749 (0.9669)	-0.1252 (0.9051)	-0.0436 (0.4611)
Mom's Age 25-29	-0.0517 (0.5062)	-0.0880 (0.5398)	-0.0107 (0.0791)	-0.0543 (0.6899)	-0.3062 (2.1666)**	0.0701 (0.7310)
Mom's Age 30-34	0.1316 (1.1884)	0.0666 (0.4105)	0.1975 (1.2793)	-0.1426 (1.7226)*	-0.2498 (1.6951)*	-0.0780 (0.7692)
Mom's Age 35-39	0.2320 (2.0263)**	0.3343 (1.9289)*	0.1977 (1.2762)	-0.1331 (1.5012)	-0.3437 (2.1395)**	-0.0271 (0.2518)
Mom's Age 40-44	0.1016 (0.7062)	0.2452 (1.1295)	0.0765 (0.3821)	-0.1626 (1.5049)	-0.2669 (1.3767)	-0.0766 (0.5804)
Mom's Age 45-49	-0.1694 (0.7475)	-0.7105 (2.1444)**	-0.0289 (0.1006)	-0.4386 (2.4845)**	-0.7611 (1.9099)*	-0.3388 (1.7186)*
Primary Education	0.2391 (2.2869)**	0.2301 (1.4681)	0.2489 (1.7300)*	0.2131 (2.8370)***	0.2930 (2.4697)**	0.1443 (1.4563)
Secondary Education	0.2695 (2.5788)***	0.2790 (2.2000)**	0.3209 (1.6364)	0.1327 (1.3195)	0.2172 (1.7681)*	-0.1135 (0.5667)
First Wife	-0.0398 (0.5262)	-0.1292 (0.9793)	0.0008 (0.0085)	-0.0545 (0.9751)	0.0352 (0.3370)	-0.0859 (1.3042)
Mother's HAZ	Not Available	Not Available	Not Available	0.0435 (2.1273)**	0.0380 (0.9686)	0.0420 (1.7576)*
Child's Age 12-17 months	-0.3006 (3.6051)***	-0.3191 (2.1965)**	-0.2820 (2.8095)***	-0.2639 (4.4261)***	-0.2226 (1.9402)*	-0.3035 (4.3291)***
Child's Age 18-23 months	-0.1817 (2.0667)**	-0.3552 (2.5277)**	-0.0606 (0.5368)	-0.1979 (3.0180)***	-0.1800 (1.4082)	-0.2246 (2.9371)***
Child's Age 24-29 months	-0.0765 (0.8578)	-0.2498 (1.7261)*	0.0579 (0.5101)	0.2627 (4.2475)***	0.2330 (1.9480)*	0.2643 (3.6607)***
Child's Age 30-35 months	0.1004 (1.1876)	0.0293 (0.2035)	0.1570 (1.5359)	0.3121 (5.1895)***	0.2793 (2.4568)**	0.3077 (4.3464)***
Child is Twin	-0.2107 (1.6135)	-0.3127 (1.3592)	-0.1773 (0.9931)	-0.1589 (1.9437)*	0.0533 (0.4302)	-0.2798 (2.7444)***

(Table 1 Con't)

