1992

LOCAL COMMON PROPERTY RESOURCES AND CHILD HEALTH: THEORY WITH SOME STATISTICAL EVIDENCE FROM ZAIRE

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Abstract. For poor farm households in the tropics, common property resources are main sources of productive capital as well as direct consumption goods. This paper draws on household production theory and data from Zaire to investigate the links between availability of common property resources and child health. A household model with missing markets is used to trace the various effects of these resources on household production and consumption choices and, as a result, child health status. The data show that child nutritional status is significantly better on average in forested as compared to savanna areas, while there is more variation in nutritional status in savanna areas. The empirical results suggest the magnitude of impacts on rural households that could occur as population pressure and crop land demands lead to further deforestation in the region.

The author is a Fellow in the Center for Economic Policy Studies, Winrock International Institute for Agricultural Development. The empirical section of this paper is drawn from a working paper titled "Forests and Child Nutritional Status in the Kwilu Subregion of Zaire", coauthored with Glen Rogers and Joy Green Larson, consultants to the U.S. Agency for International Development Mission in Kinshasa, Zaire at the time of the study, and Grenville Barnes, assistant professor, Department of Geodetic Sciences, The Ohio State University.

LOCAL COMMON PROPERTY RESOURCES AND CHILD HEALTH: THEORY WITH SOME STATISTICAL EVIDENCE FROM ZAIRE

1. INTRODUCTION

In poor agrarian economies in the tropics, access to natural resources controlled through various forms of common property arrangements provides a main source of productive capital for farm households as well as direct consumption goods. As a result, changed quantities and/or access of the rural poor to these resources can have a direct and substantial impact on household income and welfare. For example, Commander (1986) describes how changes in forest cover directly affect rural employment in India either through changes in Forest Department work or the collection of minor forestry products. Jodha (1986) describes and documents the variety and magnitude of benefits that are derived from common property resources by the rural poor in India. Jodha (1986, p.1177) concludes that "if the unaccounted income components are added, CPR-based income could be much higher in many areas than the per household income generated by a number of anti-poverty programmes." Thus, adverse impacts on the poor is a main reason to be concerned with the degradation of local common property resources.

This paper extends existing literature to analyze the importance of local common property resources for subsistence-oriented rural households.[1] And since much of the economic activity of these households falls outside of market channels, a non-market measure of household welfare--health status of children--is considered. In Section 2, after a brief introduction to the study area, the theory of the agricultural household is extended to examine how availability of a common property resource (CPR) influences household production, consumption, and time allocation decisions, and how these decisions in turn influence health status of children.

In Section 3, some statistical evidence is presented on the importance of local common property resources--forested lands--for child nutritional status. The study area is the Kwilu Sub-Region of Zaire, where agriculture is a main economic activity and primarily a function of land quality and women's labor. Forests and savanna are the two main sources of land for agriculture, and forested lands are more productive for crops and also provide other goods and services. Data for the study were developed by using geographic information systems (GIS) technology to integrate rural health clinic data on child nutritional status and Landsat images of forest cover. This GIS approach to data development provides an innovative way to gather and analyze socioeconomic and environmental data.

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[1] The term local common property resource is used to imply that some local population primarily obtains the benefits and pays the costs from its use in contrast, for example, to the global commons, etc. The focus of this paper differs from the bulk of the literature on common property resources, which centers on group management issues associated with the use of natural resources controlled under common property arrangements. The focus here also differs from the literature that analyzes the impacts of rural households and government policies on the natural resource base have also been analyzed (see, e.g. Lundgren, 1985; Anderson, 1986; French, 1986; Cline-Cole, Main, and Nichol, 1990; Metz, 1991; Perrings, 1989; Larson and Bromley, 1990; Southgate et al. 1991).

