Annals of Arid Zone 62(3): 197-210, 2023

Draught Animal Power for Climate-Smart Farming in Semi-Arid and Arid Nigeria: Challenges and Opportunities

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Received: March 2023

Abstract: This paper examines the challenges faced by farmers in the Sudano-Sahelian ecological zone of Nigeria, which is characterized by a semi-arid to arid climate with limited rainfall and high temperatures. The paper highlights the importance of the region for agriculture, particularly for crops such as millet, sorghum, cowpea, groundnut and maize, but also highlights the challenges faced by the farmers, including climate variability and soil degradation. The paper argues that climate-smart agriculture (CSA) practices, such as use of draught animal power (DAP), conservation agriculture, integration of trees and crops, harvesting water and integrated pest management, can address these challenges. The paper focuses on the use of DAP as a means of supporting agricultural practices in the region. The use of DAP is an important source of power for farmers, particularly those who cannot afford to buy or maintain tractors or other machinery. The paper argues that the use of DAP can increase agricultural productivity, reduce labor costs, and improve farmers' income, contributing to poverty reduction in the region. Additionally, the use of DAP can reduce greenhouse gas emissions, making it a more environmental friendly option than the tractors. The paper suggests that future research on DAP should explore the social and emotional bonds existing between humans and their working animals, as well as the cultural and societal values attached to working animals in different parts of the region. Research could also focus on how modern technology, such as GPS tracking and other monitoring devices, can improve the welfare of draught animals and enhance their productivity. By using these tools to track animal health and performance, farmers and other animal handlers can more effectively identify and address potential issues before they become serious problems. In

OPEN ACCESS

Edited by

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Citation

Sikiru, A.B. John, M.O., Ambali, M.I., Muhammad, I.R., Egena, S.S.A. and Olatunbosun, R.B. 2023. Draught animal power for climate-smart farming in semi-arid and arid Nigeria: Challenges and opportunities. Annals of Arid Zone 62(3): 197-210

https://doi.org/10.59512/aaz.2023.62.3.2

https://epubs.icar.org.in/index.php/AAZ/article/view/134723

conclusion, the use of DAP has the potential to solve some of the challenges faced by farmers in the Sudano-Sahelian ecological zone of Nigeria and promote climate-resilient agricultural practices in the region. Further research is needed to explore the human-animal relationship and sustainable, humane use of draught animals, as well as the cultural and societal values attached to working animals in different parts of the world.

Key words: Sudano-Sahelian ecological zone, climate-smart agriculture, draught animal power, agricultural productivity, poverty reduction, environmental sustainability.

The Sudano-Sahelian ecological zone of Nigeria (SSEZ-NG) is a transitional zone between the tropical rainforest to the south and the Sahara Desert to the north. It covers a large part of West Africa, including northern Nigeria and the zone is characterized by a semi-arid/arid climate with short rainy season and long dry season. Nigeria has two main climatic zones which are the southern forest zone and the northern savanna zone containing the Sudano-Sahelian ecological zone stretching from Niger-Benue trough in the South to the Sahel region in the North (Odekunle *et al*., 2008). This zone could further be divided into the semi-arid zone and the arid zone. Semi-arid area is characterized by low and erratic rainfall (400-600 mm) and grasslands with scattered trees and shrubs as primary vegetation. The arid zone covers a smaller area in the far north, bordering the Sahara Desert and is characterized by extremely low rainfall (<400 mm) and desert scrub vegetation. This region experiences long dry seasons and short rainy seasons (Bale *et al*., 2021; Odekunle *et al*., 2008; Oyebande and Balogun, 1992). Agriculture is the mainstay of the economy in this region, with the majority of the population engaged in subsistence farming where main crops under cultivation include millets, sorghum, cowpea, groundnut and maize (Sule and Sambo, 2023). In addition, livestock rearing makes important contribution to the economic activity of the region, with cattle, sheep and goats being the most commonly reared animals (Sikiru *et al*., 2022, 2016).

Farmers in this region like other places in Sub-Saharan Africa, face several challenges in their agricultural activities and one of the major challenge is the impact of climate change. The rainfall in the region has decreased while the temperature has increased and as a result crop yields have reduced and soil degradation has increased (Haider, 2019; Nyang'au *et al*., 2021). Further, high cost of inputs such as seeds, fertilizers and pesticides also poses a significant challenge to farmers in the region and make it difficult for them to increase productivity and profitability (Shimeles *et al*., 2018). Also, lack of access to input credit from formal financial institutions and markets pose a significant challenge to farmers in the region (Langyintuo, 2020) and limits their ability to expand their farms and increase productivity to sell their produce at profitable prices.

