

# An Assessment of the Contribution of The *Pfumvudza* Concept Towards Climate Smart Agriculture in Zimbabwe: A Review

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## Abstract

Concerns of food and environmental security have increased enormously in recent years due to the vagaries of climate change and variability. Efforts to promote food security and environmental sustainability often reinforce each other and enable farmers to adapt to and mitigate the impact of climate change and other stresses. Some of these efforts are based on appropriate technologies and practices that restore natural ecosystems and improve the resilience of farming systems, thus enhancing food security. Climate smart agriculture (CSA) principles, for example, translate into a number of locally-devised and applied practices that work simultaneously through contextualised crop-soil-water-nutrient-pest-ecosystem management at a variety of scales. The purpose of this paper is to review concisely the current state-of-the-art literature and ascertain the potential of the *Pfumvudza* concept to enhance household food security, climate change mitigation and adaptation as it is promoted in Zimbabwe. The study relied heavily on data from print and electronic media. Datasets pertaining to carbon, nitrous oxide and methane storage in soils and crop yield under zero tillage and conventional tillage were compiled. Findings show that, compared to conventional farming, *Pfumvudza* has great potential to contribute towards household food security and reducing carbon emissions if implemented following the stipulated recommendations. These include among others, adequate land preparation and timely planting and acquiring inputs. However, nitrous oxide emissions tend to increase with reduced tillage and, the use of artificial fertilizers, pesticides and herbicides is environmentally unfriendly.

**Keywords:** Climate Smart Agriculture, Crop Productivity, Climate Change, *pfumvudza*, Zimbabwe

## Introduction

A rapidly growing global population and changing diets are driving the demand for increased food production. As levels of crop yields fell off in many parts of the world due to climate change, health declines, and natural resources including soils, water and biodiversity are stretched. Nearly 9% of the world population is suffering from hunger and an estimated 60 million people in every five years lack enough food [1]. The food security challenge is become more difficult to manage as the world will need to produce about 70% more food by 2050 to feed an estimated 9 billion people [2]. In Africa, 33% of small-scale farmers are already undernourished [3]. This means that most farmers are unable to sustain themselves from the land that they are utilising. Most of the seed and fertilizer utilised are managed so inefficiently that it does not produce a viable return

The food security challenge is intensified by agriculture's extreme vulnerability to climate change. Climate change's negative impacts are being felt in the form of increasing temperatures, diseases, floods, droughts, shifting agro-ecosystem boundaries, invasive plants, diseases and pests [4]. On farms, climate change is reducing crop yields, nutritional quality of major cereals and

livestock productivity. Substantial investments in adaptation are required to increase crop production and improve food quality to meet the growing demand. However, agriculture is a major part of the climate problem. It currently generates 19-29% of the greenhouse gas (GHG) emissions. Without action, this percentage could rise substantially even if other sectors reduce their emissions. Additionally, one third of food produced is either lost or wasted [1]. Addressing food loss and waste is also critical to meet climate goals and reduce stress on the environment.

Yet, recurrent droughts (rising temperature and reduced rainfall) are negatively affecting the agricultural sector due to its high reliance on rainfed crop production. Prolonged dry seasons and reduction in cropping seasons have severe negative direct and indirect effects on agricultural productivity, food and nutrition security. In addition, the agriculture sector is besieged by a number of issues ranging from poor or reduced productivity due to poor access to inputs, technologies, predominance of poorly resourced smallholder farmers, uncoordinated value chain systems and non-supportive policy environment [4]. To cope with the changing socio-economic and environmental conditions negatively affecting agriculture, there is an urgent need to employ climate sensitive farming approaches.

Thus, understanding transformational change in food production systems is now widely acknowledged in order to adapt to and mitigate climate change and to address the environmental and social problems generated by current food systems [5]. But so far, despite the urgent need, studies on approaches linking agricultural practices and aspects of climate smart agriculture (CSA) and are still few. This is calls studies to evaluate the contribution of the environmentally friendly farming practices towards food and environmental security. In order to address the interlinked challenges of food security and accelerating climate change faced by most communities, climate smart agriculture (CSA) principle of increasing agricultural productivity, adapting and mitigating climate change impacts are being promoted.

