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## Transformative Change in Rural Ethiopia: The Impact of Small- and Medium-Scale Irrigation

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### Cover Page Footnote

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# Transformative Change in Rural Ethiopia: The Impact of Small-and Medium-Scale Irrigation

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## ABSTRACT

Rural livelihoods in Ethiopia are vulnerable due to their reliance upon variable rainfall and the lack of access to irrigation. Irrigation coverage in the country is low, as the existing systems tend to cover state-run and commercial operations. There is significant potential for irrigation to play a transformative role in rural lives and livelihoods. Much of the evidence available in Ethiopia focuses upon technical studies of irrigation systems or impacts on households after gaining access to irrigation. This article highlights the causes and pathways of change. We focus on more financially-viable and environmentally-sound small- and medium-scale systems, versus the large-scale operations that have attracted much governmental attention. We draw on two case studies, located in different agro-ecological settings: a cereal-based farming system and a root crop-based farming system. We highlight unintended consequences, such as the spread of malaria and shift away from food crops, creating market-based vulnerabilities for farmers.

## KEYWORDS

Africa, agriculture, Ethiopia, irrigation

## INTRODUCTION

The majority of Ethiopia's residents live in rural areas and are engaged in activities connected with the agricultural and livelihood sectors. An estimated 12 million smallholder farmer households are responsible for 95 percent of agricultural production and 85 percent of primary livelihoods (FAO 2018). The national economy is also largely agricultural, with the vast majority of its exports reliant on consistent, quality production

(Cochrane and Bekele 2018). Despite producing food for the nation and for export, smallholder farmers are highly vulnerable to food insecurity because their livelihoods are almost entirely based upon rain-fed practices. To date, access to irrigation of any form is rare for smallholders. Due to limited data on irrigation systems and their functionality, the exact coverage of irrigation varies. However, scholars and development professionals generally agree that a very small percentage of smallholder farmers have access to irrigation. In 2006, the World Bank suggested that Ethiopia's irrigation covered only 5 percent of suitable area, of a potential area surpassing 3.7 million hectares (World Bank 2006). In 2010, the Ethiopian Ministry of Water, Irrigation, and Energy stated that irrigation coverage was less than 3 percent of suitable area (Birhan 2013). Notable, however, is that existing irrigation systems are not primarily covering smallholder farmer lands, but state-owned farms and private agricultural investments. Expanding irrigation access for smallholder farmers offers significant potential for the reduction of vulnerabilities and the improvement of agricultural production.

The current situation of irrigation infrastructure in Ethiopia demonstrates potential and opportunity. Although much attention has been placed upon large-scale systems by the government, in this article, we focus on small- and medium-scale irrigation systems, which have been unevenly studied in different parts of the country (Cochrane 2018). The available evidence demonstrates that small- and medium-scale irrigation can improve food security, expand livelihood options, and reduce poverty (Agide et al. 2016; Ahmed, Mume, and Kedir 2014; Beyene and Engida 2016; Cafer 2018; Cafer and Rikoon 2017; Gebrehiwot, Mesfin, and Nyssen 2015; Hunnes 2015; Kelilo, Ketema, and Kedir 2014; van der Veen and Tagel 2011; Ven Den Berg and Ruben 2006; Villani et al. 2018). Irrigation results in several positive changes. First, there is a stabilizing effect that allows households to reduce the risks associated with seasonality and annual rainfall fluctuations and to produce quality yields on a consistent basis (Masset 2012; Passarelli et al. 2018). In addition, irrigation allows for the introduction of new crops as well as enables greater yields. The transformational components are the multipliers of those impacts combined with the ability to double the number of harvests per year (not having to wait for the seasonal rainfall). New opportunities emerge for this, but so do challenges; these have been subject to less research to date.

In this article, we contribute evidence on the impact of small- and medium-scale irrigation. We focus on the processes or pathways of

change that irrigation enables in terms of changing livelihoods as well as the resulting impacts, such as changes to income (as opposed to focusing on the outcomes, such as knowledge from training, which may not necessarily enable livelihood change). Smallholder farmers are well aware of the need for small- and medium-scale irrigation; however, their ability to develop these systems is often beyond their local capacity and/or requires resources unavailable to them. Thus, we expand the focus beyond the household farming context, and seek to present a case that resonates with governments, donors, and non-governmental organizations. We highlight the processes, pathways, and multiple effects in the short-, medium- and long-term. We also highlight challenges and unintended consequences that should be given sufficient attention when considering or planning small- and medium-scale irrigation projects.