Another major challenge faced by farmers in the Sudano-Sahelian ecological zone is the problem of insecurity, because the region has been plagued by conflicts between farmers and herders, leading to loss of lives and property (Sikiru, 2020), as well as displacement of people from their homes and farmlands due to criminal activities of bandits operating in the region which has cumulatively resulted in a decline in agricultural production and food security in the region (Bjornlund *et al*., 2022). Addressing these challenges will require a concerted effort from both the government and other stakeholders in the agricultural sector to improve the productivity and profitability of farming activities in the region.

Climate-smart agriculture (CSA) is an approach that aims to increase agricultural productivity, enhance the resilience of farmers, and reduce greenhouse gas emissions (Lipper *et al*., 2014). This approach involves the use of sustainable agricultural practices that take into account the impacts of climate change and other environmental factors. In the Sudano-Sahelian ecological zone of Nigeria, CSA has the potential to address some of the challenges faced by farmers. For example, CSA practices such as agroforestry, conservation agriculture

and improved water management can help to improve soil fertility, conserve water, and increase crop yields. This, in turn, can help to reduce the impact of climate change on farming activities in the region. CSA also has the potential to enhance the resilience of farmers in the region by helping them to adapt to the impacts of climate change. For example, use of drought-tolerant crop varieties and early warning systems can help farmers to better manage their farms during the times of low rainfall. Similarly, the use of climate-resilient livestock breeds and better management practices can help to reduce the impact of disease outbreaks and other climate-related risks on livestock production. Furthermore, CSA can also help to reduce greenhouse gas emissions from farming activities in the region. For example, the use of renewable energy sources such as solar panels and biogas digesters, and the use of animals as draught animal power (DAP) can help in reduction of the carbon footprint of farming activities in the region. This is because unlike the mechanization driven agriculture where the use of non-renewable energy is common leading to generation of greenhouse gases; the use of DAP can reduce carbon emission.

Draught animals are essential sources of farm power serving as agricultural inputs providing energy for timely and efficient field operations for enhanced productivity (Khanali *et al*., 2021). Provision of energy on farm is a basic need of every farm to effectively and efficiently use different machinery and implements. Farm power is required for farming activities such as land preparation, cultivation, irrigation, harvesting, post-harvest processing, food production, storage and conveying of agricultural inputs and products; as well as energy needs for application of fertilizers, herbicides, pesticides and insecticides used on farms (Kaygusuz, 2011). It could therefore, be implied that farm power availability could have critical consequence on food security because it could have direct implications on agricultural productivity (Workie *et al*., 2020). Therefore, attempts to alleviate hunger for the promotion of rural development and food security must be accompanied by efforts to promote adequate supply of energy on the farm. Unfortunately, for many smallholders in Sub-Saharan Africa, this is lacking due to non-availability and affordability, hence, the availability of draught animal power in the SSEZ-NG needs to be improved upon for smallholder as a means of climate-smart production technology.

Meanwhile, available data suggest that there is an increasing hunger, malnutrition, and poverty in countries within the SSEZ of the Sub-Saharan Africa which is contributing to the over-dependence of the people on food imports. Meanwhile climate threats keep increasing the intensity of these problem (Islam and Kieu, 2021; Sikiru, 2020). The implications of these are that people living in rural areas of some of these countries are now facing challenges of food production and supply, whereas, a couple of years back agriculture was contributing up to 50% of their export. Meanwhile, agriculture continues to remain a pivot for improving the livelihoods of people in these rural areas, to sustain food security and increasing exports to boost local economies and failure to achieve these could have major ramnifications (Rahaman *et al*., 2021). However, the success in achieving these lofty targets rest on availability of adequate farm power especially for small farmers who form the bulk of farmers in these countries

Furthermore, in the recent years, there is increasing labor shortage in the rural areas in some of the developing countries primarily due to migration of people to urban areas and the consequences include shortage of human muscle power for farming activities. This shortage coupled with erratic climate is clogging the progress in agricultural productivity of smallholder farmers. Therefore, in solving the problem of labor shortage impact on agricultural production in the smallholder production system in the SSEZ-NG, there is a need to identify and support opportunities which relieve the burden of labor shortages such as the use of draught animal as this would enhance households' capacity to withstand damaging effect of climate change on agricultural productivity.

