Preliminary Study of the Impact of Land Use Change and Incidence of Malaria and Schistosomiasis on Household Productivity in Tigray, Ethiopia

by
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Abstract

Several non-government organizations (NGOs) have introduced a major rural development program to increase agricultural productivity in Tigray, Ethiopia, by implementing water resource projects such as microdams and afforestation of surrounding watersheds. A potential negative impact from these projects is the spreading of diseases such as malaria and schistosomiasis from seasonal events to a year round phenomenon. This study analyzes the health effects of microdams and afforested watersheds on household production and consumption relationships. Preliminary results suggest that work time lost to illnesses have a significant impact on labor productivity and household consumption schedules. In addition, household location in relation to microdams and afforested lands may be an important factor in assessing future losses in labor productivity.

INTRODUCTION

Tigray is an arid to semi-arid region in northern Ethiopia characterized by subsistence farm households raising predominantly cereal crops for local consumption. Crop production has declined because of recurrent draughts and serious soil erosion. In addition, the region has experienced an influx of new immigrants from the aftermath of the Ethiopian/Eritrean war.

Several non-government organizations (NGOs) worldwide have introduced a major rural development program to improve agricultural productivity in Tigray. The program emphasizes water resource development in general and, specifically, the construction of microdams and afforestation of the watersheds surrounding the microdams. The problems associated with this development program lie in the potential negative effects that accompany the new resource activities. Irrigated agriculture may introduce longer-term salinization problems in the soil. The new water impoundments and afforestation systems may have even more serious side effects on local health. These effects may lead to the enhancement of environmental conditions favoring transmission of malaria and shistosomiasis. At present, outbreaks of malaria and shistosomiasis are seasonal events, but the concern is that these projects may result in endemic disease incidence and, in turn, might negatively affect labor productivity.

PROJECT OBJECTIVES

There are two main objectives for this study:

1. Measure household production and consumption gains and losses due to the construction of microdams and afforestation of watersheds.
2. Conduct a benefit/cost analysis of public investment in microdams.

Only the preliminary results related to the first objective are reported herein. The benefit/cost analysis has not yet been completed.

DATA

In 1996, an enumerated survey instrument was used to collect data from 731 households across 30 villages in Tigray. Information was collected on production and consumption decisions made during the year by each household sampled. Detailed information was collected on the amount of animal capital, fertilizers, seeds, and labor employed in various production processes. Expenditure and market sales data were also collected.

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EMPIRICAL MODELS

This section outlines the preliminary production and consumption decisions that we investigated. The decisions were simultaneous and non-separable because of the inclusion of resource and health variables (Amacher et al. 1996). All models applied to these decisions have a log-log functional form (Chung 1994). The first models described were the disease incidence functions. Models were estimated using adult male sick time, adult female sick time, and household children sick time as dependent variables. The second set of models specified and estimated were production for households. Production models were described for cereals, vegetables, fuelwood, and agricultural residues. Labor demand models were specified for hired adult males and females, household adult males, females and children by activity type. For instance, labor demand models were described for hired adult males for cereal, vegetable, fuelwood, and agricultural residue production. These models were also log-log in nature. In addition, these models included shadow prices for health care labor and the production of commodities (Jacoby 1993). The consumption model depicts the quantity consumed by a household. This consumption function includes purchased goods and goods that the household collects or produces that are not sold in the market.

RESULTS AND DISCUSSION

The results presented in this paper are preliminary in nature. Tables 1-4 present a subset of the results estimated for each of the models. The large number of independent variables in the models necessitates that only the most relevant be presented. To simplify the discussion only results for production, consumption, and labor demand of fuelwood will be presented.

The disease prevalence equation describes how sick time depends on various market and environmental factors. It is important to determine how these factors affect both male and female household time allocations, because male and female laborers may be engaged in different activities (e.g., consider healthcare for sick children). Table 1 presents parameter estimates for disease incidence for household adult males, females, and children. The first model for male sick time indicates that the dummy variable depicting cases of malaria among adult men is positive, suggesting that a 1% increase in malaria incidence causes a 2% increase in days of work lost by adult men. The coefficient for households with mosquito nets is positive, suggesting that as net use increases by 1%, more males get sick. Although this result seems counter-intuitive, only 5 households over the 731 data points declared use of mosquito nets. This evidence suggests that the sign of the coefficient, despite being significant, is not reliable.

The second model in Table 1 for sick time of adult females indicates that the dummy variable depicting cases of malaria among adult women is positive, suggesting that a 1% increase in malaria incidence causes a 1.89% increase in days of work lost by adult females.

An important connection exists between household time and the presence of the microdams. The coefficient for the distance from the microdam is negative, implying that as a household is farther away, adult females lose fewer workdays due to illness. The parameter estimates for households using mosquito nets are also positive. As previously mentioned, these variables have few non-zero observations, making the interpretation of these results unreliable. In addition, the coefficient for the distance a household is from its drinking source is positive, suggesting that water access problems for daily use may be an important factor in days lost to illness among adult women.