Based on hypothesis tests of differences between sample variances and means for forested and savanna areas, we conclude that child nutritional status is significantly better on average in forested as compared to savanna areas, while there is more variation in nutritional status in poorer savanna areas. While the mean differences are significant from a statistical stand point, the magnitude of the difference is substantial in absolute terms.[2] These results show that the positive effect on rural populations can be substantial in areas that are highly dependent on local resources. By implication, this analysis suggests the magnitude of impacts that could occur in poor rural economies such as the Kwilu Subregion of Zaire as population growth and the lack of economic development continue to increase pressure on the local resource base.

2. ACCESS TO A LOCAL CPR AND CHILD HEALTH: A HOUSEHOLD MODEL WITH MISSING MARKETS

2.1 Background

Before moving directly into the model, a brief background on the study area in Zaire will provide some perspective on specific assumptions developed in the theoretical model. Zaire is one of the poorest countries in Africa, where per-capita gross national product declined about 2 percent per year between 1965 and 1986 (World Bank, 1988). Per-capita GNP stood at $160 in 1986 (World Bank, 1988). Inflation averaged over 50

[2] This result does not prove that difference in forest availability caused the difference in means and variances; it does suggest that something systematic is occurring in the region. Household data are not available to attempt a more complete econometric analysis.

percent per year between 1980 and 1986 (World Bank, 1988), and government policies and political unrest in the fall of 1991 has resulted in hyperinflation and a virtual shut-down of the economy.

The Bandundu Region of Zaire, lying directly east from the capital Kinshasa, contains about 12 percent of the total land area in Zaire, 14 percent of the forests, 9 percent of the woodlands, 14 percent of the savanna, and 12 percent of the population (Goodson, 1988). Bandundu Region lies primarily in the Kwango-Kwilu and Kasai plateaus, which are covered by vegetation along a forest-savanna continuum (Goodson, 1988). Of the approximately 522,000 farms in the region, about 310,000 are in forests while the rest rely on savanna (Goodson, 1988).

The Kwilu subregion of Bandundu Region, which lies near the Kasai and Kwilu rivers, is described by Fresco (1984, p. 3) as a land of contrast between:

> rolling table lands, devoid of trees and having poor, sandy soils, and forested valleys of richer, loamy sands. The landscape has been and continues to be profoundly modified by human activity. The plateaus were once covered by deciduous forests, and secondary forests, which still stand in the valleys, diminish in size each year.

The Kwilu Subregion tends to be one of the more heavily populated rural areas in Zaire. For example, although there were on average about 12 people per square kilometer in Bandundu in 1984, average population density in Kwilu subregion was 25, although densities of over 45 inhabitants per square kilometer exist in rural areas. The southwestern portion of the region tends to be more savanna, while the northeastern portion tends to be more heavily forested.

In the Kwilu, forested areas are regarded to be more productive in terms of agriculture than savanna areas and can also provide other components of the diet (fruit, caterpillars, etc.). Access to land is controlled through various forms of common property arrangements and state control, for example through village authority, depending on local history and migration.

Shifting cultivation is the norm, and rural residents have traditionally relied on forest areas for crop land and for a number of food products, medicines, and fibers. Cassava (manioc) is the main agricultural crop in the area and is the main staple as is also marketed, accounting for 75 percent of calories (diets are protein deficient), and groundnuts are a cash crop. Farming remains dependent almost exclusively on land and household labor, primarily women and children. There is virtually no use of pesticides, fertilizers, and hired wage labor. Crop yields are significantly higher in forest areas than on savanna, ranging from 16 tons on best forests to 0.5 to 2 tons on frequently burned savanna (Fresco, 1984).

Palm oil was at one time an important cash crop in Zaire and Bandundu. However, due to general market trends, the export value of palm oil has dropped from 2.7 billion Belgian francs in 1958 to 10.5 million Belgian francs in 1986 (constant 1966 Belgian francs) (Hines, 1988). In general, rural road infrastructure has continually declined, especially since oil palm companies played an important role in local road maintenance. However, a main highway from Kinshasa to Kikwit in the 1980's reduced transportation costs to Kinshasa. Kinshasa is an important final destination for marketed produce and a source of goods imported into Bandundu.

