

# Agronomic and Social Adaptation to Climate Change in Subsistence Farming, Central Angola

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## Abstract

Climate change poses an increasing threat to rain-fed agricultural systems across sub-Saharan Africa. In the central highlands of Angola, subsistence farmers now face recurrent droughts, shifting rainfall patterns and rising temperatures that have the potential to reduce productivity and threaten food security. Within a local climate change context this paper identifies and assesses agronomic and social adaptations adopted by smallholding subsistence farmers in the Huambo Province of Angola. Using a mixed-methods approach that combines household surveys and participatory interviews of 418 farmers, the study establishes how climate variability is perceived and how farmers are adapting. Findings reveal high awareness of climatic change among respondents - over 85% observed reduced rainfall and prolonged dry spells. A range of agronomic, land management practices and social organisations that can mitigate climate change impacts on subsistence farming communities are also identified. The research emphasises the role of indigenous knowledge, community cooperation, and low-cost soil conservation in strengthening resilience. Policy recommendations that would further enhance resilience include promoting small-scale irrigation, improving climate information services, and integrating local knowledge into local extension services and national adaptation frameworks.

**Keywords:** Subsistence farming; climate change; adaptation strategies; resilience; Huambo Province; Angola.

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## **1 Introduction**

Climate change has emerged as one of the most pressing global challenges of the twenty-first century, exerting profound impacts on agricultural production, food security, and rural livelihoods. The Intergovernmental Panel on Climate Change [1] identifies sub-Saharan Africa as a region highly vulnerable to climatic variability with more than 70% of its population dependent on rain-fed agriculture. In this context, the effects of climate change in sub-Saharan Africa are expected to be particularly severe, largely due to the continent's high economic exposure to climate-related risks, its strong dependence on agriculture, and its limited adaptive capacity [2]. The direct impacts of climate change are projected to vary considerably across the continent. While certain areas may experience increased rainfall, much of southern Africa, including Angola, is expected to become progressively drier and hotter [3, 4]. Moreover, the dominance of smallholding and subsistence farms, combined with constrained access to resources, technology, and institutional support, renders rural livelihoods highly sensitive to even modest changes in precipitation patterns and temperature regimes [5, 6]. In Angola, agriculture contributes approximately 10% to the national GDP and is the livelihood of most rural households [7]. The central highlands - especially Huambo Province - is one of the more productive regions in the country due to their Ferralsols, which are workable but limited in inherent fertility, its moderate altitude (1,700–1,900 m asl.) and an historically reliable rainfall. However, decades of civil conflict, land degradation, and increasingly irregular rainfall have increased the vulnerability of subsistence farming. Studies indicate a progressive warming trend of 0.2–0.3 °C per decade and an annual decline of ca. 0.6% in annual rainfall since the 1970s [8, 9]. For subsistence agriculture, these trends translate into shorter growing seasons, lower soil moisture availability, and increasingly frequent crop failures. Understanding how smallholder farmers perceive and respond to these climate changes, and secondary environmental changes, is vital for designing effective adaptation measures. Adaptation is not only a technical process - often centred on crop improvement or irrigation - but also a social process that involves learning, experimentation, and local decision-making [10, 11]. Hence, this paper considers both agronomic and socio-behavioural perspectives to assess resilience in Huambo's subsistence farming. Previous studies in southern Africa have highlighted several adaptive measures in response to climate change that include intercropping, residue retention, and conservation tillage [12, 13, 14]. Yet the degree to which these practices are adopted in central Angola remains poorly documented and understood. To address this, our paper aims to establish smallholding subsistence farmer perceptions of climate variability in Huambo Province, identify and describe the agronomic and social adaptation strategies employed, and discuss opportunities to strengthen resilience through local innovation and government policy initiatives. In doing so the paper contributes empirical evidence to the broader debate on 'climate-smart' agriculture in Africa, positioning local adaptation within the framework of sustainable rural transformation.