Draught animals in agriculture

Draught animals also known as draft animals, are trained animals used for pulling loads or heavy objects, typically within the agricultural or industrial settings (Sturgeon, 2021). The animals are common within the rural communities and examples include horses, mules, donkeys, oxen, and buffaloes. These

draught animals have been in use for centuries helping humans in a variety of tasks, and they have specialized physical and behavioral characteristics which make them well-suited for the purposes of being used in these different kinds of works (Shipo, 2013). There are some special unique features of draught animals which differentiate them with others, and these include strength and power, docility and trainability, adaptability, dependability, longevity and sociability (Ramaswamy, 1998).

Draught animals usually possess very strong and muscular bodies that allow them to pull heavy loads compared with other animals, this attribute could be bred for in the animals or sometimes, animals could be trained to develop this physical strength and endurance (Davis, 2019; Norris *et al*., 2021). In order to achieve these physical features, draught animals are usually expected to be docile and easy to train to work effectively with humans through responding to commands and work together as a team (McLean *et al*., 2019). Also, draught animals can work in a variety of different environments, including fields, forests and roads as these adaptation characteristics are necessary for different types of equipment (Williams *et al*., 2021). These draught animals are also usually dependable workers, often able to work for long hours with few breaks and can live and work for many years, provided they are well cared for and are maintained using best animal husbandry practices. Draught animals are social creatures and typically work in pairs or teams; they often form strong bonds with their human handlers and other animals in their group for efficient work delivery.

Promotion of draught animals use in agriculture could be regarded as enhancing the use of a bronze age technology as a solution for the 21st century challenges. Over the centuries, humans have been inventing newer technologies to solve problems and advance societal growth; the advent of draught animal was one of such technologies which has remained unchanged and unreplaced and which could also possibly remain with us till we exist as it will cater to some of our needs even in future (Kummitha, 2020). Furthermore, compared with tractor, use of draught animal is more affordable and sustainable source of farm power for the small-scale farmers. In recognition of this, exploring this retro-innovation and of relationships between humans and draught animals use for promotion of sustainable agricultural development was suggested as a technology that could be used for surviving 21st century challenges (Garre, 2022). Also, the use of draught animal power stands to contribute to increase farm productivity via alleviation of excessive reliance on human muscle power which is becoming increasingly unavailable in the rural areas as the rural-urban migration continue to increase. Furthermore, compared with draught animals, tractors are usually not affordable for small-scale farmers, and tractor programs of the governments over the years have proved difficult to run effectively at different places within the SSEZ-NG due to corruption and ineffective policies (Akinola, 1987; Daum and Birner, 2020). Although, private sector intervention has been identified as an alternative to government's ineffectiveness, the current state of foreign exchange and reducing values of currency of Nigeria and some other developing countries have aggravated cost of imports significantly and has made smallholders dependence on private tractor hiring services effective (Ajah, 2014; Daum *et al*., 2021).

In the SSEZ-NG and some other parts of Sub-Saharan Africa, human muscle still contributes more than 60% to farm power for land preparation and this could be the reason why average cropland holding still remain <2 ha household^{-1}– a situation aggravating hunger and rural poverty (Mrema *et al*., 2018; Sims and Kienzle, 2016). In order to overcome this challenge, applied efficient use of human power is possible through combination of human muscle and draught animal power as a strategy for reducing the problem of farm power shortage in the rural areas which could culminate into increasing agricultural productivity and improving the livelihoods of millions of farming families within the shortest possible time frame (Zhou *et al*., 2018). Also, compared with draught animal power, the use of farm machine might not be highly desirable given the constraints of availability and affordability. This is because, there are reports which suggested that the use of machine had no significant difference on agricultural productivity compared with the use of draught animals for operations such as ploughing and seeding in both short and long terms (Zhou *et al*., 2018).

