Environmental Resource Collection versus Children's Schooling: Evidence from Tigray, Northern Ethiopia

Bahre Gebru[1] and Sosina Bezu[2]

[1]Department of Economics, College of Business and Economics, Aksum University, Aksum

[2]School of Economics, Addis Ababa University, Addis Ababa

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About the Author(s)

Bahre Gebru, Department of Economics, College of Business and Economics, Aksum University, Aksum, Ethiopia. bahregebru@gmail.com

Sosina Bezu, School of Economics, Addis Ababa University, Addis Ababa, Ethiopia. sosinac@yahoo.com

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Bahre Gebru[1] and Sosina Bezu[2]

[1]Department of Economics, College of Business and Economics, Aksum University, Aksum

[2]School of Economics, Addis Ababa University, Addis Ababa

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Abstract

Previous studies in Ethiopia treat child labour and schooling in a broader sense without much attention to the kind of labor they are engaged in. This paper distinctively examines the adverse effect of natural resources scarcity on children's schooling and the possible gender bias against girls' schooling due to resource collection work. It uses a cross sectional data of 316 children aging 7 to 18 years collected from 120 rural households of Enderta and Hintalo Wajerat woredas in Tigray, northern Ethiopia. The two-stage conditional maximum likelihood (2SCML) estimation technique is employed to take care of endogeneity between schooling and collection intensity decisions. The results revealed that a 50 percent increase in collection intensity reduces the likelihood of child schooling by approximately 12 percent. Even though girls more often participate on resource gathering tasks, we find no evidence of gender based difference against girls' schooling due to resource collection intensity. Timely collection of fodder resources from cultivated land—soon enough so amount and quality will not deteriorate, planting fodder-rich tree species, promoting labor sharing arrangements, and maintenance of the non-operating constructed water sources can reduce the time spent on environmental resources collection and improve the likelihood of schooling.

Keywords: Environmental resource collection, Collection intensity, Schooling, 2SCML,Tigray

1. Introduction

Children are economic assets in the rural areas of developing economies. Their importance becomes explicit when rural households heavily base their livelihoods on environmental resources including firewood, water, and fodder. Predominantly, collection of such resources is from the commons and lies on the shoulder of children and women (Cooke 2000). With natural resources scarcity, such groups will travel long distances, spending considerable labor time and effort. Rapid rates of deforestation further exacerbate the problem since access to environmental goods will be pushed further away from the households, demanding more and more time for collection. Consequently, children become indispensable for their parents with high work demand at the expense of schooling. Such phenomenon subsequently worsens the process of human capital formation (Winkler-Dworak 2003).This provides a channel through which environmental resources scarcity affects children's schooling and resource collection work. Hence, scrutinizing the trend together with the issues of the environment, child labor, and schooling is important.

In Ethiopia, forest degradation and deforestation are worsened when fuel wood and dung are used as sources of energy (Alemu and Köhlin 2008). Nyssen et al. (2004) established that environmental degradation is a real problem in Ethiopia—reflected by overgrazed rangeland. These challenges emanate from human activities and unsound use of natural resources. This problem is severe in Tigray, the most degraded part of the country (Hailu and Edwards 2006). The region's natural forest and woodland vegetations are destroyed due to the escalating household's demand for firewood, grazing land, cultivable land, and urbanization. About 50 percent of the highlands in the region experience severe environmental degradation (Yohannes and Waters-Bayer 2007). Reduced access to fuel wood, water, and fodder is, therefore, reflected by the time spent on gathering such resources, and thus has considerable welfare implications on the likelihood of children's schooling.

Compared to other regional states in Ethiopia, Tigray region generally has a good student enrolment record. For instance, the total net enrolment rate at primary level was about 94% for Tigray, 91% for Benishangul Gumuz, 89% for Gambella, , 51% for Somali and 30% for Afar region during 2009/10 (Ministry of Education, 2009/10). However, there exists a difference across woredas within Tigray region. While the national grade one net intake rate was about 77% in 2009/10 (Ibid), it was found to be around 93% for Enderta woreda, which is less than the regional average of 97%. Similarly, the grade three net intake rate was about 68% both for Enderta and Hintalo Wajerat woredas while the regional average was 77% for the same year. The net enrolment rate falls drastically starting from the first cycle of the secondary school. During the 2009/10 academic calendar for grades 9-12, from the corresponding total population aged 15-18 years a total net enrolment rate of 1.58% for Enderta and 22.63% for Hintalo Wajerat woredas is noticed. This was a record considerably lower than the 27.52% average for Tigray region as a whole (Tigray Region Education Bureau 2009/10).

While the desire is still to ensure education for all children, barriers occur from many angles. Many authors have identified different factors responsible for the low likelihood of enrolment at school in Ethiopia of which the influence of child labor, in its broader sense, is on the forefront (Getnet and Beliyou n.d.; Assefa 2002; Assefa and Bedi 2003; Chaudhury et al. 2006; Tassew et al. 2008; Weir 2010). But the impact of scarcity of environmental resources on children's schooling did not receive due attention in the literature of child labor in Ethiopia. For instance, about 1,400 donkey loads firewood are supplied to Mekelle city on a weekly basis (Tigray Region Agriculture and Rural Development Bureau 2010/11). The report revealed that about 95 percent of this supply emanates from the farmers in Enderta woreda of Tigray region where the majority of the suppliers are children. The point here is that natural resources scarcity, mostly caused by environmental degradation, may put pressure

on children's schooling. Previous studies in Africa (Nankhuni and Findeis 2004; Ndiritu and Nyangena 2010) provide supporting evidence.

