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Abstract

In developing countries such as Ethiopia, rural households spend a considerable part of their time in agriculture as well as resource collection. However, rigorous empirical studies on the impacts of scarcity of environmental resources on productive activities such as agriculture are very limited—in developing countries in general and Africa in particular. Using a panel data set collected from Ethiopia, this paper examines the effect of scarcity of fuelwood and water on time spent in agriculture. The results of the empirical analysis show that fuelwood scarcity, as reflected by the shadow price of fuelwood, has a negative and significant impact on time spent on agriculture. This suggests that addressing fuelwood scarcity has the potential to improve agricultural production, as well as other benefits. The results also indicate that scarcity of water has no effect on time spent on agriculture, suggesting that any lost time due to water scarcity probably comes out of other activities. The role of other conditioning variables on labor input to agriculture was also examined.

Key Words: agriculture, resource scarcity, shadow prices, labor allocation, rural Ethiopia

JL Codes: Q12, Q15

Contents

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1. Introduction

Agriculture is an important sector in developing countries in general and Africa in particular. People in these countries are also heavily dependent on natural resources such as fuelwood and water for their livelihood. When natural resources are degraded, rural households respond in different ways to cope with the scarcity of the resources. Among several options,[1] these households use their labor to cope with the increasing scarcity of natural resources. Rural households allocate their labor to various activities such as agriculture, off-farm work, environmental resource collection, and activities at home. In order to meet the increases in demand for labor, households must sacrifice or reduce time spent for other activities. Because labor is an important input in the production of various crops in rural Ethiopia, a reallocation of labor away from agriculture to other activities may have a negative impact on agricultural production and productivity. Whether this is the case in rural Ethiopia is something that needs to be examined empirically. For example, though there are differences in using indicators of fuelwood scarcity,[2] empirical results from Nepal and India indicate that households tend to spend more time collecting fuelwood when it is scarce (Cooke et al., 2008). However, empirical studies on the link between scarcity of natural resources and productive activities are almost non-existent in Africa in general and Ethiopia in particular. Therefore, this study will contribute to the limited empirical evidence on the interaction between environmental degradation and agriculture through labor allocation.

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[1] In the case of fuelwood shortages, for example, coping mechanisms include switching to lower-quality energy sources, changing cooking habits, etc.

[2] Different indicators are used by different authors, including market price, shadow price, physical measurement such as forest stock and collection time.

The research question that we want to answer is whether households reduce labor input in agriculture as a result of increases in scarcity of these natural resources. We also examine other variables affecting farm labor allocation. This study aims to examine these issues in rural Ethiopia based on a panel data set collected over four rounds during an eight-year period. Finally, the study suggests some policy recommendations.

We believe this paper will add to the existing literature in three ways. First, it considers two important environmental goods: forest and water. The only studies that consider the effects of multiple environmental goods on agricultural activity are Cooke (1998) and Kumar and Hotchkiss (1988). Both of them used data from Nepal collected some 30 years ago. Cooke (1998) considered the effect of time spent on collection of fuelwood, leaf fodder and cut grass on agriculture. Because water is an important natural resource, its inclusion in our analysis is an important contribution, as its scarcity is likely to affect rural households, particularly women and children. For example, Hossain and Shimelles (2009) note that water scarcity severely affects the lives of women in particular, as female family members are traditionally responsible for water collection. Hence, our work will try to examine the effect of scarcity of these two types of natural resources on agricultural activities. Second, our empirical analysis is based on a panel data set collected in four rounds covering a period of about eight years (2000-2007). This allows us to control for unobserved household heterogeneity. To the best of our knowledge, there have been no such studies on related topics using a relatively long panel data set. Unlike the data used for this paper, Cooke (1998) considered seasonal variation in a small number of observations over a single year. Third, due to the limited empirical studies, we have little understanding of the nexus between resource collection and various other activities undertaken by rural households. Hence, the study adds to the limited literature on the nexus between natural resources and agriculture in developing countries in general and sub-Saharan Africa (Ethiopia) in particular.

The results of this study will help policy makers understand the link between natural resources and agriculture. More specifically, it will help inform policy makers and other stakeholders about the nature and extent of the effect of fuelwood and water scarcity on labor allocated to farm work. In the case of Ethiopia, in light of the significant attention given to agriculture, the study may influence the thinking of policy makers by showing the importance of resource scarcity for agriculture.