Test Statistic	DHS I Pooled	Urban	Rural	DHS II Pooled	Urban	Rural
Flush	0.0918	0.0647	NA	0.0476	0.0675	NA
Toilet	(0.1486)	(0.1070)		(0.1603)	(0.2178)	
Latrine	-0.0767	-0.0911	-0.0841	0.1065	0.0705	0.1371
	(0.0865)	(0.3837)	(0.8688)	(1.2780)	(0.5761)	(1.1903)
Piped	-0.3709	-0.3213	NA	0.0847	0.1272	NA
Water	(2.663)**	(2.171)**		(0.9601)	(0.9781)	
Pump	-0.2410	0.5272	-0.3359	0.0916	0.0004	0.1147
Water	(1.4452)	(0.8280)	(2.008)**	(1.2929)	(0.0020)	(1.5277)
Joint Significance of:	$F(2,1162)$	$F(2,480)$	$F(2,661)$	$F(2,3364)$	$F(2,973)$	$F(2,2369)$
Wealth (2 and 3 + assets)	0.4964	0.0573	1.3377	2.7044*	1.8786	1.4122
Primary and Secondary Education	5.4422***	3.1427**	2.3668*	4.8273***	4.2402**	1.4053
Flush Toilet and Latrine	0.3981	0.0750	Latrine & Pump[¥]	2.9705*	1.7860	Latrine & Pump[¥]
Piped and Pump Water	3.5262**	2.1255	2.7640*	3.6845**	1.4760	1.5974
Breush-Pagan $\sim X^2$ (n – k d.f.)[§]	251.8***	110.7***	156.8***	639.6***	238.5***	416.3***
F Test Statistic	1.6479***	1.4756***	1.6179***	2.1926***	1.8776***	2.2648***
R-Squared	0.1896	0.1974	0.2045	0.1735	0.2139	0.1619
R-Squared Adjusted	0.0746	0.0636	0.0781	0.0944	0.1000	0.0904
Sample Size	1328	561	767	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

[¥]Flush toilets and piped water are not accessible in rural areas; the joint test is for latrines and pump water.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

Table 2: Regression of Selected Variables on HAZ Scores of Children 6 to 35 months

Variable†	DHS I Pooled	Urban	Rural	DHS II Pooled	Urban	Rural
Constant‡	-1.2250 (1.6383)	-0.8172 (1.5351)	-0.9262 (1.2036)	-0.5504 (1.3508)	-0.6520 (1.5198)	-0.4689 (1.7071)*
Wealth (1 asset)	0.0219 (0.1341)	0.2935 (1.1942)	-0.1506 (0.6872)	0.0421 (0.6071)	0.1727 (1.3796)	-0.0202 (0.2402)
Wealth (2 assets)	0.3723 (2.2210)**	0.5071 (2.0708)**	0.3418 (1.4219)	0.0522 (0.6828)	0.2937 (1.8617)*	-0.0447 (0.5089)
Wealth (3 + assets)	0.3390 (1.6814)*	0.6783 (2.2324)**	-0.1183 (0.4237)	0.1649 (1.7257)*	0.3412 (2.2233)**	0.0585 (0.4792)
Size of Household	-0.0030 (0.1486)	0.0156 (0.5918)	-0.0342 (0.9999)	-0.0280 (2.7392)***	-0.0110 (0.6726)	-0.0333 (2.5603)**
Number of Women 15-49	0.0018 (0.0198)	-0.0204 (0.1936)	0.0666 (0.4052)	0.0527 (1.3337)	-0.0107 (0.1901)	0.0993 (1.7044)*
Mom's Age 20-24	0.1897 (1.0311)	0.2195 (0.8559)	0.2255 (0.8874)	0.2431 (2.7163)***	0.1048 (0.6801)	0.2933 (2.6307)***
Mom's Age 25-29	0.3961 (2.1609)**	0.6034 (2.5546)**	0.2877 (1.0554)	0.1213 (1.3413)	-0.1544 (1.0006)	0.2092 (1.8632)*
Mom's Age 30-34	0.5810 (2.9202)***	0.6579 (2.6104)***	0.5663 (1.9102)*	0.2169 (2.2665)**	0.2034 (1.2857)	0.2121 (1.7547)*
Mom's Age 35-39	0.4173 (1.9226)*	0.6693 (2.3756)**	0.2381 (0.7260)	0.2947 (2.8258)***	0.4207 (2.4469)**	0.2195 (1.6720)*
Mom's Age 40-44	0.0747 (0.2508)	-0.1610 (0.4070)	0.2714 (0.6059)	0.1299 (0.9701)	-0.0017 (0.0071)	0.1603 (0.9761)
Mom's Age 45-49	0.2305 (0.5686)	0.2708 (0.6709)	0.3467 (0.6190)	0.1551 (0.6691)	1.5471 (2.1416)**	-0.0331 (0.1449)
Primary Education	0.0899 (0.4852)	-0.0717 (0.2994)	0.3255 (1.1469)	0.0829 (1.0022)	0.0654 (0.5055)	0.0815 (0.7469)
Secondary Education	0.1778 (1.0954)	0.1724 (0.8748)	-0.1583 (0.4561)	0.1017 (0.9238)	0.0187 (0.1388)	0.1845 (0.9259)
First Wife	-0.1520 (1.0343)	-0.1030 (0.4687)	-0.0906 (0.4507)	0.1019 (1.5233)	0.0643 (0.4267)	0.1320 (1.6084)
Mother's HAZ	Not Available	Not Available	Not Available	0.2505 (9.8040)***	0.2102 (4.6081)***	0.2683 (8.6906)***
Child's Age 12-17 months	-0.6727 (4.6743)***	-0.5598 (2.6095)***	-0.6895 (3.5576)***	-0.7942 (11.306)***	-1.0393 (8.3909)***	-0.6594 (8.2290)***
Child's Age 18-23 months	-0.7767 (5.1497)***	-0.5973 (3.0981)***	-0.9135 (3.9549)***	-1.5299 (20.324)***	-1.4671 (10.404)***	-1.5516 (17.342)***
Child's Age 24-29 months	-1.0052 (6.3437)***	-0.8462 (4.0880)***	-1.1560 (4.6597)***	-1.1426 (15.385)***	-1.0045 (7.3035)***	-1.2131 (13.839)***
Child's Age 30-35 months	-1.0364 (7.0553)***	-0.7381 (3.6161)***	-1.3261 (6.2413)***	-1.5965 (20.778)***	-1.5298 (10.833)***	-1.6215 (17.734)***
Child is Twin	-0.0559 (0.3081)	-0.3271 (1.3093)	0.3255 (1.2181)	-0.3520 (3.9899)***	-0.4210 (2.8624)***	-0.3244 (2.8778)***

