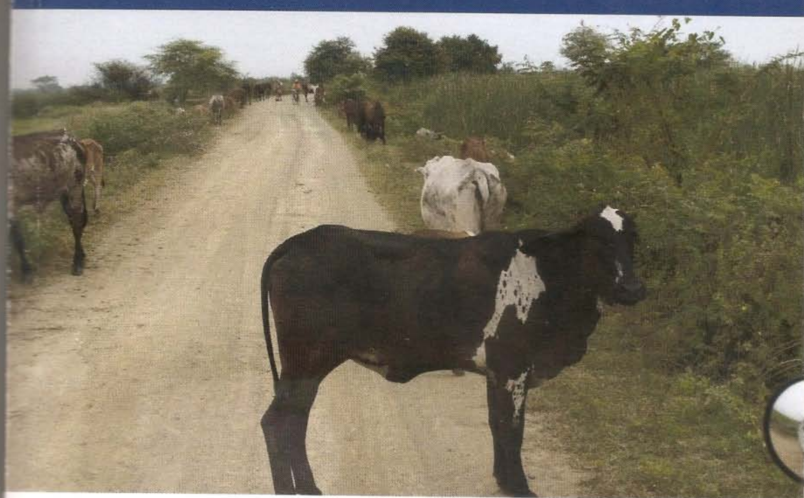

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Crossbred Cows and Food Security

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CHAPTER 1
INTRODUCTION

This chapter introduces the food insecurity problem in developing countries. The purpose of the research is to investigate the food security and marketable surplus effects of intensified dairying. A case is made for the role of livestock; particularly market-oriented dairying, in food security. Furthermore, the research attempts to identify policy options that enhance the benefits of the new agricultural technologies available for the central highlands of Ethiopia. The objectives of the study and the hypotheses to be tested are outlined. The organization of the book concludes the chapter.

Background and Justification

Twenty percent of people in developing countries, an estimated 840 million people, have inadequate access to food (FAO, 1996). These people consume fewer than 2,700 calories per person per day, live in permanent or intermittent hunger and are chronically undernourished. Energy requirements vary by region; people in cold climates need more calories to keep warm. There are also differences in individual needs. Children need less food than adults. Heavy manual labor requires about 4,000 calories a day (FAO, 1973). An estimated average of 2,700 calories per day is enough to prevent hunger and to enable everyone to lead active and healthy lives (Conway, 1997).There is also sufficient food in the world today for each woman, man and child to obtain a daily average of over 2,700 calories of energy (Alexandratos, 1995). The poor, however, do not have sufficient resources to produce, or the income to acquire adequate quantities and qualities of food to satisfy their needs.

The world’s population is projected to increase to 7.2 billion in 2010 from 5.4 billion in 1990. The increase will mostly take place in developing countries and will have impacts on food production, marketing and consumption (Sansoucy et al., 1995). Strategies are needed to guarantee food security for the increasing population.

Between 1960 and 1990, the Green Revolution, characterized by seed-fertilizer innovations in cereal production, dramatically increased wheat, rice and maize output in developing countries, making more food available and increasing farm incomes. Per capita food grain production in developing countries during this period increased from 190 to 260 kg (Pinstrup-Andersen, 1994). World output of food per head has grown by approximately 25%, despite increases in world population by 90% and land use by only 10%. Food prices in real terms have also declined by 40% (Feki, 2000). During part of this period between 1971 and 1995, there was also a dramatic, but often overlooked, increase in the consumption of foods of animal-origin in developing countries. In terms of quantity, the additional meat, milk and fish consumed in developing countries during this period was two-thirds more than the consumption of wheat, rice, and maize combined. Though the Green Revolution provided more calories than the coinciding increase in meat consumption, the additional meat consumed was worth more than three times the increase in cereal consumption at constant world prices (Delgado et al., 1999).

Despite the increase in cereal production following the Green Revolution, 25 developing countries were unable to assure minimally adequate food energy needs of 2,200 calories per person per day for their populations in the late 1980s (Pinstrup-Anderson, 1994). Today poverty and chronic malnutrition remain common problems for hundreds of millions of people in developing countries. If food consumption patterns in the developed countries indicate the trend for developing countries, as Delgado et al. (1999) suggest, future growth in consumption of cereals as food is likely to be much less than foods from animal origin. They further add that in developing countries, people will soon reach satiation in their consumption of cereals, while foods from animal origin will continue to grow robustly in the 21^{st} century. The scope for further increases in demand for livestock products is large in developing countries, given projected increases in incomes, population and urbanization growth rates and the relatively high-income elasticity of demand for livestock products (Ehui et al., 1998).

Livestock provides a significant component of the agricultural economies of pastoral and livestock-based societies in developing countries. Livestock ownership helps sustain farming and economic stability. Livestock production and sales of live animals and animal products constitute important sources of income, employment and food supply. It is a major form of investment for many farmers. Livestock ownership also significantly impacts on-farm productivity, through provision of draft power and manure for fertilizer in crop production. Livestock is also important in the social and cultural lives of millions of small-scale farmers as a symbol of wealth and for use in many ceremonies. Nevertheless, the importance of livestock to the livelihoods of millions of small-scale farmers and the contribution of farm animals to food security is often underestimated (Sansoucy et al., 1995).

The combination of higher demands for livestock and livestock products, more people and less space is resulting in the transformation of the livestock sector in many developing countries. A strategy being advocated to support smallholder dairying is the intensification of dairy production in mixed farming systems (FAO/ILRI, 1995; Winrock International, 1992; Walshe et al., 1991). Traditional resource-based animal production systems in which remote pastures, grasses indigestible by human and backyard refuse are converted into high value animal products are being substituted by input intensive, science-based animal production systems. These systems have the potential to raise growth rates of output and cash incomes, improve food security, and reduce environmental degradation.

One such system, market-oriented dairy production (MODP) technologies involving introduction of crossbred cows and utilization of complementary feed and management technologies for increased dairy production, is being used in many countries, particularly in peri-urban areas. In this system, increased milk produced is treated as a “cash crop” as milk sales generate regular cash income. Market-oriented dairying has many food security-related benefits for peri-urban smallholder communities. For producers these include increased food availability, regular cash income and creation of employment; and for consumers an increased high quality food supply and more employment opportunities. Food security impacts from use of MODP technologies could be realized directly through higher consumption of dairy products or indirectly through the use of increased cash incomes to purchase more or better quality foods or both.

Dairy production is a critical issue in Ethiopia, a livestock based society, where livestock and its products are important sources of food and income, and dairying has not been fully exploited and promoted. The greatest potential for new technologies in dairying is expected in the Highlands of Ethiopia and other sub-Saharan and Asian countries due to low disease pressure and good agro-climatic conditions for the cultivation of feed. High population densities and animal stocking rates as well as easy access to markets make it attractive to invest in MODP technologies in peri-urban areas in these regions.

Ethiopia has experienced compounding effects of civil strife, drought and famine, during the past thirty years. Poverty and malnutrition are obvious in the rural areas of the country, where paradoxically most of the population is engaged in small-scale subsistence oriented farming. This is also the case for the Ethiopian Highlands, a region well known for its outstanding biophysical farming potential. It has been speculated that Ethiopia could theoretically support two to four harvests a year and turn it into the granary of East Africa and the Near East (Steglich, 1998). Yet, agricultural productivity remains low. In addition, population growth and soil degradation have increased pressure on scarce land resources. The rural population of Ethiopia suffers from severe chronic malnutrition with high prevalence even in food surplus regions (Central Statistical Authority, 1992). The number of malnourished in Ethiopia is among the highest in the world. They often lack sufficient amounts of protein and energy in their diets, as well as micronutrients such as iodine and vitamins (UNICEF, 1993). The Ethiopian government and international agencies are most concerned about the food shortages and the high levels of malnutrition.

Problem Statement

Market-oriented dairy production has been shown to substantially raise milk production and household incomes where development efforts are market-oriented and demand driven (Baltenweck et al., 1998; Shapiro et al., 1998; Pankhurst, 1996; Thomas-Slayter and Bhatt, 1994; Walshe et al., 1991). It has been shown that if more dairy products were available and consumed there will be positive effects on human nutrition (Neumann et al., 1993). However, the food security effects of increased milk production and incomes on the active household may also depend on intra-household resource allocation, income distribution, and the expenditures made with the increased income. While smallholder intensified dairying may have positive impacts on milk production and cash incomes, questions remain about the extent to which increased cash flow is spent on more and better quality food, and seasonal[1] food consumption smoothed as a consequence.

MODP technologies also have supply-side effects, e.g., the potential to increase whole farm productivity through use of manure as fertilizer, use of animals for traction and use of increased cash flow to purchase more feed and crop inputs. The whole farm productivity effect of MODP technologies has not been evaluated, though important for the complete assessment of the effect of the new agricultural technology. This study analyzes whole farm productivity effects of intensified dairying in Ethiopia through the appraisal of marketed surplus changes.

Most studies evaluating the impact of new technologies and commercialization of small-scale farming on food and nutrition security, combine data across agricultural production stages (harvesting and pre-harvesting) to estimate food consumption–income and calorie-income elasticities. Berhman et al. (1997) point out, that such studies may result in false estimates for any particular production stage and obscure the possibility that measures directed at certain agricultural stages might be much more effective at reducing calorie deficiencies than those directed at other stages of the production cycle. The seasonal variation in calorie intake effect of MODP technologies is unknown. As a result, policy-makers do not know where and when the food security effects of dairy production growth opportunities are the greatest, and what policies are most critical to their realization. This research addresses the food security (via food consumption and calorie intake) and marketable surplus effects of the new technology, and identifies policy options that enhance positive effects.

Research Objectives

The overall objective of this study is to evaluate the effects of MODP technologies on smallholder farm households and to identify policy options that would enhance beneficial impacts and mitigate harmful outcomes of the new technologies. Specific objectives are to

i) Measure the food security effects resulting from the introduction of crossbred cow

[1] The word season is often used to refer to a complete crop cycle. It is also used to refer to stages of production within a crop cycle, such as the harvesting and planting periods. Season is used here to refer to the different stages of production – planting (the entire pre-harvest period) and harvesting.

technology.

ii) Assess the effect of market oriented dairy production on incomes handled by women and its consequence on them and food consumption.

iii) Evaluate the agricultural market surplus effects of intensified dairying.

Hypotheses

- Market-oriented dairy production may contribute to food security directly through increased livestock, dairy products and crop production that adds to household food intake and indirectly through increased cash income, from the sale of surplus dairy products, and employment generation that enable purchases of more and better quality foods.
- MODP, a commercial activity, may result in the transfer of dairy incomes, traditionally obtained by women from marketing of home produced butter and cheese to men. This may have adverse effects on women and on household's food consumption, because purchasing of food is a woman's responsibility.
- Introduction of MODP increases income through the sale of increased dairy outputs. When this additional income is used to purchase crops and livestock inputs, production of agricultural products may increase, with the consequence of raising food marketed surpluses.

These hypotheses are tested with data from the Ethiopian Highlands where research is being conducted to assess the biological performance of crossbred cows in farm conditions and its effects on human welfare.

Book Outline

The remainder of the book is organized as follows. In Chapter 2, a brief description is given of the economy and government of Ethiopia. This chapter also introduces the study site, the dairy sector of the Addis Ababa milk shed as well as the Dairy Development project in Holetta, the location of the present study. Chapter 3 discusses the concept and scope of food security. It reviews literature on the effect of livestock production, technological change and commercialization of semi-subsistence agriculture on food security. The latter part of the chapter discusses the potential contribution of market-oriented smallholder dairy production on food security. The conceptual, analytical and theoretical frameworks are presented in Chapter 4. Chapter 5 discusses the empirical framework; empirical models and hypotheses, econometric problems and estimation techniques applied in the study, as well as methods used in data collection and measurements of some variables. The later section of chapter 5 gives the descriptive statistics of the variable used in the empirical analysis. Econometric results and interpretation are presented in chapter 6. Conclusions are drawn in chapter 7 about the food security and marketable surplus effects of intensified dairying in the study area. This chapter also highlights the contribution of the study, considers policy implications, and suggests areas for future research in the mixed crop-livestock highland farming system.

CHAPTER 2

ETHIOPIA AND THE STUDY AREA

This chapter presents a brief overview of the biophysical characteristics, economy, agricultural production, and recent political changes in Ethiopia. Detailed information is given about the environment in which intensified dairying technologies are being introduced to address the current food insecurity problems of Ethiopia and the dairy development project.

Background

Ethiopia is a landlocked country that lies in the north eastern corner of the “horn” of Africa. It shares borders with Kenya in the South, Eritrea in the North, Somalia and Djibouti in the East and Sudan in the West (Appendix A). The area of Ethiopia is 1.104 million km^2; the 1998 estimate of the population was 80.7 million (World Bank, 2010). Ethiopia and Egypt are the second most populated countries in Africa after Nigeria. The average population growth rate in 2008 has been calculated at 2.6% per annum (World Bank, 2010).

Ethiopia has a wide variety of ethnic groups, languages, cultures and religions. The Oromos, a pastoral and agricultural people who live mainly in central and south western Ethiopia, form the largest tribe, with 40% of the population. The Amhara, the founders of the original nation, account for 30% of the population and are culturally the most dominant group. The Tigrayans are the third largest group comprising about 15% of the population. The Amhara and Tigrayans are related, both are highland peoples of partly Semitic origin (Gryseels, 1988). They occupy the northwestern Ethiopian highlands and the area north of Addis Ababa. The Shangalla, who live in the western part of the country, constitute 6% of the population. The Somali, a people in the east and southeast, are approximately equal in number to the Shangalla. The Denakil inhabitants of the semi-desert plains east of the highlands and non-indigenous population make up an additional 6% of the population (Keller, 1998).

More than 70 languages are spoken in Ethiopia, and most Ethiopians belong to the

Semitic and Cushitic branches of the Afro-Asiatic family. The Ethiopian church liturgy language, Geez, gave rise to the Semitic cluster of languages, such as Amharic, Tigrinya, and Tigre (Keller, 1998). Amharic is the official language of Ethiopia, spoken by more than half of the population. Orominia and Tigriniya are regional languages. Many people also speak English and Arabic.

The Ethiopian Orthodox Union Church, an autonomous Christian sect led by the patriarch and closely related to the Coptic Church of Egypt, was until 1974 the state church of Ethiopia. About 40% of the population is Orthodox Christian; Christianity exists mainly in the north. Muslims, who represent 45% of the country's population, dominate the southern region. The south also has a number of animists (Keller, 1998). All Ethiopians share a history marked by years of turmoil resulting from internal strife, claims of territorial sovereignty by Eritrea, disputes over land with Somalia, repeated drought and economic crises.

Ethiopia uses the Julian calendar, rather than the Gregorian calendar that is commonly used throughout the Western world and in the other SSA countries. According to the Julian calendar, the year is divided into 12 months of 30 days each and a 13^{th} month of five days in a normal year and six days in a leap year. The Ethiopian calendar is seven years and eight months behind the Gregorian calendar. Unless otherwise stated, the dates referred to in this study are based on the Gregorian calendar.

Ethiopia is administratively divided into 11 regions. Each region is divided into zones. The zones are further divided into districts (*Weradas*) and districts into peasant associations (PA) in the rural areas and *Kebeles* in the urban areas. Ethiopia has 69 zones and 616 *Weradas* (Central Statistical Authority, 1995). Nearly 17% of the population lives in urban areas and 83% in rural areas (World Bank, 1999).

Ethiopia is one of the poorest countries in the world and the least developed, with a per capita annual income of US $124 in 2007 (FAO, 2008). Life expectancy at birth in 2008 was 55.41 years (World Bank, 2010), compared to an average of 51.61 years for both men and women in 2000 (World Bank, 2010). Infant mortality per 1000 live births (aged under one) fell from 150 in 2000 to 119 in 2007 (World Bank, 2010). Prevalence of child malnutrition decreased by 13%, from 48% in 1997 to 35% in 2007 (World Bank, 2007 and 1999). Forty two per cent of the population had access to safe water in 2007, an increase of 16% from 1995 (World Bank, 1999 and 2007). Forty six per cent of the Ethiopian population was undernourished in 2002 (FAO, 2008). The average per capita calorie supply was 1,857.3 in 2002 (FAO, 2004). Ethiopia in recent years has been known for its widespread famine and starvation.

Biophysical Features

Ethiopia has a complex topography ranging in altitude from 500 m a.s.l. in the Danakil depression, to 4000 m a.s.l. in the Simien mountains. Its geographical diversity includes high rugged mountains, flat-topped plateaux, deep gorges, incised rivers, valleys, and rolling plains. Its main relief feature is the high central plateau, which covers more than half the total area of the country and averages 2,200 m a.s.l. Desert area makes up approximately one-third of the total area surrounding the highlands. These plains are mostly occupied by the pastoral nomads, a people that derive most of their income or subsistence from keeping domestic livestock that are fed on natural forage, rather than cultivated fodder and pastures (Stanford, 1983, in Gryseels, 1988). The Rift Valley, part of the Great Rift Valley system that extends from Syria to Mozambique, and its string of lakes divide the country from northeast to southwest. There are extensive lowland plains in the east and southeast of the highlands, with varying altitude below 1000 m a.s.l.

Ethiopia’s altitudinal range creates continental cold, temperate, sub-tropical, and tropical climates. This offers a variety of natural vegetation. The savannah and the grassland dominate the highland vegetation. Montane tropical vegetation is found in the western parts of the country, tropical forest in some parts of the South and deciduous forest in sections of the West. Tropical bush thorn dominates the east and southeast steppe and desert (FAO, 1986a). The rugged and mountainous terrain of the highlands is one of the limiting factors of economic development. Most of the rural poor live more than a day's return walk from an all-weather road (Stommes and Sisaye, 1979).

The Ethiopian Economy

The following statement has described the Ethiopian economy:

“Ethiopian economy suffers from lack of technological know-how, absence of developed infrastructure facilities, a small industrial base, shortages of skilled manpower, rapid population growth, soil erosion, recurrent drought and famine, a shortage of foreign exchange, and misguided policies of former government. The agricultural sector, which is the mainstay, has suffered the most". (UNICEF, 1993, pg. 11).

Agriculture is the dominant sector of the Ethiopian Economy. It accounts for 45% of the GDP and 85% of the employment. Agricultural products contribute over 60% of the total exports. The major source of foreign exchange is coffee, providing 35% of the Ethiopian foreign exchange earning (FCO, 2008). Other agricultural export products are oilseeds, pulses, cotton, sugarcane, fruits, flowers, hides and skin and livestock, mainly sheep and cattle. Natural resources like gold, platinum, copper, potash and petroleum exist, but exploitation of these minerals has not been done on a large scale (Gryseels, 1988).

Ethiopia has the largest livestock herd in Africa and accounts for 17% of cattle, 20% of sheep, 13% of goats and 55% of equines in SSA (FAO, 1993). Livestock contributes 16% of the GDP and 30% of the agricultural GDP (FAO, 1996a). Seventy percent of cattle, 75% of sheep, 27% of goats and 80% of equines are found in the highlands (Gryseels, 1988).

The agricultural system is divided into smallholder mixed farming in the highlands and pastoralism in the lowlands. The highlands cover only 40% of the total land area, but contain 88% of the human population, and account for 94% of the regularly cultivated cropland, 70% of the livestock and 90% of the country's economic activities (Gryseels, 1988). The highlands are favoured by good soil and suitable climatic conditions for farming. Its climate is temperate, rainfall well distributed, and disease incidence low, thus supporting higher productivity and population densities compared to the lowland areas. The highlands thus provide suitable conditions for the introduction of high yielding plant varieties and exotic animal breeds, allowing for intensification of agricultural production (Zanish and Bediye, 1991, p 129). Despite this potential, the agricultural sector's performance has been disappointing in recent years. The average growth rate in agriculture between 1980 and 1991 was 2% which is significantly lower than the rate of growth of population (Degafe and Nega, 1999/2000).

The physical resources of the highlands are at risk. For example, land degradation has been rapid. In 1986, FAO reported over 200 million tonnes of soil was being lost annually and threatened the sustainability of the farming system. The productivity of the livestock sector was being affected. Its productivity was lower than the African average: live weight gains are low, at about 20kg annually, and mortality high, 20% (FAO, 1993).

The high human population growth rate of 2.6% annually, plus the high rural to urban migration, is expected to alter food production, marketing and consumption. Population pressures on fixed agricultural land will drive crop and livestock production towards intensification. Growth of population and urbanization will increase the demand for foods because urban dwellers produce little of their own food. Therefore as more people live in the urban areas, the demand for food will create markets for produce and encourage commercialization of agriculture. As farming moves from subsistence towards commercialisation, greater specialization in production, transportation and marketing will occur, making the process more efficient. The challenge is to achieve food security for the prospective population. There is scope for intensification of agriculture and more productive use of resources through the introduction of improved technology supported by more favourable policies and better infrastructure (Winrock International, 1992). An example of such an innovation is market-orientation of smallholder dairy production.

Recent Political Changes in Ethiopia

Ethiopia was ruled by successive monarchies until 1974. A feudal land tenure system and ownership of significant portions of rural wealth, mainly land, by the state and large landlords characterised Emperor Haile Selassie, led imperial Ethiopia. Land was rented out or contracted to small-scale farmers. The land tenure system dominated by absentee landlords and the resulting land insecurity, and a feudal system resistant to change and innovation were the most frequently cited problems that contributed to agricultural underdevelopment during the imperial era (Alemneh 1987; Darnhofer, 1997).

The imperial regime was replaced by a socialist regime commonly referred to as the *Derg*, which ruled from 1974 to 1991. The *Derg* transformed the institutional and social basis for agriculture. The Land Proclamation Act of 1975 abolished tenancy relationships and private land ownership. All rural land was declared the collective property of the Ethiopian people (Darnhofer, 1997). Transfer of land by sale, lease, mortgage, and inheritance or by any other means was forbidden (Dessalegn, 1984). To implement the new laws, the Peasant Associations (PA) were created; each PA was made up of about 150 to 400 families. Their responsibilities were to distribute land equally, establish marketing and credit co-operatives, encourage resettlement through a program known as *villagization*, and move toward a socialist form of government (Darnhofer, 1997; Alemneh, 1987). The *Derg* promoted co-operative modes of production on a voluntary basis (Gryseels, 1988; Darnhofer, 1997).

The villagization program began in 1984. Farmers were encouraged to leave their individual homestead, often located at the top of scattered, isolated hills, and to build new homes at a centrally located place in each village. The aim of the programme was to facilitate the provision of social services, such as health centres, education and schools, clean water, extension services, better housing and markets, etc., to enhance the livelihoods of the rural population (Darnhofer, 1997). Critics pointed out the negative experiences of a similar program carried out in Tanzania. These include difficulties of crop protection due to long distances between villages and fields, dangers of overgrazing and infectious diseases around the village, the large financial expense by both the farmers and the government, and disruptions in agricultural production as farmers had to rebuild housing during the ploughing or harvesting period (Gryseels, 1988). By 1986, 14% (6 million people) of the total population was resettled in Ethiopia (Getachew, 1989).

Price regulation was another change implemented by the *Derg* regime. Grain prices were controlled by announcing maximum price limits at which producers and retailers could sell grain. Following the negligible effect of this policy, the *Derg* moved towards controlling supply through the establishment of the Agricultural Marketing Corporation (AMC). Farmers and merchants were obliged to sell particular grain quotas to the AMC at below free market prices (Gryseels, 1988). The official prices under-valued smallholders' labour. The price control was seen as a means of surplus extraction (Ghose, 1985). The *Derg* also instituted legal controls on domestic grain trade preventing movements of grains from surplus to deficit areas (Griffin and Hay, 1985). A suggested motive for fixing prices was to keep grain prices low in the urban areas (Getachew, 1989). Controlling trade prices and domestic grain trade policies discouraged farmers from producing above subsistence requirements (Darnhofer, 1997).

Alongside traditional small-scale farms, the *Derg* introduced producer cooperative and large–scale state farms to meet the food demands of the country through mechanisation and acreage expansion (Darnhofer, 1997). Representing the socialist mode of production, the co-operative and state farms were given more attention and encouragement. For example, state farms were allocated 76% of the fertiliser and 94% of the seeds, though their crop output was about 5% of the total production (Getachew, 1989).

The *Derg* reforms did not significantly change the wealth and incomes of the majority of the small-scale farmers. Its main achievement was in guaranteeing access to land by each farmer (Dessalegn, 1984). Although land was accessible, the price control and quota policies did not encourage sustainable agricultural production. As a result, small-scale farmers concentrated in satisfying subsistence, rather than engaging in exchange processes (Dessalegn, 1984). Lack of secure land tenure remains a major issue for farmers even today and may have negative effects on resource conservation and farmers' decisions to make investments towards improving agricultural production.

Popular support for the *Derg* regime decreased as a result of economic and political disasters, which included the unpopular resettlement program, a drought in 1984/85, and the famine in 1989/90. The real GDP growth for the last 10 years of the *Derg* period was 1.9% per year compared with an average population growth rate of 3%, leading to a net decline in per capita income of 1.1% per year (Degafe and Nega, 2000).

The Ethiopian People's Revolutionary Democratic Front (EPRDF) overthrew the *Derg* in May 1991and a Transitional Government took control of the country (Darnhofer, 1997). The authority of the new government was legitimised via the elections of May 1995.

The policies of the new government aim at transforming the economy from a centrally planned regime to an open economy. This requires trade and financial sector liberalisation, privatisation, and improvement of the investment environment to support the development of a private sector. The development strategy is "agricultural development led industrialisation", giving the agricultural sector the main role and focusing on small farms perceived as the most responsive to reform (Transitional Government of Ethiopia, 1994). The achievements of the new government have so far been the abolition of the co-operative farms, the return of many farmers to their homes outside the villages, and the ability of farmers to sell their products in the open market (Darnhofer, 1997).

The Study Site

This study was conducted in the Wolmera and Ejere *woredas*, in the central highlands. It covers Sademo, Wolmera Goro, Marcos and Dobbie Peasant Associations (PA) in Ejere *woreda*; and Rob Gegbya, Chirrie, Jerba Sefer and Sorroro Peasant Associations in Wolmera *woreda.* These PAs are situated within a 5-15 kms radius of the Holetta town, which is 40 km west of Addis Ababa. The area is positioned along a good tarmac road (the Addis Ababa – Ambo road), providing access to weekly markets in Holetta (capital of Wolmera) and Menagesha (one of the three towns in the district besides Holetta and Burayu). A larger research station of the Ethiopian Agricultural Research Organization (EARO) is located outside Holetta. The elevation of the Research Station is 2400 m a.s.l. in a high-potential, cereal/livestock zone in the Central Highlands of Ethiopia. About 90.3% of the soil in the district is chromic and orthic luvisol, with high water holding capacity and good agricultural potential. The remaining 9.7% of the soil is chromic and orthic vertisol; it is poorly drained and has limited agricultural potential (Bureau of Planning and Economic Development, 1998). The soils are heavy and sticky when wet and hard when dry. Sufficient power is needed to till the soil, thus the prevailing use of animal traction. Water logging in depression and soil erosion on slopes are serious problems inhibiting crop growth.

Holetta receives an average annual rainfall of 1100 mm (Hailu et al., 1990). The rainfall is bimodal. Short rains, *berg*, occur from February to May, and long rains, *meher*, last from June to September. The short rains are mainly used to break and prepare the soils for crop cultivation. The pattern of rainfall dictates the single cropping period starting in March and ending in December. The mean maximum and minimum temperatures are 22.5^{o}C and 6.3^{o}C respectively (Bureau of Planning and Economic Development, 1998), and average temperatures range between 11.6 and 15.3^{0}C (Buta, 1997).