### Climate smart agriculture

CSA is an integrated approach for sustainably managing farming landscapes; cropland, livestock, forests and fisheries. It aims at simultaneously increase productivity by producing more and better food to improve nutrition security and boost incomes especially of 75% of the world's poor who live in rural areas and rely mainly on agriculture for their livelihoods. Also, CSA enhances resilience by reduce vulnerability to drought, pests, diseases and other climate- related risks and shocks. It improves capacity to adapt and grow food in the face of longer-term stresses like shortened seasons and erratic weather patterns; and, reduce emissions by avoid deforestation from agriculture and identify ways to absorb carbon out of the atmosphere [2].

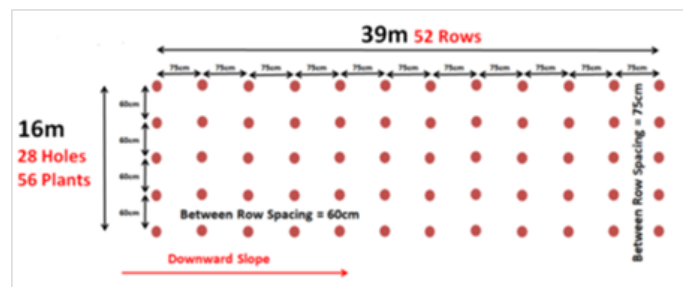
Promotion of CSA is continuing and expanding globally, while little attention has been given towards addressing the sustainability challenges related to its adoption faced by many poor smallholder farmers. Particularly, pressing challenges are balancing productivity and resource uses and preventing the risks of large-scale environmental degradation. This is important in contributing to the achievement of the SDG 6 of the Agenda 2030 [1]. In many countries, there is a need to build technical capacities among smallholder farmers to develop and implement sound policies and strengthen governance regimes at national, regional and local levels. For this, CSA can be a powerful tool to open new development perspectives and present attractive opportunities for coping with the looming threats of climate variability and change in agriculture. Variants of CSA practices include; conservation agriculture (defined by minimum soil disturbance, maintaining permanent soil organic cover or mulching, crop diversification and rotations), agroforestry, ecological agriculture, regenerative agriculture, organic farming and *Pfumvudza*.

### The Pfumvudza concept

*Pfumvudza* is a Zimbabwean vernacular language term literally referring to the blossoming of fresh leaves during the spring season signalling the beginning of a new farming season. Ideally, the concept was developed by the Foundation of Farming, a local non-governmental organisation in the country to meet cereal needs for an average household of six members over one year from a small piece of land. It is based on three core underlying principles namely of minimum soil disturbance or tillage; digging holes for planting only, permanent soil cover by using organic mulch; crop rotations and intercropping cover crops with main crops. Household food security is expected to be realised

when activities are done on time, at standard, without wastage, to the expected precision and with joy [6].

A *Pfumvudza* plot is a rectangular land measuring 16 m by 39 m, which represents 0.06 ha or 624 m<sup>2</sup>. The longer side preferably extend down the slope [Figure 1]. Three maize seeds are evenly placed in each of the 1,456 planting stations in the plot. Each of the 52 planting rows with 28 planting stations hold 2 maize plants after thinning at germination. Inter-row spacing is 75 cm and in row spacing of planting stations across the slope is 60 cm. The dimensions of each planting station are 15 cm deep, 15 cm wide and 15 cm long [6].



**Figure 1:** Layout of a *Pfumvudza* plot

Source: Edwards (2013:4)

In each row, 56 maize cobs (a staple crop in the country) each weighing 300 g on average, are expected to be harvested from the 56 maize plants. This gives 20 kg bucket of shelled kernels which when ground provides adequate mealie-meal to feed a family of six for a week. This means the 52 grain buckets from 52 plant rows feed a six-member family for 52 weeks or one year. If the plot is well managed, should give approximately 1 tonne of maize grain. This translates to a maize yield of 15 t/ha [7].