(Table 2 Con't)

Test Statistic	DHS I Pooled	Urban	Rural	DHS II Pooled	Urban	Rural
Flush Toilet	2.5768 (4.23)***	2.2114 (3.21)***	NA	-0.0813 (0.3508)	-0.1558 (0.6276)	NA
Latrine	0.1188 (0.6710)	-0.0790 (0.2343)	0.1063 (0.5392)	0.0360 (0.3688)	-0.0010 (0.0068)	0.0986 (0.7443)
Piped Water	0.0403 (0.1596)	-0.0618 (0.2426)	NA	0.0679 (0.6655)	0.1962 (1.5512)	NA
Pump Water	-0.5048 (1.5013)	-0.5965 (1.7868)*	-0.4394 (1.2186)	0.0447 (0.5069)	0.1743 (0.8477)	0.0397 (0.4124)
Joint Significance of:	F(2,877)	F(2,393)	F(2,463)	F(2,3364)	F(2,973)	F(2,2369)
Wealth (2 and 3 + Assets)	2.6907*	3.1915**	1.8135	1.5036	2.7383*	0.5229
Primary and Secondary Education	0.5646	0.6814	0.6847	0.6954	0.1218	0.5028
Flush Toilet and Latrine	2.3119*	2.1610	Latrine & Pump[¥] 1.1890	1.1379	1.5251	Latrine & Pump[¥] 0.2882
Piped and Pump Water	1.6153	0.2309		1.3683	3.4450**	
Breush-Pagan Test $\sim X^2$ (n – k d.f.)[§]	232.9***	96.1**	137.7**	1037.7***	329.4***	714.1***
F Test Statistic	1.5509***	1.2692*	1.4253***	4.0921***	2.8931***	4.5078***
R-Squared	0.2238	0.2033	0.2425	0.2815	0.2954	0.2777
R-Squared Adjusted	0.0795	0.0431	0.0724	0.2127	0.1933	0.2161
Sample Size	1041	473	568	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

[¥]Flush toilets and piped water are not accessible in rural areas; the joint test is for latrines and pump water.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

Table 3: Regression of Selected Variables on WHZ Scores of Children 6 to 35 months

