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The impact of COVID-19 and capacities of farmers in small-scale irrigation schemes in sub-Saharan Africa

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ABSTRACT

Detrimental impacts from COVID-19 restrictions on households and agricultural productivity reinforce the need for resilience building and transformation in African food systems. Capitalizing on the opportunity to learn lessons from the 'Transforming Small-scale Irrigation in Southern Africa' (TISA) project (2013–2023), we summarize TISA's outcomes and compare survey data on the perceived impact of COVID-19 between three schemes involved and three not involved with TISA. Overall, participating households had greater ability to manage the impacts of COVID-19. We highlight the need to build resilience in multiple interconnecting domains to enhance adaptability to crisis events that impact agricultural systems.

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COVID-19 pandemic; small-scale irrigation; sub-Saharan Africa; adaptive capacity; TISA

SUSTAINABLE DEVELOPMENT GOAL

SDG 3: Good health and well-being

Introduction

When COVID-19 spread across the world during the first half of 2020, it had significant impacts within communities, with more than 662 million confirmed cases and close to seven million deaths by January 2023 (World Health Organization [WHO], 2023).

Following the World Health Organization's recommendations, African governments introduced a range of quarantine and lockdown measures to control the spread of the virus and mitigate its health impact, including restricting the movement of people and goods within and between countries and closing businesses and schools (Béné et al., 2021). Based on the reported number of cases and deaths in sub-Saharan Africa (SSA), it would appear this region was less impacted than others, even though vaccine deliveries were slow in coming and were insufficient to cover essential frontline workers in most countries (Cherif & Hakobyan, 2021; James et al., 2022).

Despite comparatively fewer cases in SSA, the lockdown measures created uncertainties regarding domestic food production, and the import, transportation and distribution of food. Combined with the potential loss of income, this caused

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concern there would be less physical and economic access to food. This was particularly the case in rural SSA, where agriculture is still the main source of livelihood (Blekking et al., 2020; Nchanji et al., 2021). Initially, devastating effects were anticipated, with the expectation that millions would be pushed into poverty and starvation would be widespread (Cardwell & Ghazalian, 2020; Food Security Information Network [FISN], 2020; Laborde et al., 2020). However, Pais et al. (2020) argue that the potential impact on food security was mitigated by particularly good rainfall during the 2019 cropping season, resulting in good harvests in late 2019 in South Africa and large parts of East and West Africa. Further, when the lockdown took effect, around March 2020, the planting season had largely begun and inputs had already been purchased. Where good regional, local, or on-farm storage existed, vulnerability to food-supply shocks was mitigated (Brander et al., 2021; Huss et al., 2020). However, food security encompasses both economic and physical access to nutritious and preferred foods.

Early assessment of the impact of the pandemic found that, apart from those directly affected through the loss of family members, the major impact during the first 12 months was that the lockdown prevented access to employment and other income generating activities, which reduced income and purchasing powers (Aggarwal et al., 2022; FSIN, 2020; Picchioni et al., 2022). As lower-income households in SSA spend 60–80% of their income on food, a moderate reduction in income leads to nutritional problems, with households skipping meals, reducing calorie intake, and switching to cheaper, less-nutritious foods (Pais et al., 2020). High food prices aggravated this impact. Okou et al. (2022) found that staple food prices in SSA surged by an average of 24% between 2020 and 2022. This was driven, in part, by import dependency. However, prices on locally produced staples also spiked due to domestic supply disruptions and higher fertilizer and input costs. For example, prices for cassava in Ghana escalated by 78% in 2020–21, and during Nigeria's lockdown the price of maize and rice increased by 26% and 44%, respectively. Prices also increased in the rural markets where these crops are produced (Adewopo et al., 2021).

Households therefore experienced significant socioeconomic impacts and declines in nutrition following the lockdowns (Egger et al., 2021). The restrictions particularly impacted those earning their income through the informal economy, which is critical to secure food in rural Africa. Indiscriminate restrictions on movements of people and produce in rural areas affected access to markets and off-farm work, limiting income earning ability and people's agency in managing their risk of contracting the virus (Tom, 2021). The impact varies with the severity of the lockdown measures put in place and socioeconomic characteristics, such as education, income, race, and ethnicity (Josephson et al., 2021; Picchioni et al., 2022). Particularly severe impacts were experienced among people disadvantaged by gender, poverty, age, and undocumented migration, including wide-ranging impacts on women: resources, time use, care burden, and food and water insecurity (Alvi et al., 2022; Manderson & Levine, 2020). Béné et al. (2021) and Blekking et al. (2020) showed that affordability was the most critical factor influencing food security, with loss of income reducing economic access to food, and travel restrictions and the closure of informal markets disrupting physical access. The latter was especially disruptive for poor urban consumers who were unable to afford food from formal outlets, which were the only retailers deemed essential and allowed to stay open (Nchanji &

Lutumia, 2021). Livestock production and access to improved storage proved important and were effective in reducing food insecurity (Huss et al., 2021).

Particularly for smallholders, COVID-19 and government lockdowns impacted access to farm credit, farm inputs, farm workers and markets (Nchanji & Lutumia, 2021). Broadly, smallholders do not have the collateral to borrow from banks, and therefore often rely on agri-business finance to provide credit for inputs, which are repaid with outputs after harvest. Consequently, even when grain is produced locally the market price is controlled by agri-business/merchants who accrued opportunistic profits during COVID-19 (Adewopo et al., 2021; Agri-Logic, 2022). Apart from access to credit, farmers also reported a reduction in private transfers and remittances (family funds), which reduced their liquidity (Nchanji & Lutumia, 2021) and their ability to access farm inputs. Reduced mobility also meant that farmers could only access buyers within a restricted trading area, which reduced competition. For example, Adewopo et al. (2021) found in Northern Nigeria that the travel distance to markets halved between 2019 and 2020. These mobility restrictions gave merchants and suppliers market power to accrue opportunistic profits (Africa Policy Research Institute [APRI], 2021; INKOTA, 2022; World Bank Group, 2022). The closure of many borders, the reduction and slowdown of international trade, and import/export restrictions all caused continuing supply shortages. As a result, the retail price of NPK fertilizer increased by 30% from June 2020 to 2021 and more than doubled between 2021 and 2022, with the price of urea tripling between 2020 and 2022 (United States Department of Agriculture [USDA], 2022). Many of these impacts are relevant to farmers on small-scale irrigation schemes; however, specific literature on COVID-19 impacts on schemes is sparse, with some suggesting variable impacts on governance arrangements in common pool resource management contexts. In groundwater-fed schemes, for example, Chitata et al. (2023) found that temporary and innovative governance arrangements can emerge in crisis situations like COVID-19, but arrangements can also degenerate and create further challenges for farmers.