## LITERATURE REVIEW

Much has been written on irrigation, and its small and medium forms specifically (Agide et al. 2016; Ahmed et al. 2014; Beyene and Engida 2016; Cafer 2018; Cafer and Rikoon 2017; Gebrehiwot et al. 2015; Hunnes 2015; Kelilo et al. 2014; van der Veen and Tagel 2011; Ven Den Berg and Ruben 2006; Villani et al. 2018). In this article we draw upon available evidence to contextualize the pathway of transformation outlined in this study (Figure 1). In so doing, we present a general timeline and aggregated description of activities as well as critically analyze the positive and negative changes that results along the pathway. Much of the available literature regarding irrigation in Ethiopia promotes the potential impact or the actualized impact (e.g. income or food security; Ahmed et al. 2014), often relying upon household survey data. Studies of this type are important, as they present statistically significant studies of impact (by isolating change that is unlikely to have resulted by chance). However, these studies tell us less about how those impacts materialize. For example, incomes may increase through a range of activities and forms; it may involve intensification of existing practices, diversification into new agricultural practices, or a transition into non-farm and off-farm activities. Drawing upon mixed-methods data, we present insight into the “how” and “why” questions of the transformational potential of small- and medium-size irrigation. This approach enables us to better understand how and why the positive impacts occur, enabling us to explore the vulnerabilities and challenges of the changes that occurred, which may not appear in the household survey data.

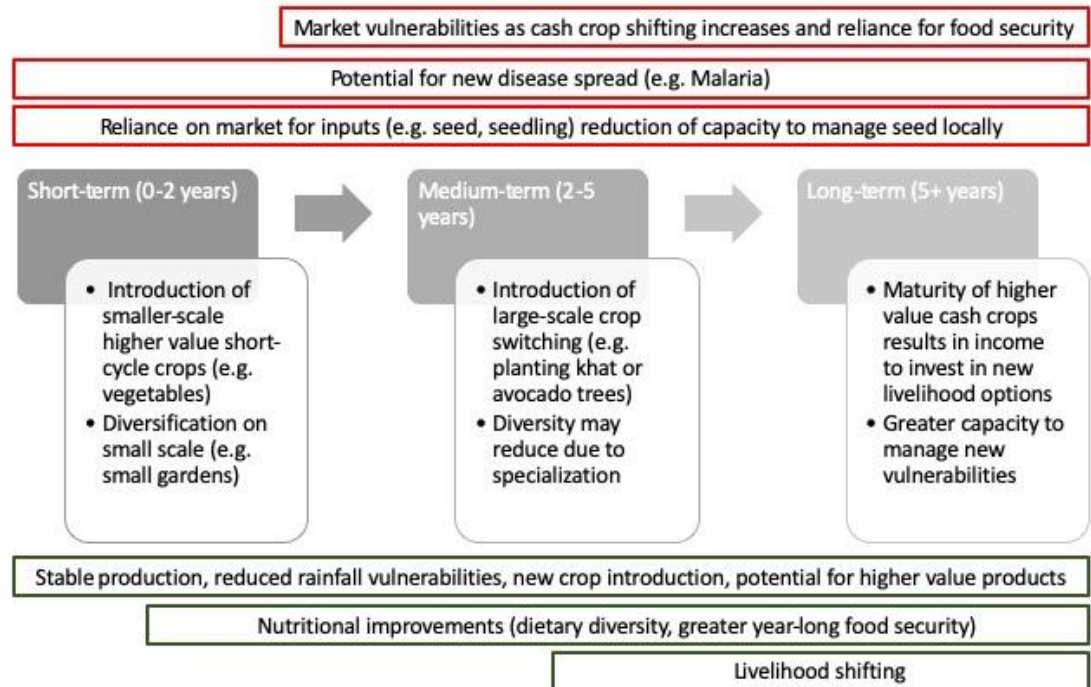


Figure 1: Pathway of Transformation Highlighting Challenges (red) and Opportunities (green)

