Climate Change Threats to Semi-Arid Transhumance Grazing Systems: Proposals for Adaptation in Cabo Verde

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Abstract

Global warming has changed the rainfall regime in the Sahelian region, endangering and widespread poverty and chronic famines in Cape Verde, where rural communities' well-being and food security depend on rainy agriculture. Local responses to rainfall new patterns and scarcity have been livestock reduction with significant revenue losses. Together with dry mist occurrences, these environmental constraints demand to define priority actions to adapt and mitigate climate change's direct impacts. According to fifty household inquiries, this work explains the transhumant grazing practices on a semi-arid plateau in Tarrafal (Santiago, Cabo Verde), prospecting adaptation alternatives for sustainability. We related grazing patterns and pastoral infrastructures to the household's socioeconomics, analyzing the livestock system - composition and management - and their relationship to rangeland utilization. Livestock of male-headed households is different from female-headed ones, mainly cattle in the firsts and goats in the lasts. Herds decreased during the 2016-2018 drought, including equine that lost interest in supporting farmers that abandoned the most remote agriculture patches. Based on a carrying capacity zoning, the geographical analysis assessed existing water supply structures' suitability and designated new ones to improve transhumance effectiveness. New watering points along principal depressions allow to establish forage species - *Parkinsonia aculeata*, *Opuntia ficus-indica*, *Pannisetum pedicellatum*, and *Desmanthus virgathus* – and reduce stormwater runoff. It also means to improve natural resources by biodiversity conservation and wildlife management. These and other proposals could sustain and adapt the Tarrafal transhumant grazing system to climate change, reduce the farmers' income loss, and improve food security.

Introduction

The role of livestock in food security and poverty reduction in West Africa is globally acknowledged. Livestock products provide global calories and protein for human consumption (Bowles *et al*., 2019). Furthermore, extensive livestock is carried out in disadvantaged areas for agriculture or in locations where it is not feasible. Also, it provides manure for agricultural production (FAO 2011).

Pastoral systems are mostly found under harsh environmental conditions, usually in dryland areas. They show a remarkable ability to take advantage of fluctuations in resource availability. Through the ages, pastoralists and their animals have developed adaptive capacities to face spatial and temporal scarcity of pastoral resources (Schoenbaum *et a*l. 2017). Animal mobility is one of the main strategies to respond quickly to fluctuations in resource availability, and they are used in different forms: nomadism, transhumance, or moving herds around outside the structural limits of the farm (Castro *et al*. 2020). However, the capacity for adaptation and resilience is not limitless, and these systems now face the global challenge of climate change.

Climate change is a major concern for current livestock systems worldwide (Godde *et al*. 2021). Their variable dependence on the climate will variably affect the different livestock production systems: industrial or landless, crop-livestock and grazing or pastoral (Nardone *et al*. 2010). Pastoral systems will be exposed to harsh climatic effects, particularly in dryland areas; some studies forecast up to 50% loss of available biomass (Nardone *et al*. 2010).

Therefore, climate change is a challenge both for pastoral systems and millions of pastoralists worldwide, at risk of losing their livelihoods (FAO 2020). Global warming and its associated changes in mean climate

variables and climate variability affect feed and water resources and animal health and production (Godde *et al*. 2021). Those threats are particularly severe in Small Island Developing States such as Cabo Verde, characterized by isolation, vulnerability to natural disasters, scarce soil and subsoil resources, recurrence of droughts, fairly small market size, despite a huge opening to the outside world (ADB 2013)

This study investigates the transhumance system of Tarrafal (Santiago island, Cabo Verde) to perceive how the herders' expectations to adapt their rangelands and practices to climate change relate to pastoral communities' socio-economic conditions.

Study Site and Methods

The study focuses on five communities of Tarrafal in the north-east of the Santiago island (15º16'N, 23º45'W) that benefit from 2494 hectares of a fenced semi-arid pastoral plateau (20-300m a.s.l, 24.5 °C, 300 mm): Trás-os-Montes and Fazenda are inside, and Mato Brasil, Achada Moirão, and Biscainhos are outside the plateau. The rangeland is a savanna-like landscape of *Prosopis juliflora* promoted by FAO in the 70s with important shrublands of *Euphorbia tuckeyana*, *Sarcostemma daltoni*, *Paronychia illecebroides* in uplands, *Compylanthus glaber* and *Nauplius daltonii* in southern slopes, *Cynodon dactylon*, *Melinis repens*, *Aristida sp*, *Ipomoea purpurea,* and *Commicarpus helenae* in low lands, and *Ricinus communis*, *Jatropha curcas*, and *Cassia bycapsularis* around water streams.

