Climate adaptation and sustainable rural health outcomes in Southern Africa

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Acknowledgements

This report is a product of a three-year project conducted by 10 researchers based at seven institutions (Institute of Natural Resources in South Africa, Human Sciences Research Council in South Africa, University of the Free State (South Africa), Marondera University of Agricultural Sciences and Technology (Zimbabwe), University of Manchester (UK), University of Washington (US), and University of Zimbabwe), with financial support from Wellcome Trust.

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Executive Summary

Introduction

This is a close-out report for the project "*Climate adaptation and sustainable rural health outcomes in Southern Africa*" which was funded by the Wellcome Trust (Ref: 216034/A/19/Z) and undertaken from 01 October 2019 to 01 October 2022.

The project was implemented by a team of 10 researchers from seven institutions (Human Sciences Research Council (South Africa), Institute of Natural Resources (South Africa), Marondera University of Agricultural Sciences and Technology (Zimbabwe), University of the Free State (South Africa), University of Zimbabwe, University of Manchester (UK), and University of Washington). The project team was multidisciplinary in outlook as it was composed of researchers with backgrounds and research interests in climate change adaptation, livelihoods, health economics, gender, food and nutrition security, development policy, food science, sociology, agricultural economics, and public health. The interdisciplinary outlook of this diverse research team allowed for: a) the exploration of issues from multiple dimensions, b) a robust mixed-methods research process, and c) a robust synthesis of findings. This close-out report presents all aspects of the study, including the aims, objectives, methodology, conceptual underpinnings, key findings, recommendations and limitations of the study.

The main aim of the project was to evaluate the nutritional and psychosocial health impacts of three major climate change adaptation actions in rural Southern Africa, using case studies of communities situated in the mid-Zambezi Valley area of Zimbabwe's Mbire District, in Mashonaland Central Province. The adaptation actions in focus were: a) Shifting from predominantly maize farming in main dryland fields, to drought-tolerant sorghum production over the years, b) Increased reliance on indigenous knowledge vis-à-vis consumption of wild fruits (during crop failure), and c) Increased reliance on indigenous knowledge with respect to using unique meteorological, insect and atmospheric indicators to predict rainfall patterns and droughts.

Key findings

In terms of positive impacts

1. Shifting from the traditional maize crop to growing drought tolerant crops in the main upland fields is the adaptation action which was most associated with both highly positive nutritional and psychosocial health outcomes. Nutritionally, this adaptation action was shown to result in improved food availability for the majority of sampled households and in raising the levels of consumption of acceptable nutritional diets. In terms of psychosocial outcomes, shifting to drought-tolerant crops was associated with elevated levels of control of one's livelihoods and life in general, excitement, and pride in relation to being able to counter adverse life circumstances.
2. The consumption of wild fruits (particularly during periods of crop failure) was also highly valued in terms of the realisation of positive nutritional and psychosocial health outcomes. Nutritionally, wild fruits prevalent in the area (such as baobab fruit /*Adansonia digitata* or *mawuyu* in vernacular and *masawu* fruits/*Ziziphus mauritiana*) – rich in Vitamin C, carbohydrates and fibre – are great sources of nutrients in addition to enabling households to meet basic food availability during increasingly repeated periods of crop failure. In terms of psychosocial outcomes, the use of indigenous knowledge related to the consumption of wild fruits was found to contribute to lowered levels of anxiety around food

availability in periods of drought and crop failure.

3. The use of rainfall and drought indicators to predict rainfall was associated with the lowest prevalence of positive psychosocial health outcomes. The reason for such an observation is not immediately clear, however, it might reflect challenges around attributing any changes to such a 'fluid' adaptation action – making it difficult to link to psychosocial and nutritional health effects both temporally and geographically.

In terms of negative impacts,

1. For the wild fruit consumption adaptation action, nutritionally, some wild fruits consumed in the area (e.g. katunguru (*Maerua decumbens*) and manyanya *(Strychnos spinosa)* fruits) were reported to be poisonous if not carefully and adequately prepared. Many cases were reported of people falling ill after having eaten these specific wild fruits – with most of those affected developing swollen legs and stomachs. Psychosocially, consumption of wild fruits was reported to result in negative psychosocial outcomes emanating from competition with wildlife in accessing these fruits, and the associated anxiety, fear and distress involved when thinking about the dangers and risks of encountering, being injured or killed by wild animals – particularly elephants – prevalent in the area.

2. Shifting from the maize crop to drought tolerant crops was not associated with any significant negative nutritional health impacts. However, in terms of psychosocial health, interestingly, it was the adaptation action associated with the most adverse psychosocial health indicators, with the highest proportion of respondents reporting experiencing worry, annoyance or fear for several days, over half the days or nearly every day in connection with (the success of) this strategy compared to other adaptation actions. This is despite the fact that this adaptation action was also linked with the highest levels of positive psychosocial outcomes. While it is unclear why both negative and positive psychosocial outcomes were simultaneously reported for this particular adaptation action, it is possible that the pursuit (and implementation) of certain adaptive strategies might be both stressful and difficult enough to generate negative reactions, and yet, at the same time, elicit excitement and satisfaction through promoting control for people seeking to make improvements in their production and livelihood systems when necessary.

Subsequent recommendations following from the above findings are as follows:

For Government, NGOs and private players

1. In the wake of climate change and variability, governments and other development partners should promote diversification of rain-fed cropping systems, including production of drought-tolerant crop types and varieties, to build resilience as well as deal with food and nutrition insecurity. In the context of this study, the following are key: (i) accessible markets for inputs (seed, fertilizers, agrochemicals) and outputs (grain and other by-products); (ii) mechanisms and platforms for seed exchange and multiplication within the farming communities; (iii) robust and efficient extension services to allow for training of farmers, collective action and timely access to inputs, including the creation of local champions towards popularisation and uptake of drought tolerant crops in such marginal and drought prone areas as Mbire district; and (iv) community level platforms for knowledge and information exchange on production, processing, and marketing.

   The shift from maize to sorghum in the case of Mbire district was mainly due to the efficient distribution of suitable sorghum varieties, training of farmers on the advantages of the shift, extensive extension services by both government and development partners around the production of the crop, and the creation of

viable markets for selling the sorghum crop at harvest.

2. It is important to encourage and create opportunities for NGOs and relevant government entities to spearhead value addition activities and projects in local communities, revolving around such adaptation actions as harvesting of wild fruits – e.g., the processing of *mawuyu (Adansonia digitata)* into grounded powder for porridge-making and *masawu (Ziziphus mauritiana)* fruit into jam, etc., as is happening in Mbire district. This will enhance the resilience of livelihoods and production systems towards nutritionally and psychosocially beneficial adaptation actions in such complex vulnerability contexts.

For Researchers and Academics

1. There is urgent need for systematic documentation by researchers on what is, or is not, working in different contexts e.g. vis-à-vis the use of local rainfall and drought indicators as adaptation action – given a key finding of this study showing no significant nutritional and/or psychosocial health impacts around the adoption and use of this particular adaptation action. This is an interesting and somewhat curious finding, considering that in many other rural communities in Africa, the adoption and use of local rainfall and drought indicators have long been shown to be highly beneficial across a range of measures.

2. There is a need for the recognition of psychosocial health as a major component of climate adaptation action. Psychosocial health has not been much recognized in climate discourse; not only in Zimbabwe, but in sub-Saharan Africa at large. From interviews conducted with key state and non-state actors working in health, climate and adaptation-related sectors, some entry points for incorporating psychosocial health into climate interventions and discourse should involve: awareness; collaborations; trainings, and embedding psychosocial health aspects into agricultural extension programs.

For Communities

1. Communities should be proactive in documenting, preserving and communicating indigenous knowledge and indicators associated with key adaptation actions to climate challenges. This could be done through existing formal and/or informal community structures.

2. Communities should also engage in peer-to-peer sharing of ideas through local community forums and support groups vis-à-vis the positive and negative nutritional and psychosocial health outcomes of adopted climate adaptation actions.

3. Communities should also explore the idea of forming cooperatives towards working together in value-addition activities associated with some of the adaptation actions explored e.g. with respect to purchasing advanced machinery to process wild fruits into finished products, accessing capital from financial institutions to upscale the value addition activities, and seeking other institutional support from NGOs and the government.

Introduction

Climate change is now a reality. Now also called the climate crisis, it is impacting heavily on people's physical and mental wellbeing across the globe. Climate change takes an incalculable toll on human health and wellbeing, in terms of disease, injury, and death as well as homelessness, hunger, and emotional trauma.

The climate crisis is, therefore, a health crisis. With the focus now mostly on responses to the effects of climate change, various studies have assessed different aspects of climate mitigation and adaptation actions. Explicit focus on understanding the health impacts of adaptation actions in different countries and communities has, however, not been appreciated[1]. Yet the health impacts of adaptation actions are directly linked to livelihood resilience, sustained household and community adaptive capacity as well as the physical, social and economic wellbeing of a society. In addition, although adaptation policy instruments in most countries acknowledge the need for strengthening the surveillance of human health under climatic variability and change, many do not proffer strategies for doing that nor do they address the "how" of tracking and evaluating direct health impacts of adaptation actions in different contexts. This project therefore aimed to contribute in closing these gaps by investigating the nutritional and psychosocial health impacts associated with selected adaptation actions in rural Southern Africa, using a case study of communities in Zimbabwe's mid-Zambezi Valley area. The project sought to assess the effectiveness of selected adaptation actions over the years vis-à-vis the specified health outcomes; their mechanisms of action; and if they have been unsuccessful, understanding the reasons why. The evaluation ultimately aimed at providing evidence-based recommendations for assessing and dealing with differential health impacts of key climate change adaptation pathways in marginal rural communities in Zimbabwe and in Southern Africa at large

Pursuant to this overall purpose, four interrelated objectives were articulated:

Objective 1: To identify the positive and negative nutritional and psychosocial health impacts of three selected adaptation actions in the case study area.

The selected adaptation actions were:

a) *Shifting from predominantly maize farming in main dryland fields, to the drought-tolerant sorghum crop over the years;*

b) *Increased reliance on indigenous knowledge in wild fruits consumption (during crop failure), and*

c) *Increased reliance on indigenous knowledge to predict rainfall patterns and droughts using unique meteorological, insect and atmospheric indicators*

Objective 2: To evaluate the ways in, and extent to which the impacts have manifested in different social and vulnerable groups (e.g., children, women, the elderly, households of different wealth statuses).

Objective 3: To explore how best the positive health outcomes can be sustained and the negative ones addressed, and

Objective 4: To proffer ways on how recommendations from this impact evaluation can be effectively upscaled and applied in similar vulnerability contexts in Zimbabwe and in Southern Africa at large.

These objectives were to be understood in the context of the emphasis of the third focal area of the original Call for Proposals by the

[1] Adaptation actions are tangible actions taken to alter behaviour, institutions, policies, programs, built environments, or mandates in response to experienced or predicted risks of climate change (Biagini et al 2014).

Wellcome Trust, around assessing the health impacts of existing climate adaptation actions[2].

For easier implementation of work and to avoid losing track and sight of processes influencing outcomes of interest and how impact around the outcomes have been realised, we divided the project areas of focus into three work packages, namely:

- the adaptation work package;
- the nutritional health work package; and
- the psychosocial health work package.

The adaptation work package traced the application and implications of the three adaptation actions in focus. This work package traced how and why the adaptation actions came about, how they have been implemented, and their successes and/or failures as measured according to the project evaluation criteria (discussed in detail in the conceptual section of the report). The nutritional work package's starting point of inquiry was the nutritional impact story of the assessment exercise; working backwards towards understanding how and to what extent the adaptation actions in focus led (and/or contributed) to observed nutritional outcomes. Similarly, the psychosocial work package's starting point of inquiry was the psychosocial health story of the impact assessment and it also worked backwards in exploring and assessing how and to what extent the two adaptation actions under focus led and/or contributed to observed psychosocial outcomes.

[2] The original Call for Proposals had three focal areas from which projects could select one area of focus: (a) developing tools, data sources and other resources to support research into climate change and health; (b) assessing the health co-benefits of actions to mitigate climate change, and (c) assessing the health impacts of actions to adapt to climate change.

Background

Contextual setting for the impact evaluation

This impact evaluation study was undertaken in the mid-Zambezi Valley area of northern Zimbabwe, in Mbire District, Mashonaland Central Province (see Figure 1 below).

