Abstract

In this study, we investigated whether irrigated agriculture results in improved child nutrition outcomes among farm households in southern Ghana. Using panel data collected between 2014 and 2015, the results from the inverse probability weighted regression adjustment (IPWRA) estimator suggest that children living with irrigating households have, on average, higher weight-for-age and weight-for-height than children residing with non-irrigating households. Males and under-five children gained substantial improvements. Disaggregating irrigation by type, the results indicated that households planting on riverbeds or
riverbanks had improved child nutrition. Additionally, children living with households lifting water from water sources had higher height-for-age and weight-for-age. Further analysis of the underlying pathways suggests that an increase in health care financing and improvement in environmental quality rather than decreases in illness incidence may be the crucial channels. Altogether, the findings showed the importance of investments in agricultural development, particularly in small-scale irrigated agriculture technologies, to reduce childhood undernutrition.

Introduction

In many low and middle-income countries (LMICs), reducing undernutrition remains a primary public health goal. This is more evident in the Sustainable Development Goals (SDGs), where 12 of the 17 (about 70%) goals are related to nutrition (Scaling-Up Nutrition, 2017). Globally, undernutrition accounts for about 45% of deaths of children under five years old (Black et al., 2013). Despite several nutrition-sensitive interventions, undernutrition remains disproportionately higher in LMICs. The health effects of child undernutrition are often irreversible and have long-term consequences. Many empirical studies show that undernutrition can impair cognitive and physical development, school performance and labour productivity in later years (see, e.g., Humphrey, 2009; Almond and Currie, 2011). In Ghana, about 19% of children under 5 years old are stunted (low height-for-age z-scores), and 11% of children are underweight (low weight-for-age z-scores) (GSS et al., 2015). The prevalence of child undernutrition is higher in rural areas than in urban areas. This could be attributed to several factors, including limited infrastructure investment and high poverty levels in rural areas compared to urban areas.

Investments in agriculture are essential to enhance food and nutrition security. Agriculture employs about 38% of the labour force despite Ghana’s population being increasingly urbanized, and the gross domestic product (GDP) shares of the agriculture sector declined sharply over the last decade (GSS, 2019). Public investments can improve agricultural yield and productivity through knowledge transfer and infrastructure expansion (Dercon et al., 2009). In Africa, expanding irrigation technology is one of the agrarian policy goals, and is emphasized in the 2018 Malabo Montpellier Panel report (Malabo Montpellier Panel, 2018). However, public investments in agriculture remain low in many African countries. In Ghana, for example, public agricultural expenditure (% GDP) averaged about 3.3% from 2001 to 2015, significantly lower than the 10% target of the Comprehensive Africa Agriculture Development Programme (CAADP) commitment (Benin, 2019).

Previous studies have shown that irrigation technology increases production and household income. For example, by expanding irrigation technologies households can extend the growing season (produce more than once annually) and reduce
dependence on rainfed agriculture by making crop production possible in marginal land where rainfall is inadequate (Lipton et al., 2003). Irrigation also increases land productivity using an appropriate input mix, thereby generating higher farm incomes. In addition, small-scale irrigation (SSI) using tube wells in Nigeria increased per hectare returns from 65% to 500% (Burney and Naylor, 2012), and treadle pump irrigation increased income per hectare by over 500% in Malawi (Mangisoni, 2008). Balana et al. (2020) showed that, although access to SSI can significantly increase net returns in northern Ghana, the use of diesel-powered irrigation schemes generates more net income than other types of irrigation. The cost–benefit analysis, however, shows that the use of watering-cans generates higher returns per capital investment, indicating potential differential impacts of irrigation technologies. Altogether, the literature suggests that SSI schemes generate the highest economic payoffs and are more sustainable (You et al., 2011; Xie et al., 2014). The main objective of our study was to examine the impact of irrigated agriculture on child health and nutrition outcomes in southern Ghana using four rounds of panel data collected between 2014 and 2015.

