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Jacqueline S. Van Gilst

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By

Jacqueline S. Van Gilst

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ABSTRACT

STRATEGIES TO IDENTIFY HOUSEHOLDS AT RISK FOR CHILDHOOD MALNUTRITION: THE CASE OF RWANDA

by

Jacqueline S. Van Gilst

Understanding that seasonal food shortages continue to be a common occurrence and high prevalence of malnutrition continues to be of concern among rural households in many developing countries, this thesis investigates possible strategies for identifying agrarian households at risk for malnutrition. The data analyzed are from the National Nutrition and Food Security Survey (NNFSS) conducted by UNICEF/Kigali and the Ministry of Agriculture in Rwanda. Land area seemed to be related to nutritional status, while the degree of slope was not related to nutritional status.

Household coping patterns as reviewed in this study were not consistently associated with higher prevalence of malnutrition and land resources were not shown to influence the coping patterns used. However, households reporting one or more months of shortage tended to have children with lower mean weight-for-age z-scores. Understanding the lack of association between coping patterns and childhood nutritional levels requires more research to be fully understood.

To my parents for all their love and support.

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Chapter 1

ANALYSIS OF THE PROBLEM

1. Analysis and statement of the Problem

We know that undernutrition, defined by the World Health Organization as weight-for-age less than -2 SD of the reference population[1], and food insecurity, defined as inadequate access at all times to enough food for a healthy and active life, continues to be a concern in many developing countries. The FAO's Fifth World survey estimates 22 million children in Africa (26% of children under 5) have a weight for age below 80% (approximately -2 SD) of the median (FAO, 1985). Despite attempts to the contrary, efforts to improve food security within families and to improve the nutrition of each family member have sometimes not been successful. Indeed, de Onis estimates that one third of the world's children are effected by malnutrition (de Onis, et al. 1993). Population growth and environmental degradation are putting severe stress on the adequacy of food production. It would be useful to agriculture and nutrition policy planners to be able to identify individuals and communities most at risk for food shortages.

This research will examine some characteristics of land farmed by smallholder households in Rwanda to determine if a predictive relationship exists between the

---

[1] Waterlow (1977) recommended defining weight-for-age in terms of standard deviations above or below the mean for an international reference population, usually the National Council for Health Statistics/Center for Disease Control reference population. Weight-for-age below -2 SD of the reference population corresponds approximately with the 80% of the median for the reference population, a point defined by the World Health Organization as undernourished.

characteristics studied and child nutrition. It will also explore the mechanisms households utilize to cope with periods of food insufficiency. Such mechanisms may indicate household resilience to dietary stress and therefore may constitute an additional determinant of risk status.

In areas of high population densities and rapid population growth, rural households must survive on smaller and smaller plots as land is divided among children. Many farmers react to the shortage of land by planting more intensely and increasing inputs into the land to which they have access. Eventually, the plot becomes too small to provide enough for a household and child nutritional levels may begin to fall. When this occurs, the farmers may try to acquire land of lower quality (i.e., on steeper slopes), may seek employment from neighbors or may decide to migrate from the area in search of more land or employment. If land size or land characteristics (i.e., steepness of slope) are linked with child nutritional status, development workers may be better able to identify households or areas at risk for malnutrition.

Households experiencing dietary stress will seek to remove the stress by 1) avoiding the stress, i.e., finding a new job or leaving the area, 2) repartitioning the stress, i.e., shifting income away from non-food items, 3) developing resistance to the stress, i.e., purchasing cheaper food items, 4) developing tolerance of the stress, i.e., accepting some degree of hunger (Payne & Lipton, 1994). This research will examine the identified coping mechanisms utilized by Rwandan households when faced with food shortages.

This research will determine if relationships exist between (1) characteristics of the land resources and child nutrition and (2) characteristics of land resources and mechanisms for coping with food insecurity, and (3) mechanisms for coping with food insecurity and child nutrition.

1.1 Why an emphasis on nutrition?

Nutritional status is often quantified using anthropometric measures. While these measures are only indicators of nutritional status, studies have shown that risk of mortality does increase as such anthropometric measures fall (Schroeder & Brown, 1994; Chen, Chowdhury & Huffman, 1980; Smedman, Sterkey, Mellander & Wall, 1987).

However, poor nutritional status is not equated with not having enough food. Diskin (1994) acknowledges that consuming an adequate diet is "*necessary but not sufficient* for maintaining a healthy nutritional status." However, inadequate consumption remains a primary determinant of undernutrition. As such, Kennedy and Haddad (1992) argue for an emphasis on childhood nutritional status as a measure of real food security. According to these authors, some policy makers assume improved national food security will automatically increase consumption for everyone in the household. Kennedy and Haddad believe this assumption is false. Further, they call for a framework that links macroeconomic decisions with consumption changes in the households to see how such decisions affect food security and subsequently nutrition for individuals. If this link is established, decision makers may better understand how policy affects the nutritionally vulnerable within the community.

1.2 Risk reduction activities of households experiencing food insecurity

Households at increased risk of food insecurity are involved in a variety of activities to reduce that risk. According to Frankenberger, "Households do not respond arbitrarily to variability in food supply. People who live in conditions that put their main source of income at recurrent risk will develop self-insurance coping strategies to minimize risks to their HFS [household food security] and livelihoods" (Frankenberger, p. 40, 1993). Identifying areas and sectors that are at risk of food insecurity because of environmental or resource issues is what Frankenberger (1993) referred to as vulnerability mapping. As farmers become more resource poor, they have fewer options for coping with periods of insecurity. Characterizing these farmers is key to identifying those most vulnerable to food insecurity and the potential for poor nutrition.

A household's vulnerability to food insecurity can be evaluated by its response to food shortages. Frankenberger developed a continuum of responses to food shortage based on the reversibility of each activity (See figure 1-1). Households that are able to cope with food shortage while maintaining the resources needed for their continued livelihood (i.e., land resources, seeds for next season crops, animals, etc.) are thought to be much more resilient to food shortages. Secondarily, the more resource poor household's are forced into less reversible responses to food shortages which renders them less well equipped to recover when the time of shortage has passed.

2. Rwandan National Nutrition and Food Security Survey

This research utilizes data from the Rwandan National Nutrition and Food Security Survey (NNFSS) conducted by the *Division de Statistiques Agricoles* (DSA) of the Ministry of Agriculture at the initiative of and with partial financial support and technical assistance from the staff of UNICEF-Kigali, Serge Rwamarisabo and Katherine Krasovec. The survey was conducted in three rounds based on a stratified random sample of approximately 2500 total households that were followed by DSA since October 1988. Only those households in this cohort of 2500 with children under five years of age were included in the nutrition survey (Grosse, 1995a).

DSA collected monthly economic information on half the cohort (the intensive sample) as part of the first phase or agricultural phase of this project (beginning October 1988). Information collected included production and income data as well as records of sales and purchases. Extensive analysis of the agricultural and economic data is being conducted by Dan Clay, Scott Grosse, Jean Bosco Sibomana, Jaakko Kangasmiemi, and others.

The nutrition survey was conducted in three rounds beginning late November 1991, Mid-February 1992, and August 1992. Anthropometric information was collected during all three rounds on children under five. The number of children included in each round was 1939 children in the first round, 1791 children in the second round, and 1643 in the third round (Grosse, 1995a). Scott Grosse is involved in extensive analysis of these data utilizing the anthropometric indicator height-for-age.

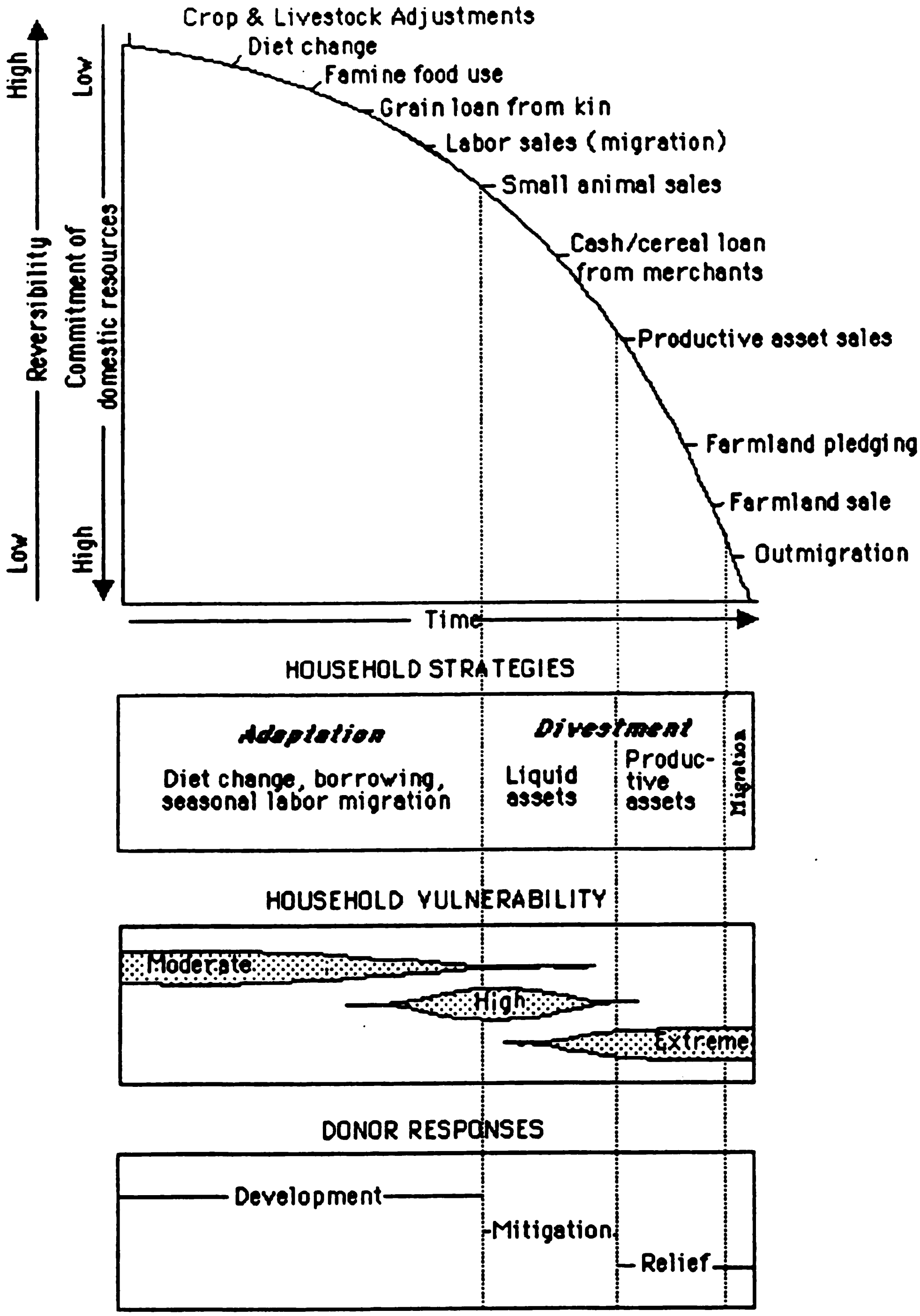

Figure 1-1
Responses to household food shortages
From Maxwell and Frankenberger, p. 95, 1994

This research will focus on some of the land characteristics data collected as part of the agriculture survey on this cohort of households and anthropometric measures taken as part of the second phase or nutritional phase of the research. Additionally, the nutritional phase of the survey included a list of questions during the first and third rounds that assessed a family's response to reported times of food shortage. These questions asked the following:

1. Do you reduce the frequency of meals eaten?
2. Do you search for outside employment?
3. Do you seek food aid within the commune?
4. Do you seek food aid from neighbors?
5. Do you seek food aid at the church?
6. Do you seek food aid at another organization or a feeding center?
7. Do you send your children to stay with someone else?
8. Do other adult members of the home leave?
9. Do you harvest your food early?
10. Do you eat foods set aside as seed?
11. Do the children quit school?
12. Do you sell land?
13. Do you sell other possessions?

These coping mechanisms may indicate the household's access to resources, consequently its resilience to food shortages. This research will attempt to link these coping mechanisms to land characteristics and to child nutritional status.

3. Research questions and Hypotheses

This study will address the following questions and pose the hypotheses indicated:

- Do characteristics of the land resources available to the household correlate with the nutritional status of children under five years of age in rural Rwanda?

    E-1. Children of households farming lands of steeper slopes will be more poorly nourished as defined by a lower z-score for weight-for-age than children of households farming lesser slopes.

    E-2. Children of households with greater area of land resources will be better nourished as defined by a higher z-score for weight-for-age than children of households with lesser areas of cultivated land.

- Will the type of coping strategies utilized by the household correlate with the characteristics of the land resources available?

    R-1 Households with larger land areas will utilize coping strategies that are characterized as more reversible than households with smaller land areas cultivated.

    R-2 Households farming land areas of lesser slopes will utilize coping strategies that are characterized as more reversible than households farming areas of steeper slopes.

- Will the household's strategies to cope with food shortages correlate with child nutritional status?

  S-1 Children of households reporting greater numbers of months of food shortage will be more poorly nourished as defined by lower weight-for-age z-score than children of households reporting fewer months of food shortage.

  S-2 Children of households reporting less reversible responses to food shortage will have children of poorer nutritional status as defined by lower weight-for-age z-score than children of households reporting more reversible responses to food shortage.

4. General background on Rwanda.

4.1 General description

Rwanda is a small, landlocked nation of 26,338 km^2 situated in the highlands of central Africa. (See figure 1-2 for location of Rwanda). At the time of these data were collected, Rwanda's population was 8.6 million and population density was 300 per km^2. (See figure 1-3 for distribution of population density). The estimated annual population growth rate was 3.7% (Clay, 1990, Grosse, 1994). Most of Rwanda's population lives at altitudes of 1300 meters to 2300 meters. These high altitudes provide Rwanda with a mild

Figure 1-2
Location of Rwanda

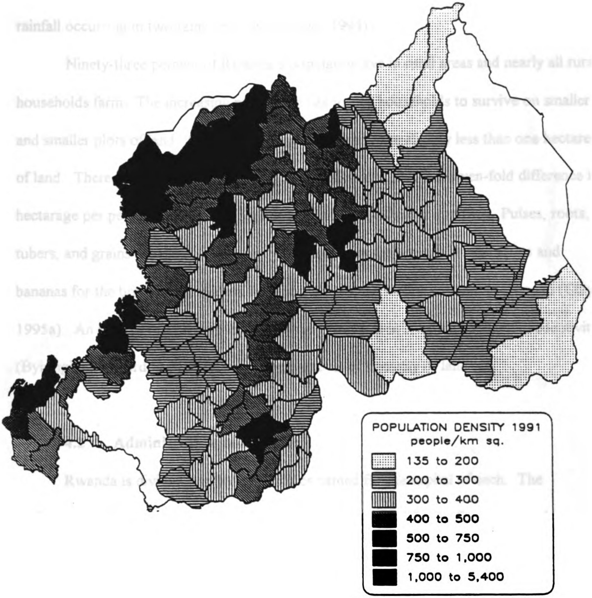

Figure 1-3
Population Density (Campbell and Hu, 1992)

climate with mean monthly temperatures ranging from 21 degrees Celsius at the lower altitudes of the Eastern zone to 15 degrees Celsius in the higher altitudes of Ruhengeri prefecture. Average rainfall in Rwanda is from 800 to 1400 mm per year with most rainfall occurring in two rainy seasons (Grosse, 1994).

Ninety-three percent of Rwanda's population live in rural areas and nearly all rural households farm. The increasing population has forced households to survive on smaller and smaller plots of land. On average, households cultivate slightly less than one hectare of land. There is a large differential in size of land holdings with a seven-fold difference in hectarage per person between the highest and lowest landholder quartiles. Pulses, roots, tubers, and grains are the main staples. Coffee and tea are important cash crops and bananas for the brewing of beer are common. Nearly all land in rotation is cropped (Clay, 1995a). An inverse relationship exists between farm size in Rwanda and land productivity (Byiringiro & Reardon, 1995), indicating the level of intensity of land use.

4.2 Administrative boundaries

Rwanda is divided into ten prefectures named for the capital of each. The prefectures of Ruhengeri and Gisenyi are in the Northwest; Kibuye, Cyangugu and Gikongoro are in the Southwest; Gitarama, Butare and Kigali are in the Central; and Byumba and Kibungo are in the East.

