Transforming smallholder agriculture in Africa through irrigation: an assessment of irrigation impact pathways in Ghana

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Abstract

Agriculture in Africa is dominated by smallholder farmers who mostly undertake rain-fed agriculture. Unfortunately, the current trends of unpredictable rainfall patterns is putting the livelihoods of these smallholder farmers under threat. To overcome this threat, governments across Africa relentlessly invest in water harvesting strategies for irrigation purposes. Thus, the provision of irrigation facilities in strategic locations across Africa is deemed an important component of the agricultural transformation agenda being pursued in the continent. This paper therefore examines the role of irrigation in transforming smallholder agriculture in Africa by assessing the different impact pathways of irrigation, using Ghana as the case. The paper employs mixed methods that provide the opportunity for triangulation and cross validation. Qualitative and quantitative data were collected using focus group discussions, key informant interviews and household survey questionnaires. The impacts of irrigation were analysed using propensity score matching (PSM) and narrations. The results indicate that irrigation has significant and positive impacts on farm output, income, employment, consumption, food security and non-farm businesses. The impacts of irrigation on health and environmental sustainability are mixed - the positive being the ability of irrigators to pay for improved healthcare for themselves and their families and the negatives include the outbreak of waterborne diseases associated with irrigation water. Construction of irrigation facilities causes destruction to the environment but improves provisioning ecosystem services. It is generally concluded that access to irrigation is associated with higher farm outputs, income levels, employment, consumption, food security, and engagement in non-farm business activities.

Key Words: Africa, Agriculture Transformation, Ghana, Irrigation, Livelihoods

1. Introduction

Agriculture remains the main source of livelihoods to a large proportion of people resident in rural Africa and Ghana for that matter. In the specific case of Ghana, it is estimate that nine out of ten people in rural areas derive their livelihoods from agriculture and agriculture related activities (GSS, 2014). Rural livelihoods are however, currently going through stress due to the adverse effects of climate change. Crop yields continue to dwindle, as rainfall patterns are now unpredictable. There are instances of double tragedy of droughts and floods occurring within same seasons. The experience in recent times has been the rain either over raining or under raining and each of these episodes negatively affects agricultural production and rural livelihoods for that matter. The situation is particularly dire in northern Ghana, which experiences mono-modal rainfall patterns. The key to getting out of this phenomenon is to institute mechanisms that ensure stable supply of water for production purposes and one of such mechanisms in provision of irrigation facilities.

The provision of irrigation facilities in strategic locations in rural areas, especially in northern Ghana is expected to help promote livelihoods in those areas. This is because it has been established in the empirical literature that access to irrigation has positive impacts on agricultural production and the reduction of poverty levels of farmers (Hussain and Hanjra, 2004; Smith, 2004; Lipton, 2007; and Hussain, 2007a,b). Access to irrigation provides farmers with a reliable water source at critical times in the crop's life cycle, removing the dependence and inherent uncertainty of rain-fed and lake-based agricultural systems in arid and semiarid areas (Dollon, 2008). Irrigation minimises unforeseen production shocks particularly relating to bad weather conditions. According to Lipton (2007), in India irrigated areas had 2.5 times lower standard deviation of crop output per year than rain-fed crop production.

To take advantage of the positive impacts of irrigation, small, medium, and large-scale irrigation schemes have been provided across Ghana to enhance agricultural production and encourage all year production, which will ultimately lead to improvements in livelihoods through increased food availability and income levels. Despite these concerted efforts spanning decades to facilitate rural livelihoods development using irrigation as a strategic tool, there is still high incidence of poverty in the country and northern Ghana in particular. This raises fundamental questions among researchers, policy makers, policy implementers, and development practitioners about the role of irrigation in transforming smallholder agriculture in the country. This paper therefore examines the role of irrigation in transforming smallholder agriculture in Ghana by assessing the different irrigation impact pathways.

