

DEVELOPING AN INTEGRATED CAPABILITY-RESILIENCE FRAMEWORK FOR SMALLHOLDER FARMERS: EVIDENCE FROM MUSHANDIKE IRRIGATION SCHEME, ZIMBABWE

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Abstract

This study develops and proposes an Integrated Capability-resilience Framework (ICRF) to strengthen the climate change adaptation capacities of smallholder farmers using the example of the Mushandike Irrigation Scheme in Zimbabwe. This scheme experiences a 42% loss of irrigation water each year. Through interviewing smallholder farmers within the irrigation scheme using phenomenological qualitative methodology, the study finds that various factors impact their climate resilience, including irrigation infrastructure, local governance, access to finance and climate change knowledge. Specifically, the lack of legal authority for Irrigation Management Committees (IMCs) within irrigation schemes and the strained relationships that many IMCs share with the Zimbabwe National Water Authority (ZINWA) are detrimental to the management of irrigation waters within these schemes. Furthermore, various adaptation models to date have not adequately addressed these capability issues within smallholder farmers. Existing adaptation models underplay the interaction between physical infrastructure, farmer agency, finance, local knowledge and irrigation. The ICRF aims to provide a holistic approach to improving the adaptive capacities of

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smallholder farmers by enhancing the effectiveness of irrigation infrastructure, integrating local knowledge systems, providing financial access aligned with weather patterns and reforming local governance institutions. Using this framework, it is possible to enhance the climate change resilience, adaptive capacity and food security of smallholder farmers within the semi-arid regions of Africa.

Keywords: *climate change, food security, water index, water governance*

INTRODUCTION

Within Zimbabwe's semi-arid landscape, climate change has ceased being simply a potential and anticipated threat on the horizon, but has evolved into a daily lived experience for the people in Zimbabwe's Natural Region IV (Ogwu *et al.*, 2024; Gebeyehu *et al.*, 2025; Saccone and Valino, 2025; World Meteorological Organization [WMO], 2025). The Mushandike Irrigation Scheme was designed as a strategic response to food insecurity, but now serves as a continual source of uncertainty within an increasingly volatile hydrological context (Malacho, 2018; Moyo, 2023; Zvokuomba and Batisai, 2023). Over the past decade, this region has experienced compressed growing seasons, historical levels of thermal stress throughout the growing season and more frequent El Niño-related droughts (most notably the 2023/24 drought) (Mutengwa 2023; ZimLAC, 2024; WMO, 2025). These hydro-meteorological shocks caused by these droughts have not only decreased agricultural yield, but have also systematically dismantled the underpinnings that support smallholder livelihoods, causing traditional flood irrigation

methods to become obsolete (Chitsungo, 2023; ZimLAC, 2024; Saccone and Valino, 2025).

In a critical review of current academic literature, there is a lack of analytical work focusing on the analysis of agricultural resilience (WMO, 2025). The majority of literature looks at the 'what' of adaptation, for instance, documenting adaptive coping mechanisms including diversification of crops and dry planting (*kupandira*) and distress livestock sales. The majority of current academic literature does not provide any empirical analysis that interrogates the capabilities necessary for smallholder farmers to move out of reactive coping and into a position of transformative agricultural resilience (Ogwu *et al.*, 2024; Gebeyehu *et al.*, 2025; Saccone and Valino, 2025). The existing frameworks do not adequately account for the capability deficit resulting from the combination of decaying physical systems and a cognitive 'perception-action' gap (ZINWA, 2024; Gebeyehu *et al.*, 2025). According to ZINWA (2024), 42% of available transmitting water is lost in the process. Farmers recognise the risk but are incapacitated from acting due to a lack of access to a successful, trusted institutional resilient framework. For this reason, the objective of this study is to develop an Integrated Capability-Resilience Framework (ICRF) to strengthen smallholder farmers' capabilities and enhance resilience to climate-induced food insecurity in Zimbabwe.

Existing climate adaptation frameworks have largely emphasized technological interventions, infrastructure development and externally driven resilience strategies (Ogwu *et al.*, 2024; Gebeyehu *et al.*, 2025; Saccone and Valino, 2025). However, these approaches often inadequately address the institutional, financial, governance

and knowledge-related constraints that limit smallholder farmers' adaptive capacity. Furthermore, many existing models pay insufficient attention to farmer agency and the integration of local knowledge systems, thereby reducing their effectiveness in addressing the complex realities of climate-induced food insecurity in semi-arid regions such as Zimbabwe's Natural Region IV.

The existing literature on adaptation focuses primarily on technological interventions and the rehabilitation of existing infrastructure (Chanza and Musakwa, 2022; Oyadeyi and Oyadeyi, 2025). While these interventions have been used as a form of adaptation to the effects of climate change, there has been a relative under-appreciation of the interaction between irrigation infrastructure, smallholder farmers' financial and cognitive capabilities, indigenous knowledge systems (IKS) and irrigation governance. As a result of this lack of consideration of these aspects of smallholder irrigation systems, the capabilities of smallholder farmers to adapt to the effects of climate change have been largely ignored in the existing literature. Such deficiencies are apparent in the case of smallholder farmers in countries like Zimbabwe, who face a range of challenges resulting from the effects of climate change, even though they have irrigation infrastructure. To address these challenges, an ICRF is developed to centre the capabilities of smallholder farmers in the adaptation and climate change mitigation interventions suggested for them.

CONCEPTUAL FRAMEWORK: THE INTEGRATED CAPABILITY-RESILIENCE FRAMEWORK

The Integrated Capability-Resilience Framework proposes an approach that draws on Sen's Capability Approach to enhance the

adaptive capacity of smallholder farmers affected by food insecurity. This framework is founded on the idea that the resilience of these farmers is not determined by the availability of certain resources, but dependent upon their capability to make use of those resources.

The framework includes four main pillars: Physical and Natural Capital, Cognitive Empowerment, Financial Agency and Institutional and Governance Reform. The first of these pillars focuses upon improving the efficiency of the infrastructure and managing water sustainably within irrigation systems. The second pillar encourages the integration of IKS with scientific information regarding climate change. The third one increases the access of smallholder farmers to financing and insurance plans that account for the impact of climate change on agriculture within these irrigation systems. Finally, the fourth suggests reforms to the institutions that manage water within the irrigation systems. Together, these four components of the framework are designed to increase the adaptive capacity of smallholder farmers, their resilience to the impacts of climate change and the amount of food security they can achieve within their irrigation systems.