The rest of the paper is organized as follows. Section 2 presents a brief review of the literature. The conceptual framework used in this study is briefly presented in Section 3. Section 4 presents data and methodology. Results and discussion are presented in Section 5. Finally, Section 6 presents conclusions and policy implications

2. Brief Literature Review

There are a number of empirical studies on the poverty-environment nexus in developing countries. These studies mainly focus on the relationship between natural resource use and people's livelihood. A number of these focus on the impact of forest scarcity on the use of other alternative sources of energy or labor supply, including production and consumption of biomass energy sources. Examples include Mekonnen (1999) in Ethiopia; Cooke (1998) in Nepal; Heltberg et al. (2000) and Vant'Veld et al. (2006) in India; and Palmer and MacGregor (2009) in Namibia.

When natural resources are scarce, the lives of most rural households in developing countries will be severely affected. Cooke et al. (2008), in their review, explain the effect of natural resource scarcity (forest scarcity) on the livelihood of rural people. Some of these effects are increase in labor burden on women and children; negative effects on health, particularly of women and children; reduced ability of women and children to participate in other important tasks such as agriculture, food preparation, and child care; and the need to use alternative sources of energy such as dung and crop residues[3], which reduces the amount of dung and residues available for use as fertilizer. Dewees (1989), Arnold et al. (2003), and Brouwer et al. (1997) have also indicated the effect of fuelwood scarcity on people's livelihood and the means by which rural households cope with shortages of these resources. However, their argument is based on a qualitative analysis and rigorous empirical analysis was not applied to support their arguments. Bandyopadhyay et al. (2011) examined the extent of the effect of fuelwood scarcity on poor Malawian households. Their findings show that, although rural women spend more time on fuelwood collection where biomass is scarce, the effect on their overall welfare is small. This suggests that rural households cope with biomass scarcity in a variety of ways. Using survey data from randomly selected rural households in Ethiopia, Abebe et al. (2012) found that rural households in forest-degraded areas respond to fuelwood shortages by increasing their labor input for fuelwood collection. However, they have not investigated whether the increase in labor comes from agriculture or other activities.

We found two studies more directly related to the issues addressed in this paper. Kumar and Hotchkiss (1988) studied the link between women's time allocation behavior and deforestation in Nepal. They found that women's time spent in farming declines with a higher

[3] See a good review by Cooke et al. (2008).

degree of deforestation. They considered the time per trip for fuel collection as a measure for degree of deforestation. A decade after the work of Kumar and Hotchkiss (1988), Cooke (1998), in the same country, Nepal, found that scarcity of fuelwood does not cause a shift of labor away from agriculture. Instead, Cooke (1998) concluded that it must come from other, non-productive activities. Cooke (1998), however, found a surprising result in that increasing scarcity of water has a positive and significant effect on time spent on agriculture. The author also suggested that use of time per trip as an indicator of the shadow price of water might be misleading.

Besides the effect of environmental good scarcity on own farm labor allocation, household socioeconomic characteristics may also affect the decision of rural households to allocate labor to agriculture. For example, Cooke (1998) found that the amount of land a household owns significantly increases the time men and women spend in agriculture. In the analysis, Cooke (1998) also included the number of young children and male and female adults in a household. An additional child in the household reduces the total time spent by both women and men in agricultural activities (Cooke, 1998).

There are also some related studies on the agriculture-environment relationship. Bluffstone (1995) and Shively and Monica (2004) have both examined the interaction between labor markets and deforestation in rural Nepal and the Philippines, respectively. Bluffstone (1995) examined the effect of labor market performance on the deforestation behavior of smallholder agriculture in Nepal. Based on results from simulation exercises, he argued that the presence of off-farm labor opportunities is crucial for reducing deforestation rates among Nepalese farmers. Shively and Monica (2004) also examined the links between labor market opportunities and deforestation by jointly estimating a system of labor share equations for forest clearing, on-farm production, and off-farm employment. Similar to Bluffstone's findings, forest clearing can be reduced by increasing the returns to off-farm employment. They also found that tenure security and credit are negatively correlated with forest clearing. While both studies focus on the deforesting aspects of household labor allocation, our study focuses on the link between natural resource scarcity and agricultural labor.