4.3 Agroecological Zones

Rwanda can be divided into five distinct agroecological zones. These do not correspond to the prefectures (See figure 1-2). The Northwest zone has mostly volcanic

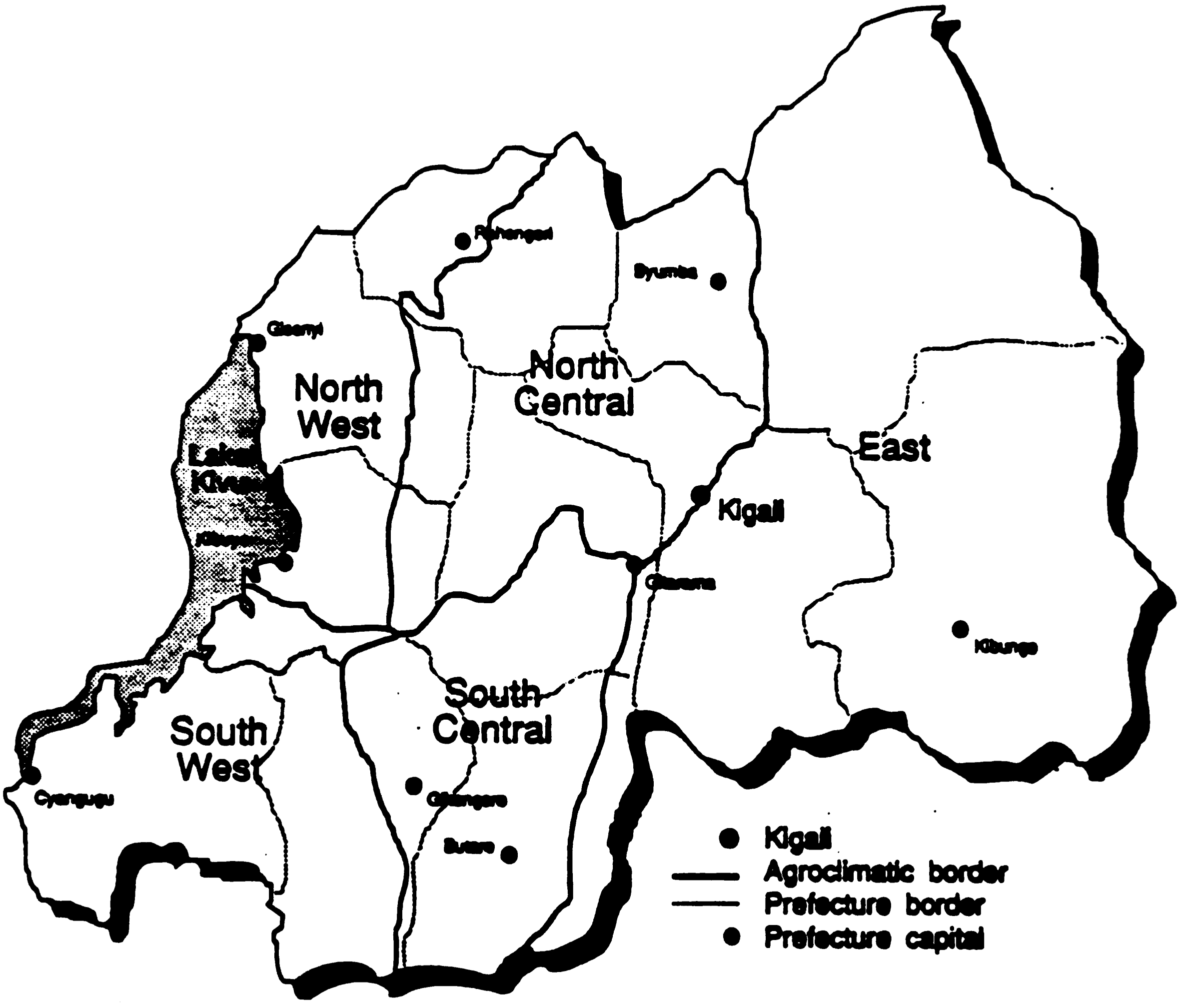

Figure 1-4
Map of Agroecological Zones and Administrative Prefectures
From Schnepf, p. 19, 1992

soils that are highly susceptible to erosion. The altitudes are high so temperatures are cool with heavy rainfalls. Major cash crops in this area are coffee and white potatoes. Bananas grow at elevations below 2,000 meters. Staple crops include maize, sorghum and beans. Much of this area is densely populated.

The Southwest zone is characterized predominantly by high altitudes, steep slopes and high rainfall. Soils are acidic with a high proportion of clay, so they are poorly to moderately suitable for agriculture. A substantial portion is covered by a protected forest. Major cash crops are bananas and coffee while major food crops include beans, sweet potatoes, colocase and cassava. Soils are poor on the steep slopes and fertile on the coast of lake Kivu.

The North-Central zone similarly is characterized by steep slopes. Major cash crops are potatoes, wheat, and coffee while food crops include beans, peas, sweet potatoes, maize and sorghum. These steep slopes are more difficult to farm so were settled later than other parts of Rwanda. Therefore, this zone is less densely populated than much of Rwanda.

The South-Central zone is characterized by sandy soils and serious degradation. Major cash crops are bananas and coffee while food crops include beans, sweet potatoes, cassava and sorghum. The region includes marshes that allow a third cropping season. This region has had high population densities for a long time and agricultural land has degraded over the years.

The East zone is characterized by gentle slopes and lower altitudes. This area is drier than the rest of Rwanda and was traditionally used as pasture land. Population densities in other parts of Rwanda have resulted in migration into this area so it is now densely settled, although farm sizes remain larger than in other areas. Major cash crops are coffee and bananas while sorghum, beans, and cassava are the major staples (Riley-Miklavcic, 1995).

4.4 The People

Rwanda was one of the few countries of sub-Saharan Africa whose boundaries were not created by their colonial powers (Grosse, 1994). The people of Rwanda speak a single language, Kinyarwanda, and comprise a single nationality, Banyarwanda. The Banyarwanda are divided into three ethnic groups, the Hutu comprising 90% of the population, Tutsi comprising 9% of the population, and Twa comprising 1% of the population. The Tutsi monarchy dominated Rwanda during the pre-colonial era. The Belgian and German colonial rulers continued to rule Rwanda through the Tutsi leaders. Between 1959 and 1962 the Tutsi minority were overthrown by the Hutu majority and the Rwandan republic was recognized by Belgium in July 1962. At the time of this study (1988-1992) the Hutu majority remained in power.

4.5 Macro-Economic Conditions and agricultural production

The mid-1980s were a negative turning point in Rwandan agriculture. Until 1983, Rwandan agriculture had grown at a rate of nearly 4% per year, exceeding the rate of population growth, estimated to be 3.1% from 1965 to 1985 (von Brun, 1991). In the same period, Sub-Saharan Africa saw a population growth rate of approximately 2.7%

(World Bank, 1989). In the early 1980s, agricultural growth began to stagnate and total food production fell from 1984-1990 by 5%. During this same period, the population rose by 20% (Grosse, 1995b). The mean growth rate for other low income economies world wide was 3.9% a year (World Bank, 1989).

With the fall of coffee prices on the world market in 1987, Rwanda was thrown into economic decline. In 1989, parts of Rwanda experienced conditions that required food aid from international donor agencies. In October of 1990, armed forces of former Rwandan refugees invaded from Uganda along the Northeastern frontier. These events, coupled with a decrease in donor agency support and government funding, placed a new urgency on monitoring food availability and malnutrition in Rwanda (Schnepf, 1992).

4.6 Nutrition in Rwanda

Prevalence of child malnutrition in Rwanda has been relatively steady in recent years. A national survey conducted in Rwanda in 1983 determined a malnutrition rate of 30%[2] (Schnepf, 1992). In 1992, the *Office National de la Population* conducted the Rwanda Demographic Health Survey (RDHS). This national survey determined that 29% of children under 5 years of age were underweight[3] (Rwanda DHS Survey, 1994).

4.7 Population pressures and environmental conditions

Most developing countries with serious population problems have seen a move away from communally owned lands. In Rwanda this shift is nearly complete.

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[2] Defined at below -2 SD of the NSCH/CDC/WHO international reference.
[3] Defined at below -2 SD of the NSCH/CDC/WHO international reference.

Concurrently, there has been a shift toward tenant farming and absentee ownership. Rwandan farmers are more likely to piece together holdings by renting land from more affluent neighbors. This is significant to the environment of the area because studies have shown that farmers are more likely to invest in their own fields than in those rented from others. In Rwanda, at the time of this study, farmers rented 18.7% of all parcels operated, an increase of 1% per year since 1983 (Clay, 1994).

One consequence of increasing population pressure is that farmers must utilize more marginal lands. In Rwanda, population pressures have forced farmers to move from the more fertile uplands, where farming was easier, onto the steeper slopes. A consequence of this move has been the high incidence of soil loss due to erosion, resulting in lowered fertility of these lands (Clay, 1995a). Further perpetuating the problem of decreased soil fertility and erosion on these steeper slopes, farmers tend to place larger inputs on farms of gentler slopes where the soil is better and more inputs are likely to show results (Clay, 1995b). The combination of slope and heavy rainfall leads to high risk for environmental degradation. Households farming these marginal lands may be at subsequent risk for food insecurity.

Chapter 2

REVIEW OF THE LITERATURE

1.0 Introduction

This chapter includes a review of literature addressing some determinants of malnutrition in agrarian societies. The chapter begins with a discussion of the anthropometric measures used to describe malnutrition and the determinants of malnutrition as defined by these measures. Malnutrition is of complex etiology. Even though anthropometric measures and malnutrition are often not directly related to the amount or types of foods eaten, consumption remains a primary determinant and, as the focus of this study, will receive the greatest emphasis. This section includes: (1) a review of disease-malnutrition synergism, (2) a review of the commonly collected anthropometric measures and an assessment of risk of mortality associated with each of these indicators and, (3) a review of the linkage between agricultural characteristics and nutritional status.

A second part of this chapter continues with a discussion of the literature on land characteristics. It will include a discussion and review of the literature on (1) land availability and use of marginal lands related to nutritional status, (2) population pressures and (3) environmental degradation issues specifically related to Rwanda.

A final section of this chapter discusses the literature on household mechanisms used to cope with episodes of food shortage. Much of the food shortage literature has evolved from an interest in developing famine early warning systems. While the food shortages experienced in much of rural Sub-Saharan Africa do not involve the dramatic effects of famine (i.e., starvation and destitution), these food shortages are on a continuum with famine being an extreme result. The goal of early warning systems is to identify areas of food shortage prior to the onset of famine. Realizing that most food shortages are short lived and do not result in famine, some of this body of literature may be useful in analyzing the food shortages more commonly experienced which may contribute to less drastic outcomes, i.e., malnutrition. The seasonality of these food shortages will be reviewed with frameworks commonly used in evaluating coping mechanisms used by households facing food insecurity.

2. Malnutrition in smallholder agrarian societies

The causes of malnutrition in agrarian societies are of a complex etiology. Consuming enough food is necessary for adequate nutrition, sufficient consumption does not *guarantee* adequate nutrition. Section 2 reviews a number of relationships between disease and malnutrition, the commonly used nutritional status indicators that identify populations at risk, the effects of dietary changes on nutritional status indicators, how socioeconomic indicators and the gender of the income earner interact with nutritional indicators and finally, suggested agrarian linkages to childhood malnutrition.

2.1 Disease and Malnutrition

Maxwell and Frankenberger (1994) have diagramed the interrelationships among several factors including diet and disease, which contribute to death (see figure 2-1). It is clear from this diagram that assuring adequate access to agricultural resources is important in preventing famine but this does not guarantee good nutrition. The FAO, in the **Fifth World Food Survey** states "...it is essential to recognize that undernutrition is not always exclusively a result of inadequate access to food. Adverse environmental factors and health considerations, often closely related, are also important (FAO, 1985).

Jelliffe (1966) and Scrimshaw (1968) recognized the synergism between malnutrition and infection. Malnutrition contributes to disease morbidity and subsequent mortality especially for such illnesses as tropical ulcer, infectious diarrhea, tuberculosis and measles. Conversely, the authors also recognized that disease contributes to malnutrition through decreased intake from poor appetite, diminished absorption and increased energy needs.

2.1.1 Disease occurrence, malnutrition and Socioeconomic Status

Becker et al. (1986) evaluated the relationships between socioeconomic status, morbidity, food intake and growth among Bangladeshi children in two villages. The types of food eaten were closely related to educational status of the household head but the quantity of food eaten was related to income. Diarrhea occurrence was negatively associated with income. Since nutritional status is influenced by both disease and food

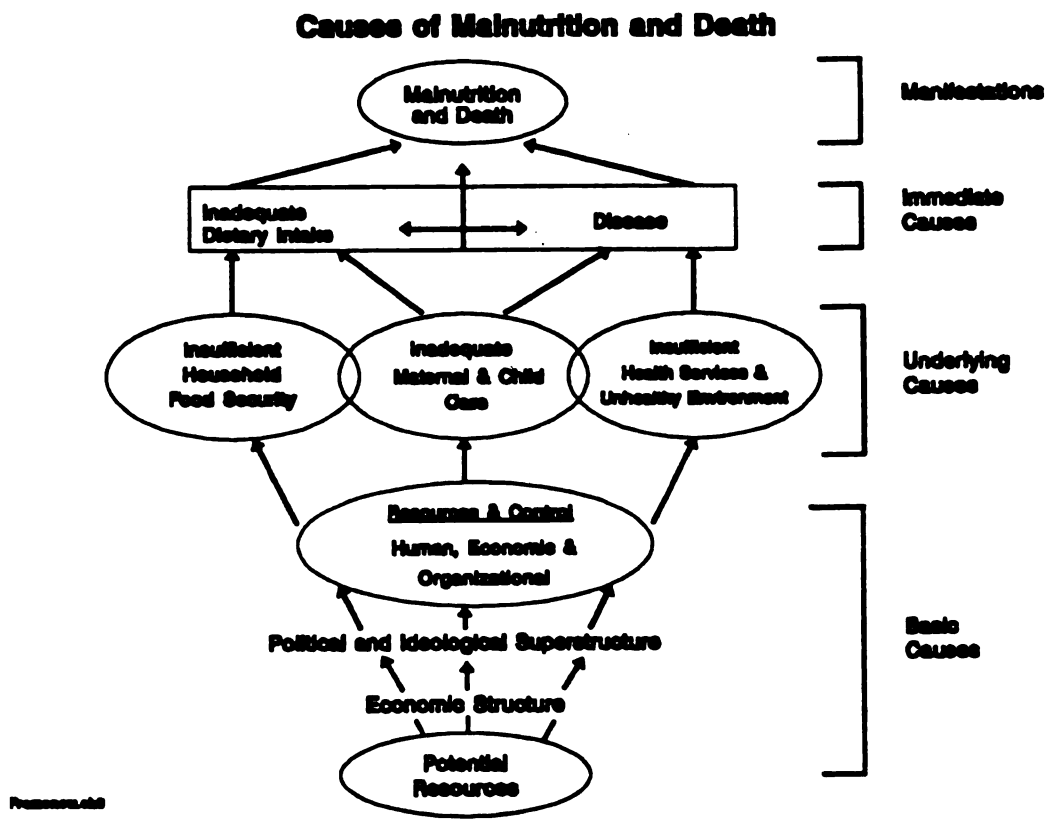

Figure 2-1
Impact of diet and disease on Malnutrition
From Maxwell and Frankenberger, p. 25, 1994

intake, children from wealthier families would be expected to be of better nutritional status than those of poorer families.

Alderman et. al., (1994) in their study from Pakistan, found that children on the nutritional margin react more favorably to health inputs than to agricultural inputs indicating that much malnutrition is the result of disease processes. Strauss (1990) in his study in Côte d'Ivoire found that policies aimed at improving the educational status of villagers, reducing major diseases, and improving the health infrastructure will improve child nutrition.

2.2 Groups at risk for malnutrition

2.2.1 Children under five

Children under five years of age are commonly understood to be at greatest risk for malnutrition and its accompanying consequences. Growth (which is most dramatic in this age group) falters when a child's access to caloric intake falls below requirements to maintain tissues and increase size. This situation occurs when energy requirements rise because of illness or increased activity, or similarly when intake is low due to poor access to food. Absorption problems related to disease such as diarrhea, may also be a factor. Children older than 6 months of age are at highest risk. These children are usually being weaned from breast milk and are, for the first time, being exposed to a variety of pathogens.

Pelletier, et al., (1995) determined the role malnutrition plays in the mortality rates within populations. He was able to determine the population attributable risk (PAR) related to both severe malnutrition and mild-moderate malnutrition as determined by low weight-for-age. The PAR takes into account the prevalence of malnutrition within the population to determine more accurately the role malnutrition plays in mortality. The results from the 53 countries analyzed showed 56% of child deaths were attributable to the potentiating effects of malnutrition. The authors found 83% of these deaths were cases of mild-to-moderate malnutrition demonstrating a larger impact of mild-to-moderate malnutrition than what was commonly considered (Pelletier, 1995).