A few studies have investigated the relationship between irrigation and consumption/nutrition outcomes. Alaofe et al. (2016) reported that households with irrigation increase yield and consumption of fruits and vegetables, spend more on food and healthcare services than households without irrigation. This suggests that increased income from irrigation leads to investment in productive expenditures/assets. Other studies that explore the relationship between irrigation and dietary diversity found that irrigation is positively and significantly associated with household dietary diversity and production diversity (Bhagowalia et al., 2012; Benson, 2015; Passarelli et al., 2018; Akudugu et al. 2016). Although investment in irrigation is supported to ensure food and livelihood security (e.g., Domenech, 2015), there is an ongoing debate over which types of irrigation technologies could be more nutrition sensitive.

Irrigation technology is a key strategy to improve yield and productivity and thereby to ensure food and nutrition security among smallholders. To that end, various types of SSI technologies have been promoted in many LMICs. The impacts of irrigation on household nutrition and health outcomes greatly depend on the scale and types of irrigation schemes. For example, homestead irrigation, typically owned by women, is used to grow vegetables for their own consumption and/or for local markets. However, in large-scale irrigation schemes farmers produce mainly cash crops and women often do not have much control over the income (see, for example, Theis, 2016; Bryan and El Didi, 2019; Bryan and Garner, 2022).

Studies assessing the impact of irrigated agriculture on child nutrition using anthropometric measurements are few (e.g., Benson, 2015; Usman and Gerber, 2020). To the best of our knowledge, evidence on the impacts of irrigated agriculture by its type on child nutrition is also scarce and no previous study has examined the gender-differentiated impact of irrigated agriculture on child nutrition outcomes. A strong
evidence base should be built for policy makers and development practitioners to guide on the design of successful programmes and facilitate the adoption of irrigation technologies. This study attempted to fill these gaps.

With the growing interest in expanding SSI in Ghana, this is an important and policy-relevant topic. With the implementation challenges encountered with the so-called “One Village: One Dam” programme, the results from this study could shed additional light by providing evidence on the nutritional benefits of SSI. Furthermore, the implementation challenges of the government’s current irrigation programme make it a critical issue in terms of agricultural policy. Therefore, studying the impact of irrigated agriculture on child nutritional outcomes is a topical issue in Ghana due to the slow pace of implementation of this flagship programme and the reported complaints about the quality of completed dams (GhanaWeb, 2019). Furthermore, policy decisions require information on the types of irrigation technologies that are nutrition-sensitive and quick implementation of the programme.

This study contributes to the literature in many ways. First, the study focuses on the effect of irrigated agriculture on child nutrition using anthropometric indicators. Previous studies (e.g., Passarelli et al., 2018; Mekonnen et al., 2019) mostly relied on food consumption diversity. Second, this study uses panel data allowing to control for time dimension in the analysis. Other studies (e.g., Kiroge et al., 2007; Benson, 2015; Gerber et al., 2019; Usman and Gerber, 2020) have relied on cross-sectional data affected by endogeneity issues. Third, and most important, the study disaggregates the impacts based on irrigation types and gender of children and discusses the potential pathways through which irrigated agriculture could impact child nutrition outcomes. Using four rounds of panel data collected between 2014 and 2015 in southern Ghana and employing the inverse probability weighted regression adjustment (IPWRA) estimator, the findings were that children living in irrigating households had, on average, higher weight-for-age, and weight-for-height than children residing in non-irrigating households. The results are robust to various model specifications and alternative estimation approaches.

