# Examining the inter-linkages of population growth, poverty, and natural resources in Tanzania

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**Abstract**

This study presents an empirical analysis of relationships between population growth via fertility rates, natural resources deterioration, and poverty in Tanzania. The study uses recent household data from the Demographic and Health Surveys. Unlike previous studies, this study uses a negative binomial model which is considered appropriate for the dependent variable used. This study is unique because it employs three models to distinguish combined rural and urban, rural, and urban populations. The findings indicate that water scarcity is associated with lower fertility rates in two of the three models used, and that higher levels of family wealth are associated with lower fertility rates for all three models. These findings provide evidence for Malthusian pressures by suggesting that population growth coupled with poverty leads to resource depletion, which in turn acts as a check on population growth by lowering fertility rates.

## Introduction

Researchers in the disciplines of Economics, Ecology, Sociology and other social sciences have long debated the impact of population growth on our environment. In general there are two different and opposing perspectives on the relationship between environment and population growth. In one, which can be called neo-Malthusian, a growing population exerts pressure on the environment (Hardin, 1968; Ehrlich, 1971; Meadows, Meadows, Randers, and Behrens, 1972). The other perspective sets out a Cornucopian view, which posits that a growing population does not necessarily exert pressure on the environment (Boserup, 1976, 1981; Simon, 1980, 1981a, 1981b, 1990, 1991, 1992). However, in an attempt to link population growth, poverty and environmental scarcity, Dasgupta (1995, 2000) proposes a vicious cycle theory. According to this theory, environmental scarcity can lead to population growth via positive effects on fertility.

Since the introduction of the vicious cycle theory, only a few studies have examined it (Loughran and Pritchett, 1997; Aggarwal, Netanyahu, and Romano, 2001; Filmer and Pritchett, 2002; Sutherland, Carr and Curtis, 2004; Biddlecom, Axinn, and Barber, 2005; Ghimire and Mohai, 2005). Most of these studies use as the dependent variable the number of children born, which is a count variable. The count dependent variable takes only non-negative integer values, which requires the use of special count data regression models (Cameron and Johansson, 1997). However, the studies that have examined the vicious cycle theory have used econometric models that are not designed for count dependent variables. The use of these models can lead to biased results (Wooldridge, 2002).

In this study a negative binomial model, which is considered appropriate for the dependent variable, is used to estimate the effects of environmental scarcity and poverty on fertility rates. This study is unique because it employs three models to distinguish combined rural and urban, rural, and urban populations.

**Literature Review**

The empirical literature on the relationship between population growth, environmental scarcity, and poverty comes from an emerging area of research that analyzes the vicious cycle hypothesized by Dasgupta (1995, 2000). This section of the paper summarizes the empirical works that examined the vicious cycle theory.

Loughran and Pritchett (1997) used data from Nepal Living Standards Survey collected in 1996. This study used cross-sectional data to test whether variation in fuelwood and water scarcity affects fertility by altering the relative value of children in resource collection activities. Loughran and Pritchett concluded that the perception of deforestation and water scarcity by farmers in Nepal increases the perceived net cost of children, which leads to a reduction in demand for children. Their findings imply that there is no positive relationship between environmental degradation and the demand for children as suggested by the vicious cycle theory.

Aggarwal, Netanyahu, and Romano (2001) used data from the South African Integrated Household Survey (SAIHS) collected in 1993 to examine a positive link between fertility increase and environmental degradation. The authors found a positive link between wood scarcity and number of children ever born alive. The effect of water

scarcity on fertility is also positive but not significant. In general, their study suggests that there is a positive feedback between environmental degradation and fertility rates.

Filmer and Pritchett (2002) used data from the 1991 Pakistan Integrated Household Survey (PIHS) to empirically detect measurable effects by indicators of environmental scarcity on fertility. They found that children (at least female children for which they have the data) are relatively specialized in collecting natural resources such as fuelwood at young ages. One of the study findings substantiates the vicious cycle theory that environmental scarcity could possibly raise the demand for children.

Sutherland, Carr, and Curtis (2004) used a cross-sectional data from the 1998/99 DHS to examine potential relationships between factors related to fertility and the access to and use of natural resources in Peten, Guatemala. Their multiple regression findings show perception of land availability and ownership of cattle as the only two natural resource variables that are significantly associated with the number of living children. Their result shows that people who perceive land is available for their children had significantly fewer children than those who perceive land to be scarce.

Biddlecom, Axinn, and Barber (2005) used a data set collected in Western Chitwan Valley in Nepal. The focus of their study was to investigate the relationship between environmental degradation and men's and women's family size preference and subsequent reproductive behavior. Their results provide support for the vicious cycle argument that environmental degradation leads to population growth through raising fertility rates.