However, there exists a dearth of empirical evidences in Ethiopia as to whether natural resources scarcity leads to lower likelihood of children's enrolment at school through the opportunity cost of time spent on collecting environmental resources (firewood, water, and fodder). To this endeavor, this study presents substantiation from Tigray region using a cross-sectional data set for children in the age group of 7 to 18 years. It empirically explores the central hypothesis that scarcity of firewood, water, and fodder reduces the likelihood of children's schooling and that girls, relative to boys, are discriminated against schooling because of the resource collection intensity.

Examining the link between environmental resources scarcity, resource collection and children's schooling fills the gap in literature on child labor in Ethiopia. This kind of research is crucial by providing information for policy makers in formulating sound educational, labor, and environmental resource management policies. It can also serve as a point of reference for further researchers in the area.

The rest of the paper is organized as follows. Section 2 reveals the conceptual framework of the paper. Section 3 brings about the empirical model and estimation technique while the data and descriptive statistics are described under section 4. Section 5 provides the results, and section 6 brings the concluding remarks and implications.

2. Conceptual framework

Theoretically, this study bases its analysis on Becker's (1965) seminal paper on the allocation of time and its extensions to household behaviour. This household production model assumes that parents' utility maximization is constrained by market purchased goods and time endowment. As per this model, the number of children that a family desires to have and the pattern of household member's time allocation towards schooling, market work, and household production demands joint decisions.

In the original specification of the model, home produced goods (like collected firewood, water, and fodder in our case) and market goods (for instance, oil lamp) are perfect substitutes to each other. Gronau (1977) further developed the model by arguing that household's home goods production is characterized by the diminishing marginal productivity mainly due to tiredness and limited access to local resources. With increasing local resources scarcity, this may require more helping hands (larger number of children) spending a considerable portion of their time on the collection of firewood, water, and fodder. The implication is that resource collection tasks may ultimately keep children out of school. This is substantiated by Rosenzweig and Evenson (1977) who examined the joint parents' decision concerning child work, schooling, and that of fertility in the rural economic setups.

Parents maximize utility by choosing the quality of their children (measured by investment on human capital formation) and their quantity (measured by the number of children), household leisure, and home produced goods subject to their income and time restriction in the agricultural sector. In doing so, parents allocate their time between work and leisure. Children, on the other hand, can for simplicity purposes be assumed to distribute their time towards leisure, education, and home production activities.

3. Data and empirical model

3.1. Data

The study was carried out in South Eastern Tigray covering two woredas: Enderta and Hintalo Wajerat. We used a cross-sectional data set of 120 rural households. While 42 households are chosen from Hintalo Wajerat, the remaining 78 are from Enderta woreda. These woredas are chosen on purpose. This is because the relative proximity of the two woredas to Mekelle (the regional capital) increases the demand on children to collect and sell natural resources (firewood and fodder) beyond their family's domestic consumption. Evidence showed that about 1,400 donkey loads firewood are supplied to Mekelle per week mainly from farmers in Enderta woreda (Tigray Agriculture and Rural Development Bureau 2010/11).

A detailed, structured, and close ended questionnaire was prepared and pre-tested in the study areas. Consequently, important corrections were made and some redundancy totally removed. Using a multi-stage sampling, two 'tabias'[1] (5 villages) from Hintalo Wajerat woreda and three 'tabias' (6 villages) from Enderta woreda were chosen. A simple random sampling technique was employed to select 'tabias', villages, and households consecutively.

The survey data collected provide evidence on children's participation on schooling and resource collection, collection intensity, household socio-economic characteristics, household income, sources of environmental resources, and the time spent on other domestic tasks. Focus group discussions were carried out with teachers and students in two selected schools (with one from each woreda) and with firewood distributors in Quiha and Mekelle.

Even though rural children in Ethiopia actually begin environmental resource collection work in their early ages, this study focuses on children in the 7-18 years age category. The lower limit of the age range is chosen because it is the official age for any child to start schooling in Ethiopia (Assefa 2002; Getnet and Beliyou n.d.), while the maximum age boundary is used following the International Labor Organization's (ILO) 1999 convention that regards all persons under 18 years as children (ILO 1999). As a result, 316 children (175 boys and 141 girls) who fall in this age category are used for the analysis. 184 children belonging to the 78 households are from Enderta, 132 children belonging to the 42 households are from Hintalo Wajerat woreda.

3.2. Empirical model and issues of estimation

Decisions by parents concerning children's time allocation are likely to consider more than one activity and calls for modelling simultaneous equations. The decisions by a parent to send any child to school or work are jointly determined competing with the time endowments. To this end, the bivariate probit model (Greene 1998; Nankhuni and Findeis 2004; Ndiritu and Nyangena 2010) is adopted to trace the resource collection versus schooling interactions.

$$Y_{1i}^* = \beta_1' X_{1i} + \varepsilon_{1i} \qquad (1)$$
$$Y_{2i}^* = \beta_2' X_{2i} + \varepsilon_{2i} \qquad (2)$$

Where Y_{1i}^* and Y_{2i}^* are latent variables observed by the following conditions:

$$Y_{1i} = 1 \text{ if } Y_{1i}^* > 0, Y_{1i} = 0, \text{Otherwise}$$
$$Y_{2i} = 1 \text{ if } Y_{2i}^* > 0, Y_{2i} = 0, \text{Otherwise}$$

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[1] It is the lowest administrative unit in the region, anonymous to 'Kebelle' in the urban setting.

Y_{1i} shows whether the child is currently attending school based on the question: "Is [name of the child] attending school at present?". The value is 1 if the answer is yes and 0 otherwise. Y_{2i} refers to whether [name of the child] participated on collecting at least one of the resources—firewood, water, or fodder—in the past seven days before the survey. The value is 1 if the answer is yes and 0 otherwise.