*Pfumvudza*, farming as a low input sustainable agriculture, characterised by intensive maize crop production with less inputs on a small piece of land measuring launched by the Zimbabwe government in June 2020 when preparing for the country's cropping season that runs from October to March. Out of a target of 1.6 million vulnerable households, about 7,000,000 households were trained and provided with the maize seed and fertilizer inputs [3]. Nevertheless, a key question that remains to be answered is: To what extent will *Pfumvudza* contribute towards improving food security, adapting and mitigating climate change impacts on agriculture? This study therefore explores the potential role of the *Pfumvudza* concept in climate proofing and, enhancing household food security.

### Materials and Methods

#### Study Area

Zimbabwe is an agro-based low-income country covering an area of 39,000 km<sup>2</sup> in the semi- arid region of southern Africa. Its population stands at 14 million and almost 60% of the population resides in rural areas where agriculture is the mainstay economic activity. Approximately 70% of the population depend on agriculture as a source of livelihood [4]. Both rainfed and irrigation agriculture underpin the country's economic growth, food security and poverty reduction. The sector contributes an average of 11.3% to annual GDP and 16% of the country's ex-

port earnings. The national maize yield is less than 0.5 Mt/ha [3]. Water shortages due to frequent droughts is significantly compromising the agricultural productivity.

### Literature Search

For the present study, a review of the existing literature was made to compile data for comparing crop yield, climate adaptation and mitigation in soils under zero tillage with mulching, and conventional tillage. A search strategy comprising Boolean logic, wildcards and truncation was used to locate relevant scientific literature. Specifically, the search targeted “*Pfumvudza*” OR “mulching\*” OR “zero tillage\*” OR “climate smart agriculture\*” OR “conservation agriculture\*” OR “minimum tillage\*” AND “climate change\*” OR “climate change mitigation\*” OR “climate change adaptation\*” OR “climate proofing\*” OR “greenhouse gas\*” OR “global warming\*” OR “crop yields\*” used in the title, abstract, keywords and references. A two-tier screening approach was then used to assess the appropriateness of the studies retrieved by the search strategy. First, titles, abstracts, and keywords of publications available in English were reviewed. The retrieved publications were then further examined to select those focusing on *Pfumvudza*, climate smart or conservation agriculture as their core subject matter. Results from reviewed papers were assumed reliable because they had undergone some peer review. Nevertheless, the limitation of this approach is that some relevant articles besides those written English were not included. This review can also be susceptible publication bias, where data from statistically significant studies were more likely to be published than those that are not significant.

## Research Findings

### Effect on Crop Productivity

Soil tillage is among the important factors affecting crop production. It contributes up to 20% of crop yields and influence on soil properties [7]. Minimum (direct drill, reduced, no or zero) tillage positively influences several aspects of the soil by improving soil quality such as soil organic content and controlling erosion. The tillage practice conserve soil and water by not disturbing the soil surface and leaving 30% crop residues on the surface [8]. Whereas, excessive tillage operations give rise to a variety of undesirable outcomes, such as soil structure destruction, accelerated erosion, loss of organic matter and fertility, and disruption in cycles of water, organic carbon, and plant nutrient [9].

In Zimbabwe, among the 9,281 farmers who were trained the *Pfumvudza* concept in 2019 achieved varied yields depending on their levels of adherence [3]. 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% more yields as compared to conventional farming using ox-drawn ploughs. Thus, guaranteeing household cereal security. Whereas, farmers who adhered to *Pfumvudza* in a relaxed way achieved 6.1 t/ha on average. Table 1 shows increased maize crop yields obtained from zero tillage with mulching in comparison to conventional tillage.

