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Effectiveness of *Pfumvudza* as a resilient strategy against drought impacts in rural communities of Zimbabwe

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Abstract *Pfumvudza* is a Zimbabwean vernacular language term literally referring to the blooming of new leaves during the spring season signalling the beginning of a new farming season. It used to refer, to the conservation agriculture concept, a crop production intensification approach under which farmers ensure the efficient use of resources on a small area of land in order to optimise its management. The research assessed the effectiveness of *Pfumvudza* as a resilient strategy against climate change induced drought impacts in rural communities Zimbabwe, case of Munyarari ward 20. The descriptive case study was used triangulating data collection methods. The sample size was 96 households who practised *Pfumvudza* (20% of the target population) and all the 18 households (100%) which did not practise *Pfumvudza*. These were randomly sampled from five conveniently selected villages in the ward. Four key informants were purposively selected. Data was analysed using SPSS and content analysis. Climate change induced drought impacts greatly affected communal farmers who depended on rain fed agriculture. This led to food insecurity which attracted donor aid year after year. *Pfumvudza* improved yields and reduced donor aid in the area. Mann–Whitney test results indicated that there was a difference between yields of crops before and after *Pfumvudza* scheme. Mann–Whitney test results also revealed that there was a significance difference between those who practiced *Pfumvudza* and those who did not. It was concluded that *Pfumvudza* increased resilience against climate change induced drought impacts and improved yields in rural communities of Zimbabwe where it was implemented. The research recommends farmers to fully embrace the *Pfumvudza* strategy so as to realize high yields and improve food security.

Keywords *Pfumvudza* · Conservation agriculture · Climate change impacts · Resilient strategies · Rural areas

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Introduction

Climate change induced drought impacts are fast becoming a global issue and the impacts are mostly felt by the rural folks, particularly in the agricultural sector (Frischen et al., 2020; Maia et al., 2015; Tadesse, 2016). This is mainly because majority of communal farmers depend on rain-fed agriculture hence vulnerable to droughts. According to the World Bank Report (2021), food insecurity is affecting approximately 8.9% of the global populace. The problem is serious in Sub-Saharan Africa

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and occurrence of hunger in Africa from 2014 to 2019 rose by 1.5% (FAO et al., 2020). Governments and their partners have responded by embracing the concept of Conservation agriculture (CA). It is hinged on three principles, crop rotation, mulching and minimum tillage and aims to boost yields, increase resilience to climate change negative impacts. (Brouder & Gomez-Macpherson, 2014; FAO, 2013; Lipper et al., 2014). Conservation agriculture (CA) is often called by various names such as no till, zero till, conservation tillage among others and also vernacular names such as *Pfumvudza* in Zimbabwe (FAO, 2011; Government of Zimbabwe, 2020; Kassam et al., 2011; Mujere, 2021).

In European countries such as Turkey, CA has been reported in reducing climate change induced drought impacts of food insecurity which causes hunger and starvation (Gultekin, 2012). According to Arrue et al. (2007), studies done in Spain and Southern part of Europe show an improvement of 10–15% yield under CA, especially in dry years, hence, reducing climate change induced impacts. In Mexico, a comparison made on Maize yields under CA and conventional farming under Tropical Clay soil showed that 4.31 t/ha was produced on tilled land while 5.65 t/ha was produced on zero till land (Verhulst et al., 2011). Furthermore, CA practiced in the Canadian Prairies semi-arid region proved successful as it helped to increase soil water reserve, hence contributing in high crop productivity, (Awada et al., 2014). In Argentina, an improvement in productivity was due to the widespread adoption of no tillage (Peiretti & Dumanski, 2014).

In the Central Asia region of Kazakhstan, northern parts, CA was very effective as high yields were experienced although the area is a drought prone area, receiving precipitation of about 300–400 mm (FAO, 2013). Also, a study done in China's semi-arid region of Western Loess Plateau found CA to be the most successful conservation practice as it improved crop yields and sustainability of rain-fed farming systems (Lingling et al., 2014).This also reduced climate change drought impacts of hunger and starvation. According to Corbeels et al. (2020), in a study done in Sub-Saharan African countries, it was revealed that an increase in yield from CA is small compared to conventional practices which will affect the resilience in a long term. However, a study done in Mozambique by Mango et al, (2017) revealed that, conservation agriculture increased yields of farmers thereby reducing climate change induced drought impacts.

In Zimbabwe, a study done by Mujere (2021) opines that the effectiveness of *Pfumvudza* in increasing resilience can be determined by the level of adherence to *Pfumvudza* practices. Results of the study showed that farmers who adhered to all practices recommended for *Pfumvudza* managed to get more yields than those who partially adhered. To add on to that, those who adhered to *Pfumvudza* practices got about 800 percent more yields compared those who did conventional farming.This therefore solved the glitches of low levels of productivity. Defe and Matsa (2021), in their study done in Chiredzi, ward 3 and 4 discovered that CA increased food production.

Munyarari, ward 20 of Mutare district was once largely ecological region III, with rainfall pattern ranging from 500 to 700 mm, and maximum temperatures range between 25 and 29 °C (Manatsa et al., 2020; Vincent and Thomas, 1960). There is evidence that some areas in Munyarari such as Musabayana are now under region IV, with rainfall patterns ranging from 450 to 600 mm according to the recent re-classification of agro ecological zones in conformity with climate variability and change (Manatsa et al., 2020). Furthermore, Manatsa and et al, (2020) postulate that a discussion with stakeholders noted climate change especially in the South and South West of Manicaland Province, as evidenced by temperatures increase and shrinkage in rainfall. Munyarari, ward 20 of Mutare district depends on rain-fed agriculture, hence low yields, increased pests and diseases among others have been experienced over the last decade. Due to food insecurity, the ward became a priority on the list of most donor organizations for food assistance in Mutare district (Saungweme & Magodo, 2014).

Impacts of climate change induced droughts contribute in hindering the attainment of sustainable development goals (SDGs) in Zimbabwe which include SDG1 of eradicating poverty, SDG 2 of eradicating hunger and SDG 3 of promoting good health and wellbeing of people (Frischen et al., 2020). Therefore *Pfumvudza* concept was initiated in 2020/1 cropping season, in Munyarari, ward 20 of Mutare district, with the aim to increase productivity and counter climate change related impacts on agriculture. This was done to attend to the problems of low levels of productivity and production, making the farmers and households more resilient to climate shocks and ultimately ensuring food security in Zimbabwe (FAO, 2020). Also, the *Pfumvudza* initiative is in line with national vision 2030 where the poor are to be elevated through agriculture and up streaming them in the main economy (National Development Strategy, 2020). However, since this *Pfumvudza* strategy was implemented, little has been done to find out its effectiveness as a resilient strategy against climate change induced drought impacts in rural communities which are drought prone. It is against this background that this research seeks to:

- Examine the trend of household yields before and after implementation of *Pfumvudza* in Munyarari, ward 20, Mutare district.
- Evaluate the challenges faced in implementation of *Pfumvudza* in Munyarari, ward 20, Mutare district.