This framework forms the conceptual basis upon which the findings of this research are analyzed and upon which suggestions for increasing the resilience of smallholder farmers within the Mushandike Irrigation Scheme are made.

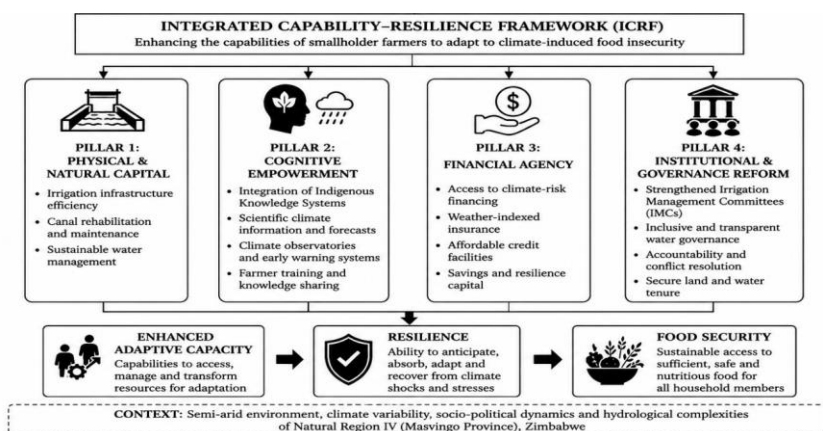


Figure 1: Conceptual Framework for the Integrated Capability-Resilience Framework (Sen, 1999)

THEORETICAL FRAMEWORKS

The main theoretical perspective employed in this study is Amartya Sen's Capability Approach. Sen's approach posits that development should be assessed in relation to the freedoms and capabilities that individuals have to achieve the outcomes that they value most for themselves (Sen, 1999). Furthermore, this perspective has been applied to the assessment of adaptation to climate change for smallholder farmers, as it can measure their capabilities beyond crop yields alone (Brown *et al.*, 2019). For these reasons, the Capability Approach is a perspective that can be applied to evaluate the resilience of smallholder farmers in Zimbabwe in particular.

The Capability Approach forms the theoretical foundation for the development of the ICRF. While the Capability Approach evaluates development as the fulfilment of individuals' freedoms and capabilities to achieve the lives/values that they themselves hold most dear, the ICRF examines the physical, cognitive,

financial and institutional capabilities of smallholder farmers as they relate to their capacity to adapt to the effects of climate change. Thus, the Capability Approach provides the theoretical lens through which the ICRF can be understood and applied in the study of climate change and food insecurity in Zimbabwe.

Given the nature of Zimbabwe and its smallholder farmers in particular, the Capability Approach is a relevant perspective to employ in observing the food security challenges that exist within the country. According to Sen (1999), the concept of capabilities refers to the various freedoms and opportunities that individuals have to achieve the functionings (outcomes) that they value. Thus, if smallholder farmers in Zimbabwe have the capabilities (freedom) to respond to climate change, they are more likely to exhibit resilience in the face of food insecurity.

Another of the major benefits of the Capability Approach is its focus on the people (as opposed to the resources) within communities (Brown *et al.*, 2019). Thus, the Capabilities Approach recognises that smallholder farmers have knowledge and freedoms that should be expanded upon to increase their resilience to the impacts of climate change. Furthermore, this theoretical framework has been applied to various studies in the Global South regarding agriculture and climate change adaptation (Brown *et al.*, 2019; Joakim, Mortsch and Oulahen, 2021).

Finally, the Capability Approach represents a shift in agrarian studies from focusing upon the provision of resources to those who farm (such as water) to those that focus upon the capabilities of those individuals to utilise such resources effectively (Sen, 1999; Brown *et al.*, 2019). Thus, the Capability Approach not only

provides the theoretical lens through which to observe climate change and food insecurity, but also justifies its use relative to existing literature on the topic. For instance, existing literature indicates a capability deficit for smallholder farmers in Zimbabwe in relation to the resources that they have (such as water from the Mushandike Dam), yet lack the physical (deteriorating irrigation canals), financial (limited access to credit), or institutional (land tenure) capabilities to effectively utilise these resources to increase their food security (Zvokuomba and Batisai, 2023).

LITERATURE REVIEW

CLIMATE VARIABILITY AND SMALLHOLDER FARMERS

Recent research highlights a worldwide smallholders' paradox: small-scale farmers are the main architects of food security in the Global South, but are still the most vulnerable to human-caused climate change (Ogwu *et al.*, 2024; Gebeyehu *et al.*, 2025; Saccone and Valino, 2025; WMO, 2025). In southern Africa, and particularly Zimbabwe's Natural Region IV, the risk is worsened by the desynchronisation of seasonal rainfall patterns and the increased number of El Niño Southern Oscillation (ENSO) events that occur (WMO, 2025). Most scholars suggest that, because of hydrological pressure and outdated colonial-age systems, irrigation, which was once an ultimate climatic buffer, is now less effective (Zvokuomba and Batisai, 2023).

The effects of climate variability on smallholder farmers in irrigated rural settings, such as Zimbabwe's Mushandike Irrigation Scheme, are far-reaching and intensifying, with profound implications for livelihood security. Globally, climate change has been shown to disrupt rainfall patterns, reduce water

availability and increase temperature extremes, disproportionately affecting smallholder farmers who depend on predictable weather cycles and basic irrigation infrastructure (WMO, 2025). These climatic shifts, combined with limited access to capital, credit and institutional support, compound the precariat of smallholder livelihoods, particularly in arid and semi-arid regions (*ibid.*).

Ultimately, available literature indicates that while irrigation schemes like Mushandike hold potential for enhancing food security in the face of climate variability, their current structure, management and resilience capacity are deeply inadequate (Chitsungu, 2023; Zvokuomba and Batisai, 2023;). There is a clear research and implementation gap around community-based, climate-resilient food systems that are both productive and equitable. This underscores the need for integrative frameworks that move beyond infrastructure provision and address the socio-institutional dynamics of food security under changing climatic conditions.