	DHS II Community Covariates			DHS II Community Fixed Effects		
Variable[†]	**Pooled**	**Urban**	**Rural**	**Pooled**	**Urban**	**Rural**
Constant[‡]	-2.0139 (6.2479)***	-1.1081 (1.5048)	-2.7659 (6.8104)***	-1.4492 (5.4982)***	-1.2982 (4.4117)***	-0.8255 (4.1935)***
Wealth (1 asset)	0.1317 (2.4156)**	0.1392 (1.3811)	0.1322 (2.0291)**	0.0934 (1.6317)	0.1303 (1.2789)	0.0852 (1.2206)
Wealth (2 assets)	0.1884 (3.2257)***	0.1600 (1.3469)	0.1656 (2.4521)**	0.1259 (2.0159)**	0.1508 (1.1960)	0.1177 (1.6191)
Wealth (3 + assets)	0.2561 (3.4736)***	0.3229 (2.4345)**	0.2183 (2.4088)**	0.1619 (2.0247)**	0.2593 (1.8339)*	0.1217 (1.2318)
Size of Household	0.0014 (0.1845)	0.0003 (0.0202)	-0.0008 (0.0791)	0.0018 (0.2198)	-0.0020 (0.1398)	-0.0004 (0.0354)
Number of Women 15-49	-0.0117 (0.3679)	-0.0215 (0.4517)	0.0160 (0.3562)	-0.0142 (0.4352)	-0.0148 (0.2995)	0.0023 (0.0485)
Mom's Age 20-24	-0.0392 (0.5227)	-0.0876 (0.6495)	-0.0317 (0.3484)	-0.0749 (0.9669)	-0.1252 (0.9051)	-0.0436 (0.4611)
Mom's Age 25-29	-0.0335 (0.4430)	-0.3125 (2.3324)**	0.0850 (0.9244)	-0.0543 (0.6899)	-0.3062 (2.1666)**	0.0701 (0.7310)
Mom's Age 30-34	-0.0788 (1.0016)	-0.1909 (1.3373)	-0.0250 (0.2626)	-0.1426 (1.7226)*	-0.2498 (1.6951)*	-0.0780 (0.7692)
Mom's Age 35-39	-0.0859 (1.0183)	-0.2880 (1.9581)*	-0.0027 (0.0264)	-0.1331 (1.5012)	-0.3437 (2.1395)**	-0.0271 (0.2518)
Mom's Age 40-44	-0.1039 (0.9879)	-0.1660 (0.8840)	-0.0462 (0.3600)	-0.1626 (1.5049)	-0.2669 (1.3767)	-0.0766 (0.5804)
Mom's Age 45-49	-0.3603 (2.1797)**	-0.9675 (2.7411)***	-0.2545 (1.3876)	-0.4386 (2.4845)**	-0.7611 (1.9099)*	-0.3388 (1.7186)*
Primary Education	0.1947 (1.9143)*	0.1734 (0.5098)	0.1738 (1.5828)	0.2131 (2.8370)***	0.2930 (2.4697)**	0.1443 (1.4563)
Secondary Education	0.1364 (0.9842)	0.0651 (0.1782)	0.0667 (0.3310)	0.1327 (1.3195)	0.2172 (1.7681)*	-0.1135 (0.5667)
First Wife	-0.0699 (1.2918)	0.0198 (0.1994)	-0.0938 (1.4542)	-0.0545 (0.9751)	0.0352 (0.3370)	-0.0859 (1.3042)
Mother's HAZ	0.0477 (2.5043)**	0.0507 (1.3474)	0.0462 (2.1061)**	0.0435 (2.1273)**	0.0380 (0.9686)	0.0420 (1.7576)*
Child's Age 12-17 months	-0.2527 (4.3517)***	-0.2223 (1.9888)**	-0.2832 (4.1785)***	-0.2639 (4.4261)***	-0.2226 (1.9402)*	-0.3035 (4.3291)***
Child's Age 18-23 months	-0.1928 (3.0223)***	-0.1356 (1.1033)	-0.2294 (3.0656)***	-0.1979 (3.0180)***	-0.1800 (1.4082)	-0.2246 (2.9371)***
Child's Age 24-29 months	0.2210 (3.6847)***	0.1760 (1.5455)	0.2367 (3.3572)***	0.2627 (4.2475)***	0.2330 (1.9480)*	0.2643 (3.6607)***
Child's Age 30-35 months	0.3030 (5.1446)***	0.3102 (2.8118)***	0.2911 (4.1835)***	0.3121 (5.1895)***	0.2793 (2.4568)**	0.3077 (4.3464)***
Child is Twin	-0.1719 (2.3380)**	0.0618 (0.4917)	-0.3019 (3.4337)***	-0.1589 (1.9437)*	0.0533 (0.4302)	-0.2798 (2.7444)***
Flush Toilet	0.0402 (0.1686)	0.1280 (0.4891)	NA	0.0476 (0.1603)	0.0675 (0.2178)	NA
Latrine	0.0873 (1.1717)	0.0914 (0.8529)	0.0275 (0.2587)	0.1065 (1.2780)	0.0705 (0.5761)	0.1371 (1.1903)
Piped Water	-0.1145 (1.8516)*	0.0742 (0.7894)	NA	0.0847 (0.9601)	0.1272 (0.9781)	NA
Pump Water	0.0482 (0.2171)	0.2419 (1.5547)	0.0420 (0.6793)	0.0916 (1.2929)	0.0004 (0.0020)	0.1147 (1.5277)