Orthodox Christians dominate the Wolmera and Ejere *woredas*. Religious holidays including Sundays are strictly recognized. This limits the fieldwork of the farmers, who observe about 144 religious days each year. The religious restrictions normally relate to cropping activities that involve breaking of the soil, such as plowing, weeding and harvesting. Threshing is also not allowed during the religious holidays. The average working days in crop production related working days, including hay making, are 222 in any crop year. Of these days, about 74 days are in the rainy period between June and September and the remaining 148 are in the dry and short rainy seasons of the year. Apart from small children, consumption of animal protein is forbidden during 55 days of fasting between February and April, 15 days in August, in addition to Wednesdays and Fridays. Most of the milk during this period is processed into cheese and butter.

The farming system in the study area can be referred to as a smallholder traditional crop-livestock farming system. It is oriented toward providing subsistence requirements for the farm household. The family is a production and consumption unit. Although about 80% of all crops produced on the farm are consumed at home (Getachew and Shapiro, 1993), the market plays a significant role in the rural areas. It gives farmers the opportunities to sell agricultural surpluses and to buy products that are not produced on-farm. It is also a meeting place for relatives and friends and for the exchange of information (Dessalegn, 1991).

Mixed crop-livestock smallholder farming is the dominant mode of production in the area. In 1996, 41% of the total land in the Welmera district was cultivated and 19% was used for grazing (Bureau of Planning and Economic Development, 1998). Farmers produce a mixture of cereals, pulses and oil crops. Teff, barley and wheat are the common cereals grown. Maize, oats and sorghum are grown in smaller quantities. Legumes grown include horse beans, field peas, lentils, rough peas, chickpeas and vetch. Oil crops such as noug, linseed and rapeseed is grown in small quantities in the cultivated areas. Vegetables such as onions, potatoes, cabbage, carrots, garlic, and false banana, *enset*, are grown on smaller scales, generally in backyard gardens.

The fertility of the soil is poor, except for *kossi* land[2]. Most of the cultivated land has been ploughed continuously for a long period because of high population pressure. This has contributed to the poor fertility of the soil. The problem is compounded by limited use of fertilizer and manure, and reduction in the frequency and length of fallow

[2] This is land around the homestead, where organic waste is deposited.

periods. As a consequence of wood scarcity, dung is normally used as fuel for cooking rather than manure. Farmers practice crop rotation and use inorganic fertilizer as means of maintaining soil fertility. The Ministry of Agriculture supplies limited quantities of fertilizer (DAP and urea), along with improved seeds, herbicides and pesticides on a credit basis.

Cattle, sheep, equine and poultry, are important components of the farming system. Oxen plough all the cropped land. Cattle are mainly kept to supply and replace draft oxen. Livestock dung is used as fuel and building material. Meat, milk, hides and skins are also important sources of food and income for farm households. Livestock also provide security during periods of crop failure when they are sold to purchase grain. Cattle are the most important species in terms of monetary value and contribution to the farming system. Mutton is the main source of meat in the farmer's diet and sheep are a major form of investment. Donkeys are the prime transporters of agricultural products, while horses and mules are used for human transport.

Gender division of labor is fairly distinct in the study area. Unlike in western and southern Africa, women in Ethiopia do not play a dominant role in crop production. Men do more than 75% of the crop production activities. Ploughing, seeding, seed covering and herbicide application are exclusively done by men. Women and children help in weeding, harvesting, and transport of pulses. Women are also responsible for preparing threshing grounds and for constructing containers for storing crops, *gotera*. They also assist in threshing and winnowing, and are active in the marketing of grains, vegetables and pulses. Appendix B shows the farming activities schedule of the study area. Revenues are used to purchase needed household items. Women cultivate backyard vegetable gardens.

Men, women and children also contribute significantly to livestock rearing. Men participate in herding of animals, barn cleaning and sometimes in milking. Milking and processing of milk are primarily women's responsibilities. In households with local cows, men do not sell milk, women do. Women also collect, make, dry and sell dung cakes. Herding is mostly the task of children between the ages of 10 and 16 years. Children also assist in milking, barn cleaning, and in the collection and making of dung cakes. In addition to agricultural tasks, women perform domestic chores, such as preparing and processing of food, fetching of water, collection of wood for fuel, cleaning, washing, and caring for children, the sick and the elderly. Women plaster walls and floors and also raise extra cash by brewing local beer, *tella,* and local whisky, *katicalla.*

Although livestock plays an important part in the traditional farming system, its productivity is low. Native cows first calf at an average age of over 4 years and at an interval of 20 months (Darnhofer, 1997). Some of the main problems farmers face in raising animals are shortage of grazing land, limited veterinary services and a general shortage and high cost of feed and exotic breeds. The primary sources of animal feed are grazing and crop by-products. In addition, cattle are given minerals (ordinary salt) and sometimes by-products from the production of *tella* made from barley. Hay is also used, but because its harvest coincides with the harvesting of the *meher* crops, labor shortage is a problem, leading to poor quality hay. Animals are fed differently on the farm. The hay and straw are normally saved for working animals, such as oxen used for ploughing or threshing, or lactating cows. Small ruminants and equines are fed via grazing (Darnhofer, 1997).

Dairy Sector in the Addis Ababa Milk Shed

Milk, *kebe* (butter) and *ayib* (fresh cheese) are dairy products traditionally produced, consumed and traded throughout the highlands of Ethiopia. This section however, focuses on the fresh milk market of the Addis Ababa milk shed. In this area both private and state farms supply milk. The Addis Ababa milk shed includes areas located within a radius of about 120 km from the main roads radiating from Addis Ababa. Small private producers supply 95% of all milk produced in the milk shed in addition to their subsistence consumption. Seventy-three per cent of the private milk producers are small-scale urban and peri-urban farmers (Staal and Shapiro, 1996).

Fresh milk sales occur through formal and informal channels. The Dairy Development Enterprise (DDE), a government parastatal is the only formal outlet for liquid milk and sells about 12% of wholesale-marketed milk in the milk shed. It is the only organised large-scale milk collector, processor and distributor in the country. The DDE has a processing plant at Shola on the outskirts of Addis Ababa, with milk collection centres established along roads leading out of the city. Milk is collected from producers located within a radius of 120 km from the plant (Darnhofer, 1997). The collection centres are simple kiosks spaced along the road, where milk is weighed and tested for contaminants. Each household's record of milk supply is kept, normally under the name of the household head and payments made to them at the end of the month. In the urban areas, collection of the fresh milk occurs at the DDE plant. The plant pasteurizes fresh milk, processes part of it into butter and cheese and also reconstitutes liquid milk from imported powdered milk and butter oil.

The majority of the milk marketed by producers, approximately 88% of production in the Addis Ababa milk shed is sold via informal channels, unregulated by authorities (Staal, 1995). This is done to obtain higher milk prices, and to avoid taxation and quality controls. Sales here include direct sales by producers to individuals, hotels and catering institutions, private raw milk traders, retail outlets, and informal dairy processors. Direct sale by farmers to individuals is the most common way of selling milk, constituting 44.1% of total milk marketed in the milk shed (Staal, 1995). The sales entail contractual arrangements whereby farmers agree to supply particular quantities of milk over specified periods of time. The milk is either collected by the consumer, or supplied by the producer. Direct sale of milk to institutions such as hotels, restaurants and offices make up 26.9% of total milk marketed. These two types of direct sales largely define the dairy market, representing 71% of total milk marketed in the Addis Ababa milk shed (Staal and Shapiro, 1996).

Rural producers located further away from the towns and closer to DDE collection centres sell their milk to the DDE. This accounts for 20% of the milk produced. The DDE price for milk is lower, 1.25 Birr/litre, than the average milk price of 1.5 Birr/litre in the informal markets. Farmers depend on the reliable delivery to DDE collection centres. This lowers transaction cost, particularly during the fasting period and the two fasting days (Wednesdays and Fridays) of each week, when meat and dairy products are not consumed, hence creating an unstable demand for milk. Dairy producers far away from the towns and collection centres process the milk and sell it as cheese and butter. This permits excess production to be conserved and marketed economically.

Dairy Development Project in Holetta

The Holetta Dairy Development Project was part of the overall Dairy Development Program aimed at developing technologies to enable small-holder mixed crop-livestock farmers, in the Ethiopian Highlands, to participate in commercial agricultural activities that can have a significant impact on sustainable food production, food security, farmer incomes, and human nutrition through substantially increased milk production. The project is based on the use of crossbred cows for dairy and possibly draft power. Crossbred dairy cows were introduced along with improved animal husbandry and intensified feed production technologies as means of increasing milk production and incomes.

The conditions in the Ethiopian Highlands are well suited to dairy animal management because of the favorable climate, controllable pest and disease situation and high production potential for integrated agriculture. Dairy cow management was selected as the development strategy because farming families cannot increase their incomes via expansion in crop production or improving forestry because of the dwindling land holdings.

On-station research was conducted during 1989 to 1993 to determine if there was a trade-off between traction and milk production and to develop strategies for feeding crossbred cows for both milk production and traction in order to increase their overall efficiency. The research results indicated that with appropriate feeding regimes, dairy cows could be used for draft purposes without significant detrimental effects on lactation or reproduction, but the calving interval would be extended. High productivity indices for well-fed working crossbred cows indicated that the technology has the potential to reduce stocking rates, particularly reduce the need for draft oxen, increase efficient use of on-farm resources, as well as raise farm productivity (Zerbini et al., 1996).

In 1993, EARO and ILRI initiated on-farm testing of the technology in villages around EARO's Holetta research station in a joint effort with 14 farmers, half using crossbred cows for milk production only and the other half using crossbred cows for both traction and milk production. The purpose was to establish whether and how crossbred cows requiring new feed production and feeding strategies could be managed for dual purposes under real farm conditions. Another objective was to evaluate the economic performances (investment returns) of crossbred dairy cows on smallholder farms and their impact on total household resource use, including labor.

Implementation of the on-farm trials involved the following major activities, described by Larsen (1997) and divided into six packages, mostly carried out in close collaboration with extension personnel and veterinarians from the Zonal and Wereda offices of the Ministry of Agriculture (MoA):

(i) *Improved genotype*: A pair of F_1 crossbred cows (Holstein-Friesian x Boran or Simmental x Boran) with large body frames and a higher production potential than the local cows was provided to the project farmers on cash and credit at subsidized prices.

(ii) *Forage Package*: Farmers were advised to plant a minimum of half a hectare of oats and vetch for hay production each year. In addition, a backyard forage package was developed recommending that farmers plant Napier grass, fodder (Tagasate and Sesbania) and fodder beets on their compounds.

(iii) *Health Package:* The project provided drugs and veterinary services, at subsidized prices. The health scheme consisted of regular administration of vaccination, de-worming and spraying procedures as well as routine visits to all project farmers. Farmers were advised to use improved practices. Emphasis was on advising farmers to improve hygiene procedures and practice restricted grazing.

(iv) *Breeding Package:* The scheme consisted of heat detection, timely insemination, pregnancy testing and control of reproductive diseases. All project cows were served with 50% Friesian x Boran or Simmental x Boran semen through artificial insemination. The offspring were served either with crossbred bulls (50%) or with local bulls. The aim is to maintain a population close to 50% exotic blood on farm.

(v) *Improved Management of Crossbred Animals, Milk and Dairy Products:* This package involved training at the Holetta Research Station on the following aspects: stall feeding, calf rearing, crossbred cow management, milking, milk handling, processing and marketing of dairy products, cow traction, manure handling and construction of improved barns.

(vi) *Training Package:* The aim of this package was to increase farmers' awareness of the advantages and constraints of the new technologies. A secondary objective was to obtain a direct feedback from farmers on the use of the new technology; i.e. farmers were to cooperate with the enumerators in their daily recording of data for the duration of the project.

In 1994, intensive biological and socio-economic data were collected. Whole farm analysis, based on the concept of the farm as a system, indicated that it was feasible and profitable to use crossbred cows for both milk production and traction (Buta, 1997). The analysis showed gender division of labor for various farming activities as traditionally practiced and also revealed that total household labor input for farms with crossbred cows would increase, compared with local livestock rearing, but did not show what changes would occur by gender.

Prior to the introduction of cow traction, only oxen were used for traction in the study area. EARO and ILRI felt the need to find out whether farmers would be willing to use cows for traction, since it was not a traditional practice. Thus in 1993, an anthropological study was carried out by a consultant at the on-farm testing site of 52 farmers without prior experience with crossbred cows to understand their attitude on the use of cross-bred cows for the dual purposes of milk production and traction. The study was conducted in the period just before and then just after most of the 14 selected farmers received their crossbred cows. These farmers were included in the 52 who took part in the anthropological study. Only nineteen percent of the farmers surveyed thought it was feasible to use cows for ploughing (Pankhurst, 1993). In this survey, household members' attitudes and perceptions about the technology on their welfare were not solicited, although the technology would have implications for their workload, income, and food and nutrition security. Whether discussions with all members of a household about their perceptions of the potential benefits and costs would have changed the household's decisions about dual use of cows was not known.

In 1995, the on-farm research program was expanded to study the effects of resource endowment on the utilization of dairy-draft technology. In order to select farmers to participate, volunteers were sought from a number of villages. Fifty-nine farmers were selected - 30 with crossbred cows and 29 with indigenous cattle. The selection criteria included the willingness to 1) use crossbred cows for traction and milk production; 2) plant and use improved fodder and forages; 3) use artificial insemination and veterinary services; 4) practice improved management of cows, calves and milk; and 5) share information with the project. The participating farmers were stratified according to their resource endowment – rich, medium and poor. Observation of the initial 14 farmers indicated that the sexes and ages of household members were important variables in the use and performance of crossbred cows. At this stage, along with the biological data, on-farm monitoring also included data on intra-household resource allocation, task sharing, income generation and expenditure patterns.

While preparing for the expanded on-farm testing program, another anthropological survey was conducted in 1995 to assess the acceptability and potential diffusion of the new technology and to understand the attitudes of the farmers selected by the project in 1993 and 1995 (Pankhurst, 1996). The study attempted to verify whether there had been any change in farmers' attitudes toward the use of crossbred cows for traction and milk production since the previous survey of 1993. The survey also aimed to identify the likely innovators of the new technology and to predict which of the selected farmers were likely to be the most successful adopters. The survey showed that fifty-one percent of the farmers believed that crossbred cows could plough and give milk simultaneously. Forty percent of the farmers believed that using cows for ploughing would result in a decrease in milk yield. A few farmers even suggested that milk yields would increase after traction because the body of the cow would be relaxed. Some claimed that ploughing and milk production were complementary, since cows that plough eat more and hence give more milk. It was the younger, more educated and smaller landholders who believed crossbred cows could plough and produce milk (Pankhurst, 1996).

Dairying with crossbred cows could have a positive impact on human nutrition both directly via consumption of increased milk and dairy products and indirectly via sale of increased output and the purchase of more and better quality food. In traditional cattle production systems, local cows produce 2-3 liters of milk per day, part of which is consumed and the rest sold as butter or cheese processed by women. Crossbred cows produce 6-8 times more milk per day than traditional cows. More milk was sold and consumed by households with crossbred cows than with traditional cows. In 1997, additional questions on food consumption, nutrition and health were added to the on-going survey to assess the effect of intensified dairying on human nutrition, particularly of children.

In July 1999, an informal survey was conducted by EARO and ILRI to assess and evaluate the utilization of the dairy-draft technology in the Holetta area. A total of 83 farmers were interviewed, consisting of 29 project farmers, 28 control farmers and 26 non-project farmers[3].

Project farmers indicated that they have obtained numerous benefits from participating in the project, some of which included (Alemayehu et al., 1999):

(i) Improvements in livelihood due to higher consumption of milk and dairy products, and sale of milk, which was only after the introduction of crossbred cows.

(ii) Regular source of income enables farmers to pay off farm loans from the MoA, due immediately after harvest, without having to sell produce at low prices typical at post harvest periods. Also, the higher cash flow made it possible for some farmers to hire labor.

(iii) Improved knowledge of modern livestock management, milk handling and processing improved milk hygiene and increased sales of milk to DDE.

Although farmers expressed benefits from the project, they also stated its weaknesses, which were as follows (Alemayehu et al., 1999):

(a) Using crossbred cows for traction reduced milk yields and increased calving intervals. Other farmers did not see the need to be overburdening cows when oxen could be used. They added that the natural purpose of the cow was to give milk and have calves. In fact, most farmers discontinued the use of cows for traction after fulfilling the requirement of the project.

(b) Farmers with crossbred cows were not properly trained as to how to use these cows for traction and were not getting timely breeding services, resulting in

[3] Project farmers were those who participated in the dairy-draft project and had obtained crossbred cows for milk production and draft use. Control farmers were farmers participating in the project, but did not have crossbred cows. The third group represented non-participants.

reproductive inefficiency and less profit from investments in crossbred cows.

(c) Crossbred cows are more susceptible to diseases and nutritional deficiencies and need more feed and water than the indigenous breeds.

(d) Scarcity and high prices of seeds of improved forages.

(e) High feeding requirement of crossbred cows. Farmers noted that utilization of crossbred cows has increased labor requirements, which sometimes compete with crop production.

(f) Low milk prices from DDE, the only regular purchaser of liquid milk, forcing farmers to sell milk privately and face price variation. For example, during the fasting periods, the demand for milk reduces, causing farmers who do not supply milk to the DDE to process it to cheese and butter.

(g) The prices of concentrates such as oil seed cake, wheat bran and wheat middling have been rising over the last few years, while the quality and availability of feed have been declining.

Overall, farmers expressed the willingness and need to keep crossbred animals, for milk production. They suggested that veterinary and breeding services be improved, and Napier grass and fodder beet seeds be made more accessible for successful dairy production.

Crossbred cow technologies have food security, intra-household resource allocation (e.g. labor) and increased agricultural marketable surplus effects in the region. These impacts were analyzed in this study using data collected in 1997 and 1999. The aims of this study were to identify policies that could minimize the potential adverse effects and enhance benefits of MODP technologies on food security and agricultural production.

CHAPTER 3
LIVESTOCK PRODUCTION AND COMMERCIALIZATION OF SEMI SUBSISTENCE AGRICULTURE: CONSEQUENCES FOR FOOD SECURITY

This chapter discusses the food security concept, and reviews literature on the effect of livestock production, technological change and commercialization of semi-subsistence agriculture on food security. First, the evolution, types, levels and dimensions of food security are presented. Then a brief discussion of where and who are the food insecure is given. The later part of the chapter discusses the contribution of livestock production to food security and reviews literature on the food security and marketed surplus effects of technological change and commercialization of semi-subsistence crop production.

The Modern Meaning of Food Security

Background and Definitions of Food Security

Although food security was given international recognition and the term coined in the mid-1970s during the discussions of international food problems at a time of global food crisis, poverty and hunger are problems as old as mankind. Attention was focused on food supply problems to assure the availability and stability in the prices of basic foodstuffs at the national and international levels. The changing organization of the food economy that precipitated the food crisis and the international negotiation led to the World Food Conference of 1974. The supply-side and international institutional preoccupations during the World Food Conference reflected the concerns of the periods.

First, the high population growth rate relative to growth in basic food production, particularly in South and Southeast Asia in the preceding two decades, raised Malthusian concerns. The specific food crisis of 1972/4 associated with drought in arid and semi-arid regions of Africa and Western India, floods in parts of Bangladesh and North-East India, bad weather in Europe, North America and the former USSR affected cereal supply, and marked the transition from an era of abundant export supplies of cheap foods and excess productive capacity to one of highly unstable food supplies and prices. The impact of the Green Revolution, combining seeds with more intensive use of fertilizer and irrigation on production in South-East and South Asia on food supplies was still unclear (Clay, 1997).

Second, the effect on the world grain markets of increased demand of imported cereal by the former USSR, following changes in its livestock policy were also uncertain (Clay, 1997; Thomson and Metz, 1997). Third, the OPEC oil price rise of 1973 increased the price of energy and other inputs for the agricultural sector, soaring food prices as grain reserves fell to their lowest level in 25 years (Philips and Taylor, 1991).

These concerns shared in both international policy circles and national governments resulted in the promotion of new international efforts for establishing and maintaining adequate national, regional and international food stocks. The food security goal emphasized food insurance (Phillips and Taylor, 1991) and was implicitly identified with commercial food prices and physical availability rather than with demand and consumption of nutritionally vulnerable groups (Falcon et al, 1987). Food security was defined in the proceedings of the 1974 World Food Summit as:

> "Availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (UN, 1975).

Following the World Food Summit in 1974, the emphasis on creating and strengthening systems such as physical food supplies in the event of crop failure formed the basic tenets of food security thinking. Such efforts were enhanced by a series of favorable crop years. At the end of the 1970s, surpluses reached record levels and real market prices were the lowest in 30 years (Falcon et al., 1987). Although there were more than adequate food supplies and large surplus stocks, worldwide, sufficient to feed everyone, widespread hunger was still a common problem.

The 1980s witnessed a clearer understanding of the nature and extent of food insecurity. The important factor in modifying views on food security was the evidence that the technical successes of the Green Revolution, reflected in the rapid growth in food production and build-up of public stocks, did not result in dramatic reduction in poverty and levels of under- and mal-nutrition. Chronic hunger remained a staggering problem for millions of people because they could not afford to buy the food they needed; i.e. they lacked effective demand. The change in perspective to a new emphasis on consumption, the demand side and issues of access to food by vulnerable people is most closely identified with the study by Sen (1981). Sen eschewed the use of the concept of food security and focused on the entitlements of individuals and households. Sen (1981) also pointed out that hunger occurs because people are not entitled to the means to obtain food. They may be unable to grow enough food on the land they own, rent or are entitled to cultivate; buy enough food because their incomes are too low, or because they are unable to borrow, beg or steal enough money; or acquire enough food as gifts or loans from relatives or neighbors, or through entitlement to government rations or aid. Donations from more affluent countries are means by which people can acquire more food. However, food surpluses, e.g. in the Western countries, do not mean that surpluses are distributed on to the poor. All countries endorse the idea of improving food security for every human being in the world, but too few work towards achieving this goal. Countries may however be constrained by individual policies.

Hunger is closely related to poverty, defined as living on less than $1 a day. It was also noted that a large group of mal- and under-nourished people, whose common bond is their poverty, could be widespread within countries that appeared to be food secure at the national level. Reaching them has proven to be a much more intractable problem than the food crisis in the 1970s. Though production must be increased to resolve hunger problems, the connection between hunger, viable employment opportunities, and income generation were better appreciated in the 1980s than in the 1970s. The hungry were no longer seen as existing in isolation from their surrounding economic and social environments; instead, they were closely linked to their particular food and labor market conditions and to the impact of changing technologies in their societies. Paradoxically, the food insecure are often engaged in food production (Falcon et al, 1987). The change in perspective was reflected in the effort to balance between the demand and the supply sides of the food security equation. This led to a broader concept of food security, first officially articulated by the FAO in 1983:

> “The ultimate objective of world food security is to ensure that all people at all times have both physical and economic access to the basic food they need. To achieve this objective, three lines of action need to be undertaken: production of

> adequate supplies; stability in the flow of supplies; and access to available supplies by all people" (FAO, 1983).

The World Bank in 1986 put forward a similar concept of food security, defining it as:

> "access by all people at all times to enough food for an active, healthy life" (World Bank, 1986),

This is the most widely recognized definition of food security today.

The World Bank (1986) also introduced the widely acceptable distinction between *chronic* food insecurity, associated with problems of continuing or structural poverty and low incomes, and *transitory* food insecurity, which involved periods of intensified pressure associated with natural disasters, economic collapses and conflicts. The 1980s also saw burgeoning interest in relationships between livelihoods and food security at the household and individual levels. This interest was fueled by the food crisis in sub-Saharan Africa, variously caused by the drought in the Sahel, Kenya, and Southern Africa, conflicts in Ethiopia, Sudan and Chad, and the economic collapse of some countries, for example Ghana and Somalia.

Food security continues to evolve in the 1990s as an operational concept in public policy. The most recent redefinition of food security is that adopted by the November 1996 World Food Summit:

> "Food security, at the individual, household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active life" (FAO, 1996).

Poverty was recognized as a major cause of food insecurity and sustainable progress in poverty eradication as important in improving access to food. It was also noted that conflict, terrorism, corruption and environmental degradation contributed significantly to food insecurity (FAO, 1996).

A comparison of these definitions that have evolved during the past twenty years highlights the thinking on food security. The statements also denote food security as international and national problems. In the mid-1970s, the principal concern was to ensure availability of basic foodstuffs, particularly cereals, to feed a growing population, the Malthusian problem, and to stabilize food prices in the international markets. In the 1980s food security thinking included issues of economic access, i.e. effective demand, but the focus was still on basic foods (cereals and other high-calorie, starchy food) and avoiding problems of protein-energy malnutrition. Food security was recognized in the 1990s, as an issue faced from the individual to the global levels. Food security concerns will continue to be broadened, in the new millennium, from protein-energy malnutrition, to incorporate food safety, nutritional balances and food preparation methods. This reflects a growth of interest in matters about food composition and micro-nutrient requirements for an active and healthy life. Currently, food security also involves food preferences that are culturally and socially determined (Clay, 1997) and environmental concerns. Food insecurity is also recognized as the result of both man-made and natural phenomena and is increasingly being recognized as a dynamic concept that does not affect all segments of the population equally.

There have been two critical conceptual developments in the concept of food security. The first is the introduction of access and effective demand into food security analysis in the 1980s as reflected in Sen (1981) and FAO (1983). The second is the introduction of a temporal dimension into the concept of food security, through the distinction made by the World Bank (1986) between transitory and chronic insecurity.

Individual developing country efforts to improve food security are mainly through policies to increase food production and domestic supplies. These efforts include agricultural research, training and extension; agricultural input supply; mechanization; irrigation; rural infrastructure and institutions; land reform; agricultural marketing and pricing policies and agricultural credits. The specific natural, political, social, and economic conditions in a given country determine which of the approaches are needed and are appropriate. The approaches available differ in their regional design characteristics.

Types of Food Insecurity Frequencies

Food insecurity has both – *chronic* and *transitory* components. *Chronic* food insecurity is a continuously (long-term) inadequate diet resulting from lack of resources to produce or acquire food. *Transitory* food insecurity occurs when there is a short-term decline in access to food. Transitory food insecurity can have both *temporary* and *cyclical* or *seasonal* components. Temporary food insecurity occurs when sudden and unpredictable shocks affect food entitlements, for example pest attack, drought and unemployment (Thomson and Metz, 1997). Famine is one of the worst forms of transitory food insecurity (Reutlinger, 1988). Chronically food insecure people, typically the poor, are the most affected by transitory food insecurity problems (von J. Braun et al, 1992). Cyclical or seasonal food insecurity occurs when there is a regular pattern of inadequate access to food. This is usually linked to stages of agricultural production, particularly when it is difficult for households to even out flows of food over time. Chronic food insecurity may result from transitory food insecurity, depending on its severity and frequency. For instance, households that suffer more than one drought year in a row, and have to sell their assets to survive may move from situations of transitory to chronic food insecurity (Thomson and Metz, 1997).

Levels of Food Security

Food security is defined at the national, household and individual levels. Food security at the national or regional level is described as a satisfactory balance between food supply and food demand at reasonable prices based on assumed per capita physiological requirements (Thomson and Metz, 1997; Sansoucy et al., 1995). According to this definition, increasing food insecurity can be identified over time by raising prices. The poorest will be affected most, as they spend a higher proportion of their income on food. The absence of disparity between food supply and demand in a country does not, however, imply that all households are food secure. Some households may still suffer from food insecurity because they lack effective demand for food, i.e. they have no way of expressing their full need for food in the market place.

A household is food insecure if its food requirements for a minimally adequate diet are greater than its ability to produce and/or buy food. Household food security can be equated with sufficiency of household entitlements, i.e. that bundle of food production resources, income available for purchases, and gifts or assistance sufficient to meet the aggregate needs of all household members (Sansoucy et al., 1995).