Some governments and private players took action to reduce the impacts of the pandemic on food security. For example, Burkina Faso's governmental support to the agricultural sector included input subsidies, food assistance to households, local business support, and price control by purchasing stocks of consumer products and strengthening surveillance of food prices (Nwafo, 2020). The Kenyan government enhanced and expanded smallholders' access to credit. Botswana suffered from the closure of the border to South Africa and in response the government stopped imports of critical food items to encourage local food production and force retailers to buy from local producers (Ministry of Agricultural Development and Food Security, 2021; Morris, 2022). While immediate relief responses were critical and may have some long-lasting impact, the pandemic exposed weaknesses in African food systems, reinforcing the already acknowledged broad consensus around the imperative for transformation and resilience building (Shilomboleni, 2020; Uyanga et al., 2024).

The need for greater resilience in farming systems extends beyond pandemics, encompassing many concerns – persistent poverty, food insecurity and inequality, climate disasters, adaptation to and mitigation of climate change, and redressing or preventing natural resource degradation – with a particular need for attention on vulnerable groups so the gaps in inequality do not widen (Alvi et al., 2022; Shilomboleni, 2020). Valuable resilience lessons can be learnt by exploring what does and does not work when systems

navigate and respond to shocks and crisis events, which requires investment in research and development (Berbés-Blázquez et al., 2022; Uyanga et al., 2024). This paper capitalizes on COVID-19 as a research opportunity, and analyses whether small-scale irrigation households that were exposed to interventions designed to transform the functionality of their schemes had greater capacity to adapt and were better able to deal with the impact of COVID-19 compared to households not exposed to these interventions. In so doing, the paper adds to the limited literature on impacts of COVID-19 on small-scale irrigation schemes, and also contributes to sharing lessons on whether interventions designed to improve profitability and functionality of irrigated farming systems have also increased the capacity of farming communities to respond to emerging crises.

The analysis draws on data and experiences from the project 'Transforming Small-scale Irrigation in Southern Africa' (TISA). TISA worked with small-scale irrigation schemes in Zimbabwe, Tanzania, and Mozambique from 2013 to 2023. This timeframe includes the period leading up to the introduction of COVID-19 restrictions and continued for the duration of these restrictions. Therefore, it was realized that TISA's assessment of end-of-project outcomes would need to encompass collecting data on COVID-19 impacts. This presented an opportunity to extend data collection and compare COVID-19 impacts for households from schemes that were engaged or not with TISA interventions. Based on the outcomes from this project, we test the hypothesis that TISA farmers improved their resilience and adaptive capacity due to the TISA interventions and therefore should have been less impacted by COVID-19 restrictions compared to farmers who were not engaged in the TISA project (non-TISA farmers).

The second section provides background and context on the COVID-19 restrictions within each country and data collection. The third section first provides an overview of TISA's interventions and then synthesizes already published results to argue that, at the time of the onset of COVID 19 restrictions, the TISA approach had increased farmers' resilience and capacity to adapt to shocks to their production systems, such as COVID-19. The fourth section substantiates our hypothesis by analysing the findings of the perceived impact of COVID-19 on farmers within irrigation schemes benefitting from the TISA interventions and farmers within irrigation schemes which have not benefitted from TISA. This section is followed by a discussion and conclusion.

Background and method

COVID-19 restrictions within each country

The impact of COVID-19 has been found to vary depending on the severity of the lockdown (Josephson et al., 2021; Picchioni et al., 2022). As the restrictions and their severity differed across the three countries of interest in this research, the following subsections explain the COVID-19 restrictions and thus provide important context for the interpretation of findings. The focus is on the restrictions most expected to impact agricultural production systems.

Zimbabwe

A state of emergency was declared on 20 March 2020. By 20 November 2020, more than 20 COVID-19 regulations had taken effect to minimize casualties and associated

socioeconomic impacts (UNZ, 2020). An initial 21-day national lockdown took effect from 30 March 2020 (Dzobo et al., 2020), and all unnecessary movements were restricted. The lockdown was extended indefinitely subject to fortnightly reviews from 31 May 2020. Gatherings of more than two persons were banned. In June 2020, restaurants and hotels were allowed to serve sit-in meals. From September, public gatherings could have up to 100 people. Educational institutions were closed until 31 September 2020, when higher learning institutions and exam-writing classes opened and by 9 November remaining classes resumed.

From 30 March 2020, land borders and airports were closed, except for returning residents. The movement of goods and people across towns and cities and between urban and rural areas remained restricted until mid-September 2020. From 23 September 2020, local and regional flights resumed under strict COVID-19 screening and air, rail and road transportation of food, agricultural inputs, and other essential products were allowed as well as the importation and exportation of basic food commodities and key medical and industrial supplies. From 1 October 2020, international air transport of passengers and non-essential cargo resumed subject to strict COVID-19 screening. The pandemic measures were strictly enforced by the security forces.

The agricultural sector was considered an essential service and remained operational subject to strict COVID-19 regulations. Food markets were initially restricted to formal markets. Despite the transport of essential services being opened on 23 September 2020, it took time for transport and logistics to be registered as essential services. This limited the availability and increased the cost of transporting agricultural produce to markets. When transport was possible, most markets were closed as they were informal. As a result, many farmers incurred huge losses, especially for perishable products. Some buyers were not immediately registered as essential services and were therefore unable to receive produce. Some farmers failed to deliver produce due to travel restrictions or were hampered by lack of storage facilities, resulting in huge stock piling and produce losses (Muvhuringi et al., 2021; Rukashal et al., 2021).

Tanzania

The Government introduced several COVID-19 measures in March 2020 to address the spread of the virus, for example: closure of learning institutions, restrictions on non-essential movement, bans on mass gatherings, suspension of international flights; and behavioural measures such as social distancing, face masks and hand sanitization (The Citizen, 2020a). The government stopped enforcing these restrictions in May 2020 (Mumbu & Hugo, 2020), and the President announced that Tanzania would not go into a lockdown and business must continue as normal (The Citizen, 2020b). Compared to its neighbours, the policy responses were considerably less restrictive. That neighbouring countries closed their borders and international trade was restricted, had a far greater impact on farmers within small-scale irrigation scheme and urban low-income consumers. The inability to export crops reduced demand for and, thereby, the prices of locally grown agricultural products. Similarly, the supply of agricultural inputs was reduced, and prices soared (Mugabe et al., 2022; Tripathi et al., 2021).