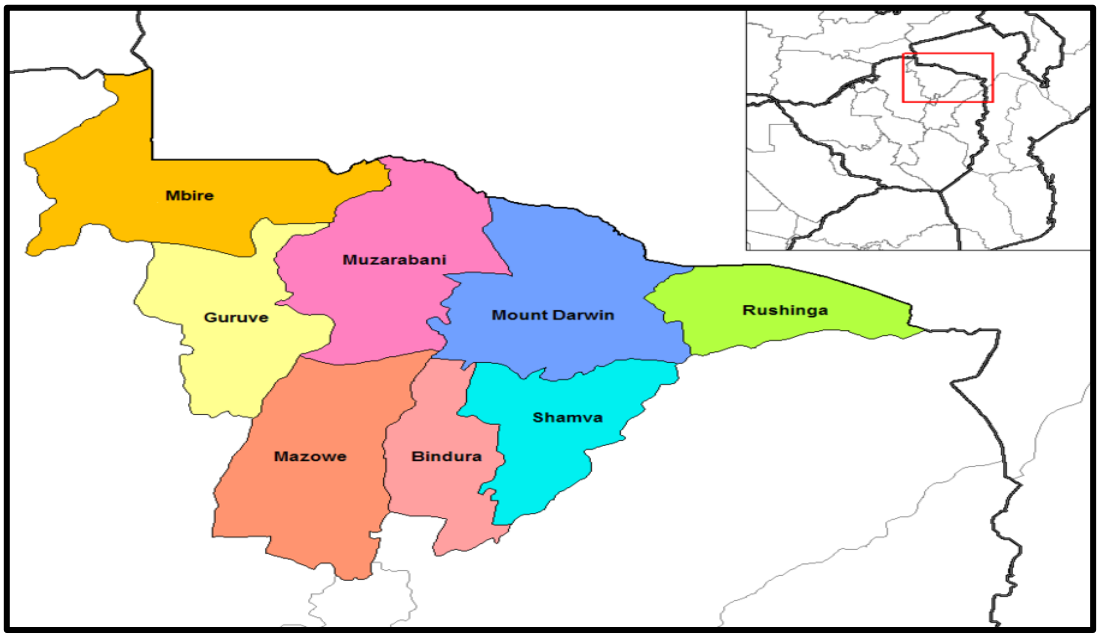

Figure 1. Map of the districts in Mashonaland Central Province, including Mbire District.

The mid-Zambezi Valley area presents interesting cases for this evaluation as it is classified among Southern Africa's climate change hotspots (Beilfuss, 2012). The mid-Zambezi Valley is part of the Zimbabwean lowveld, and it particularly refers to lands lying north of the Zambezi escarpment bordered by Mozambique to the north and east, and Zambia to the north-west (Mupangwa et al., 2006). It consists of an extensive undulating plain averaging 450m above sea level, descending to 350m above sea level to the north towards the Zambezi River (Pwiti, 1996). Mbire district forms the major part of the low-lying, mid-Zambezi Valley in Zimbabwe's Mashonaland Central Province, and it is a semi-arid, remote area listed in the country's agro-ecological region IV and V[3], specifically located 30° 25" E and 16° 30"S, and Osborne and Parker (2002) note that the area encompasses roughly 2,700 square kilometres.

Mbire district consists of 17 wards[4]. The district experiences temperatures reaching over 40°C in summer, and irregular rainfalls which average 450-650mm per year. There are two main seasons in the district: December to March – which is the rainy season, and April to November which is the dry season (Baudron et al., 2011).

Livelihood sources

Major livelihood sources in Mbire district mainlyrevolve around the production of crops and livestock. Two systems of crop production

[3] There are five agro-ecological regions in Zimbabwe. These are divided based on different soil types, agricultural activities, vegetation, varying climatic conditions and rainfall averages. Natural regions IV and V are characterised by low rainfalls and poor soils and have less conducive conditions for undertaking diversified and intensive crop production activities than natural regions I to III.

[4] Wards in Zimbabwe are the second smallest administrative geographical boundaries after villages.

are apparent in Mbire district: an upland crop production system and a riverbank crop production system (Nyamwanza, 2012). Almost all local households have an upland field and these fields average 7 to 12 acres per each household (ibid). The riverbank crop production system takes place along the banks of major rivers. Most villagers in the area have either personal or borrowed plots in these spaces which average 1 to 5 acres per household. Upland fields are mainly made up of clay sandy soils. The major crops which are produced in upland fields include cotton – which is the major cash crop in the area, and sorghum. Maize, groundnuts, millet, cowpea and sunflower are the other prominent crops cultivated in upland fields. Maize is the major crop which is cultivated in riverbank fields together with tomatoes, onions and green vegetables – in smaller proportions.

The main livestock raised in Mbire are cattle, goats and poultry. Other animals like pigs and sheep are found in small numbers. Livestock play critical roles in the area as sources of food (i.e. meat and milk) as well as draught power and manure. Cattle are the most valued form of livestock just as in other rural African communities, with the number of cattle a household has being equated to how wealthy that household is perceived to be (Nyamwanza, 2012).

Local casual agricultural work, known in vernacular as *maricho,* is another source of livelihood. Much of this casual work involves people working in other villagers' fields to prepare land, plant, weed and other harvesting and post-harvesting activities. People also engage in non-agricultural livelihood activities such as fishing and small-scale trading in goods and services.

Vulnerability factors

The mid-Zambezi Valley is beset by a number of climatic and non-climatic vulnerability factors. The main climate-related vulnerability concerns include intra-seasonal dry spells, increased drought cycles, and floods. Non-climatic stressors in the area include seasonal malaria, high poverty levels, food insecurity, and a poor health system. There is also a high presence of wildlife, which contributes to the area being marginal for livestock production. These vulnerability factors interact in complex ways, impacting negatively on household and community resilience. Since this impact evaluation primarily aims at assessing the health impacts of *climate adaptation actions*, we expand on the discussion around climate-related vulnerability factors below so as to get a clear picture and understanding of the nature of climate sensitivities in the study area.

Intra-seasonal dry spells

Previous primary research in the area (see Nyamwanza, 2012; Basongo, 2012; Nyamwanza and New, 2016; Nyamwanza, 2018) reveals an increased frequency in dry spells during cropping seasons. These spells usually occur between the months of October and December, which will be early in the season, and which is also the period when crops will be at germination stage and very sensitive to moisture stress. Whilst a season may receive normal or even above-normal rainfalls therefore, the intra-seasonal dry spells have led to a reduction in the quality and quantity of crop yields because of the critical stage of crop development at which they occur. Shifts have also been noticed in the area with respect to the onset of rainfalls and lengths of seasons.

Picture 1. Dry maize crop in an upland field in Mbire

Increased drought cycles

Drought cycles have also been increasing in the area. Previous research reveals that drought cycles have, in recent years, been occurring every three years on average which is different from the 1980s and 1990s when these were experienced after every five years on average (Nyamwanza, 2018). Droughts have led to many devastating effects, mostly around crop failure, the deaths of livestock, and the drying up of boreholes and rivers.

Floods

Floods in the mid-Zambezi Valley area have mainly occurred due to two factors:

(1) Excessive local rains which occur in the months of January/February; and
(2) The release of water upstream from Kariba Dam and backflow from Cabora Bassa Dam which is further downstream (in Mozambique).

The second factor enabates from the fact that the mid-Zambezi Valley is geographically positioned downstream of Kariba Dam and upstream of Cabora Bassa Dam. The levels of Kariba Dam are usually higher between December and February which necessitates the release of water from the dam to avoid dam failure. This then leads to increased discharge of water into, not only Zambezi Valley, but many other major rivers in Mbire district, and backflow pressure from Cabora Bassa Dam leading to localised flooding in the area. Primary research evidence (obtained by the principal investigator between 2010 and 2017 – see Nyamwanza, 2012; Nyamwanza and New, 2016; Nyamwanza, 2018) revealed an increase in flood frequency in the area over the past two decades.

Evaluation framework

Evaluation design

As highlighted in the introduction section, this study was designed to be an impact evaluation. Evaluation scholars use the term 'impact' to denote causal effects of an intervention, or programme, (or adaptation actions in this case), on outcomes, whether immediate or intermediate, positive or negative, direct or indirect, intended or unintended (IEG, 2012). The key aspect is measuring change, i.e. the impact, that has occurred from a specific activity, on a range of stakeholders, based on the principle of measuring what matters most vis-à-vis the intervention under investigation, as well as what matters most to stakeholders (NEF Consulting, n.d).

O'Flynn (2010) posits that in assessing impact, the following four basic questions should be answered:

a) What has changed because of the intervention(s)?
b) Which group(s) of people have been affected by the change(s)?
c) How significant were/are the changes?
d) Are the changes likely to last (or have they lasted)?

Impact evaluations can be ex-ante or ex-post. Ex-ante evaluations focus on measuring intended impacts of future interventions, whilst ex-post evaluations, such as the one conducted, seek to measure actual impacts after the interventions have already happened. A key question in impact assessment is that of attribution i.e. to what extent are the observed outcomes due to interventions under focus (e.g. selected adaptation actions, in the context of this study) rather than other factors. Three three design options are commonly available vis-á-vis causal attribution: non-experimental, experimental, and quasi-experimental designs.

The current study used a non-experimental evaluation design. Non-experimental designs explore whether the evidence falls in line with what would be anticipated if an intervention was associated with the impacts, and whether there is provision for an alternative explanation. A non-experimental design may be used in cases where no randomised control exists and where there is no sufficient baseline information available on the intervention(s) under focus, to be able to conduct a 'before and after' analysis. It is usually based on building a strong causal logic chain or programme theory where analysis can identify breaks in the chain and so very plausibly argue for impact (OECD, 2010). We settled for a non-experimental design for the study because:

- No baseline data was collected for the targeted population vis-à-vis interventions under focus to be able to conduct a plausible 'before and after' analysis; and
- It would have been cumbersome to establish either a randomised or even non-randomised control groups due to time and resource implications.

Although this design suffers from a number of challenges to internal validity, chief among them being that it does not afford control over extraneous factors that may have influenced post-exposure measurements, it still provides strong evidence for intervention impact especially when supplemented with complementary information, and through a prior thorough check of assumptions. Careful triangulation of data collection and analysis techniques as done for this impact assessment (see Section 4) also helped to minimise these challenges. Furthermore, threats to internal validity were also dealt with through a thorough interrogation of various potential intervening factors pre-identified as possibly influencing the outcomes of interest

over the years, in addition to the interventions under focus.

The evaluation design was essentially based on the use of *contribution analysis* hinged on a robust theory of change for interventions under focus. Contribution analysis explores attribution through assessing the contribution an intervention has made to observed outcomes (Mayne, 2008). Contribution analysis is a way of combining evidence for systematic causal inference and it derives from theory driven approaches to impact assessment, which emphasise a programme theory of change or programme logic of an intervention, while at the same time addressing the need to consider external factors that may have affected outcomes.

Evaluation criteria

Evaluation criteria can be thought of as 'concepts' against which the evaluation must be addressed (Rogers, 2014). These concepts must be sufficiently defined and must be applied systematically to make evaluative judgments about interventions under focus. Evaluative criteria commonly used include those about human rights, equity and gender equality. Some, used particularly for such development interventions as humanitarian assistance, include such concepts as coherence, coverage, protection and coordination. This work used the OECD-DAC criteria (OECD, 1991) commonly used for evaluating and assessing development assistance and which have been utilised by many development agencies as standard of good practice in evaluation and impact assessment. These criteria include the following concepts:

Relevance: The extent to which the interventions under focus (which are the adaptation actions under scrutiny in the context of this study) are suited to the context i.e. nutritional and psychosocial health needs and priorities of households and communities in the case study area.

Effectiveness: The extent to which the interventions (again, here, the adaptation actions in focus) have met their intended objectives over the years, including an understanding of the factors contributing to the achievement, or non-achievement, of the intended objectives.

Efficiency: How the inputs towards undertaking the adaptation actions e.g. information, technical support etc., translated to outputs.

Impact: The extent to which adaptation actions under focus have led to differentiated positive and/or negative health outcomes, either directly or indirectly, intended or unintended.

Sustainability: The extent to which the positive nutritional and psychosocial health impacts realised from the adaptation actions in focus may continue over time.

Theory of Change

As mentioned, the evaluation framework selected for this study hinged on the development of a clear and explicit Theory of Change (TOC). A TOC is a systematic well-thought-out and systematic assessment of the complex links between processes, activities, outcomes and context, and the changes that occur in the short, medium and long-term (Rogers, 2014). A TOC sets out a roadmap that describes how a set of activities are intended to lead to a series of results which are meant to produce the final impacts. A TOC was therefore central in guiding causal attribution for this impact assessment study.