GOVERNANCE VACUUM AND INFRASTRUCTURE DECAY

In Zimbabwe, Vision 2030 aims for a quantitative increase in the number of irrigated hectares, but scholars have pointed out that "Infrastructure without Governance" leads to systemic failure (Zvokuomba and Batisai, 2023; Government of Zimbabwe (GoZ), 2025). The dilemma of Irrigation Management Committees being in a legal grey area creates procedural injustices, where head-end farmers can overuse their allocations of water, resulting in tail-end farmers being in an ongoing state of hidden water poverty. The hydrology of Mushandike has evolved from one of "hope" to one of "despair", as described by Zvokuomba and Batisai (2023), due

to the failure to maintain and modernise irrigation systems. Despite these well-documented vulnerabilities, scholarly literature remains limited on solutions that are context-specific and co-produced with farmers themselves.

Joakim *et al.* (2021) argue that prevailing models often transplant foreign technical solutions that neglect the embedded socio-cultural and economic realities of Zimbabwean smallholders. Similarly, Chitsungo (2023) notes that while irrigation has marginally improved productivity in Masvingo District, the sustainability of such schemes remains questionable due to weak institutional backing and non-inclusive planning mechanisms. This critique is supported by global evidence from Roan (2023), who identifies similar patterns in Ghana, where centralised dam-based schemes failed to align with local needs and climatic variations. A noticeable gap in the reviewed literature is the absence of holistic, gender-sensitive frameworks that integrate socio-technical, institutional and ecological dimensions of livelihood vulnerability within irrigation schemes.

CONFLICTING SOURCES OF CLIMATE KNOWLEDGE

Building resilient smallholder agricultural systems demands the integration of agro-ecological knowledge with local cultural and farming practices (Bellanthudawa *et al.*, 2025). However, most adaptation frameworks marginalise this potential by sidelining IKS, thereby reducing the ownership, sustainability and effectiveness of resilience strategies (Shilomboleni *et al.*, 2024). Literature on climate services reveals that there is a significant perception-to-action gap (Shilomboleni *et al.*, 2024; Bellanthudawa *et al.*, 2025).

Although there has been an increase in the technical accuracy of observational data collected by the Meteorological Services Department (MSD), in many cases, smallholder farmers are experiencing a trust deficiency with top-down and generic weather forecasts from MSD. Due to this low trust in scientific weather forecasts, there needs to be an investigation into IKS that may be more culturally relevant. However, IKS are facing difficulties adapting to rapid and changing climatic conditions (Bellanthudawa *et al.*, 2025). Increasingly, scholars are recognising the combination of the two systems of knowledge as a critical precursor to achieving transformational resilience (Shilomboleni *et al.*, 2024; Bellanthudawa *et al.*, 2025).

Oyadeyi and Oyadeyi (2025) argue that green economy pathways should combine local ecological knowledge with enabling institutions such as agricultural extension, market access and microcredit to scale up agro-ecological innovations. However, they caution that government policies often ignore the socio-cultural context, which leads to poor adoption and long-term abandonment of interventions. Although smallholder farmers in places like Mushandike Irrigation Scheme have historically utilised floodplain farming, local seed exchanges and seasonal calendars, these practices are increasingly excluded from formal resilience efforts. This not only disempowers local participants, but also reduces contextual fit and sustainability.

INTEGRATING EXISTING FRAMEWORKS

Existing frameworks developed by international organisations such as the United Nations Food and Agricultural Organisation (FAO) and Department for International Development (DFID), provide a foundational basis for conceptualising resilience beyond

localised adaptation. These models not only offer multidimensional constructs, but also foreground the interplay between environmental, social, institutional and policy-based factors in shaping food security outcomes.

The United Nations Office for Disaster Risk Reduction (UNDRR) outlines resilience as the ability of a system, community or society to resist, absorb, adapt to and recover from shocks while maintaining essential functions (UNDRR, 2015). However, Zimbabwean smallholders, constantly facing climatic and market shocks, require resilience strategies that not only cope with hazards, but structurally transform agricultural systems to reduce long-term vulnerability (Bellanthudawa *et al.*, 2025).

Similarly, the FAO's Climate-Smart Agriculture (CSA) framework promotes adaptation through three pillars: increasing productivity sustainably, building resilience (adaptation) and reducing emissions. While the CSA model is globally influential, scholars like Bellanthudawa *et al.* (*ibid.*) and Chanza and Musakwa (2022) argue that its implementation in African contexts often lacks sufficient localisation.

Another widely referenced model is the DFID Sustainable Livelihoods Framework, which centres on the integration of five capitals: human, social, financial, natural and physical, to understand vulnerability and intervention pathways. According to Brown *et al.* (2019), this framework offers an inclusive structure for assessing constraints and leveraging local assets. However, in practice, smallholder-targeted interventions in Zimbabwe often emphasize physical capital (such as inputs or infrastructure) while

underinvesting in human and social capital, especially knowledge-sharing platforms and gender-sensitive institutions.

Joakim *et al.* (2021) advocate for resilience thinking that incorporates systems-based approaches, where vulnerabilities are not treated as isolated but interconnected with governance, economics and ecological functions. This resonates with critiques raised by Akinkuolie, Ogunbode and Adekiya (2025), who argue that failure to integrate institutional resilience, such as strong policy environments and regulatory coherence, renders many frameworks operationally ineffective, even when technically robust.

Furthermore, the World Bank's Adaptive Social Protection (ASP) framework suggests linking climate adaptation to social protection systems. Nevertheless, the model is instructive in identifying the role of safety nets, public works and livelihood diversification in stabilising smallholder food systems during shocks. However, Mbuli *et al.* (2021) emphasize that without functional institutions and inclusive policy design, such frameworks may deepen inequality by bypassing the most marginalised.

In Zimbabwe, adopting a blended framework informed by global models offers strategic value. Yet, as Oyadeyi and Oyadeyi (2025) caution, wholesale importation of global paradigms without localisation undermines both relevance and community ownership. Hence, the need to integrate them with local realities. It offers an opportunity to bridge scientific adaptation paradigms with bottom-up, socially embedded resilience strategies that truly serve the lived realities of Zimbabwe's smallholder farmers.