## **2 Materials and Methods**

### **2.1 Study Area**

The research was conducted in Huambo Province, located in the central highlands of Angola between latitudes 12°30'–14°30' S and longitudes 14°00'–16°00' E. (Figure 1). The region exhibits a subtropical highland climate with, historically, a distinct wet season (October–April) and dry season (May–September). Average annual rainfall

has typically varied between 1,200 and 1,500 mm, while mean annual temperature ranges from 17°C to 22°C. Elevations between 1,700 and 1,900 m and gently undulating topography make Huambo one of Angola's most suitable zones for rain-fed crop production, particularly maize, beans, potatoes, and vegetables. Scenarios of climate change for Huambo Province based on colonial and postcolonial local climate data sets for 1960-2017 demonstrates increases in average annual temperatures, decline in average annual rainfall, increase in the length of the dry season and reduction in the number of rainy days [9], while the worst drought in 30 years across the south western part of Angola substantially lowered productivity in the 2020-21 agricultural season [15].



**Figure 1:** Study site location map, Huambo Province, Angola

Soils are predominantly Ferralsols and Acrisols, moderately deep and rich in iron oxides but low in organic matter and nutrients and can have limited water holding capacities [7, 16, 17, 18]. Recurrent cultivation without adequate soil amendment has accelerated nutrient depletion, making farmers increasingly dependent on manure and crop residues for fertility maintenance. The landscape consists of small, dispersed villages and farms averaging 1–2 hectares in size, divided into often discontinuous small plots.

## **2.2 Population and Sampling**

The population of interest comprised subsistence farmers engaged in rain-fed agricultural production. Participants were selected from four municipalities within Huambo Province: Huambo, Bailundo, Longonjo and Mungo. Using a purposive sampling approach, 418 farmers were interviewed between May and August 2019. Eligibility criteria required that each respondent be aged 18 years or older, have a minimum of three years of farming experience, and rely primarily on agriculture for household income. Participants typically represented a family household of that included between 3 and 7 children. Land is often acquired through its passing from generation to generation with traditional village authorities mediating this transaction. For subsistence farmers, secure access

to land is the fundamental foundation for decent living conditions and is considered the main wealth of the family.

The sampling design captured the range of local agro-ecological conditions associated with the Province's smallholder subsistence farming in Huambo Province and included land of varying terrain and soil water capacities growing a range of crops that included maize, potato, beans, millet and sorghum [19, 20]. Participation in the study was entirely voluntary. Respondents were informed about the purpose of the research and their right to withdraw at any time. Informed verbal consent was obtained before each interview. The data collected were anonymised to ensure confidentiality (see [20] for further details of methodology).

### ***2.3 Data Collection and Analyses***

Data were collected through a mixed-methods approach, combining both quantitative and qualitative techniques.

- Structured questionnaires with 53 closed and semi-open questions were administered to all 418 participants. The questionnaire covered topics that included climate perception, adaptation practices, resource access, and household characteristics.
- Participant interviews were conducted by local agricultural extension officers and experienced community leaders of farmers to gather contextual insights on adaptation and knowledge transfer.
- Focus group discussions (FGDs) were held in each municipality, with the participation of members of the community as a group, to explore shared experiences and local adaptation narratives.
- Climatic data (1960–2017) were obtained from the Agronomic Research Institute (IIA) of Chianga, providing long-term records of temperature and precipitation trends that were statistically analysed using statistical reduction methods (regression, correlation, time series) and statistical prediction methods (integrated autoregression models, moving average - ARIMA) (see [9]).