Both the schooling and collection participation choices are modeled as a function of some explanatory variables (the complete list and definition of these variables is given in Annex A.1). β_i' is the vector of coefficients for the explanatory variables. ε_{1i} and ε_{2i} are the disturbance terms in the school attendance and resource collection participation activities respectively. They are assumed to be independently and identically distributed as bivariate normal $[\varepsilon_{1i}, \varepsilon_{2i}, \rho]$ ~ bivariate normal. ρ stands for the correlation coefficient between the errors of schooling and resource collection participation equations.

Since environmental resource collection participation and school enrolment are likely to be jointly decided, the bivariate probit model is firstly estimated. If the ρ coefficient is statistically significant, involvement in schooling and resource collection participation are undertaken jointly. On the other hand, univariate probit models are used if the error terms are not correlated (Greene 1998).

Because the children's time spent to collect firewood, water, and fodder increases with natural resources scarcity, their likelihood of attending school may be negatively affected. Consequently, the amount of time spent on environmental resource collection (hereafter the collection intensity) is considered as an endogenous regressor in the school attendance model.

$$Y_{1i} = \beta_1' X_{1i} + \omega Y_{3i} + \varepsilon_{1i} \qquad (3)$$

Here, Y_{3i} stands for the collection intensity for child i introduced as a continuous variable in the school participation model and ω its coefficient.

If the resource collection intensity is an endogenous predictor in the school enrolment equation, the Rivers and Vuong (1988) correcting technique—the two-stage conditional maximum likelihood, henceforth 2SCML procedure—is preferred to other estimators. Greene (1998) argued that this procedure works well if at least one endogenous and continuous explanatory variable exists in the probit model. The computation of the 2SCML involves two steps. Firstly, a reduced form Ordinary Least Square regression is carried out on collection intensity as a function of all exogenous explanatory variables and, the instrumental variable (IV), and then residuals are saved. Next, both the saved residuals and the endogenous collection intensity variable are included in the probit for school enrolment equation. If the standard t-statistics for the estimated coefficient of the residual is statistically different from zero, one can conclude that collection intensity is found to be endogenous in the school attendance probit model (Wooldridge 2002).

The structural form equation for the school enrolment model (equation 3) and the reduced form equation for the collection intensity model (equation 4) are estimated, where 'X' stands for the common exogenous covariates in both equations, Z is an instrumental variable in the collection intensity model with δ its coefficient.

$$Y_{3i} = \theta' X_{3i} + \delta Z + \varepsilon_{3i} \qquad (4)$$

While Nankhuni and Findeis (2004) used wood and water scarcity variables and own-piped water access dummy as an IV instrument for resource collection intensity, Ndiritu and Nyangenna (2010) employed the household energy fuel expenditure and the ratio of children who collect resources in a household to family size as justifiable instruments. Unlike them,

the number of donkeys available per household is chosen here as a valid instrument for resource intensity to judge the impact of environmental resource collection work on the likelihood of a child's enrolment. Such an IV is preferred because children living in households where such animals are available are likely to reduce their frequency and intensity of engagement on collection. On the other hand, households having pack animals may seek their children to handle some extra resource related tasks frequently. Moreover, most of the sample households interviewed have acknowledged the importance of such animals on resource fetching. This may, therefore, justify the appropriateness of this instrument for environmental resource collection intensity. Donkeys in the study area are mostly busy with transporting cereals to (from) grinding mills and particularly salt from Arho—a salt rich area in the Afar region. Hence, the number of donkeys does not directly affect child schooling except through its net impact on collection intensity.

4. Results

4.1. Descriptive statistics

As summarized in Table 4.1, a descriptive analysis of the survey data shows that about 79% of the households are headed by males. In 75% of the households, the parents live together. On average, the age of household heads is found to be 48 years and about 33% of them are literate—it implies they obtained at least an informal[2] education and can at least read and write. The mean household size is 7. The composition depicts that each family has an average of 3 individuals within the 7 to 18 years age range. The average number of elderly (above 60 years) is 1 per household. Households have an average monthly per capita income of about 84.7 ETB (Ethiopian Birr) from various sources of income.

Table 4.1. Summary statistics of households' socio-economic characteristics

Household Characteristics	Mean	Standard Deviation	Minimum	Maximum
Male headed households (ratio)	0.792	0.408	0	1
Parents living together (ratio)	0.750	0.435	0	1
Household head's age	48.017	9.706	28	68
Literate household heads (ratio)	0.325	0.470	0	1
Household size	6.458	1.748	3	11
Monthly per capita income (ETB)	84.684	42.781	33	333
Household composition (number)				
Members 1-6 years	1.050	0.897	0	4
Members 7-18 years	2.633	1.053	1	6
Members 19-24 years	0.658	0.783	0	3
Members 25-60 years	1.733	0.590	0	4
Members above 60 years	0.383	0.638	0	2
Dependents (<7 and >60 years)	1.475	0.970	0	4

Source: Computations from the Survey Data, 2011

To better recognize the relationship between resource scarcity and schooling, the study looks into the extent to which rural households spend their time on environmental resource collection. Children on average make one trip per week in each resource collection, spending about 7 hours on firewood, 1.5 hour on water and 2.5 hours on fodder collection per week (see Table 4.2). Most variation is noted in the collection time of firewood, followed by the collection time of fodder and water. Moreover, significant variation in collection intensity is noticed across boys regarding the time spent in each resource collection. On average, during the reference period parents collected firewood 2 times per week, water 3 times per week and fodder once per week, spending about 13 hours/week on firewood, 7 hours on water, and 5 hours on fodder collection.

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[2] It includes religious education and basic education.