Rogers (2014) articulates that when developing a TOC, it is important to ensure that it adequately represents what the interventions under focus are intended to achieve and how. Figure 2 presents an articulated TOC which informed the study. In Figure 2, the first column on the far left shows the three project work packages of the study and the arrows in that column depict how work within the three work packages was linked. As shown, the adaptation work package sought to explore and unpack the nutritional and psychosocial health impact pathways of the selected adaptation actions. On the other hand, the nutritional and psychosocial work packages worked backwards towards understanding the observed impacts of the

adaptation actions in focus. From the second column on the left side going to the right side, the Figure outlines the logic framework linking the adaptation actions to the observed impacts – including the inputs, activities, outputs and outcomes involved.

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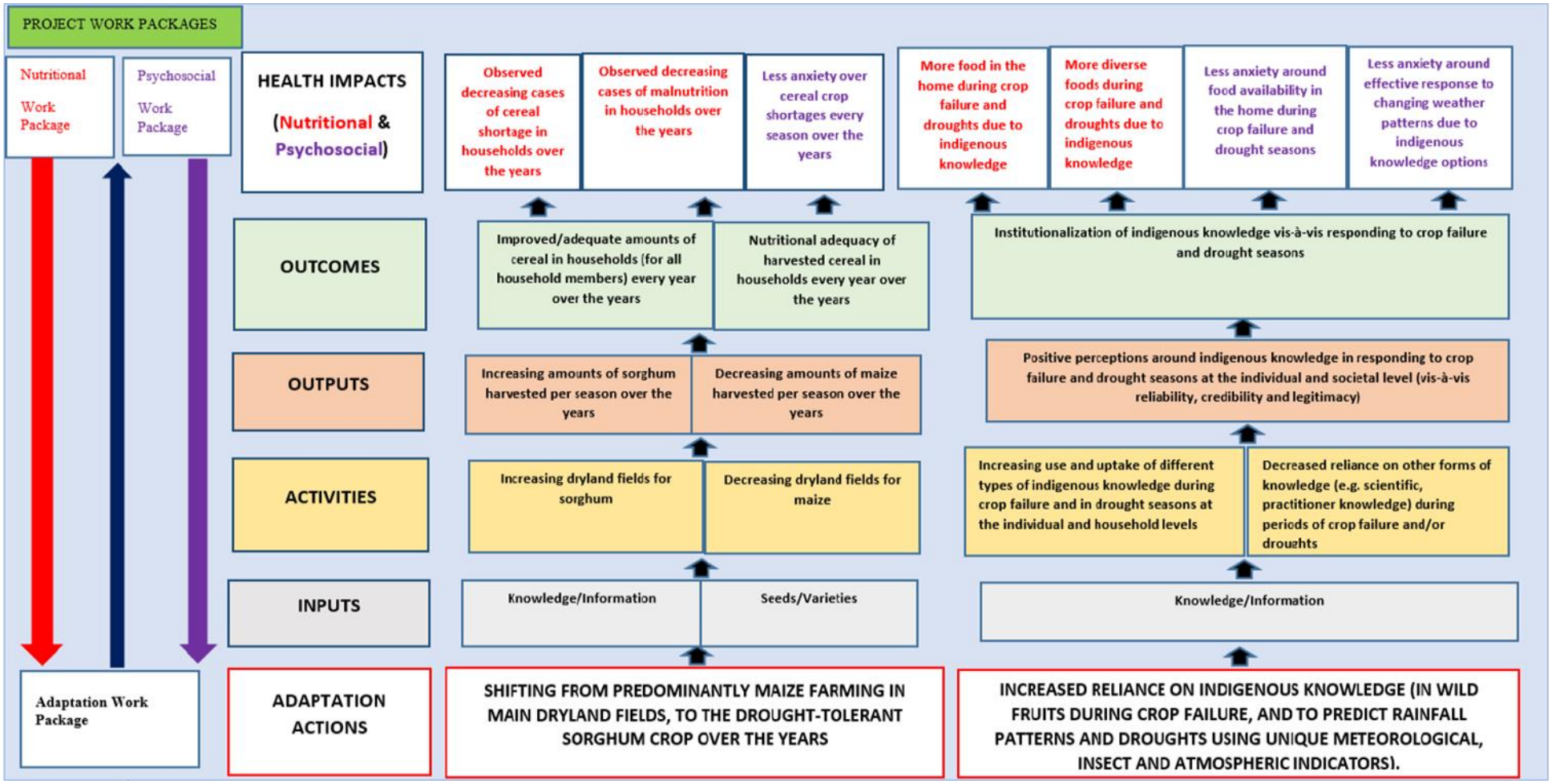

Figure 2. Theory of Change

Methodology

Data collection techniques

The impact evaluation used a phased, mixed-methods approach combining both qualitative and quantitative data collection techniques as outlined below:

Desk-top reviews

These included an analysis of relevant literature and policy documents on climate variability and change, climate change adaptation, the local health system, the agricultural system, livelihoods, as well as climate services in the case study area.

Key informant interviews (KIIs)

KIIs were conducted with a select sample of relevant stakeholders at national, provincial and local levels. At the national and provincial levels, stakeholders interviewed included officials from the Department of Climate Change Management, Food and Nutrition Council of Zimbabwe, Ministry of Health and Child Care, National Meteorological Services, the Ministry of Lands, Agriculture, Water, Fisheries and Rural Resettlement, as well as academic researchers who have worked on issues related to the impact evaluation's aims and objectives in the case study area and in similar contexts in Southern Africa. At the local level, KIIs were conducted with local agricultural extension officers, local health officers, traditional leaders, officials from organisations involved in food aid and social support in the area, officers at the local meteorological office as well as heads and senior teachers at local schools. Questions in key informant guides at all levels were informed by all the four research questions.

Stakeholder workshops

Two stakeholder workshops were conducted - one at the national level and another one at the sub-national/provincial level - bringing together selected stakeholders to explore issues around the four research questions. The workshops were important in simultaneously collecting ideas and views from different players who hold significant knowledge, as well as insights and experience which informed the impact evaluation.

Household survey

A household questionnaire was administered to selected respondents in the area. The questionnaire was informed by:

a) Specific tools used for assessing diet quality and nutrition over time such as the Household Food Consumption Score (FCS)[5], the Household Dietary Diversity Scale (HDDS)[6], and the

[5] The FCS was measured by collecting both consumption and frequency of different food groups by a household during the past seven days before the survey. The food consumption groups include: starches, pulses, vegetables, fruit, meat, dairy, fats, sugar. The consumption frequencies of the different foods in the groups were summed, with the maximum value for the groups capped at 7. The formula, based on these groups, with the standard weights, is: FCS = (starches*2) + (pulses*3) + vegetables + fruit + (meat*4) + (dairy*4) + (fats*.5) + (sugar*.5) (Oils*.5). The FCS therefore ranges from 0 to 112. FCS values from zero (0) to 28 indicates a poor FCS, 28.5 to 42 indicates a borderline FCS and from 35.5 to 112 indicates an acceptable FC.

[6]HDDS is used to measure the quality of diet, especially macro- and micronutrients. It depicts household access to a variety of food groups. HDDS as an indicator gives a better reflection of food security at household and intra-household levels. HDDS was calculated based on 12 foods namely, (1) Cereals, (2) Roots and tubers, (3) Vegetables, (4) Fruits, (5) Meat, poultry, and offals, (6) Eggs, (7) Fish and seafood, (8) Pulses, legumes, and nuts, (9) Milk and milk products, (10) Oils/ fats, (11) Sugar/ honey and (12) Miscellaneous. The value of HDDS therefore ranges from zero (0) to twelve (12).

Minimum Dietary Diversity Scale for Women (MDDS-W)[7].

b) Three indexes that are commonly used in assessing child health and nutritional status i.e. underweight, reflecting both the cumulative and current effects of malnutrition; stunting, which reflects chronic under-nutrition and, which, in most cases, is a result of prolonged food deprivation and/or illness; and wasting, which is a reflection of acute food shortages and/or illness[8].

c) The Generalised Anxiety Disorder (GAD) tool (Spitzer et al, 2006), which focuses on negative psychological health measurement, complemented by other self-reported survey indices, such as depression, anxiety, social support and happiness, key mainly in assessing the psychosocial health aspects[9] (see Box 1 for a detailed picture of how the GAD tool was utilised in the study).

Box 1. Use of the GAD tool

In using the GAD tool, we originally deployed all the seven aspects (GAD-7) for eliciting psychosocial health-related reactions. GAD-7 consists of the following conditions: (1) Feeling nervous, anxious or on edge; (2) Not being able to stop or control worrying; (3) Worrying too much about different things; (4) Trouble relaxing; (5) Being so restless that it is hard to sit still; (6) Becoming easily annoyed or irritable; and (7) Feeling afraid as if something awful might happen. Each of these conditions is measured on the following four-point scale: Not at all (0), Several days (1), More than half the days (2), and Nearly every day (3). Individuals who checked off any of the difficulties are asked how hard those problems made it for them to engage in the following: do their work, take care of things at home, and get along with other people. Each of these latter conditions was evaluated along the following four options: not difficult at all (0), somewhat difficult (1), very difficult (2), and extremely difficult (3).

Both sets of questions were aggregated into an index, with the former increasing with worsening psychological health, and the latter increasing with difficulties engaging in activities of daily living (ADL). However, upon testing the instrument in the field after translation into the local language, it was discovered that respondents were confused by the questions, as some of the questions were literally indistinguishable from each other in the local language. Consequently, only four questions were retained in the final instrument, as these were judged to unambiguously capture the range of conditions intended in the original GAD instrument in the context of the study area. These were: Feeling nervous, anxious or on edge;

[7] MDDS-W measures micronutrient adequacy in the diets of women at the population level. All the foods consumed by women of reproductive age (15 - 49 years) at or outside the home during the previous day or night (last 24 hours) was recorded. To compute the score, the foods were assigned into the following 10 food groups: (1) Grains, roots, and tubers, (2) Pulses, (3) Nuts and seeds, (4) Dairy, (5) Meat, poultry, and fish, (6) Eggs, (7) Dark leafy greens and vegetables, (8) Other Vitamin A-rich fruits and Vegetables, (9) Other vegetables, (10) Other fruits. The threshold for adequacy is 5 or more food groups.

[8] In essence, stunting is a condition in children aged 0–59 months who are more than two standard deviations (moderate and severe) below the median height-for-age of the World Health Organisation (WHO) Child Growth Standards; Underweight - children aged 0–59 months who are more than two standard deviations (moderate and severe) below the median weight-for-height of the WHO Child growth standards median; Wasting - children aged 0–59 months who are more than two standard deviations (moderate and severe) below the median weight-for-height of the WHO Child Growth Standards

[9] In assessing positive psychosocial health indicators specifically, respondents who embarked on the adaptation measures under focus were asked about any positive effect such actions had on their well-being over the previous four weeks. The relevant positive effects included: A sense of control over my life despite the challenge; Excitement at the opportunity to explore a new way of life; Pride in finding a new solution during adversity; and Grateful for having a viable option. Each of these options was ranked on a four-item Likert scale as follows: Not at all (0), Somewhat (1), About half of the time (2), and Most/All the time (3). The resulting positive indices displayed a high degree of reliability, with Cronbach alpha coefficients of 0.97, 0.97, and 0.99 for each respective adaptation action.

Worrying too much about different things; Becoming easily annoyed or irritable; and Feeling afraid as if something awful might happen. Consequently, our adaptation of the GAD-7 instrument in light of the lived reality of respondents ranged from 0-12 (instead of 0-21 as derived in the original GAD-7 instrument). However, similar to the original GAD-7, our index increases with worse psychological health, and so can be used to ascertain the direction of relationship between psychosocial health and phenomena of interest. To ascertain if the conditions used in creating the index displayed internal consistency, we calculated the Cronbach alpha coefficient for each adaptation-induced set of questions. Their alpha coefficients were very high: 0.93 (for the measures related to planting drought-tolerant crops), 0.95 (for the measures related to consuming wild insects, fruits and vegetables), and 0.97 (using local drought and rainfall indicators to predict climate patterns). Thus, each resulting index displayed a high degree of reliability based on the underlying questions used in deriving it (Cronbach, 1951).

Sampling framework

Random sampling was used in selecting households for the survey. However, this (random) sampling was conducted in wards which were proportionally selected. Communities in the case study area are divided into 17 wards/local administrative boundaries. Besides the ward boundaries, a major geographical feature in the area that influenced ward selection is the Zambezi River. The river not only forms the border between communities on the Zimbabwean, Mozambican and Zambian sides, but has a huge bearing on agro-ecological variations in the area depending on proximity to the river – with favourable agricultural potential decreasing as the distance from the Zambezi River increases (Moore et al., 2007). Out of the 17 wards in Mbire district, we focused on nine wards, which were proportionally selected, with three representing those closest to Zambezi River, three in the middle (of the area), and three furthest from the river.