Previous work by the authors and others point to initial short-term benefits of irrigation in promoting crop diversification, but on a small scale (Cochrane and Cafer 2018; Cochrane and Gecho, 2016; Amede 2015). This short-term diversification is often into higher value crops, such as khat<sub>1</sub> or vegetables (Cochrane and Cafer 2017; Cafer 2018; Amede 2015). These initial forays into diversification play an important risk mitigation role in areas with erratic rainfall and often provide households with enough stability and income to invest further into improved irrigation schemes and expand production of these high value crops, in Ethiopia and globally (Cafer 2018; Rao, Deepika, and Rejani 2018; Stevenson, Serraj, and Cassman 2014; Gebrehiwot et al. 2015). The investment in irrigation is often combined with an investment in other infrastructure and allows further specialization and expansion of planted area in more lucrative crops, the benefits of which manifest in the medium- and long-term (Cafer 2018; Emanu and Genana 2012). This mid-term effect of small-scale irrigation investment ultimately leads to livelihood diversification due to synergies with off- and on-farm income (Alobo Loison 2015). As a result, a long-term trend is enabled whereby irrigation users build and expand their asset holdings (on a relative scale),

ultimately reducing vulnerability to shocks (Loison 2015; Rao et al. 2018; Stevenson et al. 2014; Gebrehiwot et al. 2015).

## METHODS

This article draws upon two research projects in Ethiopia, one in the northern cereal-based highlands, and the second in the southern root-crop farming areas (see Figure 1). Both projects have rural and peri-urban sites (as per Iaquinata and Drescher 2000), and the livelihoods of focus in the respective studies were predominately small-scale agriculture. The majority of households in both regions do not have access to irrigation, particularly complex, capital intensive irrigation; however, this study takes advantage of the existence of irrigation in some areas to compare the impact of irrigation for livelihoods, food security, and poverty. In both research areas, farming communities gained access to irrigation with external support (governmental and/or international agencies), yet both manage the irrigation systems and have modified, expanded, or developed the initial irrigation system to better serve their needs. One might consider these as “natural” comparative study sites, as the existence of irrigation within each of the two location provides a means through which the processes and pathways of change can be understood, by way of comparison to neighboring communities without irrigation. This methodological approach has limitations, as ideas, attitudes, behaviors, and practices are not bound by these irrigation systems. In recognition of this limitation, we believe that the two sites offer unique insight into the role that irrigation plays in lives and livelihoods. While this comparative case study approach allows for analysis based on differences, the exact causes cannot be isolated using this methodology, as might be able to be done had it been a designed from the outset as a random controlled trial. Rather, we utilize the existence of these systems to compare outcomes, supporting the findings with qualitative and quantitative data.

The individual research approaches utilized in the two sites, combined with their comparison, provide a compelling examination of the impact of small- and medium-scale irrigation on smallholders (Figure 2). The study in the northern highlands focused on peri-urban locales and utilized a comparative design (see Cafer 2016) between villages. This study utilized a combination of survey and qualitative interviews regarding technology adoption. The second utilized a knowledge co-production methodology, wherein community members and the researcher worked collaboratively to determine the most suitable questions and metrics for data collection. Knowledge co-production was also utilized in the analysis



of the data within and between communities (see Cochrane 2017). Data from both sites were collected from 2014 to 2016. The northern communities are all located in the South Wollo Zone of the Amhara Regional State. In these communities, irrigation is a mix of gravity-fed irrigation and drip irrigation using both tube wells and water-lined catchments. At the southern site, a medium-scale gravity-fed irrigation system that requires no pumps, generators, or electricity, and was constructed largely with locally-available materials was used (although funded by an international donor, that also provided technical expertise). The southern irrigation system is located in Buge kebele, Damot Gale district, Wolaita Zone, in the Southern Nations, Nationalities, and Peoples' Regional State. As comparison, two other communities in the same district, without irrigation, were also surveyed. In total, 517 farmers were surveyed (115 in the northern site and 402 in the southern sites). Data from these surveys were combined with interview data from farmers, extension agents and administrators, agricultural faculty, and kebele administrators. The specific data collection processes and approaches used in each of the site are not detailed here; however, other publications are listed for readers who are interested in gaining a more detailed understanding of the two research studies (Cafer and Rikoon 2017; Cafer 2018; Cochrane 2017).

The two irrigation sites explored in this study have unique characteristics. In the northern site, small-scale technologies are adopted more on an individual basis, whereas in the southern site, the medium-scale system provides more general access (based upon proximity to the irrigation system, as opposed to wealth status). In the northern site, the three study communities each have a unique relationship with irrigation systems. In the relatively poorest community, irrigation is rarely used and farmers rely almost exclusively on rain-fed agriculture due to a lack of proximity to sources that can easily be diverted for irrigation (for all crops, typically cereals, such as maize or sorghum in the main season). Whereas in the relatively wealthier community (all households are impoverished by international standards; these are relative differences), an irrigation source is much more easily accessed and is used by more than 20 percent of farmers, entirely for the production of khat (a stimulant, see Cochrane and O'Regan 2016). The third, and somewhat transitional community, uses irrigation on more limited basis (18.9 percent of households), and mostly for vegetable production. In the third transition community, those that use irrigation for vegetable production have plans to scale-up to produce irrigated khat. In the southern, root-crop based agricultural setting, a



“natural experiment” exists wherein one community gained access to irrigation in a region where irrigation is rare. This provided a comparison of the impacts on a more general level, being less dependent upon relative economic status as an access factor. While the unique traits of each community limit the ability to identify exact causation, the comparisons offer some insight into the processes and pathways that enable change as well as explanatory insight into how the impacts of irrigation are manifested.