METHODOLOGY

RESEARCH APPROACH

In order to develop empirical evidence that would help in the development of the ICRF, a qualitative phenomenological research approach was adopted (Bouncken *et al.*, 2025). The rationale for employing this research approach was to gain an understanding of the physical, institutional, financial and mental barriers that prevent smallholder farmers within the Mushandike Irrigation Scheme to transform their resources into food security (Tajik, 2024). Thus, the phenomenological approach was used to investigate the various challenges that smallholder farmers within the study area face regarding resource distribution and availability. The phenomenological approach to the research study allows for an in-depth exploration of the various challenges that smallholder farmers within the Mushandike Irrigation Scheme face and the factors that prevent them from developing climate resilience in the face of climatic variability (Ahmad and Wilkins, 2024).

The goal of exploring these factors and gaining insights into these challenges allowed research to determine the barriers that limit adaptive capacity and resilience among smallholder farmers within the study area. Based on these findings, the ICRF can be developed. Hence, the qualitative research approach was utilised to find out what the smallholder farmers within the Mushandike Irrigation Scheme perceive to be the challenges that limit their adaptive capacity and climate resilience; rather, the qualitative approach was employed to gain an understanding of the factors that the ICRF will seek to address to improve their resilience and food security situation.

DESCRIPTION OF THE STUDY AREA

This study is situated within the Mushandike Irrigation Scheme, located approximately 20km south of Masvingo Town in the semi-arid Masvingo District, Zimbabwe. Established in 1939, the scheme is one of the oldest and largest communal irrigation projects in the country, covering an area of approximately 847.5 hectares. It serves as a critical adaptation mechanism for smallholder farmers in Ecological Regions IV and V, areas characterised by low and erratic rainfall patterns, making rain-fed agriculture increasingly unreliable (Manatsa *et al.*, 2020). The scheme draws water from the Mushandike Dam, situated within the Mushandike Sanctuary and is designed to support over 565 households across 11 villages (Chaota, 2022). Each beneficiary is allocated 1.5 hectares of irrigated land, with a significant proportion of participants being women, who play a pivotal role in agricultural production and decision-making processes within the community (*ibid.*).

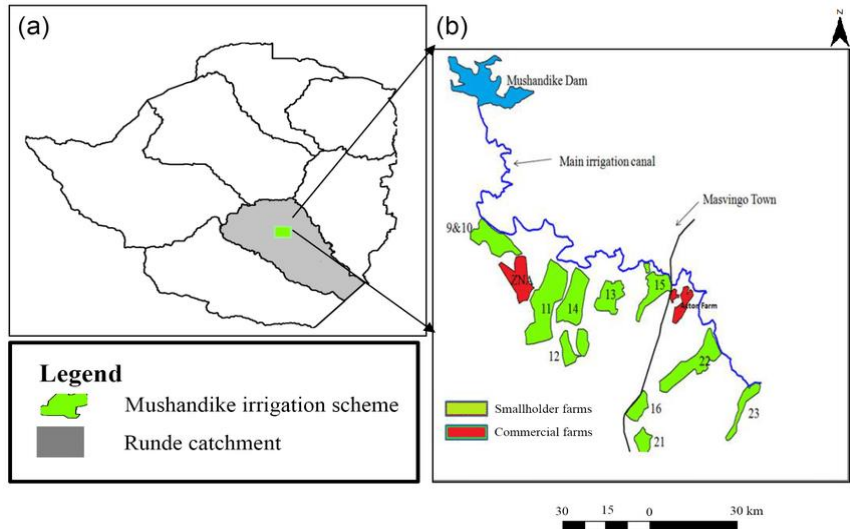


Figure 2: Study Area, Mushandike Irrigation (Malanco *et al.*, 2018)

Focusing on the Mushandike Irrigation Scheme provides a unique opportunity to examine the interplay between irrigation infrastructure, climate change adaptation and socio-economic factors in a semi-arid context. By analyzing these elements, the study aims to develop a comprehensive framework to enhance the capabilities and resilience of smallholder farmers in Zimbabwe. Engaging with farmers, extension officers and local institutions ensures that proposed interventions are practical, locally grounded and sustainable, aligning with broader national policies aimed at climate change adaptation and smallholder agriculture development (Zvokuomba and Batisai, 2023).

SAMPLING AND SAMPLE SIZE

Purposive and snowball sampling techniques were employed to identify participants with extensive knowledge and experience on the topics to be covered in this study (Ahmad and Wilkins 2024; Tajik, 2024). The determination of the sample size was informed by data saturation considerations, a qualitative research principle emphasizing depth rather than breadth of understanding (Tajik, 2024). Twenty smallholder farmers participated in the study, complemented by two focus group discussions (FGDs), each comprising ten participants. The farmers were purposively selected from the head-end, middle-section, and tail-end areas of the Mushandike Irrigation Scheme to capture variations in farmers' experiences and access to irrigation resources across the scheme. The sample included both male and female farmers of different ages and levels of farming experience. In addition, six key informants were purposively selected from relevant stakeholder groups, including AGRITEX officers, ZINWA officials, Irrigation Management Committee (IMC) members, and traditional and community leaders. Data collection continued

until thematic saturation was reached. In total, data from 26 participants were collected and included in the analysis.

DATA ANALYSIS: THEMATIC CONTENT ANALYSIS

All of the interviews and FGDs were performed in Shona, the local language and were audio-recorded. They were then translated from Shona to English before being transcribed so that they could be analyzed. The data were analyzed using Thematic Content Analysis, which includes a recursive six-step process consisting of:

Familiarisation - Understanding the transcripts

Initial Coding - Developing open codes, such as water theft, government neglect

Searching for Themes - Categorising the codes into larger groupings, such as Governance Gaps, Epistemic Tension

Reviewing Themes - Validating the themes against the Capability Approach theoretical framework

Defining Themes - Naming the final pillars of ICRF

Reporting - Using the direct words/quotes of the farmers to keep the voice of the farmer as the primary narrative of the analysis

In order to enhance the trustworthiness of the findings, the themes emerging from each of the FGDs, key informant interviews and documentary evidence were compared with one another (Bouncken *et al.*, 2025). This process of triangulation helped to ensure the consistency of the findings from each of the research methods and contributed to the credibility of the themes that would eventually develop the ICRF (Dahal, 2024).