**Table 1: Maize Yields Under Zero Tillage and Conventional Tillage Farming Stems**

Study area	Climate	Soil texture	Tilled (t/ha)	Zero till t/ha	Reference
Nigeria	Tropical	Clay loam	2.58	3.64	Opara-Nadi (2000)
Zimbabwe	Tropical	Clay loam	5.67	6.55	O’Dell et al. (2020)
Zimbabwe	Tropical	Sandy clay loam	1.00	7.80	FAO (2020)
Morocco	Temperate	Clay	2.41	2.47	Mrabet (2000)
China	Temperate	Sandy loam	5.19	5.35	Wang et al. (2011)
New York	Temperate	Clay loam	6.42	7.26	Karunatilake et al. (2000)
Mexico	Tropical	Clay	4.31	5.65	Verhulst et al. (2011)
China	Temperate	Clay Loam	6.79	4.86	Chen et al. (2011)
Germany	Temperate	Silty loam	5.39	4.78	Vogeler et al. (2009)
Alberta	Temperate	Loam	3.24	2.09	Nyborg et al. (1995)
Alberta	Temperate	Silty clay loam	3.75	2.64	Nyborg et al. (1995)
Argentina	Temperate	Sandy loam	5.20	5.00	Buschiazzo et al. (1998)
Argentina	Temperate	Sandy loam	2.15	1.40	Buschiazzo et al. (1998)
China	Temperate	Sandy loam	4.83	4.68	Wang et al. (2012)
China	Temperate	Silt loam	10.73	9.95	He et al. (2011)
Brazil	Tropical	Clay	6.62	5.75	Franchini et al. (2012)
Croatia	Temperate	Silt loam	7.69	7.54	Filipovic et al. (2006)
US	Temperate	Silty clay loam	6.75	6.20	Wilhelm and Wortmann (2004)
Mexico	Tropical	Sandy loam	3.57	5.29	Govaert et al. (2005)

From [Table 2], the maize yields from conventionally tilled areas are lower (mean = 4.85, median = 5, range = 1.73, standard deviation = 2.18, variance = 4.75) than those obtained from zero tilled farms (mean = 78.75, median = 5.2, range = 7.70, standard deviation = 2.26, variance = 5.11). However, the differences in yields are not statistically significant ( $p > 0.05$ ,  $n = 19$ ,  $df = 36$ ) as indicated by the t-test for equality of means ( $p = 0.516$ ), Levene's test for equality of variance ( $p = 0.981$ ) and Mann-Whitney test for comparing medians ( $p = 1.00$ ) at 95% confidence level. Thus, the null hypothesis is retained since the mean, median and variance are statistically the same between the categories.

### Effect on climate change adaptation and mitigation

*Pfumvudza*, farmers dig holes in straight lines and mulch them to harvest water. The net effect of zero tillage and mulching reduces moisture loss from inner soil layers not exposed through tillage. It also and increases water infiltration and improves the soil structure in the long term. Mulch also smothers weeds, minimises soil compaction by intense rainfall, thus, reducing runoff and soil erosion. Mulching reducing direct sunlight and temperature on soil, thus lowering the rate of soil water evaporation [8, 10]. In this way, it moderates the temperature of the soil, which is important for all the micro- and macro-organisms (such as earthworms) required to promote good soil health. Thus, the effects of reduced moisture during seasonal and mid-season droughts are mitigated.

Inter-cropping and crop rotations involving cereal and legumes under *Pfumvudza* helps to improve soil fertility, reduces pest infestations and diseases, and minimises total crop loss during severe weather occurrences. Legumes also provide a protein source to complement cereals [8]. Thus, farmers spread risks associated with climate change and variabilities. If one crop fails, then the other is likely to reach maturity and be harvested.

### Effect on Climate Change Mitigation

Modifying agricultural practices appear to be an obvious choice for climate change mitigation, since cropland occupies 11% of the earth's land surface (FAO, 2011). Like forests, crops remove  $CO_2$  from the atmosphere. Minimal soil disturbance, maintaining soil cover with crop residue and/or mulch, and crop rotation have the potential to sequester soil carbon (i.e. to be a negative emission) as opposed to conventional disc ploughed agriculture which contributes towards  $CO_2$  emissions from soils.

Soils store more carbon than atmosphere and vegetation combined. Land tilling release large amounts of carbon trapped in soils into the atmosphere, thus worsening climate change. While minimum tillage adopted in *Pfumvudza* increases food production and soil moisture, it also reduces carbon dioxide emissions. Potholing keeps large amounts of carbon in the ground and disturbs the soil at planting stations and releases less carbon to the air where it causes global warming [Table 2].