Use of draught animals for agricultural purposes has a long and rich history, with evidence of their use dating back to thousands of years in various regions of the world. In Sub-Saharan Africa, the use of draught animals has been a traditional and integral part of agriculture for centuries, particularly among smallholder farmers (Mota-Rojas *et al*., 2021). Oxen, horses, donkeys, and other animals have been used for plowing, planting, harvesting, and transportation, and have been essential to the livelihoods of rural communities. Despite the decline of draught animal use in other parts of the world in recent decades, they remain an important source of farm power in Sub-Saharan Africa, where they are often more accessible and affordable than other forms of farm power.

In Nigeria, the use of draught animals has a long history, with evidence of their use dating back to the Iron Age (Kay *et al*., 2019). In recent decades, the use of draught animals has declined in some parts of Nigeria, as other forms of farm power generation have become more widely available. However, in many rural areas, draught animals remain an important source of farm power for smallholder farmers, who rely on them for plowing, planting, and transportation (Starkey, 2020). In East Africa, the use of draught animals has also been a traditional and integral part of agriculture for centuries. In countries such as Kenya, Tanzania, and Ethiopia, oxen, horses, and donkeys have been used for plowing, planting, harvesting, and transportation, and continue to play a significant role in the livelihoods of rural communities (Gebregziabher *et al*., 2006).

In other parts of the world, such as Europe, the Middle East, and Asia, the use of draught animals have long and rich history (Haque *et al*., 2000; Ramaswamy, 1998). In ancient civilizations such as Mesopotamia and Egypt, oxen and horses were widely used for farm work, and in medieval Europe, horses and oxen were the primary source of farm power. In recent decades, the use of draught animals has declined in many parts of the world, as other forms of farm power generation have become more widely available. This implies that the use of draught animals for agricultural purposes has a long and rich history, with evidence of their use dating back to thousands of years in various regions of the world (Johannsen, 2011). Despite the decline of draught animal use in some parts of the world in recent decades, they remain an important source of farm power in many regions, particularly in Sub-Saharan Africa, Nigeria, East Africa, and other rural areas where other forms of farm power generation may not be feasible. Meanwhile, the mention of draught animal power usually triggers a returning back to ancient agricultural practices, but in contrast, draught animals as sources of farm power could serve as a means of promoting agricultural mechanization even in the modern era. This is because, in practical terms, agricultural mechanization involves the use of different forms of tools, implements and machinery for improving the productivity of farm labor through either human, animal or motorized power, or a combination of any of these sources of farm power (Baudron *et al*., 2015; Karekezi and Kithyoma, 2002).

Climate-smart agriculture in the Sudano-Sahelian ecological zone

Climate-smart agriculture (CSA) is an approach to sustainable agriculture that aims to address the interlinked challenges of climate change, food security, and rural development (Lipper *et al*., 2014; Loboguerrero *et al*., 2019). It involves the implementation of practices that enhance the resilience of agricultural systems to the impacts of climate change, reduce greenhouse gas emissions, and increase the productivity and income of farmers. The CSA seeks to improve agricultural productivity and income for farmers, while also promoting the sustainable use of natural resources. In the promotion of adaptation to climate change, CSA aims to enhance the adaptive capacity of agricultural systems to the impacts of climate change by promoting the use of climate-resilient crop varieties, improved soil and water management practices, and the diversification of livelihoods. CSA also encourages the reduction of greenhouse gas emissions in agricultural systems through the adoption of practices such as agroforestry, conservation agriculture and integrated nutrient management. Conservation and sustainable use of natural resources is also associated with CSA because it seeks to promotes the conservation and sustainable use of natural resources, including land, water and biodiversity by encouraging the use of sustainable land management practices and the protection of ecosystems. CSA is also associated with the promotion of gender equity and social

inclusion since it usually ensures that women, men, and marginalized groups have equal access to resources and benefits and that their needs and priorities are taken into account in the design and implementation of agricultural interventions.