The analysis in this paper is based on field research, mainly community level focus group discussions, key informant interviews and a household survey in in selected irrigation sites in northern Ghana. The study was conducted in the second quarter of 2015 and was the survey was a non-random experiment. This means that identification problems exist leading to selection bias arising from two main sources. The first source of selection bias is the non-random assignment of irrigation projects to communities using implicit targeting rules, which has implications for access to irrigation water. Thus, the factors considered in allocating irrigation projects might correlate with the outcome variables of interest. For instance, irrigation projects might be allocated either to highly productive areas to ensure success or to less productive areas to improve farm productivity, which could be an outcome as well as selection variable. In either case, the estimates of irrigation effects or impacts derived from outcome indicators will contain upward or downward bias, respectively. The second source of bias is the non-mandatory participation in irrigation as a livelihood activity. As reported by Dollon (2008), access to irrigation might be correlated with household characteristics such as education, which may influence the likelihood of technology adoption, access to water, and whether households live in rural or urban areas. Education may also influence outcomes such as income levels.

To deal with the non-randomised participation in irrigation in the selected sites and adoption decisions by households within these sites, different estimation strategies are possible. These include difference in differences, propensity score matching, and matched difference-in-differences (Heckman, Ichimura, and Todd, 1997; Smith and Todd 2005; Bertrand, Duflo and Mullainathan, 2004; Jalan and Ravallion, 2003; and Gilligan and Hoddinott, 2007). This paper in addition to thematic analysis of the qualitative data generated from focus group discussions and key informant interviews adopted the propensity score matching to estimate the impacts of irrigation on livelihoods. The next section of the paper presents an empirical review of irrigation impacts on livelihoods development.

2. Empirical Review of Irrigation and Livelihoods Development Linkages

Empirical evidence suggests that investments in irrigation positively contribute to improvements in livelihood outcomes such as income, health, nutrition, food security, and employment (Dittoh *et al*., 2013; Hussain and Hanjra, 2004; Mangisoni, 2003;

Namara *et al*., 2011). The effects of irrigation on livelihoods are particularly high in areas where agriculture is the main source of livelihood. Namara *et al.* (2005) evaluated the comparative impact of micro irrigation technologies at two locations and found that, the micro irrigation adopted in both areas were generally profitable with significant effect on crop yields. The study estimated the technical and economic efficiencies in the cultivation of banana, cotton and groundnut under irrigation and the results indicate that the production of these crops using irrigation is technically and economically justifiable. The study also assessed the poverty impact of micro irrigation by comparing the poverty status of irrigators with non-irrigators and concluded that irrigators generally have higher incomes status than non-irrigators. It was also observed in the study that irrigation has significant effect on cropping patterns and intensity as well as type of crop cultivated. The authors noted for instance, that irrigators produce high value and water intensive crops and high cropping intensity than the non-irrigators. It was further observed that participation in irrigation has the power to improve the incomes of women thereby increasing the nutritional intake of their household members, as women involved in marketing of their own farm produce spent majority of their revenue on household food items. Irrigation also helps improve decision-making power of women irrigators. The authors also reported that, food and nutrition security has improved significantly among irrigators with the availability of fresh vegetables from homesteads. The general conclusion of the study is that irrigation investments lead to poverty reduction through substantial increases in farm income as a result of increased cropping intensity and area of cultivation, better crop yields, and enhanced output quality that is associated with higher output unit prices among others.

Other studies however, report that the ability of irrigation as an intervention to promote livelihoods is not as high as expected. One of such studies is that of Dinye and Ayitio (2013) who reported that although majority of farmers who are into irrigation fall under middle income brackets, most of them are not satisfied with the effect of irrigation on their economic status and general livelihood. The authors noted for instance that instead of irrigation promoting the food security situation of irrigators it rather worsened it. This is because, farmers are not able to store their perishable products hence compelled to sell them early with normally low prices making food scarce at other times of the year. The study concluded that, as modest as it is, the power of irrigation to reduce poverty and improve livelihoods was not as expected due to an array of challenges such as lack of support services and marketing difficulties. This reemphasis the fact that the poverty impacts of irrigation is dependent on a number of factors which includes but not limited to predictable and stable input/outputs markets, favourable policies, effective institutions and reliable support environment for farmers (Ofosu *et al.,* 2013).

In a two country study, Hussain and Hanjra (2004) reported that production technology, cropping patterns and crop diversification as well as equity in land distribution are important in determining the power of irrigation to promote livelihoods. The authors concluded that comparing outcomes from irrigated and rain-fed settings in Sri-Lanka, the incidence of chronic poverty is lowest in irrigated than rain-fed settings where there is estimated one-fourth of rain-fed farm households living below the poverty line throughout the year. In Pakistan however, poverty impacts of irrigation were marginal with the incidence of chronic poverty being higher for non-irrigating farm households than irrigating farm households. Following the same argument, irrigating households were identified to have enough food available through the year as compared to rain-fed households in Sri-Lanka with higher household income and expenditure. In the case of Pakistan, improvement in irrigation infrastructure increased cropping intensity and productivity and crop incomes by 5-25% and 12-22% respectively. The authors further explained that the difference in poverty impacts between the two countries was as result of equity disparities in landholdings.