Hypothesis

- Determining the difference in trends of household yields before and after implementation of Pfumvudza.

H_0 There is no significant difference in trends of household yields before and after implementation of *Pfumvudza.*

H_1 There is significant difference in trends of household yields before and after implementation of *Pfumvudza.*

- Analyzing the difference in trends of household yields of those who implemented Pfumvudza and those who did not implement Pfumvudza.

H_0 There is no significance difference in trends of household yields of those who implemented *Pfumvudza* and those who did not

H_1 There is a significance difference in trends of household yields of those who implemented Pfumvudza and those who did not.

Literature review

Globally, the food security challenge is a result of the agricultural sector's extreme vulnerability to climate change given its sensitivity to drought (Chingono, 2019; FAO, 2013). The agriculture sector of the developing world has been impacted most by climate change compared to the developed world (Chingono, 2019; Gbegbelelegbe et al., 2018). This has been witnessed in developing countries such as Sub-Saharan Africa and South Asia, where general populace is dependent mainly on agriculture as a source of livelihood and where agriculture is rain fed. The insistent change in temperature and rainfall patterns threatened agricultural yields and increased the vulnerability of those who rely on rain-fed agriculture as a source of their livelihood (Dube and Phiri, 2013).

Drought is the most persistent natural disaster impacting Zimbabwe and is responsible for causing six out of ten major natural disasters between 1991 and 2013 (Government of Zimbabwe, 2020). Brown et al., argue that there has been a decline in maize production in Zimbabwe since 2000. A shift in agro-ecological zones in Zimbabwe due to climate change is a challenge especially to small scale farmers who have limited information and resources with which to adjust to change in climate.

Conservation agriculture (CA) involves zero tilling and mulching the farm land so as to improve fertility of the soil and to conserve water particularly in dry areas and in seasons of reduced rainfall (Mhlanga et al., 2015; Gbegbelegbe et al., 2018). It was engaged to adapt to the changing socio-economic and environmental conditions negatively affecting agriculture due to climate change (Chingono, 2019; Zenda, 2020; Mango et al., 2017). Mhlanga et al., 2015). Hence, countries in the developed world initiated the conservation agriculture to reduce climate change induced drought impacts (FAO, 2011, 2013). Its implementation was vital to promote sustainability in food security and agriculture that is long term. Countries that led in adoption of CA included South and North America which was followed by Australia then New Zealand, Asia, Russia and Ukraine, Europe and lastly Africa. (FAO, 2011, 2013). It was noted that CA was of high priority in the low income regions such as Middle East, Asia and Africa due to climate change which continued to threaten and worsen severe droughts (FAO, 2013; Gbegbelegbe et al., 2018).

In Zimbabwe, *Pfumvudza* is a term that is often used to refer to conservation agriculture concept that was developed by the Foundation of Farming (FfF), a local non-governmental organisation in the country to meet cereal needs for an average households of six members over one year from a small piece of land (Mujere, 2021). *Pfumvudza* literally refer to the blooming of new leaves during the spring season signing the beginning of a new farming season (Mujere, 2021; Oldreive, 2006). It was launched by the government of Zimbabwe in June 2020 (Mujere, 2021). Conservation agriculture concept was designed to counteract and/or lessen the impacts caused by a change in climate on agriculture. Its goal is to boost productivity, increasing resilience to climate change induced impacts (FAO, 2013, 2020; Lipper et al., 2014). The Government of Zimbabwe set a target to train 1.8 million farmers in CA by October 2020 in time for the 2020/21 cropping season. To help achieve this goal, the FfF and FAO trained government extension staff to implement the *Pfumvudza* concept, which comprises CA practices, to help bring food self-sufficiency to Zimbabwe (Mujere, 2021). What makes *Pfumvudza* unique is the size of the plot, at just 16 m × 39 m, which is small enough to easily prepare, manage with mulch, weed, water by hand with harvested rainwater in the event of a mid-season dry spell or drought (Mujere, 2021). All 1.8 million beneficiaries of the Presidential Inputs Scheme, now called the Climate-proofed Presidential Inputs Scheme, were each expected to establish three *Pfumvudza* plots over 2020/21 agricultural season. Since the implementation of this *Pfumvudza* concept there is scanty literature on its effectiveness as a resilient strategy against drought impacts which is the main aim of this research.

Methodology

Study area

Munyarari, ward 20 is located about 35 km south of Mutare in Manicaland Province. It is in Mutare District as shown on Fig. 1

Munyarari, ward 20 largely lies under Agro-ecological Region III while some areas in the same region lies under region IV. Annual rainfall in the region III range from 500 to 700 mm, and maximum temperatures range between 25 and 29 °C whereas in region IV, annual rainfall in the region III range from 450 to 600 mm (Manatsa et al., 2020). Dry spells and high temperatures are often encountered in Munyarari, ward 20 and these are possible pointers of climate change and variability. Production systems are based on drought tolerant crops such as maize, groundnuts and sunflower farming and cattle and goat keeping. Predominant farming is small scale and communal farming. The types of soils that cover Munyarari, ward 20 are sandy soils which are generally acidic. The content of Phosphorus, Nitrogen, and Sulfur and cation exchange capacity are very low in sandy soils owing to organic matter and clay contents which are also very low (Nyamapfene, 1991). Liming is therefore ideal for sandy soils to correct soil acidity. There is need to consistently apply of inorganic and organic fertilizers to sandy soils to correct low Phosphorus and Potassium levels, since the soils are low in fertility. The lower the amount of rainfall, the lower the amount of Nitrogen (FAO, 2020). This, therefore increases infertility in Munyarari sandy soils hence possibility of reduced yields. There is less natural vegetation in the area due to massive deforestation.

According to Zimbabwe 2012 census statistics, the population of Munyarari amounts to about 4440 people and approximately 1800 households (ZIMSTATS, 2012). Villages in Munyarari, ward 20 include Revesai, Manyengavana, Musi, Zvoushe, among others. Economic activities include fishing which is usually practiced mostly during the rainy season in the Mpudzi dam and Mpudzi River which marks the boundaries to the East and Odzi River to the West of Munyarari area. The study area was chosen because of noted variability in rainfall and temperature changes which made it more prone to drought impacts hence food insecurity in the past years. The area became prioritized for food aid distribution by Non-governmental Organizations (NGO's) such as World Food Programme (WFP) and its partners and Plan International and government organizations such as department of Social Welfare.

