The Effects of Environmental Degradation on Women's and Children's Time Allocation Decisions in Malawi: Impact on Children's Welfare

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Introduction

The majority of the Malawi people is rural (85%) and lives primarily on subsistence farming (NSO 2001). More than 90% collect and use fuel wood as their main source of cooking energy (NEC 2001; NSO 2000). However, between 1990 and 2000, Malawi experienced an average annual deforestation rate of 2.4% that was significantly higher than both Africa's average deforestation rate of 0.78%, and the world's average deforestation rate of 0.22% (UN FAO 2001). Malawi is also reported as one of the countries that will experience water stress by 2025 (PRB 2002[b]). The rapid depletion of natural resources can have significant consequences for the quality of people's lives. Since Malawian women and children are primarily responsible for rural transportation work including collection of fuel wood and water (Edmonds et al. 1995), environmental degradation is expected to affect them disproportionately. This study will investigate the effects of environmental degradation on women's and children's time allocation decisions and the implications on children's school performance and health.

The importance of relationships between population, the environment, and poverty has been acknowledged at both international and regional levels since the 1970's (United Nations 1997). However, there is a serious dearth of empirical studies on the nature of such relationships (United Nations 1997). This lack of studies has been cited as one of the reasons frustrating policy makers in their attempt to adopt sustainable development efforts (Arizpe et al. 1994). Some recent studies in this area have looked at effects of environmental degradation on women's fertility (Filmer and Pritchett 1996; Aggarwal et al. 2001); women's time allocation decisions (Cooke 2000); farm productivity (Cooke 1998). Earlier work by the authors showed that environmental degradation was associated with lower school enrollment and high domestic child labor hours, especially for girls (Nankhuni and Findeis 2002). This analysis extends that research to investigate the impact of environmental degradation on school performance. Attempts to look at impact on child health were done by Aggarwal et al. (2001) in South Africa but no significant impact was found. This study will also contribute to the research on effects of environmental degradation on children's health.

Literature

The literature below presents a review of studies on the nature of women's work in Africa and some parts of Asia, the gender dimension of work, and how children's education is affected by work.

Women's Work

Women in Africa are primarily responsible for all domestic work and they are also significant contributors to non-household work such as cultivation of crops and processing of certain food crops. Dixon (1983) reported that women's contribution to agricultural work is highest in Southern Africa (47.8%) compared to any part of the world. SARDC-WIDSAA (2000) also reports that women's contribution to agriculture in Southern Africa ranges from 60-80%. In Malawi, women comprise 70% of full-time farmers (Green and Baden 1994, citing World Bank 1991). Since women are also primarily responsible for most of the domestic work, overall they tend to work more hours than men. In Malawi, women's total labor time is twice or more than that of men (Green and Baden 1994). This is true even in other developing countries. For example, Dasgupta (1993) reports that in South Asia women and children spend one and a half to two and a half times more time working than men, and that women and children spend up to five hours per day on water collection in India and Africa. Kumar and Hotchkiss (1988) also found women to work one and a half to two times more than men in Nepal. Men, in India and sub-Saharan Africa, on the other hand, have significant roles in production and marketing of cash crops and, therefore, have more control over resources (Dixon 1983; Dasgupta 1993). The above scenario suggests that there is a gender inequality in time and resource allocation, dis-favoring women.

Women are also primarily responsible for most of the rural transportation tasks such as fuel wood collection, water collection and accessing local services (Calvo 1994; Barwell 1996; Amacher et al. 1993; Bryceson and Howe 1993). Women are significant collectors, particularly for households that collect on commons (Amacher et al. 1993). In sub-Saharan Africa, Calvo (1994) finds that women are responsible for 77-93% of the time and effort spent on fuel wood collection. The actual quantities involved are 20-25 kilograms per trip. In a study conducted in Malawi, Semu and Mawaya (1999) reported that 91.5% of respondents said that fuel wood collection is traditionally a woman's job

when asked why it is females who collected fuel wood. Malawian women spend an average of 6-9 hours per week on fuel wood collection (UNIMA and SARDC 1997; Brouwer 1992). The average load size is 19 kgs or higher (25kgs, for adult women aged 18-59), which is collected 2-3 times a week over an average distance of 2.8 kms (Brouwer 1992)[1]. Furthermore, Malawian women make an average of 4-5 trips for water collection per day, hauling an average amount of 15-20 liters of water per trip (UNIMA and SARDC 1997). Women in Malawi are reported to spend more time on water collection than on any other activity (UNIMA and SARDC 1997). Similarly, in South Africa, women were reported to be main collectors of water in 90% of the households (Aggarwal et al. 2001). The predominance of women in natural resource collection work implies that degradation of the environment is expected to affect them more.

Children's Work

In a study on how Kenyan women manage to allocate their time among multiple tasks, self-employed women reported relying on children for water collection when they are away from home 70% of the time and they relied on hired labor to substitute for this work only 7% of the time[2] (Okeyo 1979). In Nepal, children are also reported as significant collectors of fuel wood for households that collect from common property (Amacher et al. 1993). A child labor survey in South Africa by ILO-IPEC (1996) which included fetching fuel wood and water as an economic activity in which children are involved, also found that these activities were the most dominant form of child labor with about 40% of all South African children (about 75% of all working children) involved in it. About 25% of the children spent more than 8 hours/week on fuel wood and water collection.

The Gender Dimension of Children's Work

[1] Brouwer's study covers a few villages in one district of Malawi (Ntheu).
[2] These percentages are based on number of respondents who mentioned children versus spouse, hired labor, or other relatives as being responsible for the task when the mother is away on some business.

Most studies show that boys are more likely to be employed in the formal sector while girls are more likely to work in the home (Vasques 2000; Binder and Scrogin 1999; Grootaert 1999; King and Hill 1993[3]). This is partly because work is sometimes viewed as a socialization process where children learn from adults about their responsibilities in life. Some anthropological studies show that children tend to do the same tasks as adults of the same gender (Bradley 1993, cited in Andvig 2000). Some econometric studies also find women's formal work and girl children's formal work to be complementary (Grootaert 1999; Grootaert and Kanbur 1995; Skoufias 1993 and 1994). Moser (1992)[4] shows that employed women in Ecuador rely on their daughters to take over household responsibilities. Similarly, in the Kenyan study (Okeyo 1979), children were cited as primarily responsible for all domestic responsibilities in the absence of their mothers. If the fact that women work more relative to men is extended to boys versus girls, this would imply a larger work load for girls relative to boys. Some studies actually find this to be the case when child labor is defined to include household work (Grootaert 1999; Coulombe 1998[5]). However, there are cases when the nature of the tasks involved determines the share of work between men and women. For example, in African agricultural economies where animal husbandry is important, such as in Botswana, men's and boys' roles in work are higher and the total distribution of work hours between men and women tends to be equal (Andvig 2000)[6].

The gender dimension of labor implies that girls will also be disproportionately affected by work related to collection of environmental variables. For example, Filmer and Prichett (1996) show that female children in Pakistan spent about 20% of the total female time on firewood collection, water collection, and cleaning[7]. In the South African child labor survey (ILO-IPEC 1996), female children were more involved in fuel wood and water collection activities than male children (25.5% versus 20.9%). The impact of environmental work on girls' welfare is, therefore, expected to be larger than that on boys' welfare.

[3] Cited in Grootaert and Patrinos (1999).
[4] Cited in Grootaert and Patrinos (1999).
[5] Cited in Andvig (2000).
[6] Botswana is also one of the countries in Africa where girls' secondary enrollment rates are higher than boys' (PRB 2002[a]).
[7] In general roughly 60% of total time devoted to firewood collection came from females.