An individual is food secure, if his or her food consumption is always greater than or equal to physiological requirements. Consumption is based on the claims individuals have on household food resources. In resource poor households, individual food consumption may be affected by the individuals' jobs, earnings and assets, or by their position in the household (Thomson and Metz, 1997). In households with reasonable resources, claims to food may be determined more by individual physiological needs. Food security at the individual level is rarely considered (Chen and Kates, 1994).

Food security at one level does not imply food security at the other level. A food secure country normally contains groups of the population that are food insecure and vice versa. Food security at the household level does not translate to food security by all household members. A food insecure household may equally have some food secure members (Thomson and Metz, 1997).

Food Security Dimensions

The definition of food security as assuring all humans beings with access to adequate food without undue risk of losing such access implies *accessibility* and *stability* dimensions. Accessibility refers to the ability to either produce and or purchase the needed basic foods[4]. Stability implies lack of variation in access to the basic food. It includes a time factor, distinguishing chronic and transitory household food insecurity. Households that allocate over 70% of their income to food have little flexibility in reallocating resources to meet entitlement shocks. Household food stocks and asset possessions are important in withstanding temporary shocks. However, once a household starts selling assets to meet food needs, it is no longer following a sustainable strategy and may soon become food deficient. Selling of productive assets reduces households' future food entitlements (Thomson and Metz, 1997).

Where and Who are the Food Insecure

Hunger affects all regions of the world. The majority of the world’s population suffering from food insecurity is in developing countries. The poor and hungry are not equally distributed across developing countries, as depicted in figure 3.1. Asia and the

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[4]The literature distinguishes availability and accessibility dimensions of food security. Food availability is ascribed to be determined by the level of food supplies, composed of subsistence production and market supplies stemming from domestic production, food stocks and food imports. Access to food is referred to as the ability to express food needs (beyond subsistence production) as effective demand (Thomson and Metz, 1997).

Pacific, home to 70% of the total population in developing countries accounts for about two-thirds of the undernourished people. Twenty-six percent of the developing world's hungry people live in Sub-Saharan Africa (FAO, 2009).

Food insecurity exists both in rural and urban areas. Three-quarters of the poor and hungry are rural people, living in areas where food is grown. The other one-quarter of the poor and food insecure are the unemployed or underemployed urban dwellers, who survive on less than a dollar a day. The rapid growth of urban population is in part due to relative food insecurity in rural areas.

Groups vulnerable to food insecurity vary from country to country, according to the specific socio-economic conditions. Table 3.1 classifies the main types of entitlements and outlines the major sources of risks to food security. Entitlements take the form of productive, non-productive and human capital, incomes and claims. Risks can be natural or man-made. Changes in climate, state institution and policies, removal of subsidy programs, imposition of taxes and changes in property rights are major sources of risks. Prices, employment opportunities and cost of maintaining capital and debts can all be affected by changes in market conditions. Changes in community rights and obligations can also create risk. Conflict and breakdown of the rule of law, for example, can cause chaos pushing food secure houses into extreme vulnerability.

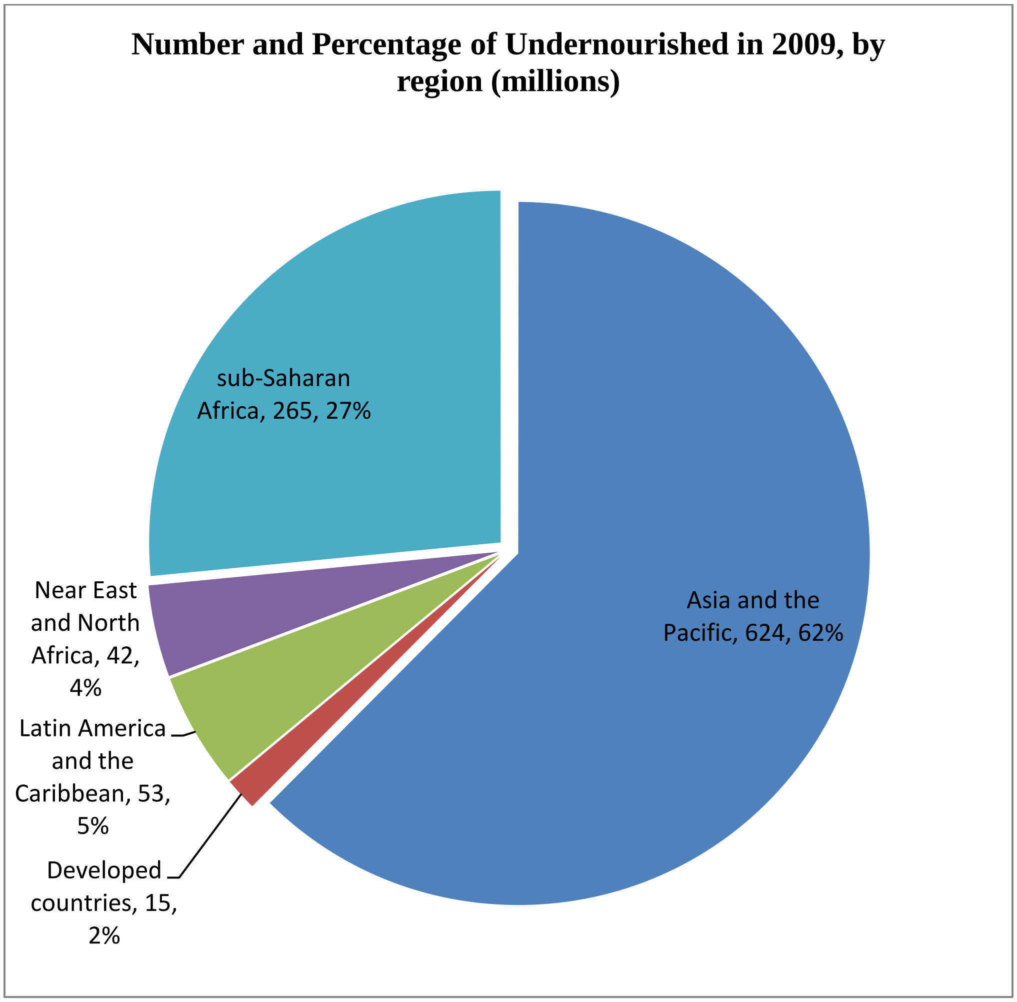


Figure 3.1. Number and Percentage of the Undernourished, by Region, in the Developing World, 2009.
Source: Adapted from FAO, 2009

Table 3.1. Sources of Risk to Household Food Security

Sources of Entitlement	Types of Risks				
	Natural	State	Market	Community	Other
Productive capital (land, machinery, tools, animals, farm buildings, trees, wells, etc)	Drought, Contamination of water supplies, Land degradation, Fire, Flood	Land or other assets redistribution or confiscation	Changes in cost of maintenance	Appropriation and loss of access to common property resources	Loss of land as a result of conflict
Non-productive capital (jewelry, dwellings, granaries, some animals, cash savings)	Pest and Animal diseases	Compulsory procurement, Villagization, Wealth tax	Price shocks (e.g. fall in value of jewelry or livestock), Rapid inflation	Breakdown of sharing mechanisms (e.g. communal granaries)	Loss of assets as a result of war or Theft
Human capital (labor power, education, health)	Disease epidemics (e.g. AIDS), Morbidity, Mortality, Disability	Declining public health expenditure and/or introduction of user charges, Restriction on labor migration	Unemployment, Falling real wages	Breakdown of labor market reciprocity	Forced labor, Conscription, Mobility restrictions, Destruction of schools and clinics during war
Income (from farm and non-farm activities)	Pests, Drought and other climatic events	Cessation of extension services, subsidies on inputs or price support schemes, Tax increases	Declining commodity prices, Food price shocks	Breakdown of cooperatives	Marketing channels disrupted by war, Embargoes
Claims (loans, gifts, social contacts, social security)	Drought and Flood	Reduction in nutrition programs (e.g. school supplementary feeding), usury laws?	Rise in interest rates, Changes in borrowing capacity	Loan recall, Breakdown of reciprocity	Communities disrupted/displaced by war

Source: Adapted from Maxwell and Frankenburger (1992)

Livestock and Food Security

Food security in the developing countries is frequently defined in the literature with reference to food grains. This is inappropriate for societies where livestock, livestock products, roots and tubers are important sources of food and income (Ehui, 1997). Half of the sub-Sahara African countries with the highest risk of food insecurity obtain 40% of total food energy from foods other than cereals (FAO, 1993). Livestock production has the potential to contribute to the accessibility and stability elements of food security, via increased output of livestock and non-livestock agricultural products and through employment and income generation that may assure access to food (Sansoucy et al., 1995).

Livestock and Food Accessibility

Livestock production enhances food availability directly and indirectly. It directly increases food supply by making livestock products available for consumption, if farmers can forego cash income from marketing of these high-value products. Animals are important sources of high quality protein, minerals, vitamins and micronutrients, essential for balanced growth. Meat, milk and eggs provide 17 to 18 percent of the dietary protein in African diets (Winrock International, 1992). Quality foods of animal origin enhance human growth and development, particularly of children in chronically mild to moderate malnourished populations, because they contain amino acids absent in cereals, and essential to human health. In developed countries, animal products provide about 60% of the dietary protein, compared to 22% in developing countries. In developing countries, animal products are important in preventing malnutrition as they are concentrated sources of amino acids not found in vegetable proteins of frequently eaten staple foods. Animal products contribute 30% of total calories in developed countries and less than 10% in developing countries (Sansoucy et al., 1995).

Livestock indirectly increase the availability of food by providing inputs for crop production. For example, livestock supplies draft power for ploughing and other farming related activities like threshing and water lifting. In the highlands of Ethiopia, there is a positive correlation between draft animals and crop production (Omiti, 1995). Crop production on farms with inadequate traction power has low quality tillage, which encourages the use of low value crops requiring less tillage (Sansoucy et al., 1995).

Crossbred cows, which can be used for both milk production and power, can potentially increase efficiency by requiring fewer animals. Such cows when used for ploughing, however, need to be properly fed to minimize traction effects on milk production and reproduction (Zerbini, et al., 1996).

Livestock also indirectly increase food availability by providing manure, the principal source of fertilizer available to a large number of small-scale farmers. Animal manure used as fertilizer increases crop production. Though manure cannot replace all the soil nutrients removed by crops, it recycles a significant proportion. In addition to recycling nutrients, manure provides organic matter to the soil, helping to maintain its structure, water retention and drainage capacities. Part of the manure is converted to dung cakes and used as fuel for cooking. In parts of South and South East Asia, biogas from manure is an excellent source of energy, and effluent from biodigesters an important source of fertilizer. Furthermore, as livestock production is intensified, leguminous fodder plants and trees grown to feed livestock, provide nitrogen for crop production (Sansoucy et al., 1995).

In developing countries, livestock production is a major source of income. For many mixed, small-holder-farming systems, livestock is an important “cash crop” (Sansoucy et al., 1995). The amount of income generated from livestock production varies across regions and production systems, depending on the species and the roles of livestock in the system (Jahnke, 1982). Cash can be obtained from the regular sale of milk, eggs, butter, cheese and dung cakes; and occasionally from sale of live animals, wool, meat, hide and skin, and from services such as draught power and transport. In the mixed farming system of the Ethiopian Highlands, sales of livestock and livestock products accounts for 83% of the cash income per year (Gryseels, 1988). Approximately 52% of the cash income comes from sale of animals and 31% from sales of livestock products. Dairy products account for over 50% and manure sales 25% of the sale of livestock products (Gryseels, 1988).

An important part of the income obtained from animal husbandry is spent on food, agricultural inputs and other family needs (Sansoucy et al., 1995). This is particularly important for pastoral households for whom the terms of trade between livestock and grain is a major indicator of food security. Livestock keepers also exchange high value commodities like meat, eggs or milk for cheaper and larger quantities of food, such as local cereals and vegetables (Bouis and Haddad, 1990).

Livestock and Food Stability

Livestock production gives increased economic stability to farm households. Small ruminants serve in part as a cash buffer and large animals as capital reserves and a hedge against inflation. In mixed farming systems, livestock can also serve as a form of insurance against the risk associated with crop failures, by providing alternative sources of food and income. As an asset, livestock can be liquidated at a time of great need to stabilize food production and consumption (Sansoucy et al., 1995). In addition, the frequent cash flow from the sale of milk and eggs adds to household economic stability and has been noted as an important determinant of food security (von J. Braun and Kennedy, 1994). The view that livestock serves as insurance has been questioned by Lim and Townsend (1994, in Townsend, 1995). Using data collected by ICRISAT from India, Cote d'Ivoire and Thailand, their findings suggest that sales and purchases of livestock do not smooth income fluctuations (Townsend, 1995).

The Role of Technological Change and Commercialization of Semi-subsistence Crop Production in Achieving Food Security

Food security has strong links with issues of poverty, employment and income generation. For developing countries, where more than 70% of the population lives in rural areas and depends on agriculture for its livelihood, increasing food production and commercialization of agriculture are the corner stones for increasing food security and economic development.

The impact of commercialization of semi-subsistence agriculture on food security has been widely debated in the literature. The International Food Policy Research Institute (IFPRI) has undertaken numerous micro-level studies in Africa (e.g. Kenya and Gambia), Asia (The Philippines), and Central America (Guatemala) to assess the effect of the commercialization of agriculture on crop production, income, expenditures, food security and nutrition goals (Kennedy et al., 1992). The aim of these studies was to analyze the process of cash cropping in order to identify key factors that determine food security and nutritional outcomes, with the objective of formulating policies to enhance the beneficial effects of commercialization and minimize the harmful effects. Although the study sites were diverse in terms of geographical location and crop of interest, there were some commonalties. All of the areas were experiencing rapid commercialization of semi-subsistence crop production, thus enabling evaluation of the process of commercialization as well as the food security and nutritional effects. Smallholders primarily undertook the production of cash crops in each of the study areas. The sample households in each site were representative of both cash cropping and non-cash cropping farm households.

The survey protocols used in these studies were comparable, but not identical. The specific approach used in each study was tailored to reflect the local context. Commercial agriculture was hypothesized to influence household income and food consumption at the household level via three pathways: (1) the effects of cash cropping on household agricultural production, (2) the demand for hired labor and (3) the impact on household allocation of time, and other resources. Data were collected on income sources, expenditure patterns, calorie intake and nutritional status. The analyses were based in general on econometric approaches, using recursive and non-recursive models. The specific methods used were described in detail in the individual study reports (Kennedy et al., 1992).

Gambia: The study in Gambia evaluated the effects of the Jahally-Pacharr irrigated smallholder rice project. The study area was located on the south bank of the River Gambia, 300 km east of Banjul. The major subsistence crops in the area were rice, millet and sorghum. The effect of the new rice cultivation under modern irrigation was compared to subsistence crops. A total of 900 farmers in 10 villages were surveyed twice in 1984 and 1985. The sample included both participants and non-participants in the irrigation project and covered the four major ethnic groups of the area.

The study indicated that technological change is a key to improving food security at the household level in the Gambia and that irrigated rice with appropriate technological considerations in the riverine areas can make a substantial contribution. Rice production rose in the project area and real incomes increased by 13 percent per household. An additional 10.0 percent of income led to a 9.4 percent increase in food consumption and a 4.8 percent increase in calorie consumption. Per capita calorie consumption remained constant across seasons in the top income quartile, but dropped by 15% in the wet (hungry season) compared to the dry season for the bottom quartile.

Men's overall labor input to agriculture reduced when the household had more land in the project, women's labor remained more or less constant, but hired labor increased. Since hired labor played a marginal role in rice production before the project, increased use of hired labor in rice production was associated with commercialization. It was noted that health and sanitation constraints in this environment with weak rural health services needed to be alleviated for nutritional problems to be reduced via the introduction of new rice technology (von J. Braun et al., 1989b).

Guatemala: The study in Guatemala focused on the effects of cultivation of labor-intensive non-traditional export vegetables by farmers in the traditional small-farm sector, participating in the Cuatro Pinos farmers cooperative located in the Western Highland of Guatemala. Maize and beans were the traditional crops grown in the area. New export vegetable crops included snow peas, cauliflower, broccoli and parsley. A total of 400 families were surveyed in 1983 and 1985. The sample was divided into groups of households – those who produced the new export vegetables and those who did not (von J. Braun et al., 1989a).

The model analyzed in the study showed non-traditional export crops to be substantially more profitable to farmers than traditional crops. The net returns per unit of land of snow peas were on average 15 times those of maize, the most traditional crop. Returns of the new crops per unit family labor were about twice as high as for maize and 60 percent higher than traditional vegetables produced for local markets in 1985. Most export crop producers also had higher per capita amounts of maize available for consumption from their own production than non-export crop producing farmers with the same farm size. Bean and maize yields of cooperative members were 30% higher on average than non-members' yields. Increased fertilizer input use and more labor-intensive cropping practices are some of the factors that contributed to the increased yields (von J. Braun et al., 1989a).

Export vegetable crop production resulted in increased incomes of participants' households. Expenditures, used as a proxy for income, increased by 33% between the two surveys (1983 – 1985) in the group of new adopters. The income gains were found to be highest among the adopters on the smallest farms, moving the poorest upwards in the income balance. Additional income increased calorie acquisition significantly, but at a decreasing rate (von J. Braun et al., 1989a).

Cultivation of nontraditional export crops increased agricultural employment in the communities where cooperatives function by 21%, through backward and forward linkages and multiplier effects resulting from farm level, input supply and output market employment. Farms producing export vegetables experienced agricultural labor increase by 45%. Family members provided 50% and hired labor the other half of the additional labor required. A significant share of the family labor was provided by women and children (von J. Braun et al., 1989a).

The production and income analysis concluded with favorable effects of the non-traditional crops for food crop productivity, employment, income growth, and income distribution. Food purchases and consumption increased relatively less than expected. The nutritional benefits of commercialization were found to be substantial but could have been enhanced by appropriate health and nutrition-oriented social infrastructure (von J. Braun et al., 1989a).

Kenya: The study in Kenya was undertaken in the South Nyanza District in the southern part of Kenya, an area with the highest mortality rate (216 per 1,000 among children of up to two years of age). The aim was to evaluate the effect of a shift from maize to sugarcane on agricultural production, income, expenditure, consumption, health and nutritional status. By encouraging farmers to shift from maize production to sugarcane, the government hoped to improve the well-being and health of low-income farm households. A significant proportion of the sugarcane produced was for a government owned factory. The study was conducted from June 1984 to March 1987 and included 617 households interviewed eight times during this period (Kennedy and Cogill, 1987). Today, the sugar industry is in disarray, due to corruption. Most of the farmers have stopped producing sugar cane. This is an example of non-sustainable development.

Incomes of farmers participating in sugarcane production were significantly higher than those of non-sugar growing farmers. Marketing of agricultural surplus accounted for most of the difference in incomes – 36% of the incomes in sugarcane producing households, compared to 20% in farm households not producing sugarcane. Fifteen percent of the sugar farmers' income was from participation in the sugarcane production program. Increased income was found to affect household calorie consumption positively. The nutritional benefits would have been even stronger had there been improvements in the health and sanitation environment (Kennedy and Cogill, 1987).

The Philippines: The site in the Philippines was located in the Southern island of Mindanao in Bukidnon province, where a substantial number of households converted lands from corn to sugarcane production after the establishment of sugar mill in 1977. A large number of the sugarcane producing farms were smallholders supplying sugarcane to the Bukidnon Sugar Company. The research surveyed about 500 corn and sugar-producing households four times at 4-month intervals in 1984/85. The survey data indicated higher profits per capita from sugar production than from corn, an average of US $225 per hectare per year for sugar compared with US $100 for corn. All sugar-cane producing farm households with access to land, continued to cultivate corn and on average, produced well in excess of their household needs (Bouis and Haddad, 1990).

Cultivation of sugar increased agricultural employment. On average, approximately two-thirds of the labor devoted to corn production was provided by the family and one-third hired. With sugar production, one-third of the labor was supplied by family and two-thirds hired. Women contributed 23% of the total labor for corn production, but only 11% for sugar production (Bouis and Haddad, 1990).

Households producing sugarcane had higher incomes on average than corn households, due partly to higher profits from sugar. The estimated income elasticity for food consumption at the mean for all sampled households was 0.65, indicating that food consumption rose rapidly with income. Higher-income households were purchasing higher-priced calories, such that a doubling of the incomes at the mean led to only 11% increase in calorie intake at the household level. The survey data indicated significant proportions of the extra calories available at the higher incomes were consumed by adults. Preschool children at all levels consumed less than the recommended calorie intake. There were few improvements in nutritional status because of the high level of preschooler sickness in the sugar-cane-growing households (Bouis and Haddad, 1990).

The IFPRI studies manifest general favorable effects of commercialization of smallholder crop production on food security, incomes, employment and agricultural production. However, the apparent success stories in the short run are not always sustainable in the long run, as in the case of sugar-cane production in Kenya. Commercialization studies confirmed that poor health services and sanitation conditions are a serious constraint to improved nutrition that increases in income can otherwise make possible.

Increased market integration of semi-subsistence agriculture is part of a development strategy oriented toward growth. Market-orientation of small-scale crop production has positive impacts on food security and household incomes. However, much of the available literature focuses on the commercialization effects of semi-subsistence crop production on the accessibility dimension of food security with little attention given to the effect of market-oriented livestock production and dairying, and the stability of food security. The introduction of market-oriented livestock technology, especially dairying, is one of the principal means through which the welfare and food security in mixed crop-livestock systems such as that of Ethiopia can be improved. The effects of intensified dairying in the Ethiopian Highlands on food security (accessibility and stability dimensions) and agricultural marketable surplus are examined in this study.

CHAPTER 4
CONCEPTUAL, THEORETICAL, AND ANALYTICAL FRAMEWORK

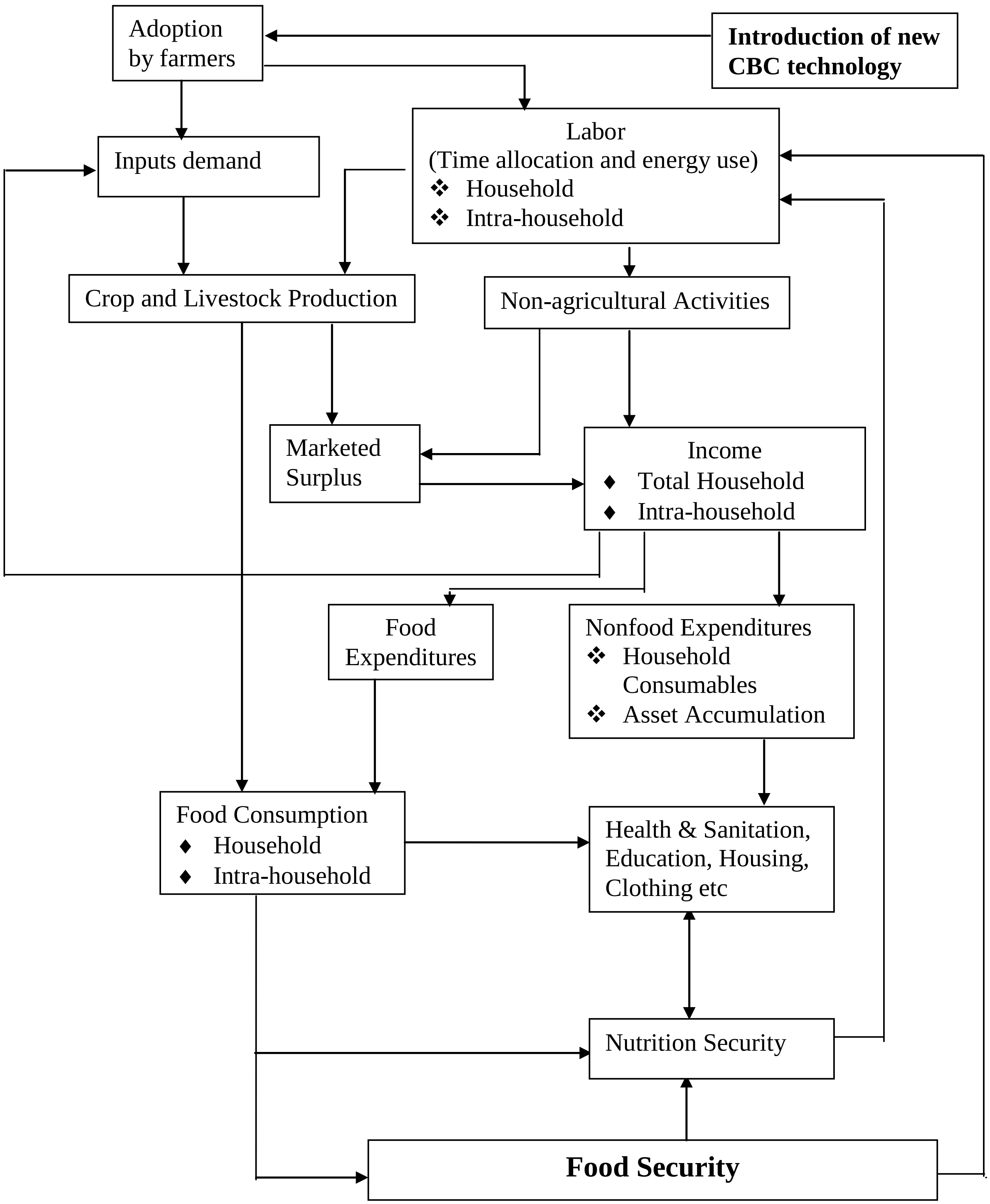
This chapter discusses the conceptual, theoretical and analytical frameworks employed to examine the contribution of intensified dairying to food security and marketable surplus in the Ethiopian Highlands. First, the conceptual framework is presented, depicting the effects of market-oriented smallholder dairying on time allocation, production and income effects, expenditure patterns and food consumption. More information is given on the potential impacts of intensified dairying on food security. Based on the conceptual framework, the analytical framework is then presented. Finally, the theoretical framework, the basis for the equations estimated in chapter 6, is developed.

A Conceptual Framework for Linking Intensified Dairying with Food Security

The pathways through which agricultural change can potentially influence food security and agricultural production are illustrated in figure 4.1 and based on the assumption that the household has already decided to intensify dairy production. The factors that influence this decision include a change in farmer's incentive structure, resource endowment of the farm household and a response to positive economicsignals, which increase the demand for cash income versus in-kind (food) income. Incentives that favor increased dairy production are: provision of credit and subsidies, a market for dairy products, feed availability, and provision of veterinary services, and training of farmers in how to manage high yielding cows.

The effects of technological change and commercialization of smallholder dairying on food security are mediated through (i) the attributes of the new technology, (ii) the utilization process, (iii) its production and resulting time and household resource allocation and employment effects, (iv) expenditure patterns and food consumption,

Figure 4.1. Conceptual Framework for the Analysis of Household-level Effects of New Technology and Commercialization.



Source: Adapted from Braun J. von et al., 1989b which may vary among households and across production stages, and (v) the health and sanitation environment that impinges on nutrition.

The most direct link between technological change in smallholder agriculture and food security is increased household food availability from own production, which is incremental in-kind income from cash “crop” production. In other words, dairy development schemes can directly contribute to food security by making more milk available for home consumption. Small-scale dairy producers have been observed, however, to sell expensive calories (milk) and increase net purchase of cheaper calories (cereals), thereby increasing food consumption (Alderman, 1987).