In a study of six countries that constitute 51 percent of global net irrigated area, Hussain (2004) reports that household income and consumption levels were 50 percent higher in irrigated areas than rain-fed areas. Again, poverty levels were much lower (20-30%) in irrigated settings than that of rain-fed areas with chronic poverty more pronounce among rain-fed households. In a study on ground water irrigation in 35 communities conducted in Ghana by Namara *et al*. (2011), various levels of impacts on poverty, food security, employment, and income among others in the study areas were examined. By employing the Foster-Greer-Thorbecke (FGT) indices with consumption expenditure as a proxy to measure poverty and inequality indices, their result suggested that although poverty levels are generally higher (57%) in the study area than the national average, poverty indices is lower (0.46-0.58) in irrigating households as compared to rain-fed households (0.62). Although disparities exist in income levels and poverty gaps between the two groups, they were found not to be significant. Further econometric analysis from their propensity estimates again revealed that, irrigating farmers had either lower poverty or fewer food shortages as compared to rain-fed farmers. However, findings about dietary diversity were mixed and this was said to be due to mono-cropping pattern of farmers in the study area. The study revealed that, irrigation have created additional labour demands estimated at 359,511 man-days during the dry season with an estimated USD11.1 million or USD 54 per capita income injection for the entire 35-villages studied. From the foregoing, it is clear that access to irrigation has positive and significant links with livelihoods of farmers and farm households. The implication of this is that irrigation should play central roles in the agricultural transformation agenda being pursued in Africa for poverty reduction and socio-economic development.

3. Methodology

3.1 Study Description

The paper employs mixed methods and the main reason for using mixed methods is to provide the opportunity for triangulation and cross validation. This makes it possible for the issues under consideration to be looked at from different viewpoints by offsetting the weaknesses inherent in each individual method whiles drawing from their strengths to ensure rigour in the research findings. The qualitative methods used provided the opportunity for in-depth understanding of the different irrigation pathways that better promote the livelihoods development of beneficiary rural dwellers. These methods involved the use of participatory qualitative research tools such as focus group discussions, key informant interviews, in-depth interviews, and so on for the data collection. The quantitative methods are used to quantify where possible, the contribution of the different irrigation pathways to the livelihoods of beneficiary rural households. The main quantitative research tool used in the paper is a household survey conducted through questionnaire administration.

A total of 32 focus group discussions were conducted with irrigators and non-irrigators across gender and generation in 8 communities across four districts in northern Ghana with irrigation facilities. In addition, 60 people deemed to have in-depth knowledge in irrigation and rural livelihoods issues were interviewed as key informants. These included influential farmers, policy makers, policy implementers, change workers, traditional rulers and local government authorities. The survey covered a total of 864 households in four districts with irrigation facilities across scales. The households were selected across the different wealth classes (i.e. poor and rich) according to local standards.

The selection of districts, communities, households and individuals to participate in the study was through multistage sampling processes. Data analyses included thematic, content and discourse analyses as well as econometric modelling for the estimation of contribution of the different identified irrigation impact pathways across the study areas.

3.2 Estimating Treatment Effect Using Non-experimental Data

In an attempt to estimate average treatment effects, it is important to recognise the problem of selection bias between treatment and comparison groups. The ideal thing would have been to estimate $\otimes = Y_t^1 - Y_t^0$, which is the difference of the outcome variable of interest at time *t* between two treatments, denoted by the superscripts 1 and 0. However, it is impossible to estimate $\otimes$ in this way because a household cannot receive two treatments simultaneously. The evaluation problem caused by missing data arises because of the impossibility of assigning households to both treatment and control groups. It is therefore prudent to measure the average treatment effect (*ATE*) given the observable data:

$$ATE = E(Y^1 \mid T = 1) - E(Y^0 \mid T = 0) \quad (1)$$

When data are generated through a properly implemented random experimental design, the expectations of the treatment and comparison groups are equal because the groups are composed of randomly allocated members, ensuring that the distribution of observable and unobservable characteristics of the groups are equivalent in a statistical sense. With a randomised design, the selection bias, $E(Y^1 \mid T = 1) - E(Y^0 \mid T = 0)$, equals zero, which establishes that the estimate of the average treatment effect provides an unbiased estimate of its impact. It is not always that randomised experiments are possible and this makes the assumption of absence of selection bias essential. This explains why in applied econometrics, it is often preferable to estimate the average treatment effect on the treated households (*ATT*), given a vector of household characteristic, *X* as follows:

$$TET = E(\Delta \mid X, T = 1) = E(Y^1 - Y^0 \mid X, T = 1) = E(Y^1 \mid X, T = 1) - E(Y^0 \mid X, T = 0) \quad (2)$$

Because $E(Y^0 \mid X, T=1)$ is unobservable, it is assumed that $E(Y^0 \mid X, T=1) = E(Y^0 \mid X, T=0)$.

There are different ways of estimating the treatment effects and these include difference in differences, propensity score matching, and difference-in-differences matching estimators all of which require identification assumptions with non-experimental data. These non-experimental estimators have been tested against experimental benchmarks and against each other in the empirical literature (e.g.

Heckman, Ichimura, and Todd 1998; Bertrand, Duflo, and Mullainathan 2004; Smith and Todd 2005; and Diaz and Handa 2006). The general conclusion from these studies is that non-experimental estimators can perform well if the set of observable characteristics is rich enough to create valid treatment and comparison groups. This paper made use of propensity score matching as described in the proceeding section.

3.3 Use of Propensity Score Matching (PSM)

To estimate the effects of irrigation, propensity scores were used to match households with similar observable characteristics with access to irrigation, the treatment variable. Households are matched to each other conditional on a set of observable household and irrigation characteristics, z and *i*, respectively. Propensity scores are estimated to match households with similar observable characteristics, varying only the treatment, which is access to irrigation (Dillon, 2008). A logit model is estimated using a vector of household characteristics, z and irrigation characteristics, *i*, to obtain predictions of household propensity scores as follows:

$$P^{*} = aZ + bI + U \qquad (3)$$

To estimate equation (3), individual and household variables are used as controls, including age of respondent, generation of respondent, gender of respondent, gender of household head, household size and so on. Irrigation characteristics such as irrigation type (formal or informal), irrigation scale (small, medium or large) and irrigation water conveyance method (pump or bucket). After generating the propensity scores, the matches are restricted to within sites and this is to ensure that inter-site fixed effects do not bias the estimates.

3.4 Empirical Model Specification

Participation in irrigation, Y, is a function of individual, household and irrigation specific characteristics. Each of these characteristics either positively or negatively influence the decision of individuals and farm households to participate in irrigation as a livelihood activity. Mathematically, this is expressed as follows:

Y = f(Individual, household & irrigation characteristics) (6)

The individual, household and irrigation characteristics used in the estimation of the selection equation are:

- ✓ Generation of respondent (Elderly = 1; Otherwise = 0)
- ✓ Gender of respondent (Male = 1; Female = 0),
- ✓ Gender of household head (Male = 1; Female = 0),
- ✓ Age of respondent (years)
- ✓ Respondent’s AgeSq (years)
- ✓ Marital status of respondent (Married = 1; Otherwise = 0)
- ✓ Years of formal schooling by respondent (years)
- ✓ Origin of respondent (Native = 1; Otherwise = 0)
- ✓ Household size of respondent (number of people in the household)

- ✓ Irrigation type (Formal = 1; Otherwise = 0)
- ✓ Irrigation Scale (Medium = 1; Otherwise = 0),
- ✓ Irrigation Scale (Large = 1; Otherwise = 0),
- ✓ Water Conveyance (Pump = 1; Otherwise = 0),
- ✓ Water Conveyance (Gravity = 1; Otherwise = 0),
- ✓ Alternative livelihood activities (Has livelihood activities =1; Otherwise = 0),
- ✓ Food shortage (Experienced food shortage = 1; Otherwise = 0)

The outcome variables for the PSM are:

- ✓ Total agriculture income measured in Ghana Cedis
- ✓ Total consumption measured in Ghana Cedis
- ✓ Employment duration measured in number of months of work

4. Results and Discussion

The results indicate that irrigation has the potential to take the centerstage for agricultural transformation agenda in Africa through different impact pathways. These include direct and indirect impacts as well as on-farm and off-farm impact pathways. Each of these impact pathways critical in the transformation of smallholder agriculture in Africa and promotion of rural livelihoods development is discussed in the following subsections.