Effects of Work on Children's Education.

Literature on the effects of work on schooling mostly shows the negative impact of formal child employment (Rosenzweig and Evenson 1977; Psacharopoulos and Arriagada 1989; Psacharopoulos 1997). However, in sub-Saharan Africa (SSA), it is estimated that at least 95% of child labor takes place in private homes (Andvig 2000). Women and children in this region also bear a significant large portion of household activities (Andvig 2000; Barwell 1996; Calvo 1994; Bryceson and Howe 1993). However, few studies have quantified the effects of domestic child labor on schooling opportunities (Assaad et al. 2001). Lloyd and Gage-Brandon (1994), present results which suggest that Ghanaian girls are disadvantaged due to their role in childcare responsibilities in large families, but children's labor is not directly modeled. Grootaert (1999) combines formal and housework in her definition of child labor and finds it to be negatively related to schooling in Cote d'Ivoire. However, domestic work is not modeled separately in her study. Abler et al. (1998) study the effects of formal as well as domestic work on children's education in Peru and find domestic work to be a greater deterrent to children's schooling than formal work. Binder and Scrogin (1999) also found that both formal and household work[8] have a small negative impact on human capital formation hours (hours in school and extra-curricula activities) and that formal work is associated with less leisure for children.

Gender-specific effects of work on schooling are reported in Mexico is studies by Levison and Moe (1998) and Levison et al. (2001) and by a study in Egypt by Assaad et al. (2001). Levison and Moe (1998) find girls domestic work to affect girl's schooling negatively, although some of this effect is offset by the presence of other girls and women in the household. Levison et al.(2001) show that a broader definition of work makes girls' education to be negatively affected by work while a narrow definition (incorporating only market work) seems to suggest that girls are advantaged in schooling opportunities. Similar results are found by Assaad et al. (2001) who show that the way

[8] Their definition of children involved in household work includes those who worked in household chores more than 2 hours in the previous day. Those who worked in formal as well as household work are regarded as formal, but excluded in the household workers category.

work is defined has significant impact on the results from analyses of effects of child labor for girls while for boys, a narrow definition of work to include only market work, does not change the effects of work on schooling

Some studies in the child labor literature can be interpreted as showing some evidence of the effects of environmental work on education[9]. For example, Psacharopoulos and Arriagada (1989) found that existence of piped water was the strongest predictor of school enrollment in Brazil and that it also had substantial impact on school attainment levels (child's eventual number of years of schooling attained and reduced drop-out rates). Psacharopoulos and Arriagada took existence of piped water as one of the proxies for household's standard of living. However, this result can also be interpreted as some evidence in support of environmental degradation's impact on school attendance. That is, children who do not have a close source of water are disadvantaged in school enrollment as well as performance. One explanation for this would be the larger amount of time that these children have to spend on water collection.[10]

Background Information on Malawi

Malawi is a country of about 10 million people with a population density of 105 people per square km (NSO 2001). However, there are regional differences in population density. The south has 146 people per square km; the central region has 114 people, whereas the north has only 46 people per square km. There are also significant education level differences between the north and the other regions. The north has a literacy rate of 72% while the central a 55% rate, and the south a 57% rate. Currently, 78% of Malawian children of primary-school age are enrolled in primary schools (NSO 2001). However, drop out rates are very high. Girls face special obstacles to education. For example, data from the Population Reference Bureau shows that only 12% of Malawian girls and 21% of boys are enrolled in secondary schools (PRB 2002[a]). MoESC and DSPS (2000) also show that throughout the 1990's only about 25% of the Malawi University enrollments

[9] There are no studies that we are aware of that specifically looked at the effect of natural resource collection work on children's education.

[10] Psacharopoulos and Arriagada (1989) explain that this variable could also be reflecting location attributes, that is, communities with piped water are also likely to have more public schools and other social facilities.

were girls. The health status for Malawian children is also low. The 2000 Malawi Demographic and Health Survey (NSO 2001) reports that 49% of all children under the age of 5 were stunted, 25% were underweight and 6% were wasted. Stunting is measured by a low height for age and is indicative of chronic malnutrition. Wasting is a low weight for height and is indicative of acute malnutrition (as what happens in cases of famine). Underweight (a low weight for age) is a mixture of the effects of stunting and wasting (NEC 2000). The infant (below age of 1) mortality rate is 104 children per 1,000 live births, while the child (between 1 and 5 years of age) mortality rate is 95 per 1,000 live births (NSO 2001). This is one of the highest mortality rates in the world[11].

As outlined in the introduction, the majority of the Malawi people is rural and relies on fuel wood as their main source of cooking energy. Fuel wood availability is, therefore, crucial for sustenance of life. Figure 1 shows fuel wood availability at the district level in Malawi. The south and central regions are the most distressed, with most of the districts estimated to be experiencing fuel wood shortages since 1985. In terms of proximity to a water source, only 2.5% of the population has piped water inside their dwelling unit and another 7.0% outside their dwelling unit (NSO 2000). The degraded status of the environment can have significant consequences on children's and women's domestic work burdens since women and children especially girls, shoulder greater than 70% of the rural transport burden (Edmonds et al. 1995; PIRTP 1994).

The annual per capita income in Malawi is $170 (World Bank 2002) and it is estimated that 65.3% of the people lived below the poverty line in 1997-98 (NEC 2000). The poverty-environment hypothesis asserts that poor people tend to rely more on common property environmental resources than the non-poor (Jalal 1993). Therefore, the above situation makes Malawi to be a perfect case study for environment-poverty interactions.

Methodology

Data

[11] The average world infant mortality rate is 54, the average for Africa is 86 and for sub-Saharan Africa, 91 (PRB 2002[b]).

Cross section data from an Integrated Household Survey (IHS) of 10,698 households conducted in Malawi in 1997-98 by the Malawi National Statistics Office are used. The data contain information on demographic and socio-economic characteristics of individuals and households, including child and adult levels of education and health. The data also include time allocation on domestic activities including the time spent on fuel wood and water collection. Information on each household's access to different water sources and whether the household relies on purchasing rather than collecting fuel wood is also available. Supplementing these data are estimates of fuel wood availability (GOM 1987) and information on access and quality of school and health facilities at district level (Benson 2002)[12].

Theoretical framework

Freeman (1993) proposes that the basis for measuring the economic value of changes in resource environmental systems is the effects on human welfare. Therefore, the starting point for analyzing the impacts of environmental degradation is utility theory. The household production-utility model based on Becker (1965, 1993) and as adapted to farming households by Singh et al. (1976) will be the theoretical approach utilized in this paper. In this model, households derive utility from consumption of household farm-produced goods and from having children. They also derive positive utility from children's quality normally reflected in the children's health and education. The household's utility is maximized subject to a budget constraint, farm and household technology constraints, and a time constraint. Assuming that an interior solution to the household's maximization problem exists, reduced-form demand equations for children's health and education can be derived. These demands will be functions of shadow wages, prices, individual and household socio-economic and demographic characteristics, and the state of the environment. As the environment degrades, more hours of work are spent on fuel wood and water collection. This results in increased price of education thereby decreasing demand for education, as children may be needed for domestic work. Similarly, if women in more deforested areas cannot spend enough time on farming, cooking, cleaning, and childcare this will act as an increase in cost of children's health

[12] Malawi had a total of 24 districts at the time of the survey.

resulting in the children's poor health (Kumar and Hotchkiss, 1988). This poor health can also result from poor quality of water in areas where water is scarce or not protected.

