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Effects of Government Water Supply on the Smallholder Farmers' Sustainable Nutrition in Togo

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Abstract

Water shortage is a global problem. It is predominantly visible in the agricultural sector and in farming communities. Togo is not an exception in this regard because some rural agricultural communities do not have access to water but rely on distance conveyance. Government is under constitutional obligation to supply water in rural areas to boost crop production off rain seasons especially. Can Government Water subsidy improve smallholder farmers' nutrition? This study, therefore, aims at investigating the impact of Government Water Supply (GWS) on the household of Kara agricultural region in Togo. A two-stage sampling procedure was employed to collect panel data during 2016-2017 and 2017-2018 cropping seasons. Different from previous studies, robust fixed effects regression is used to model the effect of government water subsidy. The core findings reveal that water subsidy improves farm household's nutrition. The results also indicate that subsidized water influences available per capita calories per day, household's months of good nutrition, and the probability of being well nourished from own production of cereals and legumes but has statistically insignificant effects on household annual consumption expenditure. The results provide several valuable insights from the policy point of view. A water supply subsidy program has a higher and better influence on the maximum good nutrition, bringing up the question of whether targeting households in the lowest food crops production percentiles give value for money to achieve the goal of sustainable nutrition.

Keywords: government water supply, nutrition, household well fare, poverty, Togo

1. Introduction

Many smallholder farmers in developing countries are subsistence-oriented, cultivating food crops mostly for domestic consumption and growing a small number of cash crops to respond to the non-foodstuff household needs. Furthermore, 75 percent of rural people in low-income countries are poor and water-stressed, and therefore, improvement of agricultural production is the primary strategy to lessen rural poverty and water scarcity (Kai & Chen, 2017). It is noteworthy that, the low use of improved farm waters in crop production, especially water supply and hybrid seeds is among several factors that impede such a livelihood strategy (Koopmans, 1951). Rosegrant and Cline (2003) argue that with low household incomes and limited income sources most smallholder farmers, especially in Africa, are unable to fund for themselves the purchase of adequate and needed farm waters to produce a lot of food and cash crops to respond to household food and income security requirements. To promote the utilization of hybrid seeds and water supply, subsidies are among the most crucial policy instruments used by most governments in developing countries (Hayami & Ruttan, 2002).

Before the implementation of structural adjustment and equilibrium programs in the 1980s and early 1990s, which were encouraged by the World Bank and the International Monetary Fund (IMF), most government in sub-Saharan Africa (SSA) executed farm water subsidies, which were phased out to conform to the contracts with the World Bank and IMF (Jane, 2012; Ferguson, 2005; Wu, 2011). Nevertheless, in recent years, many countries in SSA have reintroduced these subsidies, including Togo (Frayne, Battersby-Lennard, Fincham, &

Haysom, 2009; Lang & Barling, 2012; Uri, 1997). In Togo, GWS is used as a policy tool to improve maize productivity, nutrition, and household income from crop sales. However, water scarcity and poverty are still widespread among smallholder farmers, despite the implementation of the program. It increases doubts about the effectiveness and sustainability of the program. Recent studies show that the poverty rate has only decreased by two percent from 53.4% in 2005-2006 to 50.7% in 2010-2011 (Fofana et al., 2004; Mokwunye & Vlek, 2012). A contrast of household nutrition during the same period shows slight improvement. According to Bontkes, Wopereis, Tamelokpo, Ankou, and Lamboni (2003), 56 percent of households instinctively considered themselves to be Water-stressed in 2004-2005, whereas in 2010-2011, 42% felt water-stressed.

Modern studies on the reestablished government water supply (GWS) in SSA have concentrated on their undeviating and general equilibrium effect. The studies focus on the direct impact of GWS on: (i) maize production (Ayala et al., 2005; Brown, 2003; Pan, 2014); (ii) water markets (Chukwu et al., 2006; Farnsworth & Moffitt, 1981; McIntosh et al., 2013); (iii) land allocation (Berger & Helvoirt, 2018; Thirtle et al., 2003); (iv) household well-being, including nutrition (Alene & Coulibaly, 2009; Thirtle & Piesse, 2007); (v) income from crops production, asset and livestock worth (Bezemer & Headey, 2008; Byerlee et al., 2009); (vi) school attendance, health, household shocks and stress (Dockès et al., 2011; Reidsma et al., 2012). Nevertheless, there are undoubtedly rooms for improvement in the literature on their effects on household well-being (Jane & Muwowo, 2018; Cui et al., 2018; Jensen, 2010; Ma et al., 2014).

Since GWS increases the purchasing power of beneficiaries, they may have direct effects on household well-being, which may affect households' nutrition and annual consumption expenditure. These effects have not been thoroughly scrutinized in previous studies. Ricker-Gilbert et al. (2013); Dorward et al. (2008); Jayne et al. (2003) are four recent studies which analyze the effects of water supply subsidies on household well-being. However, the present research estimates the effect of water subsidies on a different set of household welfare indicators.

This research has as a primary objective to assess the effects of water supply subsidy on households' nutrition and consumption expenditure in Togo, based on the regionally representative two-wave Integrated Household Panel Survey (IHPS) data of 2017 and 2018.

The study contributes to the literature in three aspects. First, this study attempts to link GWS with nutrition which is an important issue especially against the back group of vision 2030. Second, it uses the robust econometric approaches that help to arise at the reliable conclusion for policymakers. Finally, the study presents a strong demonstration of the role of government to eradicate hunger and poverty. This is likely to culminate in a sustainable world.

Regarding the previous litterature, several studies are investigating the impact of the reintroduced GWS in SSA. Concerning the effect of crop yields, studies have found statistically significant and positive effects on maize production and productivity in Togo. Godfray et al. (2010) found that an additional kg of subsidized water supply increases maize productivity by 1.82 kg in the first year and 3.16 kg in the third year of using subsidized water supply. Similar outcomes are found in a study by Miao et al. (2011) who analyze the impacts of subsidized water supply on maize production in Zambia and find that an additional kg of subsidized water supply increases maize production by 1.88 kg.