Materials and methods

This research utilised the descriptive case study research design which enabled the researchers to describe and give a vivid picture of the current

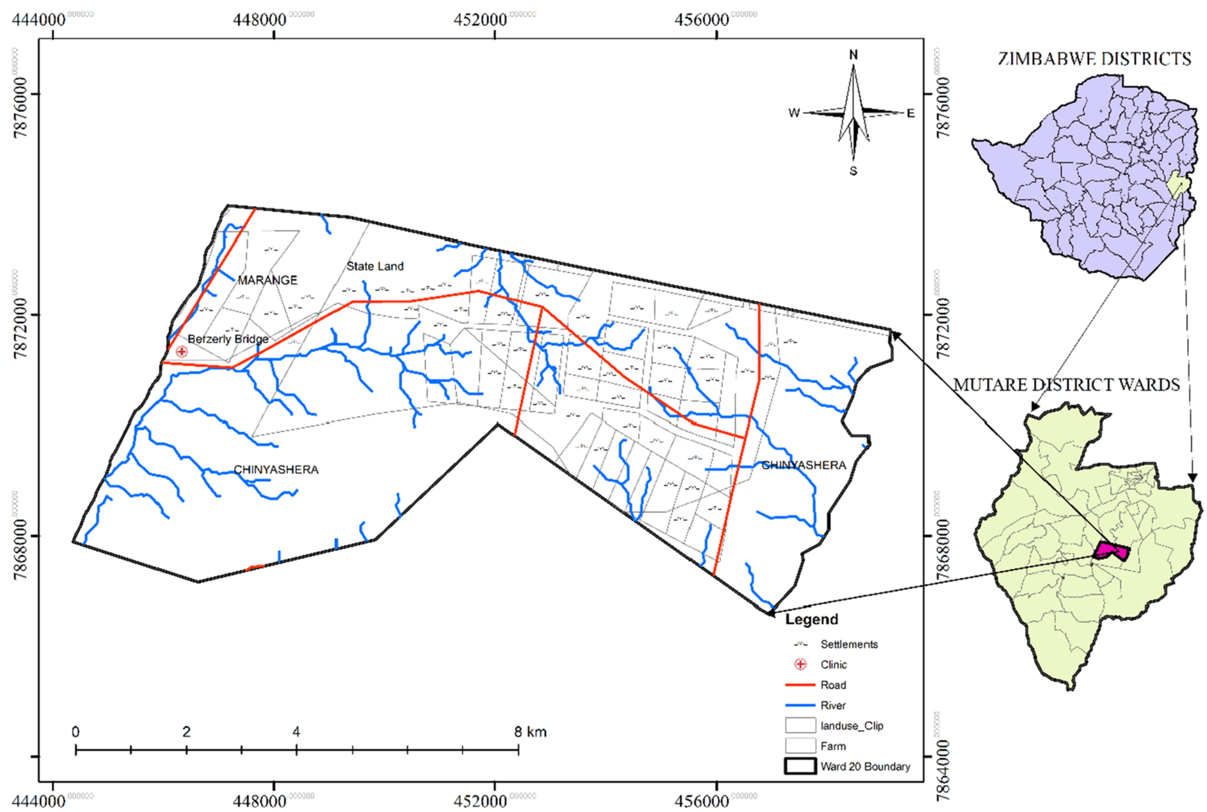

Fig. 1 Map showing location of Munyarari, ward 20, Mutare District, Mutare South constituency, Manicaland Province in Zimbabwe. *Source*: Author, 2022

situation. The descriptive case study research design triangulation approach was used by in cooperating both qualitative and quantitative methods of data collection. Triangulation increased validity of assessment, and improved the consistency of results and research findings.

The target population constituted all 1841 household heads who practiced *Pfumvudza* and 18 household heads who did not practice *Pfumvudza* in all the 20 villages in Munyarari, ward 20. The household heads who practiced *Pfumvudza* in ward 20, Mutare District were targeted because they were the ones involved in implementing the resilience strategy. Household heads who did not practice *Pfumvudza* were used as a control group which enabled the researcher to compare the level of production of those who were involved in the initiative and those who were not to see if *Pfumvudza* was effective or not. Four key informants were also targeted for interviews and these were the Mutare District Agronomist, Agriculture Extension (AGRITEX) officer, Councillor of ward 20 and Mutare District department of Social Welfare officer responsible for humanitarian food aid.

The sample size chosen was 20% of the target population which resulted in 5 villages being selected to participate in the research. A sample size of 20% was preferred so as to improve validity as supported by Crouch et al., (2001) that a sample size of 20% improves the validity of the results. Convenience sampling was used to select the 5 villages which benefited from *Pfumvudza* because working with all the 20 villages was impossible as it gives a very big sample size. Five villages were conveniently selected in terms of being easily accessible to respondents, geographical vicinity, availability at a given time, and the preparedness to take part in the research. As a result Musi, Zvoushe, Munyarari, Manyengavana and Tutsai villages were chosen.

Simple random sampling was utilised for the selection of household heads who practiced *Pfumvudza* in the selected villages. A sample size of 20% of the target population was utilised and this resulted in 96 household heads being selected to participate in the research. Also 100% of household heads who did not practice *Pfumvudza* was utilized to improve validity of results because the respondents were too few to sample hence, 18 respondents were all selected to participate in the research. Purposive sampling technique was used for the selection of key informants for interviews.

Questionnaires were designed and distributed to 96 household heads who practiced *Pfumvudza* and 18 questionnaires to household heads who did not practice *Pfumvudza.* The researchers visited ward 20 to seek for permission to conduct research in the area. Written consent was granted by the councillor. After that, the councillor introduced the researchers to the village heads and verbal consent was sought from the village heads to conduct research in their villages.

The researchers visited each village through the respective village heads who assisted in selecting the household heads who were randomly selected. Data was collected in a period of week strictly adhering to Coronavirus-2019 (COVID-19) preventive measures so as to prevent the spread of the disease. The researchers personally administered the questionnaires. Consent was verbally sought from household heads before administering questionnaires.

Semi structured interviews were carried out by the researchers through interacting with the participants. The direct-field observations were also carried out using an observation checklist that had a list of things to be observed. Quantitative data that was obtained from closed-ended questionnaires was coded analysed using Microsoft excel and the Statistical Package for Social Sciences (SPSS).

The data was presented in form of pie charts, graphs and tables. Content analysis was utilized to analyse qualitative data obtained from open-ended questionnaires, interviews and observations. Mann–Whitney test was used to tests if there is a significant difference on household yields before and after implementation of *Pfumvudza* in Munyarari ward 20, Mutare district and also to analyse the differences in trend yields of those who implemented *Pfumvudza* and those who did not. It was tested at 0.05 confidence interval. The level of significance was fixed at 0.05 ($p = 0.05$).