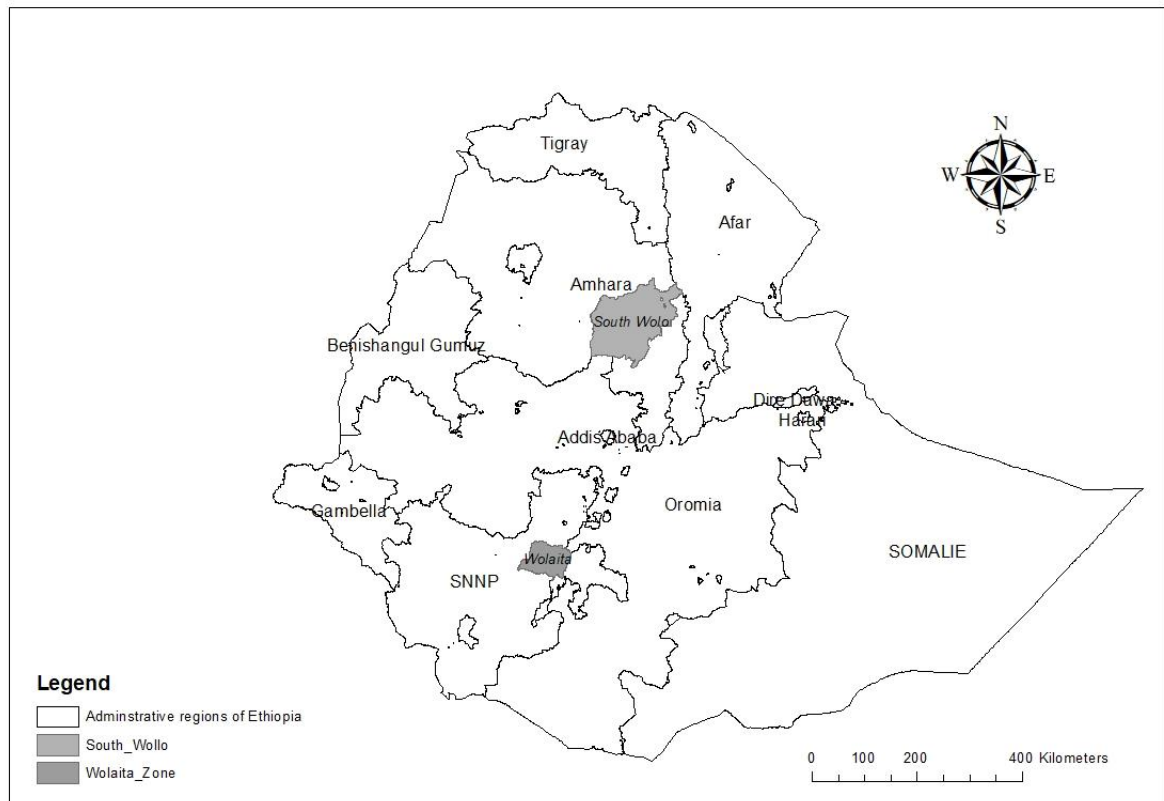


Figure 2: Two Study Areas, South Wollo Zone and Wolaita Zone. Map by Dr. Tafesse Matewos

This study has a particular focus—that of clarifying the pathways through which irrigation can enable transformative changes. A limitation of taking a broader perspective of rural development is that the specific technical details of irrigation systems are not specified. This is due to our assessment of more general processes, as opposed to site-specific details about irrigation system design, management, and challenges. The environmental management concerns, such as impacts on watersheds, sediment, and downstream flows (Yewhalaw et al. 2014; Yihun et al.

2016), as well as management challenges of specific systems (Abera et al. 2018; Hagos, Schultz, and Depeweg 2016; Berhane et al. 2016; Woldearegay and van Steenberg 2015; Zeweld et al. 2015; Yami 2016), are not outlined in this work.