We note from the above brief review of related works that the available studies on the effect of natural resource scarcity on productive activities in general and agriculture in particular are very limited. Existing studies also focus on Asian countries; evidence from Africa is even more limited. Thus, our study will contribute to the limited empirical evidence from a different geographical area, namely sub-Saharan Africa in general and Ethiopia in particular.

In addition to fuelwood scarcity, water scarcity severely affects the lives of rural households, especially women, as female family members are traditionally responsible for water collection (Hossain and Shimelles, 2009). Most women in rural Ethiopia spend a significant amount of their time on fetching water. Therefore, given the importance of these resources in the day to day activities of rural households in Ethiopia, it is essential to analyze the nature of their interaction with other activities of the household. Finally, our analysis is based on four rounds of survey data collected between 2000 and 2007, which allows us to use panel data techniques that control for unobserved heterogeneity.

3. Conceptual Framework

As in most other developing countries in general and sub-Saharan Africa in particular, rural households in Ethiopia are highly dependent on natural resources. Households depend on forests as a source of fuelwood for satisfying their energy demand; a source of food, medicines, etc.; and as grazing lands for livestock. They also rely on water for domestic use as well as agriculture. In countries like Ethiopia, these resources are mostly collected and consumed by households, involving limited financial transactions. Hence, it is difficult to get the market value of collected resources. In such cases, where there is no market for resources, we need to have an implicit price that can be used to evaluate the value of the resources. When there is a missing market for products, an option is to calculate the shadow price or implicit price of the resource, which is assumed to reflect the scarcity of the resource.

In a situation where households consume what they produce, the farm household model is an appropriate framework to understand households' behavior regarding resource collection.[4] The theoretical model is, therefore, based on a farm household model of labor allocation.[5] The main question that interests us is whether scarcity of natural resources affects time allocated for productive activities, agriculture in particular.

Households maximize utility by allocating optimal amounts of labor to different home production tasks and by purchasing market inputs subject to a full income constraint (Cooke 1998). At the margin, households equate the marginal value product of leisure to the net returns

[4] A detailed discussion on farm household models can be found in Singh et al. (1986).

[5] Farm households in developing countries mostly operate under imperfect factor and/or product markets resulting from high transaction costs, shallow or thin markets for factors and/or products or less accessibility to market information (Sadoulet and de Janvry, 1995).

to labor in different tasks. Therefore, the optimization problem yields a set of labor supply equations that can be empirically estimated. Labor supply is a function of prices, wages, and household and community characteristics that may affect productivity.

4. Data and Methodology

4.1 The Nature and Source of Data

The data for the empirical analysis is obtained from panel data based on a household survey conducted in 2000, 2002, 2005 and 2007. The survey covers two zones of the Amhara region of the country i.e., South Wollo and East Gojjam and includes 14 *kebeles*.[6] The 14 sites (kebeles) were selected purposefully to ensure variation across sites with respect to agro-ecology, forest cover and management, population and other aspects. Households from each site were, however, selected at random. The survey has also community level data.

For our empirical analysis, we need information on both household and community level variables, such as individual and household characteristics and labor allocation patterns in agricultural work and collection of water and fuelwood. Labor allocation data is needed to estimate the time spent at the household level for activities such as agriculture as well as fuelwood and water collection.

As noted, the focus of this study is to investigate the effect of scarcity of fuelwood and water on time spent in agriculture. We use shadow prices of fuelwood and water as indicators of the scarcity of these resources. Following Cooke (1998), the shadow price of a resource is calculated by multiplying the time spent for collection of a unit of a resource by the off-farm wage rate. This is calculated for each of the two resources considered. In particular,

Shadow price of resource *i*= (Total time spent for collection/ amount of resource collected) X (off-farm wage rate)[7]

where *i* is fuelwood or water.

As Cooke (1998) noted, the economic cost to a household of collecting a unit of fire wood or water is determined both by factors that influence collection productivity and by the

[6] A kebele is the lowest administrative unit in rural Ethiopia.