Table 4.2. Mean time (minutes) spent on firewood, water, and fodder collection

Group	Mean time for firewood				Mean time for water				Mean time for fodder				Average MPW
	Trip	Coll	Freq	TPW	Trip	Coll	Freq	TPW	Trip	Coll	Freq	TPW	
Children	152.6	78.4	1.2	401.9	11.1	17.5	1.2	86.2	35.3	55.5	0.7	152.5	641.0
Boys	199.6	77.9	1.2	503.4	12.5	19.8	1.0	96.2	56.1	85.0	1.1	240.7	840.0
Girls	94.4	79.1	1.1	276.0	9.3	14.7	1.3	73.8	9.59	18.9	0.2	43.1	393.0
Variance of collection time	*251,793.6*				*25,770.7*				*73,155.7*				*453,835.5*
Boys	*345,926.1*				*31,958.5*				*97,363.5*				*622,402.4*
Girls	*107,726.3*				*17,984.6*				*21,814.2*				*135,877.1*
Parents	343.8	107.0	1.6	768.7	42.6	74.5	3.2	430.8	70.2	107.1	1.3	312.4	1512.0
Father	326.5	94.5	1.2	721.0	4.2	8.8	0.3	28.3	68.8	103.3	1.3	307.1	1056.0
Mother	17.3	12.5	0.4	47.7	38.4	65.8	2.9	402.5	1.4	3.8	0.02	5.3	455.0

Source: Computations from the Survey Data, 2011
Notes: For each resource, Trip refers the double trip travel time per week, Coll to the time spent on resource collection per week, Freq to the resource collection frequency per week and TPW refers to the total time spent on the resource collection. Average MPW is used to represent the average mean time in minutes spent on all the three resources per week. All times are given in minutes.

Because parents, particularly fathers, collect firewood from the forest areas travelling for a long time, children spend less than half of the time that their parents spend on resource collection. Boys and fathers spent about double time in search of the resources as compared to girls and mothers, respectively. It is not astonishing for boys and fathers to spend higher proportion of time on firewood collection since its sources are the lowland areas adjacent to Afar regional state. Boys and girls have spent an almost equivalent time on fetching water. But the amount that mothers spent on this resource is about fourteen times higher than the one spent by fathers, showing that collecting water is mainly the task of women. Fathers spent more than a double time relative to children on gathering fodder resources. In this case, girls and mothers are almost freed, probably because collecting fodder is the task of either fathers or boys, as in other parts of Tigray. Here, the importance of pack animals, particularly of donkeys, is highly accredited in transporting these resources. On average, the respondents have about two donkeys.

A focus group discussion was also conducted with students in selected schools regarding children's participation on resource collection. They revealed that fathers wake up their children in the middle of night for the firewood collection. This is common since they usually purchase their educational equipments by selling firewood resources. This is confirmed by a group of firewood distributors in Mekelle and Quiha who reveal that they receive firewood from farmers mostly delivered by children. The marketing channel of firewood passes through many hands where the lowlanders supply to the highlanders who in turn, deliver it to the main firewood distributors in Quiha and Mekelle.

About 89% of the households have identified forests as an important source of firewood. Households spent more than 9 hours on forest firewood, of which the largest proportion (about 7 hours) is assigned to travelling. Likewise, 91% of the households have recorded village taps as a dominant source of water where queuing takes more than an hour. A useful observation is that almost all of the households fetch water from the village taps except in village Hilishe, 'tabia' Derge-Ajen in Enderta woreda. In this village, households fetch water almost entirely from a river.

The regional government of Tigray has made an utmost effort to foster the expansion of various water sources since 2002/03. As a result, 7,241 different water sources are constructed throughout the region during the last eight years (Tigray Region Water Resources Bureau 2010/11). However, there are 1,009 constructed water sources that are not functioning well. Of these, in the urban areas about 50% and in the rural areas 100% were malfunctions that could have been easily repaired. One possible explanation for the long time spent on queuing water (1 hour and 7 minutes on average) might, therefore, be due to the non-proper functioning of such water sources. Households are observed fetching water in a 3 days round basis and compete for water lining as of 3 am at night, particularly during social occasions (wedding and holidays). Concerning fodder, for 95% of the sample households own-farmland is the most common source of fodder, demanding a total time of 4.3 hours. All results are summarized in the table below.

Table 4.3. Basic sources of firewood, water, and fodder and mean time spent

Indicators	Firewood	Water	Fodder
	Forest	Village taps	Farmland
Travel time (minutes)	390.3	37.0	97.2
Collection time (minutes)	180.3	67.0	159.1
Total time (minutes)	565.3	104.0	256.3
% of households	89.2	90.8	95.0

Source: Computations from the Survey Data, 2011

Parents reported that there exists lack of grazing land in some of the study areas. Therefore, since cattle demand fodder and water, one can argue that this will exacerbate the possibility

of involvement on resource collection. The respondents have an average of 5 cattle and the amount of fodder (straws, stalks, etc) they collect from their cultivated farm was about 17 donkey-loads this year. Households indicated that they expected their total expenditure on fodder resources this year would be about ETB 401. The minimum and maximum expenditures are ETB 0 and 4,000 respectively. Households cultivated an average farm size of about 6 'tsimdi'—indicating one-fourth of a hectare—with a minimum of 2 and a maximum of 10.

Of the total households interviewed, we found 316 children in the 7 to 18 years age range. While 75 children (37 boys and 38 girls) are reported to be out of school, we found 29 children (21 boys and 8 girls) not participating on resource collection during the reference period[3]. Whether children are specializing in schooling, resource collection or a joint combination of the two tasks, or being left idle from such activities is an interesting point in the economics of child labor. The majority of the children (about 69%) are simultaneously undertaking both tasks, followed by involvement on collection only (about 22%), schooling only (about 7%), and neither of the tasks (about 2%). About 9% of the male children participated only in schooling, 18% solely involved on resource collection tasks, 70% combined both activities with the remaining 3% neither attending school nor collecting resources at the time of the data collection. On the other hand, relative to their own sample sizes, 5% of the female children were involved in schooling only, 26% on resource collection only, 68% combining school and collection while 1% were left idle from both tasks. This clearly indicates that high proportion of girls is observed on resource collection while their proportion at school was lower. However, almost equal proportions are noticed on the joint activities among both sexes.