Estimation strategy

The effect of environmental degradation on children's quality will be estimated by adding environmental quality variables in school performance and child health equations. The school performance indicators used in the paper are children's attendance of senior primary school (standards 5 to 8) and being in a certain class at the appropriate age for that class. The second variable (which is also referred to as progressing at the right age for class) was calculated by assigning a value of 1 to a child who is aged 6, 7, 8 or 9 and is attending junior primary school (standards 1 to 4) or senior primary school, or to a child who is aged 10, 11, 12, 13, or 14 and is attending senior primary school (standards 5 to 8) or is in secondary/higher levels of education. This is a rough measure of school progress because a 9 year old who is in standard 1 or a 14 year old who is in standard 5 is considered progressing at the right age [13]. Despite this relaxation in definition of progress, there were only 33 % of the children who were progressing at the right age, indicating that in Malawi there are significant overage problems. The child health variables are anthropometric measures of weight, height, and weight for height. It is expected that environmental degradation will negatively affect children's welfare.

Possible endogeneity of child schooling, child health, domestic child labor, and women's fertility will be tested and corrected for, where appropriate. In particular, bi-variate models of school performance variables with resource work participation are run to determine if the decisions to allow a child progress to a senior level of schooling or to progress at the right age for her class, are simultaneously determined with the decision to send a child for resource work collection[14]. If the Rho coefficient (the correlation of the disturbances in the two probit equations) is statistically different from zero, then this indicates that these decisions are jointly made. If not, univariate binary probit models can be estimated. In the school performance probit models, potential endogeneity of resource-

[13] The education data was collected in categorical form. Each child is reported as being in standards 1-4, standards 5-8, forms 1-2, forms 3-4, College, and University.

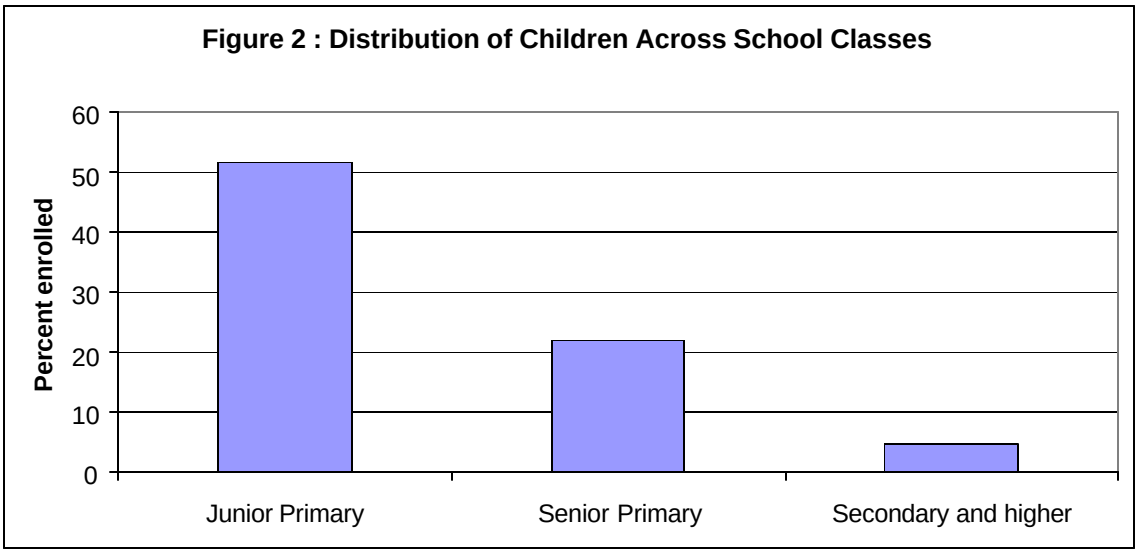
[14] Since some children did not report any information on domestic work, the sample for the bi-variate models include only those children who have information on resource work hours.

work hours (intensity) was corrected following a 2-stage conditional maximum likelihood estimation (2SCML) method developed by Rivers and Vuong (1988) and as explained in Wooldridge (2002), since the *intensity* of resource work may still be endogenous. This involves estimating an OLS regression of resource hours and retaining the residuals, which are then included as one of the explanatory variables in the probit equation for school performance, with the resource hours also included as an explanatory variable[15]. This acts as a test as well as a correction for the endogeneity problem. If the t-statistic for the estimated coefficient of the residuals is statistically significant, this indicates that hours are endogenous in the model.

Data Descriptives

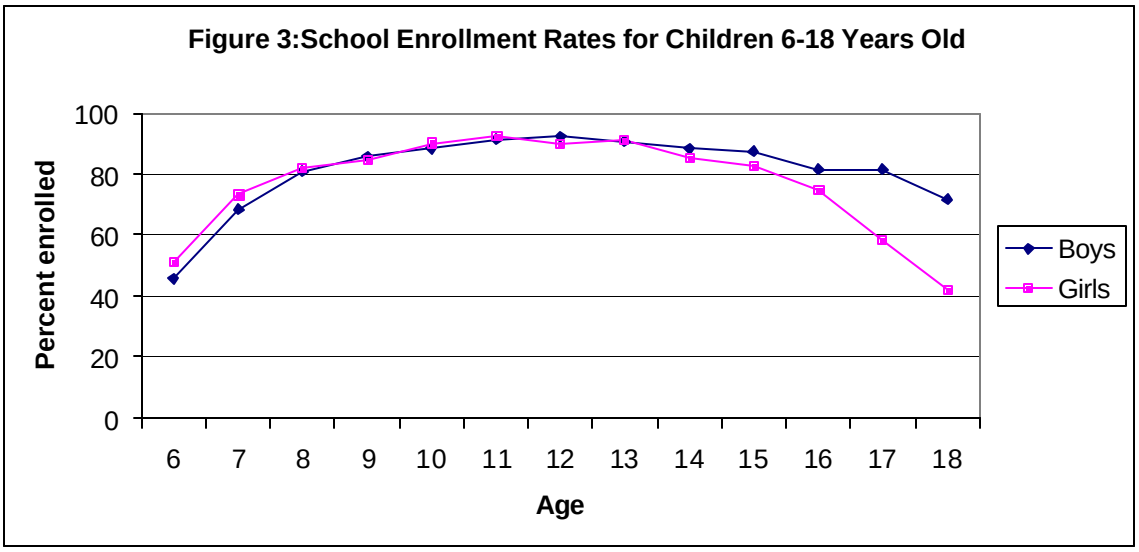
There are 16,512 children age 6 to 18 that are used for estimating school performance probit equations. The distribution of these children across the different categories of classes is presented in Figure 2. Most of the children are concentrated in the junior primary school (standards 1 to 4).

