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by

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Abstract:

In this paper we address the issue of access to drinking water in rural areas related to the productivity of the agricultural workforce. Considering an agricultural household model as our basic conceptual framework, we analyze the theoretical aspects of increasing the access rate to drinking water on the productivity of the agricultural workforce. First, we show that the increased access rate to drinking water is conducive to agricultural productivity due to increased intrinsic productivity of individuals and additional gain in time for agricultural production. Second, it comes out that the constraints on the access to drinking water may be costly in terms of decreased productivity and well-being of rural people. Moreover, the results of econometric estimates do not reject our theoretical implications. On a sample of 27 African countries, these results show mainly that access to clean water improves agricultural productivity. This positive effect is reinforced by the presence of a better sanitation system, even after controlling for country-specific effects and for the characteristics of rural areas.

Résumé :

Nous abordons la question de l'accès à l'eau potable en milieu rural en relation avec la productivité de la main d'œuvre agricole. Sur la base du cadre d'analyse des ménages agricoles, nous analysons les aspects théoriques des effets d'un accroissement du taux d'accès à l'eau potable sur la productivité de la main d'œuvre agricole. En premier lieu, nous montrons qu'une augmentation du taux d'accès à l'eau potable est propice à la productivité agricole du fait de l'accroissement de la productivité intrinsèque des individus et du gain additionnel de temps pour la production agricole. D'autre part, il ressort que les contraintes d'accès à l'eau potable sont susceptibles d'imposer des coûts en termes de baisse de productivité et de bien-être aux populations rurales. En outre, les résultats économétriques ne rejettent pas ces arguments théoriques. Sur un échantillon de 27 pays africains, ces résultats montrent principalement que l'accès à l'eau potable améliore la productivité agricole. Cet effet favorable est renforcé par la présence d'un meilleur système d'assainissement, même après avoir contrôlé pour les effets spécifiques pays ainsi que pour les caractéristiques du milieu rural.

Keywords: drinking water and sanitation, labor productivity, agricultural household model.
JEL – codes: Q12, Q52, Q53

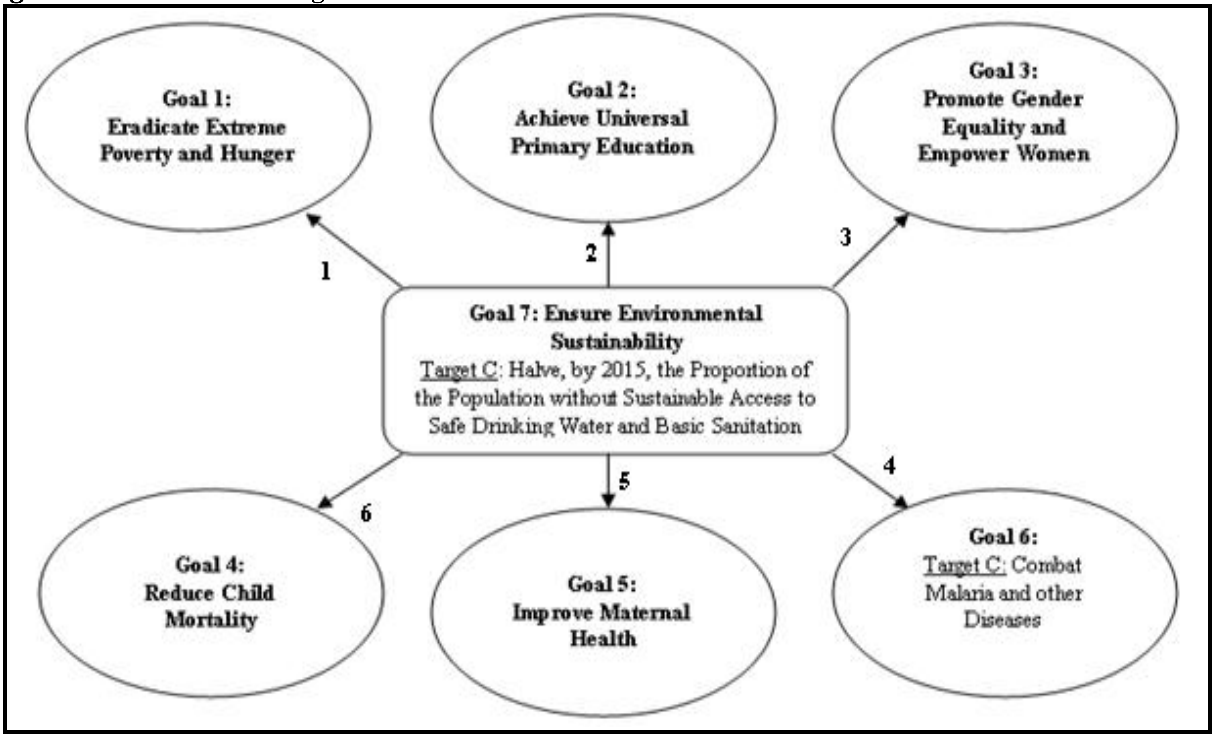
Table of content

1. Introduction

Each year, unsafe water and lack of improved sanitation facilities cause the death of more than 1.6 million children under 5 years old worldwide. In 2005, 1.1 billion people lacked access to adequate sources of drinking water worldwide and 84% of this population lived in rural areas (WHO and UNICEF, 2006).

Nowadays, the issue of access to safe water and sanitation[1] in rural areas continues to attract the attention of researchers, donors, and development practitioners. The African Development Bank (ADB), which is one of the most important donors intervening in the drinking water sector, has clearly set targets in this area through the launch in 2003 of the Rural Water Supply and Sanitation Initiative (RWSSI). The objective was to bring the access rate to drinking water in Africa to 46% by 2010.

Figure 1: Access to drinking water and other MDGs



Source: Drawn by the author based on United Nations (2005)

Access to safe drinking water and sanitation facilities is crucial in rural areas where opportunities for access to infrastructures remain very limited. In most developing countries, the level of access to safe water and sanitation has remained historically low, especially in rural areas. Peasants are still forced to travel long distances everyday on foot to collect drinking water. This can be explained by the weak and inadequate investments in water supply and sanitation. In areas where these investments have been acceptable, there was a general problem of servicing and maintaining infrastructure. Thus the non-potable water ponds and traditional wells have been widely used for consumption. This situation exposes populations to malnutrition and diarrheal diseases (WWAP, 2006). Since access to drinking water promotes country peoples' health, children's attendance to school and women's remunerative activities, investments in infrastructures for access to drinking safer water contribute to sustainably increasing agricultural labor productivity in rural areas. Thus, this issue is central in shaping international development policies. The international community has recognized that inadequate access to drinking water is harmful caused in terms of health, productivity and quality

[1]In the following section we use the term "Safe water or drinking water" to refer to both drinking water for consumption and sanitation because these two aspects, seemingly unrelated, cannot be analyzed separately.

of life. The United Nations committed very early to improve the supply of drinking water by declaring the decade 1981-1990 as the International Decade for Drinking Water and Sanitation.

This commitment has been constantly renewed since 1990, with the New Delhi Declaration, and in 2000 with the Millennium Development Goals (MDG) and the 2nd World Water Forum in The Hague. Even today, a new International Decade (2005-2015) for Action “Water for Life” was proclaimed by the United Nations. Access to drinking water is explicitly stated in the Millennium Development Goals (MDG) (target 10 of goal 7). This is one of the most important objectives given that its completion will increase the probability of achieving most of the others objectives (see Figure 1).

In figure 1, we first notice that access to drinking water helps reduce poverty and hunger. Indeed, on the one hand, it allows people to increase their income due to productivity gains and, secondly, it is favorable to improving the quality of households’ nutrition which did not access to potable drinking water (1). Also, it reduces child mortality and the prevalence of a number of diseases and improving maternal health (4, 5 and 6). In addition, it participates in the achievement of universal primary education through increased school attendance made possible by improving the health of children and the additional gain in time (2). Finally, it enables the achievement of gender equality because women are the first affected by the constraint of access to drinking water. The softening of this constraint allows them to diversify their activities, increase their productivity and income and thus reduce income inequality between the genders (3). All these arguments show that the establishment of infrastructure for access to drinking water should improve the water quality and reduce the risks related to consumption of unsafe water for households.