2.2.2 Efficiency of anthropometric measures in predicting mortality

Bairagi et al., (1985) studied weight-for-age, height-for-age, weight-for-height, weight velocity[1], and height velocity to determine which best identifies groups at increased risk of mortality. The authors determined that weight-for-age and height-for-age performed better than weight velocity and height velocity as discriminators of mortality during the one year follow-up period. The authors tested their assumptions by determining the normalized distance between the living children and the ones who died during the follow-up period; and the maximum sum of sensitivity and specificity (MSS) to determine how accurately the anthropometric indicator predicted death. (Normalized distance is the difference in the mean measures of the living and the dead children per square route of the sums of the variances/2 and squared.)

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[1] Weight velocity and height velocity refer to the change in weight and height over a specified period of time.

Three sets of data are presented in the Bairagi study: one set from June 1975 (demonstrating velocity from April-June), one set from August 1975 (demonstrating velocity from April-August), and one set from October 1975 (demonstrating velocity from April-October). The children in each phase of the study were followed for one year to determine the mortality rate of the group. The total number of subjects increased in the three phases of the study. It is unclear how much overlap takes place between the groups. If children were added to the study after the first phase began, they can not be used in the determination of the growth velocity. The authors do not adequately explain how they dealt with these additional subjects.

The authors present their findings based on the normalized distance and the MSS. As stated above they found that weight-for-age and height-for-age performed better than weight velocity and height velocity at discriminating mortality. Their findings are based on a relatively small number of deaths: 19 deaths in phase 1, 23 deaths in phase 2, and 15 deaths in phase 3. Each sample contained approximately 1000 children. The low incidence of mortality makes it difficult to draw strong conclusions regarding the power of the cross sectional indices.

Chen, Chowdhury & Huffman (1980) studied the relationship between anthropometric indices and increased risk of mortality among children. They investigated weight-for-age, weight-for-height, height-for-age, arm circumference-for-age, and arm circumference-for-height. All indicators were found to discriminate mortality although weight-for-age and arm circumference-for-age were the strongest. Additionally, the authors noted a threshold level after which mortality increased sharply.

The study group contained 2019 children. These children were registered at birth through the International Centre for Diarrheal Disease Research, Bangladesh (ICDDR,B) so exact ages were known. Children were 2-3 years old during the first year of the study. These children were measured and followed for 24 months. The children were classified according to a percentage of the Harvard median standard for the anthropometric measure.

The authors showed that children who were mildly to moderately malnourished had similar mortality rates to normal children. However, the mortality rate of severely malnourished children was nearly double that of the others. This sharp increase in mortality led the authors to hypothesize that a threshold exists in these indicators after which mortality rises drastically. Having found this threshold level provides an important step in determining what communities were at risk for higher mortality related to anthropometric measures of nutritional status.

The authors evaluated the efficiency of the weight-for-age and weight-for-height based on the sensitivity and specificity of these indicators. Neither indicator proved to be efficient. Weight-for-height proved to be the stronger indicator of mortality with the MSS at 125.2. At this point the weight-for-age cut off point is 62%. Sensitivity was 50% and specificity was 75.2%. By contrast the MSS for weight-for-height was 104.8. However, poor nutritional status does not always result in death and not all children who die are malnourished. Therefore, anthropometric indicators are inefficient predictors of mortality.

Vella, et al., (1993), after reviewing the literature, found that much of the research done in the area of anthropometry and mortality was based in south Asia. The authors wanted to explore this topic to determine if the results would be similar in an African population. The authors chose two regions in Uganda to conduct the study. Data were collected on 5498 children under 5 years of age. Anthropometric data were collected and children were classified according to the following: weight-for-age and height-for-age < -3 SD; weight-for-height < -2 SD; and MUAC < 11.5 cm. Malnutrition was significantly higher in the northwest region than in the southwest region.

When the anthropometric indicators were reviewed according to relative risk, MUAC was determined to have the greatest increase in relative risk below the 11.5 cm cut-off point. The authors do not explain why they chose 11.5 as the cut-off point for MUAC. The prevalence of measures below 11.5 was low at 2.6% when compared to height-for-age below -3 SD at 13.3%. This may suggest that the 11.5 cm cut-off point captured a much more poorly nourished aspect of the population. The sum of the sensitivity and specificity at the 11.5 cm cut-off was 117 (sensitivity 19 and specificity 98). The low sensitivity and high specificity suggest that the cut-off point chosen missed a high percentage of children at risk.

Smedman, et al., (1987) studied mortality risk in children aged 6-59 months in Guinea-Bissau determining that height-for-age, not weight-for-height was positively correlated with survival. The authors studied 2228 children in an urban area and three rural areas. The follow-up period for the study included 20,306 child months. During the follow-up period, 109 children died. The authors note that the high mortality rate in the urban area was related to a measles outbreak. The children in the urban area were followed for an entire year, while the rural children were followed for 9-11 months. While mortality rates are expressed in child months for comparisons between groups, seasonal fluctuations in food availability and disease patterns could make this sample biased.

Further, the authors found the gradient in the death rate was greatest at the beginning of the study. They hypothesized that age could be a confounding variable, so the data were stratefied according to age at entering the study and the authors identified the same gradient. Controlling for age in the multivariate analysis, the authors found age on entering the study to be the primary determinant of survival. Similarly, controlling for age, they found that height-for-age had a significant effect on survival (p=0.03) but weight-for-height did not have a significant effect on survival (p=0.12).

2.3 Diet related to nutritional status

Allen, et al., (1992) looked at the effect diet has on growth as measured by length and weight. They studied a group of children in Mexico (35 girls and 32 boys). Data collected on these children included anthropometric data, food intake and morbidity data. Analysis of the data showed that the children, on average, were stunted and of lower weight-for-age than the National Center for Health Statistics (NCHS) reference values. When growth data were compared to the intake data, it was found that higher intake of animal products correlated with higher attained size.

Dewey (1981) evaluated the impact of commercialization on diet among families relocated to Tabasco, Mexico. Increased income among farm laborers and a reliance on purchased foods resulted with an increase in the consumption of refined sugars and a decrease in the consumption of fruits. This change in diet was associated with lower height-for-age among children challenging the assumptions that increased income will result in improved diets and nutritional status.

2.4 Socio-economic Status and nutritional status

Bairagi and Chowdhury (1994) attempted to show how anthropometric data could be used as a proxy of socioeconomic status. The authors found that weight-for-age, height-for-age and mid-upper arm circumference (MUAC) are better indicators of socioeconomic status than weight-for-height. They were able to determine that anthropometric indicators are a stronger predictor of mortality than socioeconomic status. This study demonstrates the possibilities of using certain anthropometric measures (such as weight-for-age and height-for-age) as data for a measure of economic status over such indicators as dwelling space that varies from culture to culture.

2.6 Agriculture-nutrition linkages

2.6.1 Malnutrition relating to food consumption

Food consumption malnutrition occurs when "food production is inadequate, due to lack of land, labor, capital" (Fleuret & Fleuret, 1980). However, the linkage between agriculture and nutrition is not as direct as one might think. Diskin (1994) observed in regard to agriculture and nutrition linkages that: "(1) having enough food available at the national and local levels is ***necessary but not sufficient*** for ensuring that households have adequate access to food; (2) having adequate household access to food is ***necessary but*** *not sufficient* for ensuring that all household members consume an adequate diet; and (3) consuming an adequate diet is *necessary but not sufficient* for maintaining a healthy nutritional status." (Diskin, 1994).

"Nutritional status is defined as a physical state outcome of the body's ingestion, absorption, and utilization of nutrients." (Diskin, 1994). Providing for adequate consumption only assures that the first step of this process. Other health factors determine nutritional status by interfering with absorption of nutrients (i.e. diarrheal diseases) or by increasing the energy needs of the body (i.e. labor demands or diseases). Understanding the relationship between agriculture and nutrition can provide two things: (1) it can show the effect agricultural change has on food consumption in the household, (2) It can be used to identify groups of households that are at increased risk of malnutrition because of agricultural characteristics of that household.

2.6.2 Commercialization of Agriculture and nutrition

Much of the agriculture-nutrition literature has focused on the effect of commercialization or agricultural change. The proponents of commercialization believe that the increased income from the commercial crops will be used to purchase foods that formerly grown as food crops. The increased income will also result in better access to sanitation and medical care, further improving nutrition. The opponents to commercialization point out that the increased income is not always enough to replace the food crops lost. Income becomes more dependent on risky world markets and diet can suffer. They have also shown that income control is often a gender issue, with male farmers often controlling much of the income from cash crops and female farmers, who are often responsible for purchases for the family, having to provide for the family with smaller land areas. This discordance may result in an increase in purchases from household income that do not directly benefit the entire family.

Tripp (1981), in his study in Northern Ghana, found little difference in nutritional status as differences in agricultural indicators changed. He found that the child nutritional status was predominantly affected by the mother's involvement in trading practices. The mother's involvement in trading had a larger effect than the father's involvement regardless of whether the father earned more money by trading. Tripp theorizes that the person who controls the income in the family is most likely to influence the effect the income has on the child.

Kennedy, Bouis and von Braun (1992) looked at the effect cash cropping had on nutrition in 6 countries--The Gambia, Guatemala, Kenya, Malawi, the Philippines, and Rwanda. Families in the study who had participated in cash cropping did show an increase in household income. However, these gains did not show an improvement in preschooler nutritional status. This study used the z-scores for the average height-for-age, weight-for-age and weight-for-height. Two surveys were conducted, one during a time of scarcity and one just after harvest. No significant differences existed between the participants and the non-participants of cash cropping activities in any of these studies.

Among sugarcane farmers in southwestern Kenya, Kennedy & Cogill (1988) discovered that farmers who were sugarcane producers and non-sugarcane producers had approximately the same amount of land in subsistence crops per adult equivalent. There was also no significant difference in caloric intake per adult equivalent among households per quartile of household size. The results of this study seem to suggest two things: 1) It appears that sugarcane farmers tended to have larger farms than non-sugarcane farmers or non-sugarcane producers had more land idle or in non-food crop production. 2) Dietary intake did not increase substantially with the adoption of sugarcane production.

DeWalt (1993) reviewed the results of studies over the previous ten years. She observed mixed results among the studies reviewed with some finding a positive effect of commercialization on nutrition, some a negative effect, and some no effect. She theorized that four things were important. 1) Pricing policies within the country are key to a positive outcome. 2) Protecting subsistence agriculture along with cash cropping has a positive impact on nutrition. 3) The degree to which women control the income impacts child nutrition. 4) Reducing childhood morbidity positively impacts child nutrition.

Sahn (1990) reviewed the impact on nutrition of agricultural commercialization by examining communities that were involved in the production of export crops in Côte d'Ivoire. The bivariate analysis did not show any relationship between income and nutritional status in either wasting (as measured by weight for height) or stunting (as measured in height for age). In the multivariate analysis, the authors controlled for consumption indicators, child's age and sex, and birth order and the most important determinant (according to the author) landholdings and land use variables. The author found that neither landholding per capita nor share of the household's land devoted to export crops were significant in long-term nutritional status. The author did find that increasing income improved the long term nutritional status of children.

The lack of effect on nutrition and the subsequent endorsement of cash cropping per se is somewhat disturbing. If the overall improvement of the community's food security is the goal of development, an improvement in nutritional status should be sought. The rate of stunting in Sahn's study is high (19.8%) and programs should seek to reduce that rate.

Shack, et al., (1990) examined the effect of cash cropping and subsistence agriculture on nutritional status in Papua New Guinea. The sample population was studied to determine economic and agricultural production information as well as consumption patterns of families. Researchers took Anthropometric measures of both children and mothers to determine weight, height, arm circumference, and triceps and subscapular skinfold thickness. The researchers found a correlation between income from cash crops and weight-for-height and weight-for-age.

3. Land Availability

Landless families are often at increased risk for food shortages. Families without access to land rely on employment for income, and in times of food insecurity, employment, if in the agricultural sector, may also be irregular. Even access to small amounts of land in subsistence agriculture can contribute to a household's food availability.

Fleuret & Fleuret found little correlation between land holdings and child nutrition. They state that defining an area planted is difficult because of the varying degrees of planting intensity utilized by farmers. They did acknowledge the importance of access to land in their agriculture and nutrition model but describe a number of intervening factors that make the relationship difficult to define. Sahn (1990) also found no relationship between land holdings and child nutritional status. While Sahn examined families involved partially in export cropping activities, families in Rwanda (the focus of this research) are primarily involved in crops grown for own or local consumption.

DeWalt (1993) in her review of studies in the past ten years saw that land tenure was important in protecting child nutrition. Her study examined the effects land tenure, in the context of the commercialization process, on the nutritional status of the children in the household. The concern voiced by authors such as DeWalt, regarding land tenure, was that households with limited land resources were converting that land away from food crops to cash crops. However, Kennedy & Cogill (1988) contend "even in the smallest farm size category, high priority is place on attaining adequate food consumption" (p. 1076).

Kathryn Dewey (1981) studied the changes in agriculture in Tabasco, Mexico. Those in the study population were part of a relocation project sponsored by the government of Mexico. Dewey found that types of food grown on these farms seemed to be more important to nutritional status that the amount of land farmed. Households who shifted to cash crop production had lower levels of dietary diversity and lower nutritional status. While Dewey concedes that land area is important when comparing landless farmers to large land owners, in Dewey's research economic status seemed to play a bigger part in the difference than land area.

Rawson and Valverde (1976) found that children in households in Costa Rica with less that 1.4 ha, were significantly more likely to be malnourished than children from families with larger land holding. Valverde (1977) found that while the amount of land owned by the Guatemalan families studied did not significantly correlate with nutritional status of children, total amount of land owned and rented by the household did significantly correlate with nutritional status of children. Sahn (1990), as reported in section 2.6.2, found no relationship between landholder per capita nor share of land devoted to export crops.

Pelletier & Msukwa (1991) examined the relationship between cultivated area and child anthropometry finding that height for age z-score (HAZ) decreased with increasing land size for children under 24 months and that HAZ increased with increasing land size for children over 24 months. The discrepancy may be explained by the increased labor demands on the mother as farm size increases. Wandel & Holmboe-Ottesen (1992) found that increasing labor demands on women made it more difficult to prepare the foods needed by small children.

4. Food shortages and methods of coping with food shortages

4.1 Seasonality of food shortage

Seasonality of food availability in tropical regions is determined largely by the fluctuation in rainfall. Many areas of Sub-Saharan Africa experience a time of food shortage prior to the harvest of next season's crops. This food shortage often occurs in tandem with times of peak energy requirements for land preparation and crop management, exacerbating the problem. As the harvest approaches, food stores are depleted and labor demands increase. Diarrhea prevalence during this period further stress energy reserves, and is discussed in section 3.1 (Chambers, 1981).

Many researchers have reported that children are the most affected by seasonal food shortages. However, this varies greatly depending on the culture studied. Leonard (1991) assessed how households adapt to seasonal food shortages in Nunoa, Peru and determined that among households studied, children under twelve years were protected from food shortages and had more adequate pre-harvest diets than adults. In other cultures children may not be protected in the same way.

4.2 Famine early warning systems

Famine is a severe, dramatic form of the food shortages experienced in much of Africa. The idea of predicting food shortages and famine has received increasing attention since the severe food crises in Africa in the 1970s and 1980s. The concept of famine early warning systems (EWS) grew out of this concern for, and is based on, the perceived causes of famine. Famine is often thought of as food shortages so EWS were based on climatic or production changes, but Sen (1981) argued that famine is caused by "some people not having enough food to eat...not the characteristic of there not being enough food to eat." The causes of famine are many and data on available indicators of famine are sometimes incomplete. Mason (1987) emphasized the necessity of collecting a variety of information to predict where famine is likely.

Davies (1991) points out that famine is actually a continuous process including the more common, less severe, short term food shortage. She sees that much of the research in EWS has come from an emphasis on predicting future areas of crisis by a continuous monitoring of socio-economic information predictive of areas likely to be more vulnerable to food shortages. This helps generate appropriate responses so that crises are averted.