Mozambique

On 30 March 2020, Mozambique declared COVID-19 a national disaster and a state of emergency (Presidency of the Republic of Mozambique, 2020a). This prompted the implementation of regulations to curb the transmission of the virus such as social distancing, compulsory mask usage in public areas, and limitations on gatherings. Furthermore, the government enforced travel constraints, restricting movement between regions and imposing quarantine protocols for incoming travellers (Presidency of the Republic of Mozambique, 2020b).

The lockdown measures significantly impacted various sectors, including agriculture, with limitations on transportation affecting the supply chain and farmers' ability to access produce markets, labourers and, for farmers not living locally, to access their farms. This hindered the timely cultivation, harvesting, and transportation of crops. There were restrictions on international trade affecting the availability and prices of agricultural inputs such as seeds, fertilizers, and machinery (Elias & Muhamale, 2022; International Monetary Fund [IMF], 2021). Furthermore, the closure of some domestic markets and limited operating hours affected farmers' ability to sell their produce and caused produce spoilage. The second State of Emergency was declared on 8 August 2020, and was set for 30 days. After the second State of Emergency, starting from 4 September 2020, Mozambique transitioned to a State of Public Calamity for the remainder of the year (Presidency of the Republic of Mozambique, 2020c). The updated restrictions included the temporary closure of certain maritime, terrestrial, and aerial borders, restrictions on the passenger capacity of public transportation, and a limit on opening hours for markets, with a cap on the number of visitors. These constraints were gradually eased, and as of January 2023, almost all have been lifted.

Data collection

The analysis of the COVID-19 impacts is based on household surveys conducted in 2021/22. Despite several limitations, such as limited recall ability, enumerator errors, and the subjectivity of answers, household surveys are a well-established and widely used approach to collect quantitative data about rural households. To control for these limitations, the surveys were undertaken with a very large proportion of the population, surveys were uniformly designed across schemes and thoroughly piloted, enumerators were consistently trained during multiple day workshops, and for the last two surveys data were collected using tablets to eliminate data-entry errors and secure consistent answers across questions. The surveys were undertaken with households from three schemes that had been part of the TISA project since 2013 (Kiwere in Tanzania, Silalatshani in Zimbabwe, and 25 de Setembro in Mozambique). These schemes were initially selected to be representative of small-scale schemes in their respective countries, had leadership that had expressed a willingness to collaborate with the project, and were accessible for project staff within a limited budget. Households from three non-TISA schemes were also surveyed, which enabled us to have a data set that could be compared with data from the TISA schemes (Luganga in Tanzania, Siwazi in Zimbabwe, and Paulo Samuel Kankhomba in Mozambique). These schemes were selected to be within the same local government district and comparable with the TISA schemes: for example, in terms of water-supply delivery, rainfall, and crops produced. Details about the six schemes and their size, structure, and production can be seen in Table 1.

Table 1. Key characteristics of the schemes.

	Tanzania		Mozambique		Zimbabwe	
	Kiwere (TISA)	Luganga (Non-TISA)	25 de Setembro (TISA)	Paulo Samuel Kankhomba (Non-TISA)	Silalatshani ¹ (TISA)	Siwasi (Non-TISA)
Characteristics	2004–07	1999–2000	1975	1975	1968–69	1992
Year constructed	Iringa District	Iringa District	Boane District	Boane District	Insiza District	Insiza District
Location	168	380	40	84	212	80
Farmers	195	400	38	200	110	23
Total irrigated area (ha)						
Main crops	Tomatoes, onions, green maize	Paddy, maize, watermelon, onions, tomatoes, beans, and cassava	Cabbages, tomatoes, green beans, maize	Maize, cabbage, beans, green beans	Maize, wheat, sugar beans	Maize, wheat, sugar beans
Management/administration	Irrigators' organization	Irrigators' organization	Farmers' association	Farmers' association furrow	Government with irrigator organization	Government with irrigator organization
Land tenure	Customary	Customary	Historical right by occupation	Historical right by occupation	Statutory land tenure	Statutory land tenure
Soils	Sand and clay of varying fertility	Sand and clay of varying fertility	Mostly fertile clay soils	Sand and fertile clay soils	Mainly clay soils	Mostly loamy sandy soils
Rainfall (mm)	700	700	650–900	650–900	450–650	450–650
Water source and conveyance method	River, gravity canal	River, gravity canal	River, motor pump	River, motor pump, pipes, hydrants	Dam, gravity canal	Dam, asbestos pipe network to the scheme
Irrigation method	Gravity furrow	Gravity furrow	Gravity furrow	Gravity furrow	Gravity flood	Gravity flood

Sources: project data. Shading denotes non-TISA schemes. ¹Silalatshani has 845 farmers on 442 hectares and the project was conducted within the Landela Block, which has 212 farmers. When reference is made to Silalatshani it refers to the Landela Block.

TISA schemes were surveyed at the beginning, mid-term, and at the end of the TISA project. Broadly, these surveys elicited data on household demographics, farming practices, income and perceptions of changes. More detail on these surveys and outcomes for TISA schemes are reported in the references cited in the section on 'the impact of TISA'. For the purposes of comparing the impacts between TISA and non-TISA farm households, several questions were asked consistently in the surveys of TISA and non-TISA farmers, including: questions on their perceptions of COVID-19 impacts on critical livelihood parameters such as farm and off-farm income; well-being parameters such as food security, general health, and ability to pay for their children's education; severity of the overall impact on their household, farm, and scheme; and about the impacts on family members, and their farm and scheme.

Ethics approval for the survey was obtained from the Australian National University's Human Research Ethics Committee (Protocol number 2017/263). Questionnaire development and administration was undertaken with input from each country's project team to ensure consistency and comparability across countries. Surveys were carried out face-to-face in local languages and consent was obtained prior to interviews commencing and followed local rules.

TISA's interventions and their impacts

The following subsections first discuss the TISA interventions and then the documented impacts based on previous studies.