Results and discussion

Crops grown before and after by those who practiced Pfumvudza

Figure 2 indicates that those who practiced *Pfumvudza* in Munyarari ward 20 were growing maize (100%) before *Pfumvudza* and during *Pfumvudza* period (2020–2022 cropping season). The (Agriculture Extension) AGRITEX officer highlighted that majority of farmers in ward 20 grew cereals such as maize, millet and sorghum. The researcher also observed that every household had a plot or more of maize. The major reason for this is that Maize is a staple crop in Zimbabwe and almost every household in rural areas grow maize. Generally, there was an increase in percentage of respondents that indicated that they were growing all the crops during the *Pfumvudza* period compared to the period before *Pfumvudza* implementation. In terms of legumes only roundnuts reduced the percentage of those who grew it during *Pfumvudza* period because it was not part of the inputs that were given to the beneficiaries of the scheme. This means that those who continued to grow roundnuts did so but not under the *Pfumvudza* scheme.

Findings implies that there is a high production of maize on *Pfumvudza* respondents before and after. Findings could be attributed to the reason that maize is not labor intensive as compared to other grains like sorghum and millet. Findings corroborates with Chingarande et al. (2020) who states that maize remains the crop grown by the majority of households in Manicaland, for example during the 2018/19 season, 82% of households grew maize, 11% grew sorghum and 17% grew other crops. Findings also corroborates with Tsiko (2021) who articulates that each farming household under *Pfumvudza* got an input package comprising seeds massing 10 kg maize, 5 kg sorghum, 2 kg pearl millet, 5 kg soyabeans, 2 kg sunflower/castor bean (castor bean will be intercropped in the *Pfumvudza* crops for all crops) and 5 kg sugar beans or 5 kg cowpeas or groundnuts.

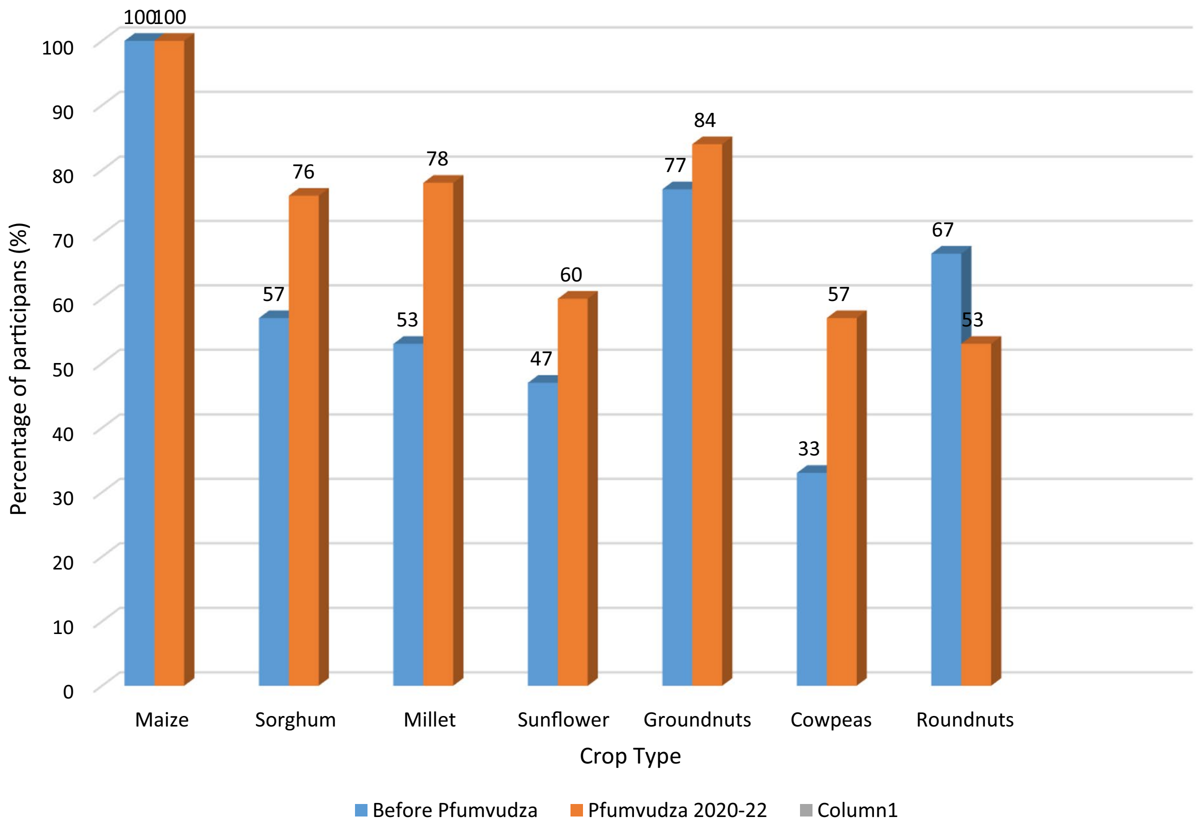

Fig. 2 Crops grown before and after implementation of Pfumvudza. *Source*: Field Data, 2022

Crop yields before and after implementation of Pfumvudza

Figure 3 indicates crop yields before and after implementation of *Pfumvudza*. The majority of respondents produced yields of less than 200 kg for almost all crops, very few produced crop yields between 201 and 400 kg and none produced yields between 400 and 600 kg. To be specific, Maize and groundnuts recorded 62% and 58% consecutively in the category

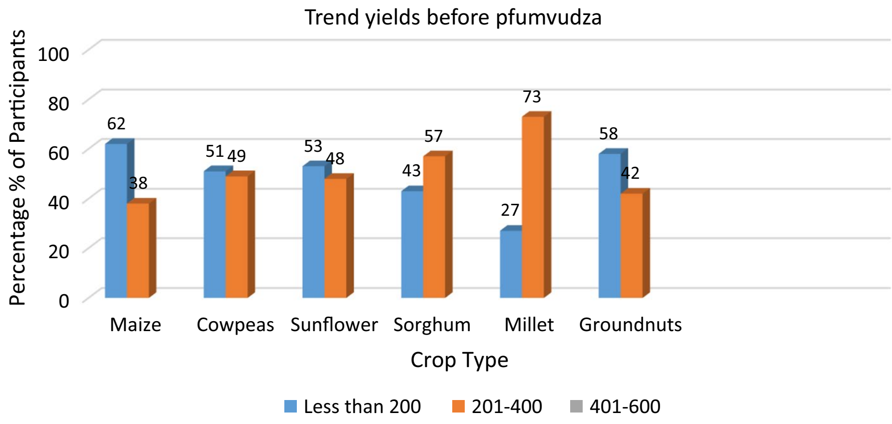

Fig. 3 Crop yields produced before Pfumvudza 2018–2020. *Source*: Field Data, 2022

of less than 200 kg. Low yields in 2018 could be attributed to low rainfall received during this period. Findings were validated by AGRITEX Officer who lamented that, 2018 had a dry spell hence most farmers harvested less than 200 kg per crop grown. Millet and Sorghum are the only crops that had many respondents that produced between 201 and 400 kg. The reason for this could be that these are drought resistant crops therefore it was possible to produce better yields even during period of low rainfall. Findings of the study resonates well with the findings of Defe and Matsa (2021) who found out that due to climate variations being experienced, agriculture production is obtaining generally low yields.