Several studies have examined the issue of access to drinking water and have highlighted the microeconomic and macroeconomic benefits of increasing the access rate to drinking water for households (see for instance Keener et *al*., 2010; Lokshin and Yemtsov, 2005; Rosen and Vincent, 1999; World Bank, 1993). However, the existing literature provides little evidence of the relationship between improved water sources and agricultural labor productivity in rural area. Rosen and Vincent (1999) provide a review of studies that emphasized the link between access to drinking water and rural productivity. Nevertheless, these studies were generally limited to the empirical analysis of national survey data (WHO, 1986; Word Bank, 1993; Briscoe et *al.*, 1990; MacRea et *al.*, 1988) and therefore obscuring the theoretical aspects of the issue of access to drinking water.

Relying on a simple agricultural household model, this paper provides a theoretical framework for the allocation of household’s time and some empirical arguments that militate in favor of investment in infrastructure for access to the drinking water and sanitation. The rest of this paper is organized as follows. Section 2 presents a brief review of the existing literature while section 3 provides the theoretical framework based on which estimates are made, highlighting the implications of increased access to safe water and sanitation services for productivity gains in the agricultural workforce. Section 4 is devoted to the empirical investigation of the effects of access to safe water and sanitation on the agricultural labor productivity on a sample of 27 African countries. Section 6 concludes and draws some policy implications.

2. Literature review

Most of the studies highlighting the impact of safe drinking water programs on the well-being of people refer to three main mechanisms based on the improvement in population health, the additional gains in time, and the increase of school attendance.

1. Access to drinking water and population health improvement

A number of studies emphasize the improving of the population’s health which is made possible through improved access to safe drinking water. Rosen and Vincent (1999) identify the reduction in costs related to waterborne diseases as being one of the main factors explaining the relationship between access to potable water and rural labor productivity. Their analysis is based on the costs in terms of quantity and quality of labor engendered by inadequate access to drinking water. Esrey et al. (1991) conducted a review of 144 studies which analyze the impact of the access to drinking water on the incidence of waterborne diseases and parasitic diseases such as ascariasis, diarrhea, dracunculiasis, hookworm, schistosomiasis, and trachoma. It comes out from their study that in most cases, access to safe water and sanitation facilities is conducive to the reduction of the incidence and severity of these diseases. Particularly, access to water and sanitation reduces child mortality by 55%. Fewtrell et al. (2004) identify 64 studies analyzing the impact in terms of health of interventions to improve the quantity and quality of water, hygiene, and sanitation. Based on a meta-analysis, they extract data from these studies to provide summary estimates of effectiveness of each type of intervention. They then conclude that in developing countries these interventions (particularly those that improve the quality of drinking water and sanitation) can reduce diarrheal mortality. Waddington et al. (2009) present a summary review of the impact evaluations analyzing the effectiveness of interventions in drinking water, hygiene, and sanitation in reducing infant diarrhea. This study updates the review proposed by Fewtrell and Colford (2004). The authors identify 65 rigorous impact evaluations (using experimental and quasi-experimental methods) covering 71 interventions for approximately 130, 000 children in 35 developing countries. Using both quantitative and qualitative data from theses evaluations, and after regrouping interventions into to five categories[2], they show that water quality treatment in the household and sanitation 'software' (hygiene) interventions are not the most effective and sustainable interventions for promoting reduction of diarrhea. While point-of-use water quality interventions seem to be effective, most of these studies are conducted over small population and short time periods. This could imply a lack of robustness and external validity of these results. Kremer and Zwame (2007) provide a critical review of studies on the effectiveness of prevention and treatment of diarrheal diseases. They suggest that to have a better understanding of the issue of efficiency of interventions, one should focus on the microeconomic determinants of access to safe water and sanitation services. Using a same approach, Zwame and Kremer (2007) analyze the factors that promote the fight against diarrheal diseases in developing countries. They show that the community facilities of drinking water can significantly and permanently reduce diarrheal diseases in rural areas. Kremer et al. (2007) evaluate the impact of water quality at its source on the prevalence of diarrhea in rural Kenya. They use the randomized evaluation method to show that the improvement of water quality at the source reduces the incidence of diarrhea.

Finally, some studies highlight the complementarity between access to clean water and access to sanitation services in the health dimension. This is particularly the case of Esrey (1996) who examines whether incremental improvements in water and sanitation services imply incremental improvements in health. He uses data from Demographic and Health Surveys (DHS) concerning eight countries in Africa, Asia, and the Latin Americas. It comes out that increased access to drinking water improves health of populations, this being but on conditional on the presence of an adequate sanitation system.

2. Access to drinking water and women's work

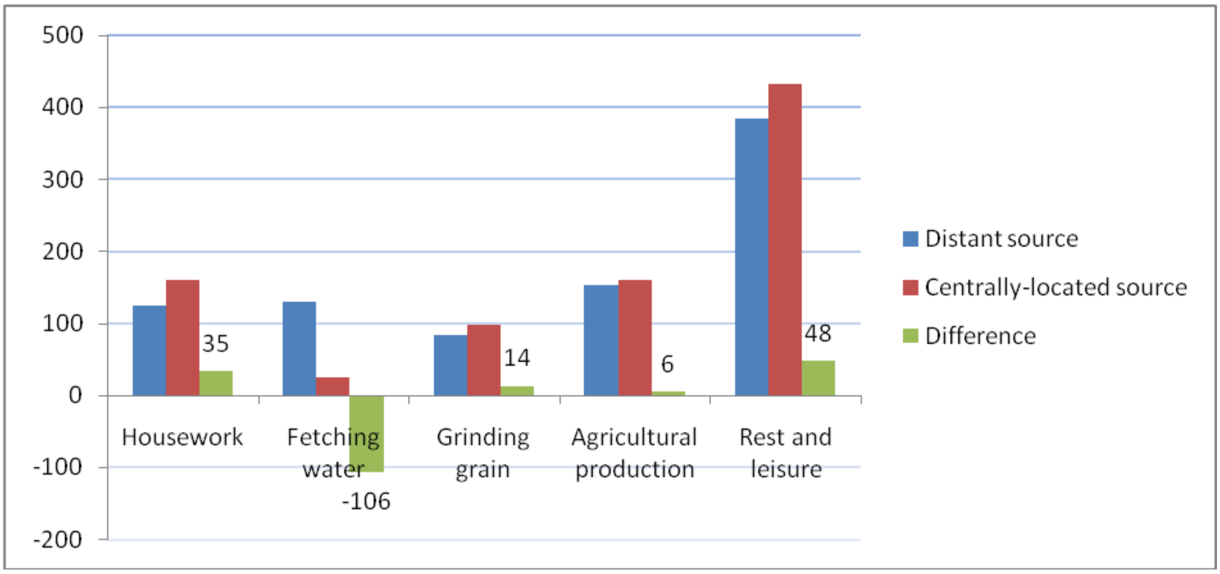
Many studies have attempted to highlight the role of access to drinking water in developing women empowerment activities, stating the argument of saving additional time due to an increase in the access to drinking water. Using data on 18 African countries, a United Nations report found that women are five times more affected than men in collecting water for the household (UNICEF and WHO, 2008). Rosen and Vincent (1999) show that direct time savings is mainly due to the reduction of the distances travelled to collect drinking water. This problem of distances is more crucial for women who take care of housework and child rearing[3]. They reviewed 12 studies that analyze the amount of time household and women spend walking to the water sources. The results of these studies

[2] These categories are water supply improvements, water quality, sanitation, hygiene and a combination of water and sanitation and/or hygiene.

[3] Rural women in Africa and South Asia are frequently reported to spend at least an hour and up to several hours a day fetching water for the household.

show that time spent per carrier is 60 minutes per day and 134 minutes per day for households. Ilahi and Grimard (2000) analyze the allocation of women's time between the collection of drinking water, empowerment activities, and leisure. Based on 1991 data for Pakistan, they found that the greater the distance women walk to collect drinking water, the greater the time allocated to this activity, the less they undertake income generating activities. They also found that women in households with private connections spend more time on leisure activities. Gayatri and Van De Walle (2010) examine the effects of water access on rural women off-farm activities. Based on national survey data for rural area, they use a new methodology to deal with the endogeneity issue which has two components: a geographic component and a household component. Their results show that access to drinking water allows women to diversify their income-generating activities. This reduces the inequality between men and women and promotes women's participation in economic growth. Cairncros and cliff (1987) provide a comparison of daily time budgets for women between 2 villages of Mozambique, one with a water supply and one dependent on a distant water source (See Figure 2).