The TISA interventions

The TISA approach was based on the understanding that small-scale irrigation schemes should be conceived as complex systems and that single and/or linear interventions were unlikely to bring about the transitions required to move schemes from dysfunctional to functional systems (Van Rooyen et al., 2020). Hence, TISA made two principal interventions within each scheme: Agricultural Innovation Platforms (AIPs) and monitoring tools. TISA's Theory of Change was that the two interventions would create two self-reinforcing feedback loops: (1) individual farmers and their organizations would gain confidence and skills to innovate further; and (2) farmers would demand more appropriate policies and support services from government agencies. Long-term outcomes should emerge from the cycle of improvement: more sustainable water use, greater food security, and higher farm incomes, resulting in increased resilience and adaptive capacity.

The project took place in two phases: TISA I from 2013 to 2017, and TISA II from 2017 to 2023. TISA I was implemented in five irrigation schemes in Tanzania, Zimbabwe, and Mozambique. TISA II was outscaled to 41 schemes within the three countries. AIPs were introduced to each scheme as a social institution to facilitate a forum of key stakeholders involved with an irrigation scheme such as input suppliers, output buyers, extension officers, irrigation management committee members, regional development officers, and farmers. The AIPs initiated the development of a vision for where farmers would like their scheme to be in five years, with the process identifying the barriers for achieving this, the

solutions to overcome them and the people capable of leading the process of implementing the solutions (for a detailed discussion see Bjornlund et al., 2020; Van Rooyen et al., 2017). The second intervention was technological: soil moisture and nutrient monitoring tools to provide learning opportunities for farmers to better understand soil moisture–nutrient dynamics at different depths in the rootzone and inform irrigation decision-making. The tools were provided to a small number of lead farmers on each scheme who were respected by other farmers and were expected to communicate their learning to others. These were identified with the assistance of extension officers. For more details of the tools and their implementation see Stirzaker et al. (2017) and Stirzaker and Driver (2024), and for learning processes see Parry et al. (2020).

The AIP initiated a range of additional interventions to overcome the barriers to improved profitability identified during the AIP visioning exercise, such as:

- soil tests and demonstration plots to improve fertilizer application, input choice and use, farming practices, and to introduce new varieties and high-value crops;
- building feedback linkages between farmers and input and output markets to enhance input quality and commodity prices;
- farmer field books to record input applications and costs, yields, and prices received;
- end-of-season workshops with farmers and extension officers to provide training in how to compute gross margins based on field books and to facilitate farmer to farmer learning and support more cost-effective decision-making about what crops to grow and which input to use in the next season;
- participatory mapping of the schemes; for example, to establish accurate and agreed on plot boundaries and sizes, identify poor irrigation infrastructure, road access and negative impacts of farmers' operations on others, and create public awareness and a shared responsibility for resolving collective problems; and
- engaging finance institutions, to provide credit for inputs, and various levels of governments to resolve issues such as: infrastructure, water allocation, conflicts over unpaid water bills, storage and milling of rice, and restrictive cropping calendars and water supply schedules.

See Bjornlund et al. (2020), Mdemu et al. (2023) and Ncube et al. (2024) for more detail.

TISA II continued during COVID-19 restrictions and some activities were restricted. Contact with project staff was limited to electronic contact. There were also restrictions on the number of participants in meetings within the communities, which varied from scheme to scheme.

Impact of the TISA interventions on farmers' resilience and adaptive capacity

The outcomes arising from TISA's interventions have been extensively reported in two special issues in the *International Journal of Water Resources Development* (volume 33, 2017; volume 36, 2020) and in TISA synthesis papers (Bjornlund et al., 2021; Bjornlund et al., 2019, 2020, forthcoming; Mdemu et al., 2023; Ncube et al., 2024), with TISA's most recent publications reporting on the adaptive capacity of irrigation schemes using an adaptation framework with four domains: field; farm/household; community/scheme; and markets (Mdemu et al., 2024;

H. Moyo et al., [forthcoming](#); Tafula et al., [forthcoming](#)). [Figure 1](#) provides a synthesis of evidence of the key socioeconomic and institutional outcomes within these four domains.

A summarized pathway of outcomes arising from TISA's two main interventions is as follows. First, the wide adoption of the monitoring tools led to a reduction in irrigation (frequency and duration), which allowed more time for improved agricultural practices and off-farm income-earning activities, increased supply for tail-end users, and reduced water-supply conflicts. Second, the AIPs with their broad stakeholder participation, facilitated information flows, multiscale learning, and improved connectivity and understanding, stimulating further interventions and solutions to challenges across all four domains. As is the nature of complex systems such as irrigation schemes, single interventions are unlikely to initiate the wide-ranging changes required to support transitions to new paradigms and ways of operating. [Figure 1](#) particularly highlights the breadth of institutional change that has underpinned farmers being able to respond to market signals and transitioning from subsistence to a market orientation. The institutional changes include household decision-making dynamics with women retaining or increasing their input into decisions, and female farmers being particularly proactive in learning activities, adopting higher-value crops and, in some schemes, having higher incomes and gross-margin improvements than male farmers (Parry et al., [forthcoming](#)). There is also emerging evidence that some female-headed household, compared to others, were able to retain the use of a greater proportion of their irrigated area though COVID-19, indicating potential greater resilience to shocks (Parry et al., [forthcoming](#)).

Complex interactions have taken place between the domains and elements of the system: for example, (i) increases in yield, gross margins, and farm income were underpinned by experiential learning, more effective irrigation, reduced fertilizer leaching, better access to quality inputs, freedom to grow higher-value crops, and improved connectivity to markets; and (ii) the capacity for self-organization and collective action was facilitated by farmers having a voice in identifying and finding solutions to challenges, enhanced agency and social capital, clarity of plot boundaries, more equitable water supply and fees, reduced conflict, and greater willingness to participate in scheme maintenance.

Importantly, the evidence summarized in [Figure 1](#) and the more recent adaptation analysis demonstrate improved adaptive capacity across the domains. A large proportion of farmers in Tanzania and Zimbabwe continued to adjust their irrigated area and select crops in response to market signals from 2017 to 2022. This happened despite the reduced presence of TISA staff and the transitioning of researchers' roles to local stakeholders, suggesting farmers' adaptive capacity was sustained as the project transitioned to an operational phase (Bjornlund et al., [forthcoming](#)).

Based on these results, we hypothesize that TISA farmers had increased their resilience and adaptive capacity prior to COVID-19 and therefore should be less impacted by COVID-19 restrictions than non-TISA farmers.