(Table 3 Con't)

Variable:	DHS II Community Covariates Pooled	Urban	Rural	DHS II Community Fixed Effects Pooled	Urban	Rural
Center for Adult Literacy	-0.0093 (0.2171)	-0.0043 (0.0480)	0.0981 (1.7868)*			
Primary School < 2km	0.0838 (1.4689)	-0.0528 (0.1239)	0.0710 (1.1962)			
Secondary School < 2km	-0.1232 (1.7928)*	0.3821 (1.6473)*	0.1029 (1.1247)			
Basic Health Facility < 2km	-0.0021 (0.0332)	0.0182 (0.1360)	-0.0344 (0.4043)			
Basic Health Facility < 15km	0.1304 (2.240)**	0.2140 (1.1173)	0.0690 (1.0669)			
Advanced Health Facility < 2km	0.0152 (0.2098)	-0.4079 (1.2566)	0.0201 (0.2038)			
Advanced Health Facility < 15km	-0.0524 (1.0564)	-0.7797 (2.384)**	-0.0544 (1.0198)			
Health Agent Provides ORT	0.0299 (0.6400)	0.0719 (0.7142)	0.0884 (1.5833)			
Mom's w/ some Educ. & Health Facility < 2km	0.0807 (0.6375)	0.1459 (0.4147)	-0.0332 (0.1756)			
Price of Millet (Month of interview)	-0.0001 (0.1163)	-0.0021 (0.4682)	0.0005 (0.6873)			
Price of Sorghum (Month of interview)	0.0063 (3.85)***	0.0008 (0.1428)	0.0082 (3.52)***			
Price of Maize (Month of interview)	-0.0021 (1.7078)*	-0.0048 (2.58)***	0.0011 (0.5061)			
Price of Rice (Month of interview)	0.0006 (0.4844)	0.0024 (0.8113)	0.0005 (0.3221)			
Millet Not Available In Market	0.0584 (0.9913)	-0.1387 (0.5943)	0.0248 (0.3969)			
Sorghum Not Available In Market	0.0799 (1.3195)	0.1523 (0.7117)	0.1237 (1.7789)*			
Maize Not Available In Market	0.0567 (1.0025)	-0.1874 (1.1854)	0.1259 (1.7612)*			
Rice Not Available In Market	0.1376 (2.152)**	0.4145 (1.2874)	0.0667 (0.9615)			
Breush-Pagan ~ X^2 (k d.f.)[§]	218.4***	101.3***	197.1***	639.6***	238.5***	416.3***
F Test Statistic	5.5970***	2.6165***	5.3876***	2.1926***	1.8776***	2.2648***
R-Squared	0.0592	0.0909	0.0766	0.1735	0.2139	0.1619
R-Squared Adjusted	0.0486	0.0562	0.0624	0.0944	0.1000	0.0904
Sample Size	3687	1115	2572	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

