Thesis

submitted in partial fulfilment of the requirements for the awards of a
Master's degree in Sciences et technologie de l'agriculture, l'alimentation et l'environnement
Parcours Ressources systèmes agricoles et développement (RESAD)

What support for agro-pastoralists in Kunene (Namibia) under increased pressure from climate change and competition with wildlife for natural resources?

Study of the agrarian systems of Ongongo and Ombujokanguindi conservancies

Léon BICKEL-PASCHE

October 2024

Host institutions :
Agronomes et Vétérinaires sans Frontières (AVSF), France
Integrated Rural Development and Nature Conservation (IRDNC), Namibia

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October 2024

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ABSTRACT

This study investigates the agrarian systems of the Ongongo and Ombujokanguindi conservancies in northwestern Namibia. Conducted in collaboration with Agronomes et Vétérinaires sans Frontières (AVSF) as part of a broader initiative to strengthen community rights and enhance livelihood resilience, this research aims to inform interventions that address the challenges posed by climate change and human-wildlife conflicts (HWC) to agricultural livelihoods. Using a mixed-methods agrarian diagnosis approach, the study characterizes the socio-economic and ecological dynamics of local farming systems as well as their technical and economic performances. It highlights the historical context of marginalization, particularly under colonial and apartheid rules, which has left livestock and crop production vulnerable. Key findings reveal that HWC and erratic rainfall significantly increase this vulnerability. Today, food security in Kunene is in an exceedingly fragile state and a majority of farmers rely on alternative incomes, pensions or food aid to feed their families. In contrast, practices focusing on irrigated agriculture show promising potential even though the type of cropping and purposes of cultivation must be carefully contemplated. Recommendations emphasize enhancing local agricultural practices, prioritizing subsistence cropping, and improving veterinary services to bolster resilience against climate shocks and market fluctuations. This study advocates for a shift in focus from state-organized safety nets in form of aid and pensions to sustainable, community-driven agricultural livelihoods strategies that ensure food security and economic sovereignty.

Key words

Agriculture, farming systems, Kunene, climate change, conservation, pastoralists, livelihoods, food security, Community-based natural resource management

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RÉSUMÉ

Titre : Quel soutien pour les systèmes agro-pastoraux de Kunene (Namibie) face à une pression accrue du changement climatique et de la concurrence avec la faune sauvage pour les ressources naturelles ?

Cette étude analyse les systèmes agraires des conservatoires de Ongongo et Ombujokanguindi dans le nord-ouest de la Namibie. Réalisée en collaboration avec Agronomes et Vétérinaires sans Frontières (AVSF) dans le cadre d'une initiative plus large visant à renforcer les droits des communautés et à améliorer la résilience de leurs moyens de subsistance, cette recherche vise à éclairer les interventions voulant répondre aux défis posés aux systèmes agro-pastoraux de la région de Kunene par le changement climatique et les conflits avec la faune sauvage. En utilisant la méthode du diagnostic agraire, cette étude caractérise les dynamiques socio-économiques et écologiques des systèmes agricoles locaux ainsi que leurs performances techniques et économiques. Elle met en lumière le contexte historique de marginalisation, en particulier sous les régimes coloniaux et d'apartheid, qui a rendu les systèmes agro-pastoraux particulièrement vulnérable. Les résultats clés révèlent que les conflits avec la faune sauvage et les pluies erratiques augmentent considérablement cette vulnérabilité. Aujourd'hui, la sécurité alimentaire dans la région de Kunene est dans un état extrêmement fragile et la majorité des agriculteurs dépendent de revenus extérieurs, de pensions ou d'aide alimentaire pour subvenir aux besoins de leurs familles. Néanmoins, les pratiques axées sur l'agriculture irriguée montrent un potentiel prometteur, même si le type de cultures et leurs fins doivent être soigneusement réfléchis. Les résultats soulignent la nécessité d'investir davantage dans le développement des pratiques agricoles locales en priorisant les cultures vivrières et l'amélioration de la santé des troupeaux par les services vétérinaires afin de renforcer la résilience des exploitations et des familles face aux chocs climatiques et aux fluctuations du marché. Cette étude plaide donc pour un changement de cap des politiques publiques et de développement, passant de l'aide alimentaire, les pensions et les activité extra-agricoles à un investissement plus important dans le développement de moyens de subsistances agricoles durables et adaptés à même de garantir la sécurité alimentaire et la souveraineté économique des ménages.

Mots clés

Agriculture, pratiques agricoles, Kunene, changement climatique, conservation, systèmes pastoraux, sécurité alimentaire, Community-based natural resource management

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FOREWORD

The present study was conducted during a six month mission for Agronomes et Vétérinaires sans Frontières (AVSF) in Namibia as an end-of-study internship for the partial fulfilment of the Master's degree in Sciences et technologie de l'agriculture, l'alimentation et l'environnement, with specialisation in Ressources systèmes agricoles et développement (RESAD) at the Institut Agro in Montpellier.

The research team was composed by a student of Institut Agro Monptellier, an agronomist project coordinator based at the Integrated Rural Development and Nature Conservation (IRDNC) Office in Opuwo, and a local conservation and natural resource management alumni recruited for translation purposes. All field trips to the study areas were coordinated with project activities of IRDNC and AVSF, in which the study team was also involved.

The overall AVSF-IRDNC project in Ongongo and Ombujokanguindi conservancies as well as the present study were supervised by a program manager based in Lyon, France.

GLOSSARY OF TERMS & ACRONYMS

AVSF	Agronomes et Vétérinaires sans Frontières
IRDNC	Integrated Rural Development and Nature Conservation
AfD	French Development Agency
CBNRM	Community-based natural resource management
NACSO	Namibian Association of CBNRM Support Organisations
WWF	World Wide Fund for Nature
HWC	Human-wildlife conflicts
MEFT	Ministry of Environment, Forestry and Tourism
MAWLR	Ministry of Agriculture, Water and Land Reform
DVS	Directorate of Veterinary Services
GDP	Gross domestic product
Meatco	Meat Corporation of Namibia
NGO	Non-governmental organisation
LSU	Large stock unit
LS	Livestock system
CS	Cropping system
GVA	Gross value-added
NVA	Netto value-added
NAD	Namibian dollar
ha	Hectare
dW	Day of work
Household	As a set of (related or unrelated) people sharing the same dwelling and who eat and live from the same resources or budget.
Homestead	As a set of households (mostly related) organised around a shared resource or livelihood (e.g. a common livestock herd).

INTRODUCTION

At the end of August 2024, the Namibian government announced the culling of over 700 wild animals, including hippos and elephants, to provide meat for its population as the arid Southern African region grapples with its worst drought in a century. This announcement made headlines in international media and sparked widespread outrage from a shocked public. In reality, this decision reveals two sides of the same coin, presenting serious challenges for Namibia and its people.

On one side, climate change and declining annual rainfall over recent decades have led to unprecedented recurring droughts. On the other hand, after several decades of one of the most successful community-based conservation policies on the continent, the growing populations of wild animals pose significant resource-sharing challenges with rural communities. These communities, at the forefront of the impacts of climate change and increasing conflicts with wildlife, include smallholder farmers—people who have suffered tremendously from a particularly restrictive colonial history that only ended in 1990.

This is particularly true for the Kunene region and its pastoralists, who have faced severe economic and demographic encapsulation until the country's independence. Today, their livelihoods are under increasing pressure from recurring droughts and the complexities of coexisting with wildlife. Moreover, Kunene remains one of the poorest regions in the country, with a large majority relying on state-organized food aid in recent years.

Through community-based natural resource management, the development of tourism, hunting, and, to a lesser extent, mining concessions in these remote and "preserved" areas of the country has offered some hope and opportunities for diversification. However, this has not eradicated the vulnerability of rural populations. Today, the main focus remains on the development of extra-agricultural livelihoods, however some development actors have started to emphasize the crucial role of developing and diversifying agricultural activities to ensure food security in the region.

International actors have stepped into the breach with funded projects, and local institutions are gradually recognizing the need for better support for farmers in developing resilient and productive agro-pastoral systems. While numerous studies have been conducted on natural resource management and governance dynamics within conservancies in Kunene, very few have focused on characterizing existing agricultural systems, their history, and their challenges. This study seeks to bridge this gap and provide a deeper understanding of local agrarian systems while identifying potential intervention levers to support farmers in sustaining their livelihoods and ensuring food security for the rural population.

CONTEXT

PROJECT BACKGROUND

This study was conducted in response to a request from the French NGO Agronomes et Vétérinaires sans Frontières (AVSF) to inform its newly started local action in Namibia as part of the project "Strengthening Community Rights, Livelihood Resilience and Biodiversity Conservation in Southern Africa and Ghana". The project is taking place in six Southern African countries and is funded by AfD and co-funded by Jamma International[1]. The overall objective of the project is "to uphold the socio-economic and environmental rights of Indigenous rural communities under community-based natural resource management (CBNRM), as well as their way of life and the sustainable use and management of natural resources".

In northern Namibia, increased human and wildlife numbers together with climate change resulting in below average rainfall and a shorter rainy season have put natural resources and communities livelihoods under tremendous pressure. This is especially true for rural communities deriving only very little benefits from tourism and wildlife as advocated by CBNRM. With the aim to strengthen the adaptation and resilience of conservancy farmers in the Kunene region, the regional implementing partner, Integrated Rural Development and Nature Conservation (IRDNC), is to conduct pilot actions, under the technical support from AVSF, in developing income-generating agricultural activities within community organisations practicing CBNRM that will enrich climate change adaptation practices and diversify income sources.

This study aims to acquire a detailed knowledge of the production systems in the intervention area of the project to support the development of agriculture and livestock, with the aim of informing actions of the current and future project and the modalities of intervention for each of the two conservancies of Ongongo and Ombuijokanguindi, which were selected for the project implementation.

CBNRM AND ITS REGIONAL STAKEHOLDERS

As a frontrunner for nature conservation in Southern Africa, the Namibian granted rights in 1996 to communities over the management of natural resources and wildlife in their territories, by recognizing conservancies and CBNRM in its Constitution.

Faced with the urgency of defending the extinction of certain species such as the black rhinoceros, desert adapted elephants and lions who were heavily poached, the conservancy

[1] https://www.avsf.org/projets/des-communautes-gestionnaires-de-la-biodiversite/

model was created in the 80's to encourage the management of natural resources by agricultural or forestry communities themselves. These communities are united under the term CBO (Communities Based Organisation) and are recognised by the Ministry of Environment, Forestry and Tourism (MEFT). They are organized around a common objective: to ensure the conservation of wildlife and the preservation of resources (water, pastures, land) allowing this wildlife to live on the territory and to generate income to meet the needs of the populations of the territory. The conservancy has a legally registered territory with clearly defined boundaries and a management body (committee) constituted and elected by the community for socio-economic development and sustainable management of wildlife and tourism[2].

The 86 conservancies are organized by region and are associate members of the Namibian Association of CBNRM Support Organisations (NACSO). NACSO provides training and support to conservancies in conjunction with NGOs such as IRDNC, Namibia Nature Foundation, Namibia Development Trust and the World Wide Fund For Nature (WWF). IRDNC was a pioneer in involving communities in stopping widespread commercial and subsistence poaching of wildlife in the 80s already and is now the main support organisation for conservancies in the three most remote corners of the country, namely Kunene, Zambezi and East-Kavango regions. By helping conservancies to develop management plans and implement donor funded projects, IRDNC is works to reduce Human-Wildlife Conflicts (HWC), strengthen local governance, capacity and skills as well as develop income generating livelihoods based on natural products, wildlife and more recently agriculture.

STARTING HYPOTHESES AND OBJECTIVES

Nearly 50% of Namibia's population reside in rural areas (NSA, 2023)[3]. 70% of such rural households depend on agriculture and natural resources gathering and many households are very poor. According to data from the Namibian Household Income and Expenditure Survey (NHIES, 2015/2016) the national multidimensional poverty incidence was reported at 43.3% (59.3% in rural compared to 25.3% in urban). At regional level, Kunene recorded 64.1%, with 62.9% of child poverty. On the other hand, the Namibia Integrated Food Security Phase Classification for July 2023-June 2024 indicate that many households are either stressed or heading into Emergency Phase and require external food support. In Kunene, it is estimated that between April-September 2024, 30% of the population were to be classified being in Phase 3 (Crisis).

Small-scale agro pastoralists in Kunene are little recognized and described as "subsistence farmers", oriented towards self-consumption, as opposed to "professional" commercial farmers,

[2] To hear more about CBNRM in Namibia: https://www.rfi.fr/fr/emission/20100622-2-conservancies-namibie-autogestion-reussie-environnement

[3] Data retrieved from https://census.nsanamibia.com/ on the 22nd of October 2024.

who export beef and generate foreign exchange. As a result, the State, as far as the agricultural and livestock sector in the north of the country is concerned, seems to intervene more in form of social safety nets (food aid and targeted social aid) than through agricultural policies to support peasant families. Access to agricultural training, advisory support, credit, subsidies, as well as access to markets for remote rural communities in Kunene is very limited and veterinary health facilities seem largely under-resourced.

With little support to face difficult socio-economic and climatic conditions, farmers' livelihoods in Kunene are increasingly coming under threat. Previous studies have shown that adaptation strategies are limited (Inman et al., 2020) and farmers are often forced to look for non-agricultural income sources to ensure their food security. In this line, CBNRM and the establishment of conservancies have provided rural communities with important opportunities to regain some control over natural resources after almost a century of restrictive colonial history (Bollig, 2016). Where revenues and jobs can be derived from wildlife (mainly tourism and professional hunting) or land concessions (e.g. mining), CBNRM has proven to be a successful approach in the promotion of human and wildlife cohabitation (concept of land sharing). Nevertheless, many conservancies have only limited potential for tourism development and the benefits of CBNRM seem to rarely trickle down to subsistence farmers, who are often the most affected by climate change and "conservationist logics". It is assumed that increasing number of wildlife and repeated droughts over the last decades have induced higher occurrences of HWC such as predation on livestock, destruction of crops and infrastructures. As a result, banking on the development of livelihoods outside of agriculture to compensate for vulnerable agro-pastoralists systems has not achieved to erase poverty. Looking at the increased threat of climate change, there is an urgent need for communities and development stakeholders to look for new ways to secure livelihoods and ultimately improve people's live in Kunene.

The present study therefore aims to characterize and analyse current farming practices in the project areas in order to demonstrate their economic, social and environmental role, and draw recommendations on *how agro pastoralists in Kunene could be supported to develop alternative agricultural livelihood options in order to promote households food security in a context of climate change and increased competition with wildlife over natural resources.*

THE STATE OF AGRICULTURE AND CONSERVATION IN NAMIBIA

Namibia is one of the nine countries of Southern Africa, with desert along the coast, in the south, and in the interior regions of the north-central and northeast. Its climate is arid and characterized by rains that fall for only a brief period each year (November to March) and high evaporation rate. As a result, soils are shallow and poorly developed, vegetation cover is sparse and much of the land can support only low densities of wildlife, livestock and people (*Atlas of Namibia*, 2022). Namibia is the driest country in Sub-Saharan Africa and depend largely on groundwater with no permanent rivers across the country other than the Kunene, Kavango (north) and Orange river (south) which respectively flow along the borders with Angola, Zambia, Botswana and South-Africa (Sector Brief Namibia: Agriculture, 2022; Herbold Green, 2024).

It is a large country (842,000 km^2) with a very small population and one of the lowest population densities in the world (second to last position ahead of Mongolia). Its population is predominantly black (Bantu, KhoÎkhoï, San and Damara) with minorities white Afrikaner and German (7%), Chinese (2%) and Métis (6.5%). In total, the population amounts to about 2.1 million inhabitants (following census of Namibian Statistics Agency of 2011) for 824,268 km2, and lives mainly in the north of the country and in the country's cities, such as the capital Windhoek (500,000 inhabitants).

Namibia is a relatively wealthy country (GDP per capita of $5031 in 2022[4], classified as a "middle-income country") but also the second most unequal country in the world, after South Africa (Gini coefficient of 59.1)[5]. Under apartheid until the early 1990s, the wealthy fringe of the population lived on large private farms (5000 ha on average) on the central plateau of the country in the hands of Afrikaner families where they mainly practiced "game ranching" (management of wild animal populations for tourism and meat sales) and cattle breeding. The most populous part of the country is located in the north of the country, on the border with Angola. The rest of the country is almost deserted by the population due to the extreme weather conditions.

Mining is Namibia's largest economic sector, followed by tourism which contributed about 7% of the country's gross domestic product (GDP) and 8% of total employment in 2022 (Namibia Tourism Satellite Account 2022, 2023) which includes foreign game hunters who are a growing and important segment for Namibian tourism operators.

[4] GDP per capita (current US$) - Namibia | Data (worldbank.org)

[5] Gini index - Namibia | Data (worldbank.org)

AGRICULTURE IN NAMIBIA

Agriculture (third position in the country's GDP) is one of the most important sectors in Namibia, with the majority of the population directly or indirectly dependent on the agricultural sector for their livelihoods. Around 70% of the country's population depends directly or indirectly on agriculture for their income and livelihood, it employs 23% of the labour force but it's contribution to the country's GDP over the past five years has been just over 4% (Sector Brief Namibia: Agriculture, 2022). The country imports a large part of its food (produces only 43% of its food demand according to the Sector Brief from GIZ, 2022). Livestock accounts for a majority of agricultural production with the export of live animals (mainly cattle – free of foot-and-mouth disease – and sheep) and has historically contributed to two third of agricultural exports by value (Sector Brief Namibia: Agriculture, 2022). In 2019, Namibia exported about 12,400 MT of meat (to the United States, Europe, South Africa and China). In 2020, Namibia became the first and only African country to export beef to the United States (Sector Brief Namibia: Agriculture, 2022). Livestock therefore remains a very important source of foreign exchange.

There are two types of farming in Namibia, namely commercial farming, mainly in the central and southern parts of the country and subsistence farming mainly on communal lands in the northern third of the country, above the infamous "red line", nowadays known as the "veterinary fence". This veterinary cordon fence across northern Namibia protects livestock to its south from infectious diseases such as foot-and-mouth and lung sickness. Meat products from this disease-free southern zone can then be exported. Quarantine facilities in northern Namibia are used to keep cattle or smallstock in isolation before their meat can be processed and sold elsewhere. However, their operations seem to have significantly diminished and are almost non-existent since the last disease outbreak in 2015. As a result, most livestock in the northern communal areas are kept as an asset for security or savings, and not for commercial production (*Atlas of Namibia*, 2022).