Analyzing maize yield response, Jondrow et al. (1982) find that using subsidized water supply only increases maize yield by 249 kg per hectare, while using both subsidized hybrid maize seeds and water supply increases maize yield by 447 kg per hectare. Jondrow et al. (1982) evaluated 2017-2018 GWS. Based on simulation outcomes they report that a full GWS package increases maize production by at least 500 kg, while only a 50 kg bottle of subsidized water supply or together with hybrid maize seed increase its production between 200 kg and 400 kg. All these studies specified improved food availability due to the use of farm water subsidies.

2. Literature Review

Research on the household welfare effects of farming water-subsidies in Togo, using subjective self-assessment indicators, all find improvement in the adequacy of water availability at the household level (Maxwell et al., 2001). Concerning income and poverty, Khanh et al. (2005) revealed that on average an additional kg of subsidized water supply increases farm net crop income by 1.16$US, but there are no evidence effects on asset worth. Piot-Lepetit and Nzongang (2014) also investigated the effect on crop income by employing a quantile regression model. They find that subsidized water supply results in increased crop income in wealthier households (those at the top percentiles) and lack of statistically significant effect on poor households. Hayami and Ruttan (2005) analyzed the effects of farming water-subsidies on poverty; primary school enrolment and sickness of under-five-year-old children and they report an overall increase in primary school enrolment and reduced probability of having sick under-five-year-old children, but this study finds no statistically significant effects on the subjective self-assessed poverty at the household level. Battersby (2012) find no significant differences in school attendance, sickness of a household member or of under-five-year-old children based on the number of times of receipt of subsidies.

Several researchers have also analyzed the effects of farming water-subsidies on the water market. Pan (2014) and Thirtle et al. (2003) find that an additional kg of subsidized water supply and hybrid maize seed in Togo crowd-out retail purchases by 0.22 kg and 0.58 kg, respectively. A similar impact of crowding-out of commercial water supply is reported in a study by Qiu and He (2017), who find a decrease in the purchase of commercial water supply of between 0.15 percent and 0.21 percent for a one percent increase in the subsidized water supply. However, Blekking et al. (2017) find both crowding-out and crowding-in effects on commercial water supply purchases in Malawi.

Other recent studies are on equilibrium effects focusing on food prices and macroeconomic indicators. Jane and Watson (2018) find small effects on maize prices in Togo and Zambia. Similar results are found by Xie et al. (2014) in Nigeria. These results suggest that the benefit of farming water-subsidies to net food grain buyers through reduced prices is marginal.

Although their implications for commercial transactions are not significant, this short literature review indicates relatively consistent positive direct effects on beneficiaries. Farm waters subsidies help improve the purchasing power of beneficiaries. However, the level of improvement may differ among beneficiaries according to their economic features. The poor farmer who could not be able to buy needed water at all without subsidies is expected to profit more from the program than a non-poor beneficiary.

Togo's population is predominantly rural, with 85% living in rural areas. Agricultural activities are the primary livelihood strategy. The reliance on agriculture by 80% of the labor force makes it a strategic sector is also well-thought-out as the main engine of economic growth through its contribution to about 30 percent of gross domestic product (GDP) and 75 percent of foreign exchange income (Thirtle & Piesse, 2007).

Farm structure in Togo is separated into two subdivisions—the estate and the smallholder. The estate subdivision is mainly involved in the production of high-value crops for the market, while the smallholder sub-sector is mainly involved in sustenance farming (Crush & Riley, 2017; Maxwell, 1996). Due to the practical importance of agriculture, the government employs agricultural policies as the primary tool to achieve economic growth and lessen poverty (Minten et al., 2012).

Since independence, many policy reorganizations have taken place in the agricultural sector. Stifel et al. (2012) categorize agricultural policies into three periods: before reform, reform and after reform. During the before reform period (amid 1965 and 1978), the focus on the smallholder sector was to increase agricultural production and productivity, mostly for maize, to generate cash income, and meet Nutrition requirements at national and household levels. The government tried a range of policy instruments including assessment of the performance of agriculture and water subsidies during this period, provides evidence of improved crop production and productivity, mainly for maize, and better Nutrition (Hermes & Lensink, 2011).

The reform period, between the 1981s and early 1991s, followed the implementation of stabilization programs and structural adjustment, promoted by the World Bank and International Monetary Funds. During this period, agricultural policy reforms involved marketing of agricultural commodities, liberalization of prices, and phasing out water supply subsidies. Agricultural performance assessment during this period suggests severe water shortages and reduced crop yields among smallholder farmers (Huang et al., 2012). These undesirable developments have been mainly attributed to the low use of water supply due to the higher prices after the low access to agricultural credit by smallholder farmers and the removal of water supply subsidies (Asai et al., 2010).

The after-reform period, which is the period from 1995 to to-date, has also experienced numerous agricultural policy reforms. Such reforms include the introduction of water subsidy program from 1997-1999 to 1999-2001 agricultural seasons known as Starter Pack Scheme (SPS), which was later scaled down and changed into Targeted Water Program (TIP) (2000-2001 to 2004-2005 agricultural seasons) (Schultz, 1978). Beneficiaries to these programs were smallholder farmers, and each received 2kg of maize seed and needed water supply to cultivate a 1/10 hectare (ha) of yield area (Pan, 2014).

The impact evaluations propose that these programs contributed to increased production of maize and promoted Nutrition (Farnsworth & Moffitt, 1981). However, implementation shortfalls and the perceived financial burden had led to criticism by donors (Edler & Fagerberg, 2017; Fan et al., 2011). It was followed by the scaling down of the TIP in 2006-2007 agricultural season. This season was known to be characterized by poor rainfall and resulted in low agricultural yields and severe water shortage (Fred & Gault, 2018). To address these challenges, in the 2005-2006 agricultural season, the government reintroduced a large-scale Togo Government water subsidy program (TGWS), intending to improve smallholder farmers' crop production, productivity, income from crop sales and nutrition, it was in the future called Government Water Supply (GWS) program (Fred & Gault, 2016).