The prominent link between intensified dairying and food security is the income – food consumption link, where increased income facilitates increased food consumption. However, this is not automatic as intra-household decision-making processes on resource and benefit allocation, and resource endowments of the household play an important role in the relationship of increased income and improvements in food security. The link between increased income and food security depends on labor and time allocation between agricultural and non-agricultural activities, allocation of income between food and non-food expenditures, and how the available food budget is spent, i.e. which types and quantities of food are purchased. A better understanding of these critical relationships is crucial to the identification of efficient modes of intervention designed to improve food security. The utilization of a given package of new technology may involve certain trade-offs, for example, it may increase incomes and at the same time, increase labor inputs and time constraints of certain household members. An early detection of such trade-offs and the design of corrective program components are important in avoiding short-term adverse effects of technological change on small scale farm households.

The Potential Contribution of Intensified Livestock Production to Food Security

Technological progress in dairy production reduces unit production cost, resulting in a downward shift in the unit cost function and a shift to the right of the supply curve i.e. lower cost of production increases supply. The total economic welfare or economic surplus defined as the sum of the Marshallian consumers’ and producers’ surpluses invariably increases. The cost of developing crossbred cows technology in the study area was borne by the Ethiopian government, via the ministry of agriculture; FINNIDA and donors supporting ILRI's research agenda. The distribution of the welfare gains between consumers and producers depends on the price elasticities of supply and demand. Assuming a downward sloping demand curve for dairy products, consumers' welfare will increase via the consumption of larger quantities at lower prices. Producers also benefit if they are able to increase output or lower cost enough to more than compensate for the price decline. If the demand is elastic, such that the price elasticity is not very low, total revenue from the sale of output increases more than the cost of production, resulting in a net gain to producers. The welfare effects of intensified dairying in the highlands of Ethiopia are illustrated in figure 4.2, in which the market supply and demand

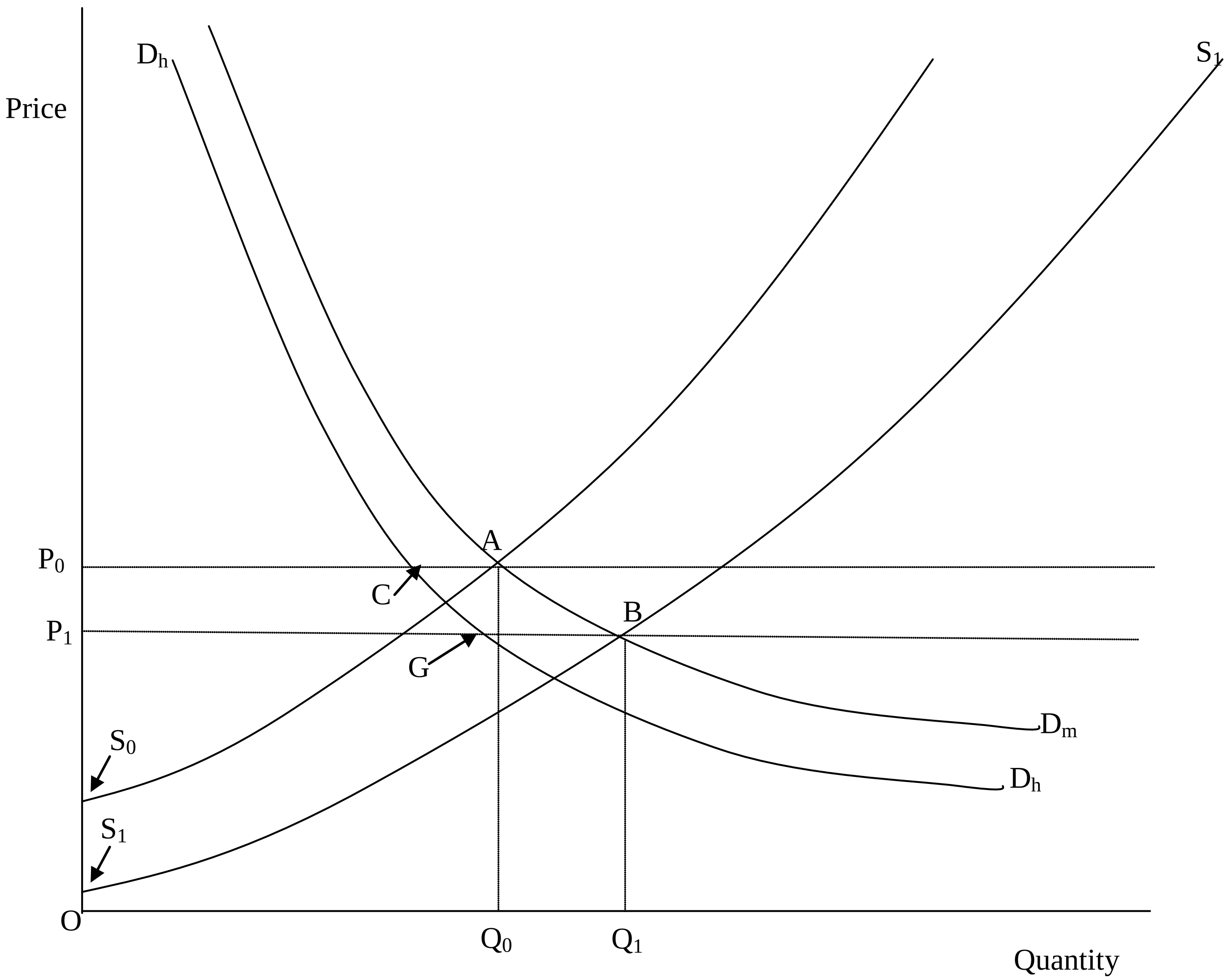


Figure 4.2. The Impact of Technological Change on Semi-subsistence Dairy Products: The Market

relationships for dairy products are analyzed. The income elasticities for milk, meat and eggs for tropical Africa are estimated at 0.82, 0.98 and 1.10 respectively, compared to 0.22 for cereals (Jahnke, 1982). D_hD_h represents the demand curve of producers for home consumption. D_mD_m represents the market demand for dairy products, and the horizontal difference between D_mD_m and D_hD_h at any given price, represents the quantity purchased by non-dairy farm households. The supply curves before and after the technological change are measured by S_0S_0 and S_1S_1. Shift in market supply moves market equilibrium from A to B. Consumers purchasing dairy products increase consumption from OQ_o to OQ_1, as prices drop from OP_o to OP_1. Consumer surplus increases by ABP_1P_0, of which P_oCGP_1 accrues to consumers in households of producers and CABG to non-producer households. Producer surplus changes from S_0P_oA to S_1BP_1. The more price elastic is the aggregate demand curve, the larger will be the producers' surplus due to the outward shift of the supply curve.

Improvements in livestock production in developing countries can contribute to food security in numerous ways. First, increased milk production and a steady flow of cash income from the daily sale of surplus milk and dairy products contribute to all dimensions of food security, accessibility and stability. Besides increasing the availability of and accessibility to more and better quality foods through increased milk production and higher incomes, a steady flow of cash income from daily sale of milk may contribute to stability of consumption in smallholder intensified dairying households.

Second, livestock production and processing enterprises are labor intensive, thus increased production implies higher employment, which can secure incomes and food entitlements of the rural poor.

Third, cost saving technological change increases production and keeps livestock product prices down, enabling more people from lower income groups to have access to food of animal origin. Fourth, increased domestic production may reduce imports and save foreign exchange which may be used to invest in productive activities that can indirectly contribute to food security.

Intensified dairying is the most regular generator of income for small-scale farmers (Sansoucy et al., 1995). Dairy development has been shown to substantially raise milk production and household incomes in developing countries where development efforts are market-oriented and demand driven (Pankhurst, 1996; Walshe et al., 1991; Shapiro et al., 1998; Baltenweck et al., 1998; Thomas-Slayter and Bhatt, 1994). An FAO/UNDP dairy project in Burkina Faso assisted 100 families in increasing their monthly incomes by US $80, an equivalent to an extra labor unit per family (Ehui, 1997). Incomes of farmers who use intensified technologies for the production of meat and milk have been shown to increase by 50 – 100% (Shapiro et al., 1995; Buta, 1997). Evidence from Ethiopian Highlands shows per capita food availability to be 67.5% higher in households with crossbred cows than in those with traditional cattle (Shapiro, 1994). Returns from market-oriented small ruminant activities in the Sahel have been found to be 24% higher than in traditional practices and capital returns of over 50% (Shapiro, 1994).

The structural changes taking place in SSA are expected to bring about more technological changes in livestock production in the next decade. Beside population growth, urbanization, and rising incomes, recent currency devaluation and price liberalization are additional factors pushing for intensification. Better integrated crop-livestock systems will need to be replaced by a more intensive and specialized crop and livestock system to obtain rapid growth rates and to respond to increasing demand for animal food products.

Modeling Household Behavior: A Review of Unitary Versus Collective Models[5]

Unitary Model

Becker (1965) brought the theory of the household into mainstream economics. The essence of his approach was that, in accordance with a single set of preferences, the household combines time, goods purchased in the market, and goods produced at home, allocating them to its members according to their competence in converting the resources into commodities that maximize some common welfare index. The majority of economists, until most recently, have shared this view of the household as a collection of individuals with one set of preferences, represented by a household utility function. This approach originates in the standard demand analysis and has been extended to include the determinants of education, health, fertility, child fostering, migration, labor supply, home

[5] This draws heavily from Haddad et al. (1997), and Quisumbing and Maluccio (1999).

production, land tenure and crop adoption. Important to the developing countries is the work by Singh et al. (1986), which provides a joint model of production and consumption decisions.

This approach is attractive because of the diversity of the issues it can address and the relative simplicity of comparative statics generated. The unitary model is quite powerful in the sense that it helps explain two important areas of household behavior: decision-making regarding the quantity of goods consumed and the equal and unequal allocation of the goods among household members. The unitary model is, thus, able to explain differences in individual well-being and consumption patterns within a household, even in situations where these differences are exhibited systematically by gender, age, or relation to household head grouping (Becker, 1981). For example, differences in allocation may be explained by variation in productivities that lead to higher incomes shared by all members. Pitt et al. (1990) provide an empirical example where they incorporate individual work effort as a choice variable in the household welfare function and showed that unequal calorie allocation across gender and age classes may reflect a different distribution of activities by those classes.

The unitary model is sometimes referred to as the ‘common preferences’ model, the ‘altruism’ model, or the ‘benevolent dictator’ model. The unitary model is used because this term describes that the household acts as one, with a single preference function; whereas the other labels tend to reflect the means by which the household is hypothesized to act as one.

Collective Model

The basis of the unitary model is the assumption that there exists a household welfare function and that all resources (land, labor, capital and information) are pooled. Concerns regarding this assumption have spawned a number of alternative models called “collective” (Chiappori; 1992, McElroy, 1990; Ulph, 1988; Kanbur, 1991; Lundberg and Pollak, 1993) that focus on the individuality of household members and explicitly address the question of how individual preferences result in a collective choice. These models explicitly consider the households as a collective entity, allowing different decision makers to have different preferences. They also do not require a unique household welfare index to be interpreted as a utility function, thereby allowing the index to be dependent on prices and incomes as well as “taste” (Haddad, 1994; Chiappori, 1992; Haddad et al., 1997). Thus both the unitary and collective models allow public policy to change intra-household resource allocation of benefits and resources.

Collective models can be structured as either cooperative or non-cooperative, depending on the allocation mechanism. Individuals in the cooperative approach can choose to either remain single or form a household. Households are formed when the advantages resulting from being part of a household are greater than those derived from being single. The existence of a household generates a surplus that is shared among its members; the central issue of cooperative analysis is the rule governing this distribution. The unitary model is a special case of the cooperative collective model where preferences are identical and resources are pooled.

The Cooperative Model: The cooperative model has two sub-classes. The first class only makes the assumption that household decisions are always efficient in the Pareto sense (Browning et al., 1994; Chiappori, 1992). The rules of distribution regulating intra-household allocation are estimated from the data. In addition to assuming Pareto optimality, the second class applies more structure on the household, by depicting household decisions as a result of some bargaining process, applying the tools of cooperative game theory (Manser and Brown, 1980; McElroy, 1990). The division of gains from household formation is modeled as a function of each member's “threat point” or “fallback” position. The threat point position is a function of extra environmental parameters (EEPs) such as laws concerning access to common property, threat of marital discord, and prohibitions on women working outside the homes.

The Non-cooperative Model: The non-cooperative approach (Ulph, 1988; Kanbur, 1991; Lundberg and Pollak, 1993; Carter and Katz, 1992) does not assume that members necessarily enter into binding and enforceable contracts with each other. Instead, an individual’s action is conditional on the actions of the others. It is assumed that household members have different preferences, do not pool resources and also act as autonomous sub-economies (Gladwin and McMillan, 1989). The only link between individuals is the net transfer of income between them. The conditionality of action implies that not all non-cooperative models are Pareto optimal.

Although there is growing evidence that the household cannot be characterized as one where individuals pool resources and share preferences, the choice of the collective model over the unitary model under different circumstances is not clear. These difficulties are compounded by the fact that gender and intra-household analyses are specific to cultural, social and institutional settings and are hence impossible to generalize (Haddad et al., 1997).

Differential allocation across household members is consistent with both the unitary and the collective model (Quisumbing and Maluccio, 1999). The empirical challenge is therefore to test whether or not the differentials are consistent with the unitary model, where household members have the same preferences, or with the decision-making process in which different household members have different preferences and ability to enforce them. A general test of the unitary versus collective model, used in this study, is the income-pooling test, where the demand (expenditure) equation is a function of total income and income of an individual household member, e.g. wife's income. Holding household income constant, the effect of individual income on demand (expenditure) can be interpreted as the impact of changing the share of household income allocated to that member. According to the unitary model, the individual income effect should be insignificant.

Theoretical Framework

This section starts with the general theoretical structure for a small-scale farm household, and then specializes it for the particular problem to be addressed in this research. The equations specified in this section provide the theoretical support for the empirical specifications of the following equations to be estimated: food consumption equations, per capita caloric intake equations, and marketable surplus equations. The resultant equations to be estimated are specified in chapter 6.

Basic Model

Following Becker (1965), the Singh et al. (1986) synthesis of the farm household model, and further developments in the human capital investment literature (as discussed in Behrman and Deolalikar, 1988), households obtain utility from the consumption of *Z*-

goods specified as:

$$U = U(Z_1, Z_2, ..., Z_n) \tag{4.1}$$

Where the *Z*'s are consumable goods. Assume for the moment there are two sets of goods: calories *(Z_1)* and other *n-1* consumable goods $(Z_2, ..., Z_n)$ such as protein, micronutrients, health, leisure, social and educational outcomes. The production functions for the *Z-goods* are:

$$Z_i = Z_i(X_m, X_a, X_s, F; R) \qquad i = 1,2,...,n \tag{4.2}$$

Where X_m is market purchased inputs, X_a *is* agricultural staples, X_s is leisure, *F* is family labor endowments; and *R* represents individual and household characteristics, such as ages, years of education, household size, dependency ratio and other environmental variables. Unlike the other variables, *R* is presumed not to be a choice variable of the household during the period being modeled. Examples would include individual's age, household size and the natural environment of the household. The household utility function can therefore be specified as:

$$U = U(Z_1(X_m, X_a, X_s, F; R), Z_2(X_m, X_a, X_s, F; R), ..., Z_n(X_m, X_a, X_s, F; R)) \tag{4.3}$$

The household picks the optimal consumption bundle subject to its production technology:

$$Q_a = Q_a(A, L, V, K) \tag{4.4}$$

where Q_a is the quantity of food produced, *A* is the household's fixed quantity of land, *L* is total labor input, *V* is the vector of variable inputs (fertilizer, pesticides, seed etc), *K* is a vector of capital (native oxen, crossbred cows and farm implements).

The household also faces a budget constraint:

$$p_m X_m = p_a(Q_a - X_a) - w(L - F) + E \tag{4.5}$$

That is, given prices, p_m, total market consumption $p_m X_m$ cannot exceed total income, the sum of non-labor income, *E*, and labor earnings, which depends on exogenous wage, *w*, and household labor supply. Q_a is the household's production of food staples, $(Q_a - X_a)$ is its marketable surplus, *L* is total labor input, *F* is family labor supply, such that, *(L - F)*, if positive is hired labor, if negative it is off farm labor supply.

The household also encounters a time constraint, for total time *T* available to the household cannot exceed the sum of time to leisure X_s and time working on-farm or off-farm, *F*:

$$T = F + X_s \tag{4.6}$$

Substituting the production constraint [4.4] for Q_a and incorporating the time constraint [4.6] into the cash income constraint [4.5] for *F,* yields the following constraint:

$$p_m X_m = p_a (Q_a (A, L, V, K) - X_a) - w(L - T + X_s) + E \tag{4.7}$$

Rearranging [4.7] gives,

$$p_m X_m + p_a X_a + wX_s = p_a Q_a (A, L, V, K) - w(L - T) + E \tag{4.8}$$

Further rearrangement of [4.8] gives:

$$p_m X_m + p_a X_a + wX_s = wT + p_a Q_a (A, L, V, K) - wL + E \tag{4.9}$$

[4.9] indicates that total consumption, including the value of time in leisure activities, cannot exceed full income. Full income is the sum of the value of time available to the household *wT,* profit from production;

$$\pi = p_a Q_a (A, L, V, K) - wL \tag{4.10}$$

and non-labor income *E.* Thus

$$p_m X_m + p_a X_a + wX_s = wT + \pi + E \tag{4.11}$$

The left-hand side of [4.11] represents total household expenditures, which include purchases of market commodities ($p_m X_m$), household's purchases of its own output ($p_a X_a$), and household's purchase of its own leisure time (wX_s). The right-hand side represents full income in which the value of the stock of time available to the household (wT), profit (π) and non-labour income (E) are explicitly recorded.

From equations [4.3] and [4.9], the household can choose (i) the levels of consumption for the Z-goods (e.g. calories, protein, micro-nutrients, health, leisure, social, educational outcomes etc.) through the consumption of the three commodities (X_m, X_a and X_s) and (ii) the total labor input into agricultural production. The first order conditions for maximizing the choice variables (labor input, *L;* marketable purchased inputs, X_m; household produced goods, X_a; and leisure X_s) can be explored. Starting with the labor input, the first order condition for maximization of unconstrained profit is:

$$p_a\, \partial Q_a / \partial L = w \tag{4.12}$$

The household will equate marginal revenue product of labor to the market wage. Labor input (*L*), is the only endogenous variable. X_m, X_a, X_s, are not present and according to [4.12] do not affect household's choice of *L*. Equation [4.12] can be solved for *L*, as a function of prices (p_a and *w*), the technological parameter(s) of the production function (*K*), and the fixed area of land (*A*). This implies that production decisions can be made independently of consumption and labor-supply (or leisure) decisions, resulting in the recursive form of the household model.

The solution for *L* is:

$$L^* = L^*(w, p_a, K, A) \tag{4.13}$$

The value of full income when profits have been maximized through the appropriate choice of labor input can be obtained by substituting L^* into the right-hand side of the full income constraint [4.9], which could then be re-written as:

$$p_m X_m + p_a X_a + wX_s = Y^* \tag{4.14}$$

Y^* is the value of full income associated with profit maximization behavior. Using [4.3] and [4.14] one can solve for (X_m, X_a and X_s) via the Lagrangian multiplier method. The expression for the Lagrangian technique is:

$$\begin{aligned}\xi(X_m, X_a, X_s, \lambda) = U((Z_1(X_m, X_a, X_s, F; R), Z_2(X_m, X_a, X_s, F; R),...,\\ Z_n(X_m, X_a, X_s, F; R)) + \lambda(Y^* - p_m X_m - p_a X_a - wX_s)\end{aligned} \tag{4.15}$$

The first order conditions require that the first partial derivatives of ξ must be zero:

$$\partial \xi(X_m, X_a, X_s, \lambda) \Big/ \partial X_j = \sum_{i=1}^{n} (\partial U / \partial Z_i)(\partial Z_i / \partial X_j) - \lambda p_j = 0 \qquad (4.16_1^a)$$

$$\partial \xi(X_m, X_a, X_s, \lambda) / \partial \lambda = Y^* - p_m X_m - p_a X_a - wX_s = 0 \qquad (4.16_2^a)$$

where j = m, a and s. Equations 4.16^a are the conditions for a critical point for the Lagrangian function ξ. Thus

$$\sum_{i=1}^{n}(\partial U/\partial Z_i)(\partial Z_i/\partial X_j)=\lambda p_j \qquad (4.16_1^b)$$

$$p_m X_m + p_a X_a + wX_s = Y^* \qquad (4.16_2^b)$$

The solution to 4.16^b yields standard demand curves of the form:

$$X_j = X_j(p_m, p_a, w, Z_1, Z_2, ...Z_n, Y^*; R) \qquad (4.17)$$

Demand depends on prices and incomes, as well as on the environmental characteristics of the households. In semi-subsistence agricultural households, income is determined by households' production activities; which implies that changes in factors influencing production, such as introduction of new technology, changes Y, which in turn affects consumption behavior. Thus

$$X_j = X_j(p_m, p_a, w, Z_1, Z_2, ..., Z_n, Y^*(A, L, K, V); R) \qquad (4.18)$$

Consumption behavior depicted in [4.18] is not independent of production behavior depicted in [4.4].

Expressing this as an expenditure equation, we have:

$$p_j X_j = E(p_m, p_a, w, Y^*(A, L, K, V); R) \qquad (4.19)$$

The demand for X_j is derived from the demand of the Z-goods. Thus demand equations of Z-goods can be written as:

$$Z_i = Z_i(X_j(p_m, p_a, w, Y^*(A, L, K, V); R)) \quad i=1,2,\ldots,n \qquad (4.20)$$

Since production is not influenced by consumption choices, this form of the model is recursive. The labor supply follows from the utility function and the income constraint and can be specified as:

$$F = F(p_m, p_a, w, Z_i, Y^*(A, L, K, V); R) \quad i=1,2,\ldots,n \qquad (4.21)$$

The labor supply of household members (F), allocated to farm and off-farm work is given by prices of market and home produced goods, wages and the utility function.

Various elements of the basic model will be modified in the following subsections to address pertinent issues specific to the problem to be analyzed. This includes the impact of intensified dairying and market-orientation of small farmers on: food consumption; per capita calorie intake; and marketable surplus of agricultural products for the harvesting and planting seasons.

Basic Model Modification

Seasonality Analysis: One interesting question is whether the utilization of crossbred cows technology reduces consumption differences in the food deficit and food surplus periods, focusing specifically on caloric intake. During the planting season, caloric stress is argued to influence productivity (Behrman, et al., 1997). There are two significant implications of the Behrman, et al. approach. First, with food insecurity at the household level, production is argued to be dependent on caloric intake:

$$Q_1^p = Q_1^p(A^p, L_e^p(Z_1^p), V^p, K^p) \tag{4.22}$$

$$Q_1^h = Q_1^h(A^h, V^h, K^h, L_e^h, A^p, L_e^p(Z_1^p), V^p, K^p) \tag{4.23}$$

where Z_1^p = calorie intake during the planting stage, $L_e^p(Z_1^p)$ is the efficiency unit of labor for the planting season. Since production is a function of caloric consumption during the planting season, the recursive nature of the model from production to consumption is lost.

Second, there are two separate caloric equations, one for the planting season (Z_1^p) and one for the harvest season (Z_1^h). The planting season is generally characterized as a stage of shortage with high food prices and a high cost of borrowing (Behrman et al. 1997 p. 191). The assumption that calories affect production follows from low levels of consumption adversely affecting labor input. Caloric consumption during the planting season is given as:

$$Z_1^p = Z_1^p(Y^p, p_m^p, p_a^p, w^p, R, G) \tag{4.24}$$

where G is the joint distribution of the stochastic variables that become known to the farmer at the beginning of the harvest period--this includes harvest stage wages and prices, the production shock, and efficiency of planting period hired workers (Behrman et al., 1997). Although caloric stress is unlikely to be a problem during the harvest season, the effects of caloric stress during the planting season are passed through to the harvest season consumption. The harvesting period consumption decision rule can be written as:

$$Z_1^h = Z_1^h(Y^h, p_m^h, p_a^h, w^h, Y^p, p_m^p, p_a^p, w^p, R, G, \varepsilon) \quad (4.25)$$

The harvest stage consumption differs from the planting stage consumption equation in that it incorporates planting stage wages (w^p), market good prices (p_m^p), prices of agricultural staples (p_a^p), income (Y^p) and the unanticipated component of income (the shock ε). Similar equations for the planting and harvesting stages can be specified for food consumption and labor allocation equations.

The above structure, i.e. specification of two caloric intake equations by season, is appropriate in the case of Ethiopia, given its transitory food insecurity problems and associated levels of caloric stress. An increased daily flow of cash income and milk production resulting from market-oriented intensified dairying has the potential of reducing seasonal caloric stress.

Commercialization Analysis: Households using dairy technology are expected to produce surplus food products, particularly milk, for sale to raise cash income that can be used to purchase needed food items in an effort to become more food secure. The market surplus analysis focuses on the marketed outcomes of food $(FOODMA)$ and explains it as an excess supply function[6]. It can be specified for the planting and harvesting seasons as a function of food production and food consumption variables for the respective seasons.

$$FOODMA^p = f(Y^p, p_m^p, p_a^p, w^p, A^p, K^p, R, G) \quad (4.26)$$

$$FOODMA^h = f(Y^h, p_m^h, p_a^h, w^h, A^h, K^h, Y^p, p_m^p, p_a^p, w^p, A^p, K^p, R, G, \varepsilon) \quad (4.27)$$

The dynamic and stochastic sequential production processes (planting and harvesting) imply that decision rules are fundamentally different for each season (Behrman et al.). The two market surplus equations are therefore needed to test for differences in

[6]If food production equation (4.4) were to be estimated, marketable surplus would be identical to the difference between the value of food production and consumption.

marketable surplus and hence cash income for the harvesting and planting seasons. Agricultural marketable surplus is expected to be smaller in the planting than the harvesting stages.

CHAPTER 5

EMPIRICAL MODEL, DATA SOURCE AND CHARACTERISTICS

This chapter focuses on the empirical procedure and data set used in the estimation of the food consumption, caloric intake, and marketable surplus equations derived in the previous chapter. The first part specifies the model and states the hypotheses. Econometric issues – problems and consequences, estimation procedures and empirical approach are then discussed. The latter section gives an overview of the data set, a description of the measurements of some variables and the descriptive statistics of variables used in the empirical analysis. Independent sample t-tests are conducted to test for differences between CBC and LBC groups.

Empirical Model and Hypotheses

The expenditure, calorie intake and marketed surplus equation derived in the previous chapter are being tested here to examine the effects of intensified dairying on food security and marketed surplus. The models are specified and estimated for the whole sample and separately for each of the two groups with and without the improved cattle. The variables are defined in Table 5.1. The logic of the regression analysis in terms of food security is to move from household food consumption to household calorie intake as diagrammed in Figure 4.1. At each link, the concern is how variables such as education and age of household head, animal value and cropped land area, and distance to the market condition the degree to which the potentially beneficial effects of increased income are transmitted to food security. The equations are specified as follows (and linked to the theoretical developments later):

Food Consumption Model

FOOD CONSUMPTION = f (HOUSEHOLD INCOME, WIFE'S INCOME, LAND AREA, ANIMAL VALUE, AGE AND EDUCATION OF HOUSEHOLD HEAD,
HOUSEHOLD SIZE, MARKET DISTANCE, DISTRICT, SEASON) (5.1)

Table 5.1 Definition of Variables Used in the Empirical Analysis

Variables Names	Definitions
Value of Food Consumed	Household cash food expenditure plus value of food consumed from own production in Birr[a], per adult equivalent).
Energy	Daily average household calorie intake (in calories per adult equivalent). This includes all food, both from home production and purchase.
Value of Marketed Foods	Household value of marketed foods (in Birr). This includes cash income from sales of crops and Dairy Products.
Land Area	Cropped land (in Hectares)
Animal Value	Livestock value (in Birr)
Age of Household Head	Age of household head (in years)
Household Size	Number of household members. Size expressed in adult-equivalents
Household Income	Composed of total farm and non-farm income, less variable cost. Farm income includes value of food from own production, revenues from sales of dairy and non-dairy farm products. Variable cost is the sum of expenditure on crops and animal feed inputs, animal feed, animal health and other services, and land rental.
Wife's Income	Household Income handled by wife. It does not include value of food from own production.
Distance to Crop Market	Round trip distance to the main market from each household (in Km)
Location	District (1 = Wolmera, 0 = Addis Alem)
E1	Education Level of household head (1 = read and write, 0=otherwise). Illiteracy is the base level.
E2	Education Level of household head (1 = Elementary, 0=otherwise). Illiteracy is the base level.
E3	Education Level of household head (1 = High School, 0=Otherwise). Illiteracy is the base level.
Season	Zero-one dummies for each quarter of the year. Fourth quarter is the base level.