Figure 2 : Distribution of Children Across School Classes

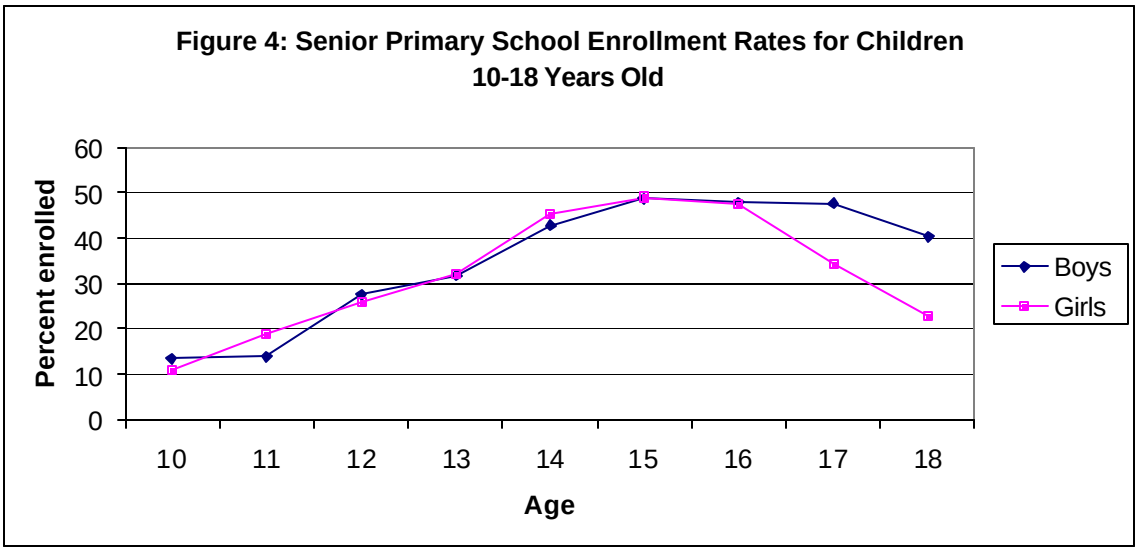


On average 78% of the children age 6-18 are in school. The gender - age distribution for junior primary, senior primary, and secondary school enrollments is summarized in the charts below:

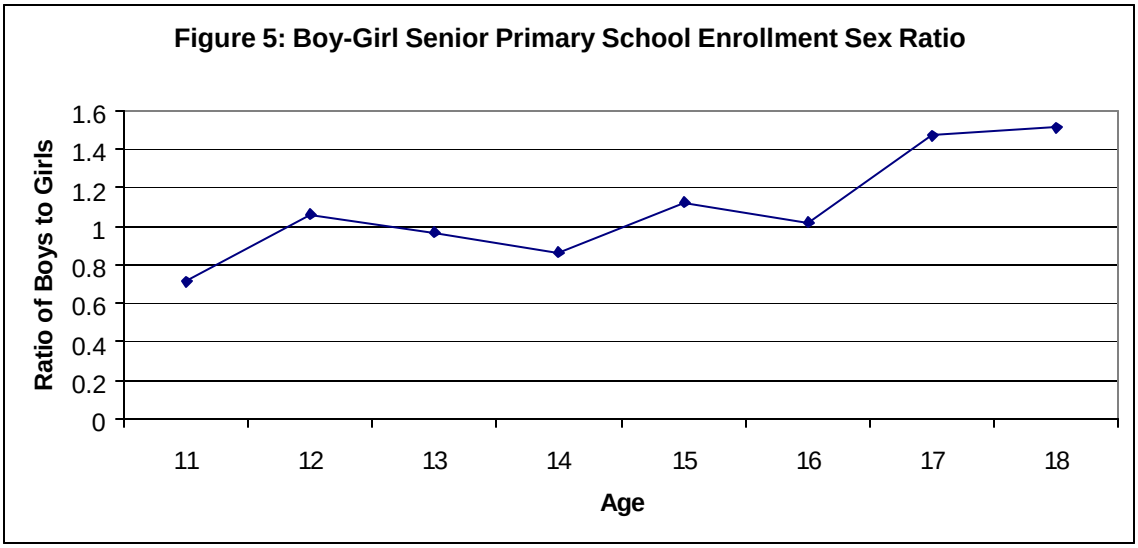
[15] The 2SCML estimation was also done on the sample of children that had non-missing information on resource work hours.



The chart shows that both boys and girls start school quite late, because only about 45% of them are in standard 1 at age 6. However, by age 8 at least 80% are enrolled in school. The gender gap in school enrollment starts manifesting after 13 years of age, beyond which girls are less likely to attend school. Looking at the senior primary school picture for children age 10-18, it shows that both girls and boys face constraints to proceed beyond the first four years of education. For a child that started out at 6 years of age, and did not repeat, they should be in the first class of senior primary school (standard 5) at age of 10. However, Figure 4 shows that only about 10% of the children who are age 10 are in senior primary school. Although this is just a cross section analysis, the above trend suggests that out of the 40% who started out at age 6 in standard 1 only about 10% made it without problems to standard 5. In general 22% of the 6-18 year olds were in senior primary school. When we restrict the sample to those above 10 years old, only 33% are in senior primary school.

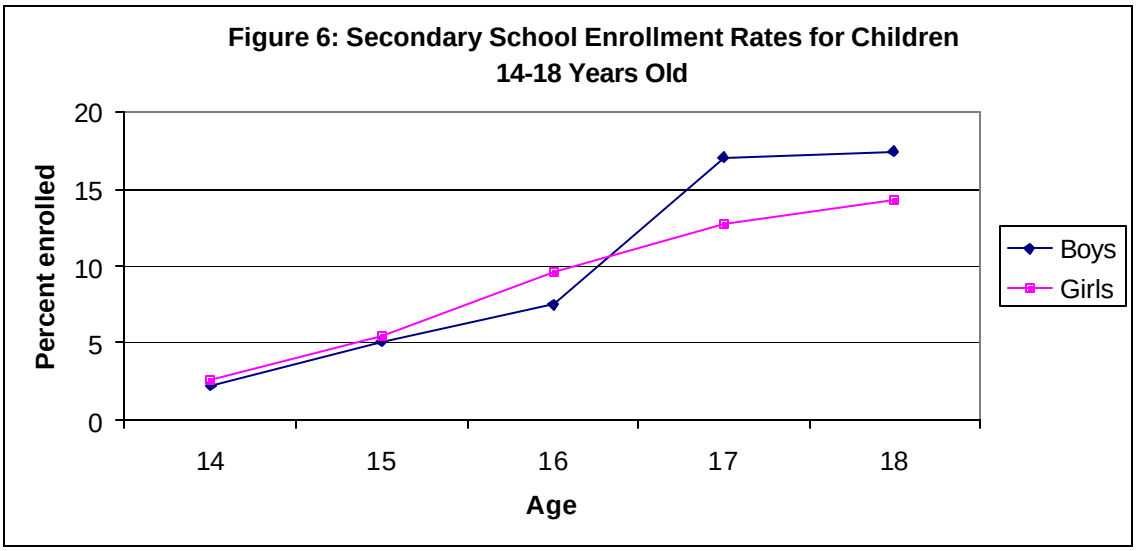


In this figure, not more than 50% of the 10-18 year olds are in senior primary school. The highest percentage of children in senior primary school is of age 15, which is supposed to be a secondary school age (Form 2) for a child that started at age 6 and did not repeat.[16] At age 16, the gender gap in children's senior primary attendance starts to show up. In terms of actual numbers of the school children, this actually translates into a real sex gap as there are about 1.5 boys for every girl aged 18 in senior primary school (see Figure 5 below).