**Table 2: Carbon stocks under conventional and zero tillage with mulching in maize crop fields**

Study area	Climate	Soil texture	Tilled (t/ha)	No till (t/ha)	Reference
US	Temperate	Clay loam	97.6	104.0	Chatterjee and Lal (2009)
US	Temperate	Clay loam	82.3	79.0	Chatterjee and Lal (2009)
US	Temperate	Loam	117.0	143.0	Chatterjee and Lal (2009)
US	Temperate	Silt loam	46.3	66.7	Chatterjee and Lal (2009)
US	Temperate	Loam	96.4	83.4	Chatterjee and Lal (2009)
US	Temperate	Silty clay loam	88.5	90.9	Puget and Lal (2005)
US	Temperate	Silt loam	117.0	106.0	Dolan et al. (2006)
US	Temperate	Silt loam	21.4	27.6	Kahlon et al. (2013)
Canada	Temperate	Silt loam	36.7	39.0	Deen and Katakai (2003)
Canada	Temperate	Clay loam	104.8	112.9	Yang et al. (2008)
China	Temperate	Sandy loam	87.6	93.1	Lou et al. (2012)
China	Temperate	Loam	95.4	96.3	Lou et al. (2012)
Nigeria	Tropical	Sandy	2.0	2.4	Lal (1997)
Mexico	Tropical	Clay	76.8	117.7	Dendooven et al. (2012)
US	Temperate	Silty clay loam	90.5	114.4	Varvel and Wilhelm (2011)
US	Temperate	Silty clay loam	104.8	138.6	Varvel and Wilhelm (2011)
US	Temperate	Silty clay loam	123.3	165.4	Varvel and Wilhelm (2011)
China	Temperate	Silt loam	6.1	6.6	He et al. (2011)
US	Temperate	Silt loam	44.8	80.0	Ussiri et al. (2009)
Brazil	Tropical	Sandy clay loam	44.6	49.2	Bayer et al. (2000)
Brazil	Tropical	Sandy clay loam	50.2	56.6	Bayer et al. (2000)
Mexico	Tropical	Clay	27.5	36.2	Fuentes et al. (2010)
US	Temperate	Silt loam	49.7	50.4	Clapp et al. (2000)



Brazil	Tropical	Clay	71.6	85.9	Jantalia et al. (2007)
US	Temperate	Silty clay loam	131.6	171.3	Varvel and Wilhelm (2011)
China	Temperate	Silt loam	19.6	18.2	He et al. (2011)
USA	Temperate	Sandy loam	20.8	24.4	Sainju et al. (2002)
Mexico	Tropical	Clay loam	35.4	44.1	Castellanos-Navarrete et al. (2012)
US	Temperate	Silt loam	51.4	54.7	Jarecki et al. (2005)
Uruguay	Temperate	Clay loam	47.3	51.8	Ernst and Siri-Prieto (2009)
Morocco	Temperate	Silt clay	33.9	37.3	Mrabet et al. (2001)
US	Temperate	Silt loam	101.6	119.2	Abreu et al. (2011)
US	Temperate	Silt loam	111.6	127.4	Abreu et al. (2011)
US	Temperate	Silt loam	104.5	116.3	Abreu et al. (2011)
Brazil	Tropical	Sandy clay loam	41.8	46.5	Zanatta et al. (2007)

From [Table 3], the carbon emissions from conventionally tilled areas are lower (mean = 68.07, median = 71.6, range = 129.6, standard deviation = 36.94, variance 1364.37) than those estimated from zero tilled farms (mean = 78.75, median = 80, range = 1698, standard deviation = 44.23, variance 1956.04). However, the differences in emissions are not statistically significant ( $p > 0.05$ ,  $n = 35$ ,  $df = 70$ ) as shown by the t-test for equality of means ( $p = 0.396$ ), Levene's test for equality of variance ( $p = 0.276$ ) and Mann-Whitney test for comparing medians ( $p = 6.35$ ) at 95% confidence level. Thus, the mean, median and variance are statistically the same across the categories and, the null hypothesis is retained.