4.1 Impacts on Outputs and Incomes

The study results revealed that the immediate and direct impact of irrigation on livelihoods and transformation of smallholder agriculture is through output levels. Irrigation increases total output in three ways. The first is that irrigation augments water supply and help reduces crop losses through erratic rainfall. Additionally, irrigation permits multiple and continuous cropping in a year and hence total farm output increases per parcel of land in a year. Finally, in areas where land is available but water supply is minimal or seasonal, irrigation allows for intensive crop cultivation. In other words, irrigation brings about increases in output levels because of the use of complimentary inputs such as fertilisers, high yielding crop varieties and modernised technology as experienced in the green revolution. The increases in outputs lead to increases income, which is a key livelihood outcome, *ceteris paribus.* This assertion is consistent with the views of Lipton *et al.* (2003) that irrigation could boost annual output and raise income levels when there are no significant changes in prices. It must however, be noted that incomes will decrease if increases in outputs are accompanied by more than proportional declines in prices. Participants of the focus group discussions and key informant interviews indicated that irrigation has greatly impacted their livelihoods through improved output levels and this is helping them transition from smallholder agriculture to medium and large scale farm production. The PSM results indicate that the average treatment effect (ATE) of irrigation on farm output is about 23.58 Ghana Cedis (GHC) and this was found to be significant at 1%. This means that on the average, irrigation has significantly contributed to agricultural out and income levels of farmers in northern Ghana. The average treatment effect of the treated (ATET) was found to be about 25.19 Ghana Cedis and this is significant at 1%. The implication of this is that on the average, irrigation has positive and significant impacts on the output and income levels of irrigators. In terms of incomes, the results indicate that the average treatment effect of irrigation on incomes is about 822.03GHC and that of the treated is about 972.86GHC, both being positive and significant at 1% respectively. The implication of these findings is that irrigation brings about increase in income levels and this is consistent with the empirical literature cited above.

4.2 Impacts on Employment

Irrigation reduces poverty through employment by creating farm labour for the farmer, wage labour for others and labour for constructing and maintenance of irrigation facility. According to Lipton *et al*. (2003), irrigation projects firstly require labour for the construction and maintenance of canals, wells, and pumps, which is important to the poor, especially the landless rural poor households with excess labour or seasonal excess labour. In addition, increased farm output as a result of irrigation stimulates demand for farm labour in two ways; in the main cropping season and the minor cropping season. This increases the number of workers required and the length of employment period. The depth of rural poverty reduces by increased employment opportunities leading to agricultural transformation. The poverty impact will be positive if vulnerable groups, normally the poor and landless especially women are rewarded. Additionally, if the employment effect is great enough, irrigation can reduce the migration to urban areas, and so reduce the number of job seekers and relieve the downward pressure on urban wages and the upward pressure on prices of housing and other urban infrastructure. With regards to employment, the PSM results showed that irrigation provides on the average about 2.72 months of work in irrigated areas with irrigators having an average of 2.65 more months of work.

4.3 Impacts on Consumption and Food Security

Increases in production also lead to increase in the quantity of food available that will lead to reduction in food prices and improvement in food security. Lipton *et al*. (2003) asserts that the positive impact of irrigation on food prices might be low for producers if there are significant transport costs from food surplus areas to towns or food deficit areas. However, for net purchasers of food, the positive impacts will be high because of cheaper food and the fall in prices is likely to be poverty reducing. However, low-income and possibly poor, small-farmers in areas not affected by extra irrigation – non irrigated or already-irrigated areas – may be net producers and so will be harmed by falling prices and may even become poor, unless the increase in output offsets the price fall.