[7] In order to adjust for price changes, the wage rate is adjusted using a general price index.

opportunity cost of the time spent collecting. In our case, we consider the wage rate at the community level and hence there is no variation in wages for households living within the same village. Households with a high opportunity cost of labor (i.e., those living in areas with better off-farm opportunities and hence better wage rates) or households in degraded areas face higher shadow prices, everything else held constant. One of the main environmental conditions that affects the shadow price of fuelwood is the distance of the household to the forest. Other important factors might be size and quality of forest, topography, type of forest management, etc. Similarly, the shadow price of water is also affected by environmental factors such as whether or not the area is drought affected, distance of water source from the household, and other factors, such as availability of piped water, availability of institutions for water management, etc.

When working on survey data sets such as the one used in this study, a researcher might have to deal with a number of issues to clean the data. Possible problems encountered in such studies include missing values, collinearity and outliers. Outliers are identified using the box plot diagram and are replaced by median values. We prefer the median to the mean as the latter is sensitive to outliers. Some of the variables are also transformed to logarithmic form to reduce the impact of outliers in the estimation. The number of hours spent for agricultural activities is calculated by taking the time allocated for all types of agricultural work by all members of the farm household using adult equivalents. The reported number of days worked is multiplied by the average number of hours in a day. The average working hours in a day is different from site to site and household to household; we used hours reported for each household.

4.2 Descriptive Statistics

A summary of the variables used in the empirical analysis is presented in Table 1. On average, sample households own 1.28 ha of land, which may not be sufficient to accommodate and fully engage members of an average household in rural Ethiopia. As an indicator of household wealth, number of livestock in tropical livestock units (TLU) is also included. The average TLU for sample households is 3.7, with little variation across the two zones. More than 85% of the households are male-headed and about 46.5% of the household heads are literate. The average age of the household head is 48 years. The average number of adult male and female members in a household is 1.6 and 1.5, respectively. The average wage rate is about 8 Birr.[8]

[8] The exchange rate (Birr per 1USD) at the time of the survey periods in 2000, 2002, 2005 and 2007 were approximately 8.22, 8.57, 8.66, and 9.03, respectively (National Bank of Ethiopia, Annual Report 2013-2014).

Table 1: Descriptive Statistics of Explanatory Variables (N=5395)

Variable	Mean	Std. Dev.
Real wage rate per day in Birr	7.95	4.14
Adult male household size	1.67	1.03
Adult female household size	1.59	0.88
Number of children	0.58	0.74
Farm land size in hectares	1.28	1.17
Livestock in TLU	3.70	3.00
Distance to the nearest town in walking hours	1.14	0.74
Gender of households head (=1 if male, 0 otherwise)	0.85	0.36
Age of household head in years	48.3	15.84
Head's education (head is literate=1, 0 otherwise)	0.45	0.5
Shadow price of fuelwood	0.17	0.34
Shadow price of water	0.08	0.16

Note: Descriptive statistics for *woreda* (district) dummies are not reported for the sake of economizing space.

Table 2 depicts time spent by household members in resource collection work and agricultural activities. The different agricultural activities include land preparation and sowing, weeding, fertilizer application, harvesting, etc. The average total time spent by a household for different agricultural activities is 941 hours per annum. On average, adult males spent around 646 hours per year in various agricultural activities. This is much greater than the time spent by adult female members, which is 259 hours per year. This is not surprising, as women are usually engaged in domestic activities and collection of environmental products such as firewood, dung and water. The data also show that children younger than15 are also involved in agricultural work in our sample sites. On average, the time taken to collect fuelwood and water by the household is 15 and 12 hours per week, respectively. Further description of the data shows that adult females spent more than 8 hours per week in a household to fetch fuelwood. Men also spent a significant part of their time collecting firewood (more than 5 hours per week).

Table 2: Total Time Spent (in Hours) by Household Members for Agricultural and Resource Collection Work (Averages for the years 2000, 2002, 2005, 2007)

	Mean	Std. Dev
Time taken for water collection per week in hrs	12.32	31.15
Time taken for fuelwood collection per week in hrs	15.07	70.07
Total time spent for agricultural activities in a year	941.13	825.99

Figure 1(a) shows the trend in the average time spent for agricultural activities over the four survey years. Though one can see some changes, the changes do not appear to be substantial and they do not appear to follow a trend over time.