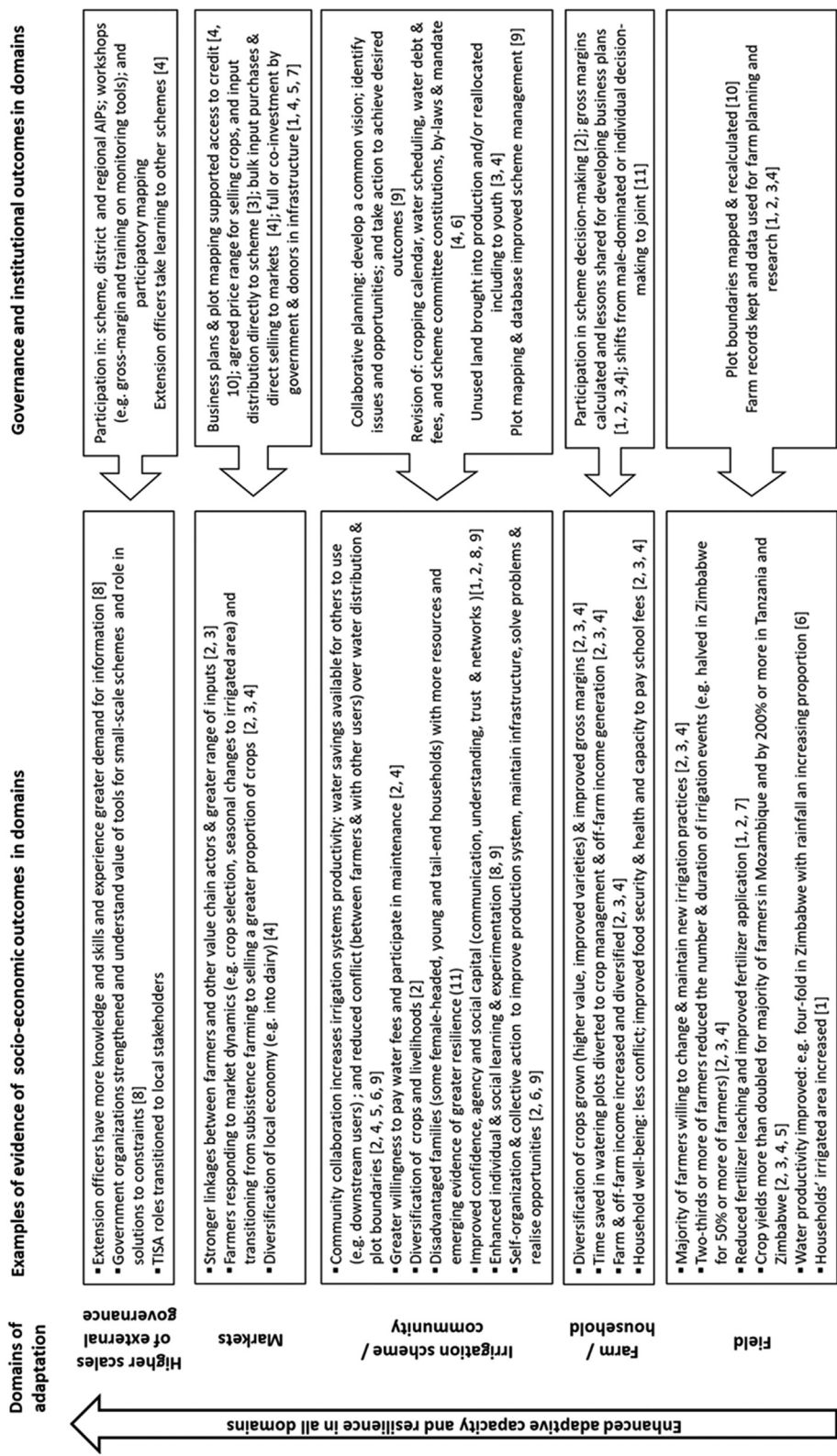


Figure 1. Evidence of outcomes from TISA. Notes: 1 (Bjornlund et al., forthcoming, p. 2; Chilundo et al., forthcoming, p. 3; Mdemu et al., 2024, p. 5, 2020, p. 6; Mdemu et al., 2023, p. 11; Moyo et al., 2020, p. 7; Parry et al., forthcoming; Parry et al., 2020, p. 9; Tafula et al., forthcoming, p. 4; Van Rooyen et al., 2020, p. 10).

Impact of COVID-19 restrictions on TISA and non-TISA farmers

This section summarizes the main trends emerging from the surveys of TISA and non-TISA farmers, with the detailed results reported in the tables and discussion of the results reserved for the discussion section. This section reports farmers' perception of: (i) changes to their farm and off-farm income; (ii) changes taking place on several livelihood parameters; (iii) the severity of the overall impact of COVID-19; (iv) the types of impacts experienced at the household, farm, and scheme level; and (v) the three most important impacts.

Impact on-farm and off-farm income

The perceived impact of the COVID-19 restrictions differs across countries and sources of income. Most farmers, both TISA and non-TISA, perceived that the farm and off-farm income had decreased, except in Mozambique where most perceived that their off-farm income had remained the same. In Tanzania, where there were fewer restrictions on movement, more non-TISA farmers perceived that their off-farm and farm income had improved. In Zimbabwe, more TISA farmers perceived that their farm and off-farm incomes had remained stable and fewer perceived that their off-farm income had decreased (Table 2). In Mozambique, more TISA farmers reported increased off-farm income; however, more non-TISA farmers reported reduced farm income.

Impact on critical parameters of farm households' well-being

There were clearer differences between TISA and non-TISA farmers' perceptions with respect to well-being parameters compared to income perceptions (Table 3). For Zimbabwe and Mozambique, far more TISA farmers perceived that their position was unchanged on all three parameters and fewer perceived that their well-being had decreased. For Tanzania, more non-TISA farmers perceived that their position improved on all three parameters; however, more TISA farmers perceived that their food security was the same and fewer perceived a decrease in general health.

Table 2. COVID-19 impact on households' farm and off-farm income.

	% households					
	Tanzania		Zimbabwe		Mozambique	
	Non-TISA	TISA	Non-TISA	TISA	Non-TISA	TISA
<i>Off-farm income</i>	<i>n</i> = 65	<i>n</i> = 66	<i>n</i> = 61	<i>n</i> = 97	<i>n</i> = 106	<i>n</i> = 40
Increased (%)	10	2	10	11	0	5
Same (%)	21	29	16	35	60	73
Decreased (%)	67	70	74	54	40	23
<i>Farm income</i>	<i>n</i> = 99	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Increased (%)	11	4	15	12	3	3
Same (%)	7	8	18	25	41	33
Decreased (%)	81	88	68	63	57	65

Note: Questions were asked using a five-point Likert scale: 1 = much worse; 2 = worse; 3 = unchanged; 4 = better; and 5 = much better. For this analysis responses are reported in three groups: improved (responses 4 and 5); same (response 3); and decreased (responses 1 and 2).