After implementation of *Pfumvudza* concept, findings generally shows an increase in yields for all the crops (Fig. 4). For example, under the maize crop the majority (48%) of respondents produced 401−600 kg whilst only 15% produced less than 200kg. 17% of respondents produced exceptional 600−800 kg of maize. The Agronomist confirmed increase in yields for 2020-2022 saying benefits of *Pfumvudza* were being recognized as such harvests of up to 800kg per plot size have never been witnessed in the ward before *Pfumvudza* implementation. The AGRITEX officer and the Agronomist also supported the findings, by indicating that the maximum yield of farmers in 2020/21 cropping season almost reached the expected 800−1000kg per plot of *Pfumvudza*.

Though findings by Paganga (2022) states that 2020/21 cropping season has seen Zimbabwe missing its maize target and this is caused by poor rains which started around October 2021, for Munyarari area most respondents celebrated getting an increase in crop yields. There was an increase in yields for small grains like sorghum and millet farmers which are drought resistant. According to Ward Councillor, those respondents who opted for small grains harvested more produce. Findings resonates well with Phiri et al. (2021) who found out there is scientific evidence and observations that small grains are resistant to climatic changes compared to maize, but majority of smallholder farmers still dedicate more hectares to maize production. Findings indicates that, in 2020/21 *Pfumvudza* farmers produced more yields than before *Pfumvudza*. Before *Pfumvudza*, no respondent said that he or she got a harvest of 401-600 kg crop yields. This shows that, *Pfumvudza* is an effective method of farming that can help rural families to get sustainable food supply. Before *Pfumvudza* respondents maintained the same level of crop yields which is below 400 kg for all the crops grown. Findings are in line with Phiri et al. (2021) who discovered that there was an increase in sorghum and millet yields in Umguza district after practicing conservation agriculture.

Findings of the study indicates that *Pfumvudza* improved food security. 86% of respondents improved

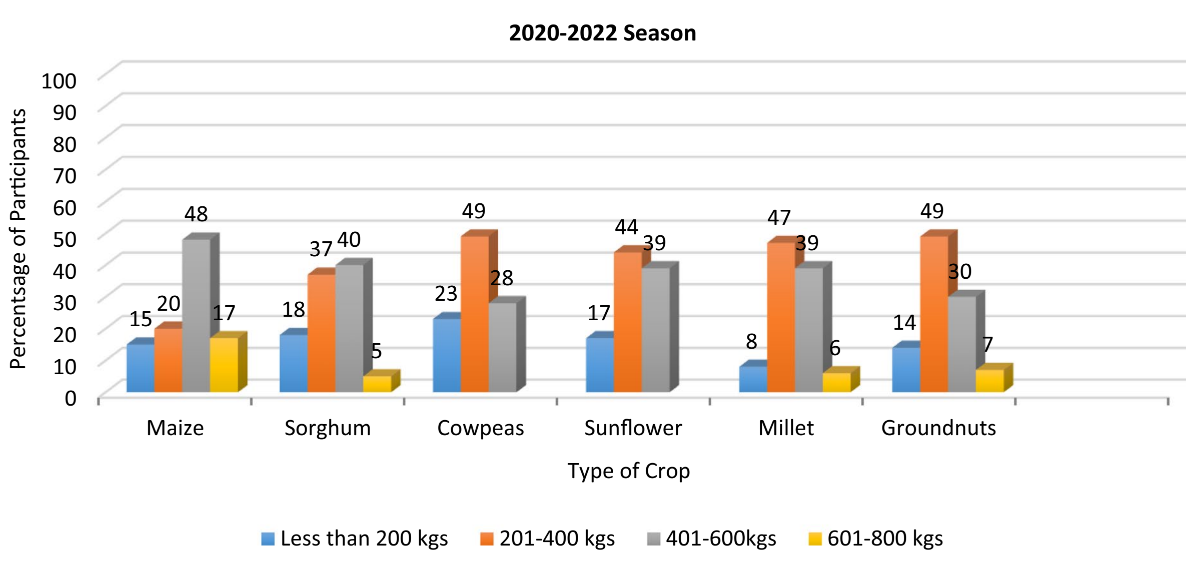

Fig. 4 Pfumvudza crop yields for 2020–2022. *Source*: Field Data, 2022

their household food security through *Pfumvudza*. According to the Social Worker, households were able to have food which sustains them rather than depending on humanitarian hand-outs. Its massive uptake has improved yields and enhanced household food security for the majority of smallholder farmers. Findings are in line with Mujere (2021) who found out that *Pfumvudza* performance indicates a significant opportunity to improve the food security and nutrition of rural and urban households, as well as the entire country. According to FAO (2020), the use of minimum tillage in conjunction with mulching has resulted in savings in machinery, energy use, and carbon emissions, an increase in soil organic matter content and biotic activity, less erosion, enhanced crop availability and thus drought resilience, improved aquifer recharge, and a reduction in the impact of weather variability (drought, floods, heat, cold) linked to climate change (Table 1).

Determining the difference in yields before and after Pfumvudza

The results show that there was a significant average difference in maize yields before and after Pfumvudza ($z = -3.917$, p value $= 0.000$). As a result, before Pfumvudza maize yields was less than after the implementation of Pfumvudza. There was a significant difference in sorghum yields ($z = -4.148$, p value $= 0.000$). This demonstrates that the value before Pfumvudza sorghum was less than the value after Pfumvudza sorghum. Furthermore, there was no significant difference between before and after Pfumvudza millet yields ($z = -1.609$, p value $= 0.108$). This means that Pfumvudza respondents received less millet on average than what they used to get prior the implementation of Pfumvudza. The findings also revealed a significant difference in sunflower fields before and after Pfumvudza ($z = -3.247$, p value $= 0.001$). There was also a significant difference in average groundnuts yields before and after Pfumvudza. That is to say, on average, pre-Pfumvudza groundnut yields were less than Pfumvudza groundnut yields at $z = -2.195$ and p value $= 0.028$. According to the findings, cowpeas yields before Pfumvudza were lower than after Pfumvudza at ($z = -4.883$, p value $= 0.000$). Therefore, the research accepts H1 indicating that there is a significant difference in trends of household yields before and after implementation of Pfumvudza and reject H0 which indicates that here is no significant difference in trends of household yields before and after implementation of Pfumvudza.

Changes in the number of households in need of humanitarian food handouts after implementation of Pfumvudza in Munyarari Ward 20, Mutare South Constituency.