Agricultural productivity and income increase for farmers while promoting the sustainable use of natural resources within the scope of CSA requires a multi-faceted approach that incorporates several strategies (Cordingley *et al*., 2015). Some of the strategies include the efficient use of inputs whereby farmers are encouraged and advised appropriately on the use of inputs such as fertilizers and pesticides judiciously by following good agricultural practices, to improve yields and minimize negative environmental impacts. The promotion of conservation agricultural practices such as minimum tillage, cover cropping and intercropping can improve soil health, reduce erosion and conserve water while improving yields. Planting of crops that are tolerant to climatic stress such as drought, floods and high temperatures to help farmers maintain yields even in the face of changing weather patterns. Efficient water management practices such as drip irrigation, rainwater harvesting and soil moisture monitoring can help farmers reduce water usage and increase water use efficiency, resulting in improved crop yields and reduced environmental impact. Integrating trees into agricultural landscapes can also contribute to CSA through the provision of a range of benefits, such as soil improvement, enhanced biodiversity, and improved resilience to climate change. Furthermore, the facilitation and solution of farmer's needs, access to credit and markets to finance inputs and sell of produce through increase access to market information and training can help farmers improve their production practices and negotiate better prices for their produce. Finally, the promotion of knowledge sharing among farmers, researchers and extension workers is essential for scaling up sustainable agricultural practices, reducing knowledge gaps and promoting the adoption of CSA. By implementing these strategies, farmers can improve their agricultural productivity under CSA operations (Azadi *et al*., 2021; Kanter *et al*., 2018).

The SSEZ, which encompasses parts of West and Central Africa, is characterized by low and erratic rainfall, high temperatures, and frequent droughts; these climatic conditions pose several challenges for farmers and serving as challenges against the practicing of CSA (Kumasi *et al*., 2019). In particular, challenges including limited access to water whereby farmers in the SSEZ face water scarcity due to low and erratic rainfall is very common. Meanwhile, the construction of water harvesting structures, such as small dams and ponds, can help farmers to collect and store rainwater for irrigation purposes but these are hardly come by within the zone. Another problem facing agricultural practice in the area is poor soil fertility; the soils in the Sudano-Sahelian zone are often low in nutrients, making it challenging for farmers to maintain soil health and crop productivity (Andrieu *et al*., 2017). Although, the use of organic inputs, such as compost and manure, have been suggested as means to improve soil fertility, while conservation agriculture practices, such as minimum tillage, can help reduce soil erosion and nutrient loss. Hence, addressing these challenges requires a comprehensive approach that involves the participation of farmers, researchers, policymakers and other stakeholders for promoting CSA in the SSEZ to improve their productivity and resilience while contributing to the sustainability of their agricultural systems and the environment (Nwajiuba *et al*., 2015).The SSEZ-NG is a region that is particularly vulnerable to the negative impacts of the climate change, including increased droughts, floods and other extreme weather events. As a result, there are several efforts that could be implemented to promote CSA in the region, which are discussed below

Promotion of agroforestry: Agroforestry is a sustainable land-use system that involves the integration of trees, crops and livestock. This approach can be promoted in the region as a way to improve soil health, enhance biodiversity, and increase resilience to climate change. Agroforestry is a proven CSA practice that has been successfully implemented in many similar regions around the world. For example, in the Sahel region of West Africa, where climate change has contributed to desertification and soil degradation, farmers have been adopting agroforestry techniques to improve their soil fertility and crop yields (Andrieu *et al*., 2017). In Niger, for instance, the Farmer Managed

Natural Regeneration (FMNR) approach involves the selective pruning and management of naturally occurring trees, shrubs and bushes in farmland, which has led to an increase in soil moisture retention, improved soil fertility and increase in crop yields (Kandel *et al*., 2022). Another example is the traditional agroforestry systems used by indigenous farmers in the Amazon rainforest (Miller and Nair, 2006); these and some other systems involve the integration of trees, crops and livestock in a way that mimics the natural forest ecosystem (Jarrett *et al*., 2017). By diversifying their agricultural production and creating a more complex agroecosystem, these farmers have been able to improve soil health, increase biodiversity and enhance their resilience to climate change impacts such as droughts and floods. Additionally, these agroforestry systems help to reduce deforestation and promote the conservation of the forest, which is a crucial carbon sink and an important ecosystem for mitigating climate change.