2.2 The Model

From the discussion of the previous section, main characteristics of agricultural production in the study area is the production of crops for market and home consumption and other minor forest products (fruits, herbs, etc..). Access to land for crops and forests and household labor are the main inputs into the production technology, and a rural wage labor market essentially does not exist. The household model developed in this section takes these characteristics as given and analyzes how utility maximizing households are affected by the availability of a CPR and, in turn, how these changes affect child health status.[3]

Specifically, a household is assumed to produce two crops, an agricultural commodity that is consumed and marketed and another good gathered (produced) from local forests that is only for home consumption. The household's joint production function for the two goods is:

$$G(q_x, q_f, q_l, X) = 0 \tag{1}$$

where q_f is production of an agricultural "food" crop, such as cassava, q_x is production/gathering of a forest product, such as fuel, fruits, nuts, and medicinal plants, q_l is household (women's) labor allocated to production, and X is an indicator that

[3] The basic structure of the conceptual model developed below is a variation of those described in Singh, Squire, and Strauss (1986), Thomas, Strauss, and Henriques (1990), Pitt and Rosenzweig (1985), de Janvry, Fafchamps, and Sadoulet (1991), and Yotopoulos and Lau (1974). For more on the economics of nutrition and health in developing countries, see, for example, Behrman, Deolaikar, and Wolfe (1988); Behrman and Deolalikar (1988); Pitt, Rosenzweig, and Hassan (1990). While the model developed in this section ignores within household issues, such issues could be easily incorporated into analyses where relevant and data permit. For more on such issues, see, for example, Behrman (1990).

represents access to common property resources.[4]

Since there is essentially no hired farm labor, the household is constrained in its labor choices by its time endowment, T (for simplicity some minimal fixed amount of leisure is already subtracted). Letting c_l denote household time allocated to child care, the household's labor constraint is:

$$T - c_l = q_l \tag{2}$$

where time not used in child care ("labor supply") equals labor demanded for agricultural production.

Besides production of q_f and q_x, labor use q_l, and time allocated to child care c_l, adults and children in the household also consume a number of other goods. For adults in the household, let d represent a minimal level of consumption of the food crop, and let c_m denote adult consumption of a non-household produced market purchased good. Children consume the food crop c_f, the forest product c_x, and purchased health services c_h.

It is assumed that food crop production q_f is for home consumption and for market sales/purchases at price p_f, while production of the forest product q_x is only for home consumption. Thus, for the forest product, household production equals household consumption:

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[4] Joint production is assumed for notational simplicity and can be changed without affecting the analysis. The index X used to represent access to resources could be easily disaggregated to include access to land for crops and access to forests for gathering other products. This disaggregation is not necessary for the main purpose of this paper.

$$q_x = c_x \tag{3}$$

Besides the labor constraint (2) and the consumption constraint (3), the household's cash income constraint is:

$$p_m c_m + p_h c_h = S + p_f(q_f - c_f - d) \tag{4}$$

where cash purchases of the non-produced market good at price p_m and health service at price p_h equal non-labor income S plus net market sales/purchases of the food crop at price p_f. For example, non-labor income S can be thought of as transfers from family members in urban areas.

The household also produces child health. For our purposes here, child health is a function of four main consumption variables, food c_f, the forest product c_x, health services c_h, and adult time allocated to child care c_l. The health production function is:

$$q_e = q_e(c_f, c_x, c_h, c_l) \tag{5}$$

which is assumed to be increasing and concave. In general, other fixed household and community level variables could influence the health production function, such as presence of specific diseases, improved water supplies, etc..[5]

The household is assumed to maximize household utility of child health q_e and consumption of the market-purchased good q_m subject to satisfying a minimum level of adult consumption d of the food crop, where:

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[5] In some situations, water quality or the presence of diseases may also be a function of the availability of a CPR, which would make them endogenous variables in empirical studies.

$$U = U(q_e, q_m; d) \tag{6}$$

is the household's utility function.