## FINDINGS

### *Processes of Change*

The introduction of irrigation to these communities created processes of change that enabled new options and reduced vulnerabilities for households. Specifically, the crops that were grown before the introduction of irrigation – during the two rainy seasons, as is done in the non-irrigated lands – produced higher yields and more consistently. Irrigation lessens the impact of rainfall variability, which has increased in recent years (Seleshi and Zanke 2004), providing not only a stabilizing effect, but also the ability to optimize moisture for improving yields. For areas that experience entire crop loss during years of poor rainfall (too little, too much, too late, or at the wrong time), irrigation can reduce these vulnerabilities (although not eliminate). This does not mean that farmers do not experience challenges with their main crops – seed access, market connectivity, flooding, pest, and disease are challenges that continue. In the short-term, small- and medium-scale irrigation can “transformation” households that “collapse under even minimum pressure” (Rahmato 2007: 10) to relatively stable and food secure households.

Despite the on-going experience of continued challenges, such as pest and disease, the introduction of small- and medium-scale irrigation systems have resulted in major agricultural shifts for smallholders in these areas. In the southern site, one of these shifts is the production of vegetables for market sale, which have a much higher value than traditionally-grown root crops and cereals. Having daily water access on a year-round basis has enabled the introduction of these new crops, and has enabled additional yields of those crops outside of the two traditional growing seasons linked with the two rainy seasons. These processes are significant on multiple accounts. First, newly introduced crops provide sources of micronutrients typically deficient, such as vitamins A and E, zinc, and iron (MoH 2016), for the household. Second, these newly introduced crops have higher market value for sale, thereby improving the economic status of the household and enabling other opportunities. Third, the ability to have multiple harvests a year compounds this positive change – households without irrigation may have one or two harvests a year, which are reliant upon rainfall, while households with irrigation have

three or four harvests a year. These are changes that occur in the short-term. In the medium- and long-term, the improved economic status translates into further benefits, such as the ability to engage in new opportunities that may have previously not been adopted due to financial barriers, such as purchasing fruit tree saplings or hybrid chicks for egg production.

In the northern communities, however, the agricultural crop choice shifts following the introduction of irrigation manifested themselves in quite different ways. In these communities, irrigation enabled the shift from seasonal cereal crop production to year-round khat production. For some, this shift might be seen as negative, as it replaces a food crop with a non-food crop in a “high potential” agricultural region of the country (for multiple perspectives on the crop, see the edited volume by Kefale and Mohammed, 2017). Further, khat as a commodity has a highly contested status (not only internationally, but also within some communities domestically, placing value judgements on the choice to grow it). However, from the farmers’ perspective, khat is the highest value commodity, with stable prices (as opposed to other cash crops that fluctuate based on global markets). Rain-fed khat can still produce two crops a year—which does improve, to some extent, household financial and food security. Irrigated khat can be harvested up to five times in a year. At this level of production, we find statistically significant improvements in household food security (Cafer 2018). Using small-scale irrigation systems, farmers are able to produce khat during market dearths and garner a higher price, increasing their return on investment when compared to rain-fed khat. The newfound, stable, and much higher income reduces the need or desire by farmers to diversify their agricultural activities (Cafer 2018). Subsequently, diversification in the communities with irrigation is less than the surrounding areas (Cochrane and Cafer 2018). This shift creates new types of vulnerabilities, ones which have been subject to limited research. For example, farmers who become reliant upon markets to meet their food needs, as opposed to their own production. Rural markets commonly do not function as well as regional centers, and traders have less incentive to provide to these markets (World Bank 2016). This is an area that requires additional research to evaluate its broader impacts.

One important finding based upon these two experiences is that the diversifications occurring in the two areas are different, but both are processes enabled by reduced vulnerability and improved economic opportunity. As we note elsewhere, it is important to add nuance to the

narratives about diversification, in that some diversification strategies are not due to opportunities and positions of strength, but contribute to vulnerability (Cochrane and Cafer 2018). In the non-irrigated areas, crop diversification was higher as vulnerability to variable rainfall was higher; households mitigate risk by including a range of crops, or switch from crops that have a longer growing cycle and higher yield to those with shorter a growing cycle and lower yield. These choices are well-informed ones, but the result is decreased farm production as crops are not selected only for productivity and potential, but for risk mitigation. In comparison, the communities that experienced less risk due to having irrigation had greater specialization in higher yielding crops as well as diversification into higher value crops, such as vegetables and fruit trees. This challenges the narrative that diversification is necessarily positive for rural development. Much more attention needs to be paid to the types of diversification and the reasons for those diversifications (Cochrane and Cafer 2018).