Sustainable land management: This involves the implementation of sustainable land use practices such as conservation agriculture, crop rotation, and reduced tillage. These practices help to conserve soil moisture and reduce erosion, which are critical in the region's semi-arid climate. Sustainable land management practices have been successfully implemented in many regions around the world with similar climatic conditions. For instance, in the Great Plains region of the United States, farmers have been using no-till or reduced tillage techniques for decades (Hansen *et al*., 2012). These practices involve leaving crop residue on the soil surface after harvest and planting crops directly into the residue. This approach helps to conserve soil moisture, reduce soil erosion, and improve soil health, which in turn leads to increased crop yields and profitability for farmers. Similarly, conservation agriculture techniques have been widely adopted in the Sub-Saharan Africa, where smallholder farmers face similar challenges related to soil degradation and climate change. In Zimbabwe, for example, the Zimbabwe Conservation Agriculture Task Force has been promoting the adoption of conservation agriculture practices such as crop rotation, minimum tillage and cover cropping (Baudron *et al*., 2012). These practices have led to improved soil health, increased crop yields and reduced production costs for farmers. Additionally, conservation agriculture practices have been shown to improve the resilience of farmers to climate change impacts such as droughts and floods, by improving soil moisture retention and reducing soil erosion. Overall, sustainable land management practices offer a promising approach for improving agricultural productivity while also promoting soil health and climate resilience in the SSEZ-NG.

Climate-resilient crop varieties: Plant breeders are developing new crop varieties that are adapted to the changing climate in the region. These varieties are designed to be more drought-tolerant and resistant to pests and diseases. Climate-resilient crop varieties are a promising strategy for improving agricultural productivity in regions that are vulnerable to climate change impacts. For example, in Bangladesh, where rice is the main staple crop, plant breeders have developed new rice varieties that are better adapted to the changing climate. These new varieties were are able to tolerate flooding, drought and salinity, which are common climate-related challenges in the region (Nayak *et al*., 2022). As a result, farmers are able to maintain their crop yields and income despite the changing climate, improving their food security and resilience to climate change impacts. Similarly, in East Africa, where maize is a major staple crop, plant breeders have developed new maize varieties that are more drought-tolerant and resistant to pests and diseases. These varieties have been shown to increase crop yields by up to 30%, even under conditions of limited rainfall and high temperatures (Chivasa *et al*., 2022). This not only helps farmers to maintain their livelihoods in the face of climate change impacts, but also promote food security and poverty reduction in the region. Overall, the development and promotion of climate-resilient crop varieties are critical components of CSA, and can help to improve agricultural productivity and resilience in the SSEZ-NG.

Meanwhile in Nigeria, drought-tolerant maize and sorghum are two examples of climate-resilient crop varieties that have been developed and promoted (Tambo and Abdoulaye, 2012). In the SSEZ-NG, which is prone to recurrent droughts and dry spells, farmers can turn to these drought-tolerant crop varieties as a way to maintain their crop yields

and income. Fortunately, the International Institute of Tropical Agriculture (IITA) has been at the forefront of developing and promoting drought-tolerant maize and sorghum varieties in Nigeria. These varieties have been specifically bred to withstand drought and other climate-related stresses, such as heat and pests. For example, the IITA has developed a maize variety called SAMMAZ 58, which is highly drought tolerant and resistant to pests, and can produce yields of up to 5 t ha^1, even under conditions of limited rainfall. Similarly, the IITA has also developed a sorghum variety called SAMSORG 47, which is highly drought-tolerant and can produce yields of up to 2.5 t ha^1, even under conditions of low rainfall (Badu-Apraku and Fakorede, 2017). This variety is also resistant to pests and diseases, and has a short maturity period, making it suitable for cultivation in areas with a short rainy season. Hence, the promotion and adoption of drought-tolerant maize and sorghum varieties in Nigeria can help to improve the resilience of farmers to climate change impacts such as droughts and dry spells, while also promoting food security and poverty reduction in the region.

Water management: Improved water management is critical in the region, and promotion of these type of efforts by implementing practices such as rainwater harvesting, small-scale irrigation, and other water conservation practices could form CSApractices in the region. In addition to rainwater harvesting and small-scale irrigation, other water management practices can be implemented in the SSEZ-NG to enhance agricultural productivity and water conservation. One such practice is the construction of water retention structures, such as dams and ponds, to capture and store rainwater during the wet season for use during the dry season. These structures can be used for small-scale irrigation and livestock watering, as well as for domestic purposes. For example, in Burkina Faso, the construction of small dams and ponds has led to increased agricultural productivity, improved water security, and enhanced resilience to climate change impacts. Another water management practice that can be promoted in the region is the use of efficient water-saving technologies, such as drip irrigation and micro-sprinklers (Yadvinder-Singh *et al*., 2014). These technologies deliver water directly to the plant roots, reducing water loss due to evaporation and runoff. They can also improve crop yields and quality, reduce water stress on crops, and enhance water use efficiency. For example, in Morocco, the adoption of drip irrigation has led to a 30-50% reduction in water use, while increasing crop yields and income for farmers (Naouri *et al*., 2017). Improved water management practices are critical for enhancing agricultural productivity and water conservation in the SSEZ-NG. By promoting the adoption of these practices, farmers can improve their resilience to climate change impacts and ensure a sustainable future for their livelihoods.