Table 3. Impact of COVID-19 on critical parameters of households' well-being.

COVID-19 impact on households	% households					
	Tanzania		Zimbabwe		Mozambique	
	Non-TISA	TISA	Non-TISA	TISA	Non-TISA	TISA
<i>Capacity to pay children's education</i>	<i>n</i> = 87	<i>n</i> = 88	<i>n</i> = 62	<i>n</i> = 98	<i>n</i> = 106	<i>n</i> = 40
Improved (%)	10	7	3	15	4	5
Same (%)	19	20	13	23	14	50
Decreased (%)	70	73	84	61	82	45
<i>Food security</i>	<i>n</i> = 100	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Improved (%)	13	7	15	11	1	5
Same (%)	34	51	28	59	20	40
Decreased (%)	53	42	57	30	79	55
<i>General health</i>	<i>n</i> = 99	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Improved (%)	16	7	3	5	9	8
Same (%)	60	64	71	78	64	73
Decreased (%)	24	29	26	17	35	20

With respect to capacity to pay for children's education, substantially more TISA farmers in Mozambique and Zimbabwe perceived it had improved while more non-TISA farmers found it had declined. While more non-TISA farmers in all three countries perceived that food security had increased compared to TISA farmers, these proportions were quite small. More importantly and in all countries, far more TISA farmers perceived food security was unchanged, and fewer TISA farmers perceived it had decreased. With respect to household members' general health, the differences were more marginal. In all three countries, more TISA farmers perceived it was unchanged, whereas more farmers in Zimbabwe and Mozambique perceived it had decreased, and far more non-TISA farmers found it had increased in Tanzania.

Perception of the severity of the overall impact of COVID-19

In the previous sections on the impact of COVID-19 restrictions, the differences between TISA and non-TISA farmers' perceptions were often marginal or moderate. In some instance, more non-TISA farmers felt their conditions improved, although the proportions were always lower than for unchanged or decreased. When asked a generic question about the severity of the impact on their household, farm, and scheme, the differences were more substantial across all three countries (Table 4). Far more TISA farmers in Zimbabwe and Mozambique reported no impact, and almost a quarter of TISA farmers

Table 4. Overall impact of COVID-19 restrictions.

COVID-19 impact on household/farm/scheme	% households					
	Tanzania		Zimbabwe		Mozambique	
	Non-TISA	TISA	Non-TISA	TISA	Non-TISA	TISA
	<i>n</i> = 100	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Impacted it positively	0	23	1	2	0	3
No impact	0	3	4	18	21	43
Minor negative impact	20	26	37	35	32	30
Moderate negative impact	49	28	40	25	42	20
Severe negative impact	31	20	18	20	6	5

reported a positive impact in Tanzania. Across all three countries, far more non-TISA farmers perceived a moderate negative impact. The proportion perceiving the impact severe is much the same for TISA and non-TISA farmers in Zimbabwe and Mozambique. In Tanzania, more non-TISA farmers perceived severe impacts, which is inconsistent with the perceptions on income and livelihood parameters reported in [Tables 2](#) and [3](#).

The types of impact experienced

When asked specific questions about the type of impacts they experienced at the family, farm, and scheme level, TISA and non-TISA farmers reported the same types of impacts, but the proportion of farmers reporting each impact differed substantially ([Table 5](#)). Generally, far more TISA farmers reported no impact and fewer reported each of the impacts, with mixed outcomes at the farm level. In Mozambique, far more TISA farmers reported no effect at the household and farm level compared to farmers within all other schemes.

Regarding the impact on family members ([Table 5](#)), far more TISA and non-TISA farmers in Zimbabwe reported that they experienced four of the five impacts: loss of transport, off-farm work, access to food, and breakdown of social networks. For all these parameters, far more non-TISA farmers reported the impact. The impact on children's education was reported by most farmers in Tanzania, especially non-TISA farmers, while more non-TISA farmers reported no impact on their families. In Mozambique, almost half the TISA farmers

Table 5. The types of impact of COVID-19 on the family, farm, and scheme.

COVID-19 impact on households	% households					
	Tanzania		Zimbabwe		Mozambique	
	Non-TISA	TISA	Non-TISA	TISA	Non-TISA	TISA
<i>Family (multiple answers)</i>	<i>n</i> = 72	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Family members lost off-farm jobs and incomes	6	12	43	28	12	13
Loss of transport	1	2	69	38	1	0
Children could not attend school, tertiary education	92	69	51	53	58	25
Reduced access to food as shops closed, or transport unavailable	19	15	44	28	12	25
Breakdown of social networks	15	7	40	20	7	23
No impact	28	13	4	17	3	45
<i>Farm (multiple answers)</i>	<i>n</i> = 100	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Access to inputs	77	83	31	47	58	23
Access to output markets	98	64	82	63	38	15
Access to labour	3	13	4	10	16	10
Access to information	3	8	35	20	11	15
Access to financial institutions banks, micro lenders, Mobile money	6	6	3	3	6	10
Reduced production and farm income	54	36	31	25	23	23
The fear of COVID-19 contamination has reduced demand for some crops	8	8	19	9	9	5
No impact	0	2	9	14	25	48
<i>Scheme (multiple answers)</i>	<i>n</i> = 86	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Farmers unable to pay their water/membership fees	74	48	12	13	26	10
Maintenance jobs have not been carried out	21	19	38	13	7	20
Extension officers could not get to the scheme	44	39	46	25	6	5
Other stakeholders who provide advice could not get to the scheme	38	27	24	26	7	18
More land farmed as family members returned to the scheme	4	3	4	11	4	0
No impact	14	21	29	47	63	65

reported no impact. Twice as many non-TISA farmers reported that children could not attend school, while more TISA farmers reported challenges accessing food and a breakdown of social networks.