Figure 2: Average time budgets for the waking day of adult women in Mozambique, in minutes



Source: Cairncross and Cliff (1987)

We notice that the difference in the time allocated by women using centrally-located source is greater for fetching water activity. Most of the time that women with distant water source, is divided between rest and leisure (43.75%), agricultural production (17.5%) and fetching water (14.88%).

Moreover, other studies focus on broadly barriers that prevent women to undertake off-farm income-earning activities (Mammen and Paxson, 2000; Feder and Lanjouw, 2001). It follows that access to drinking water can contribute to the development of income generating activities for women. In addition, some studies which have used the economic cost-benefit analysis to evaluate interventions in water supply and sanitation (Hutton and Haller 2004; Hutton, and al. 2007). Hutton and al. (2007) consider a range of interventions in developing countries. They focus on the gain in extra time made possible by increased access to potable water. Their results show that the increased rate of access to safe water and sanitation is beneficial to people. Depending on the type of intervention, the return on a US$ 1 investment is in the range US$ 5 to US$ 46. Lokshin and Yemtsov (2005) analyze the impact of rural water supply improvements on women’s wage employment in Georgia between 1998 and 2001. Using impact evaluation approaches (Difference-in-differences and Propensity score matching) on a panel of villages over two survey rounds, they find a significant reduction in the incidences of waterborne diseases, but not a clear effect on women’s wage employment.

Finally, a number of studies focus on the effects of social norms and cultural restrictions on women ability to participate in off-farm work (Kevane and Wydick, 2001). These social and cultural factors explain why women spend more time collecting water for household than men do.

3. Access to drinking water, child outcomes, and school attendance

With respect to school attendance, strong effects of access to clean water on children's outcomes have often been found in the literature. Iyer et al. (2005) show that access to drinking water can increase access to education in rural areas through the reduction of discrimination and arduous work of school-age children. Jalan and Ravallion (2003) analyze the impact of piped water on children's health in rural India. Using propensity score methods, suggest that the prevalence and severity of diarrhea are lower for Indian children living in villages with access to piped water than those in observationally identical families in villages without piped water. Fay et al. (2005) use an empirical analysis to assess the determinants of three child-health outcomes related to the Millennium Development Goals. Based on Demographic and Health Survey, they find that apart from classical factors (income, assets, education, and direct health intervention), better access to basic infrastructure as piped water reduce infant and under-five child mortality and the incidence of stunting in children. To check the robustness of these results, Ravallion (2007) shows that infrastructure impacts Fay et al. (2005) found can be explained by a combination of functional-form misspecification, latent country effects, and omitted quintile-specific schooling effects. Using an alternative estimator and augmenting Fay et al. (2005) data set to include female schooling, Ravallion (2007) finds less evidence that better infrastructure improve child health. Günther and Günther (2010) analyze the impact of water and sanitation on children's health using 172 Demography and Health Survey data sets from 70 countries. They find that, depending on the technology level and the sub-region chosen, water and sanitation infrastructure reduce the children's probability of suffering from diarrhea by 7-17 percent, and the mortality risk for children under the age of five by about 5-20 percent. Watson (2006) identifies the impact of investment in public health on infant mortality across socioeconomic and racial group. He finds that, in U.S., Federal sanitation interventions explain forty percent of the convergence in Native American and White infant mortality rates. Some authors relate this issue to the level of education of the mother. For instance, Mangyo (2008) uses a micro panel on China to show that access to drinking water has a positive effect on the health of children for households in which women are more educated.

Ultimately, this literature shows that access to drinking water is a key stimulator of labor productivity, especially in rural areas, but that this relationship is strong under some micro-foundations considerations and under the inclusion of some structural and economic characteristics of the population's living environment. The theoretical framework in the next Section strives to clarify the relationship between improved access to drinking water and rural farmer's productivity.

3. A simple analytical framework

The model developed here is based on the framework of the agricultural household model suggested by Sen (1966). The author analyzed the issue of disguised unemployment in agriculture in this model. Indeed, the author examined what would happen in agricultural production if a significant portion of the workforce was suddenly removed. Assuming a representative producer living in autarky, Sen (1966) shows that it is possible to have a result where the marginal productivity is strictly positive. In this case, a part of the labor endowment can move to other sectors without making agricultural production decline. Such result calls in question the argument of zero marginal productivity and therefore rejects the hypothesis of surplus labor in agriculture.

For analytical purposes, we make a numbers of simplifications. Let's assume an economy composed of similar households living one period and endowed with time T. We assume that the goods market and labor market are absent so that the household does not exchange with the outside world. Leisure plays no role in household behavior[4]. Representative household's utility is derived from consumption of two goods: agricultural good (X) produced by the household and drinking water (W) provided by the government[5]. However, the household must spend part of its time per day in collecting water. We also assume an unlimited availability of a water table. This should make possible the establishment of many types of improved rural drinking water sources such as piped water supply system, deep well hand pump system and rainwater collector system. The problem of access is thus limited to the availability and functionality of water infrastructures. In addition, it is assumed that only water from improved water infrastructures is drinkable. This implies that water of unprotected dug well, unprotected spring, cart with small tank/drum, bottled water, tanker-truck, and surface water (river, dam, lake, pond, stream, canal, irrigation channels) are not drinkable[6]. Moreover, the water type that is relevant to consider is the one which is exclusively intended for final consumption of households[7]. Thus, the water used for production activities such as irrigation in agriculture is not relevant.

The representative household has the choice between allocating time to the acquisition of drinking water for domestic consumption or production of agricultural good[8]. Let L_W be the time required for the acquisition of drinking water for domestic consumption and L_X that required to produce the agricultural good. The household time constraint is then in this way: $L_X + L_W \leq T$. The amount of water consumed by the household is a function of the volume of time spent in water collection as follows: $W = W(L_W) = k(\theta)L_W$, $0 < k(\theta) < 1$ and $\frac{\partial k(\theta)}{\partial \theta} < 0$, θ being the degree of accessibility to drinking water. This means that the marginal effect of time on the amount of household water consumption will be increasing as the access rate to drinking water will improve. However, gradually as the access rate increases, the impact of the use of an additional unit of time on the quantity of drinking water will be increasingly low. This implies that the household can devote more time to agricultural production. The production technology of the household can be represented by the function $X = X(L_X, S)$. Where S represents the surface of the holding of the household that is assumed to be fixed. Moreover, the household's production is assumed to be self-consumed. As the household gets its satisfaction in consuming the two goods (X and W) and under the time constraint, optimization program :

$$\begin{aligned} &Max\, U[X(L_X, S), W(L_W)] \\ &s.t.\, L_X + L_W \leq T \end{aligned} \tag{1}$$

This constrained problem can be transformed into an unconstrained problem by substituting for the time constraint that is saturated because of the non-satiation of preferences of the household[9].

$$\begin{aligned} &Max\, U[X(L_X, S), W(T - L_X)] \\ &U_X > 0, U_W > 0, U_{XX} < 0 \text{ et } U_{WW} < 0 \end{aligned} \tag{2}$$

The first-order condition associated with this maximization problem which implicitly characterizes the optimal choice is the following:

[4]These simplifying assumptions may seem unrealistic, but they reflect the situation in most rural areas of sub-Saharan Africa.

[5] We assume the absence of markets; situation in conformity with the reality of rural Africa. These areas remain isolated and almost disconnected from the outside.

[6] The WHO defines drinking water as water that does not contain pathogens or chemical agents at concentrations that could harm human health.

[7] Water used for agricultural irrigation, industrial or artisanal production is not considered here.

[8] Unlike traditional agricultural household models, we do not introduce the leisure (see Sen, A. K., 1966). This simplifying assumption does not affect our results.

[9] The marginal utility of consumption is strictly positive.