As might be expected, rural children are also involved on other[4] domestic chores. On average, children spent about 25 hours per week on all other domestic activities with the highest portion of time (about 11 hours/week) recorded on herding animals followed by cleaning and cooking (about 10 hours). Female children spent about 29 hours per week on such tasks where cleaning and cooking accounts for 18 hours per week. Boys spent about 22 hours on these other domestic activities where herding takes the largest share—about 17 hours per week. Therefore, while girls are overloaded with cleaning and cooking tasks, boys are mainly occupied with herding issues during the study period (Figure 4.1).

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[3] When a child is involved on fetching a resource(s) for a short period of time, parents report it as if the child did not participate on resource collection tasks at all. A total of one minute per week is given for these children reported not collecting resources at all during the reference time. This is made not to lose observations in transforming the collection intensity variable into its natural logarithm to have a normal distribution.
[4] It includes animal herding, caring children and the elderly, cleaning, and food preparing tasks.

Figure 4.1. Mean time (hours/week) spend on other domestic work by children
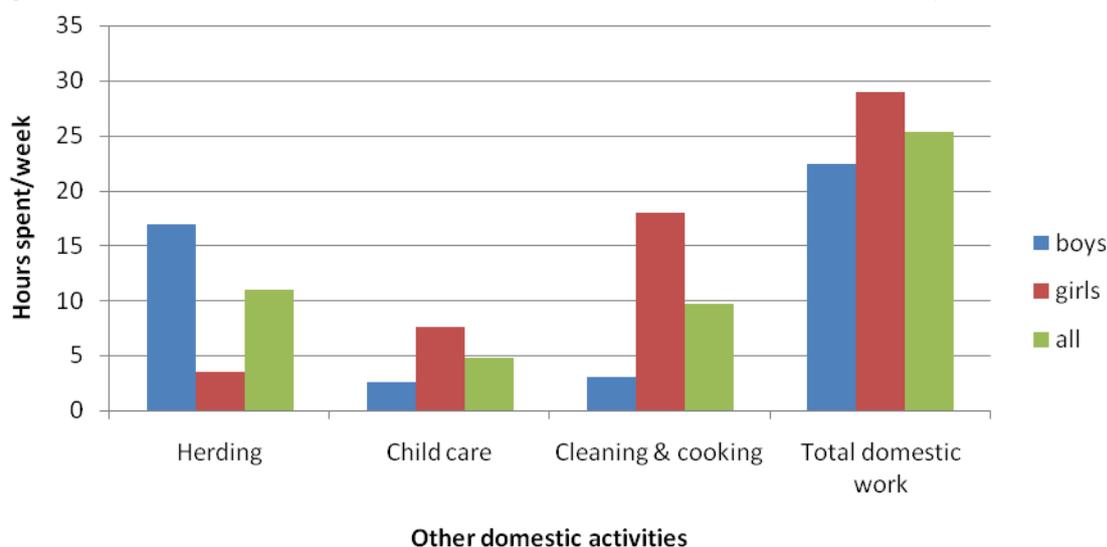
Source: Computations from the Survey Data, 2011

Similarly, men and women jointly spent about 60 hours per week on such activities with the highest amount (38 hours) reported on cleaning and cooking and the lowest (12 hours) amount on animals' herding. The time spent by women on those other domestic works outweighs that of their male counterparts by more than three times. While women are highly involved on cleaning, cooking, and child caring issues (33 hours per week), the time the men spent on these other domestic works is mainly for herding (11 hours per week).

If children not enrolled at school are excluded from the analysis, the mean grade attained is grade 5 for the whole sample and is the same across genders. As shown in Figure 4.2, 47% of the students are enrolled at lower primary school, 44% at upper primary school, 8% at lower secondary school, and the remaining 1% is enrolled at preparatory school level. School enrolment declines rapidly in both sexes as one goes to the higher grade levels. A relatively fast decline is noticed among female children; possible explanations may be found in the customary traditional practices associated with early marriage and the high burden of domestic work. The mean study time per day is about 3 hours which is also equal for both boys and girls.

Figure 4.2. Distribution of students across grades
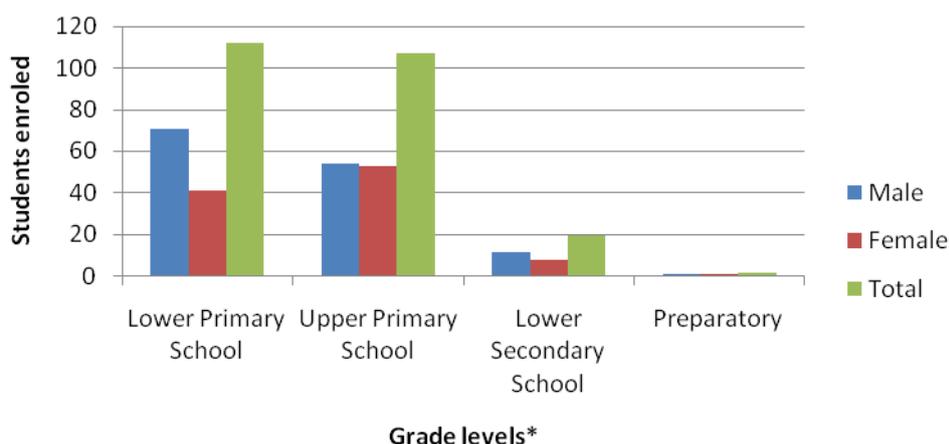
Source: Computations from the Survey Data, 2011
Notes: * Grade levels are defined in the following way: Lower primary runs from grades 1-4, Upper primary from grades 5-8, Lower secondary from grades 9-10 and the preparatory school includes grades 11-12 (Tigray Education Bureau 2009/10)