[a]Birr is a unit of the local currency. The exchange rate at the time of the study was $ ≅ 7.5 Birr.

The propensity of poor far households to spend incremental income on food is usually high. This is examined with the food consumption equation. The model is formulated taking into account conventional approaches to demand analysis and the structural determinants of food consumption decisions in the households imposed by the local situation. Demand theory suggests that in semi-subsistence societies, food consumption is determined by income level and the market prices of the major traded staples. Income raises food consumption per adult equivalent. Price variables are not included in the model because of price invariability in the cross-sectional sample. Most farmers exchange in the same markets and face the same prices at a given time. Distance to the crop market and location are included to capture transaction costs that may differ among households. Distance to crop markets for each household and district where the household is located, controls for variations in food consumption due to households residing nearer the crop market.

It has been suggested that women spend more income on food compared to men (Kennedy and Cogill, 1987; Quisumbing et al., 1995). It is therefore hypothesized that incomes in the hands of women have positive food consumption effects. The variable “Household Income handled by wife” tests for the effects of new technology in dairy production on women’s spending on food beyond its income effect, which is controlled for with total household income.

Food consumption is further hypothesized to be determined by household size and demographic variables (age and educational level of household head). These variables are important for their income earning and expenditure potentials. The household size also controls for scale effects; large households tend to spend less per adult equivalent on food. Age and education of household head are expected to contribute to greater food consumption. Literate household heads have better knowledge through their wider exposure to information. Agricultural production inputs are expected to positively affect outputs, incomes, and hence food consumption. The production inputs in the model include cultivated land area and capital stock measured by animal value.

Calorie Intake Model

CALORIE INTAKE = f (VALUE OF FOOD CONSUMED, LAND AREA, ANIMAL VALUE, AGE AND EDUCATION OF HOUSEHOLD HEAD, MARKET DISTANCE, DISTRICT) (5.2)

This equation relates the effects of food consumption to the calorie intake per adult equivalent. Numerous factors, in addition to food consumption per adult-equivalent, determine the calorie intake. It is hypothesized that higher food consumption has a positive calorie intake effect, because food purchases and higher own-farm production increase availability of calories. Likewise, cultivated land area, animal value, age of household head and educational level are expected to affect calorie intake in the same way as they affect food consumption. Household size is expected to have a non-positive effect on calorie intake. Distance to the crop market and location of the household are associated with higher transaction cost and therefore expected to have a negative effect on calorie intake.

Behrman et al., 1997 gave particular attention to the importance of seasonal variation in consumption and production. During the planting season, they argue that a shortage of calories would result in reduced production for the following season. In this case, households with the improved cattle and potential for continuing milk production with potential cash sales should face less volatility over the year in calorie consumption than households with traditional, lower productivity cattle. Seasonality is addressed by including dummy variables for each quarter of the year in the calorie intake equation.

Marketed Surplus Model

MARKETED SURPLUS = f (HOUSEHOLD INCOME, WIFE'S INCOME, LAND AREA, ANIMAL VALUE, AGE AND EDUCATION OF HOUSEHOLD HEAD, HOUSEHOLD SIZE, MARKET DISTANCE, DISTRICT, SEASON) (5.3)

The analysis of the demand-side effect of the new technology is as important as for the supply-side effects. The changes in marketed surplus are due to a combination of technological change and commercialization. Increased outputs achieved through technological change in dairy production do not translate into a straightforward expansion in marketed surplus. Substitution effects in production and consumption may either increase or decrease the marketed surplus of output growth resulting from new technology. Technological change in the study area increases milk production and dairy income but may affect crop production if the household changes its resources allocation to produce additional cattle feed and forage. As a consequence, households with dairy cows may sell some of the dairy products to purchase cereals.

The model is specified with the following hypotheses in mind: Increased income from dairying with crossbred cows increases the supply of crops, livestock and livestock products via increased purchases of inputs. As noted above, prices are unavailable in the data and are expected to be constant across the sample of households. The distance to crop markets for each household and the location of households are again used to control for differing transportation (transaction costs). More animals and land area represent greater productive capacity and are therefore hypothesized to increase marketed surplus. The age and literacy of household heads are expected to contribute to greater production and marketed surplus. Older and more literate household heads may have more farming experience and better farming knowledge through their wider exposure to information via extension agents, for example.

Econometric Problem

The literature on farm models, such as Lau et al. 1978, Barnum and Squire 1979, Strauss 1982, Pitt and Rosenzweig 1985, Singh, Squire, and Strauss 1986, Behrman and Deolikar 1987, and Behrman et al., 1997 argues that if markets are incomplete or if labor productivity depends on consumption, the consumption and production decisions of farm households are not separable and recursive. The theoretical and analytical frameworks discussed in the previous chapter, and in Kumar (1994) indicate that since food consumption is part of the farm household's utility function given by choices made in the allocation of both income and time, subject to a combination of the production function, time and budgetary constraints, income is correlated with the permanent component of the error term (fixed effect). Hence, household incomes cannot be treated as exogenous in the food consumption and marketable surplus equations. Berhman and Deolikar (1987, pg. 502 and 504) and Berhman et al. (1997, pg. 195) suggest that income is correlated with the permanent component (fixed effects), time-invariant characteristics of the household. Such factors include land quality, farming ability, and preferences that are not measured in the data.

The objective is to estimate the above equations (5.1, 5.2, 5.3) to measure the net effect of the change in dairy production on food security. Given the panel structure of data, each of the equations will have an error term such as η_{jit} consisting of a household component, α_{ji}, and the random component across households and time, ε_{jit} :

$$\eta_{jit} = \alpha_{ji} + \varepsilon_{jit} \qquad (5.5)$$

where *j* represents the equation, *i* represents the household, and *t* represents the time period. The difficulty is that α_{ji} is potentially correlated with income. If this is the case, ordinary least squares estimates of the equation will lead to inconsistent parameter estimates, leading to inappropriate inferences. The Hausman specification test is applied in chapter 6 to determine whether or not income (in the food consumption and marketed surplus equations) and food consumption (in the calorie intake equation) are correlated with the household effects for this particular sample. Since the test confirms a non-zero correlation, an alternative estimation procedure is required. Hausman and Taylor (1981), Amemiya and MaCurdy (1986), and Breusch, Mizon, and Schidmt (1989) suggest a solution to the problem by using instrumental variable techniques.

Instrumental Variables Estimators

One advantage of using panel data is the ability to control for the individual-specific effects, which are correlated with other explanatory variables in the specification of an economic relationship. The development of the instrumental variable estimators in this section draws heavily from Cornwell and Rupert (1988). Considering the stylistic equation of the model to be estimated:

$$Y_{it} = X_{it}^{'}\beta + Z_{i}^{'}\gamma + \alpha_i + \varepsilon_{it}, \quad \eta_{it} = \alpha_i + \varepsilon_{it}, \quad i = 1,..., N; \quad t = 1,...,T, \qquad (5.6)$$

where X_{it} is a *K* x 1 vector of time varying explanatory variables, Z_i is a *G* x 1 vector of time-invariant explanatory variables, β and γ are the corresponding parameter vectors.

The error term ε_{it} is assumed to be uncorrelated with the explanatory variables (X_{it}, Z_i) and the household effect (α_i), and is distributed as $N(0, \sigma_\varepsilon^2)$, i.e. it has zero mean and constant variance conditionally on X_{it} and Z_i. The latent individual effect α_i is assumed to be a time-invariant random variable, distributed independently across individuals with zero mean and constant variance σ_α^2, i.e. the α_i are $N(0, \sigma_\alpha^2)$, and may be correlated with some of the explanatory variables (X_{it}, Z_i).

The presence of the potential correlation of α_i with the explanatory variables yields biased and inconsistent least squares (OLS) and generalized least squares (GLS) estimates of the parameters β, γ, σ_e^2, σ_α^2. The common method used to purge the estimates of potential bias arising from the endogeneity of some of the explanatory variables in the sample is the 'within-groups' or 'fixed effects' estimator from the analysis of covariance. This involves elimination of the individual effects in the sample by transforming the data into deviations from individual means and performing least squares. The OLS estimates from the transformed data have two significant limitations: (a) the data transformation eliminates all time-invariant variables, so their coefficients (γ) cannot be estimated, and (b) the within-group estimator is not fully efficient since it overlooks variation across individuals in the sample. Another approach is to find instruments for the X_{it} and Z_i which are uncorrelated with α_i. The difficulty is in finding the appropriate instruments, excluded from equation (5.6), and that are uncorrelated with α_i. This approach, however, ignores the time-invariant characteristic of the latent effect, α_i.

Hausman and Taylor (1981), Amemiya and MaCurdy (1986), and Breusch, Mizon, and Schidmt (1989) proposed consistent instrumental variable estimators for panel data regression models that do not suffer from the above problems when the individual effects are correlated with some explanatory variables. The techniques depend on a correct partitioning of the explanatory variables into time-varying and time-invariant variables that are correlated and those that are uncorrelated with the unobserved household-specific effect.

The Hausman and Taylor (1981) –hereafter HT- estimator utilizes assumptions about which explanatory variables are uncorrelated with the individual effects. If there are more time varying exogenous variables than time invariant endogenous variables, the HT estimator is consistent than the within estimator. Efficiency gains are derived from the use of each exogenous time varying explanatory variable as two instruments: first as means, and second as deviations from the means.

Amemiya and MaCurdy (1986)-hereafter AM- improved the HT estimator, by proposing an IV estimator that if consistent, is no less efficient than the HT estimator. Possible efficiency gains are obtained from the use of each exogenous time-varying variable as (T + 1) instruments, i.e. as deviations from the means and separately for each of the T available time periods.

Bruesch, Mizon, and Schmidt (1989) -hereafter BMS-extended the AM reasoning and derived an even more efficient IV estimator. Efficiency gains stem from the use, as instruments of (T-1) linearly independent values of deviations from means of each of the time-varying endogenous variables in addition to deviations from means of time-varying exogenous variables also used by the HT and BMS estimators.

Combining all NT observations, equation (5.6) can be written as:

$$y = X\beta + Z\gamma + V\alpha + \varepsilon \qquad (5.7)$$

where y and ε are NT x 1, X is NT x K, Z is NT x G, and V is an NT x N matrix of individual-specific dummy variables[7]. For any matrix A, let P_A be defined as $A(A'A)^{-1}A'$ and let $Q_A = I - P_A$. Therefore for the NT x N matrix V of household dummies $P_v Y$ is the vector of individual means, while $Q_v Y$ is the vector of deviations from individual means for Y. For the time-invariant variables Z, $P_v Z = Z$ and $Q_v Z = 0$, while for the time-varying variables X, $P_v X$ is the matrix of household means of X, and $Q_v X$ is the matrix of deviations from household means for the X variables.

The traditional estimator for the model (5.7) is the within estimator, calculated by eliminating the individual effects in the sample through transforming the data into

[7] This section follows from Hausman and Taylor (1981), Amemiya and MaCurdy (1986) and Bruesch, Mizon, and Schmidt (1989) and Cornwell and Rupert (1988).

deviations from individual means and performing least squares. Given that $Q_v Z = 0$, only β is estimated, such that

$$\hat{\beta}_w = (X' Q_v X)^{-1} X' Q_v y \tag{5.8}$$

The within estimator is consistent as *N* or $T \to \infty$ - whether or not the individual effects are correlated with the regressors (Cornwell and Rupert, 1988).

In situations where some of the explanatory variables (*X* and *Z*) are correlated with the latent individual effects, the HT, AM and BMS are potentially more efficient IV procedures. Using the notation in keeping with HT, BMS and Cornwell and Rupert (1988), X and Z are partitioned as:

$$X = (X_1 \vdots X_2),\ \ Z = (Z_1 \vdots Z_2), \tag{5.9}$$

where X_1 and Z_1 are uncorrelated with the household effect, α_i, while X_2 and Z_2 are correlated with the effects. X_1 has K_1 columns, X_2 has K_2 columns, $K = K_1 + K_2$; Z_1 has G_1 columns, Z_2 has G_2 columns, $G = G_1 + G_2$. X_1 and Z_1 are assumed to be uncorrelated with α_i, while X_2 and Z_2 are assumed to be correlated with α_i.

The HT, AM and BMS estimators are all calculated in the same manner; only the sets of instruments differ. First, (5.7) is transformed by the square root of the inverse of the disturbance covariance matrix ($\Omega^{-1/2}$) to transform the error term to one that has a scalar covariance matrix. In the absence of correlation between the explanatory variables and the individual effects, the within and between groups information is used in a straightforward calculation of Ω. From equation (5.6), $\text{cov}(\eta \mid X, Z) \equiv \Omega = \sigma_\varepsilon^2 I_{TN} + \sigma_\alpha^2 \left[I_N \otimes l_T l_T' \right] = \sigma_\varepsilon^2 I_{TN} + T\sigma_\alpha^2 P_v$, a block diagonal matrix, where l_T denote a T element vector of ones. Assuming α_i and ε_{it} are normally distributed, the within group and between group coefficient estimators and the sum of squared residuals from the fixed effects and random effects models are jointly sufficient statistics for β, γ, σ_ε^2, σ_α^2 (Hausman and Taylor, 1981). The GLS estimator is, therefore, the minimum variance matrix-weighted average of the within and between group estimators, where the weights depend on the variance components σ_ε^2 and σ_α^2.

In the present situation where explanatory variables are believed to be correlated with the individual effect, i.e. $E(\alpha_i \mid X_{it}, Z_i) \neq 0$, the above GLS estimator will be biased and inconsistent since it is a matrix-weighted average of the consistent within-group estimator and the inconsistent between group estimator.

Following Hausman and Taylor (1981), the GLS estimator can be written in a different way for numerical and analytical convenience. Let $\theta = \left[\sigma_\varepsilon^2 /(\sigma_\varepsilon^2 + T\sigma_\alpha^2)\right]^{1/2}$. Then the $TN \times TN$ non-singular matrix $\Omega^{-1/2} = Q_v + \theta P_v$ transforms the disturbance covariance matrix Ω into a scalar matrix where σ_ε^2 is the variance of the basic error term (ε_{it}), and σ_α^2 is the variance of the individual specific error terms (α_i). A consistent estimate of σ_ε^2 can be obtained from the fixed effects model using the within group estimator. When there is no correlation between the individual effects and the regressors, σ_α^2 can be obtained from the random effects model. But in the presence of correlation, the variance is estimated by subtracting the within variance from the total variance as suggested by Hausman and Taylor (1981, pp. 1383-1384).

Let s^2 = total variance, s_α^2 = estimated variance of the household effect and s_ε^2 = the estimate of σ_ε^2 from the within group estimator, then

$$s^2 = (1/N)(Y - X * \hat{\beta} - Z * \hat{\gamma})' P_v * (Y - X * \hat{\beta} - Z * \hat{\gamma}) \tag{5.10}$$

$$s_\alpha^2 = s^2 - (1/T)s_\varepsilon^2 \tag{5.11}$$

s_α^2 is consistent for σ_α^2 as $N \to \infty$, i.e. consistent estimates of the variance components and may be substituted for the variance components without loss of asymptotic efficiency. With consistent estimates of σ_α^2 and σ_ε^2, we now have a consistent estimate of $\Omega, \hat{\Omega}$.

The transformed model is:

$$\hat{\Omega}^{-1/2} y = \hat{\Omega}^{-1/2} X\beta + \hat{\Omega}^{-1/2} Z\gamma + \hat{\Omega}^{-1/2}(V\alpha + \varepsilon). \tag{5.12}$$

The next step is to perform instrumental variable estimation on (5.12). This gives estimators of the form:

$$\begin{pmatrix}\hat{\beta}\\ \hat{\gamma}\end{pmatrix} = \left[(X \vdots Z)'\hat{\Omega}^{-1/2}P_A\hat{\Omega}^{-1/2}(X \vdots Z)\right]^{-1}(X \vdots Z)'\hat{\Omega}^{-1/2}P_A\hat{\Omega}^{-1/2}y \tag{5.13}$$

The set of instruments used by HT is:

$$A_1 = (Q_v X_1, Q_v X_2, P_v X_1, Z_1) \tag{5.14}$$

Each variable in X_1, the uncorrelated time varying regressors, provides two instruments since the means $(P_v X_1)$ and the deviations from the means $(Q_v X_1)$ are used separately. The HT order condition for the existence of the estimator requires that there be as many instruments as regressors:

$$2K_1 + K_2 + G_1 \geq K + G, \qquad \text{or} \qquad K_1 \geq G_2$$

The instrument set for the AM estimator is:

$$A_2 = (Q_v X_1, Q_v X_2, X_1^*, Z_1) \tag{5.15}$$

or $$A_2 = [Q_v X_1, Q_v X_2, P_v X_1, (Q_v X_1)^*, Z_1] \tag{5.16}$$

where X_1^* is an $NT \times TK$ matrix with each column containing values of X_{1it} for a single time period. Similarly, $(Q_v X_1)^*$ is a matrix with each column containing the deviation from means of the X_1 variables for a single time period. The order condition for AM to exist is $TK_1 \geq G_2$. The difference between the HT and AM estimators lies only in the treatment of the time varying exogenous variables, X_1. Whereas HT use each such variable as two instruments ($P_v X_1$ and $Q_v X_1$), AM use each of the X_1 variables as (T+1) instruments ($Q_v X_1$ and X_1^*), i.e. both HT and AM estimators use $Q_v X_1, Q_v X_2, P_v X_1$ and Z_1 as instruments, but the AM estimator uses $(Q_v X_1)^*$ as an additional set of instruments. AM treats the time-varying endogenous variables, X_2 in the same way as the HT estimator. Consistent estimates from AM estimator are no less efficient than from the HT estimator. However, AM requires slightly stronger exogeneity conditions. Whereas HT only requires that the means of the X_1 variables be uncorrelated with the individual effects, AM estimators need uncorrelatedness at each point in time, i.e. plim

$(N)^{-1}\sum_{i=1}^{N} X_{1it} = 0 \ \ (t = 1,...,T)$.

The BMS approach extends the AM estimator by its use of the $(T-1)K_2$ additional instruments in $(Q_v X_2)$,* i.e. by the extension of the treatment of X_1 variables to the correlated X_2 variables. The BMS estimator uses the instrument set:

$$A_3 = [Q_v X_1, Q_v X_2, P_v X_1, (Q_v X_1)^*, (Q_v X_2)^*, Z_1] \qquad (5.17)$$

where $(Q_v X_2)^*$ is defined in the same way as $(Q_v X_1)^*$. The order condition for the BMS estimator to exist is $TK_1 + (T-1)K_2 \geq G_2$. There are possible gains in efficiency from the BMS procedure as long as $(Q_v X_2)^*$ are valid instruments. $(Q_v X_2)^*$ is a legitimate set of instruments only if X_2 is correlated with the individual effect through a time-invariant component. If on the other hand, the time varying components of X_2 are correlated with the individual effects, then $(Q_v X_2)^*$ is not a legitimate set of instruments.

The Hausman and Taylor (1986) estimator (HT) represents a distinct improvement over the within estimator, since more efficient estimates of β and consistent estimates of γ are possible. Even more efficient estimates of β and γ are possible with the AM and BMS procedures. The extent of the efficiency gain is an empirical question.

Given the Hausman test result noted earlier, and developed later in chapter 6, the HT, AM and BMS techniques are used to estimate the food consumption, calorie intake and marketed surplus equations. In the food consumption and marketed surplus regressions, the variables are grouped as follows:

X_1 = (WIFE'S INCOME, LAND AREA, ANIMAL VALUE, AGE AND EDUCATION OF HOUSEHOLD HEAD, HOUSEHOLD SIZE)

X_2 = (HOUSEHOLD INCOME),

Z_1 = (EDUCATION OF HOUSEHOLD HEAD, HOUSEHOLD SIZE, DISTANCE TO CROP MARKET, DISTRICT)

and $Z_2 = (\phi)$.

The grouping for the calorie intake regression is:

X_1 = (LAND AREA, ANIMAL VALUE, AGE OF HOUSEHOLD HEAD, HOUSEHOLD SIZE),

$$X_2 = \text{(FOOD EXPENDITURE)},$$

$$Z_1 = \begin{pmatrix}\text{EDUCATION OF HOUSEHOLD HEAD, HOUSEHOLD SIZE,} \\ \text{DISTANCE TO CROP MARKET, DISTRICT}\end{pmatrix}.$$

and $Z_2 = (\phi)$.

<u>Data</u>

Earlier studies (reviewed by von. J. Braun and Kennedy, 1994) assessing the impacts of commercialization and market orientation of semi-subsistence farmers have three major weaknesses. First, these studies focus on the nutritional status of the cash crop adopting group without regard to the nutritional status before adoption. Second, some studies compare the nutritional status of adopting and non-adopting households without control for differences in resource bases between the two groups. Third, previous studies do not consider differences in nutritional status during different times of the year.

The optimal strategy in planning the research would have been to survey semi-subsistence households before, and at several stages after, the introduction of the intensified dairy production system. The cost and length of time involved in undertaking such surveys precluded pursuing this optimal strategy. The alternative strategy followed consisted of cross-sectional and time series comparisons of two groups – one that has switched to intensified dairy production and the other that had remained in traditional animal husbandry. This strategy required careful selection of two groups with similar resource bases that might determine the decision to use intensified dairying and affect food security.

Detailed socio-economic and demographic data at the household level and individual levels, used in this study were collected by the researcher, in collaboration with International Livestock Research Institute (ILRI) in1999. Panel data are available for 56 households: 27 with improved dairying practices and 39 using traditional dairying methods. Of the 56 households surveyed, only two were female headed. Information was obtained on income, expenditure, production, consumption, input use, resource allocation (land, labor), and demographic variables such as age, educational level and household size.

Data Collection Method

The questionnaires used to collect data from the sampled households are (1) socioeconomic, (2) food intake, (3) baseline, (4) land measurement, (5) sample yields and (6) round trip distance and time from households to main crop market.

Socio-economic Questionnaire: This questionnaire was used to collect data on incomes and expenditures on food and non-food items, production and distribution of dairy products, and labor allocation to dairying activities. The majority of the farmers were visited once a week and information was obtained on a daily recall basis. The household member who went to the market (wife, husband or child) provided information on what was bought and sold. Information on food consumption and quantities of food consumed from own production was mostly given by the wife, and that on farm income and expenditure, animal feed, and other farm inputs, animal sales and crop sales (in large quantities) was mostly by the husband. The food items listed in the questionnaires were sometimes read to facilitate recall. Children attending school assisted in recording what was bought and sold in their households, the quantities of food items eaten from own production and the production and distribution of dairy products. The households that did not have children and had trouble remembering the above information were visited more than once a week. Quantities and prices reported in local units were converted to standardized units (“Systeme Intanational” SI – International System units), and incomes and expenditures calculated. Data for labor allocation on the dairy operation were recorded once every two weeks. These data were collected on holidays, when farmers do not undertake crop activities, but can perform dairy operations. Farmers were observed for 12 hours and information recorded on the start and finish time of each dairy operation.

Food Intake Questionnaire: This questionnaire was used to obtain information from women who normally prepare the food on (1) the types and quantities of ingredients, in standardized units, used to prepare food eaten in the household during the last 24 hours, (2) the ages and number of people, including guests who consumed the meals, and (3) the proportion of meals left over. Care was taken to collect information on consumption of snack foods, especially the energy dense ones such as roasted and boiled cereals, *kolo* and *nifro*. This information was obtained every month. In the study area, there is a large day-to-day variation in food consumption, depending on whether it is a fasting or non-fasting day. Animals and dairy products are not consumed during fasting days. There were 139 fasting days spread throughout the year in the study area, populated primarily by Orthodox Christians. In order to capture a more typical food intake behavior, food consumption information was collected from six fasting and six non-fasting days, during the 1999 survey.

<u>Baseline Questionnaire</u>**:** This questionnaire was administered once each year and was used to obtain (a) demographic information on each household member, such as names, relation to household head, marital status, age, sex, education and main occupation during the wet and dry seasons and (b) livestock type, age (months), breed, origin and value in Birr. The husband, wife or both gave this information.

<u>Land Measurements Questionnaire:</u> This questionnaire was administered once each year to record the total land holding (cropped, fallow and pasture) area of the household. The area was measured by assigning fields and plot numbers and taking measurements of each plot in each field with a measuring tape. The number of plots corresponded to the different crops grown in a given field. The number of fields matched the different parcels of land the household owned in different locations. The area of the land was calculated by dividing the plots into different triangles.

<u>Sample Yield Questionnaire:</u> Samples were taken from five different spots in each plot using a one square meter quadrant before farmers began harvesting, and after the total area covered by each crop has been recorded. The crops were harvested using a sickle and collected in fertilizer bags. The bags were labeled according to the plot and field numbers, crop type and sampling date. The harvested crops were threshed carefully on dry cattle skin, *kurbert*, winnowed, and the grain yield recorded. Based on the sample yields and the total cropped area, the amounts of different grains harvested by each farm household were estimated.

<u>Round Trip Distance and Time from Households to Main Crop Market Questionnaire:</u> This questionnaire was completed once during the two years data were collected. Information was collected on the name of the market, transportation system

used (trekking, mule/horse or vehicle), round trip distance in kilometers and time (in minutes) from the household to the market.

Most studies evaluating the effects on increased income of nutritional status only collect food and non-food consumption data, because of the expense involved in collecting income and food intake information (Bouis and Haddad,1990). Many researchers also feel that total expenditure, the sum of food and non-food expenditures, a proxy for income, is a better measure for "the permanent income" than income (Bouis and Haddad,1990). Quantities of particular foods included in the food consumption questionnaire give an estimate of calorie availability. This differs from calorie intake, collected from 24-hour food intake recall, by the amount of food purchased, but not eaten, by household members. This could be due to food wasted in storage or during preparation, and food given out or fed to guests or beggars.

Bouis and Haddad (1990) discussed several questions that could be raised regarding the collection of income, expenditure, and food intake data, addressing which are more reliable and how these variables could be related empirically. Two key points are noted. First, any random errors in measuring food purchases are transmitted both to calorie availability and to total expenditures, leading to correlation among measurement errors for these three variables and the error term. This results in upwardly biased coefficients on the explanatory variables, if any pair of these variables (one as the dependent variable) is used in the regression analysis with ordinary least squares (Bouis and Haddad, pg 79. 1990). Second, systematic underestimation of meals served to non-family members may be positively correlated with income, resulting in an overestimate of family food consumption for high-income groups and to an overestimate of the relationship between calories and income, if calories available data are used. Because of the difference between calorie availability and calorie intake, and the possibility of collecting income data, this study uses income and calorie intake data in the regression analysis.

Measurements of Selected Variables

Separate sections of the questionnaires were used to determine the relationship between higher incomes from intensified dairying and household food consumption, calorie intake, and marketed surplus.

Household Income

Household income was obtained from the difference between combined farm (including value of food from own production) and off-farm household income, and expenditures on variable inputs, such as animal health/veterinary services and feed, land rent, fertilizer, herbicides, insecticides etc.