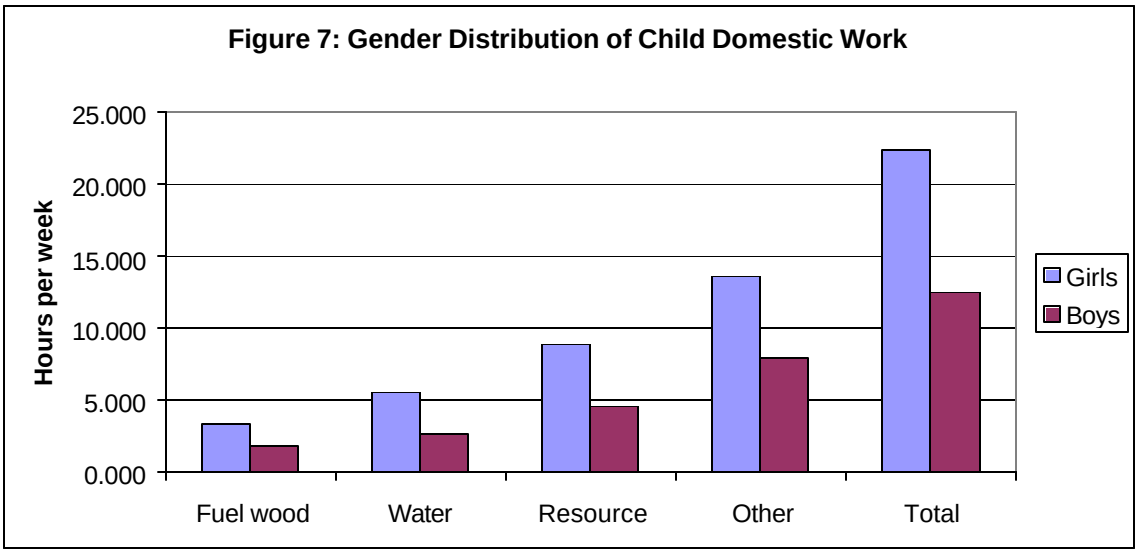
[16] From categorical nature of the education data, it is not possible to find out if the 15 year old is actually in the lowest class of senior primary school (standard 5) or the last class of senior primary school (standard 8).

This may mean that girls have progressed to secondary school or that more girls have dropped out. The secondary school enrollment chart below shows that the later is more likely:



This chart portrays a somber picture of secondary school enrollment rates in Malawi. However, in reality there are more people enrolled who are above the age of 18 and therefore fall out of the sample for this analysis.

The gender distribution of work shows that girls are more likely to participate in resource collection work as 91% of them participated compared to 82% of the boys. Girls also spend more hours on domestic work than boy. Figure 7 shows the gender distribution of children's work. In general girls work 10 hours more per week on domestic work compared to boys. In resource collection (fuel wood and water collection), girls work about 4 hours more than the boys. The other work include childcare, cooking and cleaning.



No information on hours worked on the farm or in the market was available. However, a question on main activity status was asked to all individuals age 10 and older. The girls' employment rate was slightly higher than boys' (4.4% versus 3.0%). This was so because most of the children were employed as home workers, which involves working around the home of someone as a maid. No farm employment data was available in this data set, although in a second panel data of the survey, the main activity question included farming as one of the activities. Here, girls were also slightly more likely to be full time subsistence farmers (3.4%) than boys (2.4%). This means that we can assume girls' work outside the home to be at least similar in its intensity to boys' work.

Discussion of Results

The results on school progress are trying to show the extent to which the above school trends can be explained by environmental degradation or the work resulting from environmental degradation. Variables capturing the state of the environment are included among the normal variables in school performance equations. Descriptive statistics of the variables used in the estimations are presented in Table 1. Appendix 1 gives a brief explanation of these variables.

Determinants of children's school performance

The bi-variate regression of senior school attendance with resource work participation, revealed that there is no jointness in the decision to allow a child participate in natural resource collection work and to allow her continue to senior primary school level. This regression produced a Rho of -0.008 which was statistically insignificant (p-value = 0.977). Therefore, separate uni-variate probit models of resource work participation and senior school attendance were estimated. The results of the senior primary school attendance model are reported in Table 2. The model was estimated for a sample of children age 6-18 and for a smaller sample of children age 10-18 to account for the fact that 6-9 year olds are practically outside the choice of attending senior primary school. The discussion below is based mainly on the results of the children 10-18 which are similar to those for the 6-18 year olds' sample.

The results show that children are more likely to be in senior primary school as they get older until they reach the age of 15, after which they start to drop off or proceed to secondary school. The important result is that girls are less likely to be in senior primary school. This is probably due to their heavy involvement in domestic work. From the regressions of resource work participation and intensity (see Table 3) girls were 11% more likely to be involved in resource collection work and on average, spent about 5 hours more per week on this work compared to the boys[17]. In a 2SCML model in which actual hours of resource work were included as an explanatory variable in the senior school attendance probit regression, the hours of work that children spend on resource collection work were statistically significant in reducing the likelihood that a child will attend senior primary school (see Table 4). An increase of one hour per week decreases the likelihood of attending school by 3%. Since girls spend about 5 hours more per week on resource collection work (see Table 3), this means that girls are relatively disadvantaged compared to boys through the effect of more work burdens. Estimating a 2SCML model on a sample of girls and boys separately confirms that it is girls whose performance is negatively affected by resource collection work, as the coefficient on

[17] The resource work participation and intensity models were based on a sample of 5,059 children (10-18 years old) who had non-missing information on hours of work. Therefore, the estimates may not precisely reflect the data descriptions outlined for whole sample of children 6-18 years old.

resource work hours is significant only in the girls' regression. In the 2SCML model the female children dummy turned out positive and significant, meaning that there is no conscious gender discrimination in allowing children to continue to senior primary school.

A biological child of the household head is more likely to proceed to senior primary school. This probably reflects parents' preferences over their own children compared to other children in the household. Most of the variables that are used to capture environmental condition facing the household are also statistically significant in affecting school performance. Children who live in an area where water takes long to collect, or in a district that has experienced fuel wood shortages since 1985 (districts with severe wood deficits), are less likely to attend senior primary school[18]. This is mitigated by the household's ability to purchase fuel wood, since children from households that rely on purchasing fuel wood (instead of collecting it) as the main source of cooking energy, are more likely to attend senior primary school. This result holds even after we control for the household poverty situation, therefore, this benefit must be reflecting the advantage from less involvement in fuel wood collection.[19] Similarly, having piped water in the household is associated with decreased likelihood of a child participating in resource collection and increased likelihood of a child in attending senior primary school[20]. Poverty, on the other hand, is associated with higher probability of a child getting involved in resource collection work but a lower probability of attending senior primary school. Other household variables that affect a child's likelihood to progress to senior primary school are head's education status, head's employment status, and female headship. A head that completed senior primary school or higher education (secondary and university) is more likely to have their children progress to senior primary school. Heads who are salaried/wage employees and those who own their own business, are more likely to have their children progress to senior primary school while those who rely on subsistence farming are less likely to have their children attend senior primary school[21].

[18] These are children from the south region of Malawi and most of the central region.
[19] A fuel wood participation equation showed that children from households that purchase fuel wood are 17.6% less likely to be involved in fuel wood collection.
[20] This is significant only in the model for children age 6-18.
[21] The coefficient is not statistically significant, although negative. These are termed as home workers in the data. By elimination, I considered them to be the ones who rely mainly on subsistence farming. The

Unfortunately these household head characteristics apply to very few Malawian households. Only 34% completed senior primary school, and 8% completed higher education (secondary and university). Similarly, only 21% were reported as salaried/wage employees and 6% as businessmen. A child who comes from a household headed by a female is also more likely to proceed to senior primary school. This supports intra-household allocation studies that show the importance of women's autonomy in directing household resources to the benefit of children in a household (Kennedy and Peters 1992; Thomas 1994; Lloyd and Blanc 1996),

Household composition variables also affect school performance. Children from households that have a larger number of infants and young children (1-5 years old) are less likely to proceed to senior primary school. This could be due to other work burdens of childcare, cleaning, and cooking that such children impose on school age children (Nankhuni and Findeis 2003). The girls and boys 2SCML model reported in Table 4 shows that presence of more young children is mainly significant in the girl's model, also indicating that these other work burdens are mainly the responsibility of girls. The presence of young adult women and women 25-65 years old increase the probability of a child attending senior primary school. This is probably due to women's increased role in domestic work since the women's increased presence in a household relieves the children (age 10-18) of resource work participation as well as resource work burdens (see Table 3). The presence of more old women (65 and older) is also advantageous to children's school performance. This is due to their role in relieving children's other work burdens, such as childcare, cleaning and cooking.[22] The result of women's presence relieving children's work burdens to the advantage of children's education is supported by other child labor/schooling studies such as Coulombe (1998), Levison and Moe (1998), and Assaad et al. (2001). Presence of more 6-10 year old children in a household is also associated with increased school performance for the children 10-18 years old. Considering that many of the 6-8 year olds are not yet in school, this pattern suggests that those who are not in school are more involved in domestic work (including resource work), to provide

base category is self employed. Therefore, there is no difference between the self employed and the purely subsistence farmers in their influence on children's progress to senior primary school.