With regards to methane ( $CH_4$ ), studies indicate that zero-tilled soils act as net sinks for methane. Increased absorption of  $CH_4$  in soils under zero tillage is due to reduced surface disruption, greater pore continuity developed over time and the presence of more micro-sites for methanotrophic bacteria. High soil bulk density under minimum tillage prevent the efflux of  $CH_4$  leading to its oxidation within soil [10]. Long-term experimental studies indicate a net  $CH_4$  uptake in zero-tilled soils of 2.76 kg  $CH_4$ /ha/year as compared to 0.32 kg  $CH_4$ /ha/year in conventionally tilled soils [10]. However, if zero-tillage system creates anaerobic micro-sites or conditions favourable to enhance waterlogging then that  $CH_4$  production and emissions are likely to increase.

With regards to nitrous oxide ( $N_2O$ ), studies have demonstrated higher emissions under zero tillage compared to conventional tillage [11]. This has been attributed to decreased water-filled pore space and mineral nitrogen concentration, reduced gas diffusivity and air-filled porosity, increased water content and a denser soil structure as a result of a lack of disturbance and increased anaerobic conditions provided by the increased bulk density and decreased soil porosity due to soil consolidation [11]. Increased  $N_2O$  emissions have the potential to offset 75-310% of the climate change mitigation obtainable from the sequestration of C in soil due to its higher global warming potential which is 296 times that of  $CO_2$  (IPCC, 2001). Nevertheless, studies have shown that the adoption of zero tillage over longer periods of about 20 years, lowers  $N_2O$  emissions under zero tillage than in tilled soils in humid climates while similar emissions were reported under both tillage types in dry climates [12]. However, there is still lack of comprehensive published long-term studies

investigating the impact of tillage on  $N_2O$  flux. Also, there exists high uncertainty associated with estimation of  $N_2O$  due to its significant spatial and temporal variability [10]. Thus, long-term location-specific studies combining different greenhouse gases and C sequestration are required to understand the post-conversion period at which  $N_2O$  emissions from zero tillage fall below those from conventional tillage.

## Discussion

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 [Table 1]. 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. There is also general agreement that the practice of minimum tillage can conserve and enhance soil organic carbon levels to some extent. Leaving residue on the field is critical for zero tillage practices. However, it needs about 5 years before higher and more stable yields can be realised [9]. However, the extent of mitigating climate change has been debated extensively, especially when the whole profile of carbon in the soil is considered, along with a reported risk of enhanced nitrous oxide emissions.

Research suggests minimum tillage is effective in sequestering carbon in both soil surface and sub-soil layers in tropical and temperate conditions [15]. The carbon sequestration rate in tropical soils can be about five times higher than in temperate soils. In tropical soils, carbon accumulation is generally correlated with the duration of tillage. Reduced nitrous oxide emissions under long minimum tillage have been reported in literature with significant variabilities in nitrous oxide fluxes [15]. Thus, long-term, location-specific studies are needed urgently to determine the precise role of minimum tillage in driving nitrous oxide fluxes.

The performance of Pfumvudza points to huge potential to improve the food and nutrition security status of rural and urban households and, indeed the whole country. Accordingly, FAO (2020) has shown that the adoption of minimum tillage together with mulching has resulted in savings in machinery, energy use and carbon emissions, a rise in soil organic matter content

and biotic activity, less erosion, increased crop-water availability and thus resilience to drought, improved recharge of aquifers and reduced impact of the variability in weather (drought, floods, heat, cold) associated with climate change.

Nevertheless, *Pfumvudza* is an ideal solution to climate change and poverty among peasant farmers. The concept is rather mechanistic and lacks practical relevance. The use of artificial fertilizers defeats the whole agro-ecological principle as enshrined in CSA. The concept assumes that the crops will reach maturity and harvest without losses due to pests, diseases, and weather. The assumptions are too simplistic because a significant proportion of maize crop is also consumed as green mealies thus, reducing harvests. It is also important to note that maize varieties have different grain yields per cob. Therefore, *Pfumvudza* can be considered as being too theoretical with lots of unrealistic assumptions.

Preliminary observations midway along the 2020/21 season show that some farmers have sold fertilizers available to them from the government. Due to high levels of poverty in communal areas [4, 5], most peasants rarely afford the costs of inputs and are not at liberty to plant 3 seeds in each station with the hope of thinning after germination. Besides applying artificial fertilizers, some farmers are selling them to meet other household needs. Also, the herbicides from the government are not enough to fight the scourge of aphids and armyworm.