The investigation is based on family interviews covering 50 pastoralist households that utilize the plateau – 25 woman-headed and 25 man-headed – and secondary information from qualified official sources. The inquiries included data on the population structure and educational background, composition of livestock, the organization of livestock husbandry and plateau use, and the people´s livelihoods.

ANOVA was performed to determine differences in structure and socio-economic assets of the households between locations (one-way) and to determine differences in the herd composition among locations and genres (two-way). Pearson's Chi-squared tests were used to find if there were significant differences in the livestock management (surveillance period and feeding system after going back) of different locations

Results

Structure and socio-economic assets of the households

Out of 50 households, nearly two-thirds (62%) are composed of nuclear families with children, a fourth part by nuclear without children (24%), and only 14% by extended families. More than half of these families have no children (0-15), 38% have one or two in this age class, and only 4% have three child members. Within the working population (15-64), 28% of respondents have four or more elements, 40% have three people, 14% have two or no people, and only one element compose 4%. In the older layer (> 65), 34% have two and 26% one people, 40% of households do not have people in this age group.

Education levels were generally very low - more than three-quarters (74%) of the respondents have no formal instruction, but 8% have a superior education level (Table 1). Despite being small-scale livestock keepers, most of them have another main profession; 38% of respondents have a professional activity not related to agriculture (Table 1). All households have extra income from various sources (Table 1). No significant differences were found in the structure and socio-economic assets between locations.

Table 1 - Socio-economic assets of the households in percentage.

Education level	No education 64	Alphabetization 10	Primary /secondary 12 + 6	Superior 8
Employment	Domestic 40	Farmers 22	Teachers 18	Others 20
Extra income	Remittances emigrants 45	Social grants 31	Retirement 21	Study grants 3

Livestock types, herd sizes, and genre ownership

The households own various livestock although the number of heads per household is very low (Table 2). No significant differences were found in the ownership of different livestock type and mean herd size between locations. The herd size of cattle is higher for male-headed households- ($p = 0.022$), and the number of goats is higher for female-headed households- ($p = 0.009$).

Table 2 - Livestock ownership and heads

Livestock type	Number of households	Median herd size/household
Goats	49	4 (1-70)
Sheep	36	2 (2-4)
Cattles	45	2 (1-4)
Donkeys	20	

Livestock and rangeland management proposals

Majority of 5the households practice transhumance. In the early rainy season, around July, animals move in a short migration after the long dry season, mainly cattle and sheep and goats, towards the Tarrafal plateau. While they are away from their farms, animals are surveyed every 8 or 15 days ($\chi 2 = 27.161$***), depending on smallholders' residency. With the end of the rainy season (October-November), pastoral resources start to be scarce and, in two months, they are depleted. Thus, animals back to the farms around February, some are sold, and others are kept. Smallholders living outside of the territory plateau fed their animals at home with crop residues, mainly maize straw and grass caught in remote areas. The animals of the plateau villages continue to be fed on pastures around the houses ($\chi 2 = 37.264$***).