4.3 Coping strategies

Households faced with food shortages often seek to protect their livelihood so as to be able to recover quickly once the crisis has ended. Maxwell & Frankenberger (1994) talk about two such groups of strategies households use to cope with shortages. The first group is strategies to maintain a *status quo*. These strategies rely on the household's ability to prepare for the crisis prior to its occurrence. These include: making production more secure, adequate storage of foods, maintenance of social and political ties to insure food sharing and risk spreading. The second group includes strategies that involve adapting to conditions in a way that will preserve a household's ability to recover quickly. These include occupational mobility and keeping some salable animals that will allow the household to rebuild after the crisis. The authors observe that some households will reduce their food intake in an effort to preserve their resources such as seed for next year's crops (Maxwell & Frankenberger, 1994).

Migration is a common response to famine. When attempting to use migration trends as a predictor of food shortage, it is important to distinguish between the normal seasonal migration practiced by pastoralists and farmers during the dry season and the migration associated with seeking food aid or employment. Since some migration by pastoralists, farmers and individuals in search of employment is normal, it is important to evaluate trends and watch for drastic increases in this phenomenon. Male out-migration in search of employment was identified as a coping strategy by Frankenberger (1983).

Davies identifies coping strategies that may be monitored and the source of information regarding these strategies in the chart below (See table 2-1, below). Campbell (1990) states that "adoption of coping strategies follows a sequence from more to less palatable alternatives as a shortage intensifies, ultimately resulting in the liquidation of productive assets, abandonment of the rural economy and, if access to food becomes so difficult, death" (Campbell, 1990, p. 231). In contrast to Kelly (1992) who argued that child anthropometry could be used as an early warning indicator of famine, Campbell states that anthropometry would be a late indicator and even so, households affected by shortages may be isolated from health centers where monitoring can take place.

Davies (1991) takes the model developed by Frankenberger to describe the concept of livelihood security. This model looks at what activities families undertake to secure a sustainable livelihood. This approach looks at a family's access to resources through social linkages as well as land and other natural resources. It takes into account such cultural aspects as securing one's livelihood so this approach may give a more complete picture of a household's ability to cope with food shortages (Maxwell, p. 31, 1994).

Table 2-1
Monitoring of Coping strategies
From Davies, 1991

Community mechanism to deal with food crises	Potential indicators	Possible sources of data
Change of food source	Number of households dependent on reserve	Agricultural workers, health centres
Attempt to find employment	Unusual movement of adult males: change in wage rates or applications for jobs	Chiefs, administrators, recruiting agencies, extension workers
Sell off livestock	Increase in sales, decline of livestock prices	Extension workers, cattle auctions, abattoirs
Attempt to purchase food in local markets	Increase in crop sales, increase in crop prices	Marketing agencies, local price reporters
Request assistance from government	Number requesting assistance, applying for programmes	Records of assistance programmes, NGOs
Seek assistance from relatives	Change in school enrolment, changes in clinic attendance, increase in remittances	School, clinic records, banks, post offices, (flow of remittances)
Migrate to areas not affected	Unusual movements of people	District and area administrators

Source: FSG 1990 and Eele 1987.

4.4 Anthropometry to predict famine

As food becomes scarce and households reduce their intake, anthropometric indicators will tend to fall and malnutrition prevalence will increase. However, anthropometry as an indicator of food security is thought of as an end result indicator and not as a useful predictor of where food insecurity may occur. Haddad et al., suggest a number of variables that can predict the extent to which a household may be at risk. Household size above the norm, household dependency ratios, land use and ownership and number of crops grown, all tend to be good predictors of food security (Haddad, et al., 1994).

Kelly (1992) believes that in cases where a household's initial response to food shortages is to decrease intake, anthropometry can be used as an early warning system for famine. However, Mason (1987) describes the importance of continuous monitoring of child anthropometry, if anthropometric indicators are to be used as indicators of famine. He described a difference between the 'normal' fluctuation in malnutrition prevalence in Botswana and the increased malnutrition prevalence in drought years. If Botswana had not collected baseline data on malnutrition in normal years, these normal fluctuations may have been misinterpreted as an impending crisis.

5. Conclusion

The literature reviewed in this chapter demonstrates the complex etiology of malnutrition among children under five in smallholder agrarian societies. Adequate food consumption plays a necessary role in preventing malnutrition while agricultural production plays a necessary role in providing adequate food supply for consumption. However, analyses that attempt to show relationships between agriculture and nutrition need to account for the wide variety of factors that may compound or disguise any relationships.

This research will use weight-for-age as the primary dependent variable for analysis. Both weight-for-age and height-for-age identify populations at increased risk for mortality and morbidity. However, weight-for-age incorporates a measure of stunting or chronic undernutrition, and wasting or acute undernutrition. Additionally, weight-for-age is recommended by the World Health Organization as a tool in growth monitoring.

The research for this thesis will examine characteristics of land farmed by smallholder households in Rwanda to determine if a predictive relationship exists between these characteristics and child nutrition. The authors reviewed varied in their conclusions. Population pressures in Rwanda have forced households to use their land more intensely than in many of the areas reviewed. This research may be able to demonstrate differences between households assuming that there will be less variation between households in amount of land fallow when land use is more intense.

This thesis research will also explore the mechanisms households utilize to cope with periods of food insufficiency. How a household copes may demonstrate the resilience of that household to dietary stress. The research presented in this review is based on a model for famine early warning systems. The early warning systems identify households or communities that are beginning to utilize mechanisms that are less reversible to identify areas of impending famine. This research will attempt to identify linkages between land resources, coping mechanisms and child nutritional status to determine if patterns in coping can be used to identify areas likely to be at higher risk for the less severe and more common form of food shortage.

Chapter 3

METHODOLOGY

1.0 The *Division de Statistiques Agricoles* (DSA) Survey

This research utilized existing data from the Rwanda National Nutrition and Food Security Survey (NNFSS) conducted by the *Division de Statistiques Agricole* of the Ministry of Agriculture with partial financial support and technical assistance of UNICEF-Kigali, Serge Rwamarisabo and Katherine Krasovec. Base financial support was provided by the USAID Food Security Project, with technical assistance from Catherine Tardif-Douglin.

1.1 The survey design

The research cohort was a stratified random sample of Rwandan households living outside of urban areas and engaged in farming for themselves. To determine the sample, a list of households dated July, 1988 was obtained from the Ministry of Agriculture (MINAGRI). The sample was chosen according to the following method. (1) DSA created 21 strata from these data based on a combination of agroecological zone and administrative prefecture. Next, 78 administrative sectors were randomly selected from all sectors in Rwanda. Between from 2 to 8 sectors were chosen per stratum. (2) One census district was randomly selected from each sector in the sample. Within the census district, the interviewer randomly selected four cells. The cell is defined as the sample cluster. (3) Within each cluster, 12 households were randomly selected: four households selected for the intensive portion of the sample, four selected for the extensive portion of the sample and four were selected to be kept in reserve so households could be replaced if dropped for any reason. Households included in the intensive sample had economic and agricultural data collected monthly from October 1988 through October 1991. Households included in the extensive sample had demographic data collected and were included, along with the intensive sample, in the nutrition survey. A total sample of 3744 households were identified with approximately 2500 used in the sample as either the extensive or intensive part of the sample.

The National Nutrition and Food Security survey (NNFSS) data were collected for households within the cohort of 2500 with children under five years of age, approximately 1200 households. These data were collected in three rounds: 1) between November 1991 and January 1992, 2) between February and May 1992, and 3) between July and October 1992. The number of children surveyed in round one was 1939, round two was 1791, and round three was 1643 (Grosse, personal communication).

1.2 Strengths and weaknesses of survey design

The NNFSS contains agricultural and nutrition data that can be linked by household. Few data sets have been designed to be linked in this manner. However, the agricultural and economic data and the nutritional data in the DSA survey were not collected during the same season. The agricultural and economic data were collected from crop year 1989 (October, 1988) through crop year 1991 (October, 1991). The first round of the NNFSS began collection in November 1991. Had the NNFSS been conducted in the same year as the agricultural and economic data were collected, the analysis would have been strengthened.

Demographic data were collected for all households in the sample in October of 1990. However, the register is incomplete. In many cases infants were left out and their ages were recorded in years rather than months with no consistent method for rounding. Demographic data were not collected again in 1991 or 1992 (Grosse, personal communication). Because demographic information was incomplete and not collected again in 1991, it was impossible to know for certain the number of persons living in each household at the time the nutrition survey was completed. The number of persons per household may have been important in understanding the relationship between land area and child nutrition.

The three rounds of nutritional data were collected by different teams of interviewers. The first round was conducted by supervisors (one per prefecture) and specially trained interviewers hired for the job. The supervisors received anthropometric training from UNICEF-Kigali staff and were supervised by these staff during the first round of surveys. Round two was conducted by the interviewers who had been following the households through the DSA survey since 1988 and the anthropometric measures were collected by the specially trained interviewers, sometimes on a different day than the interview. The final round was conducted by the interviewers from round one. As stated above, during round one the interviewers received the most rigorous supervision so more confidence is placed in those data.

The respondents for the nutrition surveys were asked a series of questions in the first and third rounds of the survey regarding food shortages and methods for coping with food shortages. As described in chapter 1, section 2, coping strategies were determined by "yes" or "no" answers to 13 predetermined strategies. While this method allowed for easier data collection, it may not have captured all possible coping strategies used by the household. Activities such as foraging for forest products and the use of animal products were not assessed and may be a valuable resource used by households. Additionally, information on storage of food and other strategies to prevent shortages may have provided useful information to explain why some households experience shortage and some do not.

2.0 Organization of the Data for Analysis

2.1 The nutrition sample

The nutrition sample was derived by surveying all households with Children 5 years of age and under in the cohort of 2500 households, roughly 1200 households. This included households from both the intensive and extensive portions of the DSA samples (see section 1.1 above). The National Nutrition and Food Security Survey (NNFSS) was conducted in three rounds with a series of questions and anthropometric measures collected in all three rounds. In round one and three only, interviewers asked respondents the series of questions on food security and coping with times of insecurity that are of interest for this research. For this reason, the research will focus on these two rounds of data.

2.2 Organization of data files

Since the agricultural phase of the study was conducted only on the intensive sample no agricultural data are available for roughly half the households in the nutrition survey. The first step of the data organization split the data between members of the intensive sample and members of the extensive sample. Since agricultural data are available only for the intensive sample, the analysis was restricted to this group. In round one, 926 children were included in the intensive sample and 975 in the extensive sample. In round three, 760 children were included in the intensive sample and 849 in the extensive sample.

Next, children with weight-for-age z-scores that were improbable and were likely the result of measurement error or errors in recording birth date or interview dates were eliminated from the sample. Weight-for-age z-scores below -4.5 and above +4.5 SD were defined for this research as improbable. Children with z-scores above or below these values of weight-for-age were eliminated from the sample because such scores were likely based on errors in the data. In the round one intensive sample, 29 children were eliminated. In the round 3 intensive sample, 18 children were eliminated.

Since children aged 0-6 months are likely to be breastfed almost exclusively and tend to be less affected by environmental variables, these children were eliminated from the sample. Next, to eliminate bias toward households with more than one child, one child was randomly selected for each household.

Children were then categorized in age groups as follows: 6-11 months, 12-23 months, 24-35 months, 36-47 months, and 48-60 months. Since growth patterns vary from one geographic area to another and since international references are based on US populations, analyses using child weight-for-age will control for age based on these grouping (Brown, 1982 and WHO, 1995).

The total number of children (and households) included in the round one intensive sample is 616. The total number of children (and households) included in the round three intensive sample is 507.

2.3 Weighting of the sample

Because the sample was stratified, households from less populous census districts had a higher probability of being chosen than more populous census districts. Each household in the sample is weighted according to the probabilities of being chosen.

3.0 Methods for addressing research hypotheses

3.1 Weight-for-age as the dependent variable

This study used weight-for-age as a dependent variable in analysis. Three indicators of nutritional status are commonly used in nutritional research in developing countries: weight-for-age, weight-for-height and height-for-age. Stunting in a population (prevalence of low height-for-age) provides a historical look at the food security of the community. Wasting (prevalence of low weight-for-height) provides a more immediate look at a community. Weight-for-age demonstrates a combination of both stunting and wasting. As such it provides an overview of the community's nutritional well-being.

All three indicators, have been demonstrated to be associated with increased risk of mortality (Martorell, et al, 1980, Smedman, 1987, Bairagi, 1985, Kielmann & McCord, 1987, & Chen, 1992). However, weight-for-age has been recommended by the World Health Organization in evaluating progress toward "Health for All by the Year 2000" (WHO, 1981). In growth monitoring programs weight-for-age has been used to track the growth of individual children. As an indicator that health centers are accustomed to tracking, data on weight-for-age are readily available in many areas. Because of this indicator's availability, it may be useful for agricultural and nutritional planning in a variety of contexts. Child weight-for-age z-scores, based on the Nation Center for Health Statistics/CDC, will be used as a measure of nutritional status and as a dependent variable in this research.

For this research, weight-for-age z-scores were grouped as follows. Children below -2 SD when compared the reference population were defined as malnourished, children between -1 and -2 were defined as mildly malnourished, children above -1 SD were defined as adequately nourished.

The tables 3-1 and 3-2 below demonstrate the mean weight-for-age z-score per agroecological zone.

Table 3-1
Summary of Weight-for-age variable, Round 1

Zone	Mean WAZ	Std. Dev.	# <= -2 SD	Total #	% of children undernourished
Northwest	-1.3306	0.9305	23	95	24
Southwest	-1.7022	0.7743	30	85	35
North Central	-1.4397	0.9411	40	152	26
South Central	-1.5971	1.0083	45	121	36
East	-1.6671	1.0919	68	162	42
Entire Sample	-1.5501	0.9805	206	616	33

Table 3-2
Summary of Weight-for-age variable, Round 3

Zone	Mean WAZ	Std. Dev.	#<= -2 SD	Total #	% of children undernourished
Northwest	-1.2641	1.0554	23	101	23
Southwest	-1.4416	0.9315	21	79	27
North Central	-1.4052	0.9548	34	117	29
South Central	-1.5197	0.9098	25	87	29
East	-1.2989	1.0823	30	124	24
Entire Sample	-1.3764	1.0823	132	507	26

4.0 Research hypotheses

4.1 Hypotheses addressing land characteristics

E-1. Children of households farming lands of steeper slopes will be more poorly nourished as defined by a lower z-score for weight-for-age than children of households farming lesser slopes.

Information on slope of farm was collected in season 91B or the second half of the crop year beginning in October, 1990. This variable is an average slope of all parcels held by the household. As an average value, this variable cannot take into account the variability in slope of each household's landholdings. However, the average value does allow us to distinguish between farmers who tend to farm steeper, and perhaps more marginal lands, from farmers who tend to farm less steep slopes, and perhaps less marginal lands. The range of slope, in degrees of slope, was 1 degree to 45 degrees and the entire sample was divided into three equal groups according to slope for comparison. This research examined relationships between these slope terciles and child weight-for-age z-scores. Mean slopes per zone are listed on table 3-3 below

Table 3-3
Mean Slope of land area per household / per zone in degrees of slope

Variable	Mean	Std Dev	Cases
Northwest	14.7379	8.4377	94
Southwest	17.6743	5.4992	82
North Central	17.8278	7.2221	151
South Central	11.6709	5.8572	129
East	9.0250	5.0465	170

The relationship between slope and weight-for-age z-score were examined initially with regression analysis. Scatter plot with regression lines for each round of data were constructed and analysis of the line carried out. Crosstabs procedures were employed using the terciles of slope and weight-for-age z-scores with Chi-square analysis to determine if distributions seen were by chance or evidence of a relationship. Finally, Analysis of Variance (ANOVA) procedures were employed to compare the weight-for-age z-score means per tercile and determine if significant relationships existed.

E-2. Children of households with greater area of cultivated land will be better nourished as defined by a higher z-score for weight-for-height than children of households with lesser areas of cultivated land.

This analysis utilized the land area data from crop season 91b or the second season of the crop year beginning October of 1990. While information on land area was available for multiple seasons, this variable contained information most closely related chronologically to the nutrition survey.

It was not always clear if the interviewers were asking respondents about land area owned or land area to which the household had access. This distinction may be important. Land the household is renting will likely require some reciprocation to the land owner, reducing the benefits to the household.

The range in surface area available for the household's use was 3.03 ares[1] to 483.53 ares. The range in cultivable land available for the household's use was 0.32 ares to 402.82 ares. The range in land cultivated during that season by the household was 0 ares to 317.07. The mean surface areas per household per agroecological zone are noted on the table 3-4, 3-5 and 3-6 below.

Table 3-4
Mean Total Surface area in ares available to the households / Zone

Variable	Mean	Std Dev	Cases
Northwest	54.2814	42.2640	87
Southwest	105.6399	98.6466	82
North Central	90.7412	73.7611	145
South Central	79.0279	63.3632	128
East	109.0866	64.1282	169

[1] ares are equal to 100 km^2. One tenth of a hectare.