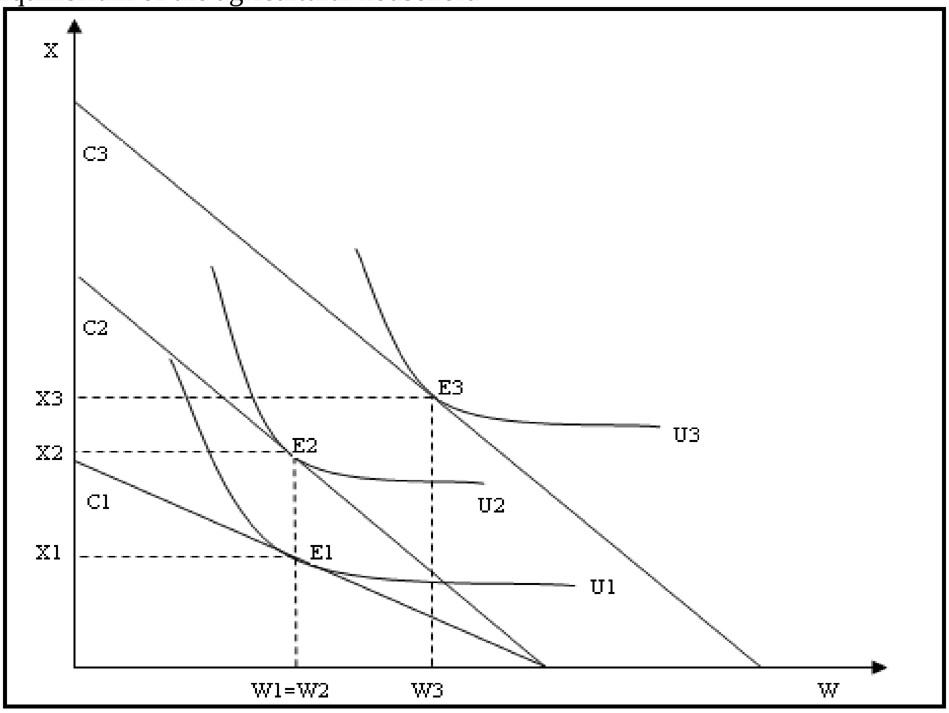
$$U_X\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]\frac{\partial X(\cdot)}{\partial L_X}-U_W\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]k(\theta)=0 \tag{3}$$

At equilibrium, the marginal utilities associated with the consumption of drinking water and agricultural good are equal to their respective opportunity costs. The optimal value of the time spent on the production of potable water for consumption will depend on the rate of access to water infrastructures. From equation 3, we can deduce the expression of the marginal productivity of household labor on farm:

$$\frac{\partial \mathrm{X}(\cdot)}{\partial L_X}=\frac{U_W\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]}{U_X\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]}k(\theta) \tag{4}$$

It may be noted that the marginal productivity of agricultural labor is not only positive but also an increasing function of the access rate to drinking water. As noted above, this could be due to the improved health of the household, additional gains in time, and increasing school attendance. The theoretical arguments backing equation 4 can be examined in the graphical analysis of the equilibrium of the representative household. The mechanism through which the increased rate of access to water infrastructures promotes productivity gains at the household level and increases the agricultural production is presented in Figure 3.

Figure 3: Equilibrium of the agricultural household



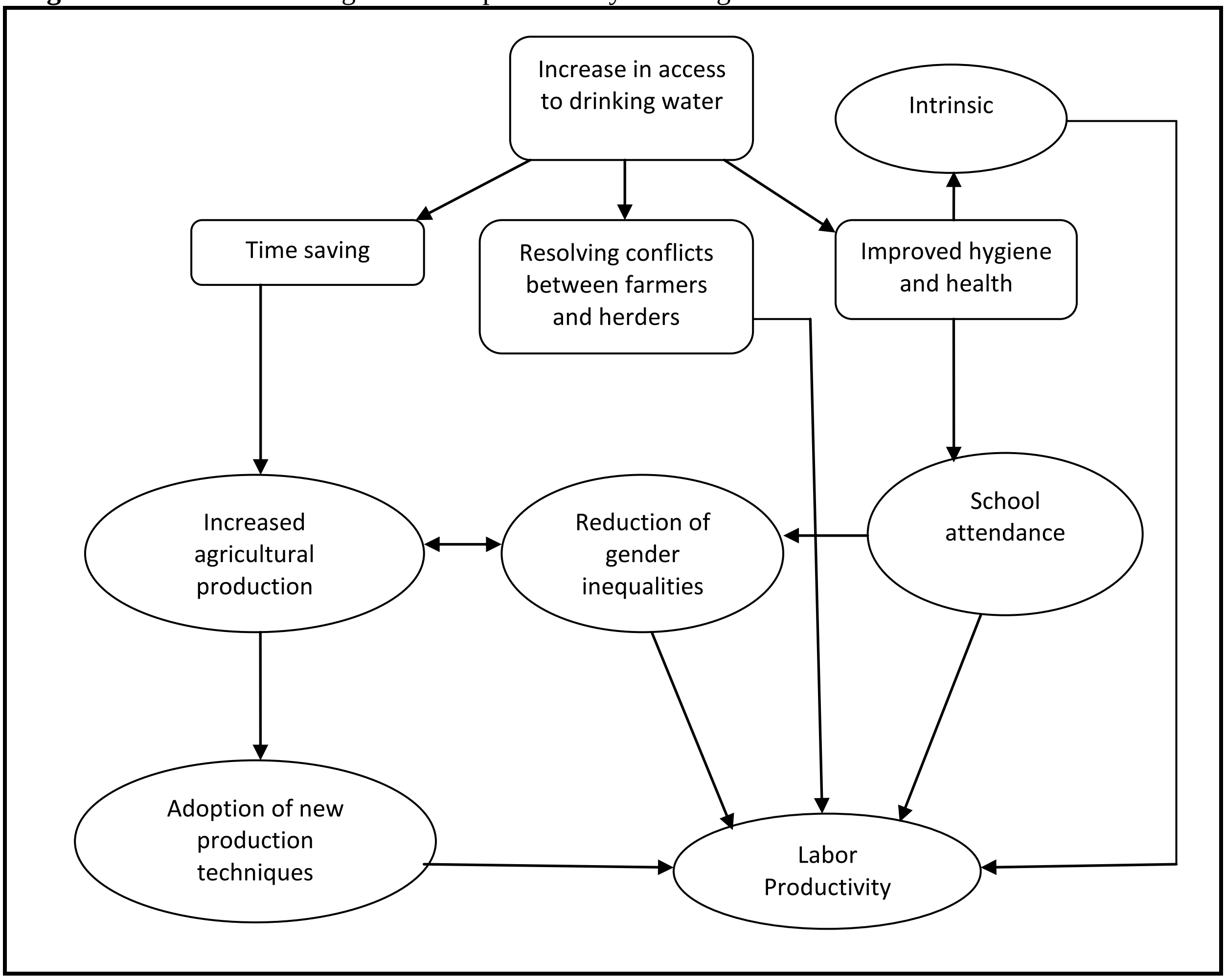
Source: The present study

As shown in equation 2, the household's preferences are convex. The household's budget constraint is represented by the lines C1, C2 and C3 as appropriate. Household preferences are represented by indifference curves U1, U2 and U3. Initially, increasing the access rate causes a pivoting of the consumption possibilities frontier (from C1 to C2) upwards, moving the equilibrium from E1 to E2. This shift is mainly due to the change in the time allocated to the production of the two goods in favor of the agricultural good. Indeed, improving access to clean water reduces the time required to produce one unit of water and increases that of the agricultural good. This causes an increase in production and consumption of agricultural good on a higher indifference curve (U2), all else being equal.

In a second step, in the medium and long run and because of productivity gains and changes in consumption patterns, the consumption possibility frontier moves in parallel from C2 to C3, shifting the equilibrium from E2 to E3. The household is again on a higher indifference curve (U3), implying a higher welfare level. In reality, the channels through which access to safe drinking water affects the productivity of households can be represented as follows (Figure 4).