Calorie Intake per Adult Equivalent

An extremely involved calculation is necessary to obtain calorie intake from the various ingredients and quantities used in preparing food consumed during different meals. The food consumption tables compiled by the Ethiopian Health and Nutrition Research Institute include the calorie content per 100 grams of various edible ingredients common in the surveyed area and were used to convert quantities of ingredients to calories. The total calories consumed by the household members were divided by the number of adult equivalent household members to obtain calorie intake per adult-equivalent person for each household. Calorie intake for individual groups of household members, such as children, women and men could not be obtained because household members mostly eat from a common plate. Quantities of leftovers were deducted and guests who joined the household in a meal were accounted for to avoid overestimating calories consumed by household members.

Household Size

Household size is obtained by converting each household member according to age and sex into an adult equivalent using the FAO/WHO coefficient for converting family size into standardized household size (Shiferaw, 1991).

Marketed Surplus

Marketable surplus is the aggregate value of all food products sold. Cereals and dairy products make the bulk of marketed food products.

Descriptive Analysis

One method to test the impact of MODP is through statistical comparison of households with and without CBC. The descriptive analysis is based on means and standard deviations (SD) computed from the 1999 data sets. Independent sample t-tests are conducted to test the differences between CBC and LBC groups. Comparison in resource allocation, income distribution and expenditure patterns of adult male and females were also carried out. The comparisons between the groups and gender were made to provide the basis for the more comprehensive assessment (via econometric analysis) of the impact of market-oriented dairying with crossbred cows on food security of participating households.

Value of Food Consumed from own Production and Cash Food Expenditure Impacts

In the CBC and LBC households, 66.4% and 67.2% respectively, of the value of total food consumed are home grown (calculated from Table 5.2). The difference in the values of food from own production and purchases from the market reflects the semi-subsistence characteristic of the households.

Given home produced food in semi-subsistence agriculture, cash expenditure on food can change as a consequence of higher and more readily available cash income from dairy operations as noted with other examples of agricultural commercialization (Kennedy and Cogill, 1987). For the households considered in this study, cash food expenditures for CBC households are significantly higher than for the LBC households. Average monthly per adult equivalent cash food expenditure is 36% higher for CBC compared to LBC households, and is statistically significant at the 1% level (Table 5.2).

Table 5.2. Cash Food Expenditures and Value of Food from Own Production

Variables	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD
Cash Food Expenditure per adult						

equivalent (Birr/Month)**	13.88	10.48	16.13	11.81	11.84	8.63
Women's Food Expenditures (Birr/month)**	57.20	52.11	65.03	51.20	50.10	51.98
Husband's Cash Food Expenditures (Birr/month)	19.15	34.34	19.27	37.28	19.05	31.49
Food Consumption from Own Production (Birr/month) **	153.62	137.99	172.03	168.03	136.76	100.42
Food Cash Expenditure (Birr/month)**	76.35	54.51	84.30	57.40	69.05	50.79

**Statistically significant differences in means between the groups at the 0.01 level using a t-test.

Earlier research (Tangka et al., 2000) shows that the wife and husband have different responsibilities based on gender to meet family needs. The literature also implies that each family member mainly uses the incomes they earn to achieve their given tasks. This is not true in all cases, as income may be earned in one way and expenditure done in another way. Women tend to spend more on food than do men. For example, in a study of the Beti in Cameroon, Guyer (1980 and 1988) reported that women contribute two-thirds of total cash expenses for food and routine household supplies. Analogous findings are demonstrated in more recent studies, such as Kennedy and Peters (1992) who illustrate that female-headed households in Kenya and Malawi spend a larger proportion of their incomes on food as compared to male-headed households. This may be partly because female-headed households are poorer and generally spend more on basics like food.

An interesting question is whether intensified dairying changes how income is handled by husbands and wives, and if these changes adversely affect food expenditures and preparation, which are traditionally women's responsibility. According to gender division of labor within rural Ethiopia, women are responsible for buying and selling certain food items (vegetables, butter and cheese, small quantities of cereals etc.) and for preparing food, among other household reproductive chores. Table 5.2 shows that women in both CBC and LBC households are spending more income on food than men do.

Women make over 70% of cash food expenditures in both groups. With the introduction of MODP technologies, purchasing of food by women in CBC increased by 30%, while men in CBC households only increased their purchases of food by about 1%. Increased cash food expenditure by women in CBC households implies that women's defined functions have not changed but have been made easier, i.e. due to higher income (shown in Table 5.4) from improved dairying they are able to spend more on culturally defined functions, such as purchasing of food.

Calorie Intake Impacts

Several studies have documented that technological change and commercialization of smallholder production improve the level of food consumption, hence the calorie intake of participating households (von J. Braun and Kennedy, 1994). Changes in food consumption is generally associated with more readily available cash income. Meanwhile, increased commercialization may result in greater self-sufficiency via increased productivity of land and labor inputs allocated to the commercial activity and with changes in cropping patterns (von J. Braun 1995). With higher income, a substitution of cheap calories for more expensive calories can take place and consequently diets gain not only in quantity, but also in quality and diversity. Consumption changes effected by technological change and commercialization have been attributed to increased income rather than to higher food availability (Binswanger and von Braun, 1991; Alderman, 1987).

The recommended minimum daily calorie intake per adult equivalent for Ethiopia is 2339 (Cleaver and Donovan, 1995). Household members in CBC and LBC households are meeting only 94% and 73% of this requirement, respectively. As depicted in Table 5.3, CBC households consume 30% more calories per adult-equivalent person than LBC households. The comparison in Table 5.3 show differences that are both nutritionally and statistically significant between the CBC and LBC groups.

Table 5.3. Calorie Intake per Adult Equivalent and per Capita

Variables	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD

Calories Per Adult Equivalent						
Person (daily)**	1941.8	680.9	2210.0	713.0	1700.7	549.0
Calories Per Capita (daily)**	1588.4	487.9	1793.2	512.5	1404.3	380.6

Source: International Livestock Research Institute, 1999 Survey

**Statistically significant differences in means between the groups at the 0.01 level using a t-test.

Figure 5.1 illustrate seasonal variation in calorie intake per adult equivalent information. The calorie intake patterns are suprisingly similar for the CBC and the LBC groups, i.e. high during and after harvest (December to June) and low just before harvesting (October and November). The primary difference is that CBC households (the higher income group) consume approximately 30% more calories per adult-equivalent than the LBC households (the lower income group) throughout the year. The results suggest substantial and significant food security improvements with the MODP technologies.

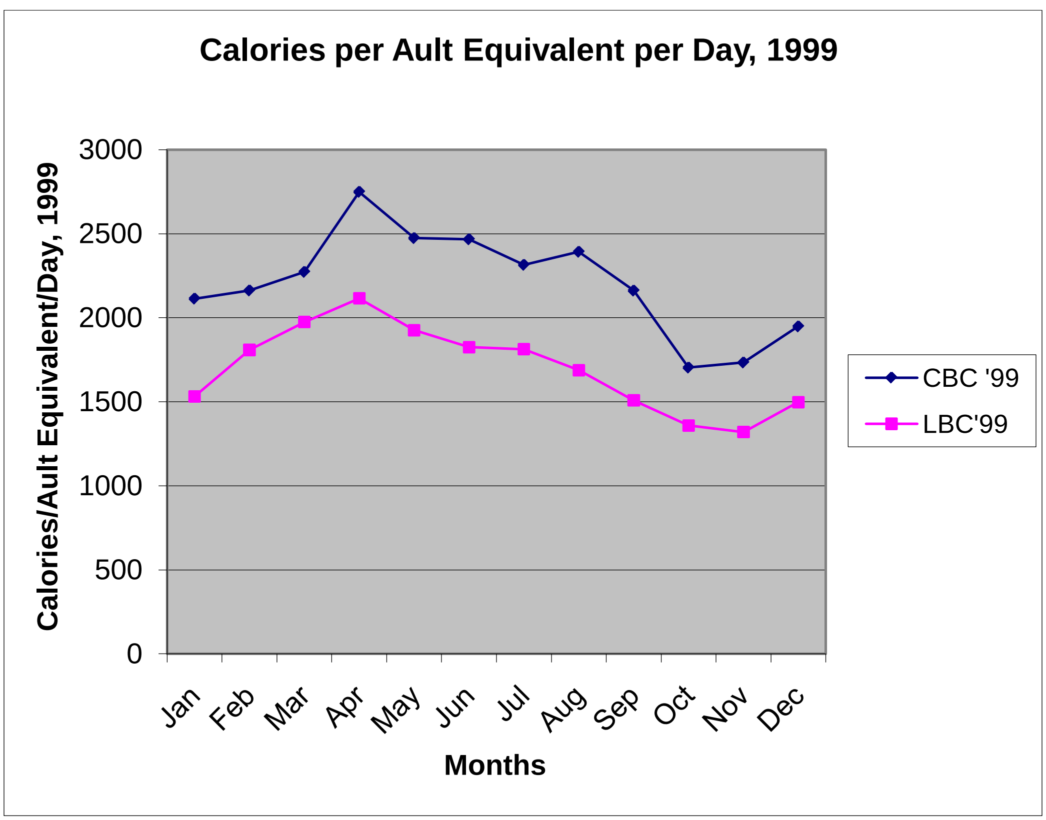


Figure 5.1: Seasonal Variation in Calorie Intake per Adult Equivalent per Day

Incomes Impacts

Numerous studies in East Africa and India have shown significant increases in cash incomes of CBC households as a result of higher milk production and increased commercialization of dairy products (Gryseels and Whalen, 1984; Kennedy and Cogill, 1987; Walshe et al., 1991; Shapiro et al, 1998). Similar results were shown for this study in Table 5.4, household and dairy cash incomes were significantly higher in households that keep CBC (208.37 and 158.85 Birr per month, respectively) than in households that keep LBC (162.58 and 13.61 Birr per month, respectively). The difference is attributed mainly to the sales of liquid milk. Disaggregating cash incomes into dairy, non-dairy farm and off-farm income sources, monthly dairy income of CBC farmers is 11.67 times higher than that of farmers using traditional production methods.

An important question is whether the introduction of intensified dairying makes women better or worse off. As depicted in Table 5.4, under traditional dairy production practices, women retain 99.9% of the dairy incomes. Whalen (1983) reported that under traditional dairy practices, most of the milk yield is processed into butter and sold in the local market, activities exclusively undertaken by women. Women use the proceeds to purchase household consumption items, primarily food. As reflected in Table 5.4, the husband's dairy incomes increased more with intensified dairying. Note, however, that the primary purchaser, the Dairy Development Enterprise, requires household heads, mostly men, to register as the seller and collect the cash income. Their monthly cash income from fresh milk sales were 58 Birr compared to zero for the LBC owners. The dairy and household incomes of women in CBC households were also 7 and 1.5 times those of women in LBC households. In addition to increases mainly from the marketing of fresh milk, women in CBC households gain additional dairy income through sales of butter and cheese, i.e., higher milk output allowed women to process more while some was sold liquid for cash. While women in LBC households realized a large share of dairy income relative to their husbands, due to defined division of work, women in CBC households earned nearly 7 times more dairy income than women in LBC households due to the same division of work but bigger opportunities with increased output. Women in

CBC households realized about 59% of total dairy income, mostly from the sell of milk and milk products. Men sell mainly liquid milk.

Table 5.4 indicates that the average monthly non-dairy farm and off-farm incomes between the CBC households and LBC households were not statistically different, with the exception of women’s non-farm incomes. This suggests that the higher household incomes occurring in CBC households were attributed mainly to dairy sales as a consequence of intensified dairying. In CBC households, men earn 65% and 63% of non-dairy farm and off-farm incomes, respectively. While in LBC households, men earned 55% of both non-dairy and off-farm incomes (Table 5.4 and Figure 5.2). Non-farm dairy incomes were obtained from sale of crops, live animals, cow dung, animal skins, animal feed, land rental, and animal service (bull service). Off-farm income sources included weaving, handicraft, house rent etc.

Table 5.4.Monthly Household and Cash Incomes

Income Types	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD
Household Income						
(Birr/Month)*	184.31	277.57	208.37	327.58	162.58	221.19
Sources of Cash Income						
1. Dairy Sales (Birr/month)**	82.54	152.14	158.85	189.60	13.61	40.47
Total Husband**	30.71	114.75	64.68	159.97	0.02	0.38
Wife**	51.83	109.87	94.17	142.39	13.59	40.09
Milk Husband**	27.39	110.51	57.70	154.98	0.00	0.00
Wife**	16.16	57.11	32.54	376.51	2.23	22.18
2. Non-Dairy Farm Income						
(Birr/month)	128.54	210	118.01	221.60	138.11	198.77
Husband			77.03	214.54	76.25	182.43
Wife**			40.98	60.08	61.86	89.04
2. Off-Farm Income	50.14	140.72	49.45	167.68	50.75	111.12
(Birr/month)						
Husband			31.24	152.38	28.14	72.24
Wife			18.21	67.08	22.61	88.58

*Statistically significant differences in means between the groups at the 0.05 level

**Statistically significant differences in means between the groups at the 0.01 level using the t-test.

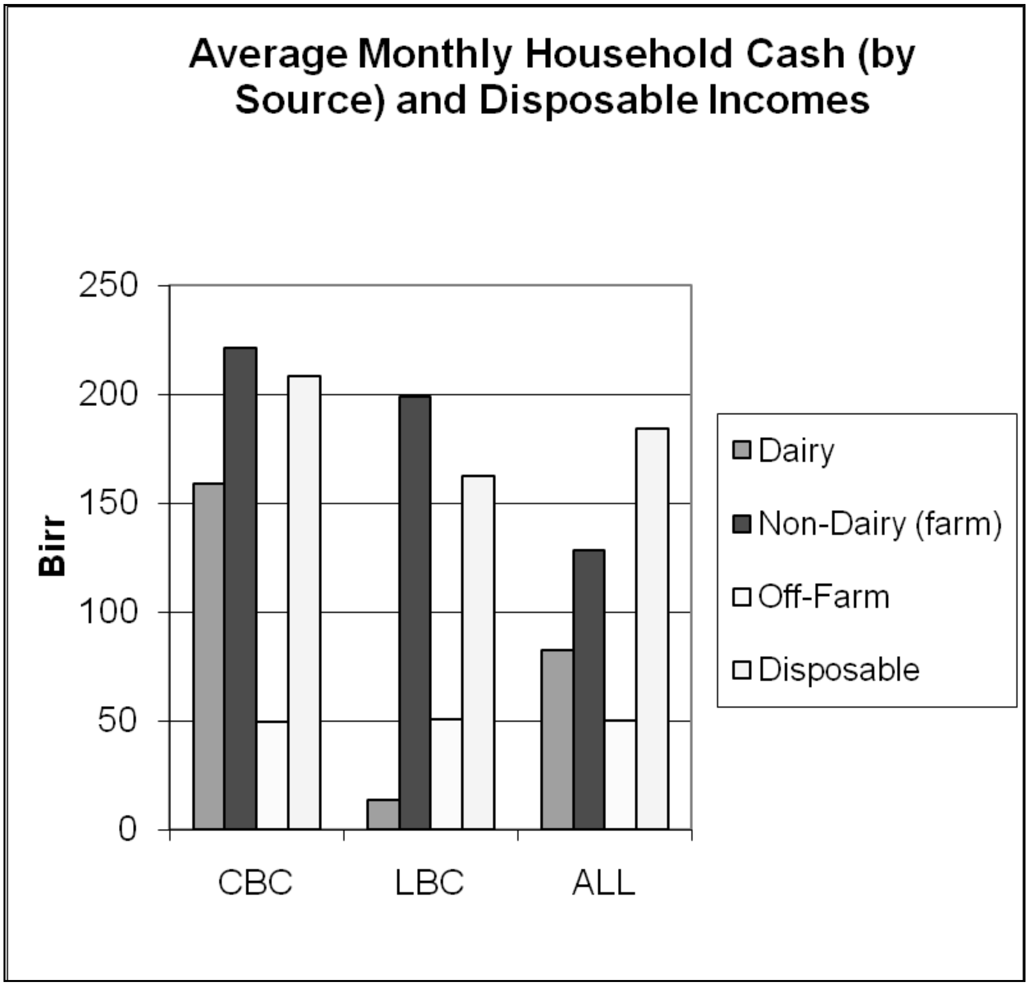


Figure 5.2. Average Monthly Household Cash and Disposable Incomes

Non-food Expenditures Impacts

Expenditures discussed in this section are cash expenditures on farm inputs (fertilizer, herbicides, insecticides, seeds etc.), animal feed, animals, animal health, land rental and non-farm commodities. Expenditure levels are expected to change as a result of higher and more readily available cash income from dairy operations. Other examples of agricultural commercialization have shown the same impact (Kennedy and Cogill, 1987; von Braun, 1995). Similar findings were shown for this study in Table 5.6, households with CBC had higher cash expenditures compared to LBC households. In addition, the expenditure levels of men were higher than those of women for all non-food categories. The differences in levels of expenditures between men in the CBC and LBC households were statistically significant, except for animals and land rental. Men in households with CBC purchased significantly more animal feed and animal health services, as reflected in Table 5.5. It can thus be concluded that while women spent increased incomes that resulted from intensified dairying on food, men used increased income for farm investment and non-farm expenditures.

Milk Production and Labor Allocation Impacts[8]

Crossbred cows in intensified small-holder production systems can produce more milk, 5 to 8 times, higher than local cows. In a conducive peri-urban marketing environment, this can result in doubling or tripling of farm income (Gryseels and Whalen, 1984). In the study area, milk production per crossbred cow was approximately 5 times higher than for local cows (Shapiro et al., 1998).

Members in households with CBC spend more time in animal husbandry compared to LBC household members. In addition, CBC households hire more labor, men and children, than do LBC households (Table 5.6). Children (as herders), and to a lesser extent men, were found to be primarily responsible for animal husbandry. The introduction of MODP technologies increase the time women spend on animal husbandry activities by approximately one hour a week. This is less than the 6 hours increase in labor demand of men (Table 5.6). Given the relatively insignificant increase in women's labor input to dairying after the introduction of MODP technologies, the impact on time women spent on household reproductive activities, such as food preparation and childcare would be expected to be minimal.

[8] This section draws heavily from Shapiro et al. 1998.

Table 5.5.Monthly Average Non-food Expenditures

Expenditure Types	CBC Households		LBC Households	
	Mean	SD	Mean	SD
Farm Inputs (Birr/month)				
Husband*	29.86	105.91	14.45	44.87
Wife	3.39	28.34	1.06	9.41
Animal Feed (Birr/month)				
Husband**	32.72	56.33	1.14	6.53
Wife**	5.35	13.88	0.26	1.90
Animals (Birr/month)				
Husband	37.06	170.93	18.03	109.29
Wife	2.44	28.23	2.75	49.28
Animal Health (Birr/month)				
Husband**	2.25	6.10	0.58	3.29
Wife	0.19	1.38	0.07	0.64
Land Rental (Birr/month)				
Husband	4.67	29.65	1.55	18.93
Wife	0.00	0.00	0.00	0.00
Non-Food, Non-Farm (Birr/month)				
Husband**	52.21	135.79	33.69	73.69
Wife**	36.30	74.46	25.74	45.72

*Statistically significant differences in means between the groups at the 0.05 level
**Statistically significant differences in means between the groups at the 0.01 level using the t-test.

Table 5.6. Weekly Average Family and Hired Labor in Person Equivalent (hours) for All Dairy Activities.

Farm Group	Family Labor (hours)			Hired Labor (hours)	
	Men	Women	Children	Men	Children
CBC	10.9	2.7	24.7	5.4	10.4
LBC	4.8	1.8	25.1	0.5	0.5

Source: Shapiro et al., 1998.

Marketed Surplus Impacts

The average monthly values of marketed foods – such as crops, milk, butter, cheese, live animals, and other livestock products - were Birr 209, Birr 277 and Birr 148, for the whole sample, CBC and LBC groups respectively. The means for the CBC and LBC were statistically different at the 1% level of significance (Table 5.7). The difference is mainly accounted for by the higher sales of dairy products by the CBC households.

Table 5.7. Marketed Surplus

Variables	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD
Value of Surplus Food Marketed (Birr/month)**	209.04	254.68	276.56	285.69	148.06	205.06

**Statistically significant differences in means between the groups at the 0.01 level using a t-test.

Cropped Area and Animal Value Impacts

Households keeping CBC cultivated about 12% more land than households with LBC (Table 5.8). A possible explanation for the difference is that CBC households have more incomes that can be used to secure the necessary inputs (oxen, labor, fertilizer, herbicides and seeds) to cultivate more land. Though land was equally distributed on a per capita basis, CBC households may belong to a slightly higher size (per household) group due to sampling procedure.

The value of animal value in CBC households were twice that of LBC households

(Table 5.8). Improved breeds were more expensive than indigenous cattle. Also, households keeping CBC have larger herd sizes than households with LBC (Table 5.8). Although households utilizing MODP technologies were expected to replace draft LBC animals with CBC, the majority of the CBC households did not do so. The crossbred cows were mainly used for dairy production, while the local cattle were used as the source of draft power.

Table 5.8. Cropped Area and Animal Value

Variables	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD
Cropped Area (hectares)	2.40	1.03	2.57	1.06	2.2	.97
Animal Value (Birr)**	5732.8	3768.6	7843.0	4135.0	3826.8	2039.4
Herd Size (in TLUs[a])	7.9	4.2	9.06	4.4	6.9	3.8

[a]TLU stands for tropical livestock units. See Jahnke (1982) for conversion of animal heads count to TLU.
**Statistically significant differences in means between the groups at the 0.01 level using a t-test.

Demographic and Other Household Characteristics

Table 5.9 shows a summary of the demographics and other characteristics of the households in Holetta. Household size averaged 6.03 adult equivalents, with no statistically significant difference between the CBC and LBC households. Likewise, there were no difference between the ages and educational levels of the household heads. The average age of household head was 46.25 years. Households with CBC and LBC were located at equal average distances from the main crop market and were equally distributed in the two districts surveyed.

Table 5.9. Demographic and Other Household Characteristics

Characteristics	All Households		CBC Households		LBC Households	
	Mean	SD	Mean	SD	Mean	SD
Household Size (adult equivalent)	6.03	2.15	5.86	2.43	6.19	1.87
Age of Household Head (Years)	46.25	15.24	45.07	15.16	47.32	15.48
Round Trip Distance to the Main Crop Market (Km)	11.17	6.27	10.99	6.73	11.33	5.94

CHAPTER 6

ECONOMETRIC RESULTS AND INTERPRETATION

This chapter presents and discusses regression results of estimated equations and predicted changes in food consumption, calorie intake and marketed surplus resulting from MODP technologies. At each level of analysis, a comparison was made between results from the cross-bred cows (CBC) group and local breeds of cattle (LBC) group. Discussions on the regression results of the food consumption, calorie intake and marketed surplus equations were based on the Hausman and Taylor (1981) estimation procedure. There was no material difference (Appendix C) among the Hausman and Taylor, Amemiya and MaCurdy, and Bruesch, Mizon and Schmidt results.

Specification Test

An important assumption of the cross-section regression specification is that the conditional expectation of the disturbances given knowledge of the explanatory variables is zero. A useful property of panel data is that by following the cross-section over time, this assumption can be tested. Proceeding with the ordinary least squares estimator in the presence of correlation, between fixed effects and explanatory variables would result in inconsistent estimates. The specification test examines the null hypothesis $H_0 : E(\alpha_i \mid X_{it}, Z_i) = 0$ against the alternative $H_1 : E(\alpha_i \mid X_{it}, Z_i) \neq 0$. Based on the discussion in chapter 5 (econometric problem section), the household income variable on the right-hand side of the food consumption and marketed surplus equations was tested for correlation with the individual effects. Likewise, food consumption was tested for correlation with the latent variable in the calorie intake equation.

Hausman (1978) developed a two-step procedure for testing the correlation between individual effects and explanatory variables. The test procedure can be outlined using the food consumption equation where it is necessary to test for the correlation between income and the individual effects (α_i). The first step is to regress total household income on all other explanatory variables of the equation (presumed not to be correlated with the individual effects) plus at least one additional identifying variable. Total expenditure was used for the additional identifying variable. The second step involves regressing the food consumption equation as originally specified, but also including predicted household income obtained from step one as an explanatory variable. If the coefficient on predicted household income is significantly different from zero, then the null hypothesis of no correlation between the individual effects and total household income is rejected.

The Hausman test rejected the null hypothesis of no correlation between the individual effects and household income in the food consumption and marketed surplus equations and also between the individual effects and food consumption in the calorie intake equation. The results of the Hausman tests for the various equations are presented in Table 6.1. The t-tests show that the coefficients of the predicted household income in the food consumption and marketed surplus equations, and that of the predicted food consumption in the calorie intake equation were all statistically significant.

Since the Hausman test results (Table 6.1), indicate that the individual effects and household income in the food consumption and marketed surplus equations, and individual effects and food consumption in the calorie intake equation were correlated, these equations were estimated using the Hausman and Taylor (HT), Amemiya and MaCurdy (AM), and the Bruesch, Mizon and Schmidt (BMS) instrumental variable estimation techniques discussed in the previous chapter. The regression results from these procedures were compared with the standard generalized least squares (GLS) estimator. As observed in the previous chapter the instrumental variable estimates are consistent whereas the GLS estimates are inconsistent in the presence of correlation between the individual effect and explanatory variables. The AM and BMS estimates in Appendix C do not appear to be substantially different than the HT results. The discussion will thus be based on the HT results. The condition for identification using the HT technique is met, i.e. there are at least as many time-varying variables not correlated with the household effect as time-varying variables correlated with the household effect.

Table 6.1. Regression Results for the Hausman Test (Step 2)

Variables	Equations					
	Food Consumption		Calorie Intake		Marketed Surplus	
	Coefficients	Standard Errors	Coefficients	Standard Errors	Coefficients	Standard Errors
Household Income	0.0486	(.0043)[a]			.386	(.037)[a]
Household Size	-31.7436	(3.357)[a]	-93.036	(39.899)	-272.215	(31.85)[a]
Household Head Age	0.4975	(.2603)	-5.408	(2.622)	4.6197	(2.469)
Land Area	-10.5327	(6.5792)	-138.85	(43.006)[a]	-461.12	(62.39)[a]
Animal Value	-0.0068	(.0028)[a]	0.0380	(0.016)[a]	-0.1680	(0.026)[a]
E1 (1=read and write, 0=otherwise)[b]	1.0813	(8.475)	155.993	(85.609)	401.83	(80.38)[a]
E2 (1=Elemetary level, 0=otherwise)[b]	-42.6862	(12.89)[a]	82.941	(94.309)	-774.533	(122.2)[a]
E3 (1=High school, 0=otherwise)[b]	-13.3925	(10.934)	-2.0787	(116.47)	-460.895	(103.7)[a]
Wife's Income	-0.1439	(0.041)[a]			-2.975	(0.386)[a]
Crop Market Distance	-3.8516	(1.322)[a]	2.3258	(6.3367)	-116.15	(12.54)[a]
District (0-1 dummy variable)	42.9865	(15.61)[a]	374.996	(90.917)[a]	1133.61	(148.1)[a]
Value of Food Consumption			-1.4975	(0.6344)[a]		
First Quarter Dummy	-76.0355	(25.55)[a]	246.153	(109.82)[a]	-1890.58	(242.3)[a]
Second Quarter Dummy	-84.5813	(27.94)[a]	523.365	(110.09)[a]	-2116.55	(264.9)[a]
Third Quarter Dummy	-14.9736	(15.71)[a]	226.288	(129.95)	-1183.23	(148.9)[a]
Predicted Household Income	0.2633	(.0688)[a]	5.210	(2.048)[a]	5.5487	(0.652)[a]
Predicted Value of Food Consumed			4.5044	(2.2131)[a]		
Constant	176.372	(22.274)	2044.53	(337.66)	1574.99	(211.3)
N	224		224		224	
R^2	0.7108		0.5619		0.7172	

Notes: Standard errors are in parentheses.
[a]Significant at the 0.05 level. [b]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

The Effect of MODP Technologies on Food Consumption

The estimated food consumption equations regression results presented in Table 6.2 relate to equation (5.1). A first question of interest is whether or not the response of food consumption to changes in the explanatory variables was significantly different between the CBC and the LBC households. The Wald statistic for equality of the parameters is:

$$W = (\hat{\beta}_{CBC} - \hat{\beta}_{LBC})' \left[(Cov(\hat{\beta}_{CBC}) + Cov(\hat{\beta}_{LBC}) \right]^{-1} (\hat{\beta}_{CBC} - \hat{\beta}_{LBC}) \qquad (6.1)$$

where $\hat{\beta}$ and Cov are parameter estimates and covariance matrices from the CBC and LBC equations. The Wald statistic, W, distributed as χ^2_{15} under the H_0, has a value of 16.56. Since the critical value for the χ^2_{15} is 22.3 at the 10 percent level, the parameters for the food consumption equation explanatory variables are not significantly different for the CBC and LBC groups. Given the result of the Wald test, the interpretation of the empirical results of the impact of MODP technologies on food consumption are based solely on the combined results.