Table 3a: Joint Significance of Selected Variables on WHZ Scores

	DHS II Community Covariates			**DHS II Community Fixed Effects**		
	Pooled	**Urban**	**Rural**	**Pooled**	**Urban**	**Rural**
Joint Significance of:	F(2,3645)	F(2,1073)	F(2,2532)	F(2,3364)	F(2,973)	F(2,2369)
Primary and Secondary Education	1.9797	0.3914	1.3807	4.8273***	4.2402**	1.4053
Flush Toilet and Latrine	0.6728	0.4442	Latrine & Pump[¥]	2.9705*	1.7860	Latrine & Pump[¥]
Piped and Pump Water	2.3525*	1.1653	0.2504	3.6845**	1.4760	1.5974
Primary and Secondary School < 2km	2.0074	1.2834	1.7665			
Basic Health < 2km and < 15 km	2.5448*	0.6869	0.6982			
Advanced Health < 2km and < 15km	0.7961	6.0678***	0.6373			
Price of Millet & Sorghum	7.8291***	0.1419	7.2082***			
Price of Millet, Sorghum, Maize and Rice - F(4,n-k)	4.1691***	1.5597	9.2782***			

[¥]Flush toilets and piped water are not accessible in rural areas; the joint test is for latrines and pump water.
* denotes significance at $p < 0.10$.
** denotes significance at $p < 0.05$.
*** denotes significance at $p < 0.01$.

Table 4: Regression of Selected Variables on HAZ Scores of Children 6 to 35 months