In Figure 4, one can see that access to clean water acts favorably on time savings and state of health of household. This time saved allows farmers, particularly women, to diversify their activities and adopt new production techniques. Indeed, rural women are more affected by the constraint of access to potable water through the housework. But additional gain in time generated for farm production may be beneficial to the productivity of household.

Figure 4: Access to drinking water and productivity of the agricultural workforce



Source: The present study

Moreover, the improvement of their health status increases their intrinsic productivity and school attendance (girls especially). Both effects are favorable for reducing inequality between men and women and, ultimately, increased productivity of labor. Finally, the availability of drinking water contributes to conflict resolution and social cohesion among farmers and ranchers that directly improve agricultural productivity.

Proposition 1: *if the marginal impact of drinking water on the marginal utility of agricultural good is positive, then an increase in the rate of access to drinking water will be favorable to additional gain in time which will be allocated to agricultural production.*

Formally, implicit differentiation of equation 3 provides the following result:

$$\frac{dL_X}{d\theta} = -\frac{\frac{\partial W(\cdot)}{\partial \theta}\left[\frac{\partial X(\cdot)}{\partial L_X}U_{XW} - k(\theta)U_{WW}\right] - k'(\theta)U_W}{\left[\frac{\partial X(\cdot)}{\partial L_X}\right]^2 U_{XX} + k(\theta)^2 U_{WW} - 2k(\theta)\frac{\partial X(\cdot)}{\partial L_X}U_{XW} + \frac{\partial^2 X(\cdot)}{\partial L_X^2}U_X} \tag{5}$$

The denominator which represents the second-order condition is negative. Hence, the sign of $\frac{dL_X}{d\theta}$ depends on the sign of the numerator which is positive.

Indeed, we know that consumption of drinking water is non-decreasing with respect to access rate ($\frac{\partial W(\cdot)}{\partial \theta} \geq 0$). Since $k'(\theta) < 0$, if $U_{XW} > 0$, then it follows that the numerator is positive and consequently $\frac{dL_X}{d\theta} > 0$.

The implication is that an increase in the access rate to drinking water lead to an increase in the time allocated to the production of agricultural good. The relative proportion of the time spent in the collection of water reflects its accessibility and its contribution to the well-being of the household. The more some time is allocated to water production, the less some time is spent on the production of other goods (X) and the less household's well-being is, other things being equal. Indeed, the high volume of time devoted to drinking water does not necessarily imply a greater consumption of drinking water. It depends largely on the degree of accessibility to water infrastructures.

Proposition 2: constraint to access to drinking water shifts the equilibrium of the household and imposes costs in terms of lost productivity and welfare.

Let's now assume that the household faces an additional constraint on access to drinking water. Due to the fact that agricultural production in rural areas is rudimentary and extensive, the household must spend a minimum time required to agricultural production. Clearly, a constraint to access to drinking water increases the time spent in water collection water and limits the time made available for agricultural production. If D is the availability of drinking water for the household, then the access constraint can be expressed in this way: $W(L_W) = W(T - L_X) \leq D$.
The household maximization program becomes:

$$\begin{aligned} &Max\, U[X(L_X, S), W(T - L_X)] \\ &s.t.\, L_X + L_W \leq T \\ &\quad W(T - L_X) \leq D \end{aligned} \tag{2'}$$

The Lagrangian associated to this problem is given by:

$$L = U[X(L_X, S), W(T - L_X)] + \lambda[D - W(T - L_X)] \tag{6}$$

The first-order condition which implicitly defines the optimum is:

$$U_X\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]\frac{\partial X(\cdot)}{\partial L_X}-U_W\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]k(\theta)+\lambda k(\theta)=0 \qquad (3')$$

It may be noted that when the constraint is saturated ($\lambda > 0$) the marginal utilities of drinking water ($U_W(\cdot)$) and the agricultural good ($U_X(\cdot)$) are no longer equal to their respective opportunity costs. The marginal productivity of agricultural labor becomes:

$$\frac{\partial X(\cdot)}{\partial L_X}=\frac{U_W\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]-\lambda}{U_X\left[X\left(L_X,S\right),W\left(T-L_X\right)\right]}k(\theta) \qquad (4')$$

It is clear that the constraint of access to clean water causes costs in terms of reduced agricultural productivity for household.

Taking the total derivative the household utility, we obtain $dU=U_X\,\frac{\partial X}{\partial L_X}\,dL_X+U_W\,\frac{\partial W}{\partial L_X}\,dL_X$

$\Rightarrow \frac{dU}{dL_X}=U_X\,\frac{\partial X}{\partial L_X}(L_X)+U_W\,\frac{\partial W}{\partial L_X}(T-L_X)=U_{m1}(L_X)+U_{m2}(T-L_X)$, where $U_{m1}(L_X)$ and $U_{m2}(T-L_X)$ denote the respective marginal utilities of both goods X and W. Therefore, the overall utility of the household can be expressed as follows:

$$U=\int_0^{L_X}U_{m1}(t)dt+\int_0^{L_X}U_{m2}(T-t)dt \qquad (7)$$

Following equation (3 '), the optimal allocation of time between the production of drinking water and that of good X is (Leibniz rule):

$$U_{m1}\left(L_X^*\right)=U_{m2}\left(T-L_X^*\right)-\lambda k(\theta)\Rightarrow U_{m1}\left(L_X^*\right)<U_{m2}\left(T-L_X^*\right) \qquad (7')$$

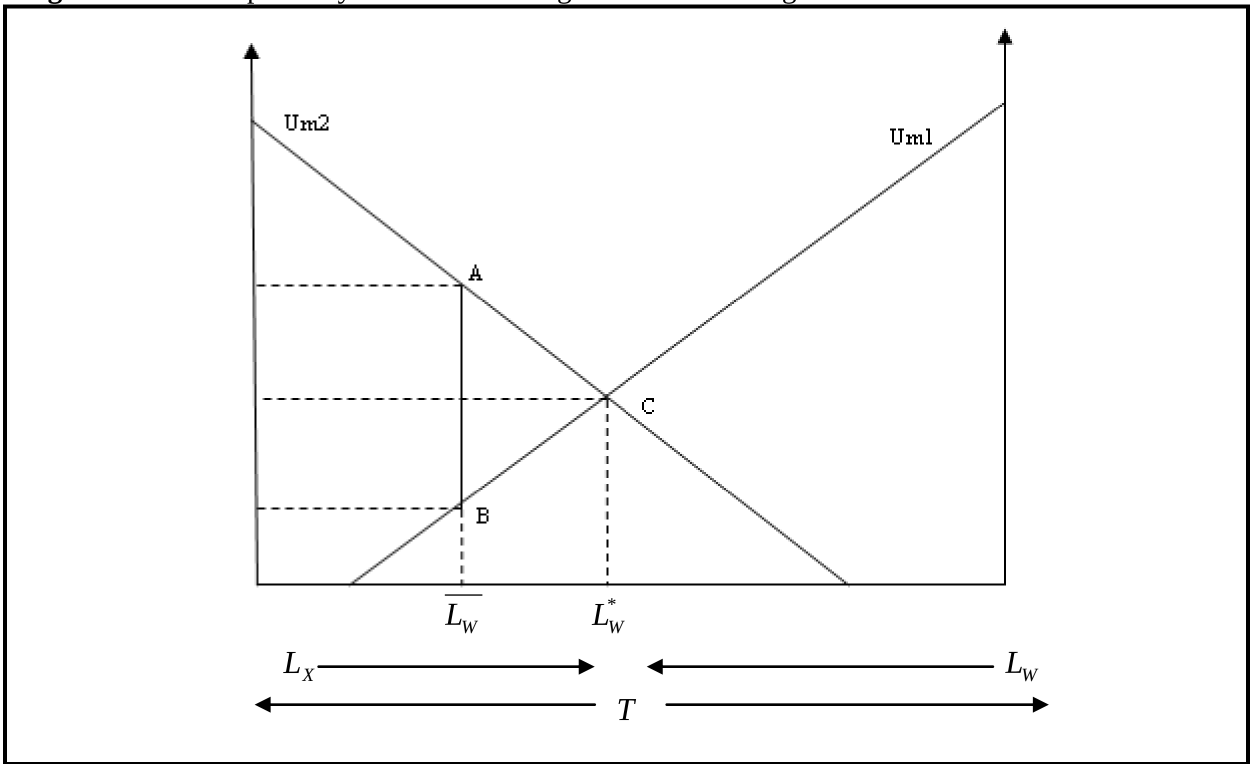
In that case, the marginal utilities are no longer equal at the equilibrium. So any deviation from this equilibrium, caused by an access constraint, generates a decline in overall consumption, which corresponds to a loss of well-being equivalent to:

$$\Delta U=\int_{\bar{L}_W}^{L_W^*}U_{m2}(t)dt-\int_{L_W^*}^{\bar{L}_W}U_{m1}(t)dt \qquad (8)$$