In terms of sample size, the total realised sample size was 403 households, averaging 44 households in each ward. The composition of the realised sample endeavoured to reflect as much diversity in social categories of people as possible, critical in addressing the research questions – such as female-headed households, the elderly, and households of different wealth statuses. All children under the age of five in the interviewed households were eligible for anthropometric measurements.

Table 1. Overview of data collection techniques

Desk-top reviews	Relevant policy documents, journal articles, books and other archival material on the case study area	
Key Informant Interviews	National and Provincial Level	• Department of Climate Change Management officials • Food and Nutrition Council of Zimbabwe officials • Ministry of Health and Child Care officials • Ministry of Agriculture officials • Officials from the National Met Office • Academic researchers
	Local-level	• Local agricultural extension officers • Local health officers • Traditional leaders • Officials from organisations involved in food aid and social support in the area • Officials from the local met office • Heads and senior teachers at local schools

Stakeholder Workshops	2 Stakeholder workshops, i.e.1 at National and 1 at Sub-national/Provincial levels
Household survey	An average of 44 households targeted in each of the 9 sampled wards. A total of 403 households reached

Data analysis

Information collected through qualitative and quantitative means was analysed separately, after which all the data were grouped into separate qualitative and quantitative datasets. The perspectives and insights from the interpretation of both forms of data were then integrated in answering the research questions.

Data collected qualitatively (through desktop reviews, key informant interviews, and stakeholder workshops) were analysed thematically. Thematic analysis focuses on identifiable themes and patterns from information collected through various techniques towards addressing research objectives. In this case therefore, information obtained from different techniques was neatly arranged and data addressing similar concerns and activities was 'extracted' and organised into specific themes as guided by the research questions.

For the quantitative data, most of the responses on the questionnaire were pre-coded; however, a few were open-ended. The open-ended ones were re-organised and then coded later. All the responses were analysed using SPSS software. The analysis and presentations involved descriptive and inferential statistics such as frequencies, percentages and averages.

Results

This section presents results from primary data collection exercises conducted. Different subsections present the adaptation, nutritional and psychosocial dynamics emerging from the data collected.

Adaptation dynamics

Proportion of households using adaptation actions

Figure 3 depicts the proportion of surveyed households which made use of the selected adaptation strategies at the time of the impact evaluation. Approximately 85% of households indicated that they grew drought-tolerant crops to minimise risk of crop failure caused by the changing climate, while 84% consumed wild edible fruits, insects, and vegetables during crop failure. A much smaller proportion of households (37%) indicated that they used local rainfall and drought indicators to monitor and predict rainfall.

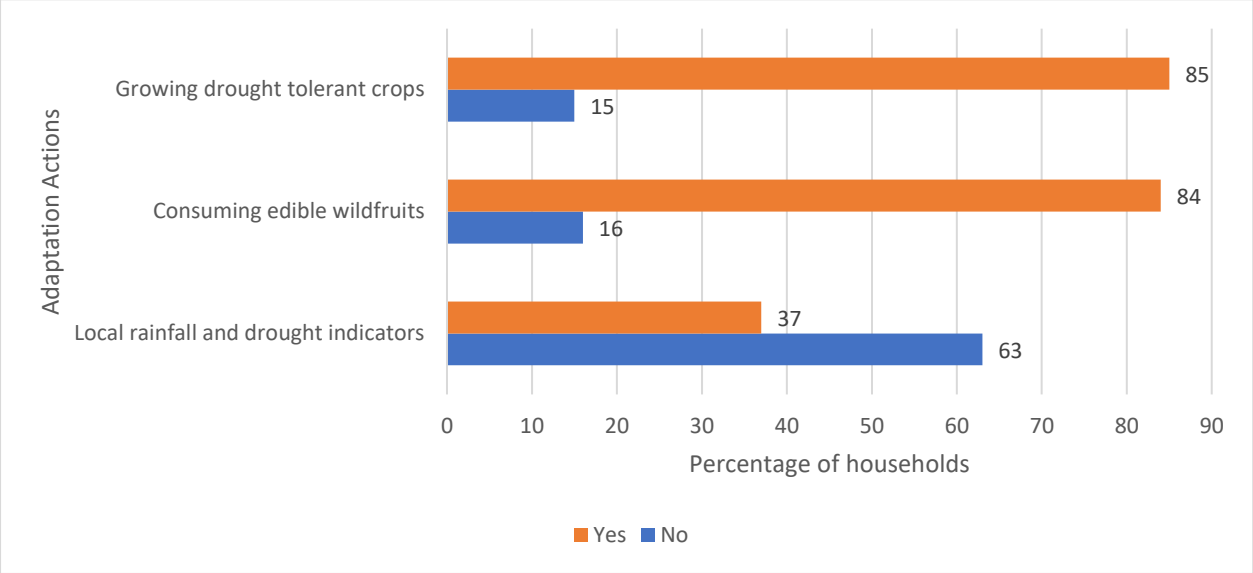

Figure 3. Proportion of households using the adaptation actions in Mbire district

Qualitative data also corroborates the heavy reliance on drought tolerant crops in Mbire district vis-à-vis adaptation to climate variability and change. From key informant interviews, it was apparent that both state and non-state actors have actively promoted reliance on drought tolerant crops as an adaptation strategy. For example, farmers have, over the years, been encouraged to focus on the production of such crops as sorghum, cotton and sesame, over less drought resistant ones, such as maize.

One local official from the ministry of agriculture interviewed noted that:

"As a ministry we (have) definitely promoted drought tolerant crops in Mbire district over the years. For example, we are currently promoting small grains. We call them additional grains, and examples are sorghum, pearl millet, finger millet, also sunflower, (and) cowpeas. We are working with (non-governmental organisations such as) the World Food Program (WFP) to promote the intensive production of these small grains, not only in Mbire district, but in most marginal

districts in the country. This season (2020-2021), we have upscaled from 13 districts to 30 districts in the country where we are giving inputs to promote these small grains; working together with WFP."

In the same vein, qualitative data also confirmed the huge role of edible wild fruits in supplementing diets and food availability during periods of drought and adverse climate events. One elderly villager interviewed in one of the targeted wards during key informant interviews highlighted that:

"We have a lot of wild fruits in the area, such as masawu and mawuyu, and these have shielded us from hunger during periods of drought – which, by the way, are increasing over the years."

Picture 2. Baobab fruit

Incidentally, the abundance in - or scarcity of - these wild fruits have also been used to predict whether a particular season will be dry, normal or will be characterised by heavy rains. This has immensely supported some households' cropping activities in the area.

Effectiveness of adaptation actions

Climate change adaptation strategies under focus were also evaluated based on their effectiveness (i.e. the extent to which households feel these adaptation actions have met their intended objectives over the years). Growing drought tolerant crops was regarded as very effective by 40% of surveyed households. Only 2% of households indicated that the use of drought tolerant crops had not been effective. About 41% of respondents mentioned that consumption of wild edible fruits, insects and vegetables is an effective adaptation action, while 36% indicated that the use of local rainfall and drought indicators has been effective to counter climate variability and change over the years.

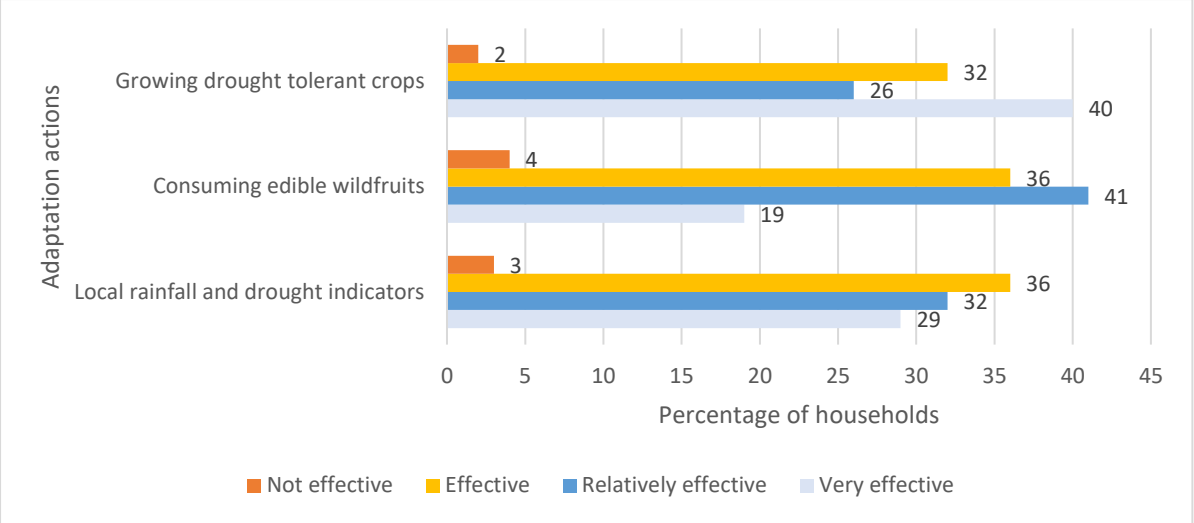

Figure 4. Effectiveness of adaptation actions in Mbire district

Accessibility of adaptation actions

Nearly two thirds (63%) of sampled households highlighted that growing drought tolerant crops, including sorghum, is an accessible and feasible adaptive strategy. A similar proportion (61%) noted that wild fruits, insects, and vegetables are accessible in the area, whilst only 40% of the households indicated that the use of local rainfall and drought indicators is an accessible adaptation action (Figure 5).

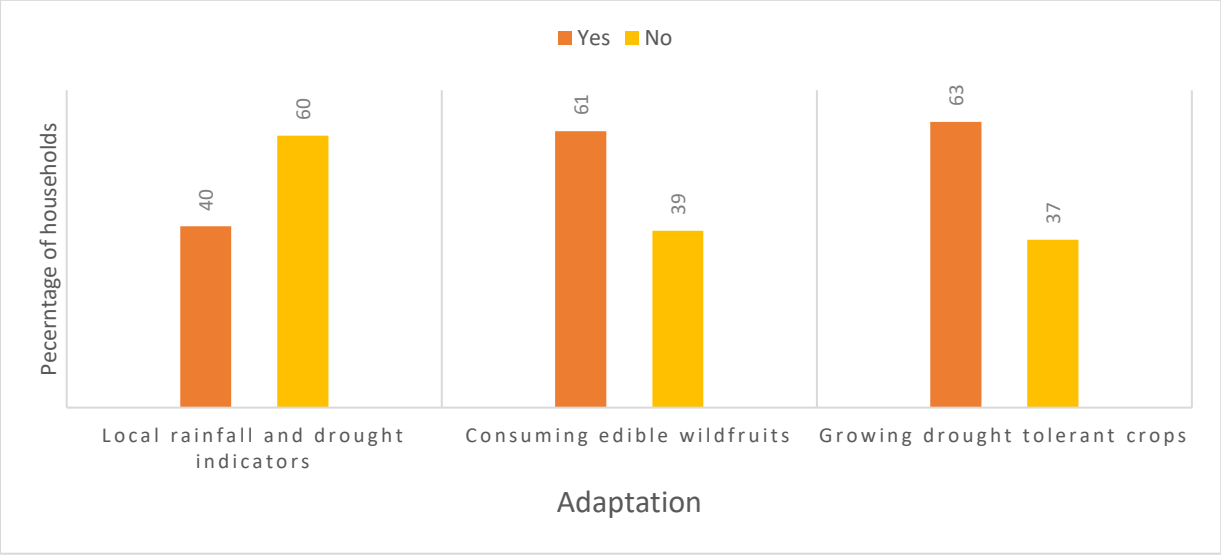

Figure 5. Accessibility of adaptation actions

Importance of adaptation actions for meeting household needs

The majority (76%) of surveyed households acknowledged that drought tolerant crops help them in meeting their food needs (Figure 6). This was followed by 65% who indicated that drought tolerant crops meet their nutritional needs. A huge percentage of households (64%) noted the importance of edible wild fruits, insects, and vegetables in meeting their food needs followed by 59% who cited the importance of this adaptation action in improving nutritional needs. Over half of the sampled households (58%) did not see the

importance of local rainfall and drought indicators on improving their nutritional needs whilst 52% did not see the importance of local rainfall and drought indicators in meeting their food needs.