ETHICAL CONSIDERATIONS

To ensure that the data are credible and trustworthy, a member-check process was used, involving the researchers providing the IMC with the preliminary findings to confirm or validate. Each

participant signed an informed consent form prior to data collection and all data was anonymised by way of pseudonyms such as Farmer A and Head-end.

FINDINGS

The following findings from the irrigation scheme are presented according to the themes that emerged during the interviews and focus groups. These findings informed the development of the four main pillars of the Integrated Capability-Resilience Framework.

1. PHYSICAL INFRASTRUCTURE CONSTRAINTS

One of the most dominant themes that emerged from the study related to physical infrastructure of the irrigation scheme. Most of the participants within the focus groups and interviewed indicated that there were many challenges related to the physical components of the irrigation system within the Mushandike Irrigation Scheme.

IRRIGATION INFRASTRUCTURE DETERIORATION

One of the most serious problems identified by the farmers regarding the Mushandike Irrigation Scheme was the deterioration of the irrigation infrastructure that was established within the irrigation system. Both head-end and tail-end farmers indicated their frustrations with issues related to the irrigation system infrastructure, such as its leakages and the maintenance of those systems.

One of the tail-end farmers indicated that there were significant issues related to the irrigation system's infrastructure, stating:

“Water rarely reaches our fields in the quantities that we need. Much of the water that enters the broken canals ends up leaking into the ground. Furthermore, it often takes several days of waiting ,till there is not enough water to irrigate the fields. These issues have become worse within the past few years.”

A head-end farmer also expressed their frustrations regarding the irrigation system and infrastructure:

“The canals into which the water from the river is dispensed into were constructed many years ago. Furthermore, the canals are often cracked and require patching every farming season with the farmers’ own resources. The canals also continue to leak water after each patching effort. Consequently, much of our time is spent patching these fields instead of dedicating that time to producing food for our communities.”

Even beyond the recognition of the problems of smallholder farmers, representatives of the IMCs and organisations also recognised the deteriorating state of the irrigation system. An IMC member indicated:

“One of the biggest problems with the irrigation system is the infrastructure that was constructed years ago to develop the irrigation system. Each week, the irrigation management committee receives complaints from the farmers regarding the broken canals and the loss of water from the fields that are irrigated by those canals. Furthermore, the irrigation management committee does not have the resources to repair those irrigation canals.”

Similarly, a ZINWA official also recognised problems associated with the irrigation system in the Mushandike Irrigation Scheme:

“The irrigation infrastructure that was constructed years ago has begun to pose significant challenges to the irrigation system of Mushandike. Canals continue to require rehabilitation to ensure that they can efficiently distribute water to the fields as when they were initially constructed. Should these canals not be rehabilitated, there

will be continued losses of water from the fields that are included within this irrigation scheme.”

2. IMPLICATIONS FOR PILLAR ONE OF THE ICRF

Considering the purpose and findings regarding the irrigation system in the Mushandike Irrigation Scheme, these findings can help to inform Pillar One of the ICRF. Pillar One intends to rehabilitate the irrigation system, as well as to provide methods for increasing the efficiency with which water is distributed to the smallholder farmers within the irrigation scheme. Thus, one method of increasing the resilience of the smallholder farmers is to increase the efficiency of the irrigation system that provides water to their fields.

COGNITIVE AND ECONOMIC BARRIERS TO RESILIENCE

A second major theme that emerged from the interviews of the smallholder farmers within the Mushandike Irrigation Scheme was the cognitive and economic barriers of those smallholder farmers to establish a climate resilience within their farms. More specifically, farmers indicated that lack of financial resources to invest in climate-resilient technologies for their farms (due to their lack of land title deeds) or their lack of trust in the climate information provided to their farms through radio and mobile communications applications presented a barrier to the ability of those farmers to establish climate resilience within their farms. Beyond the physical resources that are available to irrigate the fields of smallholder farmers, the cognitive and economic resources of those farmers are another critical factor that impacts their ability to establish climate resilience within their agricultural communities.

THE COLLATERAL TRAP

One of the major issues identified by the smallholder farmers within the Mushandike Irrigation Scheme is their inability to gain loans from banks to provide the resources necessary to implement climate-resilient technologies within their farms. They indicated that because they do not possess land title deeds for the farms that they manage, they are unable to provide the banks with the collateral required to obtain loans from banks.

One farmer within the study indicated his inability to receive loans from banks:

“Banks require individuals to provide collateral for any loan applications. As farmers, we do not have the land title deeds for the farms that we manage.” (Farmer 4)

Additionally, another farmer indicated financial difficulties that he and other farmers within the irrigation scheme experience in attempting to implement climate-resilient technologies onto his farm:

“To improve the type of crops that we grow within our farms, we must purchase irrigation equipment, improved crop seeds and other technologies that will allow us to combat the detrimental effects of climate change on our fields. However, financial institutions reject loan applications from us farmers. Consequently, we are forced to utilise other methods of farming that are not compatible with the climate within which we operate.” (Farmer 7)

Even beyond the farmers, those who work alongside the smallholder farmers within the irrigation scheme also noted the financial barriers of those farmers. For instance, an officer within AGRITEX stated:

“Many of these smallholder farmers within the irrigation scheme are aware of the changes that they must make to their farming practices to become climate-resilient. However, they are all struggling with the financial limitations that exists within their communities.”

Even traditional leaders within the irrigation system also recognised the impact of the financial challenges for the farmers. One of the traditional leaders cited:

“Many of our children have lost interest in farming because of the struggles that we face in farming the land that we own. Despite the fact that we are able to produce the crops each year, we are unable to secure the loans that we require in order to improve our farming methods.”

TRUST DEFICIT IN CLIMATE INFORMATION SERVICES

Another significant theme identified from smallholder farmers’ interviews within the Mushandike Irrigation Scheme was lack of trust in the information provided to the farmers regarding the climate conditions within their areas. The farmers indicated to the researcher that the climate information provided to the through the radio and mobile communications applications often does not accurately reflect the climate within their farms, which creates a trust deficit between the farmers and that information.