Having more consistent and higher yields, combined with additional harvests and the introduction of higher value crops, increases market engagement. More than 90 percent of households in the irrigated areas from these two sites were selling some of their harvest to the market. In the communities without irrigation, more than 40 percent produced only for their household and did not sell to the market at all. It is noteworthy to add that one of the comparative communities in the southern site was near a town, which, hypothetically, would enable a greater level of market engagement due to proximity. Yet, the findings suggest access to irrigation rather than market distance enabled greater market engagement—even when market distances were greater. Location did, however, play a greater influencing role in off-farm and non-farm activities, such as collecting and selling firework and grass or selling butter or handicrafts. These livelihood options were enabled by market access (specifically nearness to a road or marketplace) as well as resource access (nearness to a forest for firewood cutting and collection).

### *Impacts of Change*

The impacts of irrigation among northern farmers are clear—those with irrigation are able to produce more cash crops, which translates to increased financial security. Farmers with irrigation produced ten times more income (specifically from khat) than households that did not irrigate (Cafer 2018), which subsequently translated to 12 percent of the sample population achieving either food secure or mildly food insecure status

compared to the remaining 88 percent of households who were moderately to severely food insecure. Irrigation, because of its direct translation to income through market sale crops, was also associated with increased livestock holdings, which are the highland insurance policy against drought and famine. These are medium- and long-term transformations that are occurring in the northern sites as a result of irrigation. With the immediate needs of ensuring food security being largely met, households are slowly building their asset base, in the form of livestock in the northern sites or a combination of livestock, fruit tree holdings, and new business ventures (e.g., a donkey-drawn cart for transporting goods) in the southern sites.

The impacts that can be attributed to irrigation in southern Ethiopia are diverse and significant, as outlined by Cochrane (2017). While food security challenges continue to exist, the number of relatively food secure households is 10 percent higher in the community with irrigation. In the southern sites, the medium- and long-term impacts include households planting fruit trees, requiring upfront capital to purchase saplings as well as opportunity costs of unproductive land while the trees reach maturity (up to 7 years). Households with access to irrigation have more avocado, mango, and banana trees — at the community level nearly twice as many — which provide supplementary food sources, micronutrients, and income. Households with irrigation in these southern sites also plant more cash crops, such as coffee plants, which provide additional household income and offer higher sale prices than root crops or cereals. Food insecure households recognize the benefits that these cash crops offer, but are not able to overcome the financial barriers and costs (delay of returns) to adopt them. This is similarly the case for the short-term for those with irrigation, as time is required to stabilize household resources, create new forms of income sources, and thereafter seek new opportunities. For actors interested in rural development, this is notable because these impacts may not be visible during a typical three- or five-year project cycle. Yet, the processes may be ones that transform lives and livelihoods in ways that traditional rural agricultural development activities (e.g., training, model farmers, demonstration plots, provision of tools and inputs), may not.

The medium- and long-term impacts of irrigation include positive changes beyond agricultural assets and its resulting income. As noted above, livestock are a form of “insurance” for smallholders, and thus investing in livestock should be viewed not only as new asset holdings but also as an intentionally-created buffer against vulnerability and food

insecurity. In tandem, livestock are value-producing. Households in the irrigated areas, at the community level, have more than double the amount of oxen and dairy cattle when compared to those without irrigation. Oxen can be rented for plowing or fattened for sale, while dairy cows enable the sale of milk and butter. As livestock reproduce, assets expand, as do the opportunities for market sale. New livestock options are also emerging in greater levels in the community with irrigation, such as the adoption of hybrid poultry for egg production. The multiplier effect of this entrepreneurial activity is improved income as well as improved nutrition and health, as eggs provide new sources of nutrients for typically absent micro-nutrients. There are risks to engaging in new businesses, which are largely known to farmers. One example of a risk in purchasing hybrid poultry for egg production is that these livestock require vaccination and new management techniques, without which disease can result in the loss of an entire coop of poultry. This is one reason we see the emergence of these forms of business activities only beginning to emerge a decade after the introduction of irrigation – it took time to be able to accumulate the finances required as well as a sufficient buffer in the case that the business fails (as well as the interest to take the risk for the potential returns of a successful venture).