Ghimire and Mohai (2005) used data set collected by the Chitwan Valley Family Study from 1996 to 2000. The focus of their study was to examine the impact of

environmental perceptions on contraceptive use in the rural setting of Nepal. Their results do not provide support for the vicious cycle argument. Instead their results show that environmental scarcity acts as a check on population growth.

These studies reveal that there is no consensus in favor or disfavor of the vicious cycle theory. This is the first study that seeks to estimate the effects of environmental scarcity and poverty on fertility using cross-sectional data from Tanzania. Also, this is the first to employ three models to distinguish combined rural and urban, rural, and urban populations. Increasing time to get to a water source is used as a measure of environmental (water) scarcity on fertility rates. Also, woodfuel (firewood, straw, and charcoal) as a type of cooking fuel is used as a measure of environmental deterioration (air pollution) on fertility rates. In addition, a wealth index is used to measure the effect of poverty on fertility rates.

Other standard determinants of fertility such as women's education, age, place of residence (urban versus rural), mortality, marital status, son preference, and family planning programs are also used. In addition, knowledge of ovulatory cycle (Ayoub, 2004) and the effects of siblings are used.

**Data**

To examine the effects of environmental deterioration and poverty on women's fertility, this study employs preliminary data from the 2004 national survey in Tanzania of the Demographic and Health Surveys (DHS+). Funded by the U.S. Agency for International Development (U.S. AID), the DHS coordinates with ORC Macro International and institutions in developing countries to administer a survey to women

aged 15 to 49 drawn from a national sample. The DHS instrument asks respondents to report retrospectively on a wide range of demographic variables. Information concerning education, family planning, family nutrition and health, and other socioeconomic variables are also collected. Although the quality of the DHS data is potentially limited by problems of recall (due to lapse of memory) and possible underreporting of certain types of behavior due to social norms, researchers view the data as highly reliable for use in demographic analysis (Ali, Cleland, and Shah, 2003).

**Methodology**

This study employs a negative binomial technique to develop three models. The first model analyzes environmental and other socioeconomic determinants of fertility rates for the entire sample (both rural and urban population) (see eq. 1). The second and third models do the same but categorize the analysis for rural and urban respectively. Equation 1 differs from equation 2 in the sense that equation 2 excludes type of residence (urban).

$$TFR = \beta_o + \beta_1 twsource + \beta_2 woodfuel + \beta_3 edprimar + \beta_4 edsecondar + \beta_5 edhigher + \beta_6 knows + \beta_7 urban + \beta_8 mort + \beta_9 age + \beta_{10} marst + \beta_{11} sexpref + \beta_{12} sibl + \beta_{13} windex + \beta_{14} FPzin + \varepsilon_1 \quad \text{eq. 1}$$

$$TFR = \beta_o + \beta_1 twsource + \beta_2 woodfuel + \beta_3 edprimar + \beta_4 edsecondar + \beta_5 edhigher + \beta_6 knows + \beta_7 mort + \beta_8 age + \beta_9 marst + \beta_{10} sexpref + \beta_{11} sibl + \beta_{12} windex + \beta_{13} FPzin + \varepsilon_1 \quad \text{eq. 2}$$

*Dependent variables*

In both equations (eq. 1 and eq. 2) the dependent variable is the total number of children ever born during the respondent's (woman) lifetime. Since the fertility data are count data, this study estimates the three models using negative binomial regression.

*Independent variables*

For the environmental variables, this study uses time to get to a water source and the use of woodfuel as cooking fuel. Time to get to a water source is measured in minutes per trip. This variable is used as a measure of water scarcity. The use of woodfuel as cooking fuel is used to measure the impact of indoor air pollution which by itself is an environmental deterioration problem. Dasgupta, Deichmann, Meisner, and Wheeler (2003, p.8) point out studies that have suggested that indoor air pollution from woodfuel is a major cause of respiratory disease in developing countries. The woodfuel is a dummy variable which takes a value of "1" if the respondent uses firewood, straw, or charcoal; "0"otherwise.

To measure poverty, this study uses a wealth index ranging from 1 through 5, with higher levels indicating more family wealth. The index is created by DHS based upon respondent answers to various queries about wealth.

*Control variables*

*Education:* This study creates a series of dichotomous variables for the level of education completed by respondents, ranging from primary education to higher education. The omitted category is no education completed.

*Knowledge of ovulatory cycle*: This is a dichotomous variable used to measure respondent's knowledge of her reproductive behavior. The variable was measured by asking the respondent at what time of during her menstrual cycle she is likely to get pregnant. A woman was given a series of choices to choose. This study assumes that if a woman believes that she ovulates during the middle of her menstrual cycle, then the variable takes a value of "1"; "0"otherwise. This variable has been employed in previous studies (Castro, Martin, and Juarez, 1995).