**Conceptual framework**

Irrigation can affect health and nutrition outcomes through several pathways (see Figure 1). Interestingly, the adoption of different types of irrigation could affect children’s nutrition outcomes in diverse ways. Irrigation can cause adverse impacts on the environment and human health if it is poorly planned or designed. Irrigated agriculture influences health negatively through increased water-related diseases and domestic water contamination (Gerber et al., 2019; Usman and Gerber, 2019; Usman et al., 2019). Domestic water quality and quantity may also be affected by irrigation practices. Interestingly, irrigation schemes increase the availability of water for domestic purposes where multiple-use water systems are common (van
der Hoek et al. 2001; van der Hoek et al. 2002). Moreover, irrigation systems can exacerbate the incidence of waterborne diseases by creating suitable conditions for the propagation of disease vectors, such as mosquitoes (Asayehegn, 2012; Asenso-Okyere et al., 2012). Irrigated agriculture could also increase productivity, production diversity and improves food availability that allows households to improve their nutrition and household income (von Braun et al., 1989; Passarelli et al., 2018; Adela et al., 2019; Nonvide, 2018). Moreover, the increased income associated with irrigated agriculture can allow a given household to access improved healthcare services and, in turn, improve the health and nutrition outcomes of household members.

Irrigation water also serves as a source of drinking water in many developing countries where access to improved drinking water sources is inadequate (van Der Hoek et al., 2001; van der Hoek et al. 2002; Usman et al., 2018). Increasing water availability for domestic purposes helps households meet basic hygiene needs, improving health outcomes associated with water quantity (van Der Hoek et al., 2001). Moreover, where access to improved drinking water supply is inadequate, increasing water availability reduces the burden of water collection time, which is often disproportionately borne by women and girls, and can save time and energy for other income-generating activities, such as agricultural production, social activities, child-caring (Sorenson et al., 2011), with direct and indirect health consequences. A review by Domenech and Ringler (2013) synthesized the available evidence on the impacts of irrigation on health, nutrition, and women empowerment in sub-Saharan Africa.

**Figure 1: Linkage between irrigated agriculture, and health and nutrition**

Data source

This study relied on four rounds of geographic-specific surveys collected from April 2014 to June 2015. The sample households were selected using a stratified cluster sample design (for detailed information, see Okyere, 2018). Informed consent was obtained for participating households. The survey instruments for the baseline survey data (April/May 2014) collected height and weight measurements for children under eight years of age, detailed information on agricultural activities, irrigated agriculture, productive assets, income, healthcare expenses, household consumption expenditures and other socio-economic characteristics. This survey instrument was repeated for the end line survey in May/June 2015. The other two survey waves (i.e., first follow-up (November/December 2014) and second follow-up (January/February 2015)) used an abridged version of the baseline survey instrument with anthropometric measures, information on income, healthcare expenses, irrigated agriculture, and other agricultural activities, but without the detailed consumption expenses and productive assets information.

Having child-level anthropometric measures together with irrigated agriculture activities and detailed household socio-economic characteristics presents the opportunity to examine the potential mechanisms. According to Kirk et al. (2018), the short time duration between the survey waves allows controlling for time-constant child characteristics, which could not be addressed using cross-sectional data.

The household survey was conducted in Ga South Municipal (urban) and Shai-Osudoku (rural) districts in the Greater Accra Region. From the urban district, only rural and peri-urban communities (which are like those in the rural district) were targeted in the sample selection. The focus of this study was children living in agricultural households. However, children from non-agricultural households were included due to the relatively smaller sample size for the study. We restricted the analysis to children with anthropometric measures in the baseline survey or to those born after the baseline survey (see Kremer et al., 2011). The final analysis comprised 1,317 child observations across the 4 survey waves: 318, 331, 392 and 276 child observations in April/May 2014, November/December 2014, January/February 2015, and May/June 2015 respectively. Of these, 41.6% in all the 4 surveys, 32.6% in 3 survey waves, 16.9% in any 2 survey waves and 9% in only 1 survey wave were observed. Figure 2 depicts a map of the study areas. Finally, the sample was representative neither at the national nor at the district level. The study sites were selected purposely based on ex ante information. Therefore, the results may not be generalized to the whole population. While we acknowledge that the sample size was small, alternative panel data sets are lacking for Ghana (to the best of our knowledge) containing anthropometrics with representative samples for children in both irrigated agriculture and non-irrigated agriculture households. In Ghana, access to irrigation...
is extremely low. For example, the Africa RISING baseline evaluation survey (ARBES) report, a nationally representative survey in Ghana, showed that 3% of the sampled households reported irrigating their land (Tinonin et al., 2016). Similarly, various types of irrigation technologies exist in the country but less than 2% of arable lands are under irrigation (Mendes et al., 2014). These include human-powered, rope and treadle pumps to liquid fuel engine-driven systems and solar-powered pumps as well as gravity and river diversion methods (Akrofi et al., 2019).