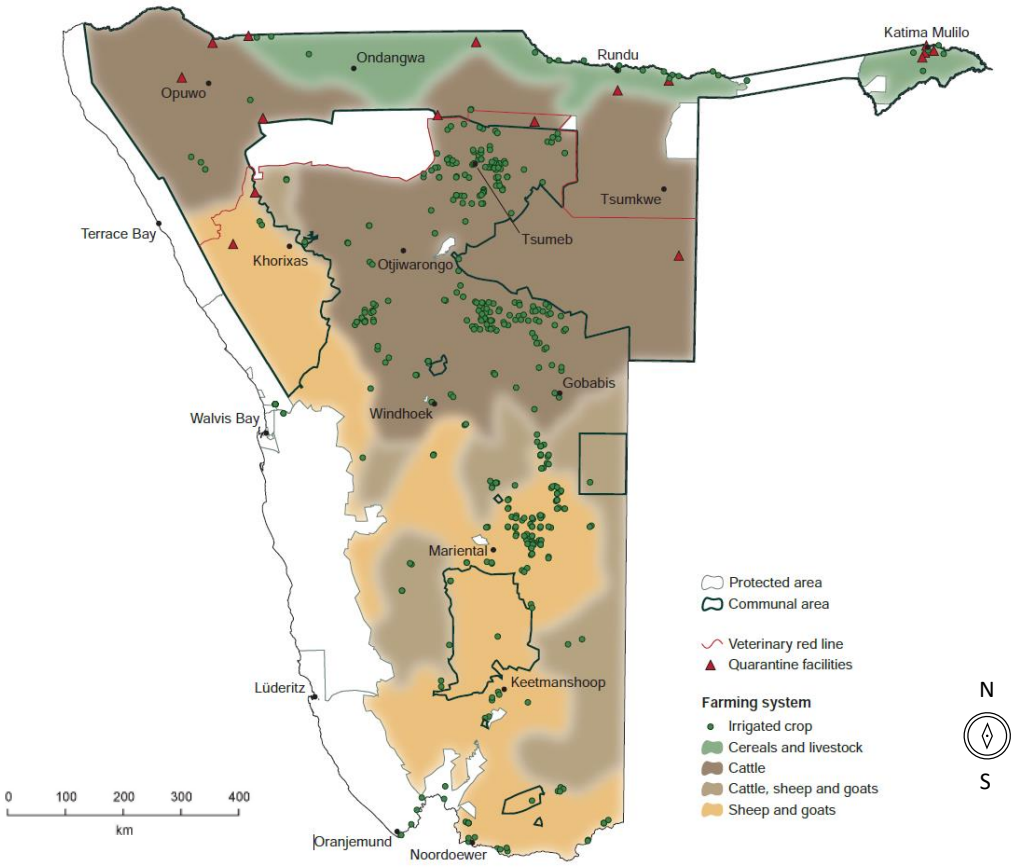

Figure 1: Major farm produces and land uses (Atlas of Namibia Team, 2022).

Historically, small-scale family agro-pastoralists have received little support from the state. Programs from the Ministry of Agriculture Water and Land Reform (MAWLR) or the Environment Investment Fund of Namibia aimed at mechanising agriculture and improved access to inputs among others exist, but their impacts seem to have been very limited so far. Indeed, since the country's independence in 1990 and despite a national land reform policy focusing on resettlement and transfer of commercially viable agricultural land (Sector Brief Namibia: Agriculture, 2022), there has been no real agrarian reform and the best land remains in the hands of white farmers (4,000 to 5,000 commercial farmers share 44% of the land and accommodate only 10% of the population according to the Sector Brief from GIZ, 2022). The country is thus still divided in two with a northern third of the country concentrating 70% of the population and a large majority of agro-pastoralists on communal lands. Livestock farming was traditionally present among the Herero and Damara populations, the latter practising more subsistence agriculture. Agricultural production – and subsequently income – is low in the subsistence sector for a number of reasons, including limited access to markets or also high-quality seed inputs which work well under drought conditions (Sector Brief Namibia: Agriculture, 2022).

Recently, Namibia, which already endures critical climatic conditions and is extremely vulnerable to climate change, has suffered a prolonged drought since 2010. While below average or insufficient rain had fallen for five years and a large part of the livestock had

perished, the authorities declared a state of natural disaster in 2016 and 2019 and requested international assistance because the livelihoods of a majority of Namibians were threatened, especially those who depend on agricultural activities. In 2019, Meatco[6] slaughtered a record 116,304 cattle as farmers scrambled to market most of their herd following drought. Since then, Below average rainfall continues to be a major challenge and slaughter numbers have remained low as most of the country is going through herd rebuilding (Integrated Annual Report 2022/23, 2023).

KUNENE AND ITS CONSERVANCIES

The region of Kunene, about 750 km from the capital, is located in the north-west corner of the country. It is the country's second-largest region but population density is very low (0.8 persons/km^2 compared with the national average of 2.5) (Dieckmann et al., 2014).

Mountainous, it is an arid and semi-desert area, with hot temperatures and low rainfall (50 to 350mm per annum), dotted with shrubby savannah. It is inhabited by the Herero and Damara ethnic groups, as well as some Himba, who live in small groups of houses of less than 1,000 inhabitants. Those communities practice subsistence farming, live in small, isolated and remote settlements often without reliable access to water and sanitation services or electricity, which depend almost entirely on livestock or tourism jobs and very limited cultivation of staple crops such as maize along watercourses during rainy season (Mendelsohn et al., 2006). The main sources of income in Kunene are salaries and wages (49.4%), followed by subsistence farming (15.8%) and pensions (13.1%) (Dieckmann et al., 2014).

It is one of the least developed regions of the country, with a very mountainous geography with recurrent drought conditions and inexistence of larger-scale agriculture. The region has many tourist attractions and tourism is a key development sector (spectacular mountain scenery and wildlife in the wild). Wildlife tourism remains the primary activity and source of income; It is organised from the capital by Tour Operators (all-terrain vehicle rental and organisation of nights in lodges or campsites).

With thirty registered conservancies, Kunene is also the region with the most conservancies in the country. Under the CBNRM model, communities especially those at conservancy level therefore play a critical role in the conservation of existing wildlife including desert adapted elephants, rhinos and lions which are only endemic to Kunene and Erongo regions. Apart from implementing wildlife conservation plans, communities further conduct annual game counts which inform policy interventions.

[6] the Namibian Public Meat Processing and Marketing Entity

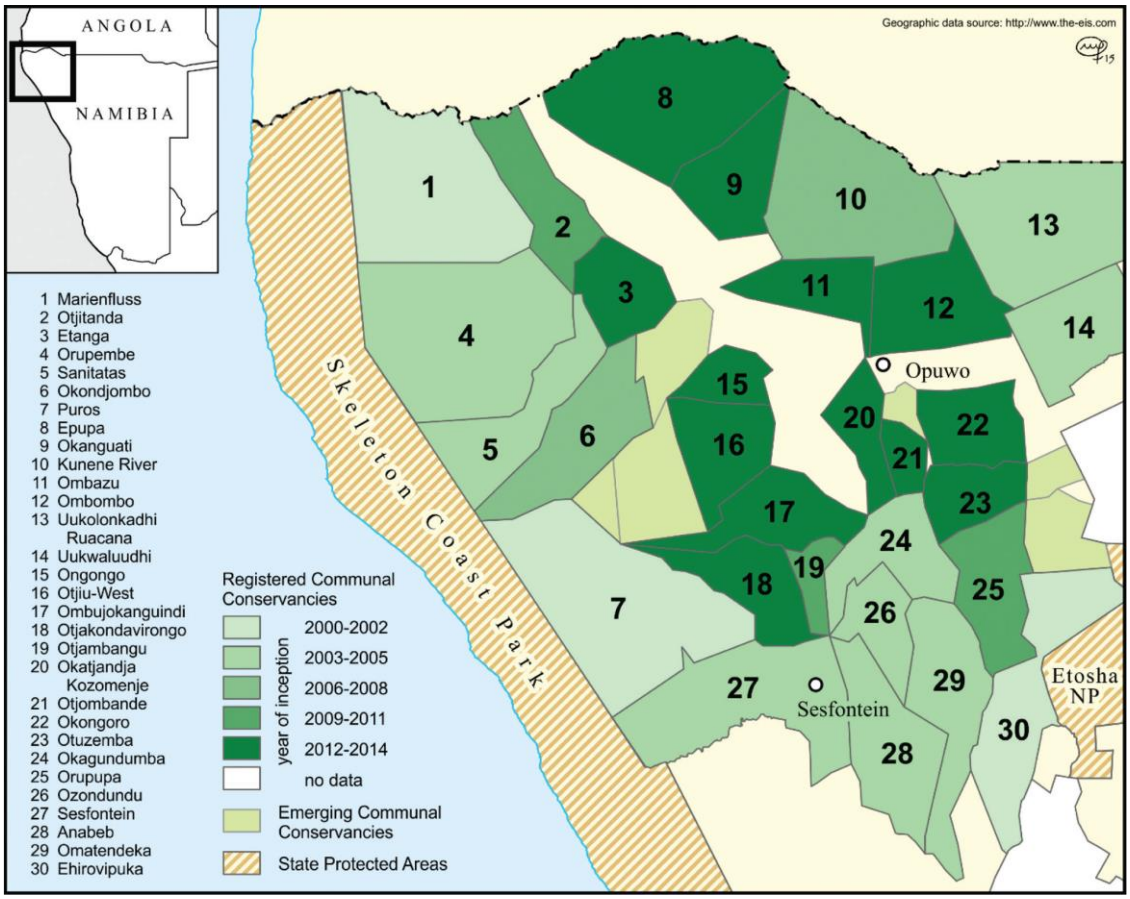

Figure 2: Map of conservancies in Kunene (Bollig, 2016).

While some conservancies have benefitted from revenues and jobs coming from development of tourism and industrial development such as mining, many communities derive limited benefits from such resources due to low wildlife population numbers, low tourism activities within their conservancies coupled with higher seasonal migration of species such as elephants. On the other hand, these communities endure HWC such as predation on livestock, destruction of water infrastructures and raiding of crop fields, resulting in crop and livestock losses which are not compensated for, although relief is offered through the Game Trust Fund administered by central government[7,8]. According to the 2022 Annual Conservancy Audit Reports compiled by NACSO, apart from hyenas, baboons, leopards and cheetahs; elephants ranked among the highest cause of HWC and most trouble species during 2020-2022 in both conservancies. The type of damages recorded were associated with water infrastructure and crop damages. Incidences and damages seemed to have increased during that period, which corelated with droughts experienced in the region.

[7] https://www.npc.gov.na/wp-content/uploads/2022/06/National-Policy-On-Human-Wildlife-Conflict-Management-2009.pdf

[8] https://www.meft.gov.na/files/files/Revised%20payments%20for%20the%20human%20wildlife%20conflict%20self%20reliance%20scheme.pdf

A MULTIDISCIPLINARY APPROACH FOR HOLISTIC RESULTS

In order to study and analyse agricultural development of conservancies in Kunene (study object) as a general, long-term, process of transformation of agriculture, the elements, causes and mechanisms of which can be both endogenous and the result of a variety of exogenous constraints, but also contributions, enrichments or innovations (Rasse-Mercat, 2023), this study will be structured around the methodology of an agrarian diagnosis[9] as presented by Ferraton & Touzard (2009). This micro-regional approach of agrarian issues is usually implemented to identify the processes of change underway in a given region and the evolutionary trajectories of the various production systems with a focus on regional interventions (project identification or impact assessment, for example), as well as systemic impact assessment of development projects, a given agricultural policy measure, or the economic assessment of an agricultural development project from the point of view of the general interest (Delarue & Cochet, 2011). By studying cultivation and livestock practices as well as particular production practices it is also useful to establish technical and economical benchmarks and can be an effective way to select innovations, design and direct farmers-supporting measures such as co-experimentation, training, counselling and more.

An agrarian diagnosis is a method stemming from the agronomic sciences with a strong technical dimension enriched by various other disciplines (history, geography, economy, anthropology of techniques, etc.) which gives it a multidisciplinary, systemic and comparative approach. It is often executed as an analysis-diagnosis of the diversity and dynamics of changes over time and space to inform research and agricultural development. As a field-based approach of observation and dialogue it focuses on implementing new attitudes in regard to established hierarchical relations (downgraded agriculture), confront local and scientific knowledge, listen and understand farmers speech in regard to their socio-professional situation and their difficulties. It is a systematic approach aimed at understanding rather than judging.

In order to verify (or refute) the starting hypotheses on the impact of climate change and CBNRM on farming practices, it is essential to study the functioning of agro-pastoralists systems and to put this information into perspective with their respective economic performances. For the following, the approach of an agrarian diagnosis focuses on the study of production systems as a combination of land, power and labour for the purposes of plant and animal production, common to a group of farms and therefore the elementary level of organisation of the production process and the scale on which the various sectors and value

[9] According to Cochet (2011), this analysis-diagnosis approach on agrarian systems was first taught at the Institut national agronomique de Paris-Grignon (now AgroParisTech) by the team at the UFR 'Comparative Agriculture and Agricultural Development'. It then spread to other higher education institutions in France (Institut Agro Montpellier, Istom) and abroad (Mexico, Brazil, Ecuador, Senegal, Vietnam, Laos, etc.), as well as to a number of international organisations, notably the FAO.

chains are interwoven (Reboul, 1976). Production systems function according to various combination of livestock and cropping systems. Livestock systems (LS) must be understood here as a set of interacting elements organised by humans with the aim to exploit resources by means of domestic animals to obtain various products (milk, meat, leather and skins, labour, manure, etc.) or to meet other objectives (Landais, 1992). Cropping systems (CS) are a set of technical methods used on plots treated in identical ways. Each cropping system being defined by (1) the nature of the crops and their order of succession and (2) the management sequence applied to these different crops, including the choice of varieties for the crops selected (Sébillotte, 1990).

The economic performances of those production systems are then assessed by the calculation of the annual wealth creation (farm income) as the difference between the added value of each livestock and cropping system (yields) and the production costs (intermediary inputs, investments, wages, etc.). Assessing and comparing performances of different production systems and their respective livestock and cropping systems gives valuable insights into the sustainability of farming practices and the identification of potential levers for improvement or change.

MATERIAL AND METHODS

In order to gather data on production systems, this study used a concurrent nested mixed-method research design where both quantitative and qualitative data are collected at the same time. In concurrent nested studies, one of the methods dominates, and the other is embedded, or nested, in it (Inman et al., 2020; Lacoste et al., 2016). In the case of such agrarian diagnosis method, qualitative is the dominant method, while quantitative data (i.e. yields, inputs) is embedded or nested within the larger qualitative study. All the information were collected during literature review, field visits, observations, interviews and focus groups:

- Literature review on the historical, socio-economic and ecological context of the study areas.
- Explorative interviews (7) with key institutional representatives to understand the context and one semi-directive interview (1) to verify the first typology and its representativeness in regard to other areas in Kunene.
- Landscape observations with local resource persons (conservancy committee members, game-guards) during project field visits and annual game counts.
- Analysis of available maps regarding the topography, hydrography, ground cover (satellite), geology and pedology.
- Participatory mapping and vulnerability and capacity assessment workshops (2) done in the earlier stages of the project in each conservancy.
- Collection of historical data through semi-directive interviews (11) with resource persons in the communities (traditional authorities, elders, conservancy committee members).

- Study of current production systems through semi-directive interviews (22) with farmers (usually head of the household or homestead) and farm in two phases:
    1. First survey (15) focusing on production systems to collect predominantly qualitative data on the characteristics of livestock and cropping systems (practices and decision-making processes) in order to draw a first typology of farms/households.
    2. Follow-up interviews with previous (4) or newly selected respondents (3) for the completion of quantitative technico-economic data of livestock and cropping systems for the identified farm/household types.
- Feedback meetings on first study results with conservancy committee and community members in each conservancy (2) as well as internal staff (2) for validation and knowledge sharing purposes.
- Final restitution (1) with institutional actors to present and debate study findings and recommendations.

Sampling of the study followed standard procedures commonly used in agrarian diagnosis (see for example Lacoste et al. 2016) where the first two steps (landscape and historical analysis) facilitate the definition of spatial units and interview guidelines for the third step (characterization of production systems). Respondents to historical and farm investigations were therefore recruited through a procedure commonly used in agrarian diagnosis (see Lacoste et al., 2016) by mobilizing directly door-to-door (cold calling), after being identified from previous participants or key informants such as conservancy committee members (snow-balling) or while driving in the study area during the first phase of the study (scouting).

Interviews were conducted with help from questionnaires (see Appendix 1) and a local translator specifically recruited for the surveys. Questionnaires were intended as a list of open-ended questions to help the interviewers guide the discussion and ask probing questions rather than a closed questionnaire. Interviews usually lasted between two to three hours until saturation, with some of the interviews on current production systems lasting up to four hours.

Secondary from literature and maps as well as primary data from landscape observations helped define an agroecological zonation based on the various characteristics of the natural environment and their utilisation by farmers. On the other hand, data from explorative interviews as well as the historical survey provided content to analyse the dynamics of farms, villages and households over time as well as the main stages of evolution of farming practices over the last century. Together with first farm visits and case studies on livestock and cropping systems, the latter were used to elaborate a farm typology based on agroecological constraints, farming practices and the socio-economic context.

This typology of farms could later be verified by the analysis of data from interviews on production systems. Qualitative data helped identify and describe the main constraints on farming practices and decision-making processes regarding resource allocation within farms and household. Quantitative data was used to calculate and compare technico-economic

performances of the distinct types of production systems. Those comparison of the productivity and operating logics of production systems together with feedback meeting with communities and one interview with a key informant helped validate the final typology of farms and households.

Finally, feedback on study results to communities and conservancy committees as well as institutional representatives provided opportunities to discuss and debate study findings to elaborate recommendations for the next stages of the project regarding the diversification and sustainability of agricultural livelihoods.

STUDY AREAS

This study focused on documenting and analysing the agrarian systems of the two conservancies of Ongongo and Ombujokanguindi in north-western Namibia, which have been targeted by the overall project and where current interventions by AVSF and IRDNC are implemented.

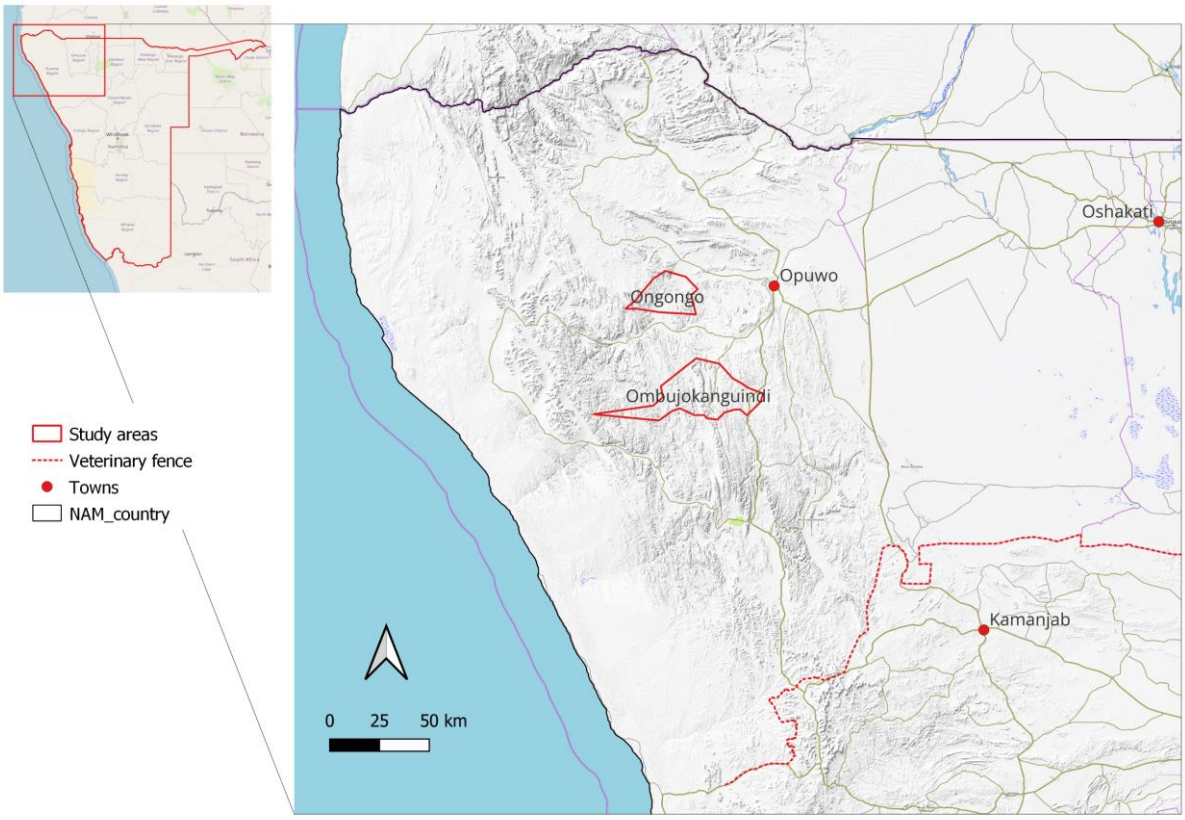

Figure 3: Topographic map of Kunene and study areas.