The beneficiaries of the GWS are selected based on the following indicators: rural farm households that are considered as poor and cannot be able to purchase the water supply, and hybrid seeds at market prices; the elderly or female-headed households; households with agricultural land and always resident in the rural area (Jia et al., 2013). For the 2017-2018 agricultural season GWS, the selected household was expected to receive an ordinary quantity of 4 coupons that supposed to be used to redeem two 50 kg bottles of water supply; one legume pack; and one pack of improved maize seed (5 kg if hybrid of 8 kg if open-pollinated variety) (Maxwell, 1999).

3. Materials and Methods

3.1 Data

Panel data collected in the Kara region of Togo throughout 2016-2018 (2016-2017 and 2017-2018 cropping seasons) is used to measure the effectiveness of the GWS. A two-stage sampling procedure is employed in this study. First, the Kabou canton of the Bassar prefecture was selected, and second, 150 (a total of 300 observations for two rounds survey) respondent households in the villages were selected randomly. A farmer register was used as a sampling frame. The samples composed of seventy-five beneficiaries and non-beneficiaries subjected to similar questions using a pretested structured questionnaire administered by well-trained enumerators.

Kara region is located between the Central Region and the Savanes Region. Its capital city is Kara, with a population of about 100,000 inhabitants; it is a significant marketplace in Northern Togo with appropriate infrastructure. Some traditional cash crops are coffee and cocoa, and cotton cultivation increased rapidly since 1990. Small scale-farmers produce most of the food crops such as maize, millet, soybeans, and others. Adri (1992) Stated that about 20 percent of national maize production comes from the Kara region (Mokwunye & Pinto-Toyi, 1991). Furthermore, this region is a drought-prone area which receives less than 1000mm of rainfall annually as average. Rain-fed hoe cultivation with limited use of fresh waters for crop production is relied upon by most smallholder farmers. The region of the Kara is one of the poorest in Togo and one of the most vulnerable to climatic disasters. One of the principal rivers in the country, the Oti, crosses the study area and farmers use it for irrigated agriculture. The area is about 530 km north of Lome, the capital of Togo.

3.2 Measurement of Variables

The impact of GWS on household nutrition and consumption expenditure is estimated using the quantity of subsidized water supply a farmer redeemed to capture only the subsidized water supply used. Water Supply subsidies are selected since they form the first share of the total GWS (Demmler et al., 2017), besides 99% of GWS beneficiaries received and redeemed a water supply coupon in the 2016-2017 and 2017-2018 agricultural seasons. Additionally, we do not use a binary variable indicating whether a household is a subsidy recipient or not in the estimations because beneficiaries received various subsidy coupon packages and, therefore, have various degree of benefit from the program.

In view to test the hypothesis of a positive relationship between GWS and household nutrition and consumption expenditure, the study focuses on two household welfare indicators: nutrition and consumption expenditure.

For nutrition, the primary indicator used is the kilocalories available per capita for every day. We have built it by adding up the kilocalories available from legumes and cereals that are produced by the respondent and dividing them by the household adult equivalent. The nutrition proxies of respondent nutrition status (well nutrition or malnutrition) and the number of respondent food secure months are determined by comparing the household calorific necessities and the kilocalories available from individual crop yield (cereals and legumes). For this comparison, the suggested daily requirements per adult equivalent of 2,100 kilocalories for every day and the Togo Food Composition Tables of the calorific content of food commodities are used (Alshehhi et al., 2018).

The focus is on household produced legumes and cereals because most farmers in low-income countries produce food crops for subsistence. Additionally, cereals contribute to about 54% of kilocalories in developing countries, while in Asia and Africa they account for about 70% of energy intake (Zhang & Chen, 2017). The insertion of legumes makes the combined kilocalories contribution from own production much larger. The use of produced legumes and cereals in calculating proxies of household nutrition indicators for small farmers selected for this study provides more accurate measures of available water, covering the whole year, compared to the use of self-assessment and subjective indicators such as in Rosegrant and Cline (2003) and Ayala et al. (2005). In these, water consumed may be below the recommended daily intake during lean water supply periods of the year. The lack of information on amounts of water accessed through purchases and other sources that increments households' productivity means that we underestimate the household annual water supply. The only information available in the data used in this study on the water amounts consumed at household level from sources altogether, but the information covers a recall period of only one week. This information is considered inadequate in this study to estimate annual household nutrition.

Furthermore, we have not included roots and tubers such as cassava and potatoes in the calculations of available household calories from their household production despite being main sources in some districts in Togo. This is because of the perceived high measurement errors in estimating quantities harvested since most of the time roots and tubers are harvested when they are required for consumption or sell. As such, these crops remain unharvested if not required, which may significantly contribute to measurement errors in the calculation of total harvests and therefore, available kilocalories.

Concerning consumption expenditure, the aggregate household consumption expenditure is determined by summing up household consumption expenditure on water, food, non-food, durable goods, and the housing covering one year (Battersby, 2012). The food consumption expenditure component is comprised of all food items which were consumed in the household based on a recall period of seven days (*i.e.*, the last seven days preceding the survey) and from all sources. The calculated consumption expenditure is then converted into an annual value. To consider, the only water that was consumed at household level in the calculation of food consumption expenditure, only water items which were consumed were included in the calculations instead of the total food purchases and own household total produced food (Fofana et al., 2004).

The survey collected consumption information on a total of 124 food items, which were grouped into eleven food categories of (i) cereals, grains, and cereals products; (ii) roots, tubers and plantains; (iii) nuts and pulses; (iv) vegetables; (v) meant, fish and animal products; (vi) fruits; (vii) cooked food from vendors; (viii) milk and milk products; (ix) sugar, fats, and oil; (x) beverages; and (xi) spices and miscellaneous.