Therefore, the household's overall decision problem is to maximize household utility in (6) subject to the production constraint (1) with multiplier "phi". the time constraint (2) with multiplier "mu", the consumption constraint (3) with multiplier "beta", the cash constraint (4) with multiplier "lambda", and the health production function (5) substituted into the utility function.

Since there is not a market for hired labor and the forest product. market prices do not exist for these goods. As a result, the household's internal prices (shadow or virtual prices) must adjust to clear the two markets equilibrium conditions defined in (2) and (3). Defining p_l = mu/lambda as the shadow price of household time and p_x = beta/lambda as the shadow price of the forest product (virtual prices in income terms), the Lagrangian for the household's problem can be written as:

$$u(q_e, c_m; d) + \lambda [\, Y - p_f c_f - p_m c_m - p_h c_h - p_l c_l - p_x c_x \,] \tag{7}$$

where:

$$Y = S + p_l T + \pi(p_f, p_x, p_l, d, X) \tag{8}$$

equals the household's full income, and:

$$\pi(p_f, p_x, p_l, d, X) = \max_{q_f, q_x, q_l} \; p_x q_x + p_f(q_f - d) - p_l q_l \quad s.t. \;\; G(q_x, q_f, q_l, X) = 0 \tag{9}$$

is the household's profit function.

Assuming interior solutions, the household's optimal production and consumption choices can be written as:

$$q_i = q_i(p_f, p_x, p_l, X, d) \quad where \quad i = f,x,l$$

$$c_i = c_i(p_f, p_m, p_h, p_l, p_x, Y) \quad where \quad i = f,m,h,l,x \tag{10}$$

And, finally, the relevant optimal consumption choices in (10) can be substituted into the child health production function to determine child health.

The model developed above can now be used to analyze how a variety of different parameter changes influence household production and consumption choices, child health, and overall household welfare. For the purposes of this study, the main interest is in how availability of X systematically affects child health status. This question is explored in the following section.

2.3 Household Adjustment to Availability of a CPR

To consider the impacts on child health status of changed availability of X, three analytical steps must be followed. First, it is necessary to understand how changes in X affect the household's shadow prices for time p_l and the forest product p_x. Second, it is necessary to understand how changes in X affect household consumption choices, taking into account adjustments in the shadow prices and income changes. And third, the affects of changed consumption levels determine the final impact on child health status through the health production function. Each step is analyzed below.

Equilibrium conditions for time allocation and the forest product imply that:

$$T = c_l(p_f, p_m, p_h, p_l, p_x, Y) + q_l(p_f, p_x, p_l, X, d)$$

$$0 = c_x(p_f, p_m, p_h, p_l, p_x, Y) - q_x(p_f, p_x, p_l, X, d) \tag{11}$$

when p_x and p_l are evaluated at their equilibrium levels, and Y is defined in (8).

Totally differentiating (11) with respect to X, p_x, and p_l (using the envelope theorem), and then applying Cramer's Rule, the response of the shadow prices to changes in X becomes[6]:

$$\frac{\partial p_i}{\partial X} \geq 0 \quad i = l, x \quad when$$

$$-\left(\frac{\partial c_l}{\partial Y}\frac{\partial Y}{\partial X} + \frac{\partial q_l}{\partial X}\right) \leq 0 \quad and \quad -\frac{\partial c_x}{\partial Y}\frac{\partial Y}{\partial X} + \frac{\partial q_x}{\partial X} \leq 0 \tag{12}$$

and vice versa

Thus, improved access to common property resources, denoted by an increase in X, leads to an increase in the two shadow prices when the two conditions hold. Intuitively, these conditions show, for example, that prices rise when increases in X shift out the consumption choices (c_x and c_l) more than the production choices (q_x and q_l). This effect would be due to a large income effect from increases in X on consumption, which is likely to occur for poorer households at low levels of consumption and income.