Ongongo and Ombujokanguindi conservancies are located 80km from Opuwo the regional town situated in the Kunene region which is approximately 800km from the capital Windhoek. Opuwo has approximatively 15’000 inhabitants and is the regional hub with different suppliers

and supermarkets, fuel stations, offices of the different ministries, high schools but no university. It is also a prominent place of trade for livestock and other commodities coming in or going out of the region. IRDNC headquarters in Kunene are located in Opuwo, from where the organisation is coordinating all field operations in the region.

Both conservancies have physical offices, are clearly demarcated and have Zonation Plans which guide land use activities to facilitate development and mitigate HWC (see Appendix 2). An Agricultural Development Centre with Extension Officers exist outside the conservancies (approx. 50km) which supposed provide extension services and access to technical infrastructures, farming inputs and nursery albeit challenged by various issues (highly strained Extension Officers, higher ration of Extension Officer: Farmer, limited knowledge of agro-ecological practices knowledge, lack of transport and communication etc.).

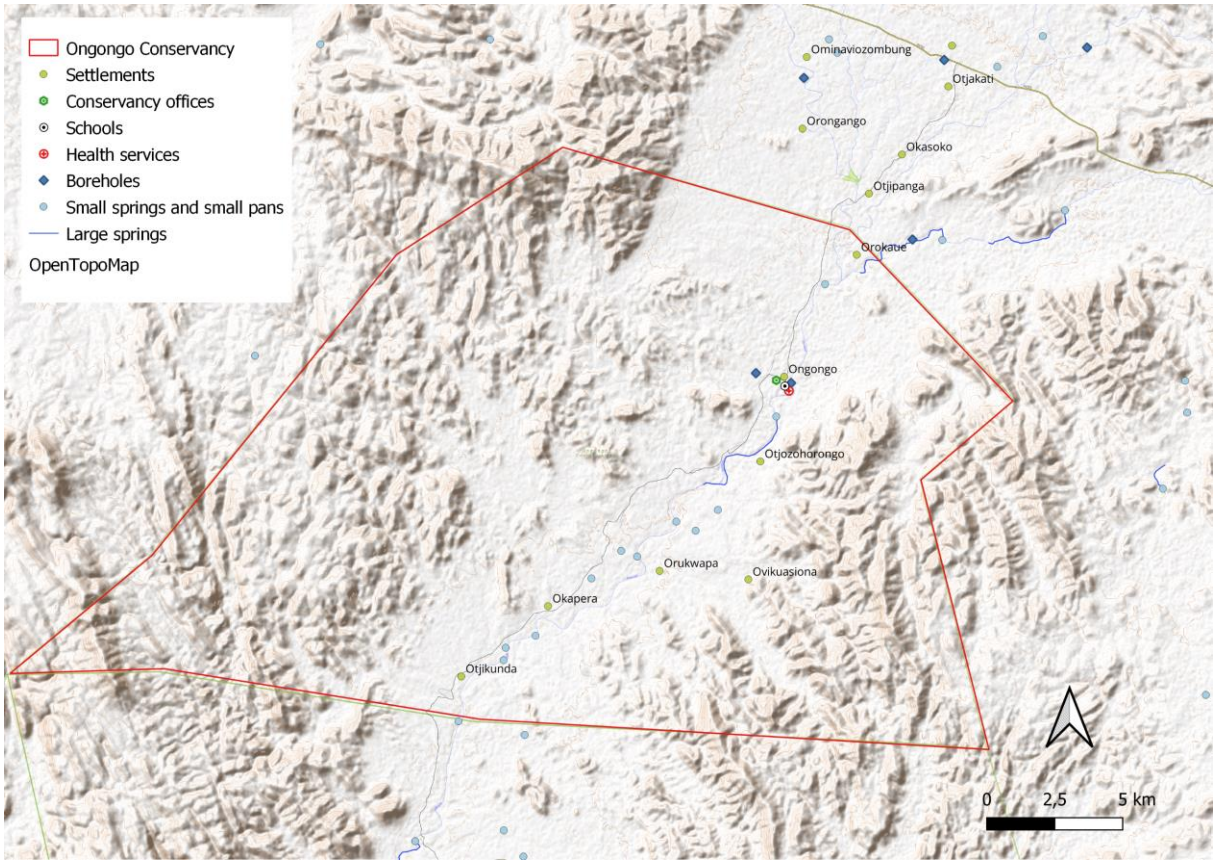

Figure 4: Topographic map of Ongongo conservancy and main infrastructures.

Ongongo conservancy (officially registered in February 2012) consists of 3 housing blocks for a population of 680 (2011 census) and has 378 members[10], 5 game guards, 10 management committee members for a size of 501km^2. It has a clinic, a primary school and 3 government-funded boreholes: one for the school, clinic and household consumption in Ongongo village,

[10] A registered member is anyone who is over 18 years and agrees to comply with general conservancy rules regarding management of natural resources. Most of the time, the majority of adult people in communities are registered members so that non-registered people are mainly made of underaged people.

and two others for cattle (see Ongongo Audit Report 2022 from NACSO[11]). Settlements are usually situated between 750m and 850m of altitude. The Hoarusib river flows through the conservancy providing vital waterpoints for wildlife, livestock and population. The conservancy has no hunting contracts or tourist lodge on its territory.

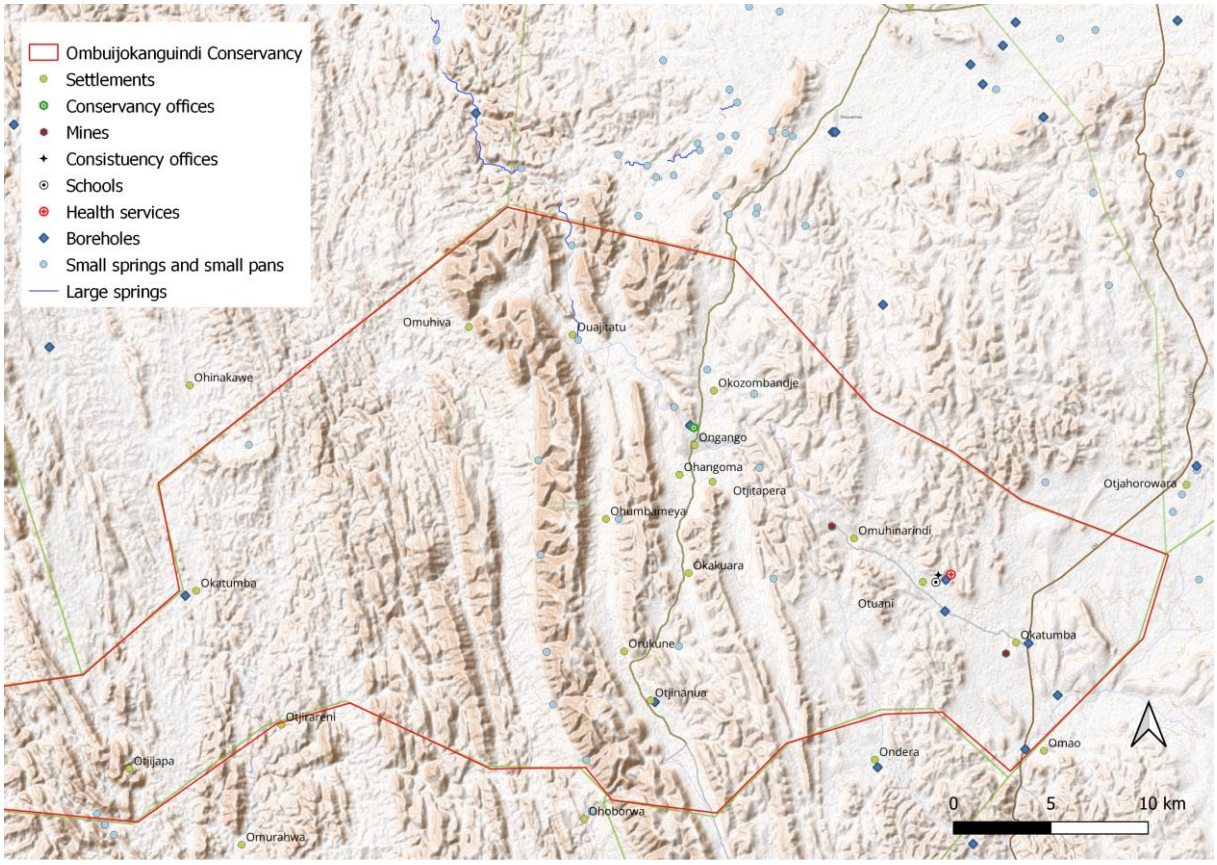

Figure 5: Topographic map of Ombujokanguindi conservancy and main infrastructures.

Ombujokanguindi conservancy (officially registered in February 2012) is made up of 448 members, 8 game guards, one conservancy staff (office), a management committee of 15 members, a committee on grazing plans (whose role is to define grazing areas and regulate its use, but the operating rules are not yet defined) as well as a water point committee. Ombuijokanguindi's population is 850 people (2011 census) for 1160 km^2 (see Ombujokanguindi Audit Report 2022 form NACSO[12]). It has several kindergarten, a mobile school as well as a central settlement counting a boarding school, a clinic and the constituency office. There are 5 boreholes for human and livestock consumption. Some are solar, others diesel. It is divided into 5 residential blocks. There are water sources in some areas of the river as well as a reliable water spring near some settlements for human and livestock consumption as well as irrigation of individual vegetable gardening plots. Settlements are usually situated at around 1100 to 1500m altitude. The conservancy has no tourist lodge. There is one current contract with a professional hunter for quotas on Baboon (5), Kudu (1), Leopard (1) and Springbok (10), but no animals were actually killed in 2022.

The study area was extended during survey on production system with some case studies (3) conducted outside the conservancies in surrounding areas westwards (max. 10km) and eastwards (max. 40km) in order to captivate a larger diversity of practices in slightly different environmental conditions (drier in western areas and rainier in eastern areas). It also provided insights on the representativity of the study results and dynamics of the evolution of farming practices on a regional scale.

KUNENE: CONSERVATION AND PRODUCTION IN A VERY UNIQUE LANDSCAPE

Kunene landscape is characterized by tree and shrub savannahs and the Namib desert along the coast. The region is crossed by the escarpment, a mountainous chain between the coast and the central plateau of Namibia. It is therefore a mountainous with various altitude with most of the settlements installed between 500 and 1500m above sea level. Those mountains and valleys are dominated by a variety of leptosols and regosols covered by the growth of grassland and shrublands with scattered trees (*Atlas of Namibia*, 2022).

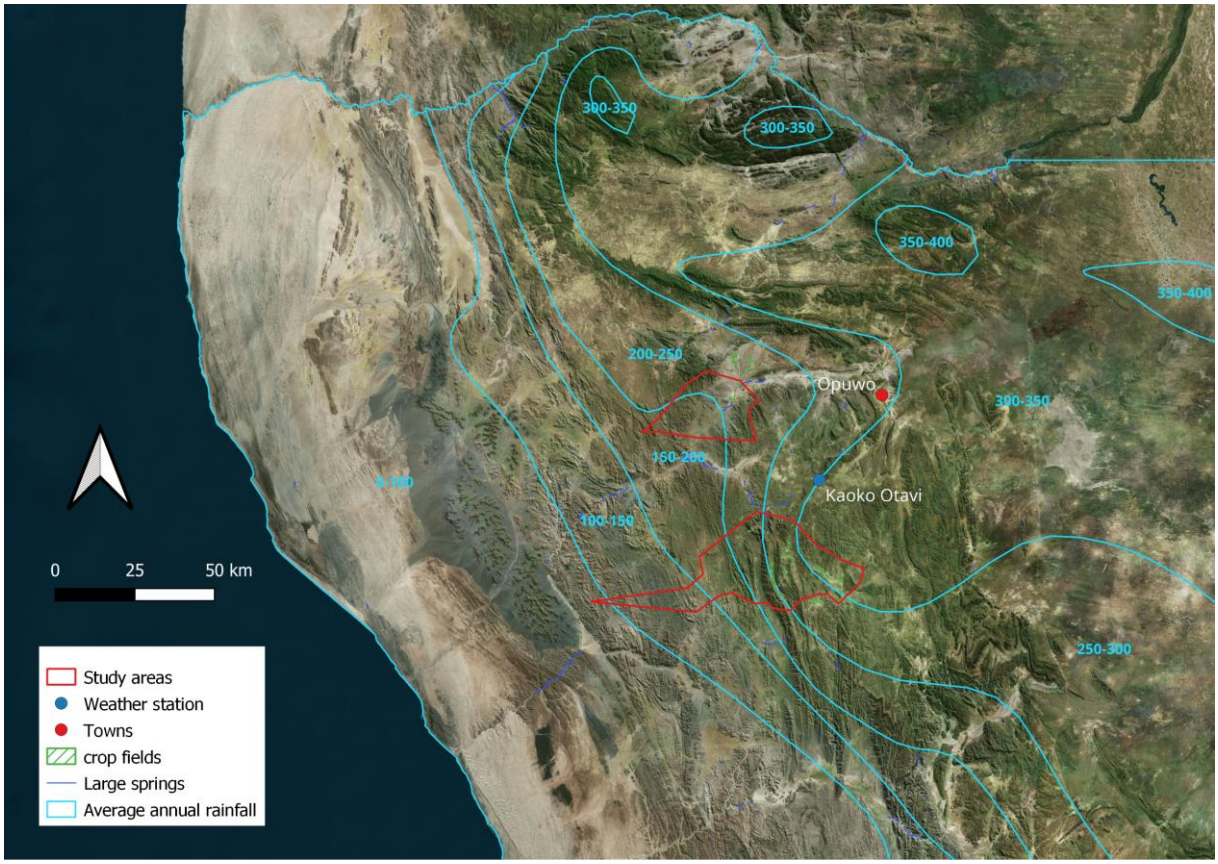

Figure 6: Satellite map of Kunene with average annual rainfall.

Kunene witnesses a very dry climate with average annual rainfall that ranges from less than 100mm along the coast to around 300mm on the east of Opuwo. There are no permanent watercourses but many ephemeral rivers and affluents which carry important amounts of water during periods of rains. Nonetheless, river basins of bigger ephemeral rivers such as the Huarosib crossing Ongongo conservancy have important underground water resources with emerging waterpoints even during the dry season and are important lifelines for communities and their livestock.

As a result, settlements in Ongongo are located along the river at around 800m above sea level and benefit from year-round water from the river bed. With around 200mm annual rainfall it is

a particular arid valley and cropping opportunities are very limited. Similar conditions are found in the eastern and drier parts of Ombujokanguindi (150 to 200mm) which are less populated and have limited water resources. In contrast, the higher valleys and plateaux of the eastern half of Ombujokanguindi (1500m above sea level) receive up to 300mm rainfall and have numerous water springs and wells sustaining a larger population with more widespread cropping practices.

Mostly determined by the altitude, temperature is usually milder in Ongongo than Ombujokanguindi where night temperatures during winter month can go below five degrees Celsius with occasional cases of frost.

Kunene's climate is very dry and hot leading to important evapotranspiration. Rainfall and temperatures data retrieved from the weather station at the MAWLR Agriculture Development Centre in Kaoko Otavi[11] (see Figure 6) suggests that besides the month of March which witnesses higher rainfall, the rest of the year is going through an important water deficit.

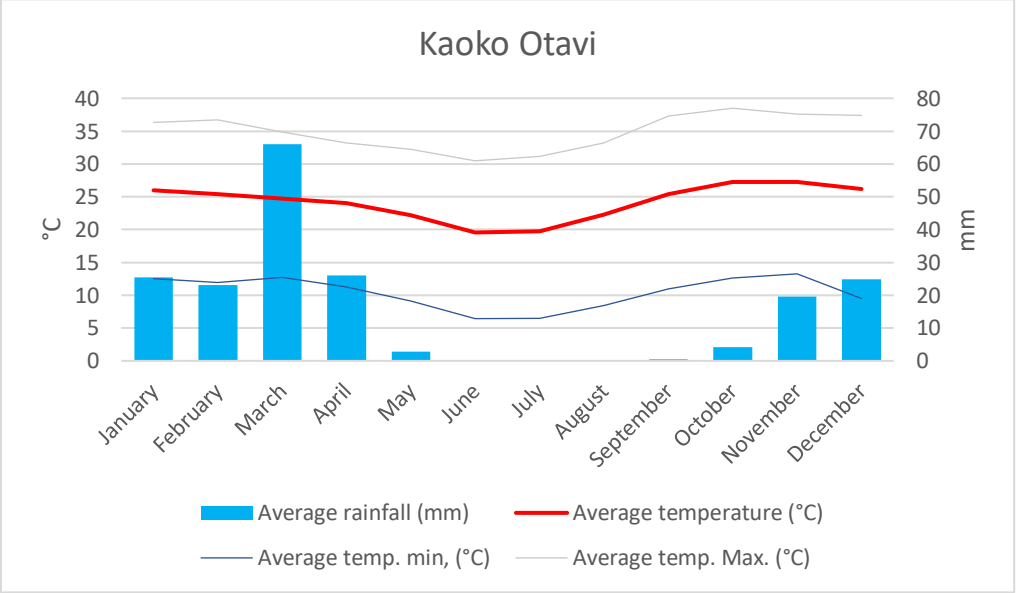

Figure 7: Average annual rainfall and temperatures in Kaoko Otavi (2016-2024).

Nonetheless, rainfall patterns allow to clearly identify two distinct seasons throughout the year. A very dry season with nearly zero millimetres rain from May to October and a rainier season beginning in November and finishing in April.

Local communities however distinguish four different seasons. The year usually starts with the peak of the rainy season (*okurooro* = "good season") when most cropping activities take place. With the last rains falling in April, it gives way to a dry and colder winter season (*okupepera* = "cold") until July. From August, temperatures rise again but no rainfall is witnessed, a very dry and difficult season (*okuni* = "nothing") sets up and people must often set up temporary outposts

[11] https://sasscalweathernet.org/weatherstat_hourly_we.php?loggerid_crit=74229

in remote areas to find grazing for their livestock and cover large distance to water the latter. By the end of September and October acacia trees begin to bloom and the return of few scattered rainfall in November signals the beginning of Spring season (*oruteni* = "regrowth") and preparation of the fields for the approaching cropping season.

In a country as arid as Namibia, rainfall is the single most crucial factor to sustain life and livelihoods. However, it varies dramatically seasonally, annually and geographically (*Atlas of Namibia*, 2022). Figure 8 illustrates this significant seasonal variability, but it also shows very variable amounts of rainfall received during rainy season depending on the year.

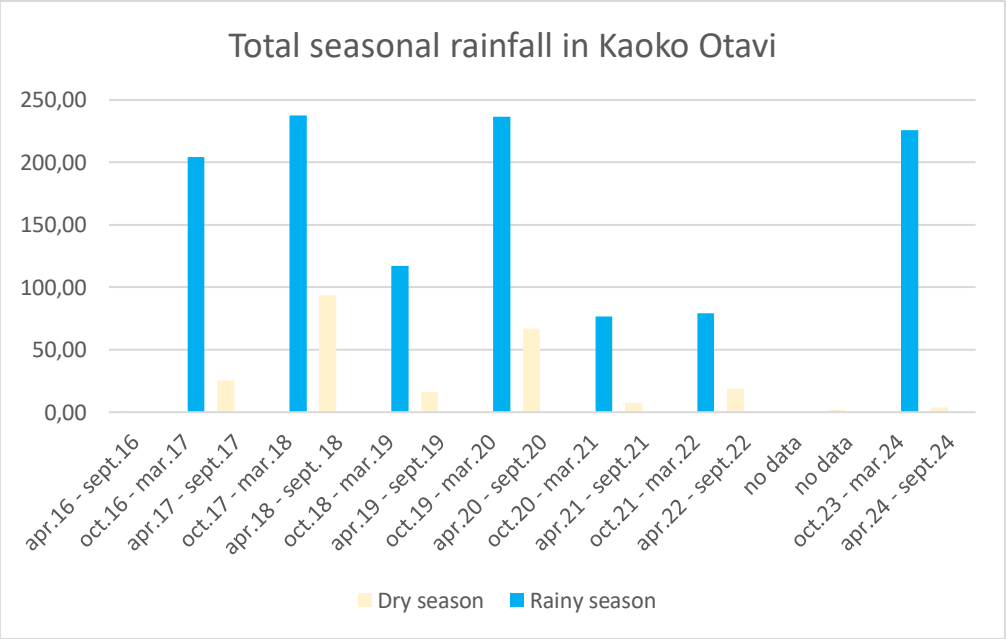

Figure 8: Seasonal and annual rainfall variability in Kaoko Otavi (2016-2024).