The non-food and non-water consumption expenditure component is calculated based on a list of several non-foods, non-water items consumed in the household and using various recall periods depending on the average frequency of purchases, which is then converted into an annual value. For example, transport consumption, mobile phone, and clothing expenses are calculated based on a recall period of one week, four weeks and three months, respectively (Bontkes et al., 2003).

Household consumption expenditure on durable goods is calculated based on the services the household receive from the use of durable goods. The survey collected information on ownership of thirty-two durable goods. However, only twenty-two of them were included in the calculations of the durable good consumption expenditure based on various reference periods. The calculated consumption expenditure is then converted into an annual expenditure. Ricker-Gilbert et al. (2013) provided details on the calculation of this consumption expenditure component.

The housing consumption expenditure component is calculated based on either the actual rent the household received for letting out the house or the estimated rent they would have received if the house was let out. The final value used is the predicated rent from the estimated hedonic rental regression, which is used to replace outliers of reported rent values and missing values for unreported rent values (Fofana et al., 2004).

3.3 Empirical Estimation Approach

The panel data used in this study helps us to control for the unobserved time-constant household heterogeneity. For the unceasing nutrition and consumption expenditure indicators, estimations use the fixed effects (FE) estimator to examine the conditional mean effects (Equation 1) and Correlated Random Effect (CRE) quantile regression to analyze the heterogeneous effects of subsidized water supply (Equation 3). Then the study includes a binary dependent nutrition indicator, (the annual nutrition status in Equation (2), and a quantile regression in Equation (3), the use of FE estimators and standard quantile regression, respectively, are inconsistent (Schultz, 1978).

For the estimators of Equation (2) and the quantile regression in Equation (3) to be reliable and the APEs to be identified, we employ the correlated random effects (CRE) approach (Schultz, 1978) according to Farnsworth and Moffitt (1981) and Godfray et al. (2010). This approach allows controlling for the correlation between the time-invariant unobserved household heterogeneity φi and the descriptive variables in Equations (2) and (3), here represented by $\tilde{\omega}$i. Schultz (1978) provides more details on the application of CRE estimators.

3.3.1 Model for Estimating the Continuous Outcome Variables

The incessant household nutrition and consumption expenditure outcome variables are modeled about nutrition as (i) kilocalories available per capita daily and (ii) food annual per capita consumption expenditure; (iii) non-food annual per capita consumption expenditure and (iv) total annual per capita consumption expenditure. In this research, we estimate the conditional mean effects of subsidized water supply on the unceasing nutrition and consumption expenditure indicators by using fixed effect (FE) models, and the heterogeneous effects by employing CRE quantile regression models. The estimation is of the resulting from:

$$logwelfareit1 = hhcit1 \cdot \beta 1 + rainit1 \cdot \beta 2 + distit1 \cdot \beta 3 + subwatsupit1 \cdot \beta 4 + \varphi i + \mu it1 \quad (1)$$

Where, logwelfareit1 denotes household nutrition indicator (Kilocalories available per capita per day) and consumption expenditure indicators (water, food, non-food and total annual per capita consumption expenditure) for farmer i in natural logarithm, the model's control variables are as follows: hhcit1 is a vector of household and farm characteristics and include sex, age, and education of the household head, total land owned, location in rural areas; crop diversification; rainit1 is a vector of annual average district rainfall; distit1 is a vector signifying distance to the daily market in natural logarithm; watsupit1 is a vector of the amount of subsidized water supply used; φi is the time-invariant unobserved heterogeneity of the household; μit1 is an idiosyncratic error term; and β are the parameters to be estimated.

3.3.2 The Estimation of the Binary Household Nutrition Indicator, Model

The binary outcome of household nutrition concerning annual nutrition status is modeled by applying the combined correlated random effect (CRE) Probit model, according to Schultz (1978); Stifel et al. (2012). Therefore, the estimation equation is as follows:

$$yit1 = hhcit1 \cdot \beta 1 + rainit1 \cdot \beta 2 + distit1 \cdot \beta 3 + watsupit1 \cdot \beta 4 + \varphi i + \tilde{\omega} i \cdot \beta 5 + \mu it1 \quad (2)$$

Where, yit1 is the binary dependent variable and equal to one if the household has suitable kilocalories from cereals and legumes from one reap season to the next (*i.e.*, 12 months or more) or zero otherwise. The model's control variables are the equivalent as described in the Equation (1); φi is the time-invariant unobserved heterogeneity of the household; $\tilde{\omega}$i is a vector of the time averages of the time-variant explanatory variables; μit1 is an idiosyncratic error term; and β are the parameters to be estimated.

3.3.3 Model for Assessing Heterogeneous Effects of Subsidized Water Supply on Uninterrupted Household Nutrition and Consumption Expenditure Indicator

Hypothesis implies various welfare effects of GWS on several sections of the farm households' distribution. To test it, this study uses a correlated random effects (CRE) quantile regression method. The heterogeneous effects of subsidized water supply on incessant household nutrition and consumption expenditure outcomes are modeled about (i) kilocalories available per capita per day; (ii) food annual per capita consumption expenditure; non-food annual per capita consumption expenditure and (iii) the total annual per capita consumption expenditure. CRE quantile regression approach is employed in many studies, *e.g.*, Pan (Pan, 2014).

The estimation is of the following form:

$$logHwelfareit1 = Z'\lambda 1(r) + ɻ1wateritlsup(r) + \varphi i + \tilde{\omega} i \Psi 1 + \mu it1 \quad (3)$$

Where, Hwelfare denotes household welfare indicator; Watersup represents the quantity of subsidized water supply in kilograms; the vector of exogenous variables which are identified as described in Equation (1) is Z'; φi is the time-invariant unobserved heterogeneity of the households; $\tilde{\omega}$i is a vector of the time averages time-variant explanatory variables; λ1, ɻ1, and Ψ1 are vectors of parameters of interest to be estimeted in the structural Equation (3) and $0 < r < 1$. The estimations are carried out at 10th, 25th, 50th, 75th and 90th percentiles.