Thus, there is an inefficient allocation of time between the two properties represented by the triangle ABC (Figure 5). We represent the marginal utilities of two goods by two curves. When one considers the agricultural good (X), the time devoted to its production is measured from left to right. For drinking water, the time spent on its collection is measured from the right to the left. In accordance with the time constraint of the household, total household time equal to T and corresponds to the total width between the two vertical axes. The time allocation (L_W^*) that maximizes the household's utility is given by the intersection of two curves (C). At this level, the total utility is given by $U=\int_0^{L_X}U_{m1}(t)dt+\int_0^{T-L_X}U_{m2}(t)dt$. This corresponds to the total area under the 2 curves.

However, in the presence of a constraint to access to drinking water, the time available for agricultural production is limited. The equilibrium shifts to the left and the marginal utilities are no longer equal. In this case the loss caused by such an inefficient allocation is represented by the triangle ABC.

Figure 5: Costs imposed by access to drinking water constraining factors



Source: The present study

Theoretically, the fact that the marginal utilities of the two goods are not equal means that the household can always increase its level of utility with the same amount of time (T). Ultimately, the constraint of access to drinking water imposes inefficiency and a loss of utility to the household. The next section sheds light on the causal impact of access to drinking water on agricultural productivity.

4. Empirical specification and main results

1. Measuring agricultural productivity

The concept of productivity is different from that of production since production refers to production of tangible goods. It is a measure of the efficiency with which the factors of production are used. The productivity of a farmer is a technical concept that is often measured by the ratio of the output(s) that he produces to the input(s) he uses. Depending on the composition of outputs and inputs, we find several measures of productivity. One can make a distinction between Total Factor Productivity (TFP) and partial productivity of a given factor of production.

TFP is a productivity measure referring to all factors of production. It can also include all output in a multiple-output setting. Its conventional measurement involves the computation of an index of total output and an index of all factor inputs. The index numbers most commonly used are Laspeyres and Paasche index numbers (Christensen, 1975).

Moreover, TFP can be measured by considering the Value-Added or the Gross Output. The first approach is the most used, but the latter is preferred because it allows taking into account the consumption of intermediate inputs.

As for the partial productivity, it refers to the additional production generated by the use of an additional unit of a given factor input. In farming, inputs used are usually land and labor. In this case, we can compute two types of partial productivity: labor productivity and land productivity (yield). Let's consider a production function with two variable inputs as follows: $Y = Y(L, S)$; where L and S represent respectively labor and agricultural land. Labor productivity and land productivity are respectively defined by $\frac{\partial Y(L,S)}{\partial L}$ and $\frac{\partial Y(L,S)}{\partial S}$. Yet, in practice, labor productivity is calculated by dividing output by the number of agricultural workers and land productivity is calculated by dividing output by the area of agricultural land.[10] In this study, we focus on agricultural labor productivity. Therefore, in our empirical analysis we use the agricultural added value per worker that has the advantage of being available for several countries over a long period.

2. Empirical specification and variable definitions

The baseline equation used in the econometric estimates can be written as follows:

$$LP_{it} = \beta_0 + \beta_1 * Access_{it} + B * W_{it} + u_i + v_t + \varepsilon_{it} \quad (10)$$

Where LP is the indicator of the agricultural labor productivity, measured by the agricultural added value per worker. $Access$ is the indicator of accessibility to drinking water in rural areas, measured by the percentage of rural population with access to improved water source. W a set of control variables including access rate to improved sanitation facilities in rural area, agricultural land, fertilizer consumption, Human Development Index (HDI), age dependency ratio and a dummy variable indicating whether the country is landlocked or not (see Appendix). u is unobserved country-specific effect, v is time-specific effect, ε is the idiosyncratic error component, "i" stands for the countries and "t" for the year.

In this equation, the direction and intensity of the effect of access to drinking water on agricultural productivity is given by the coefficient β_1. If it is positive and significant, this would imply that access to drinking water is conducive to agricultural productivity.

As shown in the previous section, the agricultural labor productivity can be defined as the per capita agricultural production. It is measured by the agricultural added value per worker. As the rural population includes active and inactive, we controlled the agricultural productivity for the age dependency ratio which is measured by the percentage of working-age population. Access to drinking water has been approximated by the percentage of rural population with access to drinking water. Human Development Index has been used to take into account the effect of human development on the productivity of the workforce. Indeed, labor productivity is greatly influenced by characteristics such as education, health and living standards which are two of the three dimensions of the Human Development Index. The influence of the natural productivity of the agricultural workforce has been controlled by the availability of arable land and fertilizer consumption. Availability of labor was measured by the percentage of agricultural land and fertilizers consumption by the number of kilograms per hectare of arable land. Furthermore, we introduced a dummy variable to control for the effect of being landlocked on agricultural productivity. This reflects the fact that countries with no access to the sea tend to have less rainfall and less fertile than those who do not. Thus, they should be more vulnerable to problems of access to potable water for non-landlocked countries. Indicator of fertilizer consumption has been taken into logarithmic values in all regressions.

The sample includes 27 developing countries in Africa of which 10 are landlocked, the remaining having access to the sea[11]. Indeed, in sub-Saharan Africa, it is generally noticed that the

[10]Usually referred to as yield per hectare and production per capita.
[11] The list of sample countries is in appendix.

coastal countries have rainfall more abundant than those that are landlocked. Thus, the former are relatively less sensitive to problems of access to water sources than the latter. Estimates are made over the period 1990-2005 which was divided into four sub-periods of five years. For each sub-period, the rate of access to drinking water and the rate of access to sanitation are those observed at the beginning of the period. For the others variables, they are measured by their average over each sub-period. Unit root tests were performed prior to the data using the test of Levin Lin and Chu (2002). There have been several approaches to testing for a unit root in panel data including Levin and Lin (1992) and Quah (1994). Levin, Lin and Chu (2002) improve on this by allowing heterogeneous panels. This test then assumed as the null hypothesis that all series are non-stationary against the alternative hypothesis that all series are stationary.

Several estimation methods have been used such as the pooled OLS (Ordinary Least Squares) estimator, the random effects estimator, the Two-Stage Least Squares (2SLS) estimator, the Amemiya and MaCurdy (AM) estimator and the Blundell and Bond system generalized method of moments (GMM) estimator. For OLS, the estimate was made without taking into account the individual-specific unobservable effects. In this case, we cannot control for possible unobserved heterogeneity. The second method allows one to control for unobserved heterogeneity that is to say, for the time invariant structural factors that can be deterministic or random. The 2SLS estimator corrects possible bias due to endogeneity of some explanatory variables. Indeed, in our econometric equation variables as the Human Development Index appear to be potentially endogenous. This endogeneity bias affects the value of the coefficient of this variable. The Amemiya and MaCurdy estimator is used not only to correct the endogeneity bias but also to solve the problems posed by possible time-invariant regressors. This estimator, like that of Hausman and Taylor correctly estimate the impact of time invariant variables. It also provides an estimate more efficient than that of Hausman-Taylor through the use of additional instrumental variables. Finally, the Blundell and Bond system generalized method of moments estimator can make estimates of dynamic panel that is to say a situation where the lagged endogenous variable appears among the explanatory variables. This method not only takes into account unobserved heterogeneity, but also corrects for possible endogeneity bias. This estimator is more efficient than the “Difference GMM” estimator which is accused of using weak instruments (Blundell et Bond, 1998). Finally, in the regressions, standard errors of coefficients have been corrected for heteroscedasticity by the White's method.