Rainfall patterns of the last decade indicates that the total amount of rainfall received during rainy season, can be halved or divided by three depending on the year. Considering that rainfall is crucial for cropping activities but also for the renewal of the vegetation on which pastoralists animals depend, those variations can have huge impacts on people's livelihoods. The last decade has seen a repetition of drought events in the region and data recorded in Opuwo over the last 60 years (see Figure 9) show a general decrease of rainfall with below average numbers since the 80s.

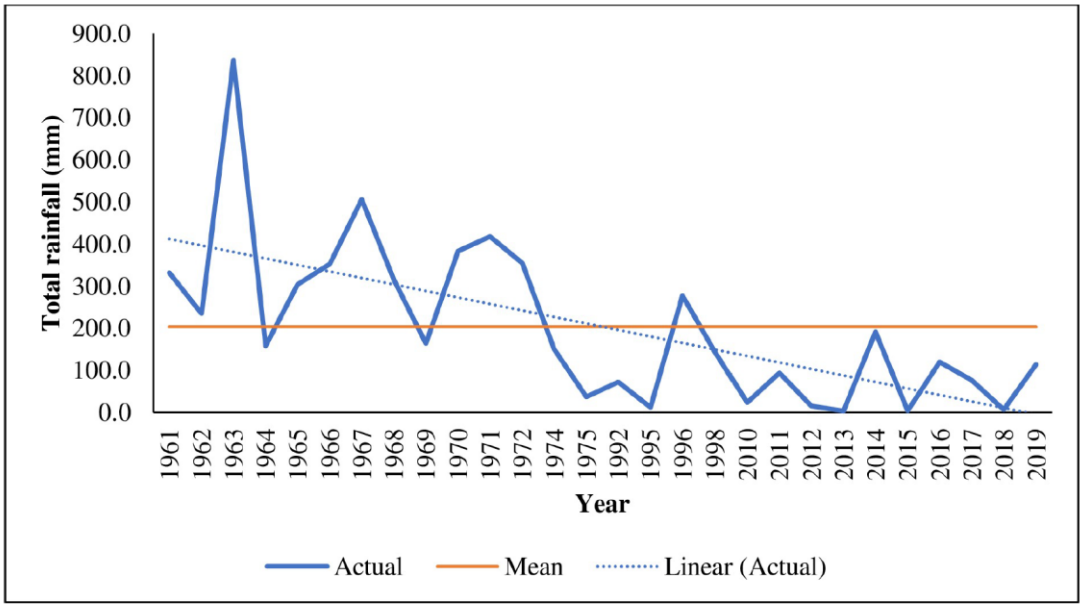

Fig 1. Total annual rainfall recorded at Opuwo town, Kunene Region from 1961–2019. Rainfall data was accessed by the corresponding author from the Namibia Meteorological Service data records in Windhoek on 25 February 2020. No rainfall data are available for the years 1976–1994 and 1999–2009.

https://doi.org/10.1371/journal.pone.0238982.g001

Figure 9: Total annual rainfall in Opuwo since 1961 (Inman et al., 2020).

In order to adapt to this harsh conditions making cropping theoretically impossible or very difficult, people in Kunene have historically relied on the rearing of cattle, goats and sheep to survive. Given the limited carrying capacity of such landscapes, varying from 10 to 40ha per large stock unit (LSU) according to previous studies (Talavera et al., 2000), pastoralists in Kunene have developed a semi-nomadic way of living where part of the family will migrate with herds of cattle and smallstock during the year for an optimal adaptation to the natural environment.

Looking at the characteristics of the natural environment as well as past and present land uses by local communities in Ongongo and Ombujokanguindi, the landscape can be divided into five distinctive agroecological zones organised along alluvial plains and intramountainous valleys and their surrounding mountains with limited access to water resources.

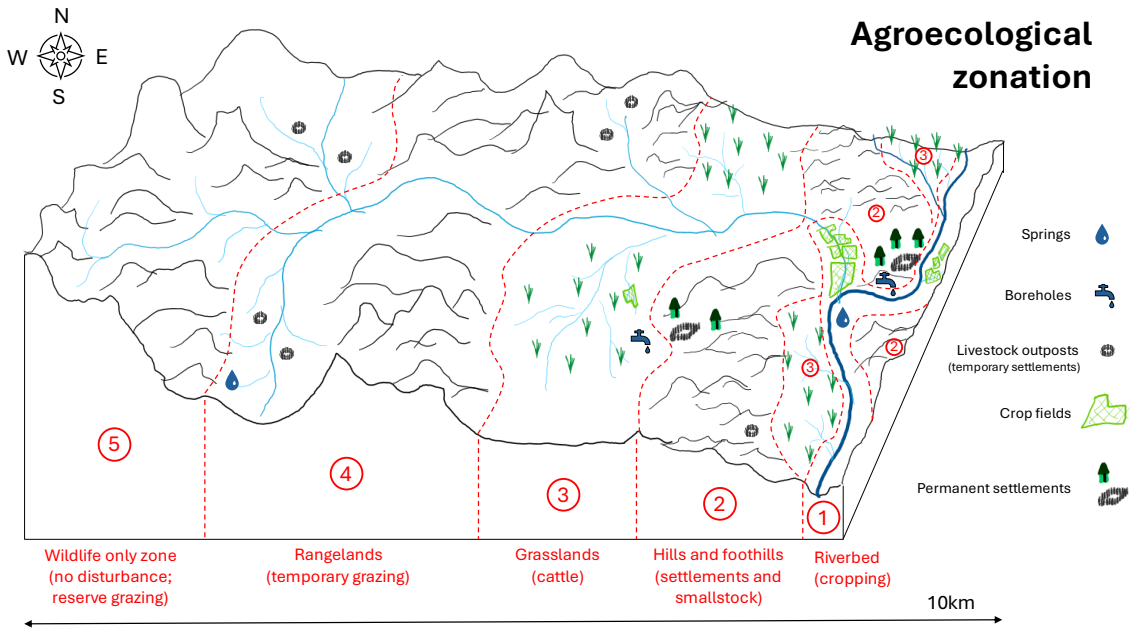

Figure 10: Agroecological zonation of Ongongo and Ombujokanguindi conservancies.

1. RIVERBEDS WHERE CROPPING IS TAKING PLACE

As stated before, ephemeral rivers represent important water resources for human and wildlife throughout the year. Important waterpoints of standing water or emerging small river flows are supplying wildlife and livestock while people depend on small temporary dugwells in the sand or permanent wells with manual or motorized pumping.

Those areas are characterized by alluvial silty clay loamy soils where sediments and material are deposited by regular flooding from the nearby ephemeral rivers or tributaries. Strong ephemeral water currents in very young sediment soils also provoke important soil erosion creating deep gullies expanding with every rainfall event. Riverbeds are populated by specific bigger tree species such as *Hyphaene petersiana* (makalani palm; omurunga) producing fruits much which are an important complementary diet for elephants and humans (mainly kids) during dry season but also an emergency feed for goats during dry season, *Acacia erioloba* (camel thorn; omumbonde), *Faidherbia albida* (omue), whose seedpods are much priced by cattle or goats as well as impala or elephants as feed reserve for the late dry season, *Berchemia discolor* (Bird plum or brown ivory; omuve), *Ziziohus mucronate* (omukaru), whose fallen leaves is an important feed source for smallstock, and few *Colosphospermum mopane* (mopane; omutati) often colonized by *Salvadora persica* (mustard bush; omungambo).

Those soils are often used for cultivation in fenced cropping field (usually around 0.5ha) given their relatively good fertility and humidity compared to other soils in the area. However not all riverbeds are suitable for cropping has some parts are subject to accumulation of gravels and rocks or too narrow and profound riverbeds with rapid and destructive water flow during rainfall

events. Accumulation of coarse sediments is usually found downstream of watershed where bigger rivers with greater water flow carry rocks (see Figure 17). As result, those areas situated downstream and westward, which usually also receiving lower rainfall, are less suitable for cropping than areas higher in altitude and in smaller intra-mountainous valleys of more eastern parts (see Figure 16). As for most soils in the area, they can also be subject to high content of salts which make them unsuitable for cultivation. Crop fields are therefore not very abundant in the landscape but can be found around most settlements, expect for those living under the 200mm rainfall isohyet (South-east for Ongongo and East for Ombujokanguindi) where they are almost inexistent. Crop fields are also rarely set far away from settlements and their corresponding water sources. One explicative factor can be found in the pressure from wildlife (elephants, Kudu, baboons and other small mammals) and livestock on the crops inducing the necessity during the cropping season to allocate available labour (mostly women and children) to watch over the crop fields despite the branches or pole and wires fences constructed all around them. Good cropping soils are therefore very limited, and people target river tributaries with limited water flow that form flat grounds where water accumulates during rainfall events. Indicators of such soils with good fertility and water availability are populated by locally known indicator species such as the bitter bush (*Pechuel-Loeschea leubnitziae*; omundumba) or *Pennisetum/Cenchrus clandestinum* (ondombora). Some cropping field also depend uniquely on rainfall accumulation rather than flooding by the river. Such crop fields are usually installed in alluvial catchments where rainwater infiltrates before accumulating into smaller water streams (zone 3). Those fields are appreciated by farmers due to the limited risk of destruction by floods and erosion. However, with limited sediment influx, their fertility is limited to a few years. In comparison the 21ha community garden of Ongongo, where small river tributaries are bringing water and sediment during rainfall events, has been cultivated since a century without any other fertility management practices such as input of fertilizers or manure. When cropping has failed or after harvest, those fenced fields provide a significant resource of tall and dense grasses for livestock, especially cattle that can be seen grazing in the fields during the early dry season.

Figure 11: Picture of rainfed crop fields in Ongongo crossed by shallow water streams.

2. STONEY HILLS OR FOOTHILLS OFTEN WITH PERMANENT SETTLEMENTS

Riverbeds are often punctuated by settlements established on stoney hills between tributaries or on the foothills of nearby mountains in valleys. They represent flood-safe areas near crop fields and water sources for humans or livestock in dugwells (human) or standing water points (livestock) in riverbeds, natural springs, or boreholes. Here the critical factor explaining the presence of settlements is the availability of a reliable water source providing drinking water for human consumption and to some extent livestock.

Those hills are characterized by very shallow or sandy soils often with a very high portion of stones of small or medium size. The famous *Colosphospermum mopane* (mopane tree; omutati) is very often dominating the landscape of those very poor and dry soils along other trees resistant to overgrazing such as *Senegalia or Acacia mellifera* (black thorn; omusaona) and *Terminalia prunoides* (omuhama). As settlements come along with large herds of smallstock (goats and sheep) returning to the houses every night as well as cattle during a big part of the year, they are often heavily grazed, with a dominance of annual grasses present only shortly during rainy season. The overgrazing can be attested by the lower base of the trees which are systematically cleared out of any small branches or leaves. The leaves of young regrowth of mopane trees before the first rains are appreciated by goats.

Settlements are characterized by a series of small houses or huts usually made out of wooden poles from mopane wood, much appreciated for its resistance to termites, covered by a mixtures of manure and clay. The houses of households either stand alone with their own livestock kraal or are regrouped in a circle of various households of the same family organised around one single kraal constituting a family homestead. The black thorn's and *Terminalia prunoides*' branches full of thorns are used to build fences around crop fields or kraals for cattle and goats.

Small roofs with maize can also be observed in villages, these are usually open wooden structure to dry maize ears, while smaller elevated mud and manure granaries with a closed roof are built to keep maize corns intended for grinding maize flour. Small structure of wooden poles, sometimes covered by mud and manure are also constructed to keep goat and sheep offsprings or chicken.

When natural springs, usually emerging at the base of the surroundings mountains, provide sufficient water during the year or at least during rainy season, small, irrigated gardens with vegetables and crops can also be found in the zone. However, as they mostly are situated on stoney, or sandy very shallow soils fertility is very low.

Figure 12: Picture of Ongango village.

3. ALLUVIAL GRASSLANDS, APPRECIATED AS CATTLE GRAZING AREAS

Those areas often are found in intramountainous valleys or plains and are crossed by ephemeral riverbeds and tributaries therefore often overlapping with areas fit for cultivation where cropping fields can be observed.

The hydrological system of tributaries caries material and water allowing for some formation of deeper soils of sediments. Those areas are also characterized by flat grounds with rather sandy or silty soils with lower proportion of stones or rocks allowing infiltration of water from floods or rainfall. Those areas are therefore producing a dense grass cover very appreciated by cattle and bigger trees providing shade and fruits or pods. Historically those areas where abundant in perennial grasses such as *Stipagrostis uniplumis* (bushman grass; ongumba) which has gradually been replaced by annual species (*Aristida spec;* ohungue, omurondji or orwejo) whose young sprouts called "*omupito*" are grazed by cattle during the rains. However, when the rains end annual grasses dry fast becoming "*ongundju*" prone to breakage and blown away by the wind, forcing cattle to move to more upland areas.

Those flat grounds also allow rainwater to accumulate where ground infiltration is low forming so-called pans (*omarindi*) where water can stand for several month and provide an important source of water for livestock during rainy season or even up to late dry season (August).

Those grasslands standing nearby settlements or permanent water sources (see zones 3 closer to zone 1 on Figure 10) tend to be used as "normal" (permanent) rangelands for cattle as well as cropping grounds, whereas areas having limited water availability have historically been rainy season pastures for cattle outposts. However, the increase in settlements as well as development of permanent water sources through drilling of boreholes or motorization of wells have slowly transformed those areas to normal grazing areas or even permanent settlements.

Figure 13: Picture of alluvial grasslands between Ongongo and Okapera.

4. MOUNTAINOUS RANGELANDS USED AS TEMPORARY GRAZING AREAS

Rangelands usually encompasses the stoney hills and foothills of lower valleys and plains grazed and browsed permanently by smallstock (goats and sheep) around settlements as well as smaller and remote intramountainous valleys with rocky terrain. Rangelands close to settlements and waterpoints are used early in the dry season and colonized by mopane trees and *Senegalia mellifera* (black thorn, omusaona) due to increased browsing pressure. More remote areas are restricted often restricted for temporary outposts from the late dry season (August).

In those areas, soils are very shallow or non-existent and dominated by rocky outcrops or eroded stones. Besides very few ephemeral torrents and small springs in upper valleys, water is almost non-existent. Humans and livestock are therefore forced to travel to settlements or the lower river valley to drink. Despite those difficult conditions those areas can be colonized by a denser cover of smaller trees such as *Colosphospermum mopane* (mopane; omutati), *Catophractes alexandri* (omukaravize) whose white leaves are very appreciated by goats, *Rhigozum virgatum* (omumbuti), *Grewia bicolor* (omuvapu) and a variety of annual or perennial grasses. The more diverse tree cover of mountainous rangelands are crucial browsing resources for goats. Standing hay from perennials such as *Eragostis nindensis* (ongangahozu), *Stipagrostis uniplumis* (ongumba), otjimbere or ondoni are very important source of fodder for cattle during dry season. Those perennials grasses are also regreening rapidly with the first rains during spring (oruteni) and are often “chased” by herders moving their herds opportunistically to take advantage of the vegetation regrowth where the first rains have been the more abundant.

However, those mountainous rangelands used during late dry season are also where most of the cases of predation (mostly cheetahs, jackal, hyenas and leopard) happen as livestock has to move further away from settlements in search of grazing.

Figure 14: Picture of mountainous and rocky rangelands north of Ongango.

5. WILDLIFE ONLY ZONES USED AS RESERVE GRAZING AREAS

Very remote mountainous areas with difficult accessibility and very limit access to water are usually not visited or used by humans and their livestock and can therefore be declared as no disturbance zones. However, with the establishment of conservancies and their zonation plans, some areas closer to crucial water and browsing resources for wildlife (zone 2 or 4) have also been declared as official "wildlife only zones" where no establishment of settlements, cropping or hunting are allowed. Temporary outposts and grazing in those areas are only allowed during severe drought years upon authorisation form the grazing and settlement committee, traditional authorities and the conservancy committee. Those zones therefore stand as reserve grazing areas with interesting opportunities for grazing and pasture management in prevision of climatic hazards. Given the recent drought that started in 2019, dry season grazing has been tolerated in some of those areas during the last few years.

Those wildlife only zone do not directly correspond to a specific distinct biophysical environment. Nevertheless, they are often in remote mountainous or hilly areas where soils are shallow, stoney with rocky outcrops and growth of well-preserved forests of abundant *Catophractes alexandri* (omukaravize), *Boscia albitrunca* (omungwindi), *Cyphostemma juttae* (omutindi) and perennial grasses such as *Stipagrostis uniplumis* (ongumba) providing grazing and browsing for wildlife and mostly goats when resources have been depleted elsewhere.

Some of the more recent zones allocated as "wildlife only" have force people to move out find new settlement or dry season grazing pastures. Because of the involvement of many instances and the recent recurrence of drought years, acceptance form communities and enforcement remain a challenge.

Figure 15: Picture of remote mountainous areas with no human disturbance.

The different agroecological zones can adopt different configurations depending on the location and the biophysical characteristics of the environment. Close to permanent water sources such as boreholes or springs, hills and foothills (zone 1) will be mostly used as permanent settlements, crop fields will be erected in the riverbeds (zone 1) or on alluvial grasslands (zone 3) where enough rain water is accumulating (see Figure 16). The surrounding mountains will be used as rangelands mostly for smallstock, while cattle will ramble between grasslands and the water source (zones 3 and 2).

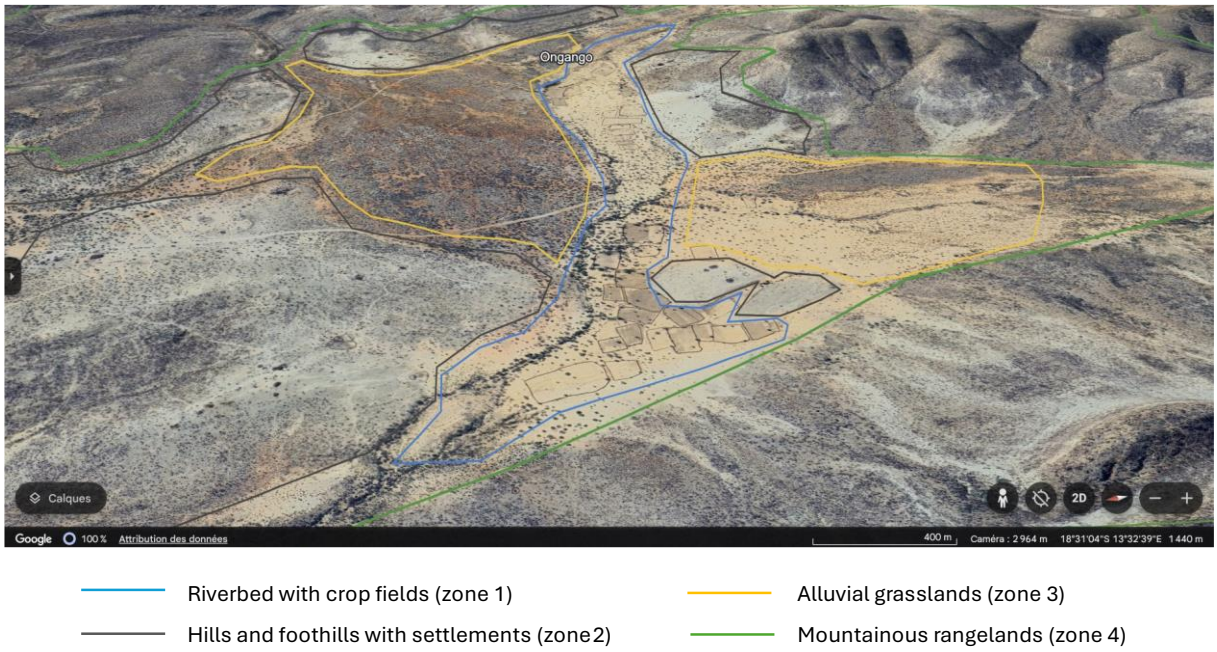

Figure 16: Agroecological zonation of Ongango village in Ombujokanguindi conservancy.