The third model for children sick time shows the dummy variable depicting cases of malaria and schistosomiasis among children is significant. This suggests that both diseases had an important impact on child labor. The coefficient for the distance to health care centers is positive, implying that children in households farther away are more likely to lose working time to illness. As with the sick time model for women, the coefficient for the distance a household is from its drinking source is positive, suggesting once again that water access problems for daily use may be important to days lost to illness among children.

Table 1. Preliminary Disease Incidence Results.			
	Dependent Variables		
Independent Variables	Male Sick Time	Female Sick Time	Children Sick Time
Constant	0.65 (0.49)	1.00 (0.60)	-0.16 (0.20)
Males with Malaria	2.22*** (0.28)	--	--
Males with Shistosomiasis	-0.70 (1.16)	--	--
Females with Malaria	--	1.89*** (0.35)	--
Children with Malaria	--	--	2.60*** (0.14)
Children with Shistosomiasis	--	--	1.02*** (0.37)
Improved Stove	-0.37 (0.24)	-0.17 (0.30)	-0.06 (0.07)
Distance to Health Center	-0.08 (0.12)	-0.19 (0.15)	0.77** (0.34)
Distance to Water Source	-0.02 (0.08)	0.20** (0.09)	0.05* (0.02)
Distance to Microdam	-0.07 (0.11)	-0.30** (0.13)	-0.10*** (0.03)
Mosquito Nets	4.04*** (0.84)	2.09** (1.05)	0.29** (0.14)

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level; -- variable not included in model.

The model in Table 2 is for fuelwood production. The sign for household adult male labor used in production is positive, suggesting that as more "man-days" of labor are added to production, fuelwood collection increases by 0.65%.[1] The coefficient signs are also positive for both eucalyptus trees grown on household property and other trees on government forestland. For a 1% increase in household tree plantings, fuelwood production increases by 0.30%, while production increases by 0.72% for additional trees found on government land. Coefficients that are significant, but have negative signs, are household adult female labor for health care and household use of improved stoves. For additional man-days that an adult female spends administering health care, fuelwood production decreases by 0.67%. The result for the improved stove coefficient suggests that households with this new technology decrease their fuelwood collection by 0.82%.

Table 2. Preliminary Production Results for Fuelwood.	
	Dependent Variables
Independent Variables	Fuelwood
Hired Male Labor	0.40 (0.36)
Household Male Labor	0.65*** (0.12)
Household Female Labor	0.01 (0.12)
Male Health Care	-0.06 (0.43)
Female Health Care	-0.67* (0.36)
Distance to Microdams	0.05 (0.15)
Improved Stove	-0.82** (0.39)
Male Sick Time	-0.05 (0.12)
Female Sick Time	-0.005 (0.11)
Child Sick Time	-0.03 (0.07)
Eucalyptus Trees on Home Sites	0.30*** (0.09)
Other Trees on Government Lands	0.72*** (0.25)

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

The first model in Table 3 is labor demand for hired adult males in fuelwood production. The parameter estimate for wages of hired adult males is negative, indicating that as wages increases by 1%

[1] Man-day is an 8-hour day that was used in the survey instrument.

labor demand for hired males in fuelwood collection decreases by 1.38%. A similar result exists for hired adult females. The coefficient for sick time of household adult males is positive, suggesting that as more males lose work due to illness, increased non-household males are hired. The parameter estimate for neem trees, a type of species that reduces malaria, on government land is positive. This implies that a 1% increase of trees on these lands stimulates labor demand for non-household labor by 12.29%. The coefficient for sick time of children is positive, conveying the notion that more outside labor is hired for the additional lost workdays by children.

The second model in Table 3 is labor demand for household adult females in fuelwood production. The coefficients for sick time by household males and females are positive, implying that, as more time is lost to illness, demand for female labor in fuelwood production increases. This may indicate that more fuel is used in cooking foods needed for health care. The parameter estimate for eucalyptus trees on the home-site is negative, reflecting the short distance women travel to collect fuelwood. The proximity of this fuel source frees up time needed for collection and shifts labor to other activities. The coefficient for other tree species grown on government lands is positive, implying that adult women require more time to travel the distance necessary for fuelwood collection.

The last model in Table 3 is labor demand for household children used in fuelwood production. The coefficient for sick time of adult females is positive, suggesting that a 1% increase in sick time of adult females increases child labor demand by 1.17%. This implies that child work time may be reallocated to replace the sick adult's responsibilities. The coefficient for distance to market is negative, implying that demand for child labor decreases by 15.29% for a 1% increase in distance to market.

Table 3. Preliminary Labor Demand Results for Fuelwood.