Given these endogenous price adjustments, the impacts of changed X on consumption choices are:

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[6] The exact expression for these derivatives is straightforward to derive but long and tedious to report here.

$$\frac{\partial c_i}{\partial X} = \frac{\partial c_i}{\partial Y}\frac{\partial Y}{\partial X} + \frac{\partial c_i}{\partial p_x}\frac{\partial p_x}{\partial X} + \frac{\partial c_i}{\partial p_l}\frac{\partial p_l}{\partial p_x} \qquad i = f, x, l, h \tag{13}$$

There are three main terms in equation (13). The first term is positive and shows the direct income effect on consumption from an increase in X, where the partial derivative of Y with respect to X is the household's shadow value of X holding p_l and p_x constant. When household income is based primarily on access to X, and such access is low, then it is expected that this shadow value will be relatively large.[7] When competitive markets exist for labor and the forest product, then this first term is the complete consumption effect of changes in X.

The second and third terms in equation (13) show how endogenous price adjustments due to missing markets influence final consumption levels. In general, these terms can be positive or negative depending on the conditions in expression (13) and whether the goods are gross complements or substitutes. Thus, in general the direct and magnitudes of effects in (13) are empirical issues.

However, the second and third terms are negative when goods are gross complements and assuming increases in X are associated with price rises in (12). This result is likely to occur for poorer households when income effects of price increases outweigh any compensated substitution effects. As a result, the overall consumption effect is <u>less</u> than the direct income effect of the first term in (13) when X increases. Under these circumstances, missing markets reduce the positive benefits from improved

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[7] And, conversely, when household income is not based primarily on availability of a CPR, then this shadow value would be expected to be small.

availability of a CPR. And, conversely, the household is able to adjust to mitigate some of the negative effects of reduced availability of a CPR.

Given the above consumption effects, the overall impact on child health to availability of a CPR is:

$$\frac{\partial q_e}{\partial X} = \sum_i \frac{\partial q_e}{\partial c_i} \frac{\partial c_i}{\partial X} \quad i = f, x, l, h \tag{14}$$

The model developed in this section illustrates some of the complexities of the relationship between natural resources, economic conditions and markets, and child health status. Besides the direct income effect of changes in X (the first term in 13), household's have the ability to mitigate adverse impacts of changed availability of a CPR through adjustments in a variety of production, consumption, and time allocation decisions. However, it seems reasonable to expect that already poor people have the least ability to mitigate these impacts.

Thus, availability of a CPR would be expected to have little direct impact on income and nutritional possibilities in areas where household income and consumption possibilities are not constrained by access to or quality of local resources.[8] However, in a rural economy that is highly dependent on the local resource base and where access to resources constrains household production and consumption capabilities, availability of a local CPR could have an important impact on income, consumption, and nutritional

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[8] Using household data from Cote d'Ivoire, Strauss (1985) estimates a minor decline in median child nutritional status between forested and savanna areas. This minor impact estimated in the Strauss (1985) study is consistent with the relatively good status of the children in the sample from Cote d'Ivoire.

possibilities. The following section provides some empirical evidence on the magnitude of this relationship.

3. AVAILABILITY OF A LOCAL CPR AND CHILD HEALTH: SOME STATISTICAL EVIDENCE

3.1 Data Development

Data were gathered and created from secondary sources and additional field research.[9] Zaire is geographically divided into health zones each serving a population of 100,000 to 200,000 people. Each health zone is divided into health center service areas with a clinic generally serving five to ten thousand people within a radius of 10-15 kilometers.

Health centers were chosen as the basic unit of observation for this analysis, primarily because basic data were available at health centers and health centers are associated with relatively small geographic areas.[10] During each month of 1990, health center staff complied weight-for-age data according to the percentage of children 5 years and below who were at least two standard deviations below standard weight-for-age as defined by the World Health Organization (1983), hereafter referred to as "below standard". A yearly average percentage of children below standard was then calculated

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[9] A geographically-referenced household survey that includes child health measures, household characteristics, economic variables, and natural resource indicators does not exist.