Where water resources are scarce and available only on a temporary basis (e.g. pans where rainwater accumulates) or in limited quantity (e.g. dugwells in the riverbed or small springs in intramountainous valleys), areas will mostly be used as grazing for livestock and the installation of temporary outposts (see Figure 17). Grasslands can be used as rainy season pastures for cattle

around pans (zone 3) or as temporary grazing in the dry season and mountainous rangelands (zone 4) are usually reserved as late dry season pastures (from August) for cattle and smallstock.

Figure 17: Agroecological zonation of Orukuapa in Ongongo conservancy.

As illustrated by Figures 16 and 17, settlements and cropping activities are usually less present in lower parts of the west where rainfall falls under the 200mm isohyet. Here the main water sources are situated along ephemeral rivers carrying greater amount of water from upwards areas. While the represent important underground water reserves for the dry season, those deeper but narrower riverbeds are mostly made out of unfertile sand and rocks deposits represent risks of heavy flooding destructing crop fields.

AGRO-PASTORALISM IN KUNENE: A HAZARD-SENSITIVE SYSTEM FRUIT OF ITS COLONIAL HISTORY

Himba and Herero communities in Kunene are often regarded as isolated groups of herders who have clung to ancient lifeway untouched by modern commodity exchange and cut off from the vicissitudes of the global system (Bollig, 1998). Depicted as the last remnants of the "old Africa" they have become a main attraction in Namibia's booming tourism industry. Caravans of tourists flock in the dry season to visit this pristine environment with free-roaming wildlife and so-called "traditionnal Himba villages", transforming Kunene into a troubling kind of living museum.

As scientist and agronomists, we are often tempted to depict current farming practices and the economic formations found in northern Namibia, as in other herding societies, as adaptations to an arid climate and in a harsh and remote landscape. As demonstrated by Bollig (1998), this is often forgetting that, the recent mode of livestock and crop production in Kunene have been profoundly shaped by a century of colonialism: boundaries restricted their spatial mobility, a prohibition on livestock trading forces them into subsistence herding and forced internal relocation of large numbers of people led to environmental degradation.

COLONIAL ENCAPSULATION UNDER THE SOUTH AFRICAN RULE

During the second half of the nineteenth century, was a period of political turmoil and socio-economic diversification in the northern Kunene or Kaokoland area Himba and Herero were wealthy pastoralists enmeshed in a network of trade and labour relations in southern Angola and northern Namibia (Vigne, 2001). Stock losses during drought and livestock epidemics were compensated for by investing more labour in non-livestock-based activities: trade, commercial hunting, wage labour and soldiering (Bollig, 1998). Pre-colonial land tenure was organised around pastoral households "owning" specific places that had reliable access to water and good cropping grounds (the so-called historic "community gardens" found in Ongongo or Ongango), from which they managed grazing in the adjoining hills. The heads of these place-owning households were addressed as *oveni vehi* (= "owners of the earth/land"). Ownership referred to their right to grant or to deny access to pastures and wells in a given area. Following findings from the historical survey, the *oveni vehi* were also acting as patrons, lending livestock, portion of crop fields or part of maize harvests to poorer and often stockless households and attracting them as clients, a claim that is also supported by literature on the subject Bollig, (2016).

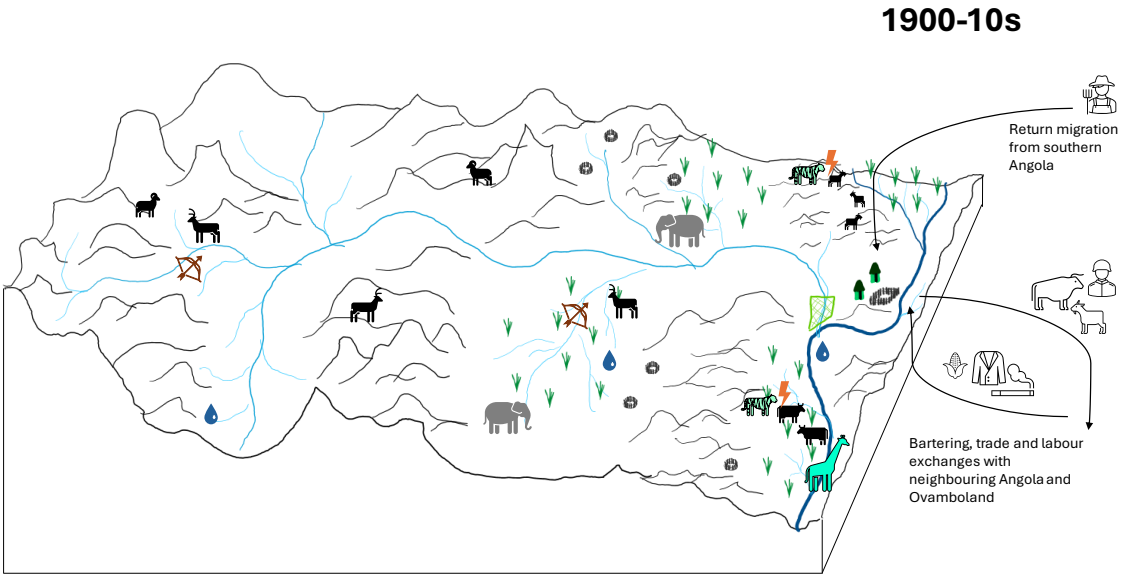

Figure 18: Land uses and livelihoods in Kunene during the early 20th century.

After the Herero and Namaqua genocide perpetrated by German colonial troops from 1904 to 1907 and with changes under the Portuguese colonial system, many Himba returned from south Angola to settle once again in Kunene (previously known as Kaokoland under colonial rule) (Vigne, 2001). In 1917 after the World War I, the South African government took control of the area. Having been enmeshed in interregional trade networks, commodity production and wage labour around 1900, they were isolated by the South African government within a period of twenty years. From 1925, Hereros from the Outjo and Kamanjab area were forcibly relocated into southern Kaokoland and the area was separated form white farms in the Kamanjab area by an empty corridor 100km wide (Vigne, 2001). Buffer zones for the commercial ranching area and prohibitions on movement across other newly invented boundaries limited spatial mobility of communities in the region. Trade across borders, including with other parts of northern Namibia, was inhibited altogether.

Those drastic measures where repeatedly depicted as safety measures for livestock disease management, Bollig (1998) argues that they were also meant to protect poor white farmers south of the unfamous Police line from competition from rich black herders and divide groups who had interacted economically and socially within one economic and political system with southern Angola and western Ovamboland. As a results, pastoralists who had diversified their assets during the previous fifty years and had taken the chance of a first wave of commercial penetration were forced back on to subsistence herding (Bollig, 1998).

During colonial times, the management of pastoral resources was transformed to align with the colonial administration's objectives (Bollig, 1998; Rizzo & Hayes, 2012). The South African government appointed chiefs early in the colonial period and gradually increased the number of traditional authorities from three in 1923 to thirty-six by 1990 (Bollig, 2006; Friedman, 2011). In the study areas, the appointment of chiefs reinforced existing power dynamics, where influential patrons known as “big men” or “headmen” (*omuhona*, sing; *ovahona*, pl.) were

elevated to the role of "chiefs." Starting in the 1930s, these chiefs appointed councillors to assist them and created a tribal administration focused on regulating land tenure. Although the colonial administration seemingly allowed local traditional authorities to manage pastures and water sources, it actually had a significant negative impact on local tenure systems: mobility was restricted, extensive migrations were limited, and pastoral families often needed official approval to relocate their homesteads (Bollig, 1998). Furthermore, local hunting was completely banned, with all game designated as state property.

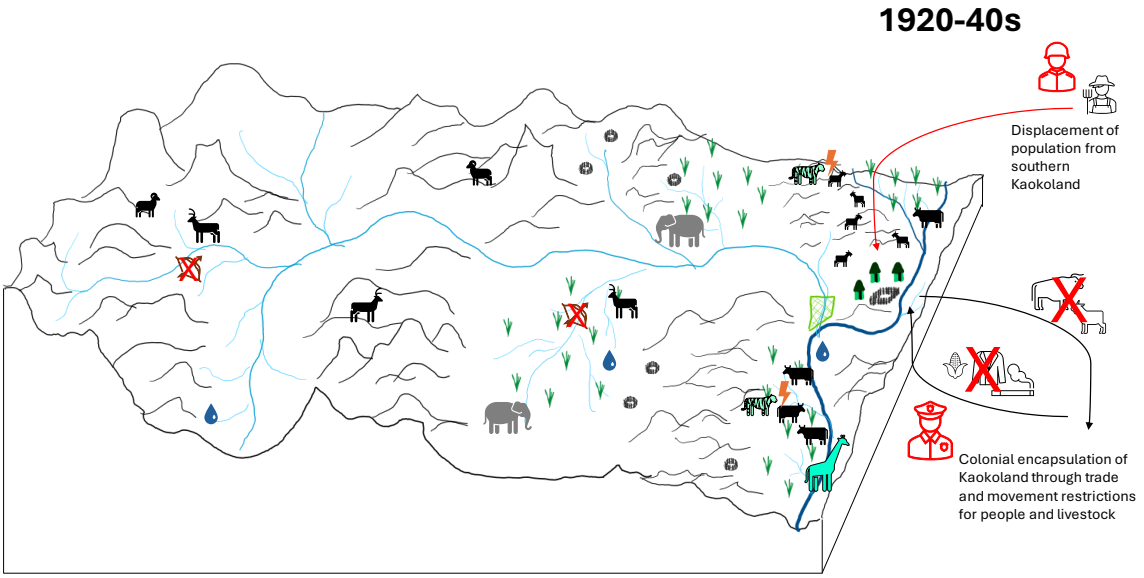

Figure 19: Land uses and livelihoods in Kunene under South African colonial rule in the 1920s to 1940s.

Not only did this encapsulation impede trading possibilities for Kaokoland pastoralists and made the population dependent on government institution for famine relief, but it also disrupted many of their historic migration routes to south-western Angola highlands and the riparian forest of the Kunene River when facing severe droughts. With a limitation of space and movements of human and livestock populations, pressure on water and grazing resources logically increased. Authorities therefore started to conceive that the area was overstocked (Bollig, 2016) and that a broader development of infrastructures, especially boreholes and roads, was needed.

Population increase and infrastructure development post 1950s

Historically, severe limitations on the availability of water had restricted the number of animals and people in the region. Most of the springs and wells could only provide for a very limited population, and so the burden on the land was kept low. The pans, and also many wells, dried up in the winter months, forcing the people to take their flock and herds elsewhere in the dry season. Large tracts of the region, especially the eastern parts of Kunene, were available for

grazing only in the summer during the rains (Paskin, 1990). During the historical survey, many respondents from Ombujokanguindi recalled migrating with their livestock only from spring season and moving towards locations where the first rains had fallen, often towards the east. Those track of lands where often left after the end of the rain as temporary pans and wells rapidly dried up. People and livestock would be returning ate their permanent settlements with access to permanent water sources.

Whereas in the 1920s, only a minority of households kept large cattle herds, by the end of the 1950s, the Himba and Herero in Kaokoland were truly cattle keepers. Reserve economies were targeted for modernisation, to produce enough food for a growing population (Bollig, 2013). The South African administration's extensive borehole-drilling initiative began in the 1960s and 1970s significantly increased access to new and more permanent water sources. This enabled both human and livestock population to grow significantly[12] and spread across the landscape, gradually establishing new permanent settlements. Those new settlements were often established by new generations creating their own homestead in locations previously used as temporarily outposts where livestock would be brought during rainy season (zone 3). Drilling of boreholes as well as mechanization of wells allowed for greater availability of water throughout the year in areas where water was limited to rainy season. According to Bollig (2016), the administration fully maintained the boreholes, providing free diesel for those equipped with engines. The year-round availability of water on remote pastures completely altered mobility patterns, allowing livestock to be moved to distant grazing areas for eight to nine months during the dry season, compared to just three to four months during the rainy season previously. This logically increased the pressure on pastures that were previously grazed only during rainy season and induced a change in the grass cover from perennials to increasing dominance of annual grasses forcing communities and traditional authorities to instore so called "rules of good grazing" (Bollig, 2013). The latter were meant to fulfil two principal goals: give all herders equal access to good pastures and to protect the latter in order to ensure their sustainable usage (Sander et al., 1998). Those rules follow the principles of intra-annual rotation to allow pastures to rest during part of the year and inter-annual rotation where grazing areas change depending on rainfall patterns and forage availability.

Malan (1974) and Paskin (1990) found that the development of such water infrastructure led to a more sedentary pattern of settlement in areas served by boreholes with movement of livestock from one cattle post to another in response to changing climatic and grazing conditions. The availability of water in sufficient quantities during the entire year did indeed provide new opportunities of establishing settlements where people and to some extend livestock could stay permanently.

As stated by respondents to the historical survey and noted by various studies (Bollig, 2013;

[12] According to Bollig (2013), between the 1920s and the late 1990s the number of cattle herded in the Kaokoveld rose from c. 35,000 to about 200,000; i.e. while the livestock population grew more than sixfold, the pastoral population increased from c. 6000 people to about 25,000 people (i.e. about fourfold).

Sander et al., 1998), the reversal of the mobility patterns and the sedentarization of the population fuelled the adoption of cropping practices by a wider number of (agro-)pastoralists, whereas cropping was before reserved to wealthier families with enough labour force (household members or clients) to cultivate and herd livestock altogether. While cropping very rarely allowed to produce sufficient maize to sustain a whole family, it was regarded as a very crucial asset in the complicated bartering and trade relations of encapsulated Kunene. Indeed, even a few hundred kilograms of maize could help save capital by limiting the number of livestock that had to be sold to buy food or wait until the next trade opportunity if prices proposed by a trader were not satisfying (Bollig, 2002). Those wo didn't have a crop field because lived in inappropriate areas with lower rainfall or difficult terrain (westwards), used to propose their labour force to relatives in the eastern parts during harvest to secure part of the harvest for their own use.

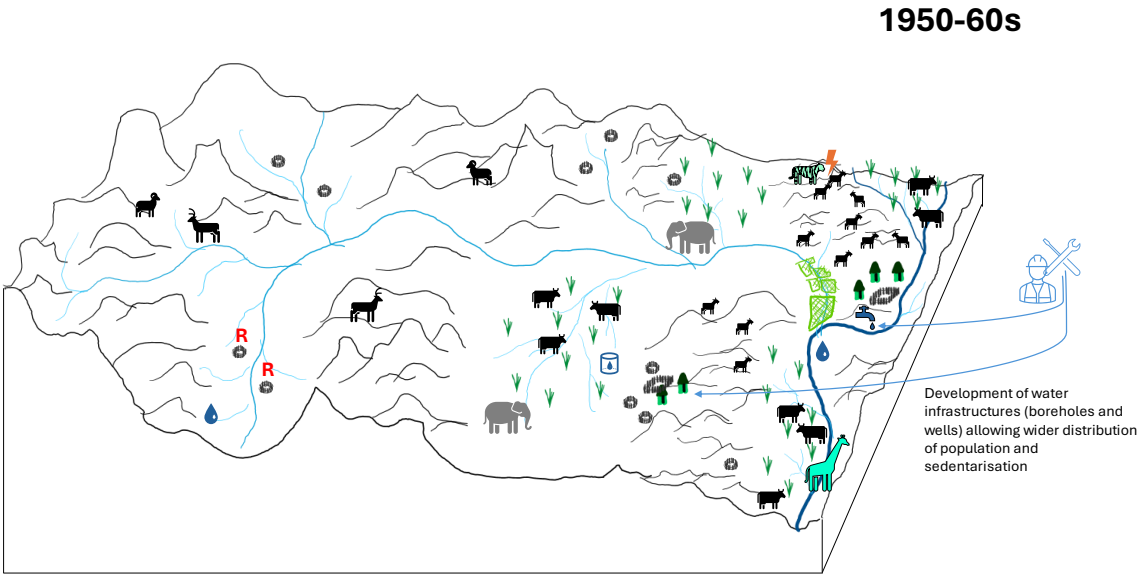

Figure 20: Development of infrastructure and land uses in Kunene under South African colonial rule in the 1950s to 1960s.

The 1950s and 1960s also marked a shift where agricultural modernization priorities overshadowed conservation efforts. Officials in semi-arid Kaokoland envisioned the region's future centred on beef production, implementing measures for "vermin control" that encouraged the hunting of animals like jackals and other predators. Certain game species, such as the Black-Faced Impala, were relocated to Etosha National Park.

Production under severe security and climatic hazards in the 70s and 80s

The agro-pastoralist system in Kaokoland that was already put under pressure by half a century of encapsulation and growing number of humans and livestock also went through some major disturbances in the 1980s. The civil war started by armed groups fighting for independence

intensified in the region in the 70s with regular raids from so-called PLAN fighters, which were operating a guerilla war from remote and mountainous parts of Kunene. Together with military rule and bombing from the South African troops, it further impacted pastoral mobility. Many participants of the historical survey in Ongongo and Ombujokanguindi mentioned having to take refuge in Opuwo or in the main settlement where chieftaincies were protected by the local police recruited by the South African authorities. Has fighting intensified, many had to leave livestock, crops and belongings behind.

As if conditions were not difficult enough, a major drought from 1980 to 1982 killed about ninety per cent of the region's cattle. According to Bollig (2013), the number of cattle in Kunene dropped from about 120,000 to about 15,000 animals in a period of only two years. This drought not only affected people's livelihoods, but it also induced a change in the vegetation with detrimental impacts on wildlife. Desperate times and increase circulation of firearms increased this pressure on wildlife as the 1970s and 1980s were marked by significant poaching by local population. This led to the decline of elephant populations and a dramatic decrease in game throughout the region (Bollig & Olwage, 2016; Owen-Smith, 2011).