The coefficient of total household income is positive and significant so that increasing household income increases expenditures on food consumption. The marginal propensity to spend on food is 0.034. The corresponding food consumption elasticity with respect to income, calculated at the means, is 0.29. With a 100% increase in income, food consumption increases by 29%.

Animal value and cropland area appear in the food consumption equation as a result of the joint production-consumption nature of the households. As such, they are also measures of household wealth, and provide a stream of permanent income. Incomes on the other hand were measured quarterly, and vary from season to season and thus are not a good indicator of permanent income. Cropland has a positive and significant influence on food consumption, with a corresponding elasticity of food consumption with respect to land area of 0.26. Animal value positively and significantly influences food consumption: a marginal increase in animal value increases food consumption by 0.034, with a corresponding elasticity of 0.183.

Table 6.2. Food Consumption Equation

Variable	All Households		CBC Households		LBC Households	
	GLS	HT	GLS	HT	GLS	HT
Constant	123.79 (21.1045)	122.57 (22.873)	170.663 (55.475)	171.41 (59.802)	99.8698 (20.128)	98.02 (15.934)
Household Income	0.0421 (0.0043)[a]	0.03407 (0.0049)[a]	0.0361 (0.0063)[a]	0.0286 (0.0069)[a]	0.0498 (0.0063)[a]	0.0466 (0.0083)[a]
Animal Value	0.0035 (0.0010)[a]	0.00384 (0.0011)[a]	0.0024 (0.0025)	0.0024 (0.0027)	0.0043 (0.0019)[a]	0.0039 (0.0016)[a]
Cultivated Land Area	11.7918 (3.6987)[a]	12.382 (4.019)[a]	15.5163 (7.089)[a]	17.109 (7.6865)[a]	4.9849 (4.539)	5.9725 (3.6907)
Household Size	-19.7826 (1.6603)[a]	-19.402 (1.8066)[a]	-19.867 (3.349)[a]	-19.161 (3.6301)[a]	-14.524 (2.204)[a]	-14.650 (1.7573)[a]
Household Head Age	-0.0155 (0.2755)	-.03123 (0.2998)	-0.3536 (0.6809)	-0.377 (0.7363)	-0.1128 (0.2826)	-0.1023 (0.2170)
E1 1=read& write 0=otherwise[c]	-9.0891 (8.8174)	-9.533 (9.5907)	-29.9799 (21.4434)	-33.860 (23.250)	3.2868 (9.867)	3.7342 (7.6601)
E2 1=elementary, 0 = otherwise[c]	-3.5982 (9.9199)	-2.3571 (10.793)	-22.8493 (26.0953)	-24.658 (28.252)	-0.6355 (9.0467)	-0.4974 (7.753)
E3 1=highschool, 0 =otherswise[c]	5.0104 (12.1172)	5.6003 (13.182)	-26.6935 (32.560)	-29.064 (35.248)	17.9226 (11.326)	17.627 (8.7711)[a]
Crop Market Distance	0.7566 (0.6608)	0.8787 (0.7178)	-0.2917 (1.4645)	-0.2890 (1.5822)	1.1493 (0.7162)	1.3280 (0.5900)[a]
Wife's Income	0.0077 (0.0081)	0.0114 (0.0085)	0.0071 (0.0124)	0.0101 (0.0128)	-0.00348 (0.0129)	0.0046 (0.0388)
Location	-9.8645 (9.0967)	-11.365 (9.8968)	-8.315 (20.404)	-9.9652 (22.113)	-8.2626 (8.6853)	-9.2469 (7.8803)
First Quarter Dummy	19.7628 (6.4417)[a]	22.750 (6.4124)[a]	29.4567 (11.026)[a]	32.115 (10.847)[a]	10.7614 (6.307)	11.243 (7.7574)
Second Quarter Dummy	20.5608 (6.4549)[a]	23.771 (6.4363)[a]	32.0294 (11.500)[a]	36.648 (11.426)[a]	12.2578 (5.963)[a]	12.391 (7.3203)
Third Quarter Dummy	40.3927 (6.291)[a]	42.094 (6.2241)[a]	48.187 (10.898)[a]	49.953 (10.694)[a]	33.3744 (5.939)[a]	33.622 (7.3052)[a]
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Food consumption elasticity with respect to income		0.29		0.24		0.41
Food consumption elasticity with respect to land		0.26		0.33		0.14
Food consumption elasticity with respect to animal value		0.18		0.14		0.15

Notes: The dependent variable is value of food consumed per adult equivalent.
Standard errors are in parentheses. [a]Significant at the 0.05 level. [b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

Controlling for the household's total income and wealth, incomes handled by women have no significant positive impact on food consumption. The regression results suggest that an extra dollar given to either husband or wife will have the same effect on food consumption. On the basis of women's income levels, the unitary model cannot be rejected for the food consumption equation, i.e., according to Table 6.2 men and women have the same preferences regarding food consumption.

Household size in adult-equivalent persons controls for differences in family size across the sample. The negative and significant coefficient on this variable indicates that large households decrease the share of the budget allocated to food, i.e., larger households spend less per adult equivalent for each additional member. This may be due to economies of scale effects - acquisition and preparation of food in bulk in the larger households permits savings.

The age and educational levels of the household head, were included to measure the effects of knowledge and experience of household heads on food consumption decisions. Older and better-educated household heads are expected to be more efficient, i.e. may spend less on food. On the other hand, increased incomes from MODP technologies may lead to more food purchases. The estimates for education and experience of household heads suggest no significant effects on food consumption within their households.

Distances to the crop market and district identifiers were included to capture transaction costs that may vary across households. The estimates indicate that distance to the crop market had no significant effect on food consumption. The opportunity costs of time and money involved in traveling to the markets are low for the studied households. The coefficients of the quarterly dummy variables indicate significant seasonality in food consumption over the year.

The Effect of MODP Technologies on Calorie Intake

The estimates in Table 6.3 pertain to the caloric intake equation (5.2). Again a test of equality of parameters for the CBC and LBC groups was examined first. The Wald-statistic (6.1) for the equality of the caloric intake equation parameters (Table 6.3) was

Table 6.3. Calorie Intake Equation

Variable	All Households		CBC Households		LBC Households	
	GLS	HT	GLS	HT	GLS	HT
Constant	2442.98 (324.67)	2386.4 (333.20)	1997.53 (408.705)	1813.6 (448.23)	2329.02 (312.23)	2323.8 (317.05)
Value of food consumed	-0.0983 (0.5399)	0.3425 (0.5804)	-0.2999 (0.6648)	0.60355 (0.8263)	-0.6032 (0.8256)	-0.5506 (0.86411)
Animal Value	0.0574 (0.0154)[a]	0.0547 (0.0158)[a]	0.0807 (0.01816)[a]	0.07869 (0.0196)[a]	0.0413 (0.0260)[a]	0.0409 (0.0239)[b]
Cultivated Land Area	-100.68 (55.886)	-106.10 (57.279)	-256.86 (52.7879)[a]	-278.05 (57.762)[a]	37.5605 (62.280)	37.605 (63.127)
Household Size	-146.822 (26.972)[a]	-139.19 (27.793)[a]	-171.815 (26.1056)[a]	-157.34 (28.924)[a]	-146.530 (32.864)[a]	-146.02 (33.376)[a]
Household Head Age	-5.7234 (4.239)	-5.6787 (4.3418)	6.2113 (4.8427)	6.8780 (5.2337)	-5.0238 (4.347)	-5.0238 (4.347)
E1=read&write 0 = otherwise[c]	127.64 (135.36)	131.66 (138.65)	73.7640 (156.568)	116.38 (170.03)	126.840 (149.63)	126.09 (151.69)
E2 1=elementary 0 = otherwise[c]	96.568 (155.94)	94.633 (155.94)	435.667 (188.386)[a]	470.85 (203.88)[a]	-109.650 (134.72)	-110.58 (136.61)
E3 1=Highschool 0 = otherwise[c]	25.752 (186.472)	21.801 (190.99)	368.431 (234.781)	411.40 (254.06)	-80.249 (172.21)	-81.895 (174.68)
Crop Market Distance	5.0259 (9.8455)	4.6426 (10.085)	25.8290 (10.343)[a]	26.644 (11.165)[a]	-6.3079 (10.175)	-6.3904 (10.319)
Location	329.720 (138.915)[a]	336.15 (142.30)[a]	335.445 (147.233)[a]	347.40 (158.95)	263.135 (130.73)	263.72 (132.53)
First Quarter Dummy	362.515 (56.094)[a]	345.99 (56.362)[a]	376.216 (88.646)[a]	337.29 (89.867)[a]	374.123 (71.825)[a]	372.43 (71.352)[a]
Second Quarter Dummy	640.28 (56.128)[a]	623.68 (56.402)[a]	753.014 (90.9934)[a]	705.12 (93.422)[a]	557.057 (69.438)[a]	555.83 (68.715)[a]
Third Quarter Dummy	380.858 (58.817)[a]	358.91 (59.484)[a]	511.337 (91.8468)[a]	460.52 (94.704)[a]	292.022 (75.862)[a]	289.72 (75.789)[a]
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Calorie Intake elasticity with respect to animal value		0.16		0.28		0.095

Notes: The dependent variable is household calorie intake per adult equivalent per day. Standard errors are in parentheses. [a]Significant at the 0.05 level. [b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

77.53. The corresponding critical value for the χ^2_{14} at the 0.005 significance level is 31.32. It can thus be concluded that the specified determinants of calorie intake have significantly different effects for the two groups. To confirm that the difference is not solely in the intercept, the corresponding Wald statistic for equality of the slopes between the CBC and LBC groups was 45.99. The critical value for the χ^2_{13} at the 0.005 level is

29.82, implying that the slopes for the explanatory variables specified in the calorie intake equations were, indeed, significantly different for the CBC and LBC groups.

The role of MODP technologies on calorie intake was reflected most significantly by the value of animals reflecting wealth and a source of permanent income. The regression estimates (Table 6.3) for the determinants of calorie intake show a positive and significant effect of animal value on calorie intake in both the combined and CBC regressions. The estimated household calorie intake elasticities with respect to animal value were 0.16, 0.28 and 0.095 and for the whole sample, the CBC and the LBC households, respectively.

Household size has a negative and significant effect on the calorie intake in all three cases. The seasonal dummy variables are quite strong in all regressions. Nevertheless, there is no evidence of reduced seasonal effects between the LBC and the CBC households. No other variables were significant in the calorie regressions.

The Effect of MODP Technologies on Marketed Surplus

The estimated results for the marketed surplus model presented in Table 6.4 relate to equation 5.3. A test for equality of the parameters for the CBC and the LBC was considered first. The Wald statistic, W, (6.1) distributed as χ^2_{15} for the equality of the marketed surplus equation parameters between the CBC and the LBC groups was 28.61. Since the critical value for the χ^2_{15} at the 0.05 significance level is 25.00, the parameters for the marketed surplus equation explanatory variables are statistically different for the CBC and LBC groups. The specified determinants of marketed surplus have different effects for the two groups. The Wald statistic, 23.3, for equality of the slopes between the CBC and LBC groups and the critical values of 23.68 and 21.06 for the χ^2_{14} at the 0.05 and 0.10 levels, respectively, suggests only weak evidence that the slopes for the explanatory variables specified in the marketed surplus equations were different for the CBC and LBC groups.

Table 6.4. Marketed Surplus Equation

Variable	All Households		CBC Households		LBC Households	
	GLS	HT	GLS	HT	GLS	HT
Constant	457.408 (219.173)	453.85 (224.89)	1182.25 (484.128)	1184.1 (506.65)	179.031 (248.58)	161.85 (201.47)
Household Income	0.4006 (0.0459)[a]	0.3790 (0.0529)[a]	0.36225 (0.0609)[a]	0.3300 (0.06889)[a]	0.4689 (0.0765)[a]	0.4608 (0.0989)[a]
Animal Value	0.04508 (0.0106)[a]	0.04598 (0.0110)[a]	0.04736 (0.02163)[a]	0.04735 (0.02273)[a]	0.0083 (0.0233)	0.02747 (0.01968)
Cultivated Land Area	9.2461 (38.3901)	10.893 (39.468)	-10.1887 (61.635)	-3.3871 (64.981)	11.9653 (55.896)	23.868 (46.575)
Household Size	-23.9284 (17.221)	-22.923 (17.724)	-20.806 (29.116)	-17.803 (30.674)	7.3141 (27.194)	3.9697 (22.221)
Household Head Age	-6.0615 (2.8564)[a]	-6.1035 (2.9353)[a]	-12.967 (5.9149)	-13.056 (6.2052)	-4.5978 (3.4949)	-4.4310 (2.760)
E1,1=read&write 0 = otherwise[c]	39.4690 (91.4171)	38.222 (93.939)	-121.324 (186.177)	-137.99 (196.08)	-9.1394 (122.01)	-9.7833 (97.221)
E2, 1=elementary 0 = otherwise[c]	36.9598 (102.852)	40.242 (105.74)	-92.023 (226.398)	-99.428 (237.74)	7.2792 (111.74)	4.9623 (90.0749)
E3, 1=highschool 0 = otherwise[c]	-79.1653 (125.617)	-77.609 (129.08)	-460.409 (282.523)	-470.12 (296.67)	-27.763 (140.02)	-36.493 (111.41)
Crop Market Distance	-19.0719 (6.8587[a]	-18.731 (7.0550)[a]	-44.4039 (12.726)[a]	-44.3664 (13.348)[a]	-2.7516 (8.8256)	-1.2518 (7.4396)
Wife’s Income	0.2404 (0.0857)[a]	0.2510 (0.0881)[a]	0.2841 (0.1143)	0.29851 (0.1175)[a]	0.1054 (0.1553)	0.18026 (0.1619)
Location	26.0464 (94.3417)	21.950 (97.046)	247.78 (176.824)	240.58 (185.87)	-65.536 (107.36)	-73.526 (85.800)
First Quarter Dummy	101.415 (69.4575)	109.35 (69.399)	59.886 (109.42)	71.223 (107.89)	137.166 (75.194)	132.15 (92.363)
Second Quarter Dummy	73.7331 (69.6006)	82.315 (69.679)	181.675 (113.818)	201.50 (113.56)	-9.0482 (71.035)	-12.726 (87.105)
Third Quarter Dummy	-30.5158 (67.872)	-25.975 (67.381)	74.11 (108.214)	81.689 (106.35)	-126.312 (70.749)	-128.59 (86.904)
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Marketed surplus elasticity with respect to income		0.60		0.458		0.888

Notes: The dependent variable is value of food marketed surplus.
Standard errors are in parentheses.[a]Significant at the 0.05 level.
[b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

The elasticity of marketed surplus with respect to household income was positive. Evaluated at the sample mean, a 10 percent increase in income increased marketed surplus foods by 6, 5 and 9 percent, for the whole sample, CBC and LBC groups, respectively. Both income in the hands of women and animal value had positive and significant effects on marketed surplus for the combined sample and CBC group. Distance to the crop market was negatively and statistically significant for the combined sample and for the CBC group. Neither the cropland, nor the demographic variables had statistically significant effects on the marketed surplus.

The Overall Effects of MODP Technologies

The food consumption, calorie intake and marketed surplus equations regression results presented in Tables 6.2, 6.3 and 6.4 show positive and significant effects of MODP technologies on food security and food production. These effects are reflected mainly through the effects of incomes and wealth (measured by animal value and land area).

The calorie intake and marketed surplus regression results showed strong linkages between MODP technologies, and calorie intake and food marketed surpluses. The Wald tests for the equality of the parameters and the slopes between the CBC and the LBC groups showed that the specified determinants of calorie intake and marketed surpluses have significantly different effects for the two groups, with the two groups having different slopes. The CBC group consumes on average 30% more calories per adult equivalent per day compared to the LBC group. The quarterly value of surplus food marketed by the CBC group is 82% higher than that of the LBC group (Table 6.5). The relevant question is how much of the increases are due to differences in the characteristics of the CBC and LBC households such as the more valuable cattle, and how much is due to the differences in responses by the two groups, i.e. the $\hat{\beta}s$. The Oaxaca (1973) procedure is an approach to separate the two components:

$$\bar{y}_1 - \bar{y}_2 = (\bar{x}_1 - \bar{x}_2)\hat{\beta}_1 + (\hat{\beta}_1 - \hat{\beta}_2)\bar{x}_2 \qquad 6.2$$

Table 6.5. Sources of Calorie Intake and Marketed Surplus Differentials between the CBC and LBC Groups

Equations	$(\bar{y}_{CBC})$	$(\bar{y}_{LBC})$	$(\bar{y}_{CBC} - \bar{y}_{LBC})$	Oaxaca Decompositions Due to Group Differences in: Means of Variable $(\bar{x}_{CBC} - \bar{x}_{LBC})'\hat{\beta}_{CBC}$		Estimated Parameters $(\hat{\beta}_{CBC} - \hat{\beta}_{LBC})'\bar{x}_{LBC}$	
				Units	Percentage of Difference	Units	Percentage of Difference
Calorie Intake	2194	1686	508	321 (85)	63	186 (104)	37
Marketed Surplus	852	468	384	290	76	94	24

Note: Standard errors are in parentheses.

where $\bar{y}_1$ and $\bar{y}_2$ represent the average daily adult equivalent calorie intake for the CBC and LBC groups, respectively, in the case of caloric intake; and the average quarterly value of surplus food marketed by the two groups, in the case of marketed surpluses. The variables $\bar{x}_1$ and $\bar{x}_2$ are the vectors of the mean values of the regressors for the CBC and LBC groups, respectively. $\hat{\beta}_1$ and $\hat{\beta}_2$ are the CBC and LBC corresponding vectors of estimated parameters. The first term on the right hand side of 6.2, $(\bar{x}_1 - \bar{x}_2)'\hat{\beta}_1$, represents the estimated effects due to group differences in the household characteristics, and the second term, $(\hat{\beta}_1 - \hat{\beta}_2)'\bar{x}_2$, represents the estimated effects due to response differences for the two groups.

Based on the above partitioning, 63% of the difference in calorie intake between the CBC and LBC households can be attributed to differences in household characteristics, while the estimated parameter differences account for only 37% of the difference (Table 6.5). Interestingly, the estimated 321 calorie increase resulting from the CBC household characteristics relative to the LBC households is statistically significant given the estimated standard error of 85, while the portion due to the different parameter estimates is not (186 with an estimated standard error of 104).

Seventy-six percent of the difference in value of marketed surplus food between the CBC and the LBC groups is accounted for by the difference in household characteristics, while only 24% of the difference can be attributed to the estimated parameters (Table 6.5).

Attributing the differences in income and animal values between the CBC and LBC groups to the MODP technologies provides a basis for evaluating the benefits of the technology in terms of increased food consumption, calorie intake and marketed surplus. The 240.7 Birr difference in income resulted in an estimated 8.2 Birr increase in food consumption, amounting to 7.8 percent of food consumption of the average LBC household. The ownership of the crossbred cattle dramatically increased the value of animals for the CBC households by 3,925.6 Birr, resulting in an estimated 15.3 Birr (14.4 percent) increase in food consumption relative to the LBC households. The large increase in the value of the animals correspondingly resulted in an estimated increase of 214.8 calories per day (12.7 percent) in the CBC households.

Improvements in the marketed surplus benefit not only the farm household, but also benefit the non-farm population by increasing the domestic supply of food. The 240.7 Birr increase in income resulted in an estimated 91.2 Birr (19.5 percent) increase in marketed surplus relative to the LBC households. The program induced increase in animal value resulted in roughly twice as large an increase in marketed surplus: 180.5 Birr (38.6 percent).

CHAPTER 7

CONCLUSIONS, AND IMPLICATIONS FOR POLICY AND FUTURE RESEARCH

The conclusions and policy implications that come out of this study to improve food security and enhanced market integration through technological change in agriculture can be applied to other regions of developing countries with similar socio-economic and agro-climatic conditions, utilizing or adopting the same technologies. Countrywide application to Ethiopia may not be appropriate, as each region has distinct characteristics that would influence conclusions and policy recommendations. However, the methodologies that are used could be replicated in other studies of food security policies.

Summary and Conclusions

This study examines the food security and marketed surplus effects of intensified dairying in the peri-urban area of Addis Ababa, Ethiopia, where a market-oriented dairy production (MODP) system has been introduced for smallholders. The system involved the introduction of crossbred cows and the utilization of complementary feed and management technologies for increased dairy production. In this system, increased milk production is treated as a commercial product since milk sales generate cash income. Data have also been maintained for a group of farmers using traditional technology and are used for comparison.

The overall objective of the study was to evaluate the effects of MODP technologies on smallholder farm households and to identify policy options that would enhance beneficial impacts and mitigate harmful outcomes of the new technologies. Specific objectives were to: (a) measure the food security effects resulting from the introduction of crossbred cow technology, (b) assess the effect of market oriented dairy production on incomes handled by women and its consequence on food consumption, and (c) to evaluate the agricultural marketed surplus effects of intensified dairying.

Theoretical Framework

The agricultural household modeling approach was used to analyse the food security and food marketed surplus outcomes of the new technologies. Its theoretical underpinnings are provided by the household economics literature where households may be modeled as either a single unit in the unitary model, or as a collection of entities in the collective models. The econometric model was specified to allow the data to be consistent with whether household decision-making in the rural Ethiopian context was joint, or whether some decisions were made independently by the husband and wife. A general examination of the unitary versus collective model used in this study is the income-pooling test, where the food consumption equation is a function of total income and wife's income. Holding household income constant, the effect of the wife's income on food consumption can be interpreted as the impact of changing the share of household income allocated to the wife.

Data

Data were collected in 1999 from 56 households in Holetta, located 45 kilometers west of Addis Ababa. The households included a group of 27 with crossbred cows and a group of 29 with native cattle. Detailed household-level data were collected weekly (income, expenditure, production and distribution of dairy products and labor allocation to dairy production), monthly (food intake) and annually (demographics, land measurements, sample yields and distance to the crop market). The contrast between households using improved crossbred cattle and those using traditional cattle provided the basis for determining the extent to which the two sets of households allocated their resources differently and how their allocation decisions affected food security and food marketed surpluses.

Descriptive Statistics

For the households considered in this study, there were significant differences in levels of income, food purchases, calorie intake and food marketed surpluses between the CBC and LBC groups. Under traditional dairy production practices, women earned 99.9% of the dairy incomes from sales of butter in the local market. The husband's dairy incomes increase substantially with intensified dairying due to the institutional requirement for household heads, mostly men, to register and collect payments from the delivery of milk to the Dairy Development Enterprise. CBC husbands' monthly cash incomes from fresh milk sales were 58 Birr compared to zero for husbands in LBC households. While women in LBC households realized a large share of dairy income compared to their husbands resulting from the traditional division of work, women in CBC households earned nearly 7 times more dairy income than women in LBC households due to the same division of work, but larger opportunities with increased output. Women in CBC households realized about 59% of total dairy income.

The average monthly non-dairy farm and off-farm incomes between the CBC and LBC households were not statistically different. This suggested that the higher household incomes occurring in CBC households could be attributed mainly to dairy sales as a consequence of intensified dairying.

Average monthly per adult-equivalent cash food expenditure was 36% higher for CBC than for LBC households. Women in both CBC and LBC households spent over 70% more income on food than did men. With the introduction of MODP technologies, purchase of food by women in CBC households increased by 30%, while men in CBC households only increased their purchases of food by about 1%. Increased food purchases by women in CBC households implied that women's primary activities did not change but were enhanced. While women spent increased income that resulted from intensified dairying on food, men used increased income for farm investment and non-farm expenditures (Table 5.5).

Household members in CBC and LBC households were eating only 94% and 72% (Table 6.6), respectively, of the minimum calorie requirement for Ethiopia. However, CBC households consumed 30% more calories per adult equivalent than LBC households. Although these results show significant improvements in calorie intake levels for the CBC over the LBC groups, the seasonal pattern of calorie intake between the two groups was very similar. The fourth quarter of the year remained a serious deficit period. The implication is that dairying with CBC improves, but does not smooth consumption in

Table 6.6. Predicted Changes in Food Security and Marketed Surplus Resulting from MODP Technologies.

Equations and Variables	$\bar{y}_{CBC}$	$\bar{y}_{LBC}$	$(\bar{y}_{CBC} - \bar{y}_{LBC})$	$\bar{x}_{CBC}$	$\bar{x}_{LBC}$	$(\bar{x}_{CBC} - \bar{x}_{LBC})$	Predicted Change in Dependent Variable: $(\bar{x}_{CBC} - \bar{x}_{LBC})'\hat{\beta}_{Combined}$	Predicted Change in Dependent Variable: Percentage Change
Value of Food Consumption	139.5	105.2	34.3					
Income				1154.7	914.0	240.7	8.2	7.8
Animal Value				7828.4	3902.8	3925.6	15.1	14.4
Calories[a]	2193.9	1686.0	507.9					
Animal Value				7828.4	3902.8	3925.6	214.8	12.7
Marketed Surplus	852.2	467.9	384.3					
Income				1154.7	914.0	240.7	91.2	19.5
Animal Value				7828.4	3902.8	3925.6	180.5	38.6

[a]Value of food consumed is not included since the parameter estimate is not significantly different from zero

CBC households.

The marketed surplus analysis indicates that crossbred cow households were much more involved in the commercial economy than households with local cattle: the CBC households had larger cash revenues from milk and dairy goods and other food surpluses, and larger market purchases of food. The value of marketed foods was found to be 82% (Table 6.6) more for households with crossbred cows than for households with local cows.

Empirical Framework

The above comparison of sample means for the two groups is indicative of changes brought about by the introduction of improved cattle. Econometric estimation was done to evaluate the extent to which particular variables influenced food consumption, calorie intake, food marketed surplus and whether or not the effects differed for the CBC and LBC households. The econometric model was specified as a panel data model with household specific effects. Income (an explanatory variable in the food consumption and marketed surplus equations) and value of food consumed (an explanatory variable in the calorie intake equation) were found to be correlated with the individual household effects. As a consequence, ordinary and generalized least squares parameter estimates would be biased and inconsistent. The instrumental variable techniques for panel data developed by Hausman and Taylor (1981), Amemiya and MaCurdy (1986) and Breusch, Mizon and Schmidt (1986) were used to obtain consistent estimates of all parameters in the presence of correlation between individual household effects and a subset of the explanatory variables. The three sets of instrumental variable estimates were not substantially different from each other. The Wald statistic was used to test for equality of parameters between the CBC and LBC households equations.