Variable[†]	DHS II Community Covariates Pooled	Urban	Rural	DHS II Community Fixed Effects Pooled	Urban	Rural
Constant[‡]	-0.4772 (1.4326)	-0.8239 (0.8969)	-0.4073 (1.0687)	-0.5504 (1.3508)	-0.6520 (1.5198)	-0.4689 (1.7071)*
Wealth (1 asset)	0.1216 (1.8072)*	0.2391 (1.9606)**	0.0719 (0.8738)	0.0421 (0.6071)	0.1727 (1.3796)	-0.0202 (0.2402)
Wealth (2 assets)	0.1353 (1.9109)*	0.3645 (2.4642)**	0.0504 (0.6122)	0.0522 (0.6828)	0.2937 (1.8617)*	-0.0447 (0.5089)
Wealth (3 + assets)	0.3220 (3.6814)***	0.4996 (3.3978)***	0.2217 (1.9679)**	0.1649 (1.7257)*	0.3412 (2.2233)**	0.0585 (0.4792)
Size of Household	-0.0276 (2.9360)***	-0.0156 (1.0632)	-0.0316 (2.5756)**	-0.0280 (2.7392)***	-0.0110 (0.6726)	-0.0333 (2.5603)**
Number of Women 15-49	0.0453 (1.2090)	-0.0002 (0.0030)	0.0786 (1.4046)	0.0527 (1.3337)	-0.0107 (0.1901)	0.0993 (1.7044)*
Mom's Age 20-24	0.1608 (1.8438)*	0.0624 (0.4290)	0.2139 (1.9511)*	0.2431 (2.7163)***	0.1048 (0.6801)	0.2933 (2.6307)***
Mom's Age 25-29	0.1079 (1.2233)	-0.1188 (0.8275)	0.1873 (1.6779)*	0.1213 (1.3413)	-0.1544 (1.0006)	0.2092 (1.8632)*
Mom's Age 30-34	0.1463 (1.5795)	0.1116 (0.7634)	0.1706 (1.4333)	0.2169 (2.2665)**	0.2034 (1.2857)	0.2121 (1.7547)*
Mom's Age 35-39	0.2291 (2.2424)**	0.3315 (2.0058)**	0.1675 (1.2829)	0.2947 (2.8258)***	0.4207 (2.4469)**	0.2195 (1.6720)*
Mom's Age 40-44	0.0771 (0.6022)	0.0082 (0.0368)	0.1027 (0.6483)	0.1299 (0.9701)	-0.0017 (0.0071)	0.1603 (0.9761)
Mom's Age 45-49	0.1580 (0.7030)	1.5683 (3.1309)***	-0.0841 (0.3702)	0.1551 (0.6691)	1.5471 (2.1416)**	-0.0331 (0.1449)
Primary Education	0.1067 (0.9573)	-0.1571 (0.3330)	0.0949 (0.7757)	0.0829 (1.0022)	0.0654 (0.5055)	0.0815 (0.7469)
Secondary Education	0.0846 (0.5861)	-0.2295 (0.4607)	0.2455 (1.2258)	0.1017 (0.9238)	0.0187 (0.1388)	0.1845 (0.9259)
First Wife	0.0970 (1.3911)	0.0303 (0.2136)	0.1250 (1.5372)	0.1019 (1.5233)	0.0643 (0.4267)	0.1320 (1.6084)
Mother's HAZ	0.2247 (9.3452)***	0.2055 (4.7108)***	0.2345 (8.0953)***	0.2505 (9.8040)***	0.2102 (4.6081)***	0.2683 (8.6906)***
Child's Age 12-17 months	-0.9242 (10.082)***	-1.1354 (5.4350)***	-0.8038 (7.2698)***	-0.7942 (11.306)***	-1.0393 (8.3909)***	-0.6594 (8.2290)***
Child's Age 18-23 months	-1.6774 (17.657)***	-1.5857 (7.3377)***	-1.6786 (14.857)***	-1.5299 (20.324)***	-1.4671 (10.404)***	-1.5516 (17.342)***
Child's Age 24-29 months	-1.2682 (11.205)***	-1.0868 (4.2715)***	-1.3633 (10.133)***	-1.1426 (15.385)***	-1.0045 (7.3035)***	-1.2131 (13.839)***
Child's Age 30-35 months	-1.7329 (15.097)***	-1.5766 (6.1483)***	-1.7840 (13.135)***	-1.5965 (20.778)***	-1.5298 (10.833)***	-1.6215 (17.734)***
Child is Twin	-0.4054 (4.6179)***	-0.4580 (2.8420)***	-0.3539 (3.3159)***	-0.3520 (3.9899)***	-0.4210 (2.8624)***	-0.3244 (2.8778)***
Flush Toilet	-0.1381 (0.6340)	-0.2331 (1.0453)	NA	-0.0813 (0.3508)	-0.1558 (0.6276)	NA
Latrine	0.0020 (0.0234)	-0.0118 (0.0959)	0.0770 (0.6179)	0.0360 (0.3688)	-0.0010 (0.0068)	0.0986 (0.7443)
Piped Water	0.0484 (0.6280)	0.1712 (1.6904)*	NA	0.0679 (0.6655)	0.1962 (1.5512)	NA
Pump Water	-0.0140 (0.1974)	0.2189 (1.1199)	-0.0428 (0.5589)	0.0447 (0.5069)	0.1743 (0.8477)	0.0397 (0.4124)

(Table 4 Con't)