For instance, one of the farmers indicated his lack of trust in the radio and mobile communications applications:

“The climate information that is provided areas often only provides information regarding the climate conditions in other areas of Masvingo. For instance, there have been instances in which the predictions of the weather radio and mobile communications applications indicated that there would be rainfall within our area, yet the rain did not arrive on the ground within the fields that we manage. Similarly, there have been instances in which there was

heavy rainfall within our area, but there were no predictions of precipitation prior to the rainfall.” (Farmer 2)

Many of the farmers indicated that they continue to rely upon their own indigenous knowledge systems regarding climate conditions within their farms, despite weather inconsistencies they experience in their area:

“We rely upon our own systems of knowing the weather, which have been established within the region and utilised for many years. For instance, the direction of the wind, the movement of birds and the flowering of certain types of trees within our area often indicate the precipitation that will occur within the upcoming days.” (Farmer 6)

Despite the fact that many farmers within the area still utilise their own systems of knowledge of the climate conditions within their farms, traditional leaders within the area also suggest that, there should be a system that combines indigenous knowledge of smallholders of the land with that of the scientific climate predictions:

“Knowledge of the land and its factors is essential to knowing the weather within that land. However, the climate within which we farm is changing rapidly. Thus, there needs to be a system that combines the traditional knowledge of farmers within the area with the scientific climate/weather predictions.” (Traditional Leader)

As with the other factors related to the farmers within the irrigation system, even the representatives of agricultural training organisations also recognised the trust deficit between the farmers and the climate information:

“Often, the knowledge that the farmers have of the climate conditions within the farms that they manage is lacking in comparison with the knowledge that is provided to them by the meteorological services. Consequently, farmers require training from organisations such as

AGRITEX to increase their knowledge of climate-resilient agricultural practices.” (AGRITEX Officer)

These findings indicate that despite the availability of climate information for smallholder farmers within the Mushandike Irrigation Scheme, their trust in that information is lacking. Thus, the purpose of the proposed framework is to address this trust deficit.

IMPLICATIONS FOR PILLAR TWO AND PILLAR THREE OF THE ICRF

Considering the findings regarding smallholder farmers’ cognitive and economic barriers to establishing climate resilience within their farms, those factors will impact the development of Pillar Two and Pillar Three of the ICRF. More specifically, Pillar Two will work to increase the climate knowledge of the smallholder farmers of the area and Pillar Three will work to increase the ability of the smallholder farmers to have access to loans and resources to implement climate-resilient technologies and methods that have been suggested. These interventions will impact individual farmers that are provided with these resources and eventually the entire irrigation system and its farmers as a whole.

GOVERNANCE AND INSTITUTIONAL CHALLENGES

An additional theme that emerged from the interviews and FGDs with key informants and smallholder farmers respectively were problems with the governing bodies of the irrigation system. Farmers indicated problems that exist within the irrigation management committees regarding their power to enforce the rules of the irrigation system.

A member of the IMC indicated that their committee is challenged in enforcing the irrigation rules established for the farmers:

“The irrigation management committees are tasked with enforcing the irrigation rules established for the farmers within the irrigation system. However, the committees do not have the legal authority to enforce these rules. As a result, many of the farmers do not adhere to the rules established by the irrigation system management committees.”

In addition to recognising that the IMCs lack authority to enforce rules for the farmers, many of the farmers also expressed their concerns on the fairness of water distribution to each of the farming communities within the irrigation system. For instance, one of the farmers expressed his concerns regarding the fairness in the distribution of water:

“Many of the farmers within the irrigation system experience conflicts in the distribution of water to each farm. The farmers that are located in the tail-end of the irrigation system are often treated unfairly by the head-end farmers in the system.”

In addition to the smallholder farmers, other individuals within the irrigation system also indicated their recognition of the issues with the irrigation system’s management committees. For instance, one of the traditional leaders in the area indicated his belief in the need for improved management of the irrigation system:

“Many of the conflicts that emerge between the farmers within the irrigation system can be resolved by establishing an improved system of governing the irrigation system. Improved collaboration among all individuals that are involved with management of the irrigation

system will lead to improvements in the management of the irrigation system itself.” (Traditional Leader)

Similarly, one ZINWA official also recognised the importance of good governance for the irrigation system:

“An effective management of the irrigation system will require the cooperation of the farmers, the irrigation committees and other regulatory bodies. Should there be a weakness in any of those governing bodies, it will be difficult for the irrigation system to effectively distribute water to its farmers and manage its infrastructure accordingly.” (ZINWA Official)

These findings help to recognise the challenges that the institutions of the irrigation system face, as well as the impact that those challenges have upon the resilience of the irrigation system. Thus, these findings help to inform the development of Pillar Four of the ICRF. Pillar Four includes interventions to increase the effectiveness of IMCs, to increase the fairness of water distribution and to increase the cooperation of the individual stakeholders within the irrigation system.

DISCUSSION

PHYSICAL AND NATURAL CAPITAL AS A FOUNDATION FOR RESILIENCE

THE RELATIONSHIP BETWEEN MAIZE YIELDS, MOISTURE LOSSES AND IRRIGATION INFRASTRUCTURE

The findings indicate that the irrigation infrastructure within the Mushandike Irrigation Scheme was failing and that the resulting moisture losses to the fields were causing the adaptive capacity of

the smallholder farmers within the scheme to decrease. The decline in the yields of farmers within the area who were dependent upon moisture from the irrigation scheme was a demonstration of how moisture availability is not automatically associated with food security. Previous studies in similar irrigation systems within Zimbabwe have indicated that the infrastructure within those systems declining in their efficiency is linked with both increased vulnerability to climate variability impacts, as well as reduced adaptive capacity of those impacted farmers (Zvokuomba and Batisai, 2023). These findings inform the development of Pillar One of the ICRF: the rehabilitation of the irrigation infrastructure within the area, the efficient management of the water resources within that system and the development of sustainable methods of utilising those natural resources within the area.