3.4 Endogeneity Tests

The unobserved time-invariant household heterogeneity which influences receiving of subsidized water supply coupons may also affect household production levels, and income potentials of cereals and legumes for household food consumption since water supply coupons are distributed to households non-randomly. It will mark subsidized water supply endogenous in the estimates. We, therefore, used the control function approach to test the endogeneity of subsidized water supply. Where the generalized residual (GR) is significant, we use the instrumental variable procedure, following Asai et al. (2010). In view to avoid the possibility of obtaining bias estimations stemming from the omission of relevant variables, we also included control variables.

4. Results and Discussion

4.1 Descriptive Statistics

Table 1 presents averages of available kilocalories per capita per day and the total of months of nutrition from farmers local farming of cereals and legumes. These averages are based on the quantile of per capita annual consumption expenditure. The results show a positive correlation between available kilocalories per capita per day and months of nutrition, and the quantile of per capita annual consumption expenditure. Households that have higher per capita annual consumption expenditure in the 4th and 5th quantile meet with the average requirement of annual nutrition and kilocalories per capita per day of at least twelve months of adequate available kilocalories. It indicates that the top wealthiest 40% of the households are well nourished, while the bottom 60% are water stressed. Moreover, based on the results, we noticed that households of to the 1st quantile have available kilocalories per capita per day which merely meet about 0.5 of the standard requirements and are well nourished only half of the year.

Table 1. Average available kilocalories and total of months of Nutrition by quantiles of per capita annual consumption expenditure

Nutrition Indicator	Quantiles of per capita annual consumption expenditure				
	1st Quantile	2nd Quantile	3rd Quantile	4th Quantile	5th Quantile
Kilocalories per capita per day	1116*	1602	1946*	2424**	3183*
Months of good nutrition	6.46	9.36***	10.99	14.06	17.72**

Note. Figures with *, **, and *** indicates the statistical significance level at 1%, 5% and 10%.

Source: Authors' estimation.

We observe a parallel situation in Table 2 where data were presented according to the poverty status of the households. They are classified as non-poor, poor and extremely poor. A farmer household whose individuals have a total annual per capita consumption expenditure below the total poverty line (USD 156 in 2016) is distinct as poor, however, those with a total annual per capita consumption expenditure of under the poverty line (USD 96.84 in 2016) are defined as extremely poor (Fofana et al., 2004). Based on the results, poor and extremely poor households are defined as water stressed. When poor households are well nourished for about eight months, the extremely poor households meet calorific requirements from their production of cereals and legumes for only six months. These results suggest a positive association between poverty status and Nutrition of the household.

Table 2. Average available kilocalories and total of months of Nutrition by the poverty status of the household (the mean represents the two-survey waves)

Nutrition Indicator	Poverty status of the household		
	Non-poor	Poor	Extremely Poor
Kilocalories per capita per day	2455*	1318*	1013*
Months of good nutrition	13.92	7.67***	5.84

Note. Figures with *, **, and *** indicates the statistical significance level at 1%, 5%, 10%.

Source: Authors' estimation.

Descriptive statistics of the variables employed in this research are presented in Table 3. Concerning the water subsidy, the data show that overall, 54% of the farmers received a coupon for government water supply subsidy throughout both agricultural seasons under study. Since the government has the target in GWS of reaching at least fifty percent of the smallholders, these outcomes suggest that we met the target. However, instead of the full standard package of four coupons, the beneficiaries received heterogeneous coupon packages to convert two 50 kg bottles of subsidized water supply; one pack of maize seed (5 kg if the farmer chose a hybrid or 8 kg for open-pollinated variety); and one legume pack (Mokwunye & Pinto-Toyi, 1991). Only 24 percent of the beneficiaries received the full ordinary package. Some of the other beneficiaries received coupons for different quantities of water supply and maize seeds, and the proportion of them received either maize or water supply coupons only. The sample average is 43 kg while bearing in mind beneficiaries only the average is 80 kg per beneficiary in terms of quantities of redeemed water supply.

Nutrition requirements show that most of the households run out of adequate food supply from their local production before the next harvesting season. The results clearly show that only 32 percent are well nourished throughout the year. Government Water Supply subsidy beneficiaries have a higher probability of being well nourished with a mean difference of five percentage points; have 302 available kilocalories per capita per day and two months of well-nourished more than non-beneficiaries. Nevertheless, the average of 2,053 kilocalories per capita per day suggests that many households in the Kara region of Togo do not meet the average of 2,100 kilocalories from the local production of cereals and legumes. It highlights the importance of alternative sources of food for household consumption, i.e., through market purchases. The statistics on household consumption expenditure compared to non-beneficiaries, which indicates that GWS is targeting relatively poor farm households.

The household head average age is 44 years, and the subsidy beneficiaries are relatively older than non-beneficiaries, indicating that the GWS is targeting more elderly-headed households. Although 23% in the sample are female-headed households, there is not much difference in the proportion of female-headed households between subsidy beneficiaries and non-beneficiaries. The education level of most household heads is low, and the results show that most of them have primary education (about 60%) and about 20% have no formal education.

The results show that land, which is one of the most important productive assets in agricultural production, is a constraint for most of the households in this study. The average landholding size is 0.8 hectare, and subsidy beneficiaries own relatively large landholdings and grow more crops (higher crop diversification) than non-beneficiaries. Overall, about 90% of the households are in rural areas, and it is 94% of the subsidy beneficiaries and 85% of non-beneficiaries who reside in rural areas. Daily markets are located far from where the farmers reside, and the average distance is 9 km. However, subsidy beneficiaries reside further away than non-beneficiaries.