Education and awareness-raising: Education and awareness-raising campaigns could also be used to promote climate-smart agriculture practices amongst farmers and other stakeholders in the region. These efforts could aim at increasing knowledge and understanding of the impacts of climate change and the benefits of sustainable land use practices. In addition to education and awareness-raising campaigns, extension services can also be used to promote CSA practices in the SSEZ-NG. Extension services provide farmers with information, training, and support to adopt sustainable land use practices and can help to bridge the gap between research and practice. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has established network of extension agents in Nigeria which could be collaborated with for the promotion and adoption of climate-resilient crop varieties and sustainable land management practices among farmers. These agents work closely with farmers to provide them with the necessary knowledge and skills to implement these practices on their farms. Furthermore, farmer field schools (FFS) can also be used to promote CSA practices in the region. Farmer field schools are a participatory learning approach that involves farmers working together to learn and test new agricultural practices in a supportive and collaborative environment. These schools can be used to promote the adoption of sustainable land use practices, as well as to build resilience to climate change impacts. For example, in Mali, FFS have been used to promote the adoption of agroforestry practices, leading to improved soil health, increased biodiversity and enhanced resilience

to climate change. Generally, education and awareness-raising campaigns, extension services and FFS are important tools that can be used for promoting climate-smart agriculture practices in the SSEZ-NG. By increasing knowledge and understanding of sustainable land use practices and their benefits, farmers can improve their resilience to climate change impacts and ensure a sustainable future for their livelihoods. These and other efforts to promote climate-smart agriculture in the SSEZ-NG are essential for ensuring food security, reducing poverty, and building resilience to the impacts of climate change.

Using draught animal for climate smart agriculture: The SSEZ-NG experiences unpredictable and erratic rainfall patterns, leading to frequent droughts and food insecurity. The use of draught animals in agriculture presents numerous benefits, because draught animals can plough the land faster and more efficiently than manual labour, resulting in increased crop yields (Mota-Rojas *et al*., 2021). Use of draught animals in agriculture can also lead to reduced soil erosion and compaction as it avoids the use of heavy machinery. Draught animals also reduce the labor required in farming activities, allowing farmers to focus on other activities, such as marketing and value addition of agricultural produce. The use of draught animals as for transporting food and water during droughts and other climate-related disasters, could increase the resilience of communities to climate change. The use of draught animals can also contribute to increased crop yields which can lead to improved food security and nutrition in the region.

However, despite the numerous benefits of using draught animals in agriculture, there are several challenges which could hinder the widespread adoption of draught animal power in the SSEZ-NG. The cost of acquiring draught animals is often high for some farmers, making it difficult for smallholder farmers to purchase the animals. There are some farmers who lack the necessary knowledge and skills to effectively use draught animals in agriculture. There is also limited access to veterinary services in the region, making it difficult to maintain the health of draught animals. Similarly, limited access to credit is often makes it difficult for farmers to finance the purchase and maintenance of draught animals. Therefore, addressing these challenges through the provision of training and extension services can increase farmers' knowledge and skills of using draught animals in agriculture. Also, the development of affordable credit schemes may contribute to the alleviation of difficulties facing farmers in accessing credit for purchase and maintenance of draught animals. The promotion of the use of local breeds of draught animals can reduce the cost of acquisition and improve their suitability to local conditions. Some of these suggested approaches can be incorporated into government intervention programs for promotion of agriculture such as the Agricultural Transformation Agenda which is a government-led initiative aimed at increasing agricultural productivity through the adoption of modern technologies, including the use of draught animals.