Regarding impact at the farm level, most farmers on all schemes reported impacts on access to input and output markets and production and farm income (Table 5). In Tanzania and Zimbabwe, more TISA farmers reported reduced access to inputs and labour, while more non-TISA farmers reported reduced access to output markets and reduced production and income. In Mozambique, fewer TISA farmers reported reduced access to input and output markets compared to farmers on all other schemes. While the same proportions of TISA and non-TISA farmers reported production and income impacts, these proportions were low compared to other schemes, with close to half of TISA farmers reporting no impact. While small proportions reported reduced access to finance institutions, this was marginally higher for TISA farmers in Mozambique.

In all three countries and particularly in Mozambique, more TISA and non-TISA farmers reported no impact on their scheme compared to impact on their family and farm (Table 5). In all countries, more TISA farmers reported no effect on their scheme compared to non-TISA farmers. In Tanzania and Mozambique, more non-TISA farmers reported the inability to pay for water fees. In Zimbabwe and Tanzania, more non-TISA farmers reported that maintenance jobs were not being carried out and extension officers could not get to the scheme. In Mozambique, fewer TISA and non-TISA farmers reported each impact compared to the other countries, except for the inability to pay water fees. In Mozambique, more TISA farmers reported reduced access for stakeholders and maintenance jobs not being carried out.

The three biggest impacts experienced by households

With respect to the three biggest impacts, most TISA and non-TISA farmers reported declining farm and off-farm income and delays in children's education (Table 6). Declining farm income was reported by fewer farmers in Mozambique, and in all three countries more non-TISA farmers reported reduced food security. Despite the findings in Table 2, more non-TISA farmers, in all three countries, reported declining farm and off-farm income. Delay in children's education was reported evenly in Tanzania, by more TISA farmers in Zimbabwe, and by more non-TISA farmers in Mozambique. Relatively few farmers reported decay of infrastructure and impact on household members' general health.

Table 6. Three biggest impacts of COVID-19.

Three biggest impacts of COVID-19 on household	% households					
	Tanzania		Zimbabwe		Mozambique	
	Non-TISA	TISA	Non-TISA	TISA	Non-TISA	TISA
	<i>n</i> = 100	<i>n</i> = 100	<i>n</i> = 68	<i>n</i> = 103	<i>n</i> = 106	<i>n</i> = 40
Household food security	26	19	37	17	42	30
Household members health	5	9	6	7	8	13
Declining farm income	91	72	81	67	48	45
Declining off-farm income	45	34	56	36	12	8
Decay of irrigation infrastructure	6	5	1	2	6	0
Children's education delayed	65	66	47	67	73	45

Discussion

We find that the main impacts of COVID-19 restrictions on small-scale farmers were those associated with market access for produce and movement of people, reducing farm income and off-farm work opportunities. This is consistent with the literature reporting that border closures reduced availability and increased the prices of fertilizer and other farm inputs (Adewopo et al., 2021; Béné et al., 2021; Picchioni et al., 2022).

The literature also suggests that the restrictions on gatherings and movements of people and the closure of borders, schools and informal markets, reduced demand and prices and caused stockpiling of produce and associated losses (Béné et al., 2021; Mugabe et al., 2022). Consistent with these authors, most farmers within TISA and non-TISA schemes reported restrictions on access to output markets as a major impact on their farm operations. Further, a large number of TISA and non-TISA farmers reported declining farm and off-farm income (Table 2) and rated these among the three most critical impacts of COVID-19. While we found that yields and gross margins within the TISA schemes declined, they remained above pre-TISA intervention levels (see Moya et al., forthcoming for gross margins; Mdemu et al., 2024 for maize yield; Tafula et al., forthcoming for both yields and gross margins). Also consistent with the literature, both non-TISA and TISA farmers reported severe impacts on their capacity to pay for children's education and children's access to schools as major impacts on their family members.

Further, the literature identified that COVID-19 had a major impact on food security and access to nutritious food (Adewopo et al., 2021; Béné et al., 2021; Nchanji et al., 2021; Okou et al., 2022). Consistent with this, and in most cases, more than half of both TISA and non-TISA farmers reported decreased food security, and many reported reduced access to more nutritious food as a major impact on their household and one of the three most critical impacts of COVID-19.

Consistent with Egger et al. (2021), we found that the impact within the schemes was influenced by the severity of the restrictions. In comparison to Tanzania and Mozambique, far more Zimbabwean farmers reported loss of access to transport and closure of shops, with resulting restrictions on access to food as factors affecting their household. This reflects the more severe lockdown restrictions in Zimbabwe. Tanzania suffered especially from border closures with neighbouring countries and limitations on international trade (Mugabe et al., 2022). As found by Nchanji and Lutomia (2021), these restrictions affected access to and the prices of inputs and the demand for some commodities, reducing commodity prices: for example, rice in Tanzania. Hence, more farmers in Tanzania perceived the loss of access to input markets as a serious impact, even though the restrictions on personal movement and domestic movements of goods were far less severe than in Zimbabwe. Because of the more severe restrictions on movement and the closure of informal markets in Zimbabwe and the import restrictions in Tanzania, farmers in these countries perceived the impact on farm income to be more severe than in Mozambique.

While our findings are inconsistent across schemes and disadvantaged groups, we found that TISA interventions had a positive impact on women, youth, and tail-end users, with these groups sometimes narrowing or reversing the gap in irrigated area farmed and income compared to the initially more advantaged groups (Parry et al., forthcoming). Several authors report that the impact of COVID-19 depended on socioeconomic characteristics, and was particularly severe among disadvantaged groups, such as female

farmers and youth (Josephson et al., 2021; Manderson & Levine, 2020; Picchioni et al., 2022). With respect to COVID-19, Parry et al. (forthcoming) found mostly little difference in perceived impact between these groups and other households. In some cases, households headed by women or younger farmers retained their irrigated area through COVID-19, with some increasing this area compared to other households. Given the input challenges experienced during COVID-19, these are positive findings and add nuance to the literature. There was also some evidence of greater vulnerability to COVID-19 disruptions among the youngest households with no non-farm income, which indicates additional intersecting barriers within the broad groupings of women and youth.

While TISA and non-TISA farmers reported experiencing similar impacts from the COVID-19 restrictions, the severity of the impacts differed. When asked about the perceived impact of COVID-19 on their farm and off-farm income, food security, and health, and their capacity to pay for their children's education, the overall conclusion was that TISA farmers experienced a lower negative impact than non-TISA farmers, especially in Zimbabwe and Mozambique. However, this was not consistent and not always conclusive. In some cases, marginally higher proportions of non-TISA farmers perceived their situation to be improved; however, the proportions perceiving positive impacts of COVID-19 (TISA or non-TISA) were always a much smaller proportion than those reporting same or decreased. We speculate that there will always be some relatively better off households that may be advantaged by shocks to the system.