Food aid beneficiaries before Pfumvudza and after Pfumvudza

Ninety two (92%) of respondents under *Pfumvudza* received food aid from various humanitarian donors before the *pfumvudza* programme was implemented. Only 8% were not beneficiaries and they indicated

Table 1 Testing for hypothesis using Mann–Whitney U Test

Crop	Group	Sum of ranks	z	P-Value	Mann–Whitney U
MZ	After Pfumvudza	2512.50	−3.917	.000	547.500
	Before Pfumvudza	1582.50			
SG	After Pfumvudza	2506.00	−4.148	.000	554.000
	Before Pfumvudza	1589.00			
MLL	After Pfumvudza	2232.50	−1.609	−.108	827.500
	Before Pfumvudza	1862.50			
SUN	After Pfumvudza	2432.50	−3.247	.001	627.500
	Before Pfumvudza	1662.50			
GRN	After Pfumvudza	2302.50	−2.195	.000	757.500
	Before Pfumvudza	1792.50			
CP	After Pfumvudza	2609.50	−4.883	.000	450.500
	Before Pfumvudza	1485.50			

MZ = Maize; SG = Sorghum; MLL = Millet; SUN = Sunflower; GRN = Groundnuts; CP = Cowpeas

Pfumvudza is the treatment group; Non-Pfumvudza is the control group

Sig** is at p value = 0.005

that they had small families and produced sufficient food to feed their families. Information from the Social Worker indicate that majority of households in Munyarari ward 20 received food aid from social welfare. Participants highlighted that, they got maize from social welfare, cooking oil and maize from Goal and porridge and maize from Plan International. Social Worker validated the findings by highlighting that there are three major donors in this wards who provide food aid to this community. She further said, social welfare usually gave households food aid on monthly basis. The Social Worker explained that under World Food Programme (WFP) guidelines, each household member was entitled to 7.5 kg of cereal, 2.5 kg of pulses, and 0.8L of vegetable oil, so a household of four received 7.5 *4 = 30 kg cereal. 2.5 × 4 = 10 kg pulses 0.8 × 4 = 4L vegetable oil. Findings are in line with Chingono (2019) who found out that the WFP food aid program distributed 7.5 kg of maize, 2.5 kg of cow peas, and 0.8 l of vegetable oil per person in Odzi.

However, after *Pfumvudza*, 43% of households said they were receiving food aid in 2020/21 season. This shows that the number of beneficiaries had reduced from 92%. This could be because, *Pfumvudza* brought better yields which were able to sustain families for a certain period of time. Further, findings indicates that for 2021/22 season, all households in the ward were not receiving any food aid. This was because the Zimvac assessment had indicated that there were better yields in the ward which removed the need for food aid. AGRITEX Officer indicated that households who engaged in *Pfumvudza* programme got better yields and this decreased the number of people in need of food aid in the ward. Moreover, the social worker explained that households who needed aid were less in 2020 because many households got bumper harvests.

However, even though Zimvac assessment concluded that there is no need for food aid in the ward, food security status remains a challenge. Findings revealed that, *Pfumvudza* brings better yields but the issues of sustainability and food security can remain a challenge in the face of frequently occurring droughts conditions. Phiri et al. (2021) purpotes that yields levels can increase in the small intensively farmed area however, even if yields go up, such approaches do not deliver food security at the household let alone national level (Table 2).

Table 2 Comparison of crop yields for those who practiced Pfumvudza per plot and those who did not per equivalent plot size using Mann–Whitney test

Crop	Group	Observations	Sum of ranks	z	P-Value
MZ	Pfumvudza	45	2257.00		
	Non-Pfumvudza	48	2114.00	– 3.008	0.001
	Total	93			
SG	Pfumvudza	45	2259.50		
	Non-Pfumvudza	48	2111.50	– 3.035	0.000
	Total	93			
MLL	Pfumvudza	45	2459.50		
	Non-Pfumvudza	48	1911.50	– 3.244	0.001
	Total	93			
SUN	Pfumvudza	45	2639.50		
	Non-Pfumvudza	48	1731.50	– 3.081	0.002
	Total	93			
GRN	Pfumvudza	45	2086.50		
	Non-Pfumvudza	48	2284.50	– .242	0.809
	Total	93			
CP	Pfumvudza	45	1809.00	– 2.709	0.007
	Non-Pfumvudza	48	2562.00		
	Total	93			

MZ = Maize;
SG = Sorghum;
MLL = Millet;
SUN = Sunflower;
GRN = Groundnuts;
CP = Cowpeas

Pfumvudza is the treatment group; Non-Pfumvudza is the control group

Sig** is at *p* value = 0.005

The differences in yields of households which implement Pfumvudza and those who did not in Munyarari Ward 20, Mutare South Constituency

The sum of the ranks for Pfumvudza maize yield was 2257 compared to 2114 for Non-Pfumvudza maize yield which indicates that a greater proportion of the scores for Pfumvudza were above the combined median of the 2 groups for maize yield. There was a statistically significant difference between Non-Pfumvudza maize yield scores and Pfumvudza maize yield score ($z = -3.008$, p value $= 0.001$). The Non-Pfumvudza participants did not get high yields for maize during 2021/2022 farming season whilst Pfumvudza participants got high maize yields in the same season. This may suggest that the Pfumvudza participants were more inclined to agreeing that their yields were improved due to Pfumvudza farming methods.

From the table, Man Whitney U Test indicates that, the sum of ranks for sorghum yield for Pfumvudza was 2259.50 compared to 2111.50 for Non-Pfumvudza sorghum yield. This shows that there was a statistically significant difference between Non-Pfumvudza sorghum yield and Pfumvudza sorghum yield at $z = -3.035$, p value $= 0.000$. The Pfumvudza participant produced high yields for sorghum during 2021/2022 farming season compared to Non-Pfumvudza.

Moreover, the sum of ranks for Pfumvudza millet yield was 2459.50 compared to 1911.50 for Non-Pfumvudza millet yield. This implies that a greater proportion of scores for Pfumvudza were above the combined median of the 2 groups for millet yield. There was a statistically significant difference between Non-Pfumvudza and Pfumvudza millet yield scores ($z = -3.244$, p value $= 0.001$).

The sum of ranks for Pfumvudza sunflower yield was 2639.50 compared to 1731.50 for Non-Pfumvudza sunflower yield. This indicates that, there is a statistically significant difference in sunflower yield for Pfumvudza and Non-Pfumvudza participants at $z = -3.081$, p value $= 0.002$.

However, the sum of ranks for Non-Pfumvudza groundnuts yield was 2284.50 compared to 2086.50 for Pfumvudza groundnuts yield. This implies that a greater proportion of scores for Non-Pfumvudza were above the combined median of 2 groups for groundnuts yield. There was a no statistically significant difference in yield for groundnuts for both groups ($z = -0.242$, p value $= 0.809$). This can be interpreted that, Pfumvudza farming methods did not change the yields of groundnuts.

For cowpeas yield, Non-Pfumvudza sum of ranks was 2562 compared to 1 809 for Pfumvudza. This also implies that a greater proportion of scores for Non-Pfumvudza were above the combined median of 2 groups for cowpeas yields. Thus, there was no statistically significant difference in cowpeas yield for Pfumvudza and Non-Pfumvudza participants for the 2021/2022 farming season in Munyarari Ward 20.