*Urban residence*: This is a dichotomous variable, for urban or rural residence. If the respondent resides in urban, the variable takes a value of "1"; "0" otherwise.

*Mortality*: This is a dichotomous variable that takes a value of "1" if the respondent had experienced a death of child; "0" otherwise.

*Age*: This study follows Mensch, Arends-Kuenning, and Jain (1996) by creating a dichotomous variables for the respondent's age group (ages 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 44-49). The age group 15-19 is omitted as a control group. Note in table 2 below, when analyzing the rural sample the variable age is not divided into groups.

*Marital status*: This is a dichotomous variable that takes a value of "1" if a woman is married or is living with a partner; "0" otherwise. This variable is included in the assumption that it is very likely that married women or women living with their boyfriends may not have stronger incentives to regulate fertility, all things being equal.

*Son preference*: There is strong evidence of son preference and its effect on fertility particularly in developing countries (Clark, 2000, Arnold, Choe, and Roy, 1998) In order to examine the effects of son preference, this study employs data on the number of girls and boys the respondent deems ideal. In this study a transformation is made into a

dichotomous variable, coded "1" for respondents who have indicated at least one or more boys than girls in their responses to the ideal number of children they would want, "0" otherwise.

*Number of Siblings*: This variable which is the total number of siblings that the respondent has is used as a measure to see if the woman is likely to mimic reproductive behavior of her parents. The study assumes that there is a positive relationship between number of siblings and the number of children she will bear.

*Family Planning program*: This is a dichotomous variable used to measure the influence of family planning on fertility. The variable is measured by asking respondents if they have listened to a radio drama series known as "zinduka" (Swahili meaning "wake up"). The respondents were given three choices for the response (no, yes spontaneous or yes probed). The variable was coded "1" for yes spontaneous or yes probed responses, "0" otherwise.

**Results and discussion**

Tables 1 through 3 present the results of negative binomial maximum-likelihood estimates and robust standard errors of fertility in Tanzania. Table 1 presents results for the entire sample (urban and rural combined). As the table shows, the coefficient for water scarcity as measured by the time to get to water source is negative and statistically significant. However, the woodfuel coefficient used as another proxy measure of natural resources deterioration is not significant. The wealth index coefficient as a measure of poverty is negative and statistically significant.

The results for control variables are presented in Table 1 as well. The coefficients for all education attainment levels are negative and statistically significant. Note that the coefficient for education increases in magnitude with the education levels. The results in Table 1 also show that women who reside in urban areas have lower fertility rates as compared to their rural counterparts. As expected, mortality incidences are associated with higher fertility rates. The results in table 1 also show that respondent age is positively associated with higher fertility rates. The age coefficients increase in magnitude with each succeeding age group. This is expected due to the fact that fertility rates are cumulative. Women who are married or live with their boyfriends are associated with higher fertility rates as the marital status coefficient suggests. Son preference is directly associated with higher fertility rates. Also, a woman who has many siblings tends to have higher fertility rates as suggested by the number of siblings' coefficient. Participation in a family planning program is inversely related to fertility rates as indicated by the family planning coefficient.

Table 1. Determinants of fertility in urban and rural residences

| Variable | Coefficient | Marginal Effects | Robust Standard Error |
|---|---|---|---|
| Time to get to water source | -0.0002** | 0.0004 | 0.0001 |
| Woodfuel use | 0.1048 | 0.1810 | 0.0574 |
| Wealth index | -0.0314*** | 0.0570 | 0.0052 |
| Primary education | -0.0346** | 0.0631 | 0.0136 |
| Secondary education | -0.2092*** | 0.3487 | 0.0353 |
| Higher education | -0.6311 *** | 0.8562 | 0.0867 |
| Knowledge of ovulation | -0.0018 | 0.0033 | 0.0131 |
| Urban residence | -0.1277*** | 0.2233 | 0.0180 |
| Mortality | 0.1427*** | 0.2592 | 0.0052 |
| Age 20-24 | 1.7403*** | 6.1442 | 0.0541 |
| Age 25-29 | 2.2959*** | 10.7847 | 0.0534 |
| Age 30-34 | 2.6490*** | 16.1788 | 0.0536 |
| Age 35-39 | 2.8670*** | 22.2231 | 0.0542 |
| Age 40-44 | 2.9657*** | 25.5104 | 0.0547 |
| Age 45-49 | 3.0303*** | 28.4987 | 0.0551 |
| Marital status | 0.3613*** | 0.6184 | 0.0193 |
| Son preference | 0.0380** | 0.0699 | 0.0147 |
| Number of siblings | 0.0098*** | 0.0178 | 0.0021 |
| Family planning | -0.0808 *** | 0.1436 | 0.0144 |
| N = 8084 | Wald Chi-Square = 13811.76 | *** p<0.01 | ** p<0.05 |