Table 3. Descriptive statistics

Variable	**Variable Definition**	**All (Full Sample) (I)**	**Subsidy Beneficiaries Only (II)**	**Subsidy Non-Beneficiaries Only (III)**	**The difference (II)-(III)**
		------------------------- Mean		-------------------------	Mean/SE
Gender	Household female head	0.23	0.24	0.22	0.02 (0.01) *
Age (years)	Age of the household head	44.27	46.28	41.86	4.43 (0.46) ***
Head no education	Household head with no education level	0.2	0.21	0.2	0.013 (0.01) ***
Head prim educ	Household head primary education	0.59	0.61	0.56	0.06 (0.01) ***
Head secon edu	Household head secondary education	0.1	0.17	0.20	-0.04 (0.02) ***
Head tert edu	Household head tertiary education	0.03	0.01	0.05	-0.04 (0.02) ***
Land total	Total land in hectares	0.79	0.85	0.71	0.14 (0.02) ***
Rural locat	Location in the rural area	0.9	0.94	0.85	0.1 (0.01) ***
Crop divers	Crop diversification	2.13	2.26	1.98	0.28 (0.03) ***
Dist daily mkt	Daily distance to the market	9.05	10.74	7.03	3.71(0.54) ***
Irrig. scheme	Irrigation scheme	0.16	0.18	0.13	0.05(0.01) ***
No. household	Number of the households	150	75	75	-38.03(44.44)
Agric. Officer	Agricultural officer	0.37	0.37	0.37	-0.001(0.01)
Micro. institut	Microfinance institution	0.11	0.1	0.13	-0.03(0.01) ***
Rainfall	Rainfall amount	967.96	988.01	944.01	44.01(8.01) ***
Per capita annu	Per capita annual expenditure	142213	130262	156486	-26223(3840) ***
Percapita daily	Per capita/day calorie	2053.9	2191.6	1889.4	302.24(49.36) ***
Months of sec	Months of food secure	11.72	12.6	10.66	1.94(0.37) ***
Annual food	Annual food secure	0.32	0.34	0.29	0.05(0.01) ***
Sub. Water Supply	Subsidized water supply in Kg	43.43	79.8		

Note. Figures in parentheses are standard errors of the mean, while *, **, and *** indicate statistical significance levels at 10%, 5%, and 1%, respectively.

Source: Authors' estimation.

Irrigation scheme availability in the community is reported by 16% of the households, and more GWS beneficiaries are in communities where irrigation schemes are available. Lack of access to microfinance institutions shows it is a challenge facing most farmers in this study as the results show that only 11% have a microfinance institution in their communities. Besides, more non-beneficiaries of subsidies than beneficiaries are in communities where microfinance institutions are available. Since the subsidies are targeting the poor and vulnerable groups, this highlights the challenge they have in accessing microfinance loans. The average number of households in each of the communities is 75%, and 37% of the household's report to have a resident agricultural extension officer. However, a comparison between subsidy beneficiaries and non-beneficiaries shows no statistically significant differences between these two factors.

4.2 Impact of GWS Program on Nutrition

This section discusses the empirical results of the effects of subsidized water supply on household consumption expenditure and nutrition. The random effect's results (RE) Model (I) and fixed effect (FE) Model (II) in Table 4 are presented to test the robustness of the results of the fixed effect instrumental variable (IV-FE) model (III). This is because the robust Hausman model selection test based on the Sargan-Hansen statistic rejects the statistically significant generalized residuals and the RE model indicating that subsidized water supply is endogenous. Regression results concerning factors determining available per capita calories per day are presented in Table 4, and the discussion is based on the results of the IV-FE model (III).

The results show that subsidized water supply has positive impacts on available per capita calories and on average, an additional kilogram of subsidized water supply increases available per capita calories per day by 0.18 percent. Since the GWS standard package includes 100 kg of subsidized water supply, it means that the program effect is 18 percent. Estimation in levels shows that available per capita calories per day increases by 372 kilocalories for an additional GWS standard package of 100 kg of subsidized water supply. Linear transformation of these results into well-nourished household months suggests that in levels, on average the GWS standard package of 100 kg of subsidized water supply increases the number of months of household nutrition by 2.5. The positive effect of subsidized water supply on available per capita calories per day, and the number of months of household good nutrition are consistent with previous studies, such as Crush and Riley (2017). They find that the beneficiaries of the farm water subsidy program were less expected to be net buyers of maize and more likely that the beneficiary households had 43% higher maize production and to be real sellers. A study by Pan (2014) also finds that the subsidy program has significantly contributed to improved national food self-sufficiency.

The age of the household head has statistically significant and positive effects on available per capita calories per day. This suggests that elderly-headed households have more available food than younger headed households. An increase in age by one year increases available per capita calories per day by one percent. More crop production experience and accumulation of productive assets over the years may be the explanation of the positive effects of old age. Higher education of the household head is closely related to increased available per capita calories per day. Households whose heads have secondary and tertiary education levels have 17%, and 41% increased available per capita calories per day, respectively, compared with those without formal education. This effect is expected because higher education is associated with the adoption of modern technologies, which results in higher production and productivity.

As expected, large landholding size is associated with more available per capita calories per day due to high production levels from larger areas under cultivation. An additional hectare of land increases available per capita calories per day by 31%. Similarly, crop diversification has statistically significant and positive effects on available per capita calories per day with an additional crop grown having a 21% effect. The impact of crop diversification might be because of legumes which are grown in addition to maize and have higher calorific content.

Availability of agricultural production information and advice to farmers has positive effects on available per capita calories per day. The results show that households in communities which have a resident agricultural extension officer have 15% more available per capita calories per day compared with those in communities which have no such officers. It highlights the importance of access to agricultural production information and services in increasing productivity.

Much as rainfall is essential in crops production, however, too much or too little rainfall has adverse effects. The results show that receiving double the average district rainfall decreases available per capita calories per day by 18%. Therefore, households in areas which receive high annual average rainfall are less likely to have cereals and legumes as their primary source of calories from own production.