Figure1(a) : Trends in the Mean Time Spent in Agricultural Activities (in Hours Per Year)

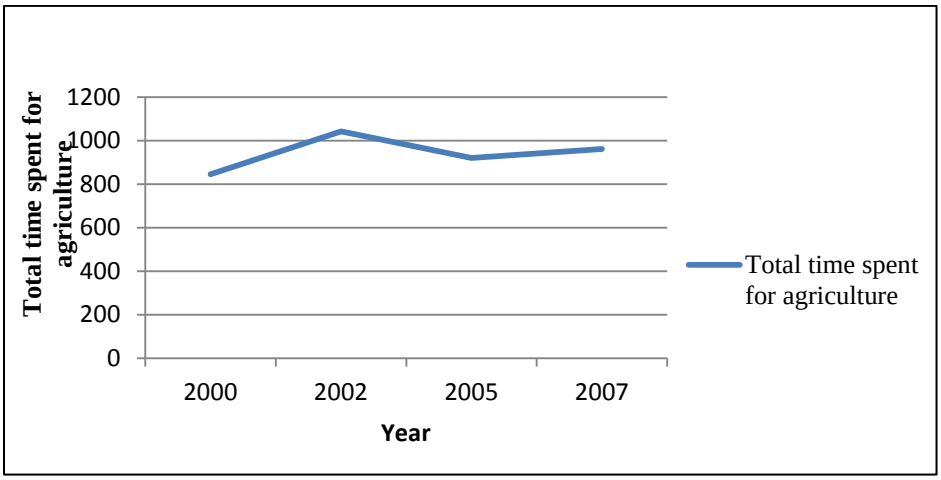
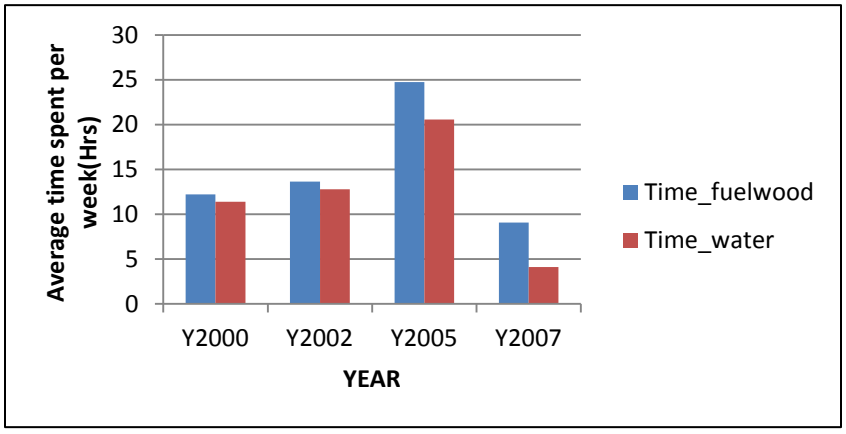


Figure1(b) : Trends in Average Weekly Time Spent for Resource Collection



The trend in both fuelwood and water collection follows the same pattern (Figure 1b). Comparing the four years covered in the data (2000, 2002, 2005 and 2007), on average the weekly time spent for resource collection was the highest in 2005 and the smallest in 2007.

The main sources of water in the study areas are rivers, streams, community water supply, hand powered wells, improved wells and lakes. A significant amount of time was spent by households to fetch water. For example, women spent 1¼ hours per day fetching water from those sources. Other, more comprehensive data sets in Ethiopia also show the importance of access to water. For example, CSA (2006) shows that about 52% of Ethiopians travel 30 minutes or more per trip to collect water and that the burden on females is higher compared to males. Similarly, findings by Gomes (2006) and Padmanabhan (2008) show that women are primarily responsible for collecting water for household consumption in their studies of Eastern Africa and Afar-Ethiopia, respectively.

4.3 Empirical Strategies

The variables to be included in the empirical analysis are based on the reduced form equations derived from household models following the literature as discussed above. In our econometric strategy, we model labor allocation to agricultural work as a function of shadow price of fuelwood, shadow price of water, household characteristics such as age, gender and education of household head, number of male and female adult members, indicators of household's economic status such as number of livestock owned, and land size and dummy for districts.

$$t = f(SP_i,\ W,\ Z,\ C,\ \varepsilon)$$

where *t* is the total time allocated to agricultural activities by a household, SP_i is the shadow price of resource *i* for a household, W is the real wage rate, Z is household characteristics, C represents community level characteristics, and ε is the disturbance term.