Therefore we reject the null hypothesis which assert that there is no significance difference in yields between Pfumvudza respondents and none Pfumvudza respondents. This implies that, Pfumvudza implementation helped in increasing yields of respondents in Munyarari ward 20. Findings concurs with the findings of Phiri et al. (2021) who found out that there was an increase in yields of small grains of Pfumvudza farmers in Umguza. Findings further implies that, Pfumvudza could be a resilient strategy to curb impacts of climate change.

Pfumvudza as resilient strategy

Findings of the study indicates that 88% of respondents agreed that *Pfumvudza* is a resilient strategy while 22% disagreed. Findings implies that, there were other farmers who do not see *Pfumvudza* as a resilient strategy. This may be because, they got yields which were similar to those which they got before *Pfumvudza*. AGRITEX officer supported the findings by indicating that *Pfumvudza* brought hope to the hopeless in the rural Zimbabwe. Moreover, in 2021/2 farming season, 75% agreed that *Pfumvudza* proved to be a resilient strategy and 25% disagreed. Probably those who said yes, they are the ones who got higher yields which sustained then to the next farming season as well as selling to the GMB. Findings resonates well with the views of Edwards et al., (n.d) who opine that *Pfumvudza* is only a starting point into smallholder farmer food security and can be applied not only to maize but to many other crops. Combinations of maize with soyabeans can even be used to feed a small chicken unit, which will create additional income and nutrition in the longer term. This is a revelation to feed a nation!

Resilient factors of the Pfumvudza concept

Figure 5 shows resilient factors emanating from *Pfumvudza* programme. Water supplement, mulching, potholing for reserving moisture and planting drought resistant crops were indicated as resilient factors of the *Pfumvudza* concept by the responsents. This implies that, by doing mulching, crop were kept moist because mulch conserve water from evaporation. More so, potholing helps in reserving moisture whilst drought tolerant seeds helps in mitigating the effects of climate change. Respondents noted that these factors offer resilience and can help in producing higher yields and fight against climate change impacts under the *Pfumvudza* concept. Increase in crop yield under zero tillage is attributed to enhanced soil water content and improved soil physical and organic matter chemicals such as nitrogen, phosphorus, potassium and sulphur (Mujere, 2021). As soil bulk particle density decrease with ploughing, the benefits of mulching and reduced tillage are presented as reducing runoff, enhancing water retention and preventing soil erosion. Findings concur with the views of Mango et al. (2017) who states that climate change resilience studies in agricultural production has identified conservation agriculture as one of many sustainable farming practices that can help households in smallholder farming systems withstand the negative effects of climate change and variability.

Challenges experienced in Pfumvudza implementation

About 98% of respondents under *Pfumvudza* unanimously agreed that they were affected by uneven distribution of rainfall (Fig. 6). While 2% said they were not affected by uneven distribution of rainfall. This was also supported by the Agronomist who indicated that the area did not receive even rainfall.

Limited rainfall was mentioned by 86% of respondents as a challenge of *Pfumvudza* programme, particularly in the 2021/2 cropping season. AGRITEX officer also mentioned the issue of limited rainfall as a hindrance to the effectiveness of the programme. This implies that, without adequate rainfall, there is also low productivity. Findings are in line with Edwards et al. (n.d) who found out that rainfall also affects the standards of many farmers' crops, either due to late start or dry spells during the season. However, a few respondents (24%) in Zvoushe area near Mpudzi River connecting to Mpudzi dam managed to supplement water during the dry spell. AGRITEX Officer also said those who were close to Mpudzi dam were able to do water supplement during dry spells.