Table 3-5
Mean Arable Land in ares per household / Zone

Variable	Mean	Std Dev	Cases
Northwest	47.0849	37.0192	87
Southwest	77.7010	58.0850	82
North Central	78.8172	63.9033	145
South Central	68.7938	50.0055	128
East	103.1257	61.6708	169

Table 3-6
Mean Land area in ares under cultivation per household / Zone

Variable	Mean	Std Dev	Cases
Northwest	34.9985	27.1411	87
Southwest	57.4624	39.8857	82
North Central	61.7389	43.1762	145
South Central	54.0404	32.8270	128
East	85.6994	48.4670	169

Regression analysis was employed to study the relationship between land area and weight-for-age. First, a scatter plot was constructed with a regression line. Linear regression analysis of this line was then carried out. ANOVA procedures using terciles of land area and weight-for-age z-score variables as the dependent variable were conducted for both rounds of data.

4.2 Hypothesis relating to food shortage

S-1 Children of households reporting greater numbers of months of food shortage will be more poorly nourished as defined by lower weight-for-age z-score than children of households reporting fewer months of food shortage.

Respondents to the NNFSS were asked in round one and round three how many months in the last year they experienced some food shortages in their households. The results per household are on the table 3-7 below.

Table 3-7
Reported months of Food Shortage

	Round 1		Round 3	
Months of shortage	**Frequency**	**Percent**	**Frequency**	**Percent**
0	389	59.8	175	31.0
1-3	163	25.0	188	33.5
4-12	99	15.2	199	35.4
Totals	651	100.0	562	100.0

The months of reported food shortage are much higher in round 3 than round 1. The explanation for this difference is unclear. If households were asked about shortages during a time of shortage, the question is likely to have more positive responses due to memory biases. However, the round one data were collected at the end of a usual seasonal shortage and the round three data were collected before the beginning of the next seasonal shortage. Additionally, production data from the survey year do not indicate any shortfall, so year to year fluctuations do not adequately explain the differences (Grosse, 1995).

ANOVA was used to analyze data for this hypothesis. The mean weight-for-age z-scores were compared for each of the three groups of shortage listed on the table above.

4.3 Hypotheses related to types of coping mechanisms reported

The remaining hypotheses addressed the reported mechanisms used to cope with times of food shortage. Only households who reported a shortage in the previous year were included in this analysis.

Households reporting one or more months of food shortages were asked if they used any of thirteen mechanisms to cope with times of food shortage. The frequency of responses to the various coping patterns are reported on the table 3-8 below. Percentages listed are the percentage of households stating they have utilized the coping mechanism specified out of all households reporting food shortage in the previous year.

Table 3-8
Frequency of "yes" responses to coping mechanisms

Mechanism	Round 1		Round 3	
	Number	% of respondents	Number	% of respondents
Harvest early	195	76.4	325	83.7
Reduce meals	178	70.0	282	72.6
Seek other employment	141	55.4	198	51.1
Eat food reserved as seed	112	44.0	222	57.3
Sell possessions (not land)	76	29.8	121	31.1
Seek aid from neighbors	70	27.5	62	16.0
Children sent away	25	9.8	18	4.7
Seek aid from within the commune	22	3.4	18	4.6
Sell land	19	7.4	17	4.3
Aid from a church	16	6.4	11	2.7
Adults leave Household	17	6.5	8	2.2
Children quit school	13	5.1	11	2.8
Aid from another organization.	9	3.5	7	1.9

Of the six most commonly reported categories--harvest early, reduce meals, seek other employment, eat food reserved as seed, sell possessions, and seek aid from neighbors--each was used by at least 10% of those experiencing shortage in both rounds. Therefore, the remainder of the analysis focused on these mechanisms.

The three most common--harvest early, reduce meals, and seek other employment--tend to be easily reversible once the time of shortage has passed. The next two--eat food reserved as seed and sell possessions--are less easily reversible, requiring households to purchase replacements once the time of shortage has passed. The final strategy--seek aid from neighbors--is not without cost and may require some reciprocation to those neighbors. Therefore this mechanism was also be grouped as less reversible. In round one, 67 households used at least one of the first three mechanisms without using at least one of the second three, while 169 households used at least one of the first three mechanisms and at least one of the second three. In round three, 100 households used at least one of the first three mechanisms without using at least one of the second three while 275 households used at least one of the first three and at least one of the second three.

In addition to the reversibility variable outlined above, a variable to determine the number of mechanisms reported to be used was created. This variable will only represent the number of "yes" responses to the thirteen questions asked as part of the survey. It did not take into account any coping mechanisms that are not a part of this survey. The number of households reporting multiple mechanisms are on table 3-9 below.

Table 3-9
Number of coping mechanisms used per household

Number of mechanisms	Round 1 # of households	Round 1 % of Total	Round 3 # of households	Round 3 % of total
1-2	67	26.8	118	31.0
3	64	25.6	94	24.7
4	63	25.2	86	22.6
5-13	56	22.4	83	21.8
Total[2]	250		381	

[2] Total only included households who reported food shortage

S-2 Children of households reporting less reversible responses to food shortage will have children of poorer nutritional status as defined by lower weight-for-age z-score than children of households reporting more reversible responses to food shortage.

This hypothesis was addressed by using the t-test and ANOVA to determine if the mean weight-for-age z-score was significantly different between the group of households using "reversible" mechanisms and those using "less reversible" mechanisms as described above.

ANOVA procedure to determine if the mean weight-for-age z-score varied significantly according to number of coping mechanisms used was also carried out.

R-1 Households with larger land areas cultivated will utilize coping strategies that are characterized as more reversible than households with smaller land areas cultivated.

Analysis to address this hypothesis utilized the t-test and ANOVA procedures. The means for surface area, arable land, and cultivated land were compared between the two groups for coping mechanisms using these procedures.

ANOVA procedure to determine if the mean surface area differ significantly according to the number of strategies used were carried out.

R-2 Households farming land areas of lesser slopes will utilize coping strategies that are characterized as more reversible than households farming areas of steeper slopes.

T-test and ANOVA were used to determine if mean slopes varied between households using reversible mechanisms versus households using less reversible households. Then, ANOVA was used to determine if the mean slopes varied between households using more coping mechanisms than households using fewer mechanisms.

5.0 Summary

All analyses described in the preceding sections were completed using SPSS for Windows version 6.1.

The analysis of land characteristics addressed land area and slope of land. Additional information on such variables as the type of soils, erosion rates, intensity of crops planted and access to other resources may further clarify this relationship between the land and child nutritional levels but their specific analysis is beyond the scope of this study. These relationships are being investigated by others involved in the analysis of this data set. Additionally, the slope variable used is a per household average of all parcels used. The practice of Rwandan farmers piecing together several parcels of different types requires the averaging of slope but may lessen the strength of any relationships identified.

Chapter 4

RESULTS

This chapter will report the results of analysis described in Chapter 3. Each section will address one of the three research questions and relating hypotheses as outlined in chapter 1.

1.0 Do characteristics of the land resources available to the household correlate with the nutritional status of children under five years of age in Rural Rwanda?

E-1. Children of households farming lands of steeper slopes will be more poorly nourished as defined by a lower z-score for weight-for-age than children of households farming lesser slopes.

Regression analysis is used to determine if this relationship exists and is significant. The first step in the regression analysis included plotting the regression line. The results for round 1 and round 3 are on figures 4-1 and 4-2 below.

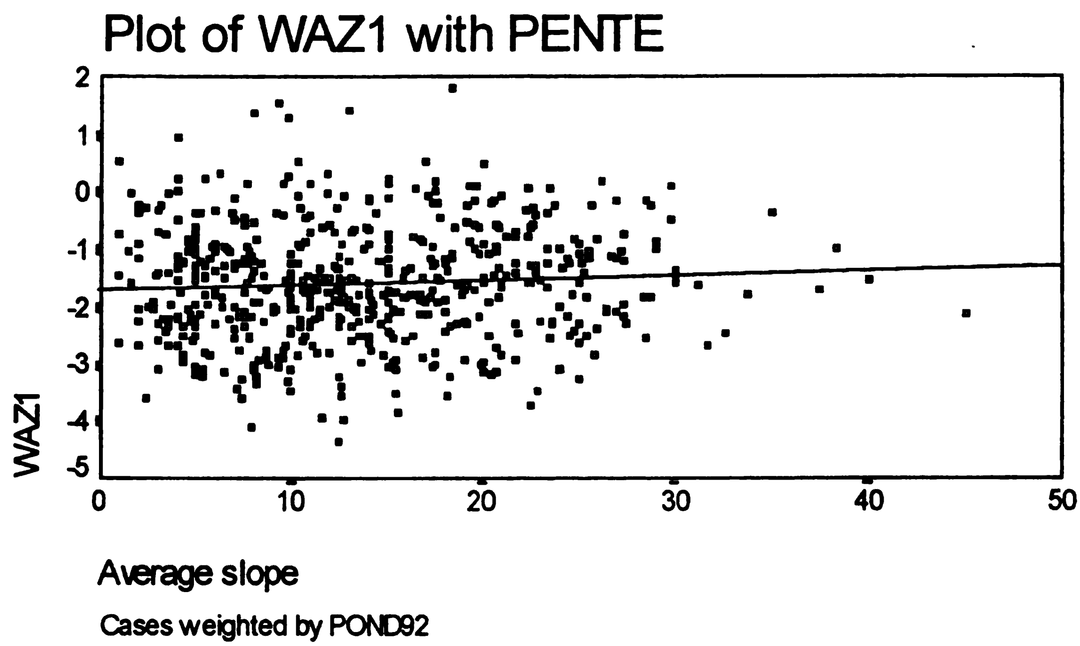


Figure 4-1
Round 1: Scatter plot of Weight-for-age z-score by slope with regression line

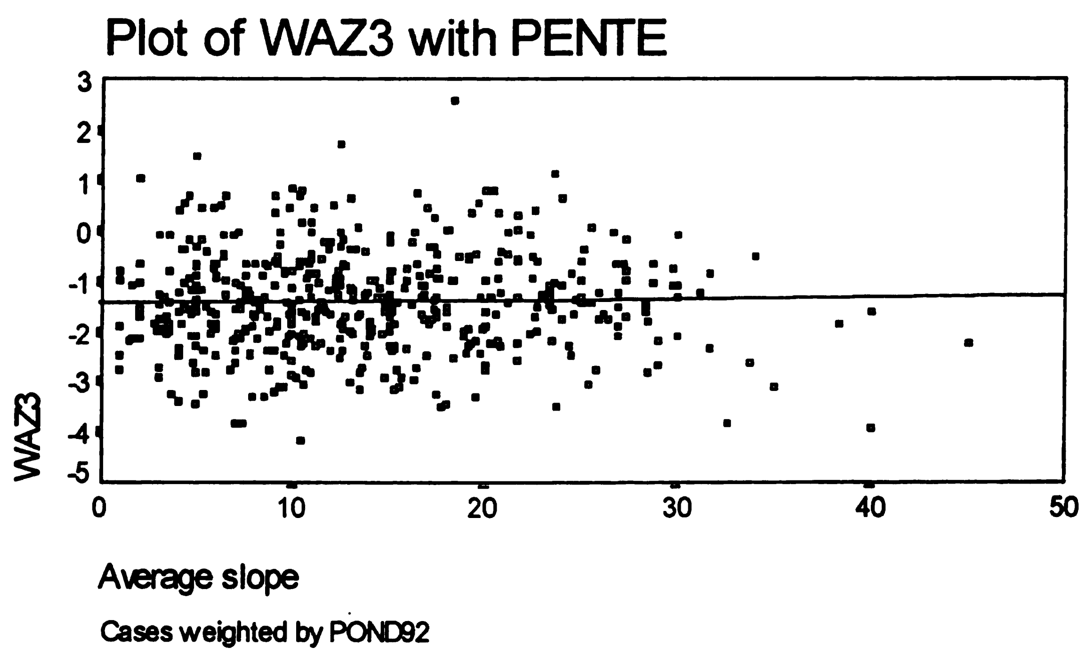


Figure 4-2
Round 3: Scatter plot of Weight-for-age z-score by slope with Regression line.

As can be seen on the figures above, the slope of the line is slightly positive, the opposite of the expected direction to satisfy the hypothesis. Multiple regression analysis using Child age group and slope as the independent variables and weight-for-age z-score as the dependent variable was then conducted to determine the significance of relationships. The results of this analysis are on the tables 4-1 and 4-2 below.

Table 4-1
Round 1: Regression Analysis of relationship between slope, age and weight-for-age z-score

Multiple R	0.06423
R Square	0.00413
Adjusted R Square	0.00069
Standard Error	0.97480

	DF	Sum of Squares	Mean Square
Regression	2	2.28228	1.14114
Residual	580	550.90020	0.95023

F= 1.20091 Significant F = 0.3017

Variable	B	SE B	Beta	T	Sig T
Slope	0.008469	0.005467	0.064263	1.549	0.1219
Age	0.000057	0.002763	0.000855	-0.021	0.9836
(Constant)	-1.689808	0.161609		-10.654	0.0001

Table 4-2
Round 3: Regression Analysis of relationship between slope, age and weight-for-age z-score

Multiple R	0.09268
R Square	0.00859
Adjusted R Square	0.00449
Standard Error	1.00359

	DF	Sum of Squares	Mean Square
Regression	2	4.22392	2.11196
Residual	484	487.48609	1.00719

F= 2.09687 Significant F = 0.1240

Variable	B	SE B	Beta	T	Sig T
Slope	0.003930	0.006062	0.029416	0.648	0.5171
Age	-0.006139	0.003095	-0.090010	-1.984	0.0478
(Constant)	-1.234904	0.133706		-6.536	0.0001

Chi-square analysis was also used to clarify the relationship between these variables. three weight-for-age groupings and three slope groupings were used in the Chi-Square and the Mantel-Haenszel test for linear association was used to determine if significance was linear. The results of this analysis are on tables 4-3 and 4-4 below.

Table 4-3
Round 1: Crosstabs of Slope tercile and nutrition category

		Nutrition Category			
Count		weight-for-age z-score< =-2	-2< weight-for-age z-score <=-1	weight-for-age z-score>-1	Row Totals
Slope tercile	1.00	76	66	52	195 33.0%
	2.00	72	78	46	196 33.2%
	3.00	54	86	60	200 33.9%
	Column Totals	203 34.3%	230 39.0%	158 26.8%	591 100%

Chi-Square	Value	DF	Significance
Pearson	8.56607	4	0.07291
Likelihood Ratio	8.77396	4	0.06700
Mantel-Haenszel	4.00149	1	0.04546

Table 4-4
Round 3: Crosstabs of Slope tercile and nutrition category

		Nutrition Category			
Count		waz< =-2	-2< waz <=-1	waz>-1	Row Totals
Slope tercile	1.00	47	70	48	165 33.9%
	2.00	44	70	54	168 34.5%
	3.00	38	63	53	154 31.7%
	Column Totals	128 26.4%	203 41.8%	155 31.9%	591 100%

Chi-Square	Value	DF	Significance
Pearson	1.25830	4	0.86841
Likelihood Ratio	1.26056	4	0.86803
Mantel-Haenszel	1.18757	1	0.27582

A significant Mantel-Haenszel score is seen in round 1 indicating that a significant linear association between slope and weight-for-age z-score is present when the data are divided in this manner.

Analysis to determine if differences existed between the mean weight-for-age z-score by the tercile of slope was accomplished by using One-way ANOVA. Results are found on tables 4-5 and 4-6 below.