3. Main results and discusion

Results of the regression of agricultural labor productivity on access to drinking water and other determinants of agricultural productivity are presented in Table 1. Column 1 contains the OLS results and the four (4) other columns contain, respectively, those of the Random Effects model, the Two-Stage Least Squares (2SLS) estimator, the Amemiya and MaCurdy estimator and the system GMM estimator. The Random Effects Model (REM) was selected after applying the Hausman specification test (see Appendix). Indeed, for this test the p-value is above 10% so we are in the null hypothesis of no correlation between explanatory variables and individual effects. In this case, the Hausman test does not distinguish between the fixed effects model and random effects model because both provide consistent estimators. However, in practice, the random effects model is preferred to the fixed effects model because it provides a minimum variance estimator in this case.

Furthermore, as it is the case in this study, the random effects model is preferred over fixed effects model when the inter-individual variability is stronger than the intra-individual variability, when the time dimension is limited, and when there are time-invariant explanatory variables of interest in the model. This presumption is strengthened by the results of the Breusch-Pagan Lagrange multiplier test for random effects (see Appendix).

In the first three specifications (Table 1) the coefficients of determination ranging between 0.728 and 0.760, therefore the overall quality of fit of the estimated relationship is acceptable. In 2SLS estimation, suspected endogenous variable (Human Development Index) has been instrumented, using Human Development Index lagged one period value. The validity of this instrument has been verified because Sargen-Hansen test statistic is statistically insignificant from zero. In the estimation of dynamic panel, the Arellano and Bond test for autocorrelation rejects the hypothesis of the presence of second autocorrelation in errors term[12]. The Hansen overidentification test does not reject the non-correlation of instruments with the error term. The estimation of the dynamic model does not give directly the value of the coefficient of productivity level lagged one period. The computed value of this coefficient is -0.054. This implies that the initial level of productivity of the workforce has a reducing effect on his current value. Hence, there is a convergence of productivity levels of the rural labor between countries in our sample.

Table 1: Improved water source and labor productivity in rural area

Dependent variable: Labor Productivity	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
	OLS	**REM**	**2SLS**	**Amemiya-MaCurdy**	**System GMM**
Labor Productivity (-1)					0.946
					(9.44)***
Improved Water Sources	0.052	0.070	0.025	0.116	0.081
	(2.04)**	(2.22)**	(2.31)**	(1.77)*	(1.97)*
Improved sanitation facilities	0.095	0.057	0.051	0.011	0.027
	(1.42)	(0.815)	(1.178)	(0.483)	(1.054)
Agricultural Land	-0.272	-0.265	-0.251	-0.236	-0.038
	(1.02)	(2.62)***	(2.07)**	(1.80)*	(0.83)
Log of Fertilizer consumption	0.067	0.021	0.027	0.017	0.013
	(3.02)***	(2.27)**	(1.47)	(1.15)	(1.95)*
Human development index	1.866	1.933	1.223	1.415	0.200
	(6.60)***	(4.30)***	(2.92)***	(2.72)***	(2.37)**
Age Dependency Ratio	-0.140	-0.443	-0.420	-0.461	-0.402
	(1.65)	(2.05)**	(2.34)**	(2.51)**	(1.88)*
Landlocked country	0.470	0.630	0.451	0.687	0.026
	(6.45)***	(3.90)***	(2.18)**	(3.00)***	(0.34)
Constant	10.37	7.189	9.168	7.269	2.487
	(7.02)***	(5.94)***	(4.40)***	(6.42)***	(1.98)*
Observations	108	108	81	108	81
Number of countries	27	27	27	27	27
R-squared	0.758	0.728	0.760		
Sargan-Hansen Test (Prob)			0.39		
Hansen Test (Prob)					0.84
AR(2) (Prob)					0.32

Source: Estimated by the author based on the World Development Indicators 2009 (Word Bank)

Notes: Labor Productivity (-1) is the one period lag value of Labor Productivity
Absolute value of robust statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%
AR(*k*) : Arellano and Bond test of *k*-th order autocorrelation

Throughout, the results show that access to drinking water induces productivity gains in rural areas. Estimates show that an increase of one point of percentage of the access rate to drinking water in rural areas leads to increased productivity of the agricultural workforce of about 0.025% to 0.116%. The coefficient of this variable is significant whatever the specification considered. Paradoxically, we note that access to improved sanitation facilities does not significantly affect agricultural productivity. The paradox is that hygiene and sanitation contribute to improving the health status of populations and thus their intrinsic productivity. Its coefficient is non-significant in all specifications. This could be explained by persistence in habits of rural populations to use natural spaces as a receptacle of all waste and excreta. Indeed, if the establishment of sanitation facilities (latrines modern public and private garbage bins, drains for sewage disposal, etc.) in rural areas was not accompanied by a wide awareness campaign, the beneficiary populations may be reluctant to use these facilities because of their habits or because they are unaware of its usefulness. Among other control variables, Human Development Index and fertilizer consumption significantly and positively explain agricultural productivity in all specifications. We note that the impact of increasing the Human Development Index on the productivity of labor varies between 0.2% and 1.93%.About fertilizer consumption, results show that

[12] By construction, the term error in the dynamic model is first-order serially correlated. However, it should not be second-order serially correlated.

the use of an additional 1% of fertilizer increases agricultural productivity from 0.013 to 0.067%. Landlocked countries are likely to record higher impact of access to drinking water on agricultural productivity. This result is quite intuitive because the non-landlocked countries have generally more fertile land and more precipitation than the landlocked countries. Therefore, they have levels of agricultural productivity relatively higher than those of landlocked countries and, ultimately, are relatively less sensitive to increases in rates of access to drinking water. Moreover, the age dependency ratio has a negative impact on agricultural productivity growth, although its coefficient is not significant for the OLS estimator. Indeed, the higher this ratio, the higher the representative household has relatively more non-active members than active members, and therefore, agricultural productivity of the household will be low. Finally, these results show that increasing the relative areas of agricultural land in total land area reduces the productivity of labor.

Subsequently, we tried to see if there is a difference between rural and urban areas in terms of impact of access to drinking water on agricultural productivity. Therefore, we evaluated the impact of increasing the access rate to drinking water in rural and urban areas on agricultural productivity (Table 2).

Table 2: Improved water source and labor productivity in rural and urban area

Dependent variable: Labor Productivity	**Urban**		**Rural**	
	Coefficient	**t-Stat**	**Coefficient**	**t-Stat**
Improved Water Source	0.106	(0.780)	0.070**	(2.22)
Improved Sanitation Facilities	0.0703*	(1.81)	0.057	(0.815)
Agricultural Land	-0.272*	(1.79)	-0.265***	(2.62)
Log of Fertilizer Consumption	0.061**	(2.271)	0.021**	(2.27)
Human development index	2.955***	(6.77)	1.933***	(4.30)
Age Dependency Ratio	-1.269**	(2.055)	-0.443**	(2.05)
Landlocked country	-0.488***	(6.40)	0.630***	(3.90)
Constant	11.938***	(7.91)	7.189***	(5.94)
Observations	108		108	
Number of countries	27		27	
R-squared	0.725		0.728	

Source: Estimated by the author based on the World Development Indicators 2009 (Word Bank)
Notes: * Significant at 10%; ** significant at 5%; *** significant at 1%
Absolute value of robust statistics in brackets

It comes out that access to drinking water significantly increases the productivity of labor in rural areas but not in urban areas. This result is due to the fact that in most countries in our sample, the bulk of agricultural production is made by rural people. Furthermore, that increasing the access rate to drinking water in urban areas has no significant impact on the productivity of the agricultural workforce. This could be explained by the fact that rural people, who are more vulnerable to problems of accessing drinking water, are more sensitive to these problems and therefore needier than urban populations. In this case, investments in drinking water should have a greater impact in rural areas.

Indeed, in developing countries, the system of water supply is managed by public enterprises that are in charge of production, storage and distribution of drinking water. These companies do not generally have sufficient financial resources to extend their services to rural areas, limiting access to drinking water in these areas. Thus, in rural areas, infrastructure access to drinking water essentially boils down to deep well hand pump system, rainwater collector system, and piped water supply system (to a lesser extent). We also note that the positive coefficient of access to sanitation becomes significant in urban areas. This reflects the fact that, unlike in rural areas where its effect is not significant, sanitation significantly increases the productivity of the urban workforce.