The surveyed data revealed that 75 children (about 24%) are kept out of school for many reasons. Among the parents who do not send their children to school, 16% of them did not send their children to school due to huge domestic work burden. Furthermore, while 13% of the households revealed that their children are not enrolled at school because of resource collection burden, 9% are due to parental interest in informal education. The relatively lower rates of enrolment at higher grades indicate that there may be significant drop out and repetition. In our sample, we found 17 children with a repetition experience, 16 with a dropout experience for at least a certain time. Repetitions and dropouts are higher for girls than for boys: 14 versus 3 for repetition and 11 versus 5 for dropout cases, respectively. Burden on other domestic work is reported as a major reason behind this. This might have in turn worsened the failure to pass the national primary school leaving certificate examination (Ministry of Education 2009/10) through tight study times. A high repetition rate is observed among girls of grades 4-8 and high dropout experience is perceived for girls' enrolled at grades 5-8 in Tigray during the 2005/06 academic year (Tigray Region Education Bureau 2009/10).

The focus group discussion carried out with selected teachers and students show that resource scarcity has an adverse effect on school enrolment. Even for those who are already involved at school, many students are not doing their home work on time—a reflection of long hours of work on domestic activities including environmental resource collection. This is further complicated when parents discourage their children from doing their academic assignments. This is reflected by the typical phrase "home work is not an academic but domestic work". Households with large farm sizes are also reported to reduce their children's probability of attending school through greater demands for farm work.

4.2. Children's resource collection participation and collection intensity

Since it is not only the likelihood of involvement on resource collection but also the resource work hours that matters for policy purpose, this section tries to see the likelihood of participation on resource collection and that of the collection intensity among children. In the bivariate probit model for schooling and resource collection participation models, the ρ coefficient between the equations' disturbance terms is -0.12. Following this, we performed the likelihood ratio test on the null hypothesis that the correlation coefficient (ρ) is zero against the alternative that rho is statistically different from zero. The results show a chi-squared statistics with one degree of freedom of 0.42 and a P-value of 52%.

For this reason, the null hypothesis cannot be rejected at conventional levels of significance. As a result, the univariate probit models are preferred to bivariate probit model. Subsequently, this section provides an estimated probit model for participation on environmental resource collection, an Ordinary Least Square model for collection intensity and the 2SCML school enrolment probit model.

Table 4.4. Estimated results of resource collection participation, collection intensity and school enrolment

Descriptions	Collection Participation		Collection Intensity		School Enrolment	
Variables	Marginal Effects	P>|Z|	Coefficients	P>|t|	Marginal Effects	P>|Z|
Constant			-4.273	0.15		
Ln(collection time)					-0.239***	0.01
Male headship	-0.022	0.19	-0.464	0.11	-0.046	0.53
Literate head	0.071***	0.00	0.508**	0.02	0.253***	0.00
No. children	-0.008	0.35	-0.122	0.24	-0.068**	0.02
Ln (Income)	-0.039	0.12	-0.285	0.37	0.018	0.81
No. cattle	0.013**	0.02	0.096*	0.09	0.034**	0.03
Farm size	-0.017***	0.00	-0.183***	0.01	-0.058***	0.00
Dependents	0.001	0.92	0.072	0.58	-0.036	0.14
Own child	0.038	0.37	0.315	0.37	0.350***	0.00
Hintalo dummy	0.006	0.75	-0.120	0.64	-0.001	0.98
Child is a girl	0.035**	0.02	-0.528***	0.01	-0.102	0.29
Child age	0.068**	0.05	0.974***	0.00	0.455***	0.00
Age squared	-0.002*	0.08	-0.027**	0.02	-0.016***	0.00
Father hours	0.001	0.17	0.017*	0.06	0.004	0.12
Child is a girl*ln(collection time)					-0.034	0.37
No. donkeys			0.308***	0.01		
Residuals					0.231**	0.02
Summary statistics of the models						
No of observations	316		316		316	
R-Squared			0.279			
Log pseudo likelihood	-67.05				-127.93	
Wald Chi-Squared	43.61				92.04	
Iterations completed	5				4	
Correct predictions	91.77%				81.33%	

Note: * Significant at 10%; ** significant at 5%; *** significant at 1%.

For the probit models, the goodness-of-fit measures are obtained by using the percentage of correctly classified observations. The percent correctly predicted is the number of times the predicted and actual values of the dependent variable match to each other. The overall percent correctly predicted reflects a weighted average of the two (Wooldridge 2002; Verbeek 2004; Cameron and Trivedi 2009).

In each probit model, therefore, the sensitivity and specificity measures give the fraction of observations with y=1 and y=0 that are correctly specified, respectively. The probit model of resource collection participation correctly predicts "the child collects resources" about 98.26 percent of the time and "he/she will not involve on resource collection" about 27.59 percent of the time. All in all, the model correctly classifies 91.77 percent of the observations. The probit model for schooling also correctly predicts "the child attends school" about 92.12 percent of the time and "the child will not involve at school" about 46.67 percent of the time. The schooling model, in general, has correctly classified about 81.33 percent of the observations. Since "it gives the rough gauge of the magnitude of the marginal effect" (Cameron and Trivedi 2009), the interpretations of the results from such models are made using the marginal effect at the mean concept. On the other hand, an Ordinary Least Square regression of the resource intensity model indicates that about 28% of the variation in resource collection intensity is explained by the predictor variables included in the model. Thus, the model fits the data reasonably well.