THE IMPACT OF DETERIORATING INFRASTRUCTURE UPON SOCIAL RELATIONSHIPS WITHIN THE AREA

Beyond its impact upon the physical ability of the farmers to produce food within the region, the findings also indicate that the deterioration of the irrigation infrastructure within the Mushandike Irrigation Scheme was leading to social tensions among the farmers. Farmers located at the tail-end of the irrigation system were often frustrated at the apparent benefit that farmers located upstream within the irrigation system appeared to gain from the available water resources. These same findings have been made within other studies of irrigation systems, common-pool resources and water management within and outside Zimbabwe (Bellanthudawa *et al.*, 2025). The deterioration of the infrastructure

has an impact upon the social components of the irrigation system as well. These findings inform the development of Pillar One of the ICRF, indicating the need for infrastructure investments that lead to both an increase in the productivity of the irrigation system as a whole, as well as an even-distribution of its resources to all participating farmers.

COGNITIVE EMPOWERMENT AND CLIMATE ADAPTATION

TRUST IN THE AVAILABILITY OF CLIMATE INFORMATION SERVICES

The findings reveal that trust in the availability of climate information services within the area was low. While climate information was available to the farmers through the provision of weather forecasts and mobile-based climate information services, the farmers within the study area often felt that such information was not relevant to the climate within Mushandike. Consequently, the scientific weather forecasts had a low likelihood of influencing farming decisions of those farmers. Similar findings have been reported in other areas of Sub-Saharan Africa, where scientific weather forecasts have often proven to be ineffective in accounting for the climatic variations within those regions (Shilomboleni *et al.*, 2024). These findings inform the development of Pillar Two of the ICRF: the empowerment of the farmers through the provision of accessible climate information that can be applied to their farming decisions.

THE USE OF INDIGENOUS KNOWLEDGE SYSTEMS IN PLACE OF SCIENTIFIC WEATHER FORECASTS

The findings clarify that the majority of farmers within the study area utilise indicators of IKS in place of the scientific weather

forecasts provided to them. These indigenous systems are based upon the knowledge of the environment that has accumulated over time and through traditional agricultural practices of the farmers. However, climate change has led to the reduction in the reliability of these indicators, as well as the fact that scientific weather forecasts often do not account for environmental factors within the area. These findings support the literature that calls for the integration of these IKS with scientific systems of knowledge regarding the weather (*ibid.*). Consequently, Pillar Two of the ICRF aims to develop systems that allow for the integration of these two forms of knowledge within the area.

FINANCIAL AGENCY

FINANCIAL BARRIERS WITHIN THE ABSENCE OF COLLATERAL

The findings reveal that the lack of land tenure rights of the farmers prevented them from securing loans from banks to purchase climate-resilient agricultural technologies. These findings are in agreement with studies that have found similar results throughout the African continent (Saccone and Valino, 2025). The inability of the farmers to secure loans and purchase these technologies is a form of deprivation of the farmers of the capabilities needed to increase the food security of their areas. These findings inform the development of Pillar Three of the ICRF: the development of innovative financial systems and methods that overcome the issue of land tenure rights as a barrier to financial access.

INSTITUTIONAL AND GOVERNANCE REFORM

THE IMPACT OF WEAK INSTITUTIONS UPON IRRIGATION MANAGEMENT

The findings indicate that IMCs have limited power to manage the irrigation systems and to enforce compliance with irrigation schedules, among other management issues within the irrigation system. Such weak institutions are associated with the inability of irrigation schemes to manage water effectively, sustainably and fairly among the farmers within the irrigation systems. These findings inform the development of Pillar Four of the ICRF, which proposes the improvement of local institutions in charge of irrigation management, the recognition of such institutions within the law and the improvement of their accountability mechanisms.

THE INTEGRATED CAPABILITY-RESILIENCE FRAMEWORK

Unlike existing frameworks, the ICRF considers the impact of the empowerment and agency of those farmers. More specifically, the framework uses Sen's Concept of Capability in the understanding that the physical, cognitive, financial and institutional capabilities of the farmers is what allows for the development of food security within those areas. The framework was developed as a result of the findings of this study, as well as additional FGDs, interviews, documents and insights from the Capability Approach theory. Thus, the framework proposes methods of increasing the resilience of smallholder farmers and the food security of these groups within the semi-arid regions in which they live.

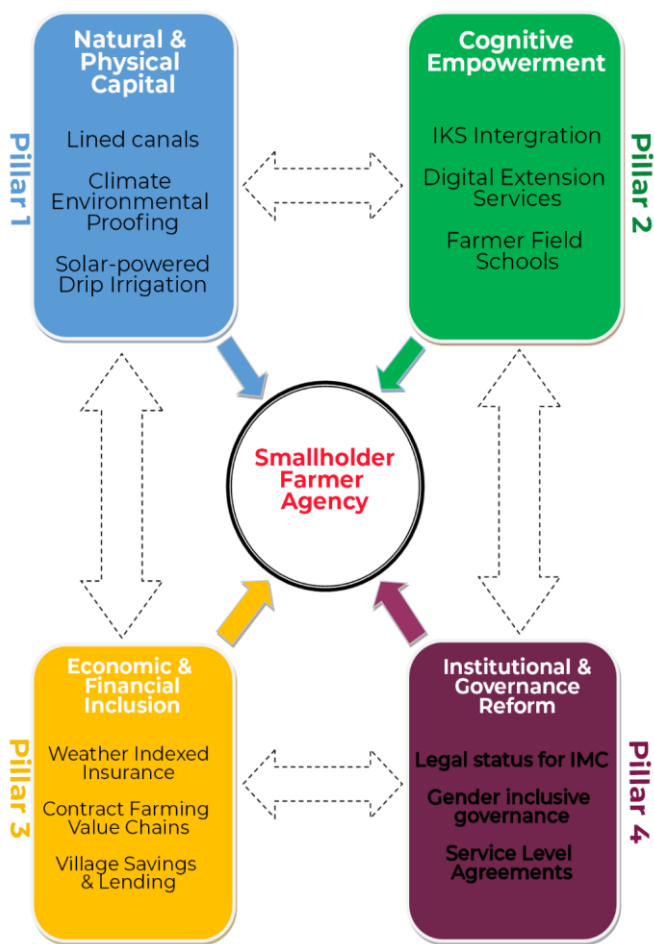


Figure 3: Pillars of the ICRF (*Author*)

LINKING THE ICRF TO SEN’S CAPABILITY APPROACH

The ICRF is rooted in Sen’s Capability Approach, which focuses on the freedoms and opportunities that individuals have to achieve their desired functioning. The first pillar of the framework, which focuses on Physical and Natural Capital, enables farmers to convert available water resources into agricultural productivity. The second pillar, Cognitive

Empowerment, allows farmers to make better decisions through the integration of scientific and indigenous knowledge. The third pillar, Economic and Financial Inclusion, increases the farmers' ability to gain the resources necessary to invest in newer agricultural technologies. Finally, the fourth pillar, which focuses on Institutional and Governance Reform, gives farmers more collective freedom and agency through the improvement to local institutions that manage water resources. Overall, each of the pillars contributes to the ability of farmers to achieve their desired functioning.