The outcome in Tanzania was less conclusive, probably reflecting that the COVID-19 restrictions were less severe and of shorter duration. Further, the differences were somewhat diluted by the success of the upscaling of the AIP to the Iringa District Council during TISA II. This District AIP communicated the outcome and changes taking place within the TISA schemes to the non-TISA schemes within the council (Mdemu et al., 2024). Further, the non-TISA scheme was less than 10 km from a TISA I and TISA II scheme. Hence, some of the improved practices introduced by TISA spread to farmers in the non-TISA scheme surveyed for this study.

When rating the overall severity of the impact of COVID-19, the differences between TISA and non-TISA farmers were more pronounced. Generally, far more non-TISA farmers perceived the overall impact of COVID-19 on their household, farm, and scheme as being moderate to severe, while far more TISA farmers perceived no impact or a positive impact. We argue that this is likely to reflect that TISA farmers at the onset of COVID-19, and after seven years of TISA interventions, had transitioned from mainly being subsistence farmers to being commercial farmers, and were selling an increasing proportion of their crops and experiencing significant improvements to their farming practices and crop selection. This has resulted in increased production and farm and off-farm income; hence, they have a need, and the capacity to pay, for farm inputs and non-family labour. TISA households were therefore more exposed to the impact of the lockdown on access to farm inputs and labour. It follows that when TISA farmers were asked to rate the specific impact of COVID-19 on their income and livelihoods, they sometimes rated it more severely than the non-TISA farmers. However, the TISA farmers reported less impact overall as they had developed more resilience and adaptive capacity to deal with these impacts.

Compared to TISA farmers, far more non-TISA farmers in Zimbabwe and Mozambique reported that the COVID-19 restrictions impacted their ability to pay for their children's education, and across all three countries more non-TISA households experienced food

security impacts. In all three countries, more non-TISA farmers also reported their households' food security impacted by COVID-19 compared to TISA farmers. Similarly, when asked to list the three biggest impacts of COVID-19 on their household, farm, and scheme, far more non-TISA farmers reported experiencing all the reported types of impacts.

Interestingly, the access to inputs and labour in Tanzania and Zimbabwe was reported as an impact of COVID-19 by more TISA than non-TISA farmers. This is likely to reflect that the increased gross margins reported by TISA farmers in these countries have allowed them to expand their irrigated area (Bjornlund et al., [forthcoming](#)), and they rely more on non-family labour. Similarly, the new farming practices and improved varieties of high-value crops, combined with the availability of soil testing, have increased farmers reliance on, and understanding of the importance of, inputs. This highlights the need for additional efforts to improve resilience by minimizing the dependence on imported inputs. This could include concepts such as circularity and, for example, identifying resource linkages between agricultural systems (irrigation, dryland, and livestock), new agricultural practices, and new synergistic businesses (Van Rooyen et al., [2022](#)).

Input and output markets are vulnerable to shocks that restrict international trade, close borders, disrupt supply chains, and limit movement and gatherings, resulting in higher input prices and reduced ability to sell produce. As our findings show, a transition from subsistence to a commercial orientation can leave more resilient farmers exposed to vulnerabilities in the market domain. National governments need to carefully consider how to protect their economies and populations from international market disruptions, while also improving the resilience of food markets against domestic shocks. In response to border closures with South Africa, Botswana's government, for example, banned imports of key agricultural produce for a period of two years to stimulate local producers and domestic supply chains. While this approach is contrary to trade liberalization policies, it helps maintain the viability of domestic production and incomes, which is critical for rural-based livelihoods and food availability.

Conclusions

Based on the results and the discussions presented in this paper, we argue that we have substantiated our hypothesis that TISA's two-pronged approach, and additional AIP-initiated interventions, have substantially improved farm households' and scheme resilience, and the capacity to adapt to shocks in the production system. Hence, they had a greater ability to respond to and manage the impacts of the COVID-19 lockdown. It is also important to note that TISA farmers had increased their understanding of the importance of quality and appropriate inputs, which has increased their reliance on imported inputs. These are critical findings. Further, we argue that COVID-19 impacts will be similar to impacts to agricultural production systems arising from climate change or supply disruptions caused by wars (such as in Ukraine) or other disruptions of shipping routes and global trade. As it is generally expected that production systems will increasingly experience these kinds of shocks, it is critical to enhance the adaptive capacity of food production systems for future food security. This includes exploring agricultural practices and farming approaches, such as circularity, that reduce dependence on imported inputs.

The imperative for building resilience and transforming food systems was recognized prior to COVID-19 and reflects concerns around persistent poverty and food insecurity as well as crisis events. A key lesson from this paper is that an approach to improve small-scale irrigation functionality and profitability has simultaneously improved adaptive capacity. Irrigation schemes, and agricultural systems more broadly, are complex systems with interactions between governance, ecological and social elements, and resilience must be built in multiple interconnecting domains. While TISA initially only made two interventions, the AIP's participatory processes empowered farmers and stimulated a suite of additional interventions, which were critical in addressing locally relevant barriers to increased productivity and improving connectivity, trust, and the willingness to engage in collective action. Hence, we strongly encourage the inclusion of multiple, locally relevant institutional and technological interventions to leverage change in projects undertaken and funded by national government and donors that are intended to build resilience and transform agricultural systems.

Global organizations (e.g., WHO) and national governments charged with responding to global threats need to carefully consider the impact of their suggested responses to COVID-19 on markets and how this could be better managed. There are difficult questions that need to be addressed: how can nations secure a buffer supply of critical farm inputs within their boundaries; should international companies be required to have local production or a storage buffer; and how can domestic and informal produce markets be kept open while minimizing transmission? Similarly, how can local agricultural production systems, such as small-scale irrigation schemes, increase their adaptability and resilience to potential future disruptions to their market linkages? One option is the concept of circularity to reduce dependency on, and maximize the efficient use of, resources. Another option is for governments to restrict the import of food products that can be produced locally but cannot compete with cheap imports, such as has been done in Botswana and Namibia. A third option is to ensure that buffer stocks of critical inputs are available nationally.

This research demonstrates that there are opportunities to build more resilient rural economies by working in partnership with farmers and other key local stakeholders to build social and economic capacities to seize sustainable development opportunities and adapt to shocks.

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