	Dependent Variables		
Independent Variables	Hired Males	Household Females	Household Children
Hired Male Wage Rate	-1.38*** (0.44)	-10.36* (5.75)	-5.83 (4.26)
Hired Female Wage Rate	-3.87*** (1.23)	-6.42** (3.17)	1.30 (3.01)
Male Sick Time	0.48*** (0.07)	1.13** (0.50)	-0.77** (0.36)
Female Sick Time	-0.08 (0.12)	0.93** (0.40)	1.17*** (0.33)
Improved Stove	0.19 (0.51)	0.92 (0.82)	0.18 (0.89)
Distance to Market	2.30 (3.28)	-4.86 (7.37)	-15.29* (8.82)
Distance to Health Center	0.15 (3.19)	6.19 (7.82)	15.32* (8.61)
Distance to Microdam	-0.06 (0.29)	-0.95** (0.47)	-0.08 (0.49)
Children Sick Time	0.21*** (0.08)	0.045 (0.23)	-0.18 (0.18)
Neem Trees on Government Lands	12.29** (5.30)	50.55 (931.4)	--
Eucalyptus Trees on Home Sites	0.18** (0.09)	-0.99** (0.44)	--

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level; -- variable not included in model.

The first model in Table 4 is consumption of cereals by households. The coefficient for male sick time is positive and significant, suggesting that as more household adults become sick, more cereal is consumed. This behavioral response may result from the increased use of cereals in household health care activities.

The second model in Table 4 is consumption of fuelwood by households. The coefficient for wages of hired adult males is negative, suggesting that as their wages increase by 1%, consumption of fuelwood decreases. The parameter estimate for sick time of adult females is positive, implying that as more women get sick, more fuelwood is consumed, perhaps because the heating requirements for the household increases. The coefficient for the price of fuelwood is negative, indicating that a 1% price increase results in a 1.26% decrease in fuelwood consumption. In addition, the parameter estimate for the distance to the microdam is negative, implying that the farther away a household is from a microdam, the less fuelwood is consumed. This confirms our expectations that areas around microdams are important sources for fuelwood.

Table 4. Preliminary Consumption Results for Cereals and Fuelwood.

	Dependent Variables	
Independent Variables	Cereal Consumption	Fuelwood Consumption
Male Sick Time	0.15* (0.09)	-0.15 (0.15)
Female Sick Time	0.08 (0.10)	0.27* (0.14)
Improved Stove	0.05 (0.27)	-0.23 (0.55)
Distance to Market	1.58 (1.38)	-1.81 (2.59)
Distance to Health Center	-1.52 (1.32)	2.38 (2.54)
Distance to Microdam	-0.04 (0.13)	-0.46* (0.25)
Children Sick Time	-0.09 (0.07)	-0.07 (0.09)
Fuelwood Price	0.12 (0.38)	-1.26** (0.64)
Hired Male Wage Rate	0.01 (0.69)	-2.89** (1.41)

Note: * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

SUMMARY OF PRELIMINARY RESULTS

There are three main results at this stage of the analysis. First, work time losses from illness result in declines in production activities. When members of the household lose work time due to illness, production activities decrease. Production also declines from additional labor shortages when non-sick family members provide care for other household individuals that are sick. This suggests that there is both a direct and indirect effect of health on household production activities.

The second key result is that greater demand for hired labor occurs when household members are sick. This is illustrated in Table 3 where the labor demand for hired adult males increases with the marginal increase in time lost to illness by household adult males. This result has important implications for household expenditure and consumption behavior.

The last key result is that labor substitution occurs between household members and production activities as a result of disease incidence. Table 3 suggests that as household adult males become increasingly sick, children shift their labor activities from fuelwood collection to other activities. Overall, results suggest that production, labor, and consumption behaviors are directly and indirectly impacted, as household members become sick.

FUTURE WORK

A component of our future work involves hypothesis testing. We hope to conduct hypothesis tests that will better reveal the effects of microdams and health on Ethiopian households. Eventually, we will be able to evaluate not only the changes in health accompanying microdams, but also whether microdams are economically efficient. The answer to the latter question will depend on whether the increase in farm productivity and farm profits brought about by the microdams compensates for the increase in expenditures and decreased household labor time that results from increased malaria prevalence. The connection between microdams and increased prevalence of disease has already been documented with our results. Other hypothesis tests will determine whether shistosomiasis or malaria prevalence is more detrimental to household income and farm productivity, the contribution of microdams to decreased health, and the relative effects of health on consumption and production.

Another result we will derive in more detail is the effect of health on welfare. If our results are negative, then this would represent a net decrease in household welfare by the value of the result, while positive results would indicate that health seems to increase household welfare. This is the case where microdams add efficiency to household production through increased sources of irrigation water and fuelwood supplies, which serve to increase household income through production activities. If these benefits outweigh the costs of microdams through decreased health, then the net effect will be positive.

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