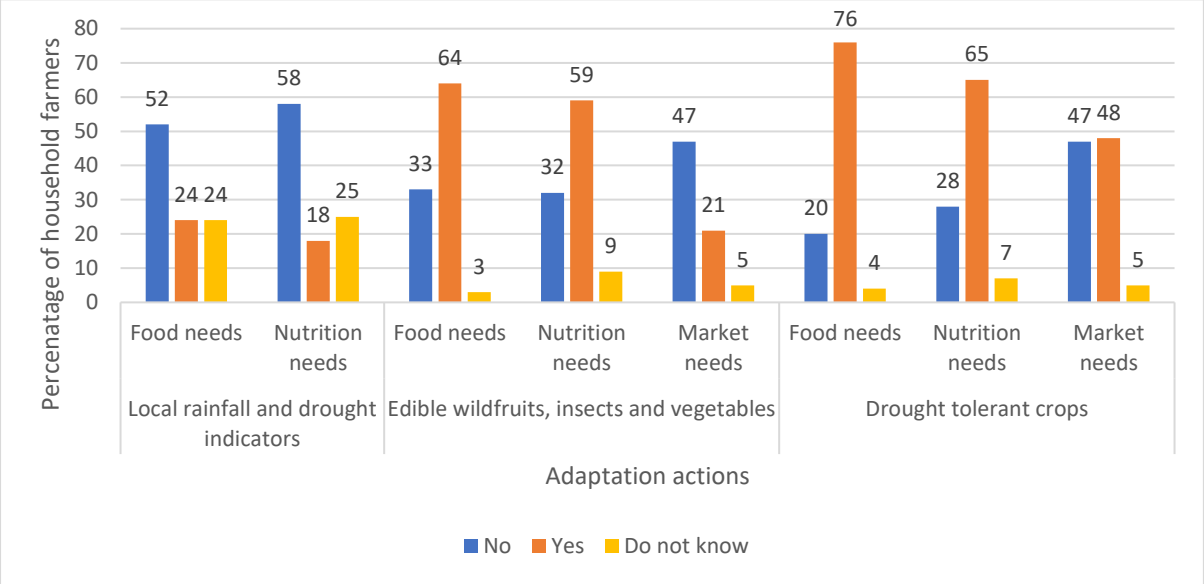

Figure 6. Importance of the adaptation actions for meeting household needs

Sustainability of adaptation actions

Surveyed respondents were asked to rank the period they thought they may continue employing the different adaptation strategies in their current form: 66% indicated that they will continue growing drought tolerant crops in the next 2 years without any challenges; 65% indicated that they can continue with consumption of wild fruits, insects, and vegetables in the next two years. About half (48%) of survey respondents indicated that they "don't know" how long they will use local rainfall and drought indicators, whilst 42% indicated that they will use local rainfall and drought indicators for the next two years.

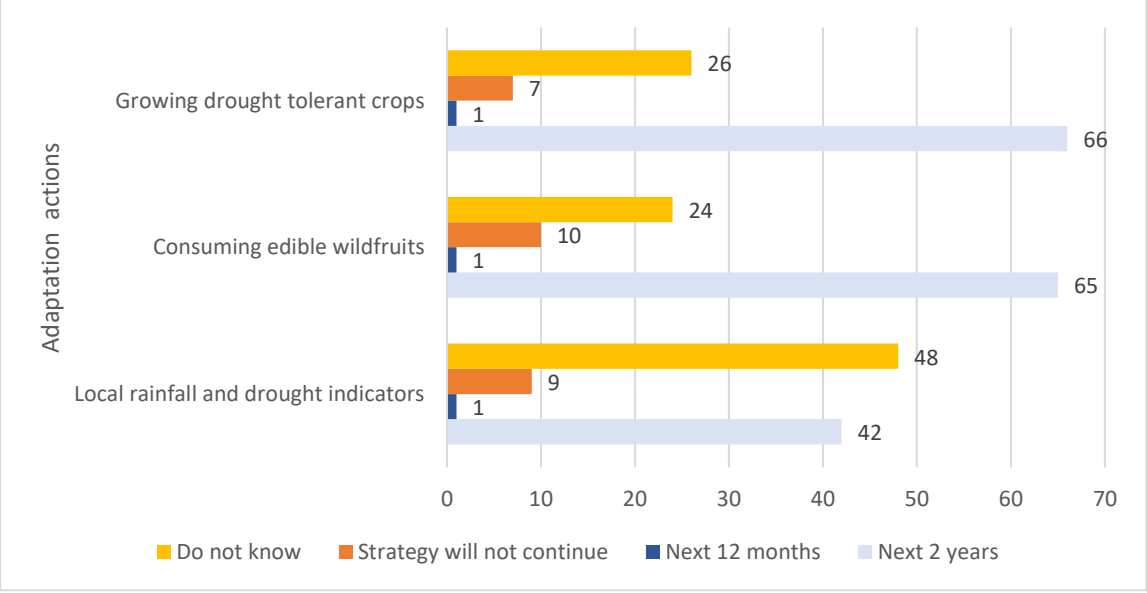

Figure 7. Sustainability of adaptation actions

Nutritional health dynamics

This section presents findings on the nutritional health dynamics of the climate adaptation actions under focus in Mbire district. The nutrition status of the sampled population targeted during the household survey is presented first, followed by inferential analysis findings vis-à-vis the impact of adopted climate change adaptation strategies on nutritional health outcomes.

Nutrition status of surveyed households

Food Consumption Score (FCS)

The FCS is a proxy indicator of household caloric availability (WFP, 2008). Results presented in Figure 8 show that about 43.9% of the households were in the poor food consumption category, 34.2% were in the borderline food consumption category and 21.8% were in the acceptable food consumption category (Figure 8). These results, therefore, indicate that a greater proportion of the sampled households were consuming a poor diet.

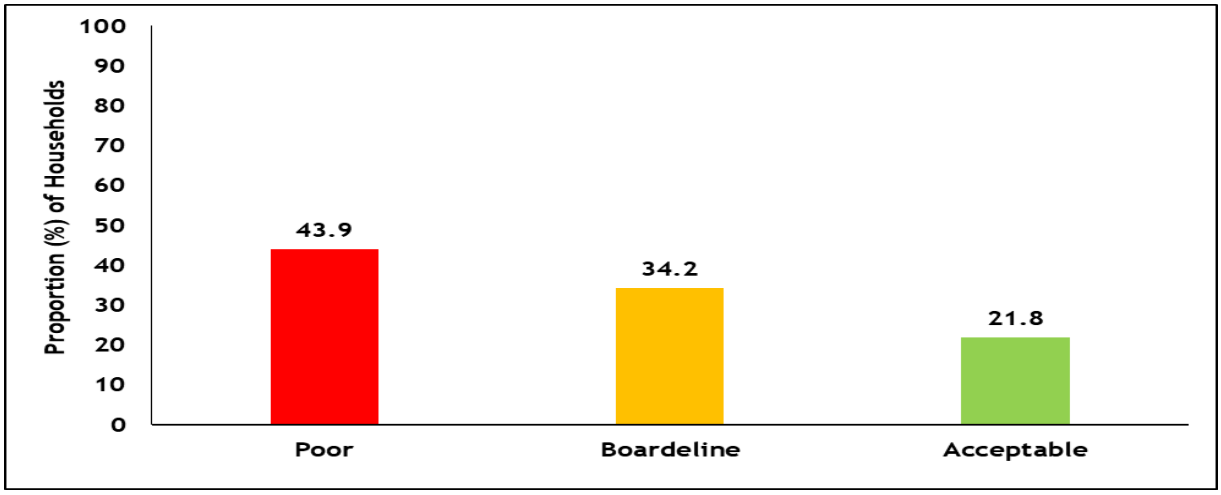

Figure 8. Food consumption score (FCS) for households in the area

Minimum dietary diversity for women (MDD-W)

The Minimum Dietary Diversity for Women (MDD-W) measures the diversity of the foods in terms of (i) grains, roots, and tubers, (ii) pulses, (iii) nuts and seeds, (iv) dairy, (v) meat, poultry and fish, (vi) eggs, (vii) dark leafy greens and vegetables, (viii) other Vitamin A-rich fruits and vegetables, (ix) other vegetables and (x) other fruits consumed by women of childbearing age (i.e. 15-49 years), 24 hours before the survey was done. The results presented in Figure 9 show that only 25.7% of the women were consuming food from five or more food groups, while 74.3% were consuming food from less than five food groups. In addition, the results reveal that the average Women Dietary Diversity Score was 3.6 out of a possible 10 food groups. These findings therefore show that women of childbearing age from the sampled households were consuming less diverse food, and this is a cause of concern considering the nutritional requirements of women of childbearing age.

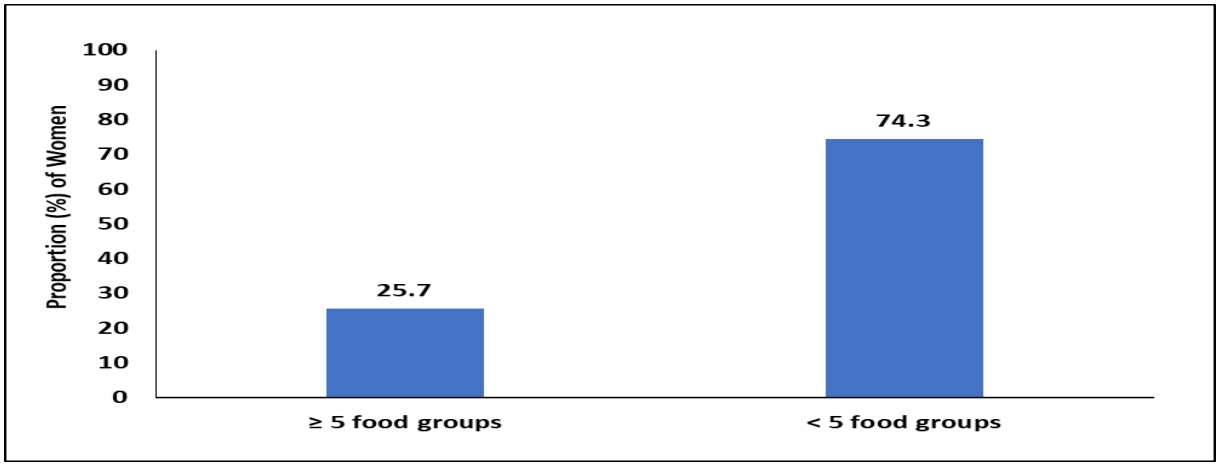

Figure 9. Minimum dietary diversity for women aged 15-49 years

Figure 10 shows an overview of the foods that were mostly being consumed by women of childbearing age. The diet was mainly composed of grains and vegetables. Other food groups such as meat (9%), orange fruits (3%) and vegetables (16%) were hardly consumed. This was also echoed in the qualitative data obtained from the district. It appears there is a lack of knowledge on other protein products in the area. Beans and cowpeas, which are common, only guarantee provision of protein for a certain period of time.

It was also noted that the nutritional components and benefits of small grains may be overstated. A nutritionist from the Ministry of Health, for example, highlighted that:

"...People need to be careful, because you find that pearl millet is very high in calcium; millet is very high in iron...but most of the iron is contaminated from the environment. Anaemia is (therefore) still high in rural areas even though small grains are consumed there."

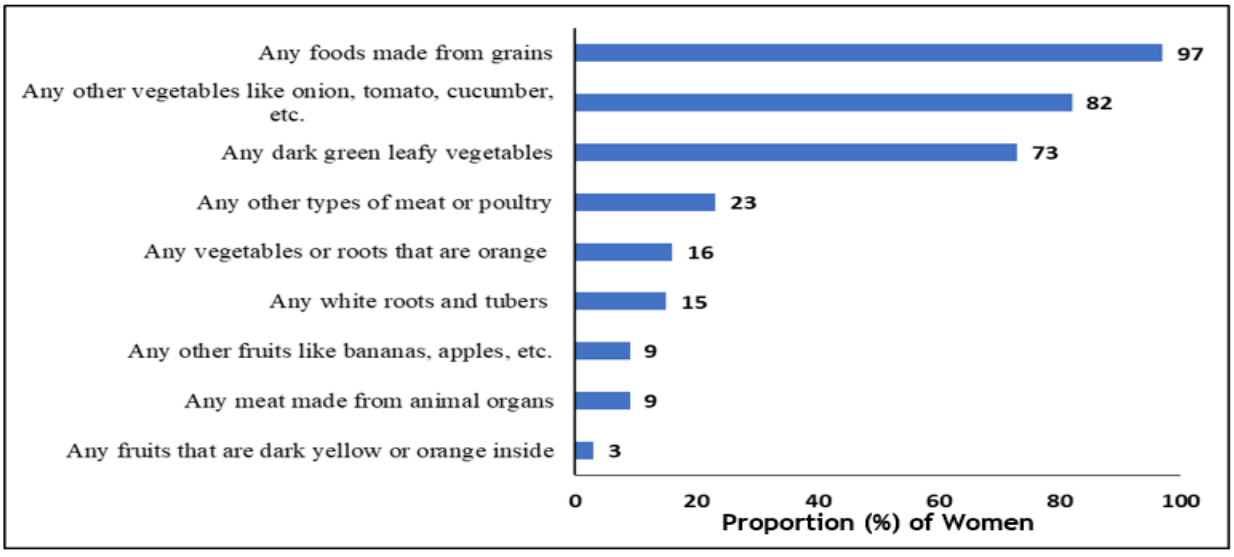

Figure 10. Food groups consumed by women aged 15-49 years

Child nutrition

Child nutrition indicators which include stunting, underweight, wasting, and overweight were analysed. The results presented in Figure 11 reveal that the prevalence of stunting was 22.7%. This is in the medium range as compared to the World Health Organisation (WHO) cut-off points for

stunting reduction (de Onis et al., 2019). The results also show that 10.3% of the children in the surveyed households were underweight and 6.8% were wasted. There was a small proportion of children who were overweight (3.4%).