As shown in Table 4.4, the first stage estimation (the collection intensity model) in the 2SCML procedure shows that the number of donkeys, used as an instrument for the

endogenous 'ln(collection time)' variable, is statistically significant at the 1% level. When the household owns an extra donkey, other things being constant, a 31% increase in collection intensity per week is expected by child. This is not unusual especially in Enderta woreda where firewood is continuously supplied to Mekelle city on a daily basis.

The 'literate head' variable in the resource collection participation model conveys that children living in households with literate household heads are 7 percentage points more likely to be involved in the collection of environmental resource, compared to those whose household heads are illiterate. Furthermore, such children spend an average 51% more time per week on resource collection compared to children living in households with illiterate household heads, holding others constant. This seems contrary to the expectation that educated household heads have a better understanding of the adverse effect of child labor and hence would not involve their own children in such activities. A possible reason is that literate household heads are likely to be occupied by 'tabia'-based government administrative issues in the rural areas. The same holds true for the religious (spiritual) leaders who are always busy with social issues, lacking time to collect resources by themselves and being poor to hire daily laborers on their behalf.

An increase in the number of cattle owned by the household is likely to increase the probability that a child between 7 and 18 years will participate in natural resource collection by 1.3 percentage points. When the number of cattle increases by one, holding other things constant, children will spend 9.6% more time per week on resource collection. In this regard, the results are inconsistent with Heltberg et al.'s (2000) report that livestock ownership had a positive significant effect on alternative private energy consumption like animal dung. Even though large livestock size can protect children from frequently collecting firewood through animal dung, it can result in higher demand for fodder and water resources. Thus, the time spend on fodder and water collection may exceed the time saved by using dung instead of collecting firewood. With the prevailing feed resource scarcity (Berhanu et al. 2002), this finding seems valid particularly in Tigray where farmers have started to keep their cattle at home as grazing land is under pressure.

The statistically significant negative coefficient of the 'Farm size' variable suggests that increasing the sizes of cultivated land by one-fourth of a hectare reduces the likelihood of involvement on collecting natural resource by 1.7 percentage points. Similarly, a one-fourth of a hectare increase in farm size operated by the household reduces children's expected weekly resource hours' burden by about 18.3%, others held fixed. This is as would be expected since greater amounts of fodder and crop-residues can be obtained with larger farm sizes, thus, reducing the likelihood of resource collection and the intensity among rural children. These findings are in line with the results of Heltberg et al. (2000) where larger land holdings reduce resource collection labor time and increase consumption of private fuels generated from own farmland in rural India.

The child labor literature gives considerable attention for the potential gender-based work participation differentials and its consequent implication on work hours. Our results reveal that relative to boys, girls are about 3.5 percentage points more likely to be involved in resource collection. This might result from the periodic engagement of women and girls particularly on water and firewood resources around their residences. Other things held fixed, however, girls spend about 53% less time per week on collection activities. This suggests that while boys are less involved, those that are involved spend more time (hours per week) than girls on environmental resource collection.

As children get older, they are more likely to be engaged in firewood, water, and fodder resource collection until they become about 14 years old, thereafter the probability of collecting resources is likely to fall with age. Furthermore, older children spend more collection hours relative to the younger ones. Previous studies (Psacharopoulos 1997; Okpukpara and Odurukwe 2006; Nkamleu 2009) confirm this finding. On the other hand, the

probability of collecting resources and the collection intensity per week falls non-linearly with a child's age.

When a child's father increases his weekly resource collection time by one hour, the weekly collection time for his (her) child is expected to increase by 1.7%, though this is only weakly significant . While this result contradicts with the findings in Malawi (Nankhuni and Findeis 2004), it resonates with the results from Kenya (Ndiritu and Nyangena 2010). This is likely to happen because while their fathers collect high quality firewood, children may collect the "thick firewood" and keep the donkeys for transporting the resources side by side. Fodder resources are also commonly transported by donkeys and, thus, children actively participate in such tasks helping their fathers.

4.3. Children's resource collection work versus school enrolment

Table 4.4 indicates that the marginal effect of the saved residuals in the school probit model has a positive coefficient and is statistically significant at the 5% level. Hence, there is substantiation to treat resource collection intensity as an endogenous explanatory variable in the schooling model supporting the use of an instrumental variable in our estimation process.

Since children on average spent 11 hours per week on resource collection activities, a 50% increase in collection time would be more than 5 hours. As expected, the weekly time spent on environmental resource collection significantly reduces the school enrolment likelihood. The implication is that a 50% increase in resource collection time is associated with a decrease of approximately 12% in the probability of attending school by the child. When environmental resource degradation causes scarcity of natural resources, the likelihood of not attending school will be aggravated through the opportunity cost of time spent on resource collection. The escalating demand for firewood, land expansion for cultivation, and overgrazed range lands in Tigray region (Edwards et al. 2010) are worsening the problem. The negative effect of collection intensity on schooling is documented from previous research findings as well (Nankhuni and Findeis 2004; Ndiritu and Nyangena 2010).

To see whether the impact of resource collection intensity on schooling likelihood differs by child gender, we include an interaction term between child sex and collection intensity in our school enrolment model. The results reveal that the time spent on environmental resource collection does not significantly reduce girls' likelihood of enrolment at school as compared to that of boys. Even though girls are frequently involved in resource collection, the average weekly collection time is lower for girls (7 hours) as compared to boys (14 hours). Therefore, girls' discrimination in schooling due to environmental resource collection intensity is not evidenced by this study. Perhaps, this discrimination emanates from girls' higher engagement on other domestic work (29 hours) relative to boys (22 hours) per week. The rest of the results are interpreted as follows.