There are other long-term measures that provide insight into the transformative impacts of irrigation, such as youth migration, and specifically unskilled youth migration because of vulnerability. Due to household vulnerability in non-irrigated areas, far higher numbers of youth are leaving the community in search of precarious, low-paid, and low-skill work, whereas more children are completing school and leaving the community for skilled work from the households in the community with irrigation (Cochrane and Vercillo 2019). The skilled opportunities have higher pay and are more secure work opportunities, offering children far better opportunities in their lives, and offering support to their families (Bezu and Barrett 2010). These changes also present challenges, particularly the loss of labor in rural communities that place high burdens on an older population to engage in laborious agricultural tasks (Cochrane and Vercillo 2019). In the southern community with irrigation, 43 percent of migrants left for skilled labor, more than double the amount from the other communities without irrigation, which were more likely to leave for the precarious, low-paid, and low-skill work (Cochrane 2017). Furthermore, in the communities with irrigation, fewer unskilled youth are leaving as their family farming enterprise has become more viable as a livelihood option. Long-term impacts, such as education for children and skilled migration,



occur on scales well beyond project cycles, and are indicators that might not be included as relevant metrics in agriculturally-oriented projects, including the introduction of irrigation. As a result, we may not be fully aware of the broader impacts these activities can have. The case studies explored in this article show that the impacts will continue to accrue over the long-term, albeit in some unique forms. Retrospectively, communities already observe this is the case. When assessing trends of change over 10-year and 25-year periods, areas without irrigation noted significant negative change, whereas change was more likely to be positively perceived in the community that gained access to irrigation.

Looking to the future, based on improved agricultural and livestock livelihoods, as well as migration trends and potential remittance flows back to the community, the potential for a positive snowballing effect are apparent. The continuation of improved livelihoods, and the multiplier effects of positive changes over time, will further enable new opportunities for the community. Thus far, we have focused on the positives. We believe these are worthy of elucidation. In comparing the relative impacts of access to markets, schools, and healthcare, it appears that irrigation infrastructure has the most transformative impact (Cochrane 2017). These positive changes, however, should not be considered in isolation. There are also new vulnerabilities being created and new challenges introduced. As these are not intentional, and often unrecognized by planners, we categorized these as “unintended consequences,” however these impacts have been studied and should be better integrated into research, policy, and planning.

### *Unintended Consequences*

The introduction of irrigation can also present new challenges. One, often neglected, unintended consequence in irrigation promotion and planning is the potential to increase disease incidence, in particular malaria (Solomon et al. 2016). Self-reported data from the southern site of this study suggests that the experience of malaria in the region is not significantly higher in the community with irrigation (Cochrane 2017), however available evidence suggests that additional research is warranted, as this can be the case (Hathaway 2008; Kibret et al. 2014; Yewhalaw et al. 2014). This is additionally important as climate change alters the areas where disease vectors can inhabit (Baer and Singer 2016), thereby enabling disease potential in areas that may have not previously experienced them (e.g. areas where malaria is present may increase, specifically rising in elevation where malaria was previously not common).



The increasing reliance on the non-food, cash-crop commodity of khat in the northern site is, in both the short and long-term, a potential liability. In the short-term, khat has translated to improved household income and food security, but increased national and international legislation banning the use, trade, and importation of khat (Cochrane and O'Regan 2016; Csete 2014) is shrinking the legal khat market. The consequences that these changes will have on khat prices is uncertain given the lack of clarity on potential Ethiopian regulation. As more smallholder producers make this switch to khat, sometimes uprooting other cash crops such as coffee, they become increasingly vulnerable to market saturation (Cafer 2018). Additionally, khat requires a significant amount of water and to continually produce year-round require extensive water use, which presents an opportunity cost for other potential water uses (in agriculture and beyond). This is particularly worthy of consideration in Ethiopia, where food aid remains a common requirement in drought years. Current water schemes are inefficient and water use is unregulated, compounding these challenges (Cafer 2018). This poses a potential threat to critical agricultural resources with increased water withdrawals and also increases the potential for village level inequalities—farmers with more resources can dig deeper wells. It also poses a medium- and long-term challenge to farmers growing khat, who become increasingly reliant upon the market to ensure food security, while the rural markets upon which they rely are vulnerable as traders have less incentive to provide to them (due to costs involved in transportation, see De Waal 2017).