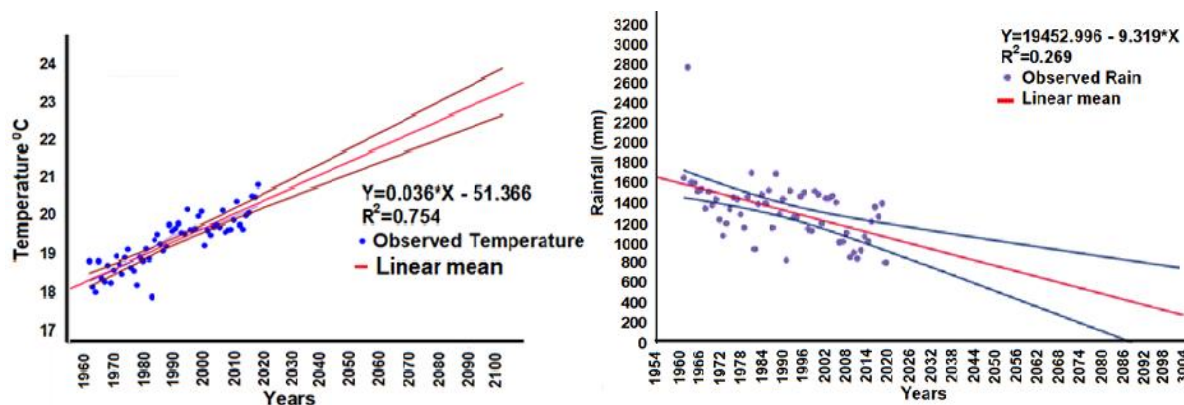
Quantitative data were analysed using SPSS (v26) and Microsoft Excel, applying non-parametric statistics to summarise frequency distributions and identify patterns among farmer responses. Descriptive statistics (means, percentages, and cross-tabulations) were used to examine relationships between variables such as age, gender, and adaptation practices.

Qualitative information from interviews and FGDs was transcribed, coded, and analysed thematically using NVivo 12, focusing on farmers' perceptions of climate risk, adaptation decision-making, and constraints. The integration of both data types ensured triangulation and enhanced the robustness of the findings.

## **3 Results and Discussion**

### ***3.1 Observed Climate Trends and Farmer Perceptions***

Long-term meteorological data (1960–2017) from the Chianga station reveal a consistent warming trend in Huambo Province (Figure 2). Average annual temperatures increased by approximately 3°C over the period, while mean annual rainfall declined by nearly 0.6% and dry season months have increased from three to five [9].



**Figure 2:** Projected Average Temperature and Rainfall Trends (1960–2100), Huambo Province. Simulated scenario based on local climate data sets showing a steady projected temperature increase (3–5°C) and a projected decline in mean annual rainfall (up to 20%) by 2100 (Kiala and Simpson, 2023)

Farmer perceptions closely relate to the trends highlighted in the local historical climate data and confirm a growing and nuanced awareness of climatic change at the community level (Table 1). 91.4% of respondents agree that the weather is getting hotter and in a related question 89% agree that the average temperature in a year is increasing. With regards to rainfall parameters, 78.4% of respondents agree that rainfall is declining with 88.3% identifying delay in the onset of rains, 70.6% recognising increase in rainfall variability and 69.5% indicating that prolonged droughts have been increasing. Concern was also expressed about soil degradation and associated fertility depletion, compounding the impacts of climate change.

These perceived trends in climate are directly linked by farmers to observed changes to crop productivities and in adaptive land management practices. Many farmers described how erratic rainfall had disrupted crop calendars and forced adjustments in sowing dates – including later planting – and in crop selection. 66.6% of respondents are of the view that climate change is making agricultural production more difficult with prolonged drought and 80.8% of respondents recognised recent decreases on crop productivity including declining yields of maize, beans and potatoes, the principal crops. Such observations align with other studies from local areas and regions, confirming increasing climate variability and its impact on subsistence agriculture across southern Africa [5, 6]. There is now clear recognition of climate change and its impacts on land productivity – actual and anticipated – and increasing acknowledgment that while progress has been made in adaptive land management this will be insufficient to manage the long-term impacts of climate change. This is now encouraging an openness to new approaches to land management, demand for additional, effective, institutional support and strong integration between stakeholders.

**Table 1:** Farmer perception of local climate change and agricultural consequences, Huambo Province

<i>Perceived Climate Change</i>	<i>Farmer Response (agreed %)</i>
The weather is getting hotter	91%
Average temperature is increasing	89%
Rainfall is declining	78%
Rainy season onset is delayed	88%
Rainfall variability has increased	71%
Droughts have increased	69%
Agricultural production is more difficult because of climate change	67%
There have been recent declines in crop productivity	81%

### **3.2 Adaptive Agricultural Practices**

The survey evidence indicates a range of local adaptation strategies by the farmers of Huambo Province in the face of climate change (Table 2). These combine indigenous knowledge and local low-cost resource-based adjustments. Three main categories of land management practices were identified, often used together, that have varying adoption, effectiveness and limitations in Huambo Province. These practices are: (i) agronomic adaptations that also give livelihood diversification, (ii) organic material management and soil fertility, (iii) mechanisation, (iv) irrigation practice and (v) social adaptations.