Ownership is another vital part of ensuring sustainability of the *Pfumvudza* concept. This is particularly true in communal farming when free handouts are issued. Thus, to promote ownership farmers should be encouraged to purchase input packs for themselves. If farmers are encouraged buy their own inputs, they are likely to use them efficiently and responsibly. Problems of diversion selling inputs can be curbed.

## Conclusion

The concept of CSA is dominating the discourse about the future of agriculture. At the same time the steady growth of the organic market has a strong impact on the global development of standards and regulatory requirements. Alternative terms, such as regenerative agriculture, ecological organic agriculture and others are also more and more widely used in different regions of the world and approaches such as zero budget natural farming and *Pfumvudza* are being scaled-up significantly. These concepts involve many actors with different visions and objectives, but they share the desire to scale-up transformational change initiatives to bring about resilient and sustainable agriculture and food systems.

This study assesses of the potential of increasing productivity and climate change management from *Pfumvudza*. The *Pfumvudza* concept was rolled during the 2020/21 farming season nationwide in Zimbabwe. The concept, a climate smart farming variant is aimed at redress the adverse effects of climate change that have, among other things, seen output in the agriculture sector declining. Research findings show that, as compared to conventional tillage, *Pfumvudza* can improve household food security. The basic no-till practices coupled with cover crops re-

duce CO<sub>2</sub> emissions than tilled treatments. This suggests that a dense cover crop and its subsequent thick residue cover reduce evaporation losses and trap nutrients. Thus, adapting to drought and promoting greater productivity in the crops. Furthermore, this research provides data regarding *Pfumvudza*'s potential to reduce C emissions and increase crop productivity. These results indicate that *Pfumvudza* help to mitigate the consequences of climate change and adapt to climate change impacts such as reduced rainfall in tropical and/or semi-arid regions like southern Africa. Organic farming and agro-ecological principles need to be incorporated in the concept to reduce the use of hybrids, artificial fertilizers, pesticides and insecticides. For example, using herbicides to control weeds destroys the soil micro-organisms.

Farmers who own limited land sizes as well as women can effectively be involved in cultivating small land pieces. By simply farming at high standards, it is possible to feed a family from such small areas of land. However, it requires training to ensure success. The availability of the input packs from the state and other locally available inputs (manure, compost, OPVs) is an encouragement for farmers. *Pfumvudza* a starting point into enhancing food security in smallholder sector and can be applied not only to maize but to other crops. Combinations of maize with beans can be used to feed poultry, which will in turn create additional manure, income and nutrition. In the long term, *Pfumvudza* can be a significant lacuna towards achieving national food security.

Nevertheless, *Pfumvudza* like the broad CSA principles, tends to be dominated by a corporate agenda and rarely focus on the transformation of agriculture and food systems that is needed, albeit in a transition to climate proofing. Although, some of the practices that are promoted within the *Pfumvudza* framework align with climate change adaptation and mitigation, the use of hybrids along with herbicides and fertilizers is environmentally unfriendly. While there is value of reducing or getting rid of conventional tillage practices, climate smart agricultural practices have been hijacked by corporates who are benefitting from their sale of GMO seeds, artificial herbicides and fertilizers.

## Research limitations and future research

The current research was limited by the time constraints and COVID-19 induced lockdown restrictions that influenced the choice of the convenience data collection method to the detriment of other techniques. Also, for this reason, the data collection was made through a literature survey, as it enabled gathering of the information quickly, with the costs involved being kept to a minimum. However, the results of the research may be starting points in formulating future research strategies on the *Pfumvudza* concept.

As future research directions, the study could be adapted and implemented in the context of attitudinal loyalty (the intention to adopt the concept or recommend) of stakeholders. This focuses on the intention of farmers to freely adopt or recommend the concept to others, how they perceive the concept in order to observe their opinions, feelings and attitudes. In addition, more elaborate research could focus on assessing the behavioural loyalty of stakeholders, by capturing the actual actions taken by

farmers and other stakeholder (e.g., how timely are the inputs availed and weeding done).

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