Table 4-5
Round 1: ANOVA for weight-for-age z-score by slope category

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	5.6711	2.8356	2.9617	0.0525
Within Groups	588	562.9538	0.9574		
Total	590	568.6249			

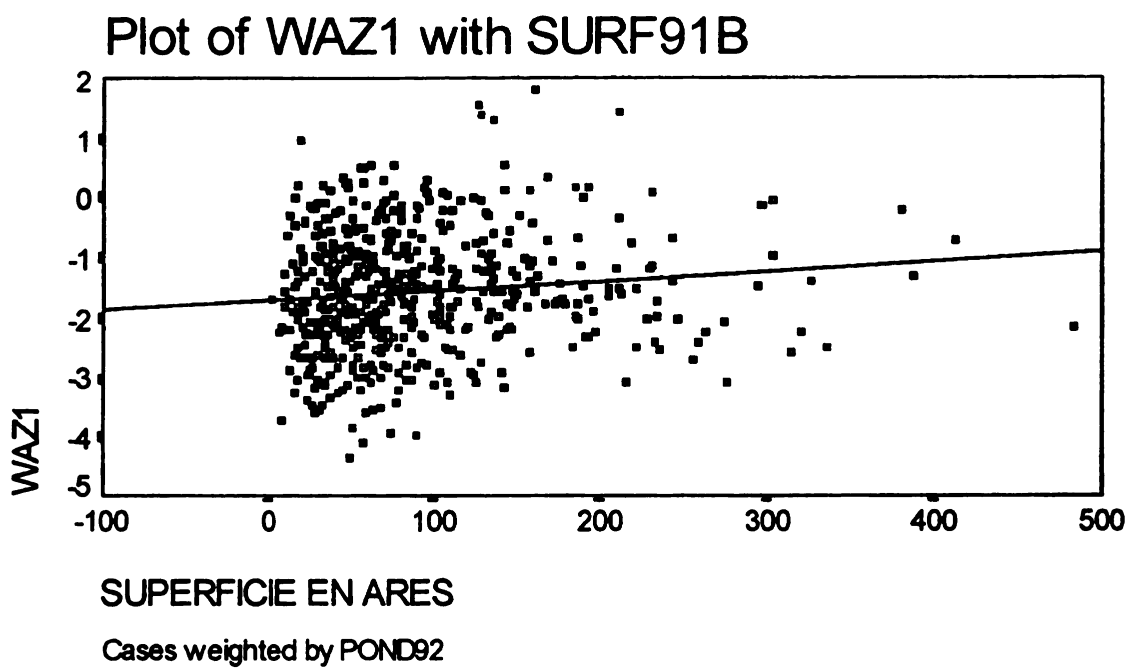
Table 4-6
Round 3: ANOVA for weight-for-age z-score by slope category

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	1.9261	0.9631	0.9517	0.3868
Within Groups	484	489.7839	1.0120		
Total	486	491.7100			

Significant differences are noted between the groups in round one but not in round three.

E-2. Children of households with greater area of land resources available to the household will be better nourished as defined by a higher z-score for weight-for-age than children of households with lesser areas of available land resources.

Regression analysis is used to determine if this relationship exists and is significant. The first step in the regression analysis included plotting the regression line. The results for round one and round 3 for all three categories of land area are on figures 4-3, 4-4, 4-5, 4-6, 4-7 and 4-8 below. Results of the regression analyses are on tables 4-7, 4-8, 4-9, 4-10, 4-11 and 4-12.



R=0.11 p=0.006

Figure 4-3
Round 1: Scatter Plot for weight-for-age z-score and total surface area available

Table 4-7
Round 1: Regression Analysis of relationship between total surface area, age and weight-for-age z-score

Multiple R	0.11380
R Square	0.01295
Adjusted R Square	0.00951
Standard Error	0.98256

	DF	Sum of Squares	Mean Square
Regression	2	7.27077	3.63538
Residual	575	554.16320	0.96543

F= 3.76556 Significant F = 0.0237

Variable	B	SE B	Beta	T	Sig T
surf91b	0.001619	0.000591	0.114061	2.740	0.0063
Age	-0.000246	0.002817	-0.003556	-0.085	0.9320
(Constant)	-1.697376	0.113679		-14.931	0.0001

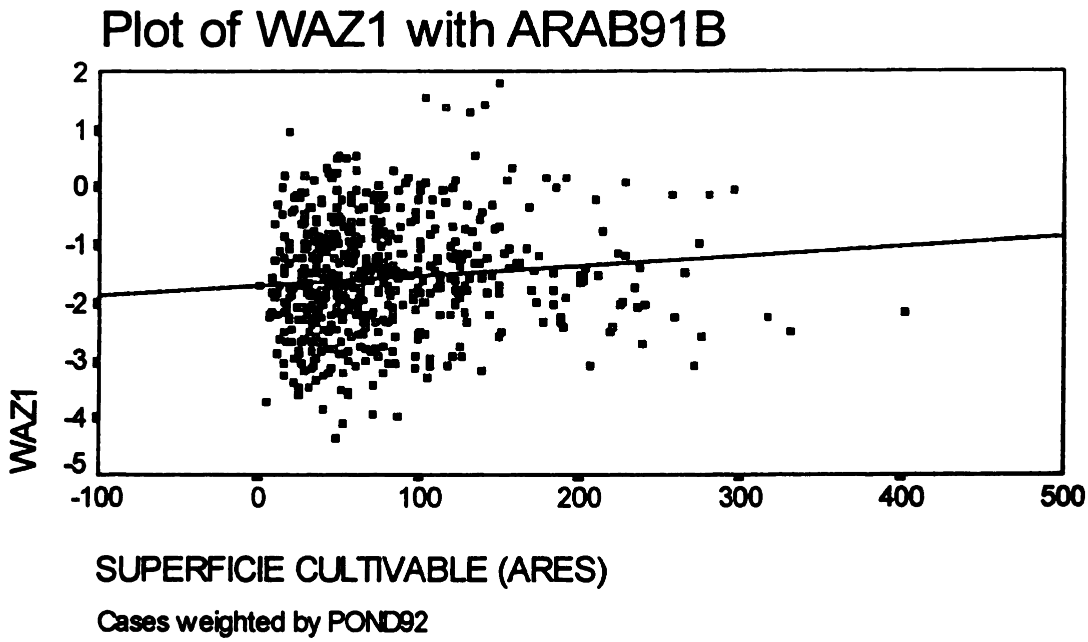


Figure 4-4
Round 1: Scatter Plot for weight-for-age z-score and cultivable surface area available

Table 4-8
Round 1: Regression Analysis of relationship between cultivable surface area, age and weight-for-age z-score

Multiple R	0.09818
R Square	0.00964
Adjusted R Square	0.00619
Standard Error	0.98421

	DF	Sum of Squares	Mean Square
Regression	2	5.41166	2.70583
Residual	574	556.02231	0.96867

F= 2.79335 Significant F = 0.0620

Variable	B	SE B	Beta	T	Sig T
arab91b	0.001661	0.000704	0.098234	2.358	0.0187
Age	-0.000053	0.002818	-0.000777	-0.019	0.9851
(Constant)	-1.689154	0.115353		-14.643	0.0001

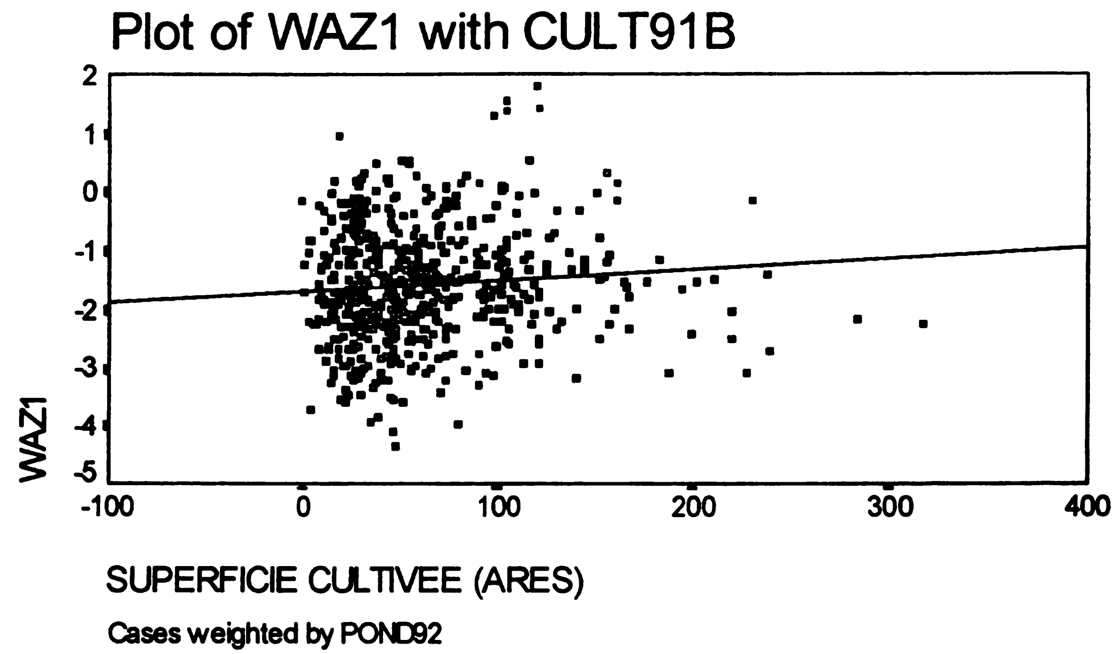


Figure 4-5
Round 1: Scatter Plot for weight-for-age z-score and cultivated surface area available

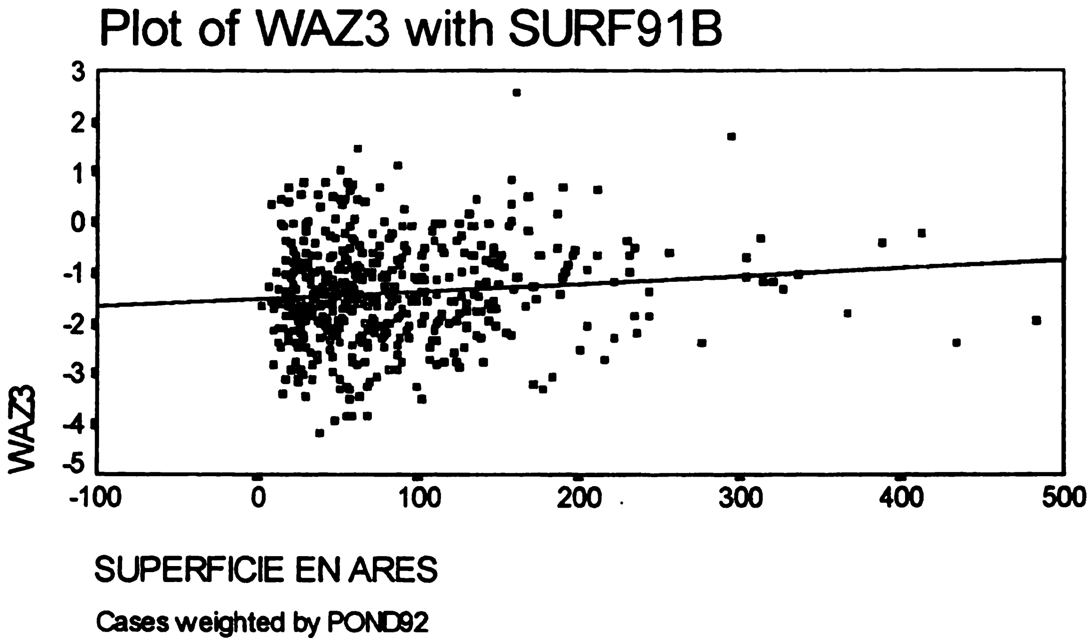
Table 4-9
Round 1: Regression Analysis of relationship between cultivable surface area, age and weight-for-age z-score

Multiple R	0.08326
R Square	0.00693
Adjusted R Square	0.00347
Standard Error	0.98555

	DF	Sum of Squares	Mean Square
Regression	2	3.89238	1.94619
Residual	575	557.54159	0.97131

F= 2.00367 Significant F = 0.1358

Variable	B	SE B	Beta	T	Sig T
cult91b	0.001912	0.000957	0.083394	1.996	0.0465
Age	0.000099	0.002827	-0.001477	-0.035	0.9718
(Constant)	-1.675994	0.116419		-10.945	0.0001



R=0.11 p=0.014

Figure 4-6
Round 3: Scatter Plot for weight-for-age z-score and total surface area available

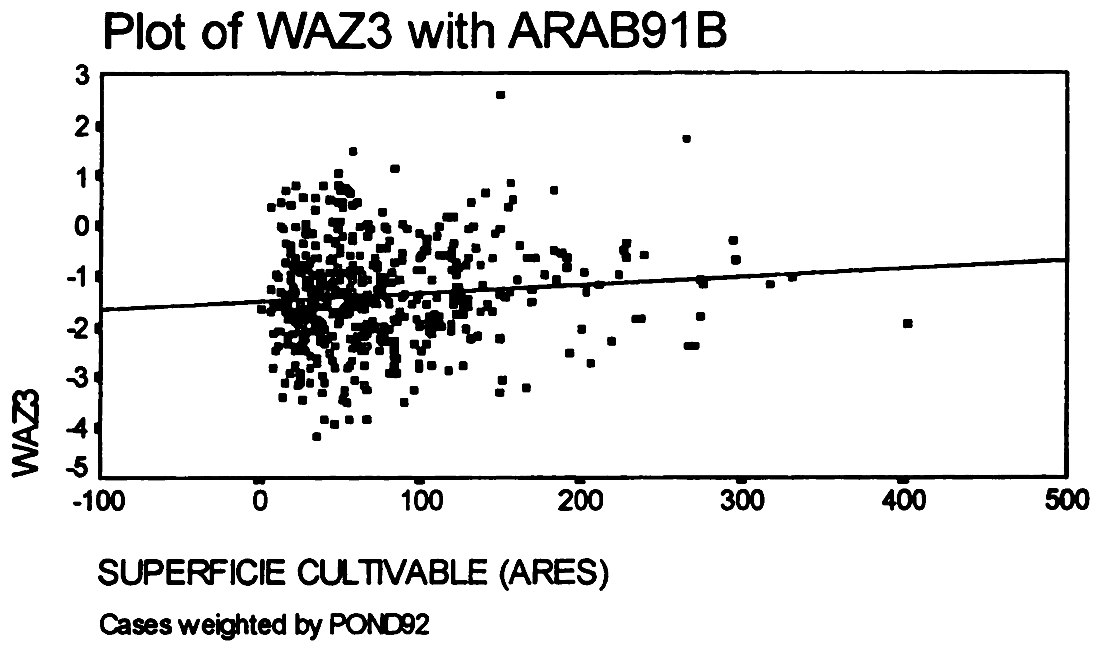
Table 4-10
Round 3: Regression Analysis of relationship between total surface area, age and weight-for-age z-score

Multiple R	0.14577
R Square	0.02125
Adjusted R Square	0.01714
Standard Error	1.00162

	DF	Sum of Squares	Mean Square
Regression	2	10.38620	5.19310
Residual	477	478.39580	1.00325

F= 5.17627 Significant F = 0.0060

Variable	B	SE B	Beta	T	Sig T
surf91b	0.001597	0.000632	0.114444	2.525	0.0119
Age	-0.006372	0.003104	-0.093040	-2.053	0.0406
(Constant)	-1.311792	0.123235		-7.159	0.0001



R=0.07 p=0.122

Figure 4-7
Round 3: Scatter Plot for weight-for-age z-score and cultivable surface area available

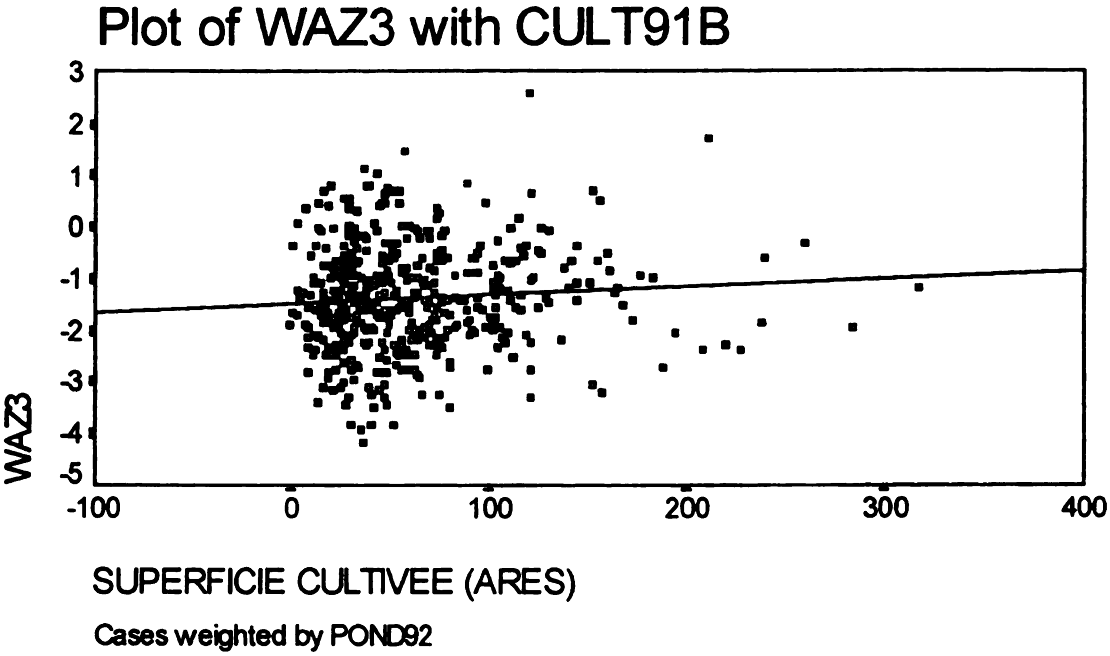
Table 4-11
Round 3: Regression Analysis of relationship between cultivable surface area, age and weight-for-age z-score

Multiple R	0.13569
R Square	0.01841
Adjusted R Square	0.01430
Standard Error	1.00307

	DF	Sum of Squares	Mean Square
Regression	2	8.99958	4.49979
Residual	477	479.78241	1.00616

F= 4.47225 Significant F = 0.0119

Variable	B	SE B	Beta	T	Sig T
arab91b	0.001710	0.000766	0.101302	2.232	0.0261
Age	-0.006390	0.003109	-0.093304	-2.056	0.0404
(Constant)	-1.302129	0.124612		-10.449	0.0001



R=0.0986 p=0.031

Figure 4-8
Round 3: Scatter Plot for weight-for-age z-score and cultivated surface area available

Table 4-12
Round 3: Regression Analysis of relationship between cultivated surface area, age and weight-for-age z-score

Multiple R	0.11785
R Square	0.01389
Adjusted R Square	0.00975
Standard Error	1.00538

	DF	Sum of Squares	Mean Square
Regression	2	6.78855	9428
Residual	477	481.9344	1.01080

F= 3.35802 Significant F = 0.0356

Variable	B	SE B	Beta	T	Sig T
cult91b	0.001738	0.001044	0.075809	1.665	0.0967
Age	-0.006472	0.003119	-0.094500	-2.075	0.0385
(Constant)	-1.272595	0.125562		-10.135	0.0001

ANOVA results for comparison of mean weight-for-age z-scores by the land area variables are on table 4-13 thru 4-18 below.