**Table 2:** Major adaptive practices in response to climate change, reported by farmers, Huambo Province

<i>Adaptive Strategy</i>	<i>Farmer Response (%)</i>	<i>Key Benefits (as indicated in farmer interview)</i>
Change to crop sowing times	37%	Reduces crop failure
Inter-cropping (maize, beans, groundnuts)	98%	Soil cover, moisture retention, minimises crop disease; risk spreading
Crop diversification (cassava, sweet potato)	63%	Food security in drought conditions
Use of drought tolerant crops	27%	Improves yield stability
Weed control (manual)	72%	Helps conserve soil moisture
Use of organic manures	61%	Soil fertility, structure improvement, moisture retention
Mulching for residue retention	44%	Reduces evaporation from soils; improves soil organic matter status
Mechanisation	8%	Improves operational efficiency
Irrigation (low technology, labour intensive)	37%	Extends growing season and increases crop yield (for vegetable crops)

*Agronomic adaptations.* Increasingly, farmers are changing their crop sowing times to reflect changes in the onset of the rainy season. 37% have changed their timings so that sowing of rainy season crops coincides with the onset of rains. Although this is a relatively low percentage currently, this adaptation is likely to increase with continuing rainy season changes; there is however a clear recognition amongst farmers that changes in sowing times often means a shorter growing season and the consequent decline in crop productivities. Throughout the discussions of agronomic adaptations, respondents consistently highlighted the need for more reliable, timely and accessible weather forecasting as a key tool in agronomic adaptations, particularly in relation to the onset of the rainy season and variabilities in occurrences and intensities of rainfalls.

98% of farmers highlighted inter-cropping as the most important cultivation technique in mitigating the impacts of climate change and sustaining food production by diversifying farm production (Figure 3). Crops typically include maize with beans, groundnuts, potatoes and leaf cabbage, although this varies with local customs, and is

considered to give greater land use efficiencies, minimize crop diseases and pests, maintain soil moisture and reduce micro-climatic temperatures beneath the crop canopy. This approach also gives a cover-crop throughout the growing season and is recognised as assisting in erosion prevention.



**Figure 3:** Intercropping maize growing together with beans, potatoes and leaf cabbage (kale) in Huambo Province, (Bailundo Mungo and Longonjo municipalities)

Further experimentation with crop diversification is also being practiced by the Huambo subsistence farmers (63%) and includes the introduction of cassava and sweet potato. This approach is seen as a further attempt to reduce the risks associated with crop failure although there is little knowledge on how these introductions may respond to new and changing climatic conditions - only 27% of farmers are using drought-tolerant varieties across all crops grown. Interviews confirmed weed control as a long-standing agricultural practice in Huambo Province that encourages crop growth, but now increasingly recognised as an essential management practice in the conservation of soil moisture [21]. 72% of farmers explicitly practice weed control, primarily through manual labour hoeing.

*Organic material management.* Organic material and soil fertility management includes use of organic manures, mulching and crop residue management and is a cornerstone of soil management in Huambo's smallholder subsistence agricultural practice. Within the surveyed households, 61% apply farmyard manure to cropping areas and this is recognised as improving soil structure, giving greater moisture retention and so helping buffer crops against dry spells, and are a vital aspect of 'climate-smart' soil management [14]. Application of animal manures to cropland is also vital in maintaining soil fertility across the region where natural soil fertility is low, especially as only 22% of respondents use chemical fertilisers and then only occasionally, with cost, availability and lack of advice constraining their use.