Waged agricultural labourers, in addition to increased employment, will benefit from lower prices. Wage labourers will have more purchasing power as they will find their wages buy more food, hence will benefit from falling prices. The effect of irrigation on prices and therefore on poverty may be particularly strong in remote areas or countries with high transport costs where, prior to irrigation project, food deficit had to be compensated by purchase from other regions. It will also affect areas with a comparative advantage in food production, which can respond more strongly to the availability of irrigated land (having a surplus of land or labor) and areas with high surplus output levels, which can be traded in wider markets. Irrigation is therefore likely to reduce poverty among net food purchasers in irrigated and non-irrigated areas as well as the urban poor. In addition, there might be positive effects on net food producers and waged labourers if increases in output and employment outweigh effects of price falls. This is increasingly likely with liberalisation of food trade, with falls in growth rate of irrigated area and with better transport and falling transport/production cost ratios (Lipton et al, 2003). The PSM results revealed that irrigation has a significant and positive impact on farm household consumption and food security. The results showed that the average treatment effect of irrigation on household consumption is 426.60GHC and that of the treated is about 348.32GHC and both are statistically significant at 1% respectively. The implication of this is that irrigation generally boosts consumption and food security situation of farm households and this is critical for the transformation of smallholder agriculture in Ghana and Africa generally.

4.4 Impacts on Non-farm Activities

Results from focus group discussions and key informant interviews conducted indicate that irrigation promotes non-farm income generating activities. For instance, when there are increases in output and incomes for that matter with declines in food prices, enriched farmers and workers are able to increase their expenditure on non-food products. This leads to demand for non-food goods and services leading to the establishment of businesses that provide these goods and services. The end result is increased employment opportunities in non-farm incomes generating activities such as transportation, petty trading, construction, food preparation and so on.

4.5 Impacts on Health

Results from the focus group discussions and key informant interviews as well as review of the empirical literature revealed that in a wider socio-economic context, irrigation affects livelihoods in many different ways including displacement of large number of people and loss of livelihoods where irrigation projects involve the construction of large dams with associated environmental effects. Access to irrigation may have very high positive impacts on nutritional outcomes, through the availability and increased stable food supplies and, sometimes, cleaner water. In addition, increased income levels will allow rural producers, assuming transport costs are not prohibitive, to purchase a wider variety of foods thereby increasing dietary diversity and ensuring balanced diets with adequate intake of balanced diets. On the flip side, irrigation, particularly involving canals, reservoirs and tanks, has negative effect on health as it encourages water-related diseases due to inadequate drainage and renders the microenvironment hospitable to mosquitoes and snails that spread malaria and schistosomiasis. Irrigation sites characterized by contaminated water are also responsible for causing serious diseases, from diarrhoea (one of the main proximate causes of child mortality) to cholera. It is likely that the poor are more vulnerable to such water related diseases. However, increased purchasing capacity of farmers following irrigation projects has made it possible for them to be able to afford to pay for the medical treatment they need to combat water-related diseases (Lipton *et al.*, 2003).

4.6 Socio-cultural Impacts

Participants of the focus group discussions and key informants indicated that irrigation affects the socio-cultural aspects of farmers in irrigating communities as institutional policies of irrigation affect the existing structures and relations. Equity concerns addressed in distribution of productive resources such as land and inputs, water supply as well as inclusive decision making benefits the poor and vulnerable especially women and poor resource farmers are empowered. However, irrigation structures that conflict with existing structures are likely not to achieve their poverty impacts.

4.7 Environmental Impacts

Focus group discussion participants and key informants noted that irrigation has positive and negative impacts on the environment. The construction of large dams and canal systems is associated with environmental problems such as loss of natural habitat and biodiversity. Generally, irrigation projects have also further detrimental impacts on the environment beyond the construction phase. Water loss through unproductive evaporation, seepage and percolation, possibly inducing problems of waterlogging and salinization are potentially negative consequences of irrigation. The question to know if the poor are more likely to suffer from these effects than the non-poor depends very much from one case to the other (Lipton *et al*., 2003).

5. Conclusion and Policy Implication

The paper examined the role of irrigation in the drive towards transformation of smallholder agriculture in Africa. The results indicate that irrigation has significant and positive impacts on farm output, income, employment, consumption, food security and non-farm businesses all of which are necessary conditions for successful transformation of smallholder agriculture in Africa an Ghana for that matter. The impacts of irrigation on health and environmental sustainability are mixed - the positive being the ability of irrigators to pay for improved healthcare for themselves and their families and the negatives include the outbreak of waterborne diseases associated with irrigation water. Construction of irrigation facilities causes destruction to the environment but improves provisioning ecosystem services. It is generally concluded that access to irrigation is associated with higher farm outputs, income levels, employment, consumption, food security, and engagement in non-farm business activities. The key policy implication of these findings is that African governments must formulate strategic policies that will accelerate investments in the provision of irrigation facilities to better promote the agenda to transform of smallholder agriculture in the continent.

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