Table 4-13
Round 1: ANOVA for weight-for-age z-score by surface area available

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	11.6928	5.8464	6.0940	0.0025
Within Groups	575	549.7142	0.9594		
Total	577	561.4069			

Student-Newman-Keuls test identified a significant difference between the highest tercile of surface area and the lower two group at a level of 0.05.

Table 4-14
Round 1: ANOVA for weight-for-age z-score by surface area cultivable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	11.8983	5.9492	6.2241	0.0021
Within Groups	575	549.6012	0.9558		
Total	577	561.4995			

Student-Newman-Keuls test identified a significant difference between the highest tercile of cultivable surface area and the lower two group at a level of 0.05.

Table 4-15
Round 1: ANOVA for weight-for-age z-score by surface area cultivated

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	11.9449	5.9725	6.2490	0.0021
Within Groups	575	549.5545	0.9557		
Total	577	561.4995			

Student-Newman-Keuls test identified a significant difference between the highest tercile of cultivated surface area and the lower two group at a level of 0.05.

Table 4-16
Round 3: ANOVA for weight-for-age z-score by surface area available

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	4.9406	2.4703	2.4354	0.0887
Within Groups	477	483.8414	1.0143		
Total	479	488.7820			

Student-Newman-Keuls test identified no significant differences between terciles of surface area at a level of 0.05.

Table 4-17
Round 3: ANOVA for weight-for-age z-score by surface area cultivable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	5.6802	2.8401	2.8042	0.0616
Within Groups	477	483.1018	1.0128		
Total	479	488.7820			

Student-Newman-Keuls test identified no significant differences between terciles of cultivable surface area at a level of 0.05.

Table 4-18
Round 3: ANOVA for weight-for-age z-score by surface area cultivated

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	3.3600	1.6800	1.6508	0.1930
Within Groups	477	485.4220	1.0177		
Total	479	488.7820			

Student-Newman-Keuls test identified no significant differences between terciles of cultivated surface area at a level of 0.05.

2.0 Will the type of coping strategies utilized by the household correlate with the characteristics of the land resources available?

R-1 Households with larger land areas will utilize coping strategies that are characterized as more reversible than households with smaller land areas cultivated.

Analysis to determine if land area was related to the months of shortage was carried out using the three groupings of shortages[1] and land area means. The results of the ANOVA are on table 4-19 to 4-24 below.

Table 4-19
Round 1: ANOVA for surface area available by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	180287.264	90143.6321	19.7346	0.0001
Within Groups	566	2585373.476	4567.7977		
Total	568	2765660.740			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

[1] Months of food shortage grouped as follows: 0, 1-3, 4-12.

Table 4-20
Round 1: ANOVA for cultivable surface area by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	113402.824	56701.4118	17.5506	0.0001
Within Groups	566	1828603.358	3230.7480		
Total	568	1942006.182			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

Table 4-21
Round 1: ANOVA for cultivated surface area by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	62993.864	31496.9321	17.9791	0.0001
Within Groups	566	991554.336	1751.8628		
Total	568	1054548.200			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

Table 4-22
Round 3: ANOVA for surface area available by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	105698.067	52849.0337	10.4519	0.0001
Within Groups	475	2401790.083	5056.4002		
Total	477	2507488.151			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

Table 4-23
Round 3: ANOVA for cultivable surface area by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	67569.264	33784.6320	9.7574	0.0001
Within Groups	475	1644677.610	3462.4792		
Total	477	1712246.874			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

Table 4-24
Round 3: ANOVA for cultivated surface area by months of food shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	33619.5427	16809.7714	8.9262	0.0002
Within Groups	475	894518.3534	1883.1965		
Total	477	928137.8961			

Student-Newman-Keuls test identified significant differences in mean land areas between households reporting no food shortages and those reporting any food shortages at a level of 0.05. There was no significant difference between households reporting 1 to 3 months of shortage and those reporting 4 to 12 months of shortage.

Using the two groupings of coping mechanisms and the variables for land area as a continuous variable, student t-tests to determine differences in land area means between the two groups were performed. Results are on table 4-25 thru 4-30 below.

Table 4-25
Round 1: T-test for surface area available by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	63	70.3268	54.300	6.850
Not easily reversible	137	67.0022	44.766	3.823

Mean Difference = 3.3246
Levene's test for equality of variances: F= 0.700 P= 0.404

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	0.46	198	0.650	7.305	(-11.081, 17.730)
Unequal	0.42	101.87	0.673	7.845	(-12.236, 18.885)

Table 4-26
Round 1: T-test for Cultivable land by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	63	63.6453	49.056	6.189
Not easily reversible	137	60.2981	40.568	3.465

Mean Difference = 3.3473
Levene's test for equality of variances: F= 0.697 P= 0.405

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	0.51	198	0.613	6.612	(-9.691, 16.386)
Unequal	0.47	102.12	0.638	7.093	(-10.721, 17.415)

Table 4-27
Round 3: T-test for Cultivated land by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	63	50.0926	38.917	4.909
Not easily reversible	137	48.0103	27.623	2.359

Mean Difference = 2.0823
Levene's test for equality of variances: F= 1.175 P= 0.280

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	0.43	198	0.666	4.812	(-7.408, 11.572)
Unequal	0.38	91.47	0.703	5.447	(-8.737, 12.901)

Table 4-28
Round 3: T-test for surface area available by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	85	74.6659	72.528	7.849
Not easily reversible	232	79.4436	62.150	4.083

Mean Difference = -4.7777
Levene's test for equality of variances: F= 0.001 P= 0.976

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-0.58	315	0.562	8.241	(-20.992, 11.436)
Unequal	-0.54	132.69	0.590	8.848	(-22.278, 12.723)

Table 4-29
Round 3: T-test for Cultivable land by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	85	66.5851	62.327	6.745
Not easily reversible	232	69.7243	52.394	3.442

Mean Difference = -3.1391
Levene's test for equality of variances: F= 0.000 P= 0.992

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-0.45	315	0.654	6.992	(116.897, 10.618)
Unequal	-0.41	130.82	0.679	7.573	(-18.120, 11.842)

Table 4-30
Round 3: T-test for Cultivated land by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	85	52.9293	42.923	4.645
Not easily reversible	232	55.9444	40.325	2.649

Mean Difference = -3.0150
Levene's test for equality of variances: F= 0.340 P= 0.561

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-0.58	315	0.562	5.195	(-13.237. 7.207)
Unequal	-0.56	142.69	0.574	5.348	(-13.586. 7.556)

To further clarify the relationship between these variables one-way ANOVA analysis was accomplished. Results are on table 4-31 thru 4-36 below.

Table 4-31
Round 1: ANOVA for surface area available by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	476.2352	476.2352	0.2072	0.6495
Within Groups	198	455038.7073	2298.1753		
Total	199	455514.9425			

Table 4-32
Round 1: ANOVA for surface area cultivable by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	482.7427	482.7427	0.2564	0.6132
Within Groups	198	372772.9202	1882.6915		
Total	199	373255.6629			

Table 4-33
Round 1: ANOVA for surface area cultivated by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	186.8169	186.8169	0.1869	0.6656
Within Groups	198	197486.7837	997.4080		
Total	199	197673.6006			

Table 4-34
Round 3: ANOVA for surface area available by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1424.109	1424.1087	0.3361	0.5625
Within Groups	315	1334803.297	4237.4708		
Total	316	1336227.405			

Table 4-35
Round 3: ANOVA for surface area cultivable by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	614.7895	614.7895	0.2015	0.6538
Within Groups	315	960980.0665	3050.7332		
Total	316	961595.7559			

Table 4-36
Round 3: ANOVA for surface area cultivated by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	567.1419	567.1419	0.3367	0.5621
Within Groups	315	530535.9474	1684.2411		
Total	316	531103.0893			

Results from the ANOVA to determine if significant differences exist between land area and the number of coping mechanisms used are on table 4-37 thru 4-42 below.

Table 4-37
Round 1: ANOVA for surface area available by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	8314.0419	2771.3473	1.1529	0.3288
Within Groups	209	502413.7738	2403.8937		
Total	212	510727.8157			

Student-Neman-Keuls test found no significant difference between these groups at the 0.50 level.

Table 4-38
Round 1: ANOVA for surface area cultivable by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	6387.8539	2129.2846	1.0658	0.3646
Within Groups	209	417532.0083	1997.7608		
Total	212	423919.8621			

Student-Neman-Keuls test found no significant difference between these groups at the 0.50 level.

Table 4-39
Round 1: ANOVA for surface area cultivated by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	4573.3697	1524.4566	1.3577	0.2568
Within Groups	209	234662.6040	1122.7876		
Total	212	239235.9737			

Student-Neman-Keuls test found no significant difference between these groups at the 0.50 level.

Table 4-40
Round 3: ANOVA for surface area available by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	35046.9916	11682.3305	2.6987	0.0459
Within Groups	319	1380911.428	4328.8760		
Total	322	1415958.420			

Student-Neman-Keuls test found a significant difference between group 1 using 1 to 2 mechanisms and group 4 using 5-15 mechanisms at the 0.50 level.

Table 4-41
Round 3: ANOVA for surface area cultivable by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	35457.3981	11819.1327	3.7742	0.0110
Within Groups	319	998967.5582	3131.5582		
Total	322	1034424.477			

Student-Neman-Keuls test found a significant difference between group 1 and group 4 at the 0.50 level.

Table 4-42
Round 3: ANOVA for surface area cultivated by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	24785.1043	8261.7014	4.8409	0.0026
Within Groups	319	544420.8153	1706.6483		
Total	322	569205.9195			

Student-Neman-Keuls test found significant differences between group 4 and all other groups at the 0.50 level.

R-2 Households farming land areas of lesser slopes will utilize coping strategies that are characterized as more reversible than households farming areas of steeper slopes.

Using the two groupings of coping mechanisms and the variables for slope as a continuous variable, independent t-tests to determine differences in land area means were performed. Results are on table 4-43 and 4-44 below.

Table 4-43
Round 1: T-test for slope by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	66	14.9867	7.379	0.911
Not easily reversible	143	14.6528	7.324	0.612

Mean Difference = 0.3339
Levene's test for equality of variances: F= 0.001 P= 0.975

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	0.31	207.00	0.761	1.095	(-1.824, 2.492)
Unequal	0.30	124.33	0.761	1.098	(-1.838, 2.506)

Table 4-44
Round 3: T-test for slope by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	87	12.1803	5.673	0.607
Not easily reversible	236	14.2319	7.809	0.508

Mean Difference = -2.0516
Levene's test for equality of variances: F= 10.451 P= 0.001

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-2.24	322.00	0.025	0.914	(-3.850, -0.253)
Unequal	-2.59	211.33	0.010	0.792	(-3.612, -0.491)

The Levene's test for equality of variances for the Round 3 analysis suggests that the variances are too close to equal for the t-test to be completely reliable.

To further clarify the relationship between these variables one-way ANOVA analysis was accomplished. Results are on table 4-45 and 4-46 below.

Table 4-45
Round 1: ANOVA for slope by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	5.0159	5.0159	0.0931	0.7606
Within Groups	207	11155.0694	53.8892		
Total	208	11160.0853			

Table 4-46
Round 3: ANOVA for slope by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	268.2757	268.2757	5.0448	0.0254
Within Groups	322	17123.5369	53.1787		
Total	323	17391.8126			

Results from ANOVA to determine if difference between mean slope for number of mechanisms used are significant are on table 4-47 and table 4-48.

Table 4-47
Round 1: ANOVA for slope by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	210.1155	70.0385	1.3114	0.2716
Within Groups	218	11642.7961	53.4073		
Total	221	11852.9116			

Student-Newman-Keuls test determined that there was no difference between groups at the 0.05 level.

Table 4-48
Round 3: ANOVA for slope by number of mechanisms used

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	516.8538	172.2846	3.2561	0.0219
Within Groups	326	17248.9874	52.9110		
Total	329	17765.8412			

Student-Newman-Keuls test determined that there was a significant difference between group 1 and group 3 in this analysis.

3.0 Will the household's strategies to cope with food shortages correlate with child nutritional status?

S-1 Children of households reporting greater numbers of months of food shortage will be more poorly nourished as defined by lower weight-for-age z-score than children of households reporting fewer months of food shortage.

This analysis is based on the grouping for number of months of food shortage[2] reported and the weight-for-age z-score. One-way ANOVA was employed to determine if differences between the mean weight-for-age for the three groups was significant. Results are on table 4-49 and 4-50 below.

Table 4-49
Round 1: ANOVA for weight-for-age z-score by months of shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	17.3617	8.6808	9.1929	0.0001
Within Groups	603	569.4086	0.9443		
Total	605	586.7703			

Group	Count	Mean	S.D.	S.E.	95% CI for mean
0 months	366	-1.4069	0.9647	0.0504	-1.5061 to -1.3078
1 to 3 months	153	-1.7284	0.9147	0.0738	-1.8742 to -1.5827
4 to 12 months	86	-1.7903	1.0908	0.0738	-2.0234 to -1.5572
Total	606	-1.5431	0.9845	0.0400	-1.6217 to -1.4646

[2] Months of food shortage grouped as follows: 0, 1-3, 4-12.

The mean for the group experiencing no shortage is significantly different than the mean for the two groups experiencing shortage according to Student-Newman-Keuls test. The two groups experiencing food shortage were not significantly different from each other.

Table 4-50
Round 3: ANOVA for weight-for-age z-score by months of shortage

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	2	10.3550	5.1775	5.2824	0.0054
Within Groups	502	492.0297	0.9801		
Total	504	502.3847			

Group	Count	Mean	S.D.	S.E.	95% CI for mean
0 months	159	-1.1781	0.9853	0.0781	-1.3324 to -1.0238
1 to 3 months	169	-1.5266	0.9753	0.0748	-1.6744 to -1.3789
4 to 12 months	176	-1.4151	1.0080	0.0760	-1.5650 to -1.2652
Total	505	-1.3780	0.9983	0.0444	-1.4653 to -1.2907

The mean for the group experiencing no shortage is significantly different than the mean for the two groups experiencing shortage according to Student-Newman-Keuls test. The two groups experiencing food shortage were not significantly different from each other.

S-2 *Children of households reporting less reversible responses to food shortage will have children of poorer nutritional status as defined by lower weight-for-age z-score than children of households reporting more reversible responses to food shortage.*

Results from t-test analysis for differences between mean weight-for-age z-scores for "reversible" versus "not easily reversible" group is on Table 4-51 and 4-52 below.