While the percentage of households applying the available manure is relatively high, the volumes applied per hectare are low and compounded by declining numbers of livestock across Huambo Province, as indicated by the survey. Availability of animal manures is low as few cattle are kept – typically two per household used as draught animals and although chickens and goats could also provide a source of manure these are typically free-range making manure collection difficult. 39% of farmers would like to more fully integrate cropping and livestock within their farming enterprise, particularly small ruminants and poultry (Figure 4) and this may become possible with careful tending and corralling management of livestock although the labour required to do so may be a

limiting factor.



**Figure 4:** Partial integration of livestock (cattle, goats and free-range poultry) within subsistence cropping systems after harvest, reflecting the limited availability of animal manure for soil fertility management Huambo Province (Huambo, Bailundo and Longonjo municipalities)

Limitations in animal manure applications could be also partially offset by the incorporation of post-harvest crop residue incorporation into the soil, enhancing soil organic matter status [22, 23]. This land management practice is encouraged by reports that the influence of crop residues on yield is closely associated with physical, chemical, and biological properties that influence soil fertility [14]. However, many subsistence farmers continue to practise the open-field burning of agricultural residues, often perceived as the only viable management option for crop residues, with intense burns also removing soil organic matter. However, although crop residue burning practice remains widespread in Huambo Province a considerable number of subsistence farmers have begun to adopt more sustainable approaches, particularly the incorporation of plant residues directly into the soil rather than through burning. From a conservation agriculture perspective, these findings reveal an evident gap between the recognised benefits of sustainable residue management and its practical implementation at the farm level. Although a significant proportion of farmers (44%) fully incorporate crop residues into the soil (Figure 5) - thereby contributing to soil cover, organic matter accumulation and the enhancement of soil biological activity - the majority (66%) continue to partially or completely burn residues., this latter practice directly contradicting one of the core principles of conservation agriculture, namely the maintenance of permanent soil cover.



**Figure 5:** Plant residue incorporation in peanut and maize crops for soil moisture conservation - Huambo Province (Mungo and Bailundo municipalities)

The continued reliance on residue burning not only accelerates nutrient depletion and reduces soil organic carbon but also disrupts soil microbial processes that are essential for long-term soil fertility and resilience. Furthermore, the absence of adequate soil cover increases vulnerability to erosion and exacerbates soil moisture losses, undermining the adaptive capacity of subsistence farming systems to climatic variability. These observations suggest that beyond technical knowledge, structural constraints - such as limited access to appropriate tools, labour availability, and extension services - play a decisive role in shaping residue management decisions. Consequently, promoting conservation agriculture in such contexts requires integrated interventions that combine farmer training, institutional support, and context-specific residue management alternatives to ensure both environmental sustainability and livelihood security.

*Mechanisation.* The survey findings indicate a pronounced reliance on manual labour and animal traction for land and crop management with 92% of farmers employing hand tools such as hoes, shovels, and machetes rather than mechanised equipment. This limited level of mechanisation has direct implications for labour productivity, timeliness of field operations, and the overall capacity of farmers to respond effectively to climatic constraints. Mechanisation adoption varies markedly across age and resource cohorts, with older and relatively better-resourced farmers (over 50 years of age) being more likely (15% of the survey cohort) to utilise mechanical or semi-mechanical equipment. Access to such equipment is typically facilitated through farming co-operatives or institutional support from government agencies and by non-governmental organisations, and is particularly the case for crops such as potatoes, maize, cassava, and sweet potato, where land preparation mechanised demonstrably enhances operational efficiency.

The restricted access to tractors observed in Huambo Province mirrors patterns reported in neighbouring Zambia and Malawi [13, 24], suggesting a broader regional constraint rather than an isolated local challenge. From an impact perspective, the predominance of manual cultivation limits the area of land that can be cultivated per household and delays critical farming operations, thereby increasing exposure to rainfall variability and shortening effective growing season windows. Conversely, farmers with access to mechanisation report measurable benefits, including reduced labour requirements, improved timeliness of planting, and the capacity to cultivate larger areas which collectively enhance adaptive capacity to climate change. These results underscore the role of mechanisation not merely as a productivity-enhancing input, but as a strategic adaptation mechanism by smallholder subsistence farmers facing increasing climatic uncertainty although affordability remains a fundamental constraint to adoption.