Another platform that can exploited for the promotion of draught animals use in the zone is the Partnership for Inclusive Agricultural Transformation in Africa (PIATA) which is a partnership program between the African Development Bank, the Bill and Melinda Gates Foundation, and other partners aimed at promoting sustainable agricultural transformation in Africa (Blair *et al*., 2021). Through the PIATA initiatives the use of draught animals in agriculture could be promoted by organization including the International Livestock Research Institute (ILRI), which is a research organization focused on improving livestock productivity in developing countries. This is because prior this time, ILRI has conducted research on the use of draught animals in agriculture in the SSEZ-NG. Another organization with potential contribution is the Sahel Alliance which is an Africa regional initiative aimed at promoting development and resilience in the Sahel region of Africa (Sendzimir *et al*., 2011). The Alliance includes initiatives to promote the use of draught animals in agriculture as a means of increasing productivity and resilience in the region.

Conclusion

The SSEZ-NG is a region that spans across the northern parts of Nigeria, characterized by a semi-arid to arid climate, with limited rainfall and high temperatures. It is an important agricultural region in Nigeria, known for

producing crops such as millet, sorghum, cowpeas, groundnuts, and maize. However, farmers in this region face several challenges that limit their productivity and income; some of the challenges include climate variability because the Sudano-Sahelian zone is prone to droughts and irregular rainfall, which can negatively affect crop yields and pasture availability. Climate variability in this region has led to continuous cultivation with poor nutrient management practices and overgrazing which have further degraded soils and have adversely affected crop productivity. Farmers in this region often experience low crop yields due to the low fertility of the soil, inadequate access to inputs and limited access to credit and markets. Pest and disease attacks, such as that of locusts, armyworms and fungal diseases are common in the zone and these can cause significant crop damage, leading to losses for farmers.

CSA is an approach that aims to increase agricultural productivity and income, build resilience to climate change, and reduce greenhouse gas emissions. In the SSEZ-NG, CSA practices can help to address the challenges faced by farmers. In specific, CSA through conservation agriculture which involves reducing soil disturbance and maintaining soil cover to improve soil health, reduce soil erosion and increase water infiltration can help to reduce the effects of climate variability and improve crop yields. The integration of trees and crops can also help to increase soil fertility, reduce soil erosion and provide shade for crops and livestock. The harvesting of water from rainfall for use during the dry season can also help to improve crop yields and increase the availability of water for livestock consumption. The practice of integrated pest management which is an approach involving the use of multiple pest control methods, such as biological control, crop rotation, and resistant crop varieties, to manage pests and diseases at the same time is another exploitable means of supporting agricultural practices in the region.

Draught animal power is the use of animals including oxen, camel, donkey and buffalo, to help farmers in ploughing, planting, and other farming activities. In the SSEZ-NG, draught animal power is an important source of power for farmers, particularly those who cannot afford to buy or maintain tractors or other machinery. This could also be environmentally beneficial CSA practice as unlike tractors their use does not emit greenhouse gases. The use of animal traction can also help to reduce soil compaction and improve soil health, which can lead to increased crop yields. DAP can be used in areas with limited access to electricity or fuel, making it a more reliable option for farmers, particularly during periods of drought or other climate extremes. The use of DAP can increase agricultural productivity, reduce labor costs, and improve farmers' incomes, contributing to poverty reduction in the region. In conclusion, the SSEZ-NG faces significant challenges that limit farmers' productivity and income but the use of draught animal as source of farm power has potential to solve some of the problem and also promote climate resilience agricultural practice in the zone.

While research on draught animals has made important strides in understanding their feeding and nutrition, husbandry practices, welfare and health, and environmental impact, there is still much to be carried out about the human-animal relationship and sustainable humane use of the draught animals in different parts of the world. These are areas of future research focusing on exploring these areas to improve welfare, health and productivity of the draught animals for human benefits. One possible future perspective on draught animal research could be to explore the social and emotional bonds existing between humans and their working animals. These types of studies could investigate how these relationships are formed, maintained, and strengthened over time to provide insights into how to improve the welfare of draught animals and promote more sustainable and productive relationships between humans and their working animals. Another potential area of research could be to examine the cultural and societal values that are attached to working animals in different parts of the world. Understanding the role, that these animals play, in local communities and how they are viewed by different cultures could help to inform policies and practices that promote more sustainable and humane use of these animals. Additionally, research could focus on how the use of modern technology, such as GPS tracking and other monitoring devices, can improve the welfare of draught animals and enhance their productivity. By using these

tools to track animal health and performance, farmers and other animal handlers can more effectively identify and address potential issues before they become serious problems.

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Printed in September 2023