[10] Due to severely constrained financial and personnel resources, the health centers did not gather additional socioeconomic information.

using the monthly data. There are 113 health centers in the data set. Weight-for-age data, while not necessarily a best measure of nutritional status (WHO, 1983), can be a useful measure of short-term nutritional status (Brown, 1990). The criteria of two standard deviations below standard had previously been chosen to simplify data collection efforts. Children were weighed in their villages at no cost (it was not necessary for mothers to travel to clinics). The 1990 monthly data collected by clinic staffs were then gathered by the study team from each health zone during June 1991. Each clinic included approximately 500 child weighings during 1990.[11] In effect, the sample percentages of children below standard from 113 clinics represent 112 independent samples of roughly 500 observations each. Across the 112 health clinics, the sample mean of the children below standard was 18 percent, with a minimum value of 0.04 percent and maximum value of 54.0 percent.

Landsat images of the study area, geographic information systems technology (GIS), and global positioning systems (GPS) were used to link the data on child nutritional status to forest cover in the health clinic service areas. The location of the 112 health centers were first identified by health zone staff on existing maps for rural Zaire (created using aerial photography in the 1950s). A sample of the health clinic locations identified in these interviews were then verified by driving to the clinic and obtaining latitude and longitude data with a hand-held GPS unit. The clinic locations were then digitized off the maps, thus creating a computerized file containing the

[11] The health centers in general provided similar basic health services, such as child vaccinations, although some provided maternity services.

latitudes and longitudes of the clinic locations.

GIS technology was used to overlay the map of health clinics with a digitized version of the Landsat image of the study area.[12] The Landstat image only covered 75 of the 112 health clinics. A visual analysis of the overlaid computer maps was used to define the service area around a health center, approximately a 15 kilometer radius, as either forest or savanna.[13] In total, 18 clinic areas were defined to be in forest, and 57 were defined to be in savanna.[14]

3.2. Hypothesis Tests

For the sample of 75 health clinics which were in the Landsat image, about 15 percent of children were below standard, with a minimum of 0.5 percent and maximum of 43 percent. The 75 health clinics were then separated into two subsamples: sample A includes the 18 clinics that were defined to be located in forested areas; and sample B includes the remaining 57 clinics that were defined to be located in savanna areas. Basic sample statistics are presented in Table 1. On average, 6.7 percent of children in forested areas were below standard, while 17.2 percent of the children in savanna areas were below standard. Thus, the increase in children below standard from 6.7 percent in

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[12] Roots software was used to digitize the clinic locations, and the GIS software Idrisi was used to link the health clinic and forest cover maps.

[13] As the Landsat image is processed into a usable form for GIS, a more precise environmental variable can be defined (e.g. percentage of forested land within a 10 or 15 kilometer radius from the health center).

[14] Use of the GPS hand-held unit as a guide to known points enabled the field team to go to specific points by airplane and overland to ground truth the satellite image for the forest variable.

forests to 17.2 percent in savanna represents a 150 percent increase in the mean between the two samples.[15]

The question remains as to whether this difference in sample means is statistically significant. Two types of hypothesis tests were conducted: a test of equality of variances across the two samples, defined as σ_A^2 and σ_B^2; and a test of equality of means across the two samples, defined as μ_A and μ_B.[16] The variance test is conducted first because mean-difference tests depend on assumptions about the equality of sample variances.