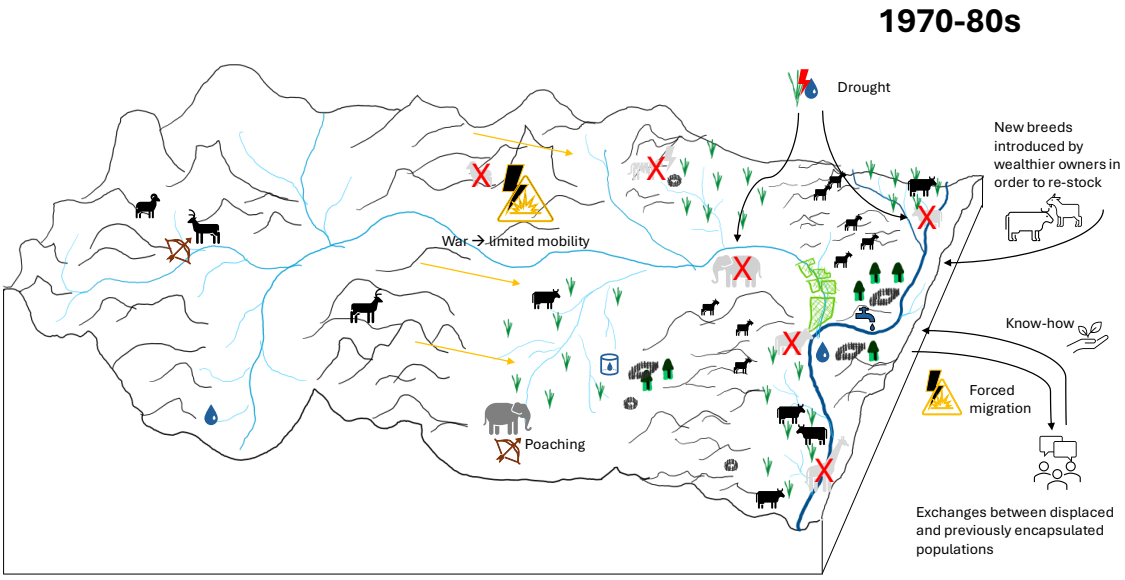

Figure 21: Land uses and mobility in Kunene affected by war and drought in the 1970s and 1980s.

It is very likely that the forced migration, drastic reduction of seasonal mobility and low livestock numbers have brought mainly families to invest more time and effort in cropping activities. Respondents of historical interviews mentioned that beside a few families counting one or more of their members recruited as police force by the South African authorities, every single household had a crop field. Population displacement due to armed conflict also brought increased exchanges between populations that were previously encapsulated in their respective chieftaincy. Knowledge on cropping practices and seeds acquired in camps in Opuwo or when staying with relatives in the main settlements were brought back home by inhabitants from remote areas.

While many mentioned a decrease in predation on livestock due to low predators numbers, incidences of crop losses due to incursions of wildlife in the gardens were on the rise. This was most likely the effect of a drastic loss of fodder in the landscape induced by the severe drought combined with the increase of cultivate areas.

In the 80s, general movement and trade (incl. livestock) with neighbouring regions was still very limited. Exchanges and movement would mainly happen across the border with Angola where surveillance had decrease because of heavy fighting between South African troops and PLAN fighters that took refuge across the border. However, a number of wealthy families managed to import new breeds of livestock from eastern Namibia (mainly Omaheke) into Kunene. Probably fuelled by the availability of new means of transport (cars) and close ties with relatives living south of the Police line, mostly Herero herders bought various Brahman, Bonsmara and even Simmental bulls and heifers to restock their herds. As no movement of livestock were allowed to cross southwards of the Police line in order to be exchanged, people had to have substantial amounts of cash to enter such transactions. Thus limited the number of people concerned to families with cash incomes from jobs in commercial areas or in the police force.

NEW INSTITUTIONAL ARRANGEMENTS IN THE 1990S POST-INDEPENDENCE

With the independence of Namibia in 1990, a number of fundamental socio-political processes were set in motion. Kaokoland, now renamed Kunene, had been isolated for many decades from the rest of the country, linkages to actors and organisations beyond the region were intensified (Bollig, 2013). Development of government institutions and services provided education and jobs for people in their communities. The transformation of the Police line into a veterinary fence still excludes pastoralists from northern Namibia from marketing options in the south today, but development of a formal meat market in the north and of quarantine facilities offered some welcomed opportunities in the 90s and 2000s. Furthermore, as travels weren't restricted anymore, young people travelled southwards to other regions or South Africa to look for opportunities and alternative revenues. On the other hand, Tourism in the region boomed and the number of tourist entrepreneurs from outside the region increased. NGO activities became prominent in various development projects (Bollig, 2013).

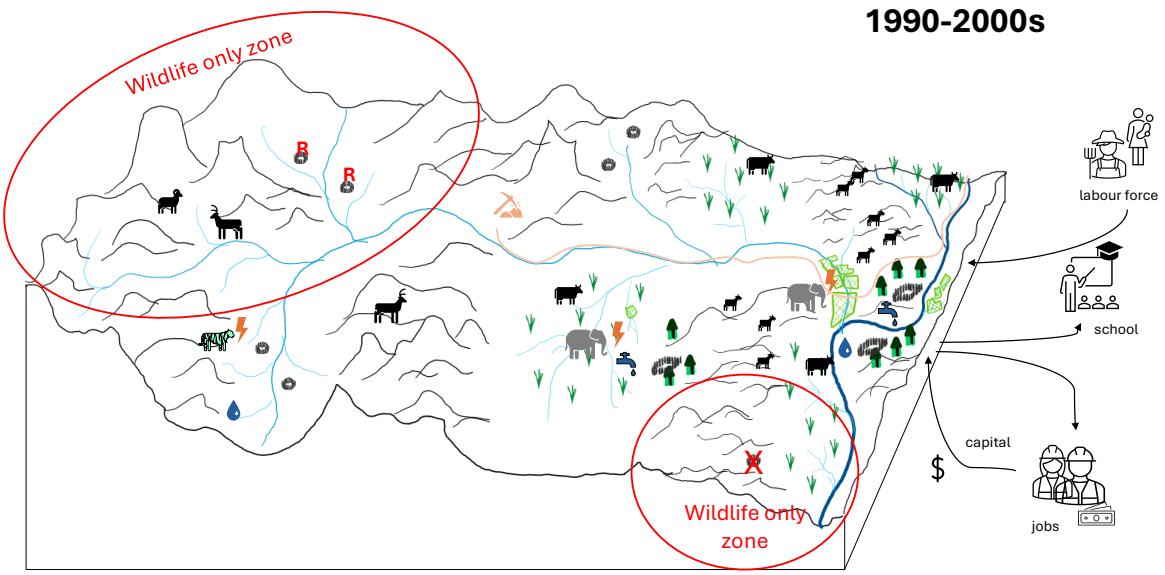

Figure 22: Land uses and development of livelihoods in Kunene since the 1990s.

Communities were keen to engage in creating new livelihoods as, degraded by a century of encapsulation, increased livestock and human pressure, sedentarization as well as new institutional arrangements, the pastoralist grazing system in Kunene was in crisis. As presented by Bollig (2013), numerous households migrated to Angola or throughout the region in the 90s to find better grazing conditions and more stable institutions of resource tenure.

On an attempt to reorganise resource tenure between 1996 and 2003, the Namibian government overhauled its legislation on natural resources in communal areas by devolving authority over natural resources to communities (Bollig, 2013). Such communities had to formalized membership, establish democratic decision-making structures, define clearly defined boundaries of the resources intended to be exploited and protected and formulate a management for the sustainable use of those key resources. Newly created conservancies, community forests, grazing associations or water-point associations were therefore also entitled to derive income from these resources through selling hunting licences, lease land for tourism or industrial development as well as stipulate user fees for water points for example. Conservancies were aimed to conserve wildlife but they brought other intangible benefits such as tighter control of immigration, clearly demarcated boundaries and institutions for internal resource-related conflicts or development initiatives (Bollig, 2013).

With the development of alternative revenues and new marketing opportunities after the country's independence, many families managed to reconstitute large herds of livestock in the 90s. Rainfall were favourable and it is often cited as a decade of prosperity, where wealthier and prominent families owned up to several hundreds of cattle. However, the more recent droughts of the 2010s and 2019, have again decimated most livestock numbers, especially cattle. In Ongongo and Ombujokanguindi, almost all families were left with very few cattle or lost their entire herd despite purchasing consequent amount of feed and fodder. This led many herders to travel long distance in search of pastures even crossing the border with Angola. This

led to conflicts in the grazing management of communities as many saw outsiders setting outposts in their allocated reserve grazing areas. Herds of smallstock, especially goats, seem to have been less impacted by the recent drought and losses in 2019 account for approximatively 20% throughout the herds in the area. Besides owners benefitting from an alternative income or previous owners of very large number of cattle and smallstock, very few seem to have been able to recover or engage in restocking their herds. Climate change with below average rainfall and the very serious degradation of availability of fodder in the landscape surely is a key factor explaining those difficulties. However, while smallstock seem to suffer from recurrent diseases outbreaks, it is also crucial to pinpoint that compared to the 90s, re-stocking difficulties are exacerbated by adverse prices relationships and the gradual decrease of the market value of livestock in Kunene. This is especially true for cattle, hence the acquisition of young pregnant heifers from commercial areas in the south has been said to be now two to three times more costly for a livestock owner in Kunene than in the 80s and 90s. Migration of livestock to Angola during the 2014/2015 drought is also said to have led to an outbreak of Foot-and-Mouth Disease (FMD) in northern Namibia after an absence of almost 27 years (FAO, 2021). This outbreak led to a rapid response from veterinarian services but had devastating consequences on the few livestock quarantines facilities and the one and only industrial abattoir of northern Namibia in Oshakati. Those initiatives, meant to promote the marketing of livestock north of the veterinary fence to other regions of Namibia and internationally where totally stopped and their rehabilitation is still on halt.

Not only are price relationships not in favour of livestock owner in Kunene, but the more recent monetization of the economy engaged with independence in the 90s and increased crop losses due to below average rainfall and a shorter rainy season, are nowadays forcing many households to regularly sell their animals, especially goats, in order to respond to the cash economy and pay for everyday expenses and services. Hence the difficulties to gain important herds of smallstock (mainly goats), mentioned as an essential asset in order to rebuild herds of cattle in the 80s and 90s.

In many aspects, patterns of resource exploitation have changed, but previous institutional arrangements remained. Conservancy constitutions have found very different ways to define linkage with traditional authorities, but there is not one constitution where traditional authorities are not of decisive relevance (Bollig, 2013). Even though they are still relevant today, ancient power relationships have been shaken by new institutional arrangements and increased differentiation of rural communities enhanced by extra-agricultural livelihoods. As a result the fragmentation of common resource management dominates: the group of resource users has become internally more differentiated and so too have the rules of resource use themselves (Bollig, 2013).

On a similar vein, the present agrarian systems in Kunene are still characterized by highly sensitive agro-pastoralists production systems shaped by a century of very restrictive history. Encapsulation of this part of the country means that farmers have been deprived from developing ways to extract their production systems from natural hazards. Nowadays, people can move freely but movement of livestock is still controlled through a zoning strategy and

movement permits meant to reduce disaster risks linked to livestock disease (FAO, 2021). Thirty years of independence and development of government services in form of vaccination campaigns, subsidies programs, food relief and pensions schemes haven't yet erased inequal economic development along the still remaining veterinary fence.

As a result, farming practices centred around livestock keeping and subsistence cropping have not changed much over the last century, nor did the society in itself. Rural communities and their livelihoods are still structured around the historically wealthy families that controlled resources in the early 1900s and later became the principal representatives of the still remaining traditionnal authorities. Today, those are often the owners of the largest livestock herds and smaller owner are either young generation establishing their own independent enterprise or representatives of the earlier "clients" of those wealthy "patrons". However, opening of regional borders and development of institutions and infrastructure post-independence did provide some new opportunities. Hence, today, part of the population is engaged in extra-agricultural livelihoods besides farming activities.

The following chapter aims at exploring and understanding current livelihood strategies of farmers in Ongongo and Ombujokanguindi conservancies and give elements of reflexions on how to support the latter in developing sustainable and remunerative agricultural production systems.

FARMING PRACTICES TODAY

This chapter provides a qualitative analysis of interviews regarding production systems in order to identify and describe the main constraints affecting farming practices and the decision-making process related to resource allocation within farms and households. It therefore provides an overview of the diversity of farming practices encountered in the study areas. Together with quantitative data collected during interviews, the results were then used to model production systems and evaluate the socio-economic performances of cropping systems (plots) and livestock systems (herds) through the calculation of wealth creation and overall farm income. Those results are presented in the second part of this chapter.

LIVESTOCK SYSTEMS

Livestock often roam around pastures during the day and can be seen spending the night around houses and settlements. This is particularly true for herds of goats and sheep, which usually consist of 50 to over 300 animals. These herds, usually escorted by young boys or hired herders, travel daily to water points to drink and return in the evenings from grazing and browsing areas to settle for the night between houses or in enclosed kraals. Goats and sheep are sometimes kraaled with cattle, sometimes kraaled in the household compound or separately.

People typically release the offspring of goats and sheep kept in small kraals during the day when the herd returns to the settlement, allowing them to be breastfed while some of the animals are milked. Offsprings are then separated again and from their mothers for the night. The same process is usually repeated in the morning. Goat herds are present in all types of terrain but are more commonly found in rocky and hilly areas with small trees that are easy to browse. Cattle are also often left to roam freely at night, with small herds (usually 10 to 30 animals) observed resting in grazing plains away from settlements in the early mornings or evenings. They can also be seen grazing in harvested crop fields right after the maize harvest in May grazing on weeds and crop residues. Predation by cheetahs on smaller livestock is frequent, while cattle face less threat from predators, being only occasionally at risk from hyenas and leopards.

Cattle breeds found in Kunene are dominated by the traditional “Himba” which is a local breed of Sanga and Nguni cattle, rather small in size but very robust to semi-arid conditions and able to walk long distances. As a result of cattle being bought from southern and eastern regions of Namibia since the 80s and 90s, most herd are mixed with breeds such as Brahman, Bonsmara or sometimes some Simmental or Simbra breeds.

While cattle is historically and socio-culturally very important in Kunene, most of the household today are surviving on herds of smallstock dominated by goats. The vast majority of goats in Kunene are from an indigenous breed close to the Indigenous Veld Goat. Genetically and as productive animals, these indigenous breeds have considerable value due to their fertility, high rates of survival and resistance to disease (Mendelsohn et al., 2006). Over the past decades, herds of indigenous goats in Kunene have increasingly been exposed to pure and

mixed genetics from goats purchased in southern areas of Namibia such as Kalahari Reds or Boer goats. Their value lies in hardiness, high reproductive rate (lambing percentages of 180% are possible as a result of frequent twins), high resistance against external parasites, and their lean, tender meat which has a low cholesterol content. They also prefer to browse on woody plants, thus consuming little grass and hardly competing with cattle that depend more on grass (Mendelsohn et al., 2006).

Most of sheep found in Kunene are stemming from the fat- and twisted-tail Damara breed. As a breed indigenous to Namibia, Damara sheep are hardy, being well adapted to conditions of limited water and food supply. Other attractive features include its tasty meat, good resistance against parasites, and a varied diet with up to 64% of its food consisting of browse (this is similar to goats and higher than other sheep that eat more grass). Damara ewes also take exceptional care of their lambs (Mendelsohn et al., 2006).

As presented in Figure 23, despite severe impacts of the 1981/82 and 1991/2 droughts, overall livestock numbers Kunene have drastically increased since independence in 1990, especially cattle. However, more recent droughts since 2015 have severely impacted cattle numbers, and as seen across households from the present study areas and in other regions (see Inman et al., 2020), smallstock has gained in importance and has become a crucial asset for most of them.

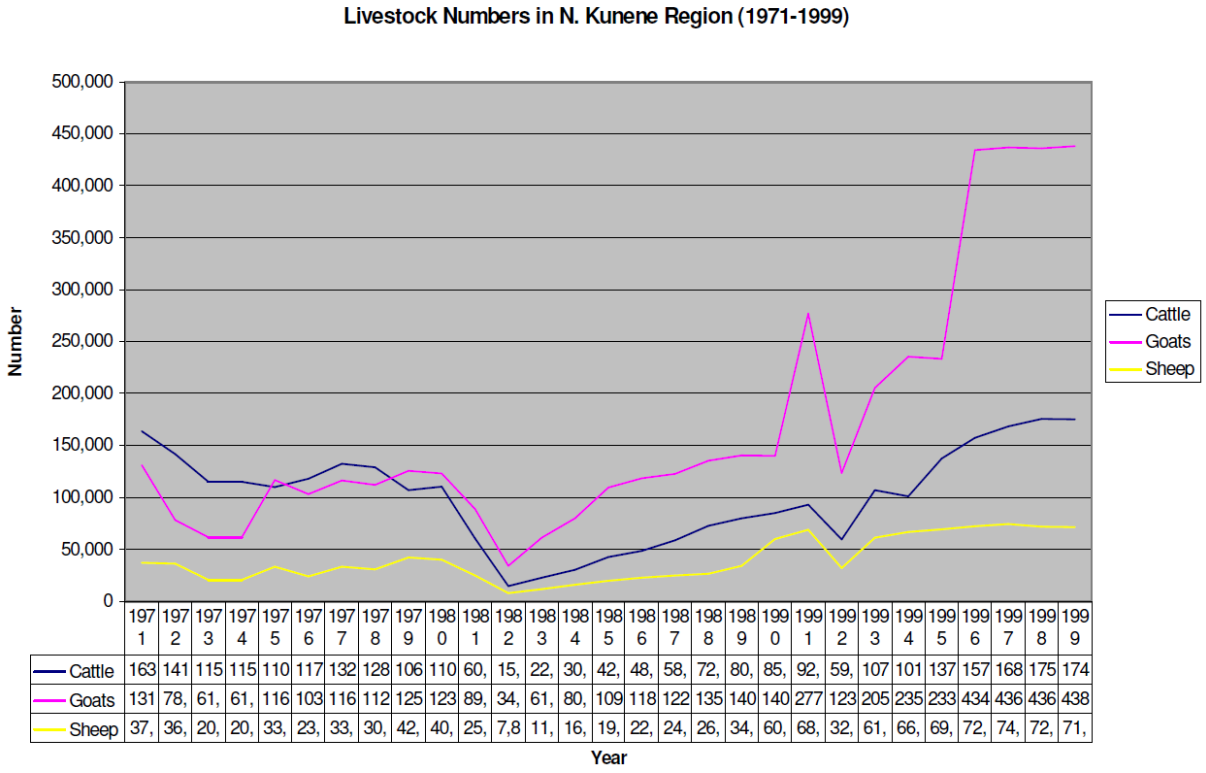

Figure 23: Livestock Numbers in Kunene North from 1971 to 1999 (Vigne, 2001).

Herd demographics

Goat herds in the study areas usually show a kidding rate of 125% with an important parturition of twins. Mortality of offspring however is high with more than 40% of kids lost before their first year. Overall mortality of adult rates at 18% and 5% are either victims of predation, theft or simply lost (see Appendix 6 for detailed demographic diagrams of herds). Sheep herds show a slightly lower lambing rate of 100% but, with no milking of ewes, the offspring mortality is lower than goat with 24%. Adult mortality and losses are quite similar to goats with respectively 15% and 6%. Goats and sheep usually reach maturity after one month with female able to mate after nine 9 month depending on the body conditions. Pregnancy usually lasts five month and offsprings are weaned after three to four month. May/June and November are the two major kidding and lambing period in the year.

Given the limited number of cattle in the study areas and the recent stripping of herds due to the 2019 drought, very little data could be gathered on cattle demographics. However, according to previous studies, calving rate in communal areas in Namibia are seldom above 50% and mortality rates from 10 to 20% per year (Mendelsohn et al., 2006; Vigne, 2001). Heifers usually mate for the first time after three or three and a half years, with calving intervals between twelve and twenty month depending on the health of the animals and pastures conditions. Most cows are giving birth at the beginning of the rainy season from November to January after a nine-month pregnancy.

Males are systematically castrated and represent the vast majority of animals sold and slaughtered for self-consumption or for socio-cultural purposes (e.g. ceremonies). For smallstock, they are usually kept three to four years until fully grown and can therefore represent a large part of the herd (up to 45%). Oxen are usually sold at thirty month and represent usually between 20 to 40% of the herd (Mendelsohn et al., 2006). The ratio of reproductive males varies a lot, but herders usually keep one ram or bull for ten to twenty females. However, the present study also counted many households relying on their cows to mate with bulls from other herds, thus impacting the breeding rates. This was especially true for owners of smaller cattle herds of less than fifteen heads.