Table 4-51
Round 1: T-test for weight-for-age z-score by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	66	-1.8429	1.010	0.125
Not easily reversible	151	-1.6822	0.979	0.080

Mean Difference = -0.1679
Levene's test for equality of variances: F= 3.034 P= 0.082

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-1.10	215	0.273	0.146	(-0.449, 0.127)
Unequal	-1.09	119.26	0.280	0.148	(-0.454, 0.132)

Table 4-52
Round 3: T-test for weight-for-age z-score by reversibility variable

Variable	# of cases	Mean	SD	SE of mean
Average slope				
Reversible	92	-1.6050	0.928	0.097
Not easily reversible	241	-1.4370	1.025	0.066

Mean Difference = -0.1679
Levene's test for equality of variances: F= 3.034 P= 0.082

t-test for equality of means

Variances	t-value	DF	2-tail Sig.	SE of Diff.	95% CI for Diff
Equal	-1.37	331	0.170	0.122	(-0.408, 0.073)
Unequal	01.44	181.76	0.153	0.117	(-0.399, 0.063)

ANOVA results for differences in mean weight-for-age z-score for "reversible" versus "not easily reversible" group is on Table 4-53 and 4-54 below.

Table 4-53
Round 1: ANOVA for weight-for-age z-score by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.1809	1.1809	1.2091	0.2727
Within Groups	215	209.9932	0.9767		
Total	216	211.1741			

Table 4-54
Round 3: ANOVA for weight-for-age z-score by reversibility variable

Source	DF	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	1.8827	1.8827	1.8865	0.1705
Within Groups	331	330.3287	0.9980		
Total	332	332.2113			

Chapter 5

DISCUSSION AND CONCLUSIONS

1.0 Discussion of results

In this section, the results of each hypothesis will be analyzed to provide possible explanations for the results seen in Chapter 4.

Do characteristics of the land resources available to the household correlate with the nutritional status of children under five years of age in rural Rwanda?

E-1. *Children of households farming lands of steeper slopes will be more poorly nourished as defined by a lower z-score for weight-for-age than children of households farming lesser slopes.*

Statistical analysis did not identify an association between steepness of slope and weight-for-age that would satisfy the hypothesis. The association was weak and not significant in either round. The regression line had a slightly positive slope, opposite of the expected direction. Therefore, the null hypothesis could not be refuted with these data.

The significant Chi-Squared analysis and Mantel-Haenszel score show that distribution is unlikely to be only to chance in round 1. Additionally, ANOVA suggests that the differences between mean weight-for-age z-scores in round one are significantly different at the <0.1 level only. The evidence is not suggestive of an easily identifiable relationship between these two variables.

According to Clay (1995), farmers in Rwanda traditionally lived on the upper ridges and farmed in a series of 'rings' around the household with the less important crops farther down the hillsides on the steeper slopes. With increasing population pressures, more farmers must farm the steeper slopes as their primary land and do not have access to the gentler slopes of the ridges.

As these farmers are forced to farm more marginal lands, one might expect higher rates of erosion and resultant poor productivity. So why is child nutrition seemingly unaffected? The answer is likely to be the result of a variety of influences. The lands farmed on the steepest slopes may be recently converted from pasture land (Clay, 1995) and not as severely eroded as some have stated (Riley-Miklavcic, 1985). Therefore, these areas may still be relatively productive but are at high risk for erosion and loss of productivity. Clay determined that investments or inputs into farmlands increased as slope decreased, describing an investment in land where higher returns are likely. However, the lower invested levels on the steeper slopes may also be the result of higher quality land being found (albeit, for the short term) on the newly converted steeper slopes. Further analysis is needed to determine the productivity of these lands. If it can be determined that these lands were, during the time of the study, at least as productive as lands on gentler slopes, the lack of association can be explained. Given the complex etiology of childhood malnutrition, there is likely to be a variety of influences not accounted for given the limitations of these data.

E-2. Children of households with greater area of cultivated land will be better nourished as defined by a higher z-score for weight-for-age than children of households with lesser areas of available land.

Scatter plots of these variables suggest a positive linear association. The regression line is significant in all but the association between cultivated land and weight-for-age z-scores. However, the small r^2 does suggest that land area accounts for only a small portion of the change in weight-for-age z-scores. ANOVA revealed significant differences between groups for all categories of land area. It appears from these data that land area does influence child nutrition as was anticipated and may be useful at identifying households at risk.

The literature reviewed in Chapter 2 described mixed results in analysis of the relationship between land area and child nutritional levels. Fleuret & Fleuret (1980) state the lack of association seen in their research may have been related to the variation in intensity of planting by farmers on their plots. The intense population pressures in Rwanda require most farmers to plant their lands intensely. Therefore, variation in intensity is likely to be less of a factor in Rwanda.

Will the type of coping strategies utilized by the household correlate with the ecological characteristics of the land available?

One difficulty in arriving at valid answers to this question may be linked to the survey design. Respondents were asked to answer "yes" or "no" to a predetermined set of coping strategies. Households in the cohort may employ added coping strategies that are not addressed in the survey or questions may have been interpreted in different ways by surveyers or respondents. This problem can lead to misinterpretations of strategies

Additionally, households tend to cope using a variety of strategies that do not allow the cohort to be easily divided into those using “reversible” versus “less reversible” strategies. Households tended to use both reversible and less reversible mechanisms. Coping strategies were likely to depend more on resources available to the household than to a particular strategy.

Additional information regarding the order in which households adopt coping strategies would provide a more complete picture of how households in the cohort cope with food shortages. The order in which the household ‘gives up’ certain things is going to be highly dependent on access to resources to be given up. Logically, households will cope by first giving up what they can more easily do without. Understanding what steps a household takes to cope will greatly enhance the usefulness of coping strategies in identifying households that are no longer able to meet their dietary needs. Further research should evaluate steps a household takes in coping with food shortages and should determine if a point exists at which children begin to suffer from lower nutritional levels. These data do not allow that determination.

R-1 Households with larger land areas will utilize coping strategies that are characterized as more reversible than households with smaller land areas cultivated.

No significant negative relationships are seen that would satisfy the hypothesis when analyzing by t-test or ANOVA. The lack of correlation is likely due to the problems discussed at the beginning of the section.

The data do not allow a determination of the order in which the mechanisms are used, but the data do allow a determination of the number of mechanisms used to cope. ANOVA to determine if there is a significant difference between the number of mechanisms used did find significant differences in round 3 data. The number of mechanisms used are associated with land area. The data, however, are likely to be incomplete. The survey asked about 13 predetermined strategies. Additional strategies are likely to have been employed.

Analysis determined that land area was related a reported shortage by the household. Households reporting any shortage had lower mean land areas than households reporting no food shortages. No significant differences in mean land area were noted between households reporting 1-3 months of shortage and households reporting 4-12 months of shortage. From this analysis, it appears that households with greater land resources are less likely to report food shortages, as would be expected.

This analysis compared mean land areas. One difficulty of this type of analysis is that the distribution of land area in developing countries is often bimodal in nature with most households holding small amounts of land and a few holding large areas of land. Analysis based on this bimodal distribution may have shown a stronger relationship between these two variables.

R-2 Households farming land areas of lesser slopes will utilize coping strategies that are characterized as more reversible than households farming areas of steeper slopes.

ANOVA and t-tests determined that there is a significant difference between mean slopes when compared according to the reversibility variable in round 3 only. The lack of association in round 1 may be related to the smaller number of cases in round 1 or it may demonstrate that households cope in a variety of patterns.

A larger number of households reported food shortage in round 3 than round 1. The differences between the two rounds may be related to the fact that more resource "rich" households were experiencing food shortages and these households were able to use the reversible mechanisms. Round 1 households experiencing shortage may have been the more resource poor households forced into less reversible mechanisms because of their lace of access to less reversible responses.

ANOVA to determine if significant differences in mean slope for the number of mechanisms used also showed significance in the third round only. There was a significant difference between the lowest and highest slope tercile. However, based on the mixed results, no recommendations about these variables can be made without further study.

Will the household's strategies to cope with food shortages correlate with child nutritional status?

S-1 *Children of households reporting greater numbers of months of food shortage will be more poorly nourished as defined by lower weight-for-age z-score than children of households reporting fewer months of food shortage.*

ANOVA for weight-for-age z-score by months of shortage showed significant differences between the mean weight-for-age z-score by months of shortage in both rounds of data. The significant differences between those experiencing no shortage and the two groups experiencing different degrees of shortage as identified by Student-Newman-Keuls test suggest the reporting of a shortage is a stronger predictor of weight-for-age z-score than the degree of shortage.

As was discussed for hypothesis R-1, households reporting a food shortage had smaller land areas than households reporting no food shortages. Further, as was discussed for hypothesis E-2, households with larger land areas tended to have children with higher mean weight-for-age z-scores. These relationships are diagrammed on figure 5-1 below.

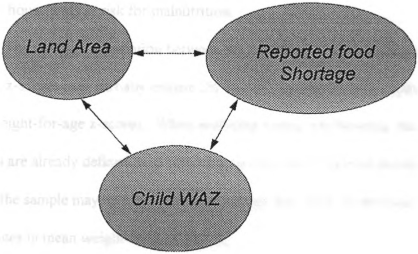


Figure 5-1
Relationships Between Land area, Food shortage and Child Weight-for-age Z-score

This diagram shows that households with large land areas will tend not to report any food shortages and will tend to have children with higher weight-for-age z-scores.

S-2 Children of households reporting less reversible responses to food shortage will have children of poorer nutritional status as defined by lower weight-for-age z-score than children of households reporting more reversible responses to food shortage.

There does not appear to be any relationship between reversibility of response and weight-for-age z-score when analyzed by t-test or by ANOVA. When evaluating the results from this hypothesis and hypothesis S-1, it appears that a reported shortage is a better predictor of child weight-for-age z-score than how that household copes with the reported shortage.

As was stated in the discussion above regarding these coping mechanisms, further research is still needed to fully understand how or if these mechanisms can be used to identify households at risk for malnutrition.

The stronger association between the reporting of food shortage and child weight-for-age z-scores may partially explain the lack of association with coping mechanisms and child weight-for-age z-scores. When analyzing coping mechanisms, households in the analysis are already defined as at risk because they have reported shortages. For this reason the sample may be more homogenous and less likely to demonstrate significant differences in mean weight-for-age z-score.

2.0 Limitations of the Survey design

2.1 Sample size and geographic area

Validity of the results is partially determined by the limitations of the survey design. This survey attempted to be representative of all rural households in Rwanda. However, the extensive agroecological diversity among Rwandan households gives rise to difficulty of drawing conclusions based on analysis for the entire group. An intensive study representative of a single zone would have been less complex, allowing for a larger number of cases that may not be influenced by differences in the zones. The relationships between variables may have differed across zones and analysis per zone would have demonstrated these differences. However, the when data were divided per zone, sample sizes in many cases became too small to establish significance. A more complete picture of a single zone would provide more assistance to policy makers in Rwanda.

A smaller research area would also aid in insuring the integrity of the data. UNICEF/Kigali staff were supervising a group of surveyors spread over the entire country, a difficult task in areas where travel is challenging. As was noted in Chapter 3, the individuals collecting data in round one received the most intensive supervision. A smaller geographical area would have allowed for intense supervision consistently across all three rounds.

2.2 Land area

More complete information on land area would have aided in the research. As was described in Chapter 3, agricultural information was only available for half the sample therefore only half the sample was used for these analyses. The complexity of the data collected on the intensive sample would have made a larger sample difficult, but doubling the sample size may have helped to establish statistical significance in some of the relationships investigated.

As was discussed previously in this chapter, land area is likely to be bimodal in nature. Further analysis based on this bimodal distribution is necessary to fully understand the relationships found relating to land area.

Additionally, the data do not distinguish between land areas owned and land area rented. It is not clear how the question was asked by the interviewers conducting the survey. Since rented land is likely to require some reciprocation to the land owner, information on land ownership is likely to influence the relationship between land area and nutrition as well as the relationship between land area and months of shortage. Any future surveys should distinguish between these factors.

2.3 Slope

Difficulties in identifying associations between the slope variable and child nutrition may be addressed in part by selecting a population with more between household variation and less within household variation. While any slope variable attached to a household must be an average value, the practice of Rwandan households piecing together several parcels provides an average value that is less representative of the actual situation faced by these farmers. Comparisons between households with more even slopes across their landholdings may have provided clearer results. If possible, any additional research on this topic could explore areas where farmers on steeper slopes tend to farm largely on steeper slopes and where these farmers can be compared to farmers on gentler slopes.

As stated above, farmers on the steeper slopes of Rwanda are likely to have been there for a shorter period of time than the high ridges. If the land was farmed a shorter period of time, erosion may not yet have significantly impacted these parcels. A trend study, following these households over a number of years, may clarify the relationship if an association appears after erosion has taken its toll on the area.

2.4 Coping Strategies

As noted above, the survey asked a series of questions on coping strategies. The respondents were asked to answer "yes" or "no" to each of these coping strategies. If these questions were the result of anthropological study of household coping patterns, they may be representative of the majority of strategies used when households are facing food shortages. However, it is unlikely that a survey captures all coping patterns used. This may also have allowed researchers to distinguish between strategies used to cope with shortages and activities that may be normal part of rural life in Rwanda (i.e., sending children to live with someone else, or seeking outside employment).

Additionally, information identifying which mechanisms households employ first, second, third, etc. may provide a more useful tool for identifying at risk households. There may be a pattern or progression of types of activities a household uses to cope with increasing food shortages. If such a pattern can be identified, researchers may be able to identify a particular point where child nutritional levels begin to fall. The ability to identify households approaching that point may allow policy planners to focus resources on these households and communities. The data available do not allow a chronological pattern to be identified.

A household's ability to use reversible coping mechanisms depends on the household's access to resources. These data do not allow for an analysis of all resources available to the household or of activities a household undertakes to avoid food shortages before the shortage arises. The survey seems to assume that all food resources relate to agricultural lands and agricultural products. Information on forest products or other food products from communally owned lands may provide information vital to understanding how households meet dietary needs. Additionally, data describing storage capabilities, access to outside markets, livestock resources, forest products resource, etc., are important to understanding household decision making when faced with shortage, but are beyond the scope of this study.

3.0 Benefits of this research

This study is a beginning point for understanding the complex relationships that may be used to identify vulnerable communities. Based on this study no clear recommendations for the use of a single variable to identify households at risk can be made. However, this topic is important and should not be forgotten. Identifying households experiencing food shortage is a vital exercise. While these short term shortages are less dramatic than famine, identifying households at risk may be key to preventing higher prevalence of malnutrition and as early warning systems for more severe famines. This research can be used as a starting point for continued research on this topic.

While reporting a food shortage seems to be a clearer indicator of risk for malnutrition, identifying how households cope with food shortages may still be a useful tool for predicting areas of food shortage. Observing communities for activities that have been associated with previous food shortage may be a better indicator of food availability than the more traditional measures. However, the mechanisms in these data are derived from a pre-determined list of mechanisms. A better understanding of coping would have come from asking more open ended questions; allowing the households to describe how they cope and what things are done when faced with shortage. These data cannot clarify the sequence in which steps taken to cope with shortages. Sequencing is only inferred from the prevalence of positive responses when asked about that mechanism. Sequencing may be an important component if this model is to be used to identify households at risk of shortage, but is beyond the scope of this study.

4.0 Summary

This research underscores the importance of defining the role environment and agriculture take in food security and child nutritional levels. No strong conclusions can be drawn from these data regarding the hypotheses proposed. Relationships are complex and the problems of high prevalence of undernutrition and food insecurity issues will not be solved easily.

As was presented in figure 2-1, the causes of malnutrition are complex. Future studies looking at the causes of undernutrition need to consider the following relationships: 1) what types of crops are grown, 2) are the crops sold or kept for family consumption or both, 3) who controls the cash income from agricultural activities, 4) what other sources of income does the family have access to, 5) to what extent is disease influencing this relationship. The data set used for this research does have information on crops grown by household so many of these areas can be addressed. Additionally, the nutrition survey included information relating to disease prevalence and hygiene; both of which play an important part in nutrition.

The literature outlined in Chapter 2 demonstrates the difficulty of addressing problems of undernutrition through a single avenue. Childhood undernutrition will not end by increasing production alone, eradicating disease alone, increasing income alone, or through the variety of additional inputs that have been used to improve nutrition. In the same manner, areas at risk cannot be identified by a single indicator. Only through the collection of a variety of indicators and analysis of these indicators can one hope to begin to identify households at risk for undernutrition.

Just as the cause of malnutrition is complex, households respond to food shortages in a variety of ways. Using household activities to identify groups experiencing food shortages will only be advantageous when a better understanding of activities employed to cope with shortages is achieved. Since households have access to varying resources for managing shortages, there is not likely to be a single mechanism or pattern of mechanisms that will apply to all households or all communities.

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