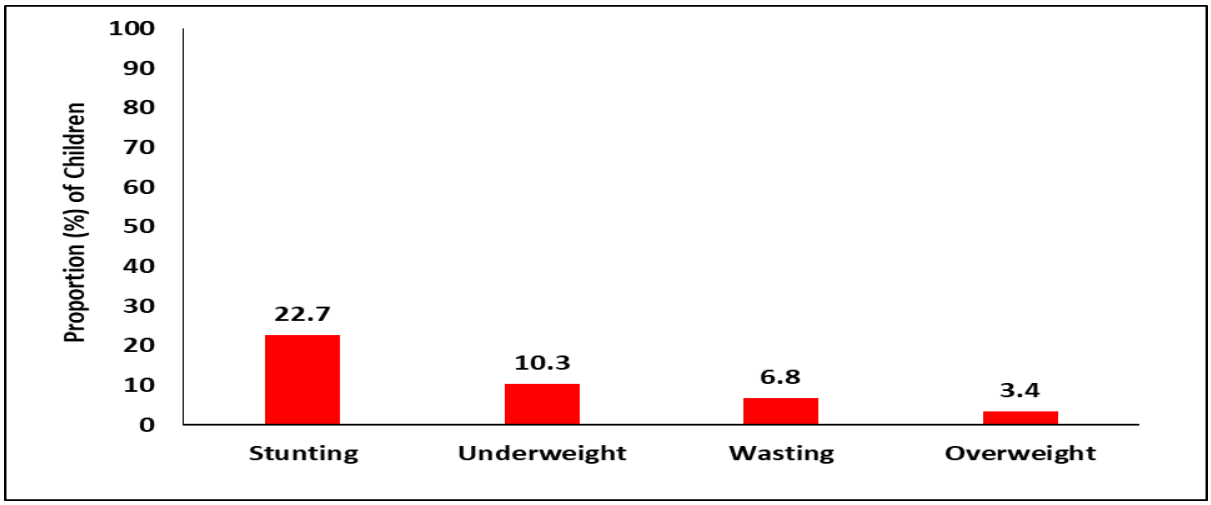

Figure 11. Prevalence of stunting, underweight, wasting, and overweight for children

Inferential analysis on the impact of adopted climate change adaptation strategies on nutrition outcomes

Impact of adopted adaptation strategies on dietary diversity for women

The multiple linear regression analysis results presented in Table 2 show a positive association between crop diversification index and dietary diversity for women which was significant at 10% level. This means that a one unit increase in the crop diversification index will lead to a 1.26 increase in the minimum dietary diversity for a woman. In simple terms, the results reveal that farming different types of food crops helps to increase the dietary diversity of women.

Table 2. Factors affecting the minimum dietary diversity for women

Variable	Unstandardized Coefficients		t	Sig.
	B	Std. Error		
Household size	-0.068	0.079	-0.864	0.388
Crop diversification index	1.264	0.726	1.741	0.083*
Indigenous knowledge index	-0.002	0.003	-0.639	0.524
Drought tolerant crops index	0.007	0.008	0.940	0.348
Wild fruit index	0.000	0.001	0.153	0.878

Age of the household head	0.012	0.012	1.013	0.312
Level of education	0.191	0.076	2.500	0.013***
N	213			
Prob>F	0.037			
Adjusted R squared	0.036			

****; **; * significant at 1%, 5% and 10% level*

Impact of adopted adaptation strategies on food consumption score

Results in Table 3 show a positive and significant (1% level) relationship between the use of drought tolerant crops and FCS. The results of the multinomial analysis show that a one unit increase in the use of drought tolerant crops may result in a 0.019 unit increase in the consumption towards an acceptable nutritional health diet holding other factors in the model constant. In simpler terms, the results show a positive relationship between the use of drought tolerant crops and the consumption of an acceptable nutritional health diet. If a household increases the production of drought tolerant crops by one unit, the multinomial log odds of growing drought tolerant crops in the category of consuming an acceptable nutritional health diet relative to those that consume in the unacceptable range would expect to increase by 0.023 units, holding other variables in the model constant.

Table 3. The effect of adaptation actions on the FCS

Food Consumption Score		Coef.	Std. error	P>|z|
Base category 0-28				
29-42	Drought tolerant crops	0.019	0.0077	0.014**
	Wild Fruits, Vegetables and Insects	0.0008	0.0010	0.463
	Age of the household head	0.006	0.0086	0.477
	Gender of the household head (Female)	-0.03	0.306	0.918
	Constant	-1.36	0.550	0.015
Above 42	Drought tolerant crops	0.023	0.0073	0.001***
	Wild Fruits, Vegetables and Insects	0.001	0.0010	0.233
	Age of the household head	0.001	0.0084	0.898
	Gender of the household head (Female)	0.224	0.295	0.448

	Constant	-1.32	0.531	0.013
Log-likelihood	*-306.949*			
Number of obs.	*290*			
LR chi2 (8)	*17.48*			
Prob>chi2	*0.026*			
Pseudo R	0.0278			

***; *** significant at 0.05 and 0.01 level respectively*

The nutritional benefits of switching to drought tolerant crops from the qualitative data are diverse. For instance, the production of drought resistant crops, such as sorghum, was noted as guaranteeing both food availability and improved health. Interviews with the local agricultural extension officer and the local nutrition officer revealed that an intensive indigenous drought tolerant crop cultivation regime in the area has not only contributed to positive food and nutrition security outcomes, but has also enhanced extensive crop diversification in the area as these (drought tolerant) crops in upland fields greatly supplement maize and vegetable farming which has now been moved to fields located near major rivers in the area.

Picture 3. Sorghum crop in upland fields

Access to, and knowledge of, wild fruits and wild vegetables have ensured food availability as well as improved nutrition to households in the area in the context of recurring droughts – as confirmed by the majority of household survey respondents. In an interview with the District Nutrition Officer stationed at the local district hospital, for example, it was noted that the wild vegetables consumed in the area are rich sources of micronutrients which are often deficient in other diets. He further noted that most wild fruits consumed were rich in Vitamin C, carbohydrates and fibre, with profound nutritional benefits. Consumption of wild fruits was also considered to be nutritious in terms of providing antioxidants.

Psychosocial health dynamics

Psychosocial health is an important aspect of human health which encompasses multiple dimensions. These include mental/psychological, emotional and spiritual domains of health which affect an individual's overall well-being. It is important to note that a key challenge faced in conceptualizing climate adaptation-induced psychosocial health impacts (vis-à-vis results and the subsequent analysis) was the issue of attribution; a challenge already highlighted by such scholars as Hayes et al (2018). One reason for this difficulty is the need to avoid casually classifying normal reactions to abnormal events as psychosocial challenges or underdiagnosing serious long-term psychosocial health effects of adaptation-related challenges due to disasters. Another challenge regarding attribution is the presence of many possible climate change adaptation and psychosocial health outcomes, as well as the potentially substantial time frame for attributing psychosocial health outcomes to climate change adaptation. Moreover, the complex relationship between psychosocial health and other social determinants of health further complicates the drawing of a causal link (Hayes et al., 2018).

As indicated earlier, measures of climate adaptation-induced psychosocial health were captured using mainly the adapted GAD-7 tool, as well as indicators of positive responses resulting from climate adaptation actions. Figure 12 depicts the proportions of those who engaged in the various adaptation actions, that reported adverse psychosocial health as a result of such actions.

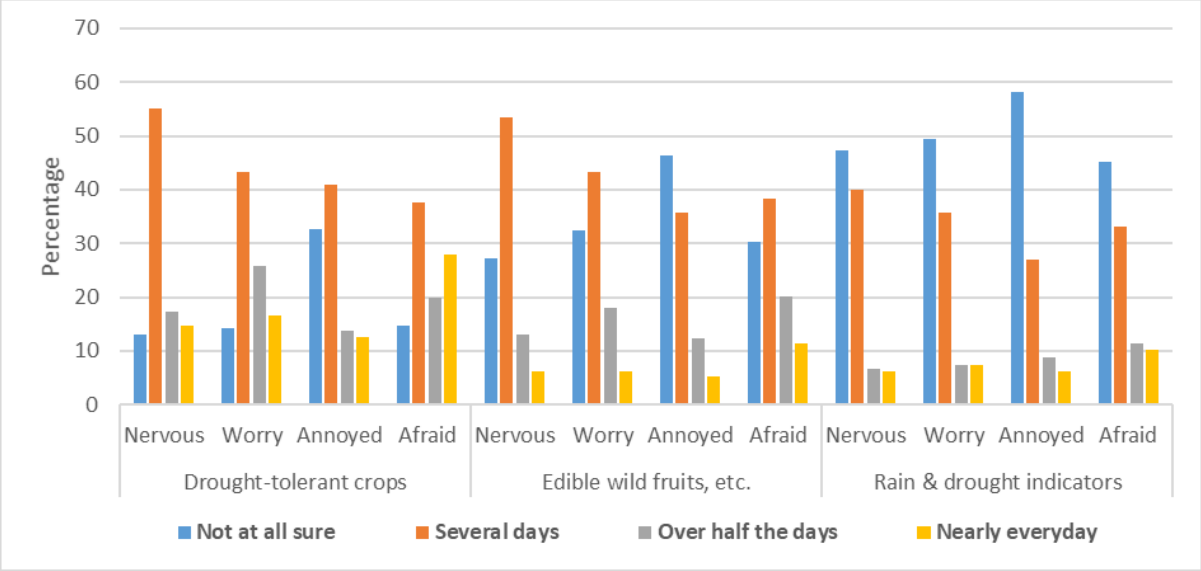

Figure 12. Adverse psychosocial health responses across adaptation actions

An emerging insight from Figure 12 is that resorting to the cultivation of drought-tolerant crops due to climate change was associated with the most adverse psychosocial health indicators, with the highest proportion of respondents reporting experiencing worry, annoyance or fear several days, over half the days or nearly every day. This was followed by dependence on wild fruits for survival. On the other hand, the use of local rainfall and drought indicators as an adaptation action was associated with the least psychosocial distress. Specifically, Figure 12 shows that 81% of respondents who reported engaging in the cultivation of drought-tolerant crops adaptation action reported feeling nervous, worry, annoyed and afraid on the average at least for several days (i.e., several days, over

half the days, or nearly every day). This compares to 66% and 50% for the edible wild fruit consumption and using rainfall and drought indicators adaptations actions respectively. Moreover, the adverse emotion mostly experienced nearly every day across the three adaptation actions was fear, with 28%, 11%, and 10% reporting being afraid due to having to rely on the cultivation of drought-tolerant crops, the consumption of edible wild fruits, and the use of rainfall and drought indicators respectively.

In terms of positive psychosocial health, Figure 13 indicates that the cultivation of drought-tolerant crops was also mostly associated with positive psychosocial health responses. This adaptation action recorded the highest proportion of respondents experiencing positive feelings most/all the time relative to other adaptation actions. In contrast, resorting to using rainfall/drought indicators as a climate change adaptation strategy was associated with the highest proportion of those indicating that it did not inspire any positive psychosocial health feeling.