[22] In a separate regression of other work burdens for children age 10-18, presence of more old women was found to be significant in reducing this work burden.

time for those who are in school to progress well. A further dis-aggregation of the children age 6-10 years old may reveal the 6-8 year old children contributing a significant amount of work in a household to enable school-children do less work[23]. It is, however, less clear why presence of more young men age 19-24 would be associated with increased school performance for the 10-18 year olds, since they are not more involved in domestic work. These men may be more likely to command a better wage in the market, and hence to contribute to the children's schooling.

In general, household composition variables are considered endogenous in child schooling equations, due to the quantity-quality trade-off in demand for children (Becker 1995; Becker and Lewis 1973). Taking out these variables from the model, gives similar results and basically strengthens the results outlined above. For example, the significance on the female children coefficient is increased from 5% to 1% level of significance.[24] Similarly, a household that purchases fuel wood was not significant in the 10-18 year old children's regression but now it becomes statistically significant at 1% level. Female headship also becomes more statistically significant while residing in the central district is only significant at 10% level. The magnituds of the coefficients do not change significantly. This suggests that whatever endogeneity may come from household composition variables does not significantly bias the results of the model. Due to lack of instruments for household composition variables, no formal test for their exogeneity was attempted.

The school progress model is reported in Table 5. Although female children are less likely to proceed to senior primary school, this model shows that they are not necessarily repeating more than boys. In fact, the female children are more likely to progress at the right age for the class in which they are, compared to the boys. This is not contradictory to the earlier results on senior school attendance. This may mean that parents are more likely to let their boys stay in school longer even if they are struggling, but to let girls drop out if they are struggling. Other cultural factors, besides girls' traditional roles in household work, may be playing a role in influencing these results. For example, girls may drop out to marry early. Other studies show that various aspects

[23] This was not done in this study but it needs further investigation.
[24] From a p-value of 0.037 to 0.008

of school quality also matter in determining school performance (Mensch and Lloyd 1997). In the models here, the quality of schools is captured by a dummy that equals 1 when the child attends a private school or a mission school.[25] The school quality variable is the most significant variable in terms of its marginal effect on the probability of progressing at the right age.

Regional differences in school performance still exist especially for the central region which fares worse than the northern region in both measures of school performance. However, controlling for variables that proxy environmental degradation has helped in explaining away the regional differences in school performance observed in the south region relative to the north.

Conclusions

The results of this study show that environmental degradation contributes to larger work burdens for children, especially girls. Children who spend more hours on resource collection work are less likely to proceed to senior primary school. This effect is particularly so for girls. This means that environmental degradation affects children's school performance, but the impact is larger on girls. This may be one explanation for the increased gender gap with increased levels of education in Malawi. The results also partly explain why children in degraded south and central regions of Malawi have lagged behind their peers in the north. The results suggest that the environment-poverty vicious circle of poverty can be established through the impact of environmental degradation on women's and children's work. This affects several aspects of women's and children's welfare. For example, the low education would cause higher fertility, poor children's health. For policy, these results add a broader perspective of looking at the benefits of environment programs such as reforestation or water supply projects that should be considered when designing such projects. Further analysis on the impact of the environment on children's health is being conducted.

[25] Government school is the base.

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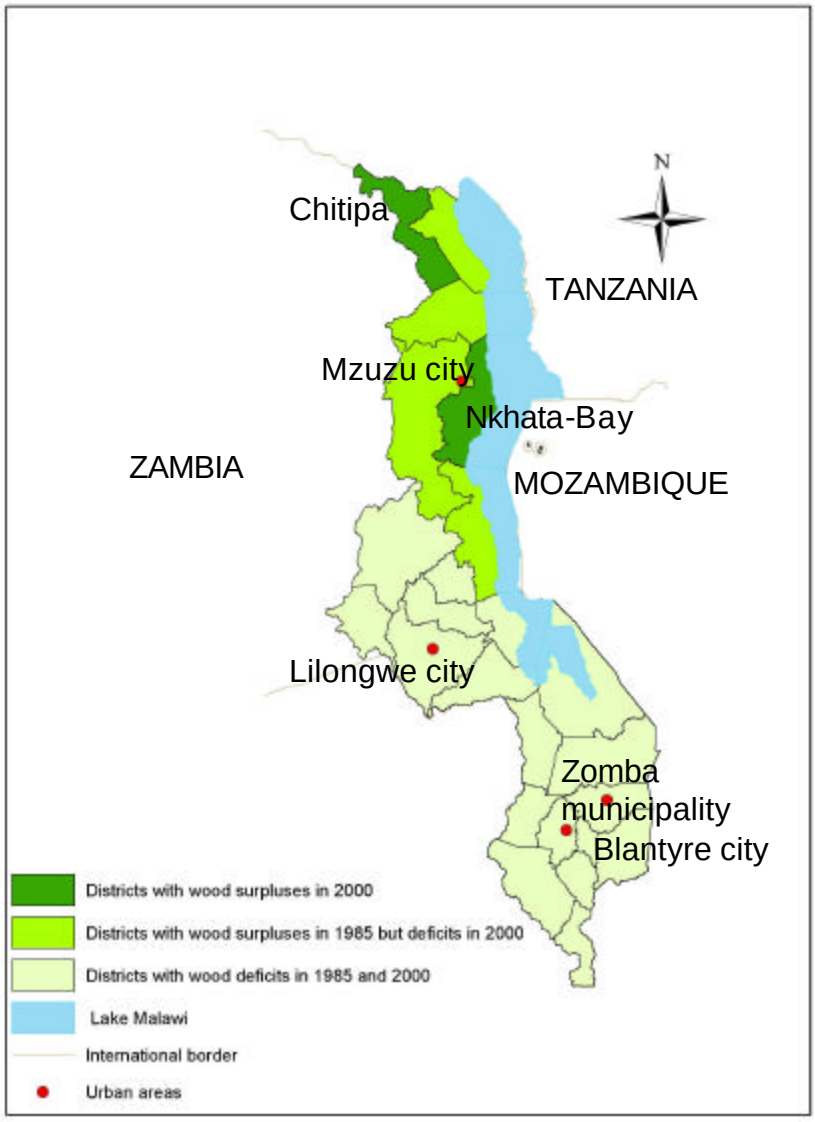
Figure 1: Fuel wood availability in Malawi



Source: National Physical Development Plan Study, OPC, Town and Country Planning Department, Lilongwe, Malawi

Table 1: Description of some of the variables used in the models (see Appendix 1 for descriptive explanation of these variables).