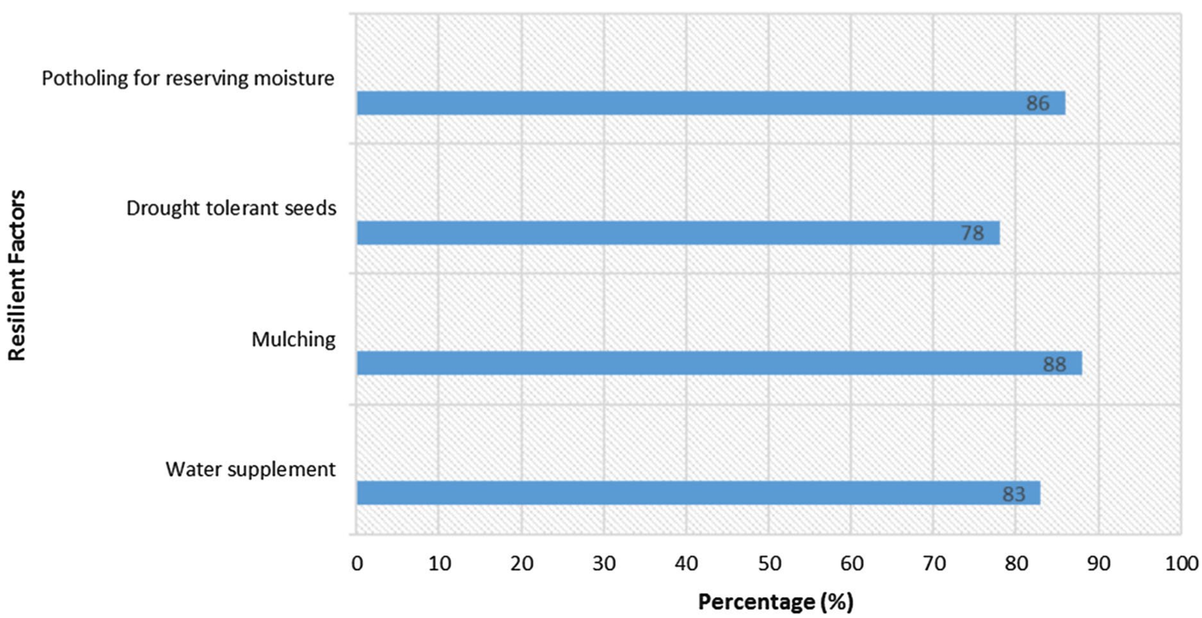

Fig. 5 Resilient factors of the Pfumvudza concept. *Source*: Field Data, 2022

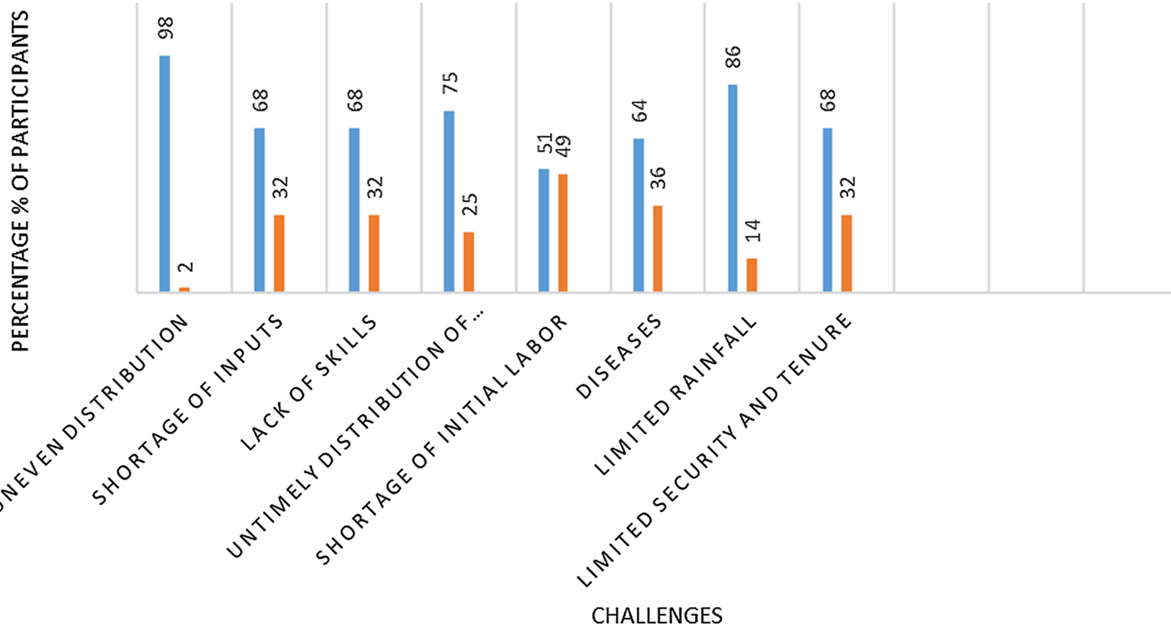

Fig. 6 Challenges experienced in the implementation of Pfumvudza. *Source*: Field Data, 2022

Additionally, findings of the study indicates that untimely distribution of inputs is another challenge faced by *Pfumvudza* respondents as indicated by 75% of respondents. The ward Councilor indicated that they faced logistical challenges in distributing inputs to farmers. AGRITEX officer also said that the reason why most farmers still have unripe crops is because they received inputs late. Findings concurs with the sentiments by The Herald (2021) which purports that, farmers in Mutoko have expressed dissatisfaction with the recent delivery of *Pfumvudza* inputs for the 2020/2021 cropping season, and have urged the government to provide them on time and in full packages to improve yields.

Furthermore, 64% of respondents mentioned diseases (maize streak virus, stalk-borers bacterial stalk rot, maize lethal necrosis) as another challenge which they faced during *Pfumvudza* implementation. AGRITEX officer said that farmers face various crop diseases and pests which affect yields at the end of the season. Findings concurs with Mujere (2021) who opines that pests and diseases is a challenge emanating from climate change impact.

Shortage of inputs was also highlighted by 68% of the respondents as another challenge. AGRITEX officer further explained that some farmers did not receive certain seeds and fertilizers. Shortage of inputs could be emanating from high rampant of corruption under the programme. Simango (2021) argued that stealing of inputs for personal gain is now a problem that is sabotaging this noble scheme. The *Pfumvudza* program should benefit those who are deserving regardless of their political, religious, or other affiliation.

Lack of skills was one of the challenges that was highlighted by 68% of respondents. Findings implies that rural farmers lack the needed skills to execute the programme. Mujere (2021) argued that lack of skills and knowledge base is rampant in most rural farmers under *Pfumvudza*. AGRITEX officer also explained that mulch is a challenge in Munyarari as a result of deforestation. Findings implies that key practices for the success of *Pfumvudza* were either not done or completely adhered to due to the challenges mentioned. Findings are supported by Mujere (2021) who found out that, Farmers who adhered to the recommended *Pfumvudza* practices of full mulch cover, fertilizer application levels, timely crop planting, crop spacing, optimal plant populations, pest and disease management achieved almost 800% yields as compared to conventional farming using ox-drawn ploughs.

Conclusion

This research concludes farmers in Munyarari used the conventional way of farming before implementation of *Pfumvudza* and relied on rain fed agriculture which resulted in low yields due to impacts of climate change. Therefore, food security status was very poor, due to climate change induced droughts which occur very often in the ward. Most farmers relied on donor aid from social welfare department and NGOs such as Goal, Plan international in form of food handouts year after year. Food basket received from the humanitarian organization per month was also very insufficient to households due to large families which increased the consumption of such food. Reliance on donor aid was never a sustainable way of solving the food insecurity problem in the ward bearing in mind that climate change is real and its effects on agriculture are expected to increase in the future.

The implementation of *Pfumvudza* in 2020/1 cropping season in the ward was aimed at addressing problems of low yields and making households more resilient to climate shocks so as to ensure food security. Farmers who practiced *Pfumvudza* witnessed an increase in yields compared to previous years hence, the positive role played by *Pfumvudza* as a resilience strategy against drought impacts. To add on, those who did not practice *Pfumvudza* got lower yields than those who practiced *Pfumvudza.* However, some few farmers continued to experience slightly lower yields due to partial and non-adherence to certain *Pfumvudza* key principles. However, when compared to yields before the introduction of *Pfumvudza*, the *Pfumvudza* yields were higher. This implied that *Pfumvudza* brought remarkable change in yields that was witnessed by farmers hence increasing resilience against climate change induced drought impacts. The development also led to reduced number of households assisted by social welfare and other non-governmental organizations after the implementation of *Pfumvudza* in the ward. The Pfumvudza concept is a viable resilient strategy that can help rural famers tha depend on rain-fed agriculture to counter effects of climate change and increase agriculture production thereby contributing to the achievement of Sustainable Development Goal number 1 and 2 (eradicating poverty and improving food security).

Recommendations

From the findings and conclusions of this research the following recommendations are made:

- The government and its partners should make use of nearby Mpudzi dam to develop irrigation schemes in the Munyarari area so as to ensure supplementation of water on *Pfumvudza* crops in mid-dry season.
- The department of AGRITEX to intensify its training, monitoring and supervisory system on *Pfumvudza* farmers so as to ensure that farmers totally adhere to *Pfumvudza* principles.
- Farmers need to fully embrace the *Pfumvudza* strategy and avoid mixing *Pfumvudza* with conventional method so as to realize high yields and improve food security. They also need to learn to adhere to given principles of *Pfumvudza* for it to be more effective.
- Non-governmental organizations and donors should help by providing finances to enable further training on *Pfumvudza*, provision of inputs so as to support resilience than to only give food hand-outs which promotes donor syndrome.
- The government to ensure timely distribution of inputs by distributing all inputs early before expected first rains in mid-November to avoid inconveniencing farmers.
- The meteorology department to give timely updates on whether such as rainfall distribution specifically for small areas like wards other than generalizing weather update of a wide area whose weather conditions may not be the same. This will help farmers to plan their farming according to change in seasons

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Declarations

Conflict of interest The authors declare that they have no competing interests.

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Ethics approval Consent was granted and all key informants signed consent forms. More details are provided under methodology section.

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