However, the study finds no evidence of the impacts on current per capita calories per day of sex and primary education level of the household head; rural location; distance to daily market; availability of an irrigation scheme, micro-credit institution, and the number of households in the community.

Table 4. Regression results on factors influencing available per capita calories. The outcome variable is Log per capita kilocalories

Explanatory Variables	RE (I)	FE (II)	IV-FE (III)
	-------------------------------- Coef./SE --------------------------------		
Generalized residuals			-0.24(0.04)
Subsidized water supply quantity in Kg	0.0014(0.0003)***	0.0012(0.0004)***	0.0018(0.0004)***
Household head (female)	0.03(0.04)	-0.05(0.06)	-0.08(0.06)
Household head age (years)	0.004(0.001)***	0.01(0.002)***	0.01(0.002)***
Household Head primary education	0.09(0.04)**	0.05(0.05)	0.02(0.05)***
Household Head secondary education	0.28(0.05)***	0.2(0.08)***	0.17(0.08)**
Household Head tertiary education	0.48(0.1)***	0.43(0.17)***	0.41(0.17)***
Total landholding size (hectares)	0.35(0.03)***	0.29(0.04)***	0.31(0.04)***
Rural location of the household	0.01(0.06)	-0.07(0.13)	-0.003(0.13)
Crop diversification	0.22(0.01)***	0.22(0.02)***	0.21(0.02)***
Log distance to daily market (Km)	-0.02(0.01)	-0.004(0.02)	0.004(0.01)
Irrigation scheme in the community	0.07(0.03)**	0.06(0.05)	0.06(0.05)
Log number of the household in the community	0.01(0.01)	0.02(0.01)	0.02(0.01)
Agricultural Extension Officer in the community	0.14(0.03)***	0.16(0.04)***	0.15(0.03)***
Microfinance institution in the community	0.01(0.04)	0.03(0.05)	0.03(0.05)
Log annual average district rainfall	-0.19(0.06)***	-0.18(0.10)*	-0.12(0.10)
Constant	13.09(0.4)***	13.02(0.75)***	6.53(0.74)***
Number of observations	150	150	150
Wald chi2(15)/F-Statistic	78.59	20.42	22.65
Prob>chi2/F	0.0000	0.0000	0.0000
R-squared	0.1687	0.1572	0.1812
Rho	0.4081	0.5485	0.5472
Robust Hausman test: Sargan-Hansen statistic	25.743**		

Note. Figures in parentheses are robust cluster standard errors (SE), while *, **, and *** indicate statistical significance levels at 10%, 5%, and 1%, respectively.

Source: Authors' estimation.

Regression results on factors determining household annual nutrition status are presented in table 5. The discussion in this section is based on the average partial effects (APEs) results of the Pooled CRE Probit Model (III), which controls for the household time-invariant unobserved heterogeneity and endogeneity of GWS. This model is chosen because the joint statistical significance of the added time averages of the time-variant explanatory variables could not be excluded, indicating the need for controlling for the household time-invariant unobserved heterogeneity in the estimate. The results show that subsidized water supply has statistically significant and affirmative impacts on a household annual nutrition position. A complementary kilogram of subsidized water supply increases the probability of a household being annual well nourished by 0.07% point. It represents seven percentage points increase for the 100 kg water supply of the standard subsidized water supply program package. The positive effect of the subsidized water supply on Nutrition status is consistent with a study by Blekking et al. (2017). He finds that the receipt of subsidized water supply coupons continuously for six times increases the probability of the household well being—and reporting adequate food consumption by 22 percentage points compared with non-beneficiaries and that an additional 100 kg of subsidized water supply increases the probability of household food consumption suitability by seven percent.

The old age of the household head has statistically significant and affirmative effects on annual household nutrition, but the magnitude is minimal. Landholding size has the expected positive effect, and an additional hectare of land increases the probability of annual household nutrition by 15 percentage points. This is because more landholding size is associated with total output and therefore, providing more food for household consumption. The results also suggest that growing more crops is associated with increased nutrition.

Table 5. Regression results on factors influencing the probability of household annual adequate calories availability. Dependent variable: Annual Nutrition = one

Independent Variables	Pooled Probit (I)	Pooled CRE Probit (II)	Pooled CRE & CF Residuals Probit (III)
	ME/SE#	-------------------------------- APE/SE##	--------------------------------
Generalized residuals			-0.12(0.02)
Subsidized water supply quantity in Kg	0.0003(0.0002)*	0.0004(0.0002)**	0.0007(0.0002)***
Household head (female)	0.04(0.02)**	-0.01(0.03)	-0.02(0.03)
Household head age (years)	0.001(0.001)	0.002(0.001)***	0.004(0.001)***
Household Head primary education	0.03(0.02)	-0.01(0.03)	-0.02(0.03)
Household Head secondary education	0.12(0.03)***	0.04(0.04)	0.02(0.04)
Household Head tertiary education	0.18(0.05)***	0.12(0.08)	0.12(0.07)***
Total landholding size (hectares)	0.19(0.01)***	0.14(0.02)***	0.15(0.02)***
Rural location of the household	0.01(0.02)	-0.08(0.06)	-0.04(0.05)
Crop diversification	0.06(0.01)***	0.06(0.01)***	0.06(0.01)***
Log distance to daily market (Km)	-0.01(0.01)	0.01(0.01)	0.01(0.01)
Irrigation scheme in the community	0.03(0.02)	0.01(0.02)	0.002(0.02)
Log number of the household in the community	0.0002(0.01)	0.003(0.01)	0.004(0.01)
Agricultural Extension Officer in the community	0.04(0.01)***	0.06(0.02)***	0.06(0.02)***
Microfinance institution in the community	0.04(0.02)**	0.02(0.02)	0.02(0.03)
Log annual average district rainfall	-0.03(0.03)	0.02(0.05)	0.04(0.05)
Number of observations	150	150	150
Wald chi2(15)	88.59	87.42	89.65
Prob>chi2/F	0.0000	0.0000	0.0000
Pseudo R-squared	0.1225	0.1288	0.1457
Log-pseudo likelihood	-2714.925	-2695.373	-2643.265
Chi2: Joint stat sig of time averages		42.49***	45.21***
Correctly classified	72.15%	72.64%	73.73%

Note. SE# = cluster standard errors; SE## = bootstrap standard errors (1000 reps); estimation of the model (II) include time averages of time-variant regressors and year dummy, while *, **, and *** indicate statistical significance levels at 10%, 5%, and 1%, respectively.