*Irrigation practice.* The survey results indicate that only 37% of subsistence farmers practise irrigation during the dry season as an attempt to extend the productivity period of vegetable crops, underscoring the continued dominance of and reliance on rain-fed agriculture in the study area. Marked spatial disparities were observed across the surveyed locations and irrigation methods remain predominantly low-technology and labour-intensive: 29% rely on manual bucket irrigation, and 37% employ gravity-fed surface irrigation systems that flood the soil using water abstracted from intermittent rivers or small, rudimentary community reservoirs (Figure 6).

From an operational standpoint, irrigation frequency is generally low, with only 7% of irrigating farmers applying water more than once per week, 22% irrigating weekly, and 8% irrigating monthly. These low application frequencies have measurable consequences for crop performance as they constrain soil moisture availability during critical growth stages thereby limiting yields and crop diversity during the dry season. The limited extent and intensity of irrigation reflect the absence of basic irrigation infrastructure across the majority of farms coupled with restricted access to reliable water sources.

Importantly, farmers consistently identified climate change as a key driver of declining water availability, citing reduced rainfall, increased inter-annual variability, and prolonged drought episodes. In several localities, subsistence farmers reported the complete drying of natural water sources, while remaining springs and streams exhibit progressively reduced discharge. As a result, irrigation - particularly manual bucket watering - has become unfeasible for many households, effectively reducing dry-season vegetable production and narrowing dietary diversity and income opportunities. This reduction in water availability is already translating into measurable declines in the range and volume of winter vegetable production, with spill-over effects on household water supply for drinking and domestic use.



**Figure 6:** A small spring and water reservoir where subsistence farmers draw water for irrigation using manual and surface flooding irrigation systems method - Huambo Province, (Huambo, Bailundo municipalities)

These productivity constraints are further exacerbated by limited labour availability, the absence of affordable water storage and conveyance technologies, and weak institutional capacity to support drought adaptation. Within the context of climate-resilient subsistence agriculture, these findings highlight the urgent need for accessible, small-scale irrigation solutions that are compatible with the limited labour and resource endowments of subsistence farming. In the effort to overcome such limitation simple technological monitoring aids for smallholder irrigation management are already available [25, 26] and such technologies represent a critical adaptation pathway for reducing dependence on increasingly unreliable rainfall and would help stabilise dry-season production and so enhance the resilience of subsistence farming under changing climatic conditions.

The strong dependence of subsistence agriculture on seasonal rainfall renders it highly vulnerable to environmental variability. Climate change - as evidenced by Kiala and Simpson [9] - has contributed to both a reduction in total rainfall and its uneven spatial and temporal distribution. This has increased rainfall unpredictability for subsistence farming communities and undermined the sustainability of agricultural production. Highly sensitive crops frequently experience water stress and, in many cases, complete crop failure due to prolonged dry conditions (Figure 7). Furthermore, the adoption of irrigated agriculture within subsistence

farming systems remains severely constrained by limited access to technology, labour shortages, and weak institutional capacity to support drought adaptation strategies. Survey data indicate that only 24.9% of subsistence farmers irrigate their fields once per week, while 7% irrigate more than once per week and 10.6% irrigate only once per month. In contrast, a substantial proportion (57.6%) of farmers do not irrigate their crops at all and remain entirely dependent on rainfall for agricultural production. The limited adaptive capacity of subsistence agriculture combined with the absence of sustainable technologies poses a significant challenge to achieving adequate food production.



**Figure 7:** Maize crop failure in a subsistence agricultural system resulting from insufficient rainfall and the absence of irrigation infrastructure, Huambo Province, (Bailundo, Mungo municipalities)

*Social adaptations.* Focus group discussions during the survey highlighted that social learning and local experimentation often underpinned adaptation success. Farmers exchange seeds, share information on rainfall patterns, and co-operate in building small irrigation dykes. Community institutions, including farmer associations and church groups, were found to play an increasingly vital role in disseminating adaptation information within informal and semi-formal forums representing a social capital that complements and enables land management adaptation measures [27].