Variable	Mean	Standard deviation
Age	10.497	2.520
Age squared	116.526	51.540
Female	0.670	0.470
Biological child	0.777	0.416
High fuel wood median time area	0.349	0.477
High water median time area	0.567	0.496
District with moderate wood deficits	0.087	0.282
District with severe wood deficits	0.857	0.350
Household with own piped water	0.058	0.233
Household that purchases fuel wood	0.058	0.233
Household poverty	0.700	0.458
Standard 4 head	0.229	0.420
Standard 8 head	0.354	0.478
Highly educated head	0.076	0.265
Standard 4 adult females	0.297	0.515
Standard 8 adult females	0.303	0.506
Highly educated adult females	0.035	0.196
Standard 4 adult males	0.188	0.408
Standard 8 adult males	0.330	0.504
Highly educated adult males	0.083	0.293
Infants	0.122	0.345
Girls 1-5 yrs	0.396	0.624
Boys 1-5 yrs	0.373	0.627
Girls 6-10 yrs	0.739	0.753
Boys 6-10 yrs	0.618	0.747
Girls 11-14 yrs	0.644	0.711
Boys 11-14 yrs	0.448	0.638
Girls 15-18 yrs	0.240	0.486
Boys 15-18 yrs	0.304	0.569
Young adult girls 19-24 yrs	0.150	0.389
Young adult boys 19-24 yrs	0.183	0.471
Women 25-64 yrs	0.907	0.443
Men 25-64 yrs	0.708	0.535
Old women = 65 yrs	0.065	0.249
Old men = 65 yrs	0.055	0.231
South	0.357	0.479
Central	0.564	0.496
Urban	0.117	0.322

Table 2: Probit model for senior primary school attendance.

Variable	Age 6 - 18 (Coefficients)	Age 10 - 18 (Coefficients)	Age 6 - 18 (Marginal effects)	Age 10 - 18 (Marginal effects)
Constant	-8.186***	-10.788***	-1.650***	-3.756***
Child's age	1.014***	1.388***	0.204***	0.483***
Child's age squared	-0.032***	-0.045***	-0.006***	-0.016***
Female child	-0.050	-0.070**	-0.010	-0.025**
Biological child	0.261***	0.274***	0.049***	0.092***
High fuel wood median time area	0.010	0.013	0.002	0.005
High water median time area	-0.091***	-0.095***	-0.018***	-0.033***
District with moderate wood deficits	-0.015	-0.015	-0.003	-0.005
District with severe wood deficits	-0.279***	-0.277**	-0.063**	-0.101**
Household with own piped water	0.118**	0.097	0.025*	0.034
Household that purchase fuel wood as main source of cooking	0.110***	0.123***	0.023***	0.044***
Household poverty	-0.110***	-0.097***	-0.023***	-0.034***
Female head	0.115***	0.104**	0.024***	0.036**
Standard 4 head	-0.066*	-0.070*	-0.013*	-0.024*
Standard 8 head	0.192***	0.204***	0.040***	0.072***
Highly educated head	0.223***	0.227***	0.050***	0.082***
Employed head	0.100***	0.118***	0.021***	0.042***
Businessman head	0.159***	0.149***	0.035***	0.054***
Home worker head	-0.058	-0.031	-0.011	-0.011
Infants	-0.143***	-0.150***	-0.029***	-0.052***
Girls 1-5 yrs	-0.122***	-0.127***	-0.025***	-0.044***
Boys 1-5 yrs	-0.158***	-0.170***	-0.032***	-0.059***
Girls 6-10 yrs	0.111***	0.115***	0.022***	0.040***
Boys 6-10 yrs	0.090***	0.098***	0.018***	0.034***
Girls 11-14 yrs	0.026	0.013	0.005	0.005
Boys 11-14 yrs	-0.008	-0.031	-0.002	-0.011
Girls 15-18 yrs	-0.010	0.002	-0.002	0.001
Boys 15-18 yrs	0.026	0.022	0.005	0.008
Young adult girls 19-24 yrs	0.104***	0.102***	0.021***	0.036***
Young adult boys 19-24 yrs	0.046**	0.049**	0.009**	0.017**
Women 25-64 yrs	0.088***	0.101***	0.018***	0.035***
Men 25-64 yrs	0.000	-0.001	0.000	0.000
Old women = 65 yrs	0.096*	0.092	0.019*	0.032
Old men = 65 yrs	0.070	0.000	0.014	0.000
Good school	0.129***	0.157***	0.027***	0.056***
South	-0.073	-0.080	-0.015	-0.028
Central	-0.176**	-0.184**	-0.035**	-0.063**
Urban	0.051	0.013	0.011	0.005

N = 16,173 for children age 6-18, of which 22.1% attended senior primary school.
N= 10,695 for children age10 -18, of which 32.5% attended senior primary school
*** means the variable coefficient is significant at 1% level of significance (P-value = 0.01).
** means the variable coefficient is significant at 5% level of significance (P-value = 0.05).
* means the variable coefficient is significant at 10% level of significance (P-value = 0.10).

Table 3: Resource work participation and resource work intensity models for children age 10-18.

Variable	Participation (marginal effects)	Time allocated to resource work[1]
Constant	0.201**	-5.202
Child's age	0.002	1.589**
Child's age squared	0.000	-0.046*
Female child	0.112***	4.790***
Biological child	-0.003	0.336
High fuel wood median time area	0.016***	1.779***
High water median time area	0.021***	1.150***
District with moderate wood deficits	-0.173**	-1.465
District with severe wood deficits	-0.059***	0.425
Household with own piped water	-0.230***	-6.070***
Household that purchase fuel wood as main source of cooking	0.017***	0.616
Household poverty	0.028***	0.396
Female head	0.007	0.329
Standard 4 head	-0.001	-0.429
Standard 8 head	0.010	-0.073
Highly educated head	-0.017	-0.263
Employed head	-0.028***	-1.571***
Businessman head	-0.006	0.300
Home worker head	0.006	1.345***
Infants	-0.009	0.063
Girls 1-5 yrs	-0.027***	-1.003***
Boys 1-5 yrs	-0.026***	-0.437*
Girls 6-10 yrs	0.005	0.243
Boys 6-10 yrs	0.010**	0.029
Girls 11-14 yrs	0.001	-0.109
Boys 11-14 yrs	0.000	-0.136
Girls 15-18 yrs	0.005	0.158
Boys 15-18 yrs	0.001	-0.414*
Young adult girls 19-24 yrs	-0.029***	-1.751***
Young adult boys 19-24 yrs	0.003	0.228
Women 25-64 yrs	-0.023***	-1.771***
Men 25-64 yrs	0.009	0.474
Old women = 65 yrs	0.003	-0.639
Old men = 65 yrs	0.004	0.562
South	-0.014	-2.725***
Central	-0.010	-5.288***
Urban	-0.085***	-3.089***
Lambda	-	10.512***

1 The resource work hours are estimated with Heckman (1979) sample selectivity correction.
N = 5,059 in the resource work participation equation, and N = 4,550 in the resource work hours regression model.
*** means the variable coefficient is significant at 1% level of significance (P-value = 0.01).
** means the variable coefficient is significant at 5% level of significance (P-value = 0.05).
* means the variable coefficient is significant at 10% level of significance (P-value = 0.10).

Table 4: Two-Stage Conditional Maximum Likelihood Model for Senior Primary School Attendance Model (Children 10-18 Years Old).