Figure 2: Map of the study areas

This study used unbalanced panel data, where some of the children not measured in all the survey rounds. Accordingly, the results may suffer from attrition bias. Although we controlled for survey round fixed effects in the analyses, the attrition rate, if systematic and affects one group more than the other, could lead to potential upward estimation bias. We undertook an analysis of the attrition rate and found it similar for both irrigators and non-irrigators. For example, we analysed the level of attrition rate based on children with only one observation and older than 12 months of age in the baseline data, following Kirk et al. (2018). The attrition rate was unaffected by the adoption of irrigated agriculture. Furthermore, the results did not change by defining attrition either to mean children with 1 or 2 observations and older than 12 months of age in the baseline data or to mean children with only 1 or 2 observations in the data.

Conclusion and Policy Implications
Agricultural development, primarily irrigated agriculture, has the potential of reducing undernutrition in LMICs. Despite its large potential benefits, investments in agriculture are low in many sub-Saharan African countries. In this study, we examined whether households engaged in irrigated agriculture have improved child nutrition outcomes. Using a panel household survey data and a doubly robust estimator, we found that irrigated agriculture led to large improvements in child nutrition outcomes, with considerable gains for males and children under five years old. For example, a child living with an irrigating household gained 0.23 units of SD in WAZ and 0.27 units of SD in WHZ during the study period. The findings on male children indicate the biases in intra-household resource allocation toward this group, which concurs with earlier findings (e.g., Pal, 1999). The estimated results are robust to alternative model specifications and estimation techniques.

Disaggregating irrigation by types, the results show that the presence of irrigated fields in the community, planting on riverbeds, and lifting water from water sources have larger impacts on child nutrition than overhead and other irrigation types. While there is a broad consensus on the importance of investments in irrigation as a policy towards the reduction of undernutrition, there is still debate on the types of irrigation that could deliver these nutritional benefits. Our findings also suggest that some of the irrigation types, such as planting on riverbeds and drawing water from water sources, generate higher nutrition benefits than overhead irrigation. Moreover, the presence of irrigated fields in the community generates improved nutrition outcomes. This implies that irrigated agriculture generates community-level benefits aside from the benefits accrued to an individual or household. The results suggest that investment in low-cost SSI generates nutrition benefits in the study context.

The potential pathways that irrigation has an impact on child nutrition could be increased demand for environmental quality and healthcare financing rather than decreases in illness incidence. This is not surprising as the results show that irrigated agriculture does not lead to investments in preventive health care (e.g., bed nets), leading to a high incidence of self-reported fever cases. Although the results are not statistically significant, incidence of diarrhoea was consistently lower. Finally, the study identified several areas for future research on the impacts of irrigation on child nutrition outcomes. The sample for the study was relatively small and due to the complexity of the linkages between irrigated agriculture and nutrition, future studies based on nationally representative data could shed additional light on these linkages. Furthermore, although we attempted to reduce selection problems to the extent possible using various econometric techniques, causal interpretation of the results may be biased. This is because treatment effects models and panel regressions may be unable to address all issues related to endogeneity and therefore, the causal interpretation of empirical findings maybe be viewed with some caution. For example, unobserved child or household characteristics can still bias the true coefficient of the impacts of irrigation on child nutrition outcome. Despite these limitations, the results obtained from this study are robust to various model specifications and are relevant for policy makers and researchers on the nutrition impacts of irrigation in LMICs, including Ghana.
The ImpaCT of irrigaTed agriculture on child NutriTioN outcomes iN souTherN ghaNa

References


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Mission

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