A third unintended consequence of the introduction of irrigation is that irrigation itself, and the transformative impacts offered, may not be permanent. Encouraging farmers to make investments based upon the assumption of permanence can result in significant negative consequences and the loss of assets if the system fails or is not sustained. For example, a medium-scale rain-filled irrigation system in Tigray Regional State has not reached the minimum refill amount to supply the irrigation system, making it non-functional (see Pankhurst 2017). In this instance, the cause for failure was an external factor: multiple seasons of low rainfall have resulted in the water level being below the irrigation feeder pipe. It remains unclear what the future holds for the irrigation system, however for the time being, the investments that farmers made that relied upon the irrigation systems, such as relatively high-cost diesel generators used for farm-level irrigation from the main system, are sitting unused. As a result, enthusiasm for irrigation and its

potential should not only be checked by questions of design, functionality, inclusion, and sustainability, but also the unintended consequences and long-term sustainability. We need to better consider the worst-case scenarios for people who are without insurance schemes when these systems fail.

## CONCLUSIONS

Across communities in the two study areas, the data show small- and medium-scale irrigation systems have played a significant, positive role in improving livelihoods, strengthening food security, and increasing incomes and asset holdings. We have outlined an aggregated, general pathway of these transformations (Figure 1), showing the short-, medium- and long-term changes, both positive and negative. In comparison to their neighboring communities without irrigation, it is clear that access to irrigation has created transformative changes, and stood out as having a significant impact on the long-term strengthening of food security status at the community level. Though other geospatial differences were important (e.g. access to markets, transportation) and reduced specific vulnerabilities, they were less transformative than irrigation infrastructure. The strength offered by irrigation is firstly a stabilization and secondly an enabler to new opportunities.

The challenge individuals and households encounter with regard to irrigation, even small-scale forms of it, is that it is often beyond the capacity of individuals and communities to develop on their own. It requires not only financial capacity, as some irrigation schemes are more labor intensive than financial, but also technical capacity. The irrigation scheme in southern Ethiopia was a gravity-fed system that required technical expertise in planning and implementation, as an example. Community members also explain that some components, such as cement to create the primary irrigation canals, or the plastic tubing for drip irrigation in northern regions, are not available in their area or are prohibitively expensive. As one farmer in southern Ethiopia explained, “it is beyond our capacity to build these canals, but we are willing to extend our hands [contribute labor] to have irrigation.” As a result, the case for irrigation is not one made at the individual or household level in the first instance, but it is one made to governments, donor agencies, and non-governmental organizations.

The recommendation for expanding irrigation has been recognized by the Government of Ethiopia, and it is working with its partners to address this. For example, the Ministry of Water, Irrigation, and Energy

has explicitly sought to expand irrigation coverage and has planned to construct medium- and large-scale irrigation schemes. This study recommends the expansion of irrigation, tempered with the knowledge that expansion must take into account issues of equity and capacity, which Yami (2016) identified as hindering the effectiveness of existing irrigation projects in Ethiopia. Rather than large-scale irrigation schemes, we argue that smaller-scale and locally-managed irrigation projects offer greater suitability and potential for sustainability, ownership, and impact. Furthermore, irrigation projects designed to serve commercial interests (as large-scale irrigation systems tend to do) may further increase inequalities and negatively impact small-scale farmers. Additionally, as demonstrated in these two research sites, irrigation was mostly used by farmers who already had access to resources or were already growing, in some form, cash crops, while resource poor farmers were unable to take advantage of irrigation. In this way, irrigation has the potential to increase income and wealth inequality among smallholders, at the community level. This, however, does not operate as a panacea, as those without sufficient land or who are landless will continue to be food insecure in the presence of irrigation access. If positive impacts are sought for smallholder farmers, the government and its partners must develop and convey explicit objectives whereby smallholder farmers are prioritized in public sector investments. It also must regulate commercial enterprises as they develop their own irrigation infrastructure lest smallholder farmers lose access to existing water resources (Bues 2011).

Investment is needed to support new irrigation coverage. It is also required for existing irrigation infrastructure so that improvements can be made in the delivery and management of water systems. Primary amongst these efficiencies is reducing water loss, particularly on-farm water loss, and enhancing management to improve fairness of distribution (Agide et al. 2016). Improving existing irrigation schemes that are non-functional or that could be optimized in terms of functionality offers a relatively low cost means to improve access to irrigation. We argue that this primarily involves empowering communities to manage, develop, and modify irrigation infrastructure based on their own priorities, needs, and experiences.

## ENDNOTES

<sup>1</sup> Khat is a shrub endemic to Ethiopia used in traditional medicine and as a narcotic (Cafer 2018). While khat is one of Ethiopia's largest exports, domestic use of khat has increased exponentially in the past ten years (Cafer 2018; Cochrane and O'Regan 2016).

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