So, according to the reasons we have argued above to justify the non-significance of this factor in rural areas, urban populations have habits to support the use of improved sanitation facilities. In addition, the coefficients of other control variables have the same signs as they had in the regression for rural areas, although their level of significance is not always the same.

Finally, in view to check whether there are factors that strengthen or weaken the impact of access to drinking water, we performed regressions including interaction terms. The results of these regressions are presented in Table 3. Under the estimated coefficients of interaction variables, we note first that the interaction term between access to improved water sources and access to improved sanitation facilities has a positive and significant coefficient (Column 1).

This is a proof that the impact of access to safe drinking water depends on the level of access to sanitation services. The more people have access to improved sanitation facilities, the more their productivity increases due to improving access to drinking water. Access to improved sanitation facilities becomes significant through the interaction effect with access to drinking water. This result is in line with that of Esrey (1996), which suggests that increased access to safe drinking water can improve people's health, when accompanied by adequate sanitation.

Table 3: Regressions including interaction terms

Labor Productivity	**(1)**		**(2)**	
	Coefficient	**t-Stat**	**Coefficient**	**t-Stat**
Improved Water Source (IWS)	0.369***	(2.698)	0.145	(1.436)
Improved Sanitation Facilities (ISF)	0.0333	(0.273)	0.00681	(1.252)
IWS*ISF	0.000273*	(1.899)		
Agricultural Land	-0.277***	(2.732)	-0.285***	(2.720)
Log of Fertilizer	-0.0146	(0.933)	-0.0189	(1.180)
HDI	1.811***	(3.779)	1.992***	(4.182)
D_Ratio	-0.471**	(2.488)	-0.525***	(2.724)
Landlocked country	-0.593***	(3.464)	-0.888**	(2.166)
Landlocked country *IWS			0.0916**	(2.464)
Constant	7.100***	(6.467)	7.548***	(6.589)
Observations	108		108	
Number of countries	27		27	
R-squared	0.716		0.713	

Source: Estimated by the author based on the World Development Indicators 2009 (World Bank)

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%
Absolute value of robust statistics in brackets

We also note that the fact that a country is landlocked reinforces the impact of access to drinking water on labor productivity (Column 2). This means that this impact is more pronounced for landlocked countries. Indeed, this group of countries experiences lower rainfall than non-landlocked countries and thus is more sensitive to problems of access to drinking water. This sensibility is exacerbated in rural areas.

5. Concluding remarks

In this paper, we analyzed the effects of increasing the access rate to drinking water in rural areas of developing countries. Built on a microeconomic framework for analyzing the rural household, this study highlights theoretically and empirically the positive impact of the access rate to drinking water on the productivity of the agricultural workforce. On the one hand, this effect is seen through improving the intrinsic productivity of farmers due mainly to the improvement of their hygiene and their health. Moreover, this effect operates through the reallocation of household's time for food production. In addition, the theoretical argument that highlights the costs in terms of reduced productivity and well-being imposed by a constraint to access to drinking water has been presented. The empirical analysis reveals that increasing the access rate to drinking water significantly increases agricultural labor productivity. This gain in productivity is higher in rural than in urban areas. In a paradoxical way, the access rate to improved sanitation facilities has not significantly impact the productivity of rural labor. The use of regression including interaction terms revealed new findings. First, we note that access to clean water and access to sanitation are complementary. Indeed, the impact of access to drinking water on the productivity of rural households is higher with improved sanitation facilities. Moreover, we find that being landlocked is a factor in strengthening the impact of access to drinking water. This suggests that landlocked countries have an impact on their agricultural productivity stronger than that of non-landlocked countries.

These results have very important policy implications. First, rural development policies and the fight against poverty must focus on access to basic social services, including the establishment of improved water sources and improved sanitation facilities in these areas. For access to drinking water, this can be piped water into dwelling (plot or yard), public tap/standpipe, ubewell/borehole, protected dug well, protected spring, and rainwater collection. About the improvement of hygiene and sanitation, emphasis should be put on flush or pour-flush (to piped sewer system, septic tank and pit latrine), ventilated improved pit latrine, pit latrine with slab, and composting toilet. Indeed, as the results show, the impact of improved water sources is reinforced by the sanitation facilities in urban areas. Moreover, in a context of limited resources, a better consideration of landlocked countries or regions would be beneficial given the sensitivity of these areas with problems of access to drinking water sources. This does not imply that investments in this sector for the non-landlocked countries should be neglected.

The results of this study would be stronger with the use of a more rigorous impact assessment. This is the case of analysis using experimental quasi-experimental or non-experimental methods. However, these methods require the availability of microeconomic data (household surveys, in particular). Finally, the analytical framework developed here could also be used to analyze other issues relating to access to basic social services in rural areas such as health services and basic education.

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Appendix

Sample countries
Burundi, Benin, Burkina Faso, Botswana, Central African Republic, Cote d'Ivoire, Comoros, Cape Verde, Algeria, Egypt Arab Rep., Gabon, Guinea-Bissau, Morocco, Madagascar, Mali, Mozambique, Malawi, Namibia, Rwanda, Sudan, Senegal, Chad, Tunisia, Tanzania, Uganda, South Africa, Zambia

Table 4: Variable definitions and sources

Variable	Notation	Source of data
Labor Productivity (Agricultural added value per worker)	LP	World Bank, World Development Indicators 2009
Improved Water Source, rural (% of rural population with access)	IWSR	World Bank, World Development Indicators 2009
Improved Water Source, urban (% of urban population with access)	IWSU	World Bank, World Development Indicators 2009
Improved sanitation facilities, rural (% of rural population with access)	ISFR	World Bank, World Development Indicators 2009
Improved sanitation facilities, urban (% of rural population with access)	ISFU	World Bank, World Development Indicators 2009
Agricultural Land (% of land area)	Land	World Bank, World Development Indicators 2009
Age Dependency Ratio (% of working-age population)	D_Ratio	World Bank, World Development Indicators 2009
Fertilizer consumption (kilograms per hectare of arable land)	Fertilizer	World Bank, World Development Indicators 2009
Human development index	HDI	United Nations Development Program
Dummy taking 1 if country is landlocked	Landlocked country	-

Table 5: Non-stationarity tests

	Trend	No trend
	t_r^*	t_r^*
Labor Productivity	-22.84	-78.72
	(0.00)	(0.00)
Improved Water Source, rural	-14.64	-15.40
	(0.00)	(0.00)
Improved Water Source, urban	-1.11	-30.69
	(0.09)	(0.00)
Improved sanitation facilities, rural	-17.27	-20.55
	(0.00)	(0.00)
Improved sanitation facilities, urban	-15.59	-33.61
	(0.00)	(0.00)
Agricultural Land	-10.90	-61.82
	(0.00)	(0.00)
Age Dependency Ratio	-23.52	-31.57
	(0.00)	(0.00)
Fertilizer consumption	18.49	-44.33
	(0.74)	(0.00)
Human development index	-45.44	-19.06
	(0.00)	(0.00)

Notes: p-values in brackets

Table 6: Hausman specification test

Coefficients				
	Coefficients		(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
	(b)	(B)		
	eq1	.		
IWSR	.0831441	.070341	.0128031	.0489558
ISFR	.1510121	-.2649433	.4159554	.3083501
Land	-.0102796	-.0218224	.0115428	.0052574
Log of Fertilizer	.0083779	.0171748	.0087969	.0050979
HDI	.4626324	.44335	.0192824	.045764
D_Ratio	-.5033685	-.5041378	.0007693	.055115
chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)= 4.04 Prob>chi2 = 0.5439 (V_b-V_B is not positive definite)				

Table 7: Breusch-Pagan test for random effects

```
Breusch and Pagan Lagrangian multiplier test for random effects
l_pml[country,t] = Xb + u[country] + e[country,t]
Estimated  results:
Varsd = sqrt(Var)
---------+-----------------------------
Lp           .6052617       .7779857
e            .0182134       .1349572
u            .1540834       .3925346

Test:   Var(u) = 0
chi2(1) =   104.00     Prob> chi2 =     0.0000
```