Table 2 shows the results for the rural sample only. To a large extent the results in Table 2 are similar with that of Table 1. However, the results in Table 2 show that the knowledge of ovulation is positive and statistically significant. This may be an indication that women use the knowledge to have more children. Surprisingly, the coefficient of secondary education was not statistically at the 5% level. The coefficient was found to be statistically significant at the 10% level and has a negative sign.

Table 2. Determinants of fertility in rural areas

| Variable | Coefficient | Marginal Effects | Robust Standard Error |
|---|---|---|---|
| Time to get to water source | -0.0003** | 0.0007 | 0.0001 |
| Woodfuel | -0.0263 | 0.0644 | 0.1102 |
| Wealth index | -0.0344*** | 0.0831 | 0.0064 |
| Primary education | 0.0492*** | 0.1181 | 0.0165 |
| Secondary education | -0.0740 | 0.1729 | 0.0412 |
| Higher education | -0.4250*** | 0.8382 | 0.1321 |
| Knowledge of ovulation | 0.0416** | 0.1016 | 0.0167 |
| Mortality | 0.1341*** | 0.3238 | 0.0073 |
| Age | 0.0622*** | 0.1502 | 0.0009 |
| Marital status | 0.6077*** | 1.3152 | 0.0241 |
| Son preference | 0.0642*** | 0.1581 | 0.0176 |
| Number of siblings | 0.0158*** | 0.0381 | 0.0027 |
| Family planning | -0.0716*** | 0.1691 | 0.0183 |
| N = 6527 | Wald Chi-Square = 8580.40 | *** p<0.01 | ** p<0.05 |

Table 3 presents results for the urban sample. Surprisingly, the environmental variables are not statistically significant for the urban sample. This is an indication that women who live in urban areas do not consider the environmental variables used in this study when making their reproductive decisions. This may be because urban women do not have to travel very far to get their sources of water. Otherwise, with minor exceptions, the results for the urban sample are similar to those of the entire and rural samples.

Table 3. Determinants of fertility urban residences

| Variable | Coefficient | Marginal Effects | Robust Standard Error |
|---|---|---|---|
| Time to get to water source | -0.0007 | 0.0009 | 0.0004 |
| Woodfuel use | 0.0947 | 0.1221 | 0.0727 |
| Wealth index | -0.0935*** | 0.1256 | 0.0138 |
| Primary education | -0.0372 | 0.0504 | 0.0438 |
| Secondary education | -0.3593*** | 0.4302 | 0.0713 |
| Higher education | -0.6275*** | 0.6403 | 0.1028 |
| Knowledge of ovulation | -0.0431 | 0.0574 | 0.0329 |
| Mortality | 0.1383*** | 0.1858 | 0.0124 |
| Age 20-24 | 1.4943*** | 3.3963 | 0.1243 |
| Age 25-29 | 2.0700*** | 6.0889 | 0.1223 |
| Age 30-34 | 2.3889*** | 9.4493 | 0.1227 |
| Age 35-39 | 2.7009*** | 14.6948 | 0.1245 |
| Age 40-44 | 2.8002*** | 16.4293 | 0.1261 |
| Age 45-49 | 2.8236*** | 18.0432 | 0.1269 |
| Marital status | 0.4334*** | 0.5689 | 0.0435 |
| Son preference | -0.0239 | 0.0319 | 0.0413 |
| Number of siblings | 0.0144*** | 0.0193 | 0.0055 |
| Family planning | -0.0751** | 0.0998 | 0.0306 |
| N = 1557 | Wald Chi-Square = 2742.18 | *** p<0.01 | ** p<0.05 |

## Conclusion

This paper has examined the effects of natural resource deterioration on fertility in Tanzania. The findings do not fully provide empirical support for the vicious cycle theory. While the findings thus far have been divided, the findings from this paper are consistent with those of Loughran and Pritchett (1997) and Ghimire and Mohai (2005). Loughran and Pritchett found out that environmental scarcity acts as a check on population growth. However, the relationship between fertility rates and poverty as measured by the wealth index is positive. This is consistent to what the vicious cycle theory suggests.

The results for this study are limited because of the failure to take into account the potential effects of endogeneity posed by the natural resources variables. Therefore, the results from this paper are considered provisional and will be investigated further when the author checks for endogeneity.

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