In the estimation, an attempt has been made to address econometric issues by conducting tests for multicollinearity, heteroskedasticity and choice between models. Using a correlation matrix and variance inflation factor (VIF), we did not find a serious problem of multicollinearity. We tested for homoskedasticity using a modified Wald statistic for group-wise heteroskedasticity in a fixed effects model. The test rejects the null hypothesis of homoskedasticity, with chi2 (1771) = 2.2e+34; Prob>chi2 = 0.0000. In Table 3, the results with robust standard errors are

reported. However, this might not be efficient if there is cross-sectional and temporal dependence. Complex patterns of mutual dependence between the cross-sectional units may arise in microeconometric panel datasets (Hoechle, 2007). Therefore, following Hoechle (2007), we also use the xtscc program, which produces Driscoll and Kraay (1998) standard errors for linear panel models. Besides being heteroskedasticity consistent, these standard error estimates are robust to general forms of cross-sectional and temporal dependence (Hoechle, 2007). Except for the variables that represent education level of the household head and distance to town, all other explanatory variables do have the same sign and level of significance as the fixed-effects estimates presented in Table 3. The results are presented in the Appendix. A joint test of whether the time dummies for all years are equal to 0 suggests that we include them (F(3, 3477) = 22.72; Prob > F = 0.0000).

By using panel data estimation techniques, it is possible to control for omitted variable bias due to the exclusion of unobserved household level factors. This can be modeled using a fixed or random effects model specification (Hsiao, 1986). For this study, both fixed-effects and random-effects models are estimated and a Hausman specification test is used to determine the correct specification. The test supports the use of fixed effects (chi2 (19) = 149.22; Prob>chi2= 0.0000) and our interpretation focuses on results from the fixed effects estimates. However, we also present the results from the random effects for comparison.

5. Results and Discussion

The estimates of the effect of resource scarcity on time spent in agriculture are presented in Table 3. As noted above, the focus of this study is to understand the impact of scarcity of fuelwood and water on labor allocated to agriculture. The effect of shadow prices of both water and fuelwood, household characteristics and district dummies are estimated and presented in Table 3. We find that fuelwood scarcity reduces household labor allocation to agriculture (the variable is significant at 5%). In particular, the results suggest that a 10% increase in the shadow price of fuelwood results in a 1.3% decrease in time spent on agriculture. Thus, as the shadow price of fuelwood increases, which is reflected by increased distance travelled to fuel collection sources and more time consumed due to degradation of forests, households reduce their labor input in agriculture to cope with fuelwood scarcity.

Table 3: Determinants of Household Agricultural Labor

	Fixed effects	**Random effects**
Real wage	0.002	-0.028
	(0.035)	(0.032)
Shadow price of fuelwood	-0.133**	-0.132**
	(0.074)	(0.065)
Shadow price of water	-0.063	-0.048
	(0.111)	(0.112)
Number of male adults	0.006	0.094***
	(0.022)	(0.013)
Number of female adults	0.040*	0.057***
	(0.024)	(0.014)
Number of children under 5	0.044**	0.053***
	(0.019)	(0.015)
Distance to town	0.033	0.055***
	(0.022)	(0.015)
Land size	0.592***	0.762***
	(0.051)	(0.043)
Number of livestock	0.311***	0.414***
	(0.032)	(0.022)
Sex of head	0.221***	0.387***
	(0.07)	(0.042)
Age of head	0.003*	-0.003***
	(0.002)	(0.001)
Head is literate	-0.040	0.012
	(0.038)	(0.025)
year_2002	0.240***	0.255***
	(0.029)	(0.028)
year_2005	0.071**	0.045
	(0.039)	(0.033)
year_2007	0.087**	0.065**
	(0.04)	(0.03)
Constant	4.98***	4.49***
	(0.172)	(0.133)
chi2	2679.458	2679.458
N	5267	5267

Notes: Robust standard errors in parentheses,*** Significant at 0.01, ** Significant at 0.05, * Significant at 0.1. Real wage, shadow prices, livestock, land and distance to town are all in log form. District dummies are also included; they are not reported for the sake of economizing space.