The general absence of culling of older animals with low milk yields or fertility can be explained by the lack of buyers for lower-quality meat animals; the preference is for young, castrated males. Furthermore, as goats are seen as a living capital it will not be beneficial to sell it. An old animal is instead valued through self-consumption at the time of its death.

In years of good rainfall and availability of good grazing resources, restocking is necessary to compensate for high juvenile mortality and to address climate shocks and epidemics, as well as to provide capital for needs and emergencies, social capital, and inheritance. In bad years, when mortality is high due to diseases or lack of forage or diseases outbreaks, the losses are significant, with the only possible valuation coming from a few animals that may be consumed after their death.

The growth curve of herds therefore fluctuates and is influenced by shocks and the ability of households to maintain and restock herds. Regular losses, often significant, are caused by

epidemics affecting small ruminants, which can see up to sixty goats die in a single year. Transhumance provides some measure of control of kraal parasites. The main diseases are pasteurellosis and pulpy kidney, and the main parasitic conditions are goat mange and sheep scab and wireworm (*Haemonchus sp.*) (source: Directorate of Veterinary Services & Talavera et al., 2000). Preventive and curative treatment of smallstock through vaccines and natural recipes is practiced but to a lesser extent than cattle as there is no vaccination services provided for smallstock. In contrast, the impact of climate shocks on smallstock is less pronounced, typically resulting in up to twenty animal losses for one household during exceptional drought years.

As illustrated by Figure 23, the highest losses of cattle are typically due to climatic shocks, as they appear to be less susceptible to epidemics. Annual vaccination campaigns for FMD and Contagious bovine pleuropneumonia (CBPP) are carried out by the Directorate of Veterinary Services (DVS) and when outbreaks happen substantial number of resources for prevention and vaccination is mobilized by the state.

Given that climatic and epidemic hazards are frequent, it becomes evident why herders feel the need to maintain large herds and off-take rates during good years. Households that can rely on external income, even if minimal, can mitigate the fluctuations in herd numbers, particularly by investing in preventive treatments and purchasing feed to reduce disease-related mortality. However, even with high inputs, maintaining a large number of animals can be challenging due to labour requirements, and significant historical climate shocks in the 80s and 2010s have also had devastating effects on these well-maintained herds. In those cases, external income allows for quicker recapitalization through the purchase of animals while any unpredictability, whether climatic or socio-economic, will force poorer households to sell animals to meet food security or respond to other expenses.

Consequently, wealthier households tend to have lower off-take rates. This trend aligns with findings from earlier studies in Kunene, where owners of large herds preferred to accumulate cattle, resulting in off-take rates below 11% for cattle (Bollig, 2002; Talavera et al., 2000). The present study found that this was especially true for herds of goats as off-take rates applied by wealthier households counting on a large herd (6,7%) or an important external revenue (4,4%) where significantly lower in comparison to owners of smaller herds without additional income (17%). However, due to limited herd sizes, off-take rates for cattle and sheep were found to vary less depending on the wealth of the household but rather linked to the immediate needs of the family and the numbers of animals that can be drawn without inhibiting rejuvenation.

Compared to survey results on livestock marketing in the Northern Communal Areas of Namibia from 2000 (Talavera et al., 2000), off-take rates appear to have significantly declined since the 1990s. The current study found off-take rates consistently lower than 10% for cattle and smallstock across the entire study area. It is important to acknowledge that the figures provided by respondents are likely to be understatements, but that low off-take rates can also be attributed to current restocking practices in Kunene following several years of repeated drought from 2012 and from 2019 to 2022. While this can be said about goats herds of over

100 animals, sheep and cattle herd demographics and off-take rates indicate that current numbers and conditions do not allow to engage in restocking strategies without resorting to the purchase of animals (see Appendix 6).

Milk production

In general, herders milk their animals sparingly for several reasons. First, the sale or commercialization of dairy products is virtually non-existent, and the milk produced is solely intended to meet the family's dietary needs (*omaere* = fermented milk) or for cosmetic purposes (*omaze* = butterfat) for the household and possibly for visiting friends or relatives, to whom it is customary to offer milk. Secondly, milking only the amount of milk required for household consumption allows for maximum milk availability for offsprings, addressing an important zootechnical function. Consequently, some households will limit milking to once a day during certain times of the year or even stop completely during the late dry season. Animals with weak juveniles, such as mothers of twins, may also be spared from daily milking. Generally, the vast majority of households maintain a minimum level of milking of their goat herd throughout the year to meet their household's needs in *omaere*. Milking also represents a significant workload, and not all households have available labour to milk all lactating animals, especially in larger herds. Moreover, the longer the morning milking takes, the later the animals will access pastures, resulting in less time for them to graze.

Goats are usually milked during three to four month after giving birth. Following respondents' statements, milk yields vary from 0,125L to 0,25L per goat per day during the dry season (June to October) and 0,25L to 0,5L per goat per day during the rainy season (November to May). This corroborates with findings from previous studies in the region (Bollig, 2002).

The peak of lactation of cows, usually during rainy season from March to May, only lasts a few weeks, but most of them can be milked for very long periods over six month to one year. From July to end of the year in November/December, milk yields are very low (less than 0,5L per cow per milking) and many respondents have mentioned stopping milking of cows during the late dry season. According to respondents, milk yields seem to vary a lot depending on individuals' genetics and condition. However, one can usually expect to collect between 1,5 to 3L of milk per cow per day during rainy season.

Milk yields for cows seem sensibly higher than those found by Bollig (2002), in the year of 1995. One hypotheses to explain such difference could be the introduction of improved genetics from breeds such as Brahman cows who are renowned to produce higher milk yields when in good conditions.

Seasonal mobility and feeding strategy

Forage production and the availability of forage resources vary over time and by area and has historically led to a high mobility of herds throughout the landscape.

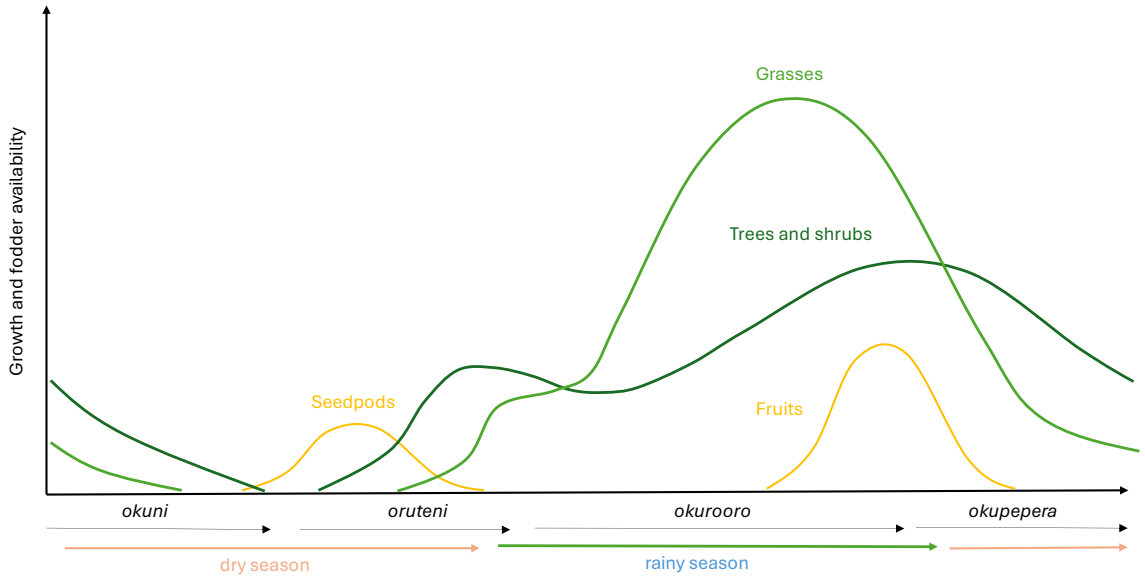

Figure 24: Seasonality of vegetation growth and fodder availability across the landscape in Ongongo and Ombujokanguindi conservancies.

The new year (January) usually starts with the peak of the rainy season (*okurooro*) when most annual grasses, trees and shrubs are in their growth phase. Trees (e.g. *Phyllogeiton discolor* = omuve) will set up fruits by the end of the rainy season. With the last rains around March and April, the grass cover will quickly disappear as annuals around settlements, riverbeds and grasslands are prone to breakage and blown away by the wind. However, the tree and shrub cover as well as standing hay from perennial grasses will last longer into the dry season, especially in areas further away from permanent settlements. During the dry season, green leaves from *Schotia afra* or *Catophractes alexandri* (omukaravize) found further away from settlements are important fodder for goats while standing hay from perennials such as *Stipagrostis uniplumis* (ongumba) is important grazing for cattle. During late dry season, the deep-rooted mopane trees (*Colosphospermum mopane* = omutati) are able to break dormancy and reshoot green leaves that together with fallen seedpods from *Faidherbia albida* or *Vachellia erioloba* are crucial fodder for smallstock that stayed with part of the household around permanent settlements. The sprouting of the mopane tree signs the spring season (*oruteni*) with the arrivals of the first sporadic rains and the rapid regrowth of perennial grasses, where they can still be found.

As a result, depending on labour availability and access to grazing and water resources, herders will have different migration practices during the dry and rainy seasons (see Figures 25 and 26).

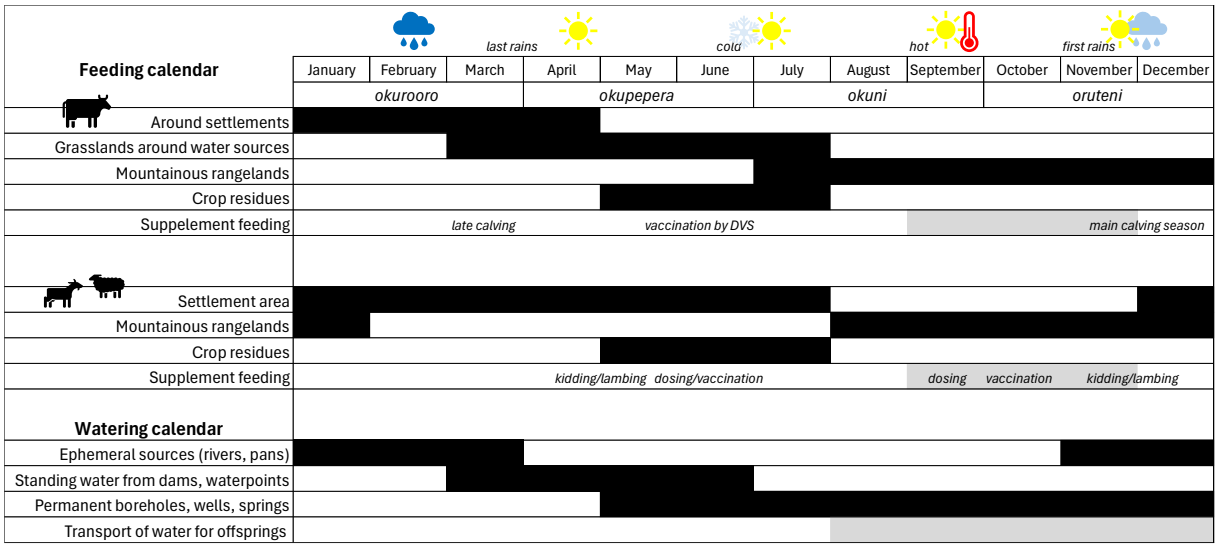

Figure 25: Feeding and watering calendar of livestock systems in Ongongo and Ombujokanguindi conservancies.

Historically, livestock owners practice a form of range management based on the seasonal use, resting and rotational grazing areas, as far as possible adjusting stocking pressure to annual rainfalls and forage production, usually overseen by a grazing committee. However, the recent decrease in livestock numbers due to drought events as well as dynamics of sedentarization as explained earlier, with a larger population spread across a larger part of the landscape, seasonal mobility of herds seem to be more limited nowadays. Indeed, farmers seem to practice a type of dual system whereas in years of sufficient rainfalls and grazing resource, an important part of households and herds will stay around permanent settlement the whole year. In some communities, specific grazing areas outside permanent settlement zones are also restricted for grazing in late dry season from August/September (mountainous rangelands or some alluvial grasslands) to the onset of the rains. Some other areas serve as "reserve grazing areas" and their access is possible only during severe drought years (e.g. wildlife only zones). Those decisions are usually taken by the whole community in form of gatherings between traditional authorities, grazing committees, conservancy committees, elders and community members.

As exposed by Sander et al. (1998), Himba usually follow a complex set of grazing regulations that are meant to fulfil two goals: to give all herders equal access to good pastures and to protect pastures in order to ensure their sustainable usage.

1. Nobody is allowed to herd livestock in the dry season grazing areas after the onset of grass growth there.
2. Livestock camps (outposts), have to move some kilometres away from the main settlement in order to ensure that the grazing orbits of the household herd and outpost herd do not overlap. This lowers the grazing pressure in the settlement area and ensures that the lactating stock kept at the main settlement has sufficient fodder.
3. Livestock camps should move in one direction, ideally moving forward together.

4. Herder should not move their camps too frequently, as it would promote trampling of grasses. Only when the first rains fall and the vegetation period of *Commiphora ssp.*, *Terminalia prunoides* and *Rhigozum ssp.* starts, are these regulations given up in favour of free trekking.

In general, cattle herds move ahead of small ruminants by several weeks during the dry season to avoid trampling the standing forage. However, when returning to pastures during the rainy season, this logic is not always followed, as the regrowth of grasses is less sensitive to trampling, and the areas grazed by cattle and small ruminants often differ. Cattle tend to prefer flat, grassy areas with taller grasses in alluvial zones, while small ruminants remain around villages or on the slopes of hills in more shrubby and stony areas.

While cattle are usually free-roaming and escorted only to temporary outposts or to waterpoints (when labour is needed to fetch water from dugwells or operate handpumps for example), smallstock is constantly herded by young boys or hired herders because of the threat of predators. This herding also ensures that smallstock graze in different areas than cattle. During the late dry season (August/September), smallstock are usually taken to outposts, but a few lactating animals are often left with elders at the main settlement and ensure milk (*omaere*) provision. Animals can be moved back and forth between the main household and various camps to ensure sufficient fodder supply for small goats near the household (Bollig, 2002).

Building on data retrieved from historical interviews and survey on production systems in Ongongo and Ombujokanguindi, the present study has identified four different livestock systems based on species composition and seasonal mobility (Table 1).

Table 1: The different livestock systems studied in Ongongo and Ombujokanguindi.

	Livestock system	*Composition*
LS1	Smallstock only with migration to outpost in late dry season or very limited movement.	<100 goats; 10 sheep
LS2	Cattle and smallstock kept at one single location and migration to outpost from late dry season to rainy season.	< 10 cattle; 100-150 goats;15 sheep
LS3	Cattle and smallstock divided into several flocks and temporary outposts throughout the dry season.	20-30 cattle; 200-300 goats; 50 sheep
LS4	Cattle and smallstock divided between main settlement, outposts, and a secondary settlement throughout the year.	30-50 cattle; 250 goats; 50 sheep

Usually, wealthier households tend to own more livestock, have a larger labour force to access several locations simultaneously and divide their herd in several flocks (LS3 or LS4), while others keep livestock in limited numbers all together at one single location at the time (LS1 or LS2). This has also been described by Bollig (2002), who states that wealthier farmers have

dependent cattle posts (managed by family members), independent cattle posts (managed by herders), and smallstock camps. Less affluent farmers typically only have dependent cattle posts. In the case of large herds, they are often divided into two or three smaller herds, each going to different outposts based on the availability of family or hired labour. This strategy serves as insurance against diseases or other disasters (Hvidsten et al, 1997 in Talavera et al., 2000). Farmers with large herds may share part of their herd with relatives or establish a secondary settlement for livestock and herders (often including one or more sons with their own families) for a few years (see Figure 26).

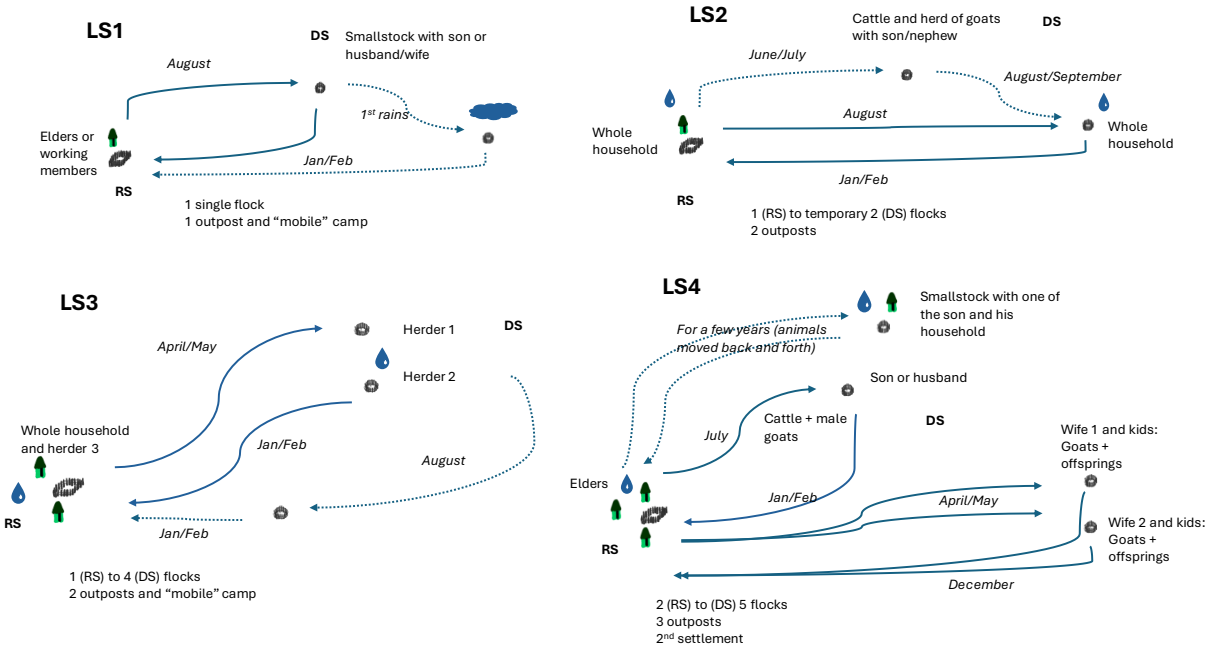

Figure 26: Examples of seasonal mobility of livestock herds during rainy season (RS) and dry season (DS).

While cattle herds generally do not exceed 70 head, smallstock are usually kept in much larger herds, often numbering in the hundreds. According to Bollig (2002), it is estimated that smallstock require about one-sixth of the pasture that cattle need, which translates to 2.9 hectares per animal compared to 17.4 hectares for cattle.

Most households will regroup all members and most of the flocks in the main settlements during rainy season for the main cropping and cattle milking season. During the dry season, some household will keep a few lactating goats or cattle at the main settlements with elders or schooling kids while the rest will move to various outposts depending on available labour. As a result agro-pastoralists in Kunene can be qualified either as semi-nomadic when they will move with their livestock to outposts and camps throughout the year or sedentary when staying at the main settlement and sending herd boys or hired herders to outposts with their livestock (Talavera et al., 2000). Both systems coexist in Kunene.

The off-take rates as well as management practices such as vaccination or supplement feeding strongly depend on the household composition, food security and economic situation of the

latter. An overview of the different management and utilization practices will be provided with the presentation of the different production systems below.