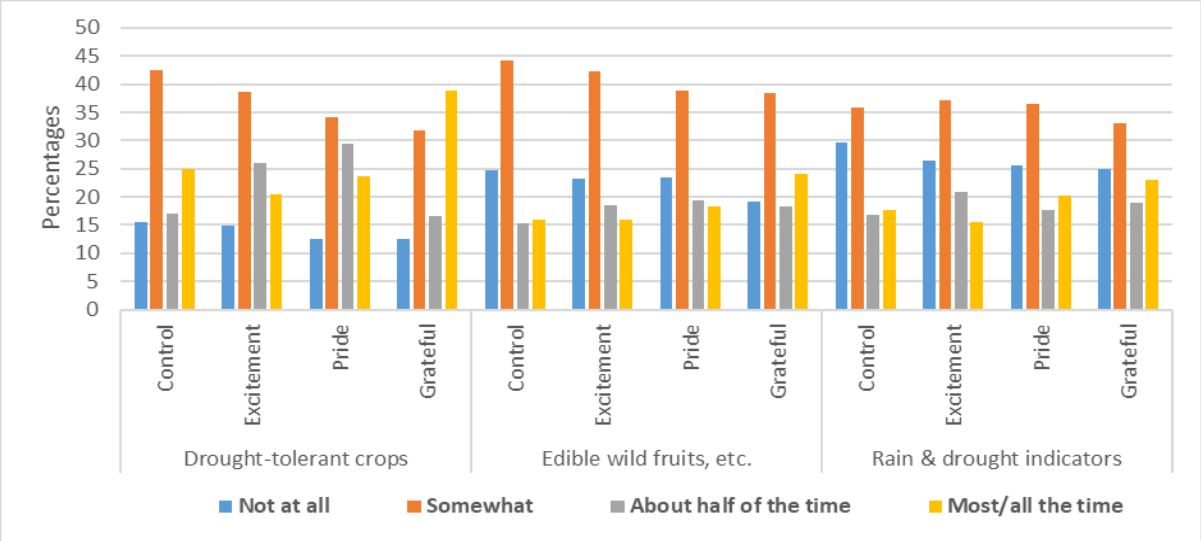

Figure 13. Positive psychosocial health responses across adaptation actions

On the average, about half of respondents who adapted by planting drought-tolerant crops reported feeling a sense of control at least sometimes. For the edible wild fruit consumption, and relying on rainfall and drought indicators, the respective proportions were 36% and 38%. Moreover, the most dominant positive feeling that respondents reported feeling most/all the time across all three adaptation actions was a feeling of gratefulness for having a viable option to fall on in the face of climate change (with 39%, 24%, and 23% respectively for the cultivation of drought-tolerant crops, edible wild fruit consumption, and reliance on rainfall and drought indicators adaptation actions).

Table 4 depicts the averages of the negative and positive psychosocial health indices across key characteristics of the sample.

Table 4. Means of the adverse psychosocial health indices across respondents' characteristics

	Drought-tolerant crops (N=342)			Edible wild fruits (N=339)			Rain & drought indicators (N=148)		
	M	Freq.	p-value	Mean	Freq.	p-value	Mean	Freq.	p-value
Gender									
Female	5.	203		4.0	201		3.1	79	
Male	5.	139	0.486	3.6	138	0.335	2.8	69	0.595
Education Level									
No formal education	6. 0	77		3.9	69		3.8	31	
Primary/secondary education	5. 6	137	0.374	3.8	145	0.834	2.5	67	0.071
Completed vocational training	5. 0	128	0.038	3.8	125	0.861	3.0	50	0.333
Marital Status									
Married	5.	269		3.8	258		3.0	113	
Separated	4.	12	0.458	3.8	14	0.959	3.3	4	0.893
Single	4.	20	0.348	3.7	19	0.843	2.1	7	0.526
Widowed	5.	41	0.447	4.0	48	0.762	2.8	24	0.779
Household Head									
No	5.	148		3.9	137		3.2	54	
Yes	5.	194	0.455	3.8	202	0.622	2.8	94	0.467
Household Head's Employment Status									
Formally employed	5.	17		4.6	11		4.2	5	
Full-time farmer	6.	161	0.326	4.3	152	0.771	3.8	47	0.839
Part-time farmer, casual worker, labourer	4. 9	110	0.541	4.0	116	0.463	2.7	53	0.281
Not employed	4.	53	0.265	2.2	58	0.007	2.1	43	0.098
Housing Type									
Traditional	5.	218		4.1	216		3.2	85	
Formal	4.	123	0.001	3.4	122	0.060	2.7	63	0.367

Two-tailed p-values are with respect to the first category for each variable; Estimates based on respondents who reported engaging in specific adaptation actions

Table 4 indicates worse psychosocial health indices for men relative to women for the drought-tolerant crop adaptation strategy. However, the converse was obtained for adaptation actions that involved the consumption of edible wild fruits and using rainfall and drought indicators, where women showed more negative results. The least educated respondents recorded the highest adverse psychosocial health scores across all adaptation strategies. Also, widowed respondents reported the most elevated adverse psychosocial health outcomes for both the cultivation of drought-tolerant crops

and relying on the consumption of edible wild fruits adaptation strategies, with those currently separated reporting the most distress for the adaption strategy that involved relying on rainfall and drought indicators for survival.

Household heads reported higher psychosocial distress associated with reliance on wild fruit consumption and the use of rainfall and drought indicators, while the converse was true for shifting to drought-tolerant crops. As expected, individuals whose household heads were full-time farmers had the most elevated levels of psychosocial distress due to having to rely on shifting to drought-tolerant crops. Household heads engaged in formal employment indicated the highest levels of psychosocial distress for having to rely on the consumption of wild fruits, as well as depending on rainfall and drought indicators for survival. Finally, respondents from relatively poorer traditional housing type indicated higher levels of psychosocial distress across all adaptation strategies. However, as shown by the relevant p-values, virtually all the above differences were not statistically significant at conventional levels. It is important to emphasize that these findings do not imply causality, as underlying characteristics (e.g., poor education and widowhood), might have been responsible for observed psychosocial health outcomes rather than adaptation actions.

Table 5 presents the averages of the positive psychosocial health outcome across the characteristics of interest.

Table 5. Means of the positive psychosocial health indices across respondents' characteristics

	Drought-tolerant crops (N=342)			**Edible wild fruits (N=340)**			**Rain & drought indicators (N=148)**		
	Mean	Freq.	p-value	Mean	Freq.	p-value	Mean	Freq.	p-value
Gender									
Female	6.5	203		5.2	202		5.3	79	
Male	6.5	139	0.889	5.4	138	0.562	5.1	69	0.841
Education Level									
No formal education	5.6	77		4.8	69		4.5	31	
Primary/secondary education	6.4	137	0.111	5.3	145	0.348	5.1	67	0.477
Completed vocational training	7.1	128	0.004	5.6	126	0.167	5.8	50	0.148
Marital Status									
Married	6.7	269		5.3	258		5.4	113	
Separated	5.8	12	0.402	5.5	14	0.880	5.5	4	0.975
Single	5.4	20	0.140	5.9	19	0.543	5.6	7	0.934
Widowed	6.0	41	0.298	4.6	49	0.229	4.0	24	0.112
Household Head									
No	6.5	148		5.6	137		5.9	54	
Yes	6.4	194	0.808	5.1	203	0.264	4.8	94	0.143

Household Head's Employment Status									
Formally employed	6.3	17		5.2	11		7.6	5	
Full-time farmer	5.7	161	0.471	4.4	153	0.435	4.1	47	0.066
Part-time farmer, casual worker, labourer	7.4	110	0.263	6.1	116	0.440	5.9	53	0.379
Not employed	7.1	53	0.409	6.0	58	0.548	5.3	43	0.244
Housing Type									
Traditional	6.5	218		5.2	216		5.1	85	
Formal	6.4	123	0.820	5.4	123	0.630	5.3	63	0.708

Two-tailed p-values are with respect to the first category for each variable; Estimates based on respondents who reported engaging in specific adaptation actions

Men and women had similar values of positive psychosocial health indices associated with the cultivation of drought-tolerant crops. However, while men experienced better psychosocial health responses to consuming edible wild fruits as an adaptation strategy, women had better psychosocial health linked to using rainfall and drought indicators.

Compared to other levels of education, respondents who completed vocational training reported the best psychosocial health across all adaptation strategies. In the same vein, compared to other partnership arrangements, married respondents reported mostly benefitting from the cultivation of drought-tolerant crops as an adaptation action, while single respondents had the highest positive psychosocial index values for the edible wild fruit consumption and reliance on rain and drought indicator strategies. Respondents who were not household heads reported higher positive psychosocial health scores across all adaptation strategies compared to household heads. Respondents whose household heads were into part-time farming or casual work or farm labourers were most likely to report feeling better due to using the drought-tolerant crop cultivation and edible fruit consumption adaptation actions. Finally, while those living in formal houses scored higher on the edible wild fruit and rain and drought indicator-based positive psychosocial health, those residing in traditional houses reported the highest positive psychosocial index associated with the cultivation of drought-tolerant crops. Similar to the negative psychosocial health variables, these differences were mostly not statistically different.

Table 6 shows the distribution of each adaptation strategy-induced adverse psychosocial health. We observed that fewer respondents indicated not being sure whether they experienced any of the adverse health outcomes used in generating the indices (i.e. an index value of zero) for the drought-tolerant crop cultivation adaptation strategy compared to the other strategies. Thus, there is a general sense that the drought-tolerant crop cultivation adaptation strategy posed the most psychosocial health threat, a result that concurs with Figure 12.

Table 6. Adaptation-related adverse psychosocial health indices

	Drought-tolerant crops		Edible wild fruits		Rain & drought indicators	
Adverse psychosocial health index	Freq.	Percent	Freq.	Percent	Freq.	Percent
0	34	10.2	75	22.6	61	41.2
1	4	1.2	15	4.5	5	3.4
2	9	2.7	16	4.8	8	5.4
3	18	5.4	37	11.1	9	6.1
4	101	30.2	80	24.1	33	22.3
5	19	5.7	28	8.4	8	5.4
6	31	9.3	16	4.8	4	2.7
7	32	9.6	14	4.2	5	3.4
8	43	12.8	30	9.0	6	4.1
9	5	1.5	6	1.8		
10	2	0.6	1	0.3		
11	2	0.6	1	0.3		
12	35	10.5	13	3.9	9	6.1
Total	335	100	332	100	148	100

Estimates based on respondents who reported engaging in specific adaptation actions.

Furthermore, we ascertained the relationship between each adaptation-induced adverse psychosocial health indicator and the associated hindrance on engaging in activities of daily living by regressing the ADL index on each related adverse psychosocial health indicator while controlling for relevant respondent characteristics. As is apparent from Table 6, some of the psychosocial health categories contained very few observations especially at higher values of the psychosocial health indices. Therefore, in order to obtain fairly robust regression coefficients (Table 7), we combined cell sizes less than 15 for each adaptation-related psychosocial health index and each adaptation-related ADL index.

Table 7. Relationship between adaptation-related adverse psychosocial health and activities of daily living

	(1)	**(2)**	**(3)**
VARIABLES	Planted drought-tolerant crops	Consumed edible wild fruits	Used rainfall & drought indicators
Psychosocial health index (base = 0)			
Psychosocial health index (1)	2.156***	2.100***	4.953***
	(0.699)	(0.802)	(1.147)
Psychosocial health index (2)	3.255***	3.658***	5.160***
	(0.643)	(0.684)	(1.130)
Psychosocial health index (3)	3.028***	3.226***	6.748***
	(0.738)	(0.627)	(1.196)
Psychosocial health index (4)	3.207***	4.015***	9.775***
	(0.711)	(0.582)	(1.380)
Psychosocial health index (5)	3.880***	4.664***	
	(0.698)	(0.657)	

Psychosocial health index (6)	4.720***	4.809***	
	(0.690)	(0.646)	
Psychosocial health index (7)	6.887***	5.336***	
	(0.747)	(0.664)	
Psychosocial health index (8)		8.148***	
		(0.826)	
Male	-0.902***	-1.062***	-1.038
	(0.348)	(0.384)	(0.772)
Education (baseline = No formal education			
Primary/secondary education	-1.144***	-0.995***	0.117
	(0.307)	(0.341)	(0.639)
Completed vocational training	-0.878***	-0.388	0.188
	(0.301)	(0.329)	(0.621)
Marital status (base = Married)			
Separated	0.975*	-0.598	1.343
	(0.585)	(0.732)	(1.374)
Single	0.059	-0.348	-1.508
	(0.474)	(0.497)	(1.157)
Widowed	0.001	-0.195	-0.707
	(0.433)	(0.458)	(0.901)
Household head	0.493	0.871**	1.331
	(0.348)	(0.380)	(0.834)
Formal housing	-0.465*	0.025	-0.534
	(0.238)	(0.260)	(0.534)
Household head's employment status (base = Full-time farmer)			
Formally employed	0.938*	0.955*	2.380**
	(0.500)	(0.580)	(1.081)
Part-time farmer/casual worker/farm labourer	0.420	0.592**	-0.288
	(0.265)	(0.284)	(0.629)
Not employed	0.833***	0.809**	0.745
	(0.316)	(0.368)	(0.607)
Age	0.015*	0.002	-0.015
	(0.008)	(0.009)	(0.018)
Cut-off 1	2.772***	3.992***	5.347***
	(0.792)	(0.805)	(1.707)
Cut-off 2	3.079***	4.415***	6.903***
	(0.796)	(0.812)	(1.767)
Cut-off 3	3.865***	5.115***	9.449***
	(0.804)	(0.824)	(1.845)
Cut-off 4	5.406***	6.827***	
	(0.822)	(0.859)	
Cut-off 5	6.218***	7.754***	
	(0.833)	(0.878)	
Cut-off 6	6.809***		
	(0.843)		
Cut-off 7	8.204***		
	(0.878)		
Observations	335	332	148

*Model is ordered logit; Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Estimates based on respondents who reported engaging in specific adaptation actions.*

Table 7 indicates that each adaptation-induced adverse psychosocial health indicator was positively and significantly associated with inhibiting ADL, with the coefficients mostly increasing monotonically with higher adaptation-related psychosocial health index values. This implies that worse adaptation-related psychosocial health was associated with a higher likelihood of experiencing adaptation-related limitations on ADLs. Being male and better educated were negatively associated with adaptation-induced ADL inhibitions, meaning fewer hindrances to performing ADL. In contrast, being a household head and a household head's non-engagement in full-time farming had positive relationships with adaptation-related inhibition on ADLs. Finally, for the drought-tolerant crop cultiivation adaptation strategy, older individuals and the separated (relative to the married) were significantly more likely to experience challenges with engaging in ADL, while living in formal housing (relative to traditional housing) was negatively associated with adaptation-related limitation with ADLs.