To test the null hypothesis that $\sigma_A^2 = \sigma_B^2$ versus the alternative hypothesis that the variances are not equal, the test statistic:

$$f = \frac{S_A^2}{S_B^2} \tag{15}$$

is distributed as an F random variable with 17 and 56 degrees of freedom, where S_A^2 and S_B^2 are the respective sample variances (Walpole and Myers, 1978). From Table 1, $S_A^2 = 0.0029$ and $S_B^2 = 0.0138$. Thus, for sample A nd B, f = 0.2085, which is less than the critical value f^c based on a 5-percent significance level.[17] Thus, the null hypothesis that $\sigma_A^2 = \sigma_B^2$ is rejected.

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[15] In general services offered by the health clinics do not vary considerably. For example, all clinics provided vaccinations against common diseases. While some clinics also provided maternity services, there were not differences in weight-for-age data between clinics that provided maternity services and those that did not.

[16] Specific tests based on binomial distribution results could not be conducted because only the sample percentages were available for all health clinics.

[17] From an F table, for a two-sided test at the 5-percent significance level, $f^c(17,56) > f^c(15,40) = 0.387$.

Since the null hypothesis of equal variances is rejected, a means test is conducted based on the assumption that the variances σ_A^2 and σ_B^2 are not equal. Following Walpole and Myers (1978), T' is distributed as a Student's T random variable with v degrees of freedom, where

$$T' = \frac{(X_B - X_A)}{\sqrt{S_A^2/n_A + S_B^2/n_B}}$$

$$\nu = \frac{(S_B^2/n_A + S_B^2/n_B)^2}{(S_A^2/n_A)^2/(n_A-1) + (S_B^2/n_B)^2/(n_B-1)}$$

For sample A and B, T' = 5.22 and v = 63. Thus, since the critical value T^c = 1.99 at the 5-percent level, the null hypothesis that $\mu_A = \mu_B$ is rejected.

Thus, these data show that child nutritional status is significantly better on average in forested as compared to savanna areas, while there is more variation in nutritional status in savanna areas. These results are consistent with the view that the quality of local resources can have a substantial impact on household welfare in rural economies where availability of resources constrains household production and consumption possibilities.

Higher percentages of below standard children in savanna areas makes intuitive sense for many reasons. Poorer quality land implies that agricultural potential in terms of yield and income is less in savanna areas. Women must devote more time to field work to make up for the poorer quality land, which implies that there is less time available for child care, cooking, etc.. Access to water and firewood for fuel is also poorer in savanna areas, which further tightens time constraints of women and children.

More variation in percentages of children in savanna areas indicates the insecure position of the rural population that occurs when population pressure and deforestation forces rural households to expand onto more marginal lands as sources of cropland. Living at the margin, households in savanna areas may have less resilience or ability to respond to adverse circumstances due to variations in weather, pest populations, the health of important family, or broader economic circumstances driven by the macroeconomic situation.

4. CONCLUSIONS

A main reason to be concerned with the management and control of local common property resources is their direct effects on the livelihoods of poor populations, who depend on such resources for a variety of goods and services. When the economic value to the household of these goods and services are not readily available through market prices and income, some non-market measures of household welfare are necessary. This paper considers child health status as an empirically available indicator of household welfare. The conceptual model identifies the complex links between natural resources and household production and consumption decisions, while the empirical results emphasize the magnitude of their importance.

Table 1: Summary Statistics

COMPLETE DATA SET: (n = 112)

sample mean = 0.1801

frequency distribution:

$0.00 \leq h < 0.10 = 42$
$0.10 \leq h < 0.20 = 19$
$0.20 \leq h < 0.30 = 41$
$0.40 \leq h \leq 1.00 = 10$

Sample A: Health Clinics in Forests

observations	$n_A = 18$
sample mean	$X_A = 0.0678$
sample variance	$S_A^2 = 0.0029$
minimum value	0.01
maximum value	0.21

Sample B: Health Clinics in Savanna

observations	$n_B = 57$
sample mean	$X_B = 0.1727$
sample variance	$S_B^2 = 0.0138$
minimum value	0.005
maximum value	0.43

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where h = percentage of children (0 - 5 years) two standard deviations below WHO (1983) standard weight for age in health clinic area.

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