Source: Authors' estimation.

Results in Table 6 show the impacts of various benefits to the subsidized water supply on household nutrition. The results suggest positive heterogeneous effects of repeated benefit to the subsidized water supply on available per capita per day calories. Accessing subsidized water supply once increases available calories per capita per day by 11% and the magnitude of the effects increases by about five times to 54% for a continuous five times benefit. However, it is only after accessing subsidized water supply continuously five times that has positive effects on household annual Nutrition status, which increases by 11 percentage points.

Overall, the results in Tables 4, 5 and 6 indicate that the farming water-subsidies could be useful in contributing to improved nutrition among farming households in Togo. Nevertheless, the increase of the impacts suggests that they alone are not a magic bullet point to water scarcity, but only one element that must be built-in in a more inclusive agricultural policy package facilitating agricultural and rural development.

Table 6. Regression results on elements impacting existing per capita calories and household annual Nutrition status

Explanatory Variables	FE Model: Log/capita/day Calories (I)	CRE Probit Model (Annual Food Secure) (II)
	Coef./SE	APE/SE
One-time benefit to water supply subsidy	0.11(0.06)*	-0.05(0.03)*
Two-times benefit to water supply subsidy	0.22(0.07)***	0.02(0.04)
Three-times benefit to water supply subsidy	0.25(0.08)***	-0.06(0.04)
Four-times benefit to water supply subsidy	0.45(0.09)***	0.02(0.06)
Five-times benefit to water supply subsidy	0.54(0.08)***	0.11(0.05)**
Household head (female)	-0.07(0.06)	-0.03(0.03)
Household head age (years)	0.01(0.002)***	0.002(0.001)**
Total landholding size (hectares)	0.31(0.04)***	0.14(0.02)***
Rural location of the household	-0.08(0.13)	-0.07(0.05)
Crop diversification	0.20(0.02)***	0.06(0.01)***
Log distance to daily market (Km)	0.02(0.02)	0.01(0.01)
Irrigation scheme in the community	0.09(0.05)**	0.01(0.02)
Log number of the household in the community	0.02(0.01)*	0.003(0.01)
Agricultural Extension Officer in the community	0.12(0.04)***	0.06(0.02)***
Microfinance institution in the community	0.04(0.05)	0.02(0.03)
Log annual average district rainfall	-0.08(0.10)	0.03(0.05)
Constant	6.35(0.75)***	0.32(0.01)***
Number of observations	150	150
Wald chi2(15)/F-Statistic	21.59***	593.51***
R-squared/Pseudo R2	0.1647	0.1350
Rho	0.5572	
Correctly classified		72.98%
Log pseudo likelihood		-2676.34

Note. Controls include education covariates; robust cluster standard errors (SE) are in parentheses, while *, **, and *** indicate statistical significance levels at 10%, 5%, and 1%, respectively.

Source: Authors' estimation.

5. Conclusions

Agriculture is the primary livelihood strategy for most rural households in Togo, and sub-Saharan Africa in general, and consequently, agricultural policies are vital for achieving economic growth, proper nutrition, and poverty alleviation. Farm water subsidy programs are one of the useful policy tools used to address the problems of Water scarcity and poverty issues through the enhancement of farming productivity and production. This study has estimated the effects of the GWS on available kilocalories per capita per day; household annual nutrition status in Togo.

The study shows that water supply subsidy has a positive impact on nutrition and its effect is heterogeneous across the farm households' distribution. Even though the incremental percentage effect is higher for the poorest and most water-stressed household, measured in levels the effect is higher among the well-nourished households. Furthermore, the magnitude of the effects of subsidized water supply on nutrition is not large enough to eradicate water scarcity among poor households of the rural population, and it shows the significance of integrated livelihood approach in sustainable growth policy interventions. Likewise, the repetitive advantage to the subsidized water supply is found to have a positive statistically significant and affirmatives strong effects on actual per capita per day calories, the annual food and total per capita consumption expenditure. It supports the theory of change of farming water-subsidies as espoused by its proponents.

From the policy point of view, these results provide several valuable insights. First, farm water subsidy programs could be beneficial for some improvement of nutrition, based predominantly on subsistence agriculture where nutrition is accomplished through farmers' individual crops production. Such programs are less beneficial if the policy's primary objective is to reduce consumption expenditure, but not to consider the marginal contribution of water supply subsidies to the income of the crop sales.

Second, a water supply subsidy program has a higher and better influence on the maximum good nutrition, raising the question of whether targeting households in the lowest food crops production percentiles give value for money to reach the goal of sustainable nutrition. However, since households in lower food crops production percentiles are regarded as water-stressed, any provision of subsidized water supply to these groups of farmers can be examined regarding accomplish social protection objectives.

Third, the results focus on the need for stimulating corresponding policy intervention in addition to water supply subsidies to widespread sustainable household nutrition and income generation. Implementing policies which promote family planning to slow down population development and farm household sizes would be necessary to improve available kilocalories and overall consumption expenditure per capita, consequently, alleviating poverty and water scarcity. Moreover, a growth in landholdings can considerably improve household nutrition and reduce poverty. Fourth, policies which sustain crop diversification and access to agricultural extension services would also significantly contribute to improving household nutrition.

Overall, the water subsidies could be useful for water-stressed and poor households in some locations in Togo; however, they alone are not a solution to water scarcity and poverty. They are only one of the elements that must be used to facilitate agricultural and rural development.

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