Test Statistic	DHS II Community Covariates Pooled	Urban	Rural	DHS II Community Fixed Effects Pooled	Urban	Rural
Center for Adult Literacy	-0.0309 (0.5903)	0.0112 (0.1166)	-0.0386 (0.5603)			
Primary School < 2km	-0.0299 (0.4136)	0.1811 (0.3124)	-0.0349 (0.4595)			
Secondary School < 2km	0.3450 (4.02)***	0.3840 (1.2586)	0.3196 (2.76)***			
Basic Health Facility < 2km	0.1528 (2.036)**	0.1517 (1.1068)	0.1203 (1.1126)			
Basic Health Facility < 15km	0.3126 (4.34)***	0.4584 (2.59)***	0.3212 (3.97)***			
Advanced Health Facility < 2km	0.0982 (1.1574)	0.1208 (0.2647)	0.1940 (1.7542)*			
Advanced Health Facility < 15km	-0.0320 (0.5257)	0.1353 (0.3045)	-0.0491 (0.7582)			
Health Agent Provides Vitamin A	0.0095 (0.1737)	-0.0402 (0.4488)	0.0167 (0.2263)			
Mom's w/ some Educ. & Health Facility < 2km	0.0248 (0.1805)	0.2804 (0.5794)	0.0849 (0.4082)			
Price of Millet (Nov. avg. by child's age)	-0.0019 (1.0082)	0.0027 (0.4842)	-0.0014 (0.6477)			
Price of Sorghum (Nov. avg. by child's age)	-0.0033 (1.6930)*	-0.0045 (0.7837)	-0.0031 (1.2728)			
Price of Maize (Nov. avg. by child's age)	0.0039 (2.135)**	0.0054 (1.1755)	0.0023 (1.0098)			
Price of Rice (Nov. avg. by child's age)	-0.0005 (0.4169)	-0.0031 (1.1298)	-0.0004 (0.3417)			
Millet Not Available in Market	0.0454 (0.2519)	1.1707 (1.6254)	0.0354 (0.1831)			
Sorghum Not Available in Market	-0.4163 (2.256)**	-0.5739 (0.7074)	-0.3928 (1.8615)*			
Maize Not Available in Market	0.2253 (1.6432)	0.3113 (0.7260)	0.1219 (0.7719)			
Rice Not Available in Market	-0.1715 (0.6649)	-0.8436 (1.3774)	-0.1809 (0.6099)			
Breush-Pagan Test $\sim X^2 (n-k\ d.f.)^{\S}$	751.7***	244.7***	525.8***	1037.7***	329.4***	714.1***
F Test Statistic	22.769***	7.358***	16.682***	4.092***	2.893***	4.508***
R-Squared	0.2039	0.2194	0.2044	0.2815	0.2954	0.2777
R-Squared Adjusted	0.1949	0.1896	0.1922	0.2127	0.1933	0.2161
Sample Size	3687	1115	2572	3687	1115	2572

[†]For all dummy variables (all variables except household size, number of women and the mother's HAZ score) a 1 indicates the presence of the dummy variable.

[‡]T statistics (H_0: $\beta_i = 0$, H_1: $\beta_i \neq 0$) are reported in parentheses.

[§]H_0: Homoscedasticity, H_1: Heteroscedasticity, and k is the number of parameters.

* denotes significance at $p < 0.10$.

** denotes significance at $p < 0.05$.

*** denotes significance at $p < 0.01$.

NA = not applicable.

Table 4a: Joint Significance of Selected Variables on HAZ Scores

	DHS II Community Covariates			**DHS II Community Fixed Effects**		
	Pooled	**Urban**	**Rural**	**Pooled**	**Urban**	**Rural**
Joint Significance of:	F(2,3645)	F(2,1073)	F(2,2532)	F(2,3364)	F(2,973)	F(2,2369)
Primary and Secondary Education	0.3969	0.1573	0.5864	0.6954	0.1218	0.5028
Flush Toilet and Latrine	0.1171	0.3353	Latrine & Pump[¥]	1.1379	1.5251	Latrine & Pump[¥]
Piped and Pump Water	0.2396	1.5766	0.3770	1.3683	3.4450**	0.2882
Primary and Secondary School < 2km	8.2788***	1.3667	4.1569**			
Basic Health < 2km and < 15 km	10.539***	2.7958*	8.5565***			
Advanced Health < 2km and < 15km	1.2280	0.0566	2.4140*			
Price of Millet & Sorghum	3.7477**	0.3643	1.0190			
Price of Millet, Sorghum, Maize and Rice - F(4,n-k)	3.2635**	4.3076***	2.9951**			

[¥]Flush toilets and piped water are not accessible in rural areas; the joint test is for latrines and pump water.
* denotes significance at $p < 0.10$.
** denotes significance at $p < 0.05$.
*** denotes significance at $p < 0.01$.

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