The study was conducted within a single irrigation farming scheme in Masvingo Province and used a qualitative phenomenological research design. The results of this study can provide valuable insights into the experiences of smallholder farmers in the area. However, the findings of the study are not generalisable to other irrigation farming schemes in Zimbabwe. Wider generalisation requires further comparative or quantitative testing.

RECOMMENDATIONS

OPERATIONALISING THE INTEGRATED CAPABILITY-RESILIENCE FRAMEWORK FOR SMALLHOLDER FARMERS

Based on the findings of this research study, it is recommended that the Integrated Capability-Resilience Framework (ICRF) be adopted as a tool to be used within the context of policy and the implementation of the Zimbabwe's Vision 2030. The framework can be used as a means of addressing the various constraints that smallholder farmers within the Mushandike Irrigation Scheme

face, as well as to effectively implement strategies that will improve the food security of the region.

PILLAR 1: PHYSICAL AND NATURAL CAPITAL

One of the first recommended areas of focus for the Government of Zimbabwe is the rehabilitation and modernisation of the irrigation infrastructure that is currently within the Mushandike Irrigation Scheme. Rather than focusing on the expansion of the area of irrigated land, the government should invest in the creation of technologies that will increase the efficiency of already existing schemes, such as canal lining technologies, leak detection systems, efficient water conveyance technologies and solar-powered irrigation systems. Rehabilitating these physical and natural resources will enable the individual smallholder farmers within the region to more effectively utilise the water resources that are available to them.

PILLAR 2: COGNITIVE EMPOWERMENT

The second recommended area of focus is upon cognitive aspects of the framework, particularly the integration of IKS within the region's agricultural extension services. AGRITEX and the Meteorological Services Department can establish climate observatories on each of the irrigation schemes within the region, which would help to provide the farmers within those areas with information about the weather, increasing their confidence in those weather reports. Furthermore, such an installation would reduce the gap between the knowledge that is often shared with the farmers and the actions that those farmers take in response to those recommendations.

PILLAR 3: ECONOMIC AND FINANCIAL INCLUSION

In addition to infrastructure rehabilitation, the Government of Zimbabwe should establish insurance programmes and other financial tools that would be available to smallholder farmers as a means of increasing their financial agency. These tools could include Weather-indexed Insurance, which would provide an alternative to the lending systems that are established upon the possession of land by farmers that do not have bankable land. By increasing financial agency, smallholder farmers will have more means of investing in their farms and increasing food security within the region.

PILLAR 4: INSTITUTIONAL AND GOVERNANCE REFORM

The fourth pillar of the framework recommends that the Government of Zimbabwe amend the Water Act (Research :2024) to ensure that IMCs are recognised as legal entities within Zimbabwe. These committees would be empowered to manage the irrigation schemes, farmers within those schemes and to provide a means of resolving conflicts between those different stakeholders within the irrigation zones. Such a recommendation will allow for the irrigation schemes to be more sustainable, as they will have a means of both governing themselves and reducing the conflicts between their members.

SCALING THE ICRF BEYOND MUSHANDIKE

Finally, recommendations for the framework include the piloting and scaling of the model to other irrigation schemes for smallholder farmers that exist within the semi-arid regions of Zimbabwe. The model's focus upon resolving the physical, cognitive, financial and institutional aspects of the constraints that exist within the Mushandike Irrigation Scheme can provide a

means of increasing the food security of smallholder farmers who are affected by the same challenges.

CONCLUSION

This study developed an ICRF that aims to enhance the food security of smallholder farmers within the Mushandike Irrigation Scheme in Zimbabwe by addressing various challenges that result from the impact of climate change in the region. The framework is based on Amartya Sen's framework of human capabilities and focuses on determining various constraints that prevent smallholder farmers from effectively transforming their available resources into livelihood income. Results from the study indicate that challenges threatening the irrigation scheme were not just climatic but infrastructural, informational, financial and governance-related challenges.

The study established four major capability constraints that limit the food security of smallholder farmers within the irrigation scheme. Deteriorating irrigation infrastructure and the loss of irrigation water significantly affect agricultural productivity. The trust that smallholder farmers have in the climate information systems managed by irrigation authorities limits their effective use of climate information to enhance adaptation to the impacts of climate change. Smallholder farmers' land tenure constraints and limited access to financial services constrain their ability to purchase climate-resilient agricultural technologies. Finally, the weakness in existing irrigation management institutions limits the effectiveness with which IMCs can manage irrigation resources within the irrigation scheme. These findings indicate that the challenges threatening smallholder farmers' food security are multidimensional and require integrated interventions to resolve.

Based on these findings, an integrated capability-resilience framework comprising four main components: components related to physical and natural capital, cognitive skills, financial capabilities, and institutional and governance reform was developed. While most adaptation strategies focus on enhancing the physical components of irrigation systems, this framework focuses on enhancing the capabilities of smallholder farmers within the irrigation system. Thus, the framework provides a more holistic understanding of the various components that contribute to the climate resilience of smallholder farmers in the irrigation scheme.

The findings of this research demonstrate that no single adaptation strategy would be sufficient for enhancing the climate resilience of smallholder farmers within the irrigation scheme. A successful adaptation strategy would require enhancing the irrigation system's physical components while improving the governance, financial and climate knowledge components of the irrigation system management structure. Thus, the Integrated Capability-Resilience Framework provides a framework for improving irrigation management practices in smallholder irrigation systems.

The principal contribution of this research is the development of an Integrated Capability-Resilience Framework that transforms the understanding of irrigation resilience among smallholder farmers from an infrastructure-centred model to a capability-centred model. Furthermore, the framework presents a means of improving the climate resilience of smallholder farming communities in the semi-arid regions of Zimbabwe and other similar areas.

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