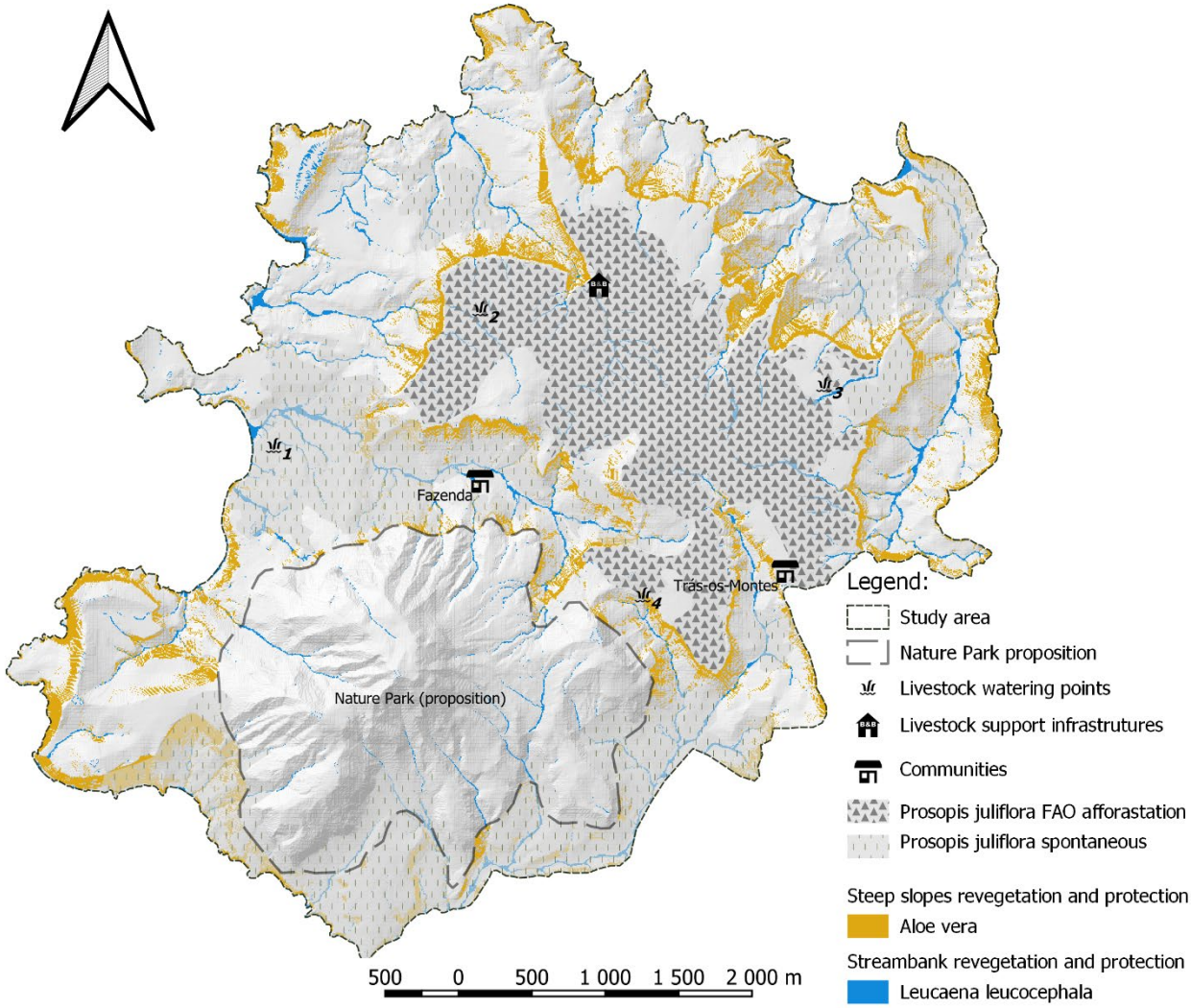

Figure 1 - Study area and pastoralists' proposals based on climate change perceptions.

Figure 1 illustrates the proposals that users perceive and refer to as necessary to adapt its plateau to climate change. It includes livestock infrastructures – watering points and support buildings – and revegetation of streams (*Leucaena leucocephala*), steep slopes (*Aleo vera*), and a gradual replacement of *Prosopis juliflora* by *Parkinsonia aculeata*, *Opuntia ficus-indica*, *Pannisetum pedicellatum*, and *Desmanthus virgathus*. Furthermore, local communities mentioned the government proposal to establish a new Nature Park inside the study area – Monte Graciosa – that is intended as an additional opportunity to invest in the recovering of its rangelands.

Discussion and Implications

About three-quarters (74%) of the respondents have no plans to increase their herds. Some livestock keepers are old aged, and working conditions are very harsh. Croplands are too far away from the homesteads, making it difficult to transport both the crops and the by-products used in animal feed at home. In turn, climate change increases livestock uncertainty and income insecurity, which may lead to the abandonment of the activity, contributing to food insecurity and poverty. Tarrafal transhumant system consists of livestock moving between dryland crop areas and rain pastures. The transhumance system reduces rural communities' exposure to hunger and poverty in preserving their livelihoods.

Livestock's vulnerability to climate shocks depends first on their exposure, which is determined by the duration, frequency, and severity of the shocks and the location of the stocks and related assets (e.g., feedstock, housing, water points) (FAO, 2013). The duration and frequency of drought periods in the Sahelian region have been increased in the last years. Thus, adaptation measures should be in place at the farm, community, and policy levels to guarantee food security and safeguard rural sustenance from climate change impacts. Possible adaptive responses include policy alternatives (e.g., infrastructural development)

Based on a carrying capacity zoning, the geographical analysis assessed existing water supply structures' suitability and designated new ones to improve transhumance effectiveness. New watering points along principal depressions allow to establish forage species – *Parkinsonia aculeata*, *Opuntia ficus-indica*, *Pannisetum pedicellatum*, and *Desmanthus virgathus* – and reduce stormwater runoff. It also means to improve natural resources by biodiversity conservation and wildlife management. These and other proposals could sustain and adapt the Tarrafal transhumant grazing system to climate change, reduce the farmers' income loss, and improve food security.

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