Discussion

In this section we discuss insights emerging from the results presented in Section 5, and we centre our discussion on the three adaptation actions around which our research and analysis revolved.

Shifting from maize farming to drought-tolerant crops

Smallholder farmers in Southern Africa, including Zimbabwe, have, for many years, been employing a number of soil and crop management strategies to adapt to a changing climate. Some of the options include crop diversification (planting different crop types and varieties), staggered planting, intensification, changing from cropping to livestock production, changing from farming to non-farming livelihood activities, soil-water conservation (e.g. conservation agriculture), and increasing land area under irrigation (Maponya and Mpandeli, 2012; Nhamo et al., 2019; Mutekwa, 2009; Nhemachena, 2007; Shava et al., 2009; Thomas et al., 2007).

Households in Mbire district have, over the years, shifted from maize farming to drought tolerant traditional cereal grains, particularly sorghum [*Sorghum bicolor* (L.), Moench], because of the devastating effects of climate change on maize production. Maize is the staple crop in Zimbabwe and in most parts of Southern Africa, but it is very sensitive to climate stress. Grain yields in Zimbabwe alone are projected to decline by between 10% and 40% by 2100 as a result (Rurinda et al., 2015). Traditional cereal grain crops namely sorghum, pearl millet [*Pennisetum glaucum* (L.) R.Br.] and finger millet [*Eleusine coracana* (L.) Gaertn] are therefore increasingly receiving attention as the "future crops" for food and nutrition security in Africa (African Union, 2014). In addition to being more tolerant to stressful climate conditions than maize, traditional cereal grains have better nutritional and health benefits than maize (Gabaza et al., 2018). This is particularly important given the heightening of diet-related health challenges in Sub-Saharan Africa (SSA) and other developing nations.

In this study, we found that in Mbire district, shifting from maize to cultivating drought tolerant crops in main upland fields is the adaptation action which was mostly associated with both highly positive nutritional and psychosocial health outcomes. Nutritionally, this adaptation action was associated with improved food availability for the majority of sampled households and in raising the levels of the consumption of acceptable nutritional diets. In terms of psychosocial outcomes, shifting to drought-tolerant crops was associated with higher levels of control of one's livelihoods and life in general, excitement, and pride in being able to counter adverse life circumstances. In terms of negative outcomes, this adaptation action was not associated with any significant negative nutritional health impacts. However, in terms of psychosocial health, interestingly, it was the adaptation action associated with the most adverse psychosocial health indicators; with the highest proportions of respondents reporting experiencing worry, annoyance or fear for several days, over half the days or nearly every day in connection with (the success of) this strategy compared to other adaptation actions. This is despite the fact that this adaptation action was also associated with the highest levels of positive psychosocial outcomes as already noted. While it is unclear why both negative and positive psychosocial outcomes were simultaneously reported for this adaptation action, it is possible that the pursuit (and implementation) of certain adaptation strategies might be stressful and difficult enough to generate negative reactions and yet eliciting excitement and satisfaction at the same time, as they may promote some control for people to make improvements in their production and livelihood systems when necessary.

Increased reliance on wild fruit consumption during crop failure

Results presented show the consumption of wild fruits (particularly during periods of crop failure) as being highly valued in terms of the realisation of positive nutritional and psychosocial health outcomes. Nutritionally, wild fruits prevalent in the area (such as baobab fruit /*Adansonia digitata* or *mawuyu* in vernacular and masawu fruits/*Ziziphus mauritiana*) – rich in Vitamin C, carbohydrates and fibre – are shown to be great sources of nutrients in addition to enabling households to meet basic food availability during increasingly repeated periods of crop failure. In terms of psychosocial health outcomes, the use of indigenous knowledge related to the consumption of wild fruits was found to contribute to lowered levels of anxiety around food availability in periods of drought and crop failure.

In terms of negative health outcomes; nutritionally, some wild fruits consumed in the area (e.g. *katunguru (Maerua decumbens*) and *manyanya (Strychnos spinosa)* fruits) were reported to be poisonous if not carefully and adequately prepared. Many cases were reported of people falling ill after having eaten these specific wild fruits – with most of those affected developing swollen legs and stomachs. Psychosocially, the consumption of wild fruits was anecdotally reported to result in negative psychosocial outcomes emanating from competition with wildlife in accessing these fruits, and the associated anxiety, fear and distress involved when thinking about the dangers and risks of encountering, being injured or killed by wild animals – particularly elephants – prevalent in the area.

Picture 4. Elephant warning sign in Mbira

Increased reliance on the use of indigenous indicators for drought and rainfall pattern prediction

The utilisation of indigenous indicators to predict drought and rainfall patterns was associated with the lowest prevalence of positive psychosocial health outcomes. The reason for such an observation was not apparently clear, however, this might be due to challenges of attribution associated with such a ‘fluid’ adaptation action – making it difficult to link to psychosocial and nutritional health effects both temporally and geographically. There also seemed to be no statistically significant connection directly established between this adaptation action and both positive and negative nutritional health outcomes.

Conclusion

This study sought to evaluate the nutritional and psychosocial health impacts of some of the main adaptation actions undertaken in rural Southern Africa (i.e. shifting from predominantly maize farming in main dryland fields to drought-tolerant crops; increased reliance on indigenous knowledge vis-a-vis wild fruit consumption (during crop failure), and increased reliance on indigenous knowledge vis-à-vis use of local/indigenous indicators to predict droughts and rainfall patterns).

We used a case study of communities in the mid-Zambezi Valley region in Zimbabwe's Mbire district – situated north of the country along the borders with Zambia and Mozambique. As an area classified among Southern Africa's climate change hotspots, the mid-Zambezi Valley provided us with an 'extreme' case study. Such extreme cases often reveal more information and are therefore more relevant from both an action-oriented and an understanding-oriented perspective (Flyvbjerg, 2006). Basing our evaluation on internationally accepted evaluation criteria i.e. relevance, effectiveness, efficiency, impact, and sustainability; we utilised a mixed-methods approach to collect data – combining both quantitative and qualitative techniques. Our key findings have already been discussed in the preceding section, and recommendations from the impact evaluation are outlined in the next section.

It is, however, important to note the major limitations and challenges associated with the study.

Firstly, we believe that the study is among the first to explore the health effects of specific adaptation strategies in developing country rural settings. The lack of empirical studies examining both psychosocial and nutritional health outcomes and the effects of adaptation-induced psychosocial and nutritional health on individual and household welfare limited the scope of the discussion of our results. Comparisons could not be made as similar studies are currently missing. Secondly, whilst this study is important in starting a conversation around the evaluation of nutritional and psychosocial health outcomes of climate adaptation actions in complex vulnerability contexts within developing country settings, we are aware that findings may not be directly generalizable to other contexts. This is due to the fact that differences in cultural, economic, environmental, and political realities may result in the different deployment of and reactions to the specific adaptation actions which were being interrogated. It is, therefore, important that similar studies be conducted in similar vulnerability contexts in the wider Southern Africa region and in Africa at large to ascertain if similar outcomes will be noted.

The last point relates specifically to the psychosocial component of the study. From our initial engagement with literature, and to the best of our knowledge, there are no validated psychosocial health indicators which link with climate change adaptation. This renders a study of the impact of climate adaptation on psychosocial health, or the impact of climate adaptation-induced psychosocial health on different measures of wellbeing difficult to make adequate conclusions or generalise beyond the current study. It is worth pointing out that many of the known indicators of psychological/mental health were developed, tested and validated in, and for developed country settings – hence we had to adapt currently existing mental health indicators towards adequately exploring and interrogating issues in our case. There is, therefore, a need for designing and validating psychological/psychosocial tools and indicators that are appropriate for rural developing country settings.

Recommendations

Following our findings from this impact evaluation study, we came up with recommendations for different sets of role players, including the government, non-governmental organisations (NGOs), the private sector, academics and researchers, as well as community members vis-a-vis climate change adaptation and nutritional and psychosocial health outcomes in marginal communities in Zimbabwe and in related contexts. These recommendations are outlined below:

For Government, NGOs and private players

1. In the wake of climate change and variability, governments and other development partners should promote diversification of rain-fed cropping systems, including production of drought-tolerant crop types and varieties, to build resilience as well as to deal with food and nutrition insecurity. In the context of this study, the following are key: (i) accessible markets for inputs (seed, fertilizers, agrochemicals) and outputs (grain and other by-products); (ii) mechanisms and platforms for seed exchange and multiplication within the farming communities; (iii) robust and efficient extension services to allow for training of farmers, collective action and timely access to inputs, including the creation of local champions towards popularisation and uptake of drought tolerant crops in such marginal and drought prone areas as Mbire district; and (iv) community level platforms for knowledge and information exchange on production, processing, and marketing.

   The shift from maize to sorghum in the case of Mbire district was mainly due to the efficient distribution of suitable sorghum varieties, training of farmers on the advantages of the shift, extensive extension services by both government and development partners around the production of the crop, and the creation of viable markets for selling the sorghum crop at harvest.

2. It is important to encourage and create opportunities for NGOs and relevant government entities to spearhead value addition activities and projects in local communities, revolving around such adaptation actions as harvesting of wild fruits – e.g., the processing of *mawuyu (Adansonia digitata)* into grounded powder for porridge-making and *masawu (Ziziphus mauritiana)* fruit into jam, etc., as happens in the Mbire district. This will enhance resilience of livelihoods and production systems towards nutritionally and psychosocially beneficial adaptation actions in such complex vulnerability contexts.

For Researchers and Academics

1. There is urgent need for systematic documentation by researchers on what is, or is not working in different contexts vis-à-vis the use of such prominent adaptation actions as reliance on indigenous indicators in predicting droughts and rainfall patterns – given a key finding of this study showing no significant nutritional and/or psychosocial health impacts around the adoption and use of this particular adaptation action in Mbire district. This is an interesting and curious finding for this study considering that in many other rural communities in Africa, the adoption and use of local rainfall and drought indicators have long been shown to be highly beneficial.

2. There is a need for the recognition of psychosocial health as a major component of adaptation action. Psychosocial health has not been much recognized in climate discourse not only in Zimbabwe, but in sub-Saharan Africa at large. From interviews conducted with key state and

non-state actors working in health, climate and adaptation-related sectors, some entry points for incorporating psychosocial health into climate interventions and discourse should involve: awareness; collaborations; trainings, and embedding psychosocial health aspects into agricultural extension programs.

For Communities

1. Communities should be proactive in documenting, preserving and communicating indigenous knowledge and indicators associated with key adaptation actions to climate challenges. This could be done through existing formal and/or informal community structures.
2. Communities should also engage in peer-to-peer sharing of ideas through local community forums and support groups vis-à-vis the positive and negative nutritional and psychosocial health outcomes of adopted climate adaptation actions.
3. Communities should explore the idea of forming cooperatives towards working together in value addition activities associated with some of the adaptation actions explored e.g. with respect to purchasing advanced machinery to process wild fruits into finished products, accessing capital from financial institutions to upscale the value addition activities, and seeking other institutional support from NGOs and the government.

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