Empirical Findings

The food consumption, calorie intake and marketed surplus equation regression results presented in Tables 6.2, 6.3 and 6.4 show positive and significant effects of MODP technologies on food security and food production. These effects are reflected mainly through the effects of incomes and wealth (measured by animal value and land area).

Food Consumption: The Wald test results suggested no difference in decisions made by CBC and LBC groups regarding food consumption. Household incomes had a positive and significant effect on food consumption; the marginal propensity to spend on food was 0.034. The corresponding food consumption elasticity with respect to income, calculated at the means, was 0.29. Animal value and cropland area, proxies for wealth and sources of a stream of permanent income both had a positive and significant influence on food consumption, with corresponding elasticities of 0.18 and 0.26. Incomes handled by women had no statistically significant impact on food consumption, implying the unitary model could not be rejected in the food consumption equation. Household size had a negative and significant effect on food consumption, indicating that large households decrease the per capita share of the budget allocated to food.

Calorie Intake: The CBC group consumed on average, 30% more calories per adult equivalent per day compared to the LBC group. The majority of the difference in calorie intake between the CBC and LBC households (63%) was attributed to differences in the values of the explanatory variables, while the estimated parameter differences for the two groups accounted for only 37% of the difference (Table 6.5).

The role of MODP technologies on calorie intake was reflected most significantly by the value of animals. Animal value had a significant and positive impact on calorie intake in both the combined and the CBC regressions. The large increase in animal values for the CBC households was calculated to increase caloric intake by 12.7% relative to the LBC households. Household size has a negative and significant effect on per capita calorie intake in all three cases. The seasonal dummy variables were quite strong in all regressions. Nevertheless, there was no evidence of reduced seasonal effects between the LBC and the CBC households.

Marketed Surplus: The value of surplus food marketed quarterly by the CBC group was 82% higher than that of the LBC group. Seventy-six percent of the increase in the value of marketed surplus food for the CBC over the LBC groups was accounted for by the difference in household characteristics, while only 24% of the increase could be attributed to differences in the estimated parameters (Table 6.5).

The elasticity of marketed surplus with respect to household income was positive.

Evaluated at the sample mean, a 10 percent increase in income increased marketed surplus foods by 6, 5 and 9 percent, for the whole sample, CBC and LBC groups, respectively. Both income in the hands of women and animal value had positive and significant effects on marketed surplus for the combined sample and for the CBC group. Distance to the crop market was negatively and statistically significant for the combined sample and for the CBC group.

Concluding Remarks

Market-oriented dairy production technologies had positive and significant impacts on food security and food production in the study area. The estimated models presented in Tables 6.2, 6.3 and 6.4 show a strong linkage between higher incomes (current and permanent as measured by animal value) resulting from the introduction of MODP technologies, and food consumption, calorie intake and marketed surplus.

The effects of changes in income and animal value resulting from the MODP technologies and their impacts on food security and food production differences between the CBC and LBC groups are presented in Table 6.6. Calculated at the means and the estimated parameters, increased income and increased animal value as a consequence of the MODP technologies resulted in 7.8% and 14.4% increases in food consumption, and 19.5% and 38.6% increases in marketed food surpluses, respectively. The increased animal value from the introduction of the MODP technologies accounted for a 12.7% increase in calorie intake. Households that used MODP technologies increased their incomes and animal values significantly relative to households using traditional dairy production methods. The increased resources led to significantly higher food consumption, calorie intake and marketed surplus.

Households with crossbred cows consumed on average 30% more calories per adult-equivalent person than households with local cattle. This is consistent with the greater profits possible from dairying with crossbred cows. Increases in food consumption and calorie intakes realized by respondent CBC households, confirm the widely held view of proponents (for example the World Bank) of commercialization of small-scale farms that food security will improve with the improvements in income that accompany the development process. The calorie intake patterns of the CBC and LBC households were similar (Figure 5.1), and suggested that intensified dairying improved but did not significantly smooth calorie intake in CBC households.

Studies in other areas have indicated that as cash crops were introduced in smallholder production systems and there was greater market integration, women may lose control over cash incomes to men who tend to spend less on food for the household. A concern expressed in the literature (Kennedy and Cogill; Thomas-Slayter and Bhatt,) has been that with commercialization of dairying, men may take over the marketing of milk from women. If women lose possession of the milk income, food consumption could decline since women typically spend the income on food and household essentials. In contrast to the findings of other studies, commercialization of dairy production in the Ethiopian Highlands made both men and women better off in terms of increased income. The dairy income of women increased, although in relative terms, men's income increased much more. The results of this study showed that women in households utilizing improved crossbred cows maintained possession of income allocated to food purchases and continue to purchase more than 60% of the food eaten at home. Women's abilities to fulfill traditionally defined tasks (such as food purchases and sale of dairy products, according to gender division of labor) were enhanced by the introduction of market-oriented dairying in the study area.

Although market-oriented dairying made a significant contribution towards improving food security, the prevalence of food insecurity in Ethiopia remain high. The findings that the CBC and LBC households were only meeting 94% and 72%, respectively, of the recommended minimum daily calories per capita, confirmed the significance of the problem and continued needs.

Contributions of the Study

This study contributes to the food security, agricultural commercialization and women in development literature. Specifically, it contributes to the understanding of the roles of improved dairying and commercialization of smallholder agriculture in enhancing food security. It also provides an empirical examination of the unitary and collective models.

The preceding analysis suggests the following:

- *Dairying with crossbred cows improves, but does not smooth consumption.* Earlier findings (Bouis and Haddad, Kumar) came to the same conclusion that commercialization of small-scale farmers improved food security. The above studies did not address the issue of income smoothing.
- *Commercialization of dairy production in the Ethiopian Highlands makes both men and women better off in terms of increased income, but men more so than women. Intensified dairying increased income in the hands of women, and enhanced their ability to purchase more food, a task traditionally ascribed to women by the gender division of labor.* This contrasted with findings from other areas (e.g., Thomas-Slayter and Bhatt) which suggested that with commercialization of dairying, women may lose "control" over cash incomes to men who tend to spend less on food for the household.
- *On the basis of women's income levels, the regression analysis results did not lead to a rejection of the unitary model.* This is in contrast to findings by Quisumbing and Maluccio (1999) who suggest weak gender preferences in Ethiopia, i.e. individuals within the households have some differences in preferences.

A major contribution of this study is the innovative and multifaceted approach which used consistent instrumental variable panel data analysis techniques in assessing food security consequences in the context of livestock production. Previous studies of the food security effects of commercialization of smallholder agricultural production, traditionally modeled the food consumption and calorie intake equation as a system of recursive equations in the context of cash crop production only. When variables on one side of the equation are simultaneously determined with the variables on the other, either traditional instrumental variable techniques using instruments from outside the model or "within" panel data estimators are normally used. Although the "within" estimator for panel data purges the correlation problem from the model, it does not permit estimation of the parameters of the time-invariant variables. This study used instrumental variable techniques developed for panel data by Hausman and Taylor (1981), Amemiya and

MaCurdy (1986) and Breusch, Mizon and Schmidt (1989) and used instruments from within the models that permitted consistent estimation of all parameters in the presence of correlation between household effects and a subset of the explanatory variables.

The study utilized the Oaxaca procedure to separate the sources of differences in calorie intake and food marketed surplus between values of the explanatory variables and the response differences for the CBC and LBC households.

Policy Implications

The findings of this study suggest that agricultural growth fostered by technological change and commercialization of small-scale farmers is a powerful contributor to the improvement of food security. With the strong positive relationship established between food security improvements and increased income and wealth, the research has illustrated an improved livestock technology where economic welfare is improved via agricultural development.

The results of the study indicate that incomes in the hands of women did not have additional beneficial effects on household food consumption beyond the total household income. The finding suggests that men and women in the Ethiopian Highlands have common preferences in household food consumption. Policies that increase household incomes without regard to gender will have the same effects on food consumption as those that target individuals by gender.

The new initiative increased income of men and women, though men more so than women. Men use the increased income for investment in farm operations, such as for the purchase of fertilizer, herbicides, animal feed and the provision of animal services. The consequence was increased food production.

Farmers using MODP technologies received numerous sources of financial and technical support from the program. This included subsidized prices of crossbred cows, animal medicines and veterinary services, advice on forage production, breeding practices; management of animals, milk and dairy products. An interesting question is whether MODP system will be viable when the program ends. Will the animals and services be available in the open market and will farmers be able to purchase them without subsidies? Wide adoption of the MODP technologies in the Ethiopian Highlands will require a level of profitability for the farmers to finance the purchase of the crossbred cattle. The adoption of the new initiative can be facilitated with the development of the necessary infrastructure and institutions, such as veterinary services, improved livestock extension services, transportation services, etc.

Animal feed scarcity, diseases and poor genetic makeup of cattle and poor extension services result in depressed milk production. This situation encourages importation of milk and dairy products to meet the local demand, despite the fact that Ethiopia is the first in Africa and the tenth in the world in livestock production (Belachew et al.). Facilitating and strengthening services such as artificial insemination and other veterinary services, credit and provision of upgraded cattle to peri-urban small-scale farmers are all essential to increase milk production.

The incentives for better production of dairy products are likely to improve with the liberalization of the dairy market. These incentives are eroded by a state dairy product marketing monopoly, Dairy Development Enterprise (DDE). This agency virtually eliminates seasonal milk price fluctuation in contrast to the wide price fluctuations of other commodities in the region. Public and private investment in infrastructure improvements that facilitate technological change, such as roads, collection points and chilling centers, are likely to be important in a liberalized market environment for farmers to increase their productivity.

The income opportunities in dairying for smallholders make a strong case for further policy attention to market-oriented dairying. Improving the effectiveness of livestock services, freeing imports of animal medicines and feed markets from constraining regulations, and enabling functioning dairy cooperatives may be central to these efforts. Encouraging market-oriented dairy production will require producer price incentives coupled with the market outlets in outlying areas. The DDE that targets domestic urban sales, has not demonstrated the potential for expansion or the ability to support higher producer prices, especially if compelled to operate without subsidy (Staal and Shapiro, 1996). One feasible option for market-oriented dairying expansion could lie in informal collection and processing of milk, operated by, say, small dairy cooperatives. This could overcome transport constraints to the marketing of milk. Such dairy cooperatives may go on to provide other services, such as credit to members, strengthening the institution and contributing to dairy development, and may also give producers a voice in policy-making. Other constraints to the successful expansion of commercial dairying in more rural areas lie in livestock services, and scarcity of feeder roads.

Limitations of the Study and Suggestions for Future Research

The research focused on evaluating the effects of new technology on food security, marketed surplus and on identifying policy implications for dairying with crossbred cows within the framework of the household model. The shortcomings of this study noted below suggest areas for future research.

The best way to achieve the objective of identifying the key factors that drive food security and marketed surplus outcomes in the process of commercialization of smallholder agriculture would have been to collect data from the same households both before and after the technology was introduced. Such an approach requires additional time and money not available within the confines of this study. The second best option was utilized: a comparison of households with and without crossbred cows, but having the same resource endowment.

Data on calorie intake at the household rather than the individual level were used. Separation of household consumption by age and gender would have been appropriate for intra-household analysis, particularly for studies that target vulnerable members within the household, such as children under age five, or pregnant and lactating women who require unique nutritional needs. In the Ethiopian Highlands, the normal practice is for household members to eat from a common plate, thus precluding the collection of data at the individual level. Evaluating the calorie intake effect at the household level assumes equitable distribution of calories within the households. This may not be the case in low-income calorie deficient households. Calorie stress during heavy farming activity periods may result in household farm workers consuming more food than children.

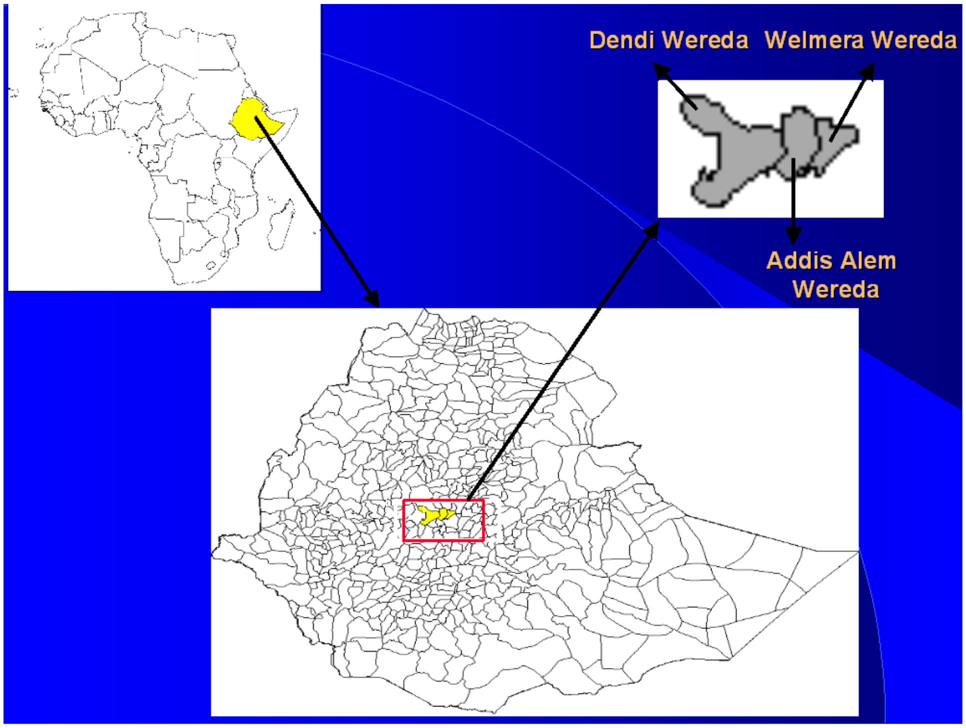
The data set used in this study pertains to a relatively small number of households, 56. Although statistically significant effects were found, inferences from a large data set would be valuable. In addition, the households were part of an experiment, and not a random sample of the population utilizing the technology in the absence of a concerted effort by various institutions to evaluate or monitor its viability. Nevertheless, the households are believed to be representative of the Ethiopian Highland households.

As confirmed in this study, the introduction of new technologies and commercialization of smallholder farming systems can directly affect food security. The positive effects of this process can be strengthened by effective agricultural development policies.

Appendix A

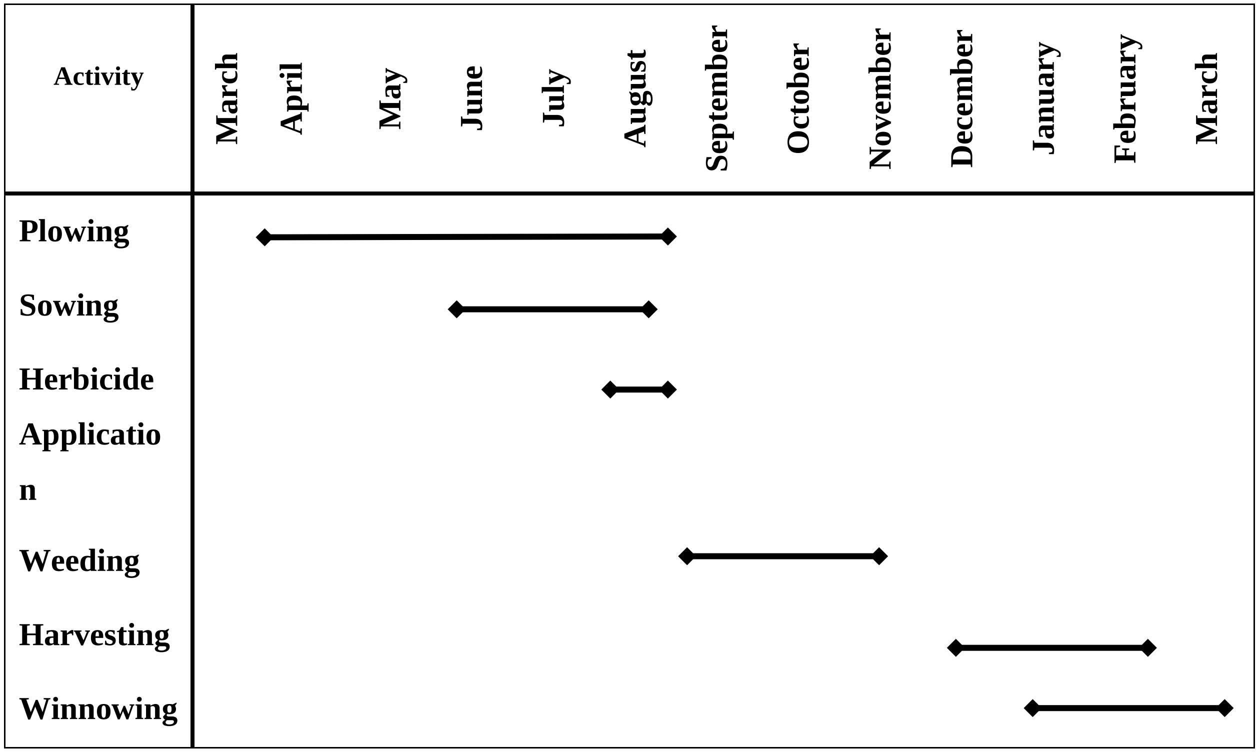
1. Map of Ethiopia

2. Map of Study Area



Appendix B

Crop Production Activity Schedule



Appendix C

Amemiya and MacCurdy (AM) and Breusch, Mizon and Schimdt (BMS), Regression Results

Table 6.2. Food Consumption Equation

Variable	All Households		CBC Households		LBC Households	
	AM	BMS	AM	BMS	AM	BMS
Constant	122.55 (22.877)	123.38 (22.761)	171.37 (59.848)	171.90 (59.469)	97.946 (15.941)	97.606 (15.976)
Household Income	0.03398 (0.0049)[a]	0.03778 (0.0047)[a]	0.0283 (0.0069)[a]	0.0348 (0.00657)[a]	0.0463 (0.0083)[a]	0.04477 (0.0082)[a]
Animal Value	0.00384 (0.0011)[a]	0.003704 (0.0011)[a]	0.0024 (0.0027)	0.0024 (0.0027)	0.0039 (0.0016)[a]	0.0039 (0.0016)[a]
Cultivated Land Area	12.390 (4.020)[a]	12.052 (3.998)[a]	17.199 (7.6918)[a]	15.798 (7.6310)[a]	5.9868 (3.6924)	6.0532 (3.7009)
Household Size	-19.398 (1.8069)[a]	-19.566 (1.7971)[a]	-19.121 (3.6327)[a]	-19.730 (3.6048)[a]	-14.635 (1.7581)[a]	-14.567 (1.7612)[a]
Household Head Age	-.03141 (0.2998)	-.02410 (0.2983)	-0.377 (0.7363)	-0.3679 (0.73221)	-0.1025 (0.2171)	-0.1035 (0.2176)
E1 1=read& write 0=otherwise[c]	-9.5393 (9.5923)	-9.2768 (9.5439)	-34.085 (23.267)	-30.584 (23.095)	3.7956 (7.6635)	4.0803 (7.677)
E2 1=elementary, 0 = otherwise[c]	-2.3440 (10.794)	-2.8923 (10.739)	-24.742 (28.273)	-23.436 (28.091)	-0.4133 (7.1784)	-0.04499 (7.1874)
E3 1=highschool, 0 =otherswise[c]	5.6065 (13.184)	5.3495 (13.118)	-29.175 (35.275)	-27.454 (35.048)	17.669 (8.7751)[a]	17.867 (8.7944)[a]
Crop Market Distance	0.8804 (0.7179)	0.8106 (0.7140)	-0.28722 (1.5844)	-0.3148 (1.5744)	1.3366 (0.5922)[a]	1.3763 (0.5925)[a]
Wife's Income	0.0114 (0.0085)	0.0091 (0.0085)	0.0104 (0.0128)	0.00675 (0.01266)	0.0049 (0.0139)	0.0065 (0.01385)
Location	-11.384 (9.8984)	-10.605 (9.8456)	-10.069 (22.130)	-8.4823 (21.985)	-9.2965 (6.7654)	-9.5261 (6.7784)
First Quarter Dummy	22.782 (6.4134)[a]	21.427 (6.366)[a]	32.265 (10.855)[a]	29.941 (10.762)[a]	11.349 (7.7605)	11.838 (7.7657)
Second Quarter Dummy	23.807 (6.4373)[a]	22.305 (6.3867)[a]	36.916 (11.431)[a]	32.769 (11.287)[a]	12.441 (7.3236)	12.672 (7.3381)
Third Quarter Dummy	42.113 (6.2251)[a]	41.325 (6.1887)[a]	50.055 (10.702)[a]	48.471 (10.623)[a]	33.674 (7.3085)[a]	33.912 (7.3228)[a]
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Food consumption elasticity with respect to income		0.29		0.24		0.41
Food consumption elasticity with respect to land		0.26		0.33		0.14
Food consumption elasticity with respect to animal value		0.18		0.14		0.15

Notes: The dependent variable is value of food consumed per adult equivalent.
Standard errors are in parentheses. [a]Significant at the 0.05 level. [b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

Table 6.3. Calorie Intake Equation

Variable	All Households		CBC Households		LBC Households	
	AM	BMS	AM	BMS	AM	BMS
Constant	2386.4 (333.20)	2431.3 (332.28)	2004.8 (436.73)	1813.6 (448.23)	2323.8 (317.05)	2344.7 (316.89)
Value of food consumed	0.3425 (0.5804)	-0.0074 (0.5637)	-3358 (0.7055)	0.60355 (0.8263)	-0.5506 (0.86411)	-0.7614 (0.85618)
Animal Value	0.0547 (0.0158)[a]	0.05689 (0.0158)[a]	0.08083 (0.0194)[a]	0.07869 (0.0196)[a]	0.0409 (0.0239)[b]	0.04254 (0.02637)[b]
Cultivated Land Area	-106.10 (57.279)	-101.80 (57.175)	-256.02 (56.494)[a]	-278.05 (57.762)[a]	37.605 (63.127)	37.428 (63.138)
Household Size	-139.19 (27.793)[a]	-145.25 (27.655)[a]	-172.39 (27.918)[a]	-157.34 (28.924)[a]	-146.02 (33.376)[a]	-148.06 (33.363)[a]
Household Head Age	-5.6787 (4.3418)	-5.7142 (4.3357)	6.1848 (5.1863)	6.8780 (5.2337)	-5.0238 (4.347)	-5.0796 (4.3476)
E1=read&write 0 = otherwise[c]	131.66 (138.65)	128.47 (138.45)	72.069 (167.63)	116.38 (170.03)	126.09 (151.69)	129.09 (151.71)
E2 1=elementary 0 = otherwise[c]	94.633 (155.94)	96.169 (155.72)	434.27 (201.74)[a]	470.85 (203.88)[a]	-110.58 (136.61)	-106.86 (136.62)
E3 1=Highschool 0 = otherwise[c]	21.801 (190.99)	24.937 (190.72)	366.72 (251.43)	411.40 (254.06)	-81.895 (174.68)	-75.303 (174.67)
Crop Market Distance	4.6426 (10.085)	4.9469 (10.070)	25.797 (11.078)[a]	26.644 (11.165)[a]	-6.3904 (10.319)	-6.0599 (10.319)
Location	336.15 (142.30)[a]	331.05 (142.09)[a]	334.97 (157.69)	347.40 (158.95)	263.72 (132.53)	261.37 (132.55)
First Quarter Dummy	345.99 (56.362)[a]	359.11 (56.056)[a]	377.6 (87.370)[a]	337.29 (89.867)[a]	372.43 (71.352)[a]	379.22 (71.263)[a]
Second Quarter Dummy	623.68 (56.402)[a]	636.86 (56.094)[a]	754.92 (90.046)[a]	705.12 (93.422)[a]	555.83 (68.715)[a]	560.75 (68.671)[a]
Third Quarter Dummy	358.91 (59.484)[a]	376.33 (59.020)[a]	513.36 (91.017)[a]	460.52 (94.704)[a]	289.72 (75.789)[a]	298.94 (75.627)[a]
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Calorie Intake elasticity with respect to animal value		0.16		0.28		0.095

Notes: The dependent variable is household calorie intake per adult equivalent per day. Standard errors are in parentheses. [a]Significant at the 0.05 level. [b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

Table 6.4. Marketed Surplus Equation

Variable	All Households		CBC Households		LBC Households	
	AM	BMS	AM	BMS	AM	BMS
Constant	453.87 (224.89)	452.33 (224.96)	1184.1 (506.54)	1184.6 (506.22)	161.76 (201.47)	156.33 (201.64)
Household Income	0.3790 (0.0529)[a]	0.3719 (0.0508)[a]	0.3328 (0.06866)[a]	0.3428 (0.06436)[a]	0.4603 (0.0988)[a]	0.4363 (0.09763)[a]
Animal Value	0.04598 (0.0110)[a]	0.04625 (0.0110)[a]	0.04735 (0.02272)[a]	0.04735 (0.02273)[a]	0.002743 (0.0197)	0.002510 (0.01969)
Cultivated Land Area	10.884 (39.467)	11.515 (39.462)	-3.9641 (64.956)	-6.0740 (64.723)	23.886 (46.575)	24.942 (46.617)
Household Size	-22.928 (17.724)	-22.609 (17.719)	-18.055 (30.663)	-18.976 (30.566)	3.9884 (22.221)	5.0828 (22.232)
Household Head Age	-6.1033 (2.9353)[a]	-6.1172 (2.9363)[a]	-13.051 (6.2038)	-13.032 (6.1998)	-4.4313 (2.7601)	-4.4470 (2.7628)
E1,1=read&write 0 = otherwise[c]	38.229 (93.939)	37.740 (93.970)	-136.56 (196.02)	-131.32 (195.50)	-9.7056 (97.221)	-5.1556 (97.273)
E2, 1=elementary 0 = otherwise[c]	40.227 (105.73)	41.269 (105.75)	-98.862 (237.69)	-96.794 (237.49)	.5967 (90.747)	6.4857 (90.0756)
E3, 1=highschool 0 = otherwise[c]	-77.616 (129.08)	-77.128 (129.13)	-469.38 (296.60)	-466.66 (296.35)	-36.439 (111.41)	-33.273 (111.50)
Crop Market Distance	-18.733 (7.0550)[a]	-18.603 (7.0527)[a]	-44.373 (13.345)[a]	-44.405 (13.337)[a]	-1.2410 (7.4393)	-0.608 (7.4352)
Wife's Income	0.2509 (0.0881)[a]	0.2553 (0.0876)[a]	0.2971 (0.1174)[a]	0.2919 (0.1167)[a]	0.18067 (0.1692)	0.2047 (0.1686)
Location	21.971 (97.045)	20.508 (97.037)	241.22 (185.82)	243.56 (185.62)	-73.588 (85.800)	-77.254 (85.853)
First Quarter Dummy	109.32 (69.398)	111.89 (69.226)	70.265 (107.85)	66.761 (107.46)	132.29 (92.360)	140.10 (92.310)
Second Quarter Dummy	82.275 (69.678)	85.116 (69.463)	199.80 (113.48)	193.58 (112.45)	-12.663 (87.105)	-8.9595 (87.159)
Third Quarter Dummy	-25.996 (67.380)	-24.504 (67.338)	81.039 (106.32)	78.664 (106.11)	-128.53 (86.904)	-124.71 (86.955)
	N=56 T=4	N=56 T=4	N=27 T=4	N=27 T=4	N=29 T=4	N=29 T=4
Marketed surplus elasticity with respect to income		0.60		0.458		0.888

Notes: The dependent variable is value of food marketed surplus.
Standard errors are in parentheses.[a]Significant at the 0.05 level.
[b]Significant at the 0.1 level. [c]E1, E2, E3 are dummy variables representing the education level of the household head. Illiteracy is the base level.

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