Variable	All Children (Marginal effects)	Girls (Marginal effects)	Boys (Marginal effects)
Constant	-3.512***	-4.019***	-2.364***
Child's age	0.471***	0.561***	0.273***
Child's age squared	-0.016***	-0.019***	-0.008***
Female child	0.048**	-	-
Biological child	0.123***	0.123***	0.106***
Resource work hours	-0.017***	-0.019***	-0.001
OLS regression residuals	0.017***	0.020***	0.001
Household poverty	-0.005	-0.010	-0.007
Female head	0.025	0.030	0.022
Standard 4 head	-0.021	-0.020	-0.012
Standard 8 head	0.089***	0.082***	0.114***
Highly educated head	0.125***	0.105***	0.153***
Employed head	0.035*	0.031	0.072*
Businessman head	0.109***	0.132***	0.041
Home worker head	0.046**	0.057***	0.005
Infants	-0.070***	-0.072***	-0.047
Girls 1-5 yrs	-0.045***	-0.048***	-0.026
Boys 1-5 yrs	-0.061***	-0.054***	-0.072***
Good school	0.093***	0.112***	0.053
South	-0.127***	-0.158***	-0.050
Central	-0.178***	-0.223***	-0.038
Urban	-0.049**	-0.071***	-0.008

N = 5,034 for all children (10 -18 years old) of which 32% attended senior primary school.
N = 3,467 for girls age10 -18, of which 31% attended senior primary school.
N = 1,567 for boys age 10-18 of which 32% attended senior primary.
*** means the variable coefficient is significant at 1% level of significance (P-value = 0.01).
** means the variable coefficient is significant at 5% level of significance (P-value = 0.05).
* means the variable coefficient is significant at 10% level of significance (P-value = 0.10).

Table 5: Probit model for progressing in primary school at the right age for class.

Variable	Coefficients	Marginal effects	Mean
Constant	-0.469***	-0.145***	-
Child's age	0.269***	0.083***	11.607
Child's age squared	-0.022***	-0.007***	148.862
Female child	0.060**	0.019**	0.503
Biological child	0.093***	0.028***	0.763
High fuel wood median time area	0.024	0.007	0.368
High water median time area	-0.031	-0.010	0.571
District with moderate wood deficits	-0.006	-0.002	0.118
District with severe wood deficits	-0.167	-0.054	0.851
Household with own piped water	0.248***	0.082***	0.071
Household that purchase fuel wood as main source of cooking energy	0.100***	0.032***	0.163
Household poverty	-0.147	-0.046***	0.709
Female head	0.002	0.001	0.271
Standard 4 head	-0.040	-0.012	0.224
Standard 8 head	0.128***	0.040***	0.338
Highly educated head	0.219***	0.072***	0.078
Employed head	0.087***	0.027***	0.211
Businessman head	0.200***	0.065***	0.064
Home worker head	0.029	0.009	0.175
Infants	-0.088***	-0.027***	0.134
Girls 1-5 yrs	-0.024	-0.007	0.386
Boys 1-5 yrs	-0.031	-0.010	0.361
Girls 6-10 yrs	0.028	0.009	0.650
Boys 6-10 yrs	0.041**	0.013	0.656
Girls 11-14 yrs	0.042**	0.013**	0.494
Boys 11-14 yrs	0.038**	0.012**	0.487
Girls 15-18 yrs	-0.067***	-0.021***	0.399
Boys 15-18 yrs	-0.103***	-0.032***	0.460
Young adult girls 19-24 yrs	0.030	0.009	0.198
Young adult boys 19-24 yrs	0.020	0.006	0.257
Women 25-64 yrs	0.020	0.006	0.933
Men 25-64 yrs	-0.045	-0.014	0.729
Old women = 65 yrs	0.031	0.010	0.065
Old men = 65 yrs	-0.053	-0.017	0.062
Good school	0.331***	0.111***	0.108
South	-0.098	-0.030	0.495
Central	-0.137***	-0.042*	0.385
Urban	0.169***	0.055*	0.131

N = 16,173 of which 22% attended senior primary school.????

*** means the variable coefficient is significant at 1% level of significance (P-value = 0.01).

** means the variable coefficient is significant at 5% level of significance (P-value = 0.05).

* means the variable coefficient is significant at 10% level of significance (P-value = 0.10).

Appendix 1: Description of some of the variables used in the models

Variable	Description
Age	Age of the child
Age squared	Age squared
Female	Dummy equal to 1 for all female children
Biological child	Dummy equal to 1 for a child who is reported to be a biological child of the household head
High fuel wood median time area	Dummy equal to 1 if a child lives in an enumeration area where the median value of hours spent on fuel wood collection is higher than the IHS sample median value of 2.0.
High water median time area	Dummy equal to 1 if a child lives in an enumeration area where the median value of hours spent on water collection is higher than the IHS sample median value of 3.0.
District with moderate wood deficits	Dummy equal to 1 if a child lives in an area where fuel wood supply was in surplus in 1985 but was estimated to be in deficits in 2000.
District with severe wood deficits	Dummy equal to 1 if a child lives in an area where fuel wood supply was in deficits in 1985 and was estimated to remain in deficits in 2000.
Household with own piped water	Dummy equal to 1 if a child comes form a household that has access to own piped water.
Child's resource work hours	Hours that a child (age 6 to 14) spent on resource collection work (fuel wood and water collection) in the week preceding the interview date.
Child's other work hours	Hours that a child (age 6 to 14) spent on other domestic work (cooking, cleaning, and childcare) in the week preceding the interview date.
Household poverty	Dummy equal to 1 if child lives in a household that is below the poverty line.
Standard 4 head	Dummy equal to 1 for a child who lives in a household whose head completed up to first four years of primary school education.
Standard 8 head	Dummy equal to 1 for a child who lives in a household whose head completed five to eigh years of primary school education.
Highly educated head	Dummy equal to 1 for a child who lives in a household whose head completed any level o secondary education, high school and university education.
Infants	Total number of children below age one who live in the child's household.
Girls 1-5 yrs	Total number of girls age 1 to 5 who live in the child's household.
Boys 1-5 yrs	Total number of boys age 1 to 5 who live in the child's household.
Girls 6-10 yrs	Total number of girls age 6 to 10 who live in the child's household.
Boys 6-10 yrs	Total number of boys age 1 to 5 who live in the child's household.
Girls 11-14 yrs	Total number of girls age 11 to 14 who live in the child's household.
Boys 11-14 yrs	Total number of boys age 11 to 14 who live in the child's household.
Girls 15-18 yrs	Total number of girls age 15 to 18 who live in the child's household.
Boys 15-18 yrs	Total number of girls age 15 to 18 who live in the child's household.
Young adult girls 19-24 yrs	Total number of young women age 19 to 24 who live in the child's household
Young adult boys 19-24 yrs	Total number of young men age 19 to 24 who live in the child's household
Women 25-64 yrs	Total number of women age 25 to 64 who live in the child's household
Men 25-64 yrs	Total number of men age 25 to 64 who live in the child's household
Old women ≥65 yrs	Total number of old women age 65 and above who live in the child's household
Old men≥65 yrs	Total number of old men age 65 and above who live in the child's household
Adult women = 15 yrs	Total number of women age 15 and above who live in the child's household
Adult men = 15 yrs	Total number of men age 15 and above who live in the child's household
South	Dummy equal to 1 for a child who lives in the southern region of Malawi.
Central	Dummy equal to 1 for a child who lives in the central region of Malawi.
Urban	Dummy equal to 1 for a child who lives in urban areas of Malawi: Blantyre city, Lilongwe city, Mzuzu city, and Municipality of Zomba (see Figure 2).