The focus groups also highlighted the increasingly vital role of female farmers, who comprised just over half of the respondents, and who play a critical role in maintaining household food security especially through seed selection, residue management and small livestock care. However, women face systemic barriers such as unequal land tenure and limited access to extension services and it was evident in our focus groups that these factors constrain adaptive capacity within Huambo Province [28]. Focus groups and interviews also brought forward literacy limitations, with the survey indicating a 21% literacy rate within the Huambo subsistence farming community. This is seen as a barrier that limits understanding the phenomena of climate change as well as in communicating the possibilities of new adaptations.

#### **4 Conclusions**

Subsistence farming in Huambo Province, and by extension much of central Angola, faces mounting vulnerability due to increased temperatures, declining and variable rainfall that is further exacerbating existing land

degradation, and socio-economic constraints. Farmers recognise and have a high level of awareness of these climate changes leading to modifications in land management practices, although there are a significant minority in the smallholding farmer community who don't recognise the nature of climate change nor are evidencing adaptation to these changes. For those that are adapting, the findings of this study reveal a remarkable, if variable, degree of adaptation, innovation and resilience. This is demonstrated through enhancements in inter-cropping, crop diversification, organic material management for soils, mechanisation, irrigation practice and community-based cooperation, but these activities are limited by structural constraints. The coexistence of both traditional and adaptive agronomic practices indicates that smallholder farmers in Huambo province are actively responding to climate induced environmental stress even in the absence of formal institutional support. These locally developed responses are cost-effective and sustainable but are arguable insufficient of themselves given the intensity of climate change being faced by these communities; they require external support and reinforcement to achieve long-term and sustainable resilience across the whole farming community

We recognise the limitations of our study – it is confined to one agro-ecological zone, there is further quantitative and modelling analyses to be undertaken that explores the complex relationships between climate change drivers, social settings and agricultural adaptations, and assessment of productivities resulting from land management adaptations is required. Nevertheless, our current study does permit four key recommendations to be proposed that will enhance adaptive capacities and subsistence farm community resilience in Huambo Province, and which has resonance for other smallholder farming communities across sub-Saharan Africa. These recommendations are:

- Strengthen access to climate information, meteorological data and early-warning systems through community-based dissemination networks. Giving anticipated weather conditions throughout the farming year will enhance the effectiveness of local responses.
- Assess where small-scale irrigation technologies and water harvesting can be most effective and promote these as critical buffers against drought.
- Integrate indigenous knowledge with national adaptation policies, ensuring that local innovation informs extension and research agendas. This should incorporate new understandings of how to manage drought resistant crops, encouraging greater use of inter-cropping and incorporation of post-harvest crop residues into soils.
- Further emphasise and support the vital role of women in farm management and give further support to broader literacy programmes.

Similar trends in recognising climate changes and adaptation to these changes are evident in smallholder farming communities across sub-Saharan Africa [29, 30, 31], varying with local environmental and socio-cultural contexts Reference [32]. Here we see the same range of adaptation activities, with perhaps a greater emphasis on adjusting planting dates resulting from rainfall pattern change and in the adoption of more than one adaptation management practice by individual farmers. Failure to adapt is frequently related to socio-economic inequalities that are gender driven and limited access to markets, carrying major consequence that leave local farmers susceptible to nutritional limitations and mental health issues. Local farmer adaptation initiatives across sub-Saharan Africa, as in Huambo Province, are also hampered and limited by structural constraints with minimal state or NGO support,

particularly in relation to collective irrigation and water management systems, restoration of damaged environmental resources, regulation of bush burning and provision of trusted agricultural extension services. This has led to persistent calls for supportive interventions that strengthen community-based adaptation strategies together with monitoring and evaluation [33, 34]. Where institutional support has been put in place - such as farmer field schools and climate information services in Zambia and Zimbabwe – adaptation outcomes are significantly enhanced [13].

Adaptation in Angola's subsistence agriculture to climate change is underway and must be viewed as both a social and agronomic process - one that depends on empowering farmers, improving information access, and investing in soil and water management. Sustainable and resilient rural transformation in the face of disruptive climate change will rely on integrating these low-cost, farmer-led innovations into national development frameworks.

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