Household heads who can at least read and write are by 25 percentage points more likely to send their children to school, as compared to their illiterate counter parts. This connection has been widely acknowledged in the literature (Nielsen and Dubey 2002; Assefa 2002; Gage 2005; Sackey 2007). On the other hand, an increase by one in the number of children between 7 and 18 years per family is likely to adversely affect the household's probability of sending that child to school by about 7 percentage points. This gives a signal for the quantity (number of children) and quality (investment on child education) trade-off as poor households may be constrained to cover the school expenses of their children.

An increase by one head in the number of cattle improves the probability of attending school for a child by 3 percentage points. This is, perhaps, an indication that, given an informal contract (Nielsen and Dubey 2002) between children and the head of the household at large,

rural parents may still prefer to currently invest their assets on human than physical capital. With strong social interactions, parents may think that educated children will support them during old age and, hence, committed to their current enrolment. Thus, they may send their children to school and employ a shepherd for their animals. This is against the findings by Assefa (2002) and Tassew et al. (2008) in Ethiopia who established a negative relationship between ownership of livestock and child schooling. On the contrary, a one-fourth of a hectare increase in the size of cultivated land reduces the child's likelihood of attending school by about 6 percentage points. Similar evidence is reported from India (Nielsen and Dubey 2002), revealing that large farm size reduces the likelihood of school enrolment through increased work demand on the farm.

Relative to the non-own children, an own child of the household head is about 35 percentage points more likely to attend school. This reflects that household heads favor their own children in deciding who should attend school and who should carry out other household tasks. These results resonate with the previous findings by Jensen and Nielsen (1997) and Assefa (2002).

The coefficient of the 'Child age' variable in the probit model for schooling shows that the probability of school enrolment increases with age until 14 years after which it starts to decrease with age. This relationship is confirmed by other studies in Ethiopia (Assefa 2002; Weir 2010).

5. Conclusions and implications

Access to and distribution of environmental resources including firewood, water, and fodder have a substantial implication on producing tomorrow's intellectual human resources through the time spent on resource collection. This study examined the relationship between resource scarcity (measured by the weekly hours spent on collection) and the likelihood of schooling for children between 7 and 18 years old. It also addressed whether collection intensity leads to any gender bias in schooling. Using a multi-stage random sampling technique, 120 rural households having a total of 316 children from Enderta and Hintalo Wajerat woredas of the south eastern part of Tigray are incorporated in the analysis.

On average, children spent about 7 hours on firewood, 1 hour on water, and 3 hours on fodder collection per week. The findings revealed that a 50% increase in hours per week spent on collection activities is likely to reduce children's enrolment at school by 12%. This reflects that environmental resource collection intensity adversely affects the process of human capital formation. Girls are more frequently involved on resource collection. However, they spent shorter resources collection time as compared to boys, opening a room for engagement on other domestic tasks. The results showed no evidence about the lower probability of girls' schooling due to resource collection intensity. Moreover, children living in households with literate household heads have a higher probability of schooling but also a higher probability of involvement in resource collection, and these children are burdened with higher resource collection time. The number of cattle owned by the household increases the likelihood of resource collection as well as the likelihood of schooling. Large size of land significantly reduces the collection intensity perhaps due to access to crop-residues and fodder resources, however, large sizes of farm lowers the schooling likelihood through high labor demand for farming, sowing, weeding, and harvesting activities.

Therefore, since educated households promote child schooling, the provision of functional adult literacy programs is important. The proper collection of farm-based fodder resources, including straw and stalks, can relieve children from frequent collection of fodder resources and from longer hours involved in collection activities. The negative impact of large farm sizes on school enrolment can at least be minimized through labor sharing arrangements among farmers.

That resources collection time has adversely affected the likelihood of enrolment at school indicates the importance of reducing the resource collection intensity by children. In this regard, repairing the already constructed but currently non-functioning or mal-functioning water sources is a key policy instrument since it minimizes at least the waiting time at water sources. Moreover, timely collection of fodder resources from cultivated land—soon enough so amount and quality will not deteriorate, planting fodder-rich tree species, and promoting labor sharing arrangements can reduce the time spent on environmental resource collection and improve the likelihood of schooling. Examination of the link between the intensity of environmental resource collection work and the extent of class absence and presence among students plus their academic achievements is left for future research agenda.

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Annex

Annex A.1. List, definition, and observation levels of variables used in the econometric analysis

Variables	Definition of the Variables	Observation Level
Dependent Variables		
Model-1. Collection	Child collected at least one environmental resource over the reference period: 1 if yes, 0 otherwise	Child
Model-2. ln(collection time)	Weekly hours of resource collection by a child in natural logarithm	Child
Model-3. Schooling	Child currently attends school: 1 if yes, 0 otherwise	Child
Independent Variables		
Child Attributes		
Child is a girl	Sex of the child: 1 if female, 0 otherwise	Child
Child age	Age of the child in years	Child
Age squared	Square of the child's age in years	Child
No. children	Number of children per household in the 7-18 years	Child
Own child	Child is own child of the household head: 1 if yes, 0 otherwise	Child
Parental Characteristics		
Male headship	Household is headed by male: 1 if yes, 0 otherwise	Household
Literate head	Household head can at least read and write: 1 if yes, 0 otherwise	Household
Household Characteristics		
ln(Income)	Exogenous monthly income (excluding income from sale of environmental resource) of the household in natural logarithm	Household
No. cattle	Number of cattle owned by the household	Household
Farm size	Total area of land cultivated by the household in 'tsmdi'	Household
Dependents	Number of persons less than 7 years and above 60 years in the household	Household
Father hours	Weekly hours of resource collection by a father	Household
Child is a girl *ln(collection time)	An interaction term between child sex and resource collection intensity	Child
Woreda (Child location) dummy		
Hintalo dummy	Child lives in Hintalo Wajerat woreda: 1 if yes, 0 otherwise	Child

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