The results also suggest that scarcity of water has no significant effect on the time allocated to agriculture. A possible explanation of this result is that rural households might respond to shortage of water by increasing their labor supply but might reallocate time from other activities such as leisure. Another possible explanation is that, given that female members are traditionally responsible for fetching water in rural Ethiopia, household members (especially females) could reduce their time from other activities such as domestic work to spend more time in water collection. A similar explanation is given by Ilahi and Grimard (2001), who noted that, in rural Pakistan, poor infrastructure – as indicated by the state of water supply available to the household – induces women to reduce their market-oriented work and thus affects their household income.

The role of other conditioning variables was also examined. The number of both adult male and female members in the household is positively and significantly correlated with the time spent in agricultural activities, though the former is not significant. This is not surprising as more adult members in the family means more labor available. We have also included the off-farm wage rate[9] reported at the kebele level. This may reflect the opportunity cost of time spent working on one's own farm. Distance to the nearest town has a positive impact on time spent for agricultural activities, perhaps due to more limited work opportunities in places where the household resides far from towns.

The positive and significant effect of land size on the time spent on agricultural activities is because households with larger farms require more labor for agricultural work. Number of livestock owned is significantly and positively correlated with time spent in different agricultural activities, reflecting the common mixed crop-livestock practice in rural Ethiopia. As expected, we also found that male-headed households spend more time on agricultural activities than do female-headed households. The results also suggest that labor supply to agriculture increases as the age of the head increases. Education level of the household head has no significant effect on the head's labor input to agriculture. The current nature of traditional agricultural activities in rural Ethiopia may not demand educated labor, though studies have found that education is an important factor in modern agriculture. The district dummies (not reported) show that there are differences in labor supply to agriculture among the sample districts. Our results also show

[9] The off-farm wage rate is adjusted for inflation and hence it is the real wage rate.

variation in labor input to agriculture over time, which may be explained by factors such as changes in weather conditions over time.

6. Conclusions and Policy Implications

Agriculture and natural resources such as fuelwood and water are important for developing countries in general and Africa in particular. However, empirical evidence based on rigorous studies on the role of scarcity of natural resources in productive activities such as agriculture is very limited, especially in Africa.

Using a unique panel data set collected in four rounds in 2000, 2002, 2005 and 2007 from Ethiopia, this paper examines the effect of scarcity of two types of natural resources (fuelwood and water) on the time spent in agriculture. The results of the empirical analysis show that scarcity of fuelwood, as measured by shadow prices, has a negative impact on the time spent for agriculture. This suggests the importance of addressing fuelwood scarcity in helping agricultural production, in addition to other benefits of such measures. Work on increasing the supply of fuelwood and its substitutes, as well as addressing demand side issues (such as dissemination of fuel-saving technologies), could contribute toward addressing the negative effect of fuelwood scarcity on agriculture. Our results also suggest that water scarcity does not affect labor allocation to agriculture. This suggests that additional labor needed for water collection due to water scarcity may come from leisure or from household activities other than agriculture.

In this study, we used household level measures of scarcity of fuelwood and water. A detailed survey on the physical characteristics of these resources, which includes other natural resources such as grazing land, will enable policy makers to have a comprehensive understanding of the impact of environmental degradation on different activities of households.

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Appendix

Determinants of Household Agricultural Labor using Driscoll-Kraay Standard Errors

Variables	Coef.	Drisc/Kraay Std. Err.	P>t
Real wage	0.002	0.04	0.969
Shadow price of fuelwood	-0.133	0.03	0.000
Shadow price of water	-0.063	0.06	0.321
Number of male adults	0.006	0.01	0.625
Number of female adults	0.040	0.01	0.007
Number of children under 5	0.044	0.01	0.000
Distance to town	0.033	0.01	0.000
Land size	0.592	0.06	0.000
Number of livestock	0.311	0.03	0.000
Sex of head	0.221	0.03	0.000
Age of head	0.003	0.00	0.000
Head is literate	-0.040	0.01	0.000
year_2002	0.240	0.02	0.000
year_2005	0.071	0.02	0.000
year_2007	0.087	0.03	0.002
_cons	4.979	0.13	0.000