CROPPING SYSTEMS

Crop production, which is often neglected is quite important for the region. Almost every household in the study area owns a garden and as confirmed by Talavera et al. (2000), cropping calendars suggest that crop production cannot be neglected as it is time consuming and requiring high inputs for low outposts and as farmers are committed to it. In fact, maize has been cited as an essential asset for farmers to have greater negotiating power in trade relationships, having a few sacks of maize flour to survive on until the arrival of another merchant willing to put up a better price for their livestock (Bollig, 2002). During this study, many stressed out the importance of cropping in order to be able to stock or re-stock their herds and build wealth. It is interesting to note that some authors have stated than prior to the 80s, less cropping was practiced in years of good rainfall. This further support that crop production is an important strategy and effective way to "save capital (Talavera et al., 2000).

According to study respondents, cropping has been present in Kunene since a very long time and their forefathers that came to settle in the region after the German war were already cultivating maize on a yearly basis. This seems to be mainly the case for the family members of wealthy newcomers while others were depending more on livestock and wild products to survive. However, since the 80s and 90s, there has been a sedentarization of the communities and the promotion of a more widespread crop production system (Talavera et al., 2000). Beside maize, Himba and Herero communities mainly cultivate pumpkins, melons, watermelons, calabash (gourds), sometimes beans and a variety of sweet sorghum.

Location of crop fields in the landscape

Giving the generally rocky and shallow characteristics of soils in Kunene, crop fields are always located either on affluents streams or on flood plains where years of accumulation have created deeper alluvial soils. Farmers cited loamy soils along riverbeds where rainwater and sediment from smaller river streams will gather but where water quickly infiltrates in the soil to be the best suited for cropping.

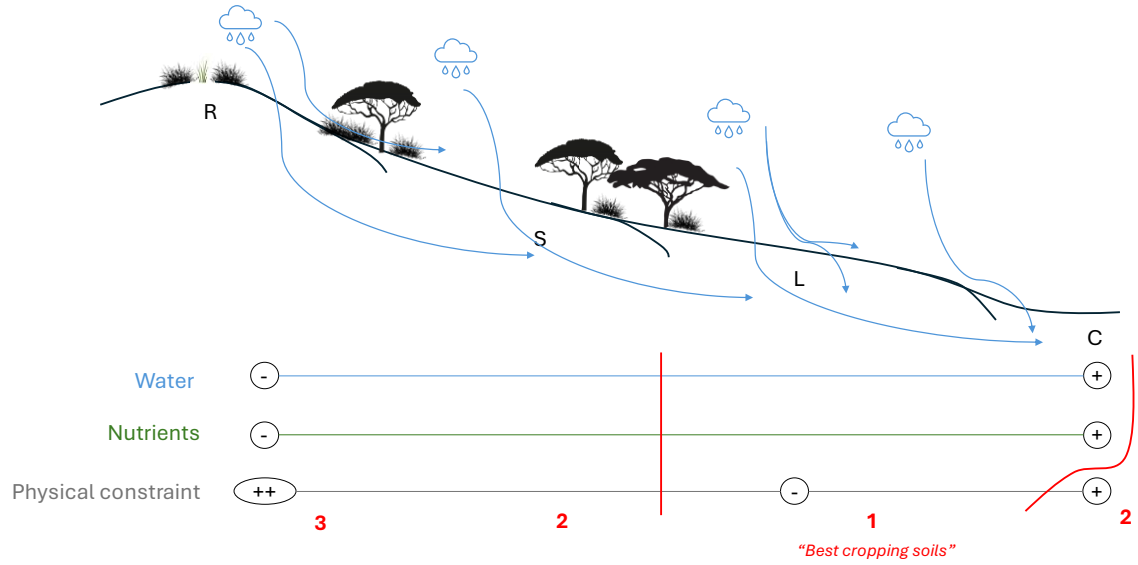

Figure 27: Ecological constraints depending on soil types and localisation of crop fields (R=rocky ; S=sandy; L=loamy; C=clayey).

As illustrated by Figure 27, soils with a high fraction of clay that are regularly flooded will have difficulties to let water infiltrate with the first rains, thus retarding the growing period. Once humected clay soil have low drainage and are therefore difficult to till, especially when using hand hoe or donkey to plough the field. Excess of water on clay soils will also have negative effect on the maize growth. On the other hand, sandy soils are easy to work with but having very low water and nutrient holding capacity, climatic hazards can have big impacts on maize yields. Loamy soils represent therefore a good balance between those constraints where drainage is sufficient, but water and nutrients are more easily accessible.

Gardens situated along riverbed or on smaller affluents in alluvial catchments are used by one household for several decades and soil fertility is replenished by annual flooding and deposition of sediments (Sander et al., 1998). The best located gardens occupied by the newcomers beginning of the 20st century have even been continuously cultivated until today. A garden located on a flood plain will receive water even if the rain is falling on the hills and mountains upwards which make it possible for agro pastoralists in the region to cultivate crops even under 300mm of rain. Cropping by communities in Kunene is in is vast majority rainfed and depending on flooding (Crandall, 1992). However, simple furrow irrigation is also practiced in eastern and southern parts of Kunene where large springs enable the cultivation of crops and tobacco under irrigation (Behnke, 1997; Malan, 1974).

Today, cropping practices are widespread in Kunene. However, they gradually disappear towards the west of the region with the pluviometry falling down to less than 200mm per annum. Those communities usually relying only on livestock or small irrigated gardens where water is available, and extra-agricultural activities. In the study areas, it was claimed that people from western areas would come and help relatives during harvest to secure part of it to take home and feed their households. It was also observed that many households having access to

better cropping grounds through relatives in eastern areas will travel up to 60km (as the crow flies), to cultivate. A tendency that seems to have increased in recent years for households living in areas with under the 200 or 250mm pluviometry threshold.

Crop fields cultivated by individual households in both study area very rarely exceed 1ha and usually range between 0,25ha to 1,3ha (for an average size of 0,6ha). Other studies in Kunene observed gardens sizes ranging from 0,1ha to 2 or 3ha depending on the areas (Bollig, 2016; Talavera et al., 2000). Gardens are always surrounded by a fence carefully made out of cut down bushes and branches and more recently also poles and wires, to keep wildlife and livestock from entering the fields. One single fence sometimes surrounds a group of individual crop fields belonging to several different households. This is often the case for old cropping fields with the best soils that belonged to one single family at his debut but has been gradually divided into the member of the family or even the larger community. As presented in Talavera et al. (2000), those "pool" gardens, also called "community gardens" allows to join forces and divide labour for fencing of the fields or surveillance from birds and other animals which is very time consuming during the whole growing period.

Crop-management sequence

The cropping season begins with the clearing and fencing of the fields towards the first rains in November or December. Paid labourers, often migrant workers or OvaZemba people from Angola, frequently clear the field and erect the garden fences.

Ploughing and planting is usually done after the first heavy rains from December to February with a hand hoe or with a plough pulled by four (sometimes six) donkeys. Historically, people used oxen to plough fields, but this practice seem to be nowadays limited to only a few households owning sufficient cattle and their immediate relatives or neighbours. Farmers who do not use animal traction will prepare the field after the first rain and wait for sufficient moisture to plant when rains are setting up properly. Farmers using animal traction usually operate ploughing and planting simultaneously with maize, pumpkins and melons seeds sowed by hand in the furrows right behind the plough. The study found that most farmer practice intercropping of maize, pumpkins, melons, watermelons and sometimes sorghum by sowing three to four holes of three or four maize seeds before sowing a pumpkin, melon or watermelon seed in intervals of 40 to 50cm (two feet). Some claimed sowing maize, pumpkin and melons seeds in the same hole or allocating specific areas of the field to the different crops. Pumpkin and melons seem to grow better in "upper" parts of the field where humidity is lower and thus reducing the risk of rot, while maize can be grown everywhere. A small portion of the field (usually a corner) is sometimes allocated for growing beans under the cover of a few maize crops. Sweet sorghum is usually sown over half a row in interval with a few rows of maize. Farmers sometimes plant only part of their field because of lack of seeds or depending on where the water and sediments were discarded during the rains, thus reproducing a type rotational cropping with part of the field in fallow. Nonetheless, because of the very limited arable surface area and limited ploughing and planting capacity, farmers tend to cultivate the whole plot when sufficient seeds are available.

Some farmers with fields located near Agricultural Development Centre, sometimes benefit from a tractor tilling service provided by the Ministry of Agriculture (MAWLR) in exchange of a fee of approximatively NAD 400 per hectare. The ministry resource being scarce (31 tractor operators in Kunene for thousands of families) the services' outreach is very limited (longer distances equal to higher costs) and good timing is difficult. As a result, besides, two respondents residing outside the study areas closer to the Agricultural Development Centre and resorting to tractor tilling every three to four years when the timing is good, no households had access to this service, which is true for the vast majority of farmers in Kunene.

Irrigated Fields are usually smaller than rainfed crop fields (0,05ha to 0,25ha). Families that have historically planted crops under irrigation from spring water used to plant maize and wheat as well as some vegetables. Crops were planted after the cold season (August) and harvest by the end of the year (December) before planting vegetables and working in the rainfed crop fields. The harvested corn from irrigated crop fields were then also used as seeds for the rainfed fields. In those areas irrigated maize is said to yield only two third of the production of a rainfed maize. Respondents mentioned that maize "prefers to be watered from above by the rain" (interview n°25), but those differences in yields could be explained by a more limited amount of water receiving by the plants as irrigated maize is usually planted after winter (August), way before the return of rains and the main cropping season. Some maize is still cultivated under irrigation but cultivation of wheat which was used to bake bread has apparently disappeared in most parts, only remaining active on a very small scale around some springs in areas of the south of the Kunene region where Damara communities live. On the regional scale, irrigated cropping is quite limited and reserved to a few location with access to sufficient spring water and good cropping soils. More recently (since the 2010s) more households seem to have started gardening under irrigation at new locations with spring water but usually very rocky and less suitable soils. This is the case for two locations in one of the study area (Ombujokanguindi) were people are trying to cultivate small vegetable gardens around springs or river streams previously used only for human and livestock consumption.

Farmers in Kunene are usually planting a local maize variety about which little is known. Usually seeds from the previous harvest are planted and when no seeds could be kept from the previous season because needed to sustain the family, seeds are either obtained from exchanges with other farmers or bought from the informal market or the agricultural supply shop (Agra) in the local town. Local seeds are usually preferred to other varieties bought from suppliers as they mature earlier, easier to grind (proper texture) and the maize meal tastes well (Talavera et al., 2000). A study respondent also specified, when buying seeds from the supply shops, preferring the yellow variety (Sahara) over the white one (Zama select) because the latter would "grow very tall and put up cobs late" (interview n°29).

When consuming pumpkins and melons, people will usually keep the seeds and store them after drying to be planted the next season. Vegetables or lucerne seeds are usually bought from suppliers in town (Agra) and some farmers then produce their own seeds for tomatoes, chilis, spinach, tobacco, cabbage, etc.

While there are a few accounts of the use of manure as fertiliser in the literature, chemical fertilisers seem to be non-existent in Kunene-north (Bollig, 2016; Talavera et al., 2000). In the study area, despite some farmers recognising the benefit of manure as fertilisers, none of them stated using manure to fertilise their fields. Manure is usually left to dry in kraals or mixed with clay and ash to cover house walls. The present study also found no use of other fertilisation or pest-management methods, besides a few farmers with irrigated gardens using pesticides to control pests on their vegetables. Some of the latter also specified making their own compost out of manure and green residues and using it to fertilise their growing beds.

Weeding is usually executed with a hand hoe and, following literature, done at least twice; before planting while clearing and after the seedling are ten to twenty centimetres high (Crandall, 1992). However, farmers were found to weed their field up to three or five times depending on available labour or the possibility of hiring paid labourers. The weeding usually takes place during the first two month of the growing period. It is often stated as the most time-consuming operation on crop fields and can take up form several days to several weeks depending on available labour, the size of the field and the amount of weed. Besides a few crop fields with resistant fences, most of the crop fields were found to be grazed by livestock after harvest. Livestock was either let in intentionally by the field owners or entered by breaking up the branch-made fences. Animals are not "parked" in the crop fields at night after being escorted on pastures during the day so rather than a real input of nutrients and a mean of fertilisation, grazing of crop field mainly represent a way to control weed pressure.

Surveillance of the crop fields is crucial during the early days after planting to keep birds away from the sprouting crops Many household however devote their time to watch over their field during the whole growing period as the risk of wild animals like kudus, baboons, squirrels or livestock returning from outposts entering the fields can be very high depending on the locations. Some farmers combine surveillance of the fields with weeding operations while others find arrangements with households staying near the crop fields to watch over their fields.

Harvest is usually done between May and June and is undertaken by all able hands in the family as most of the people who have gone to outpost are back at the main settlement. The mature dried ears are harvested by hand and transported from gardens to the house by filled baskets on women's head, on donkey back, by a donkey drawn sledge or on a car bucky (Crandall, 1992).

After harvest, each family will spread out the ears on the roof of a wooden shelter specifically made for drying maize or on the roof of their houses. The ears of the maize are left on the roofs for six to eight weeks until completely dried (Crandall, 1992; Talavera et al., 2000). At this point, the maize kernels are removed by hand from the cob and stored in traditional grain silos (*ombombo* or *otjindu*), maize meal sacks or drums. Threshing is usually carried out by women and kids and the whole process of shucking and storing can take weeks to complete Crandall 1992, (Crandall, 1992). Seeds used for planting are sometimes threated with ashes and stored in bottles apart. Other products like pumpkins and melons are stored in rooms and tend to be subject to rot. Grinding of the maize corns to make flour is traditional by crushing the corns between two stones and is a daily activity for women. Nowadays, household tend to bring their

bags of maize corns to town and pay a milling service (NAD 60 per bag of 50kg). The grinding of the maize corns is spread over the dry season depending on the households need so not to grind too much maize at once as flour tends to be attacked by vermin and is difficult to safeguard.

Crop residues are usually left in the field for livestock to browse, but some farmers do collect and store the maize stalks in order to grind them and sometimes mix them with molasses purchased from suppliers to supplement livestock during the dry season.

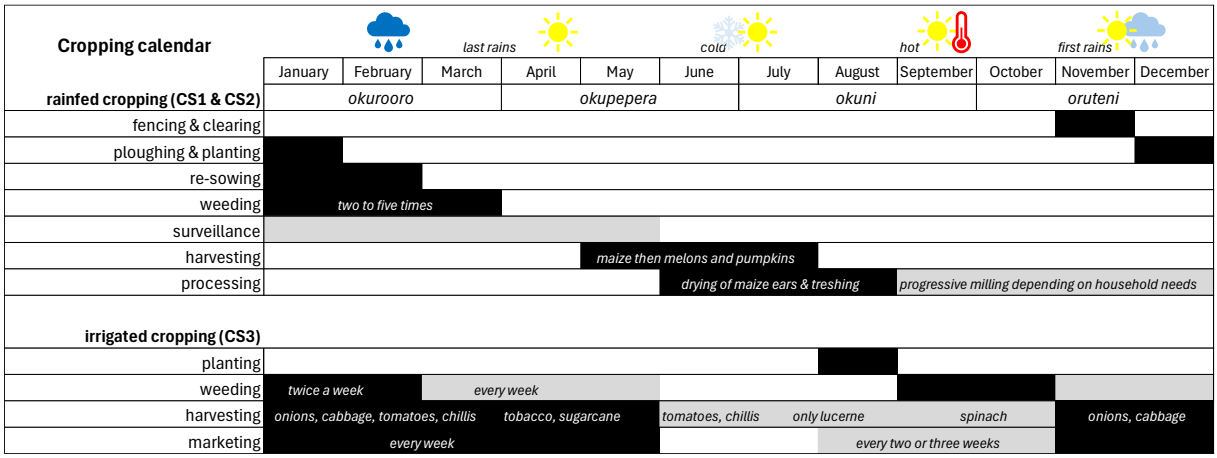

Figure 28: Calendar of activities for rainfed cropping (CS1 and CS2) and irrigated gardens (CS3) in Ongongo and Ombujokanguindi conservancies.

Not a single record about yields in any place in Kunene North was found in the literature, but it seems that in the 90s, "a harvest that sustains a family till the next ploughing season was a good harvest" (Talavera et al., 2000). The present study found a very high variability of yields depending on the location of the crop fields (soil fertility and moisture), recurrent crop failures (flooding, damages by wildlife or livestock or crops drying out) and management (notably recurrent and thorough weeding). For an average year, those yields range from 333kg to 574kg of maize flour per hectare. Considering that households are cultivating on 0,6ha on average, they each harvest between four to seven 50kg bags of maize flour to sustain a household of a dozen members. It seems that times have changed compared to the 90s and 2000s. Only two households cultivating on better cropping grounds outside the study areas have mentioned sufficient harvest combined with drought relief this year not to have to sell livestock to buy maize to sustain their family.

Building on data retrieved from historical interviews and survey on production systems in Ongongo and Ombujokanguindi, the present study has identified three different cropping systems based on cultivation techniques, water management and type of crops (Table 2).

Table 2: The different cropping systems studied in Ongongo and Ombujokanguindi.

	Cropping system	*Main crops*	*Average area cultivated*
CS1	Manual rainfed cropping	Maize, melons, pumpkins	0,3ha
CS2	Rainfed cropping with use of animal power for ploughing and planting	Maize, melons, pumpkins	0,8ha
CS3	Cultivation of vegetables and fodder crops under spring water irrigation	Vegetables, tobacco, sugarcane and lucerne	0,1ha

Crops under manual rainfed cropping (CS1) are usually planted randomly after clearing and preparation of the soils with a hoe. Some household plant crops separately depending on the characteristics of the field and water requirements.

Animal power used for ploughing rainfed crop fields (CS2) is usually provided by donkeys and very rarely oxen. Here crops are usually planted in rows following a logic of intercropping maize with a few of the other crops.

Finally, irrigated cropping (CS3) characterized in this study involves cultivation of a variety of vegetables (tomatoes, chilis, spinach, onions, etc.) together with cash crops such as tobacco, sugar cane and lucerne as fodder for livestock.

FOOD SECURITY AND SELF-CONSUMPTION

Meat consumption among families varies significantly between households. According to figures from the 1990s cited by Talavera et al. (2000), households with small herds consume an average of 9.1 goats, 1.6 sheep, and 1.8 cattle per year, while those with larger herds consume 37.2 goats, 6.3 sheep, and 6.5 cattle . It is important to note that beef, and to some extent sheep meat, is not consumed daily but is reserved for ceremonies such as weddings, funerals, circumcisions, or celebrations of the "holy fire" (Kakongo, 1999 in Talavera et al., 2000). Other studies indicate that meat consumption does not only vary based on herd size but also on the amount of maize flour produced and the access to markets (infrastructure and transport). Households in remote areas of the western Kunene region reportedly consume twice as much meat as those who grow their own grains or have market access (Livestock Marketing in the Northern Communal Areas of Namibia Nolidep, 2000 in Talavera et al., 2000). During poor harvests, animals (primarily goats) are exchanged for grains and other necessities (Bollig, 2002; Talavera et al., 2000), a practice also observed among the majority of households in the study area of this research.

The present study found that on average, every household (8 members and 5 adult equivalent) of both study areas would slaughter 3,2 goats, 2,1 sheep and 0 cattle for a consumption of 10,6 head per annum as animals dying from diseases are often consumed when there is no risk for

human health. Adding to that, households sell on average 6,9 goats every year, mainly to buy maize flour (1 goat equivalent to one 50kg maize meal bag), with two or three person registered for drought relief each receiving one 20kg maize meal bags per month (increased to two bags per month in 2024) amongst other goods as oil, canned fish, etc.

As a result, this study found that maize porridge and sour milk (omaere) are the main staple food in the study areas and correlate with earlier studies son the subject (Crandall, 1991; Paskin, 1990); Paski, 1990). However, as cropping practices are limited in Kunene (31,7% do not produce crops according to Paskin (1990), and production is low (only 21,7% of household produce enough to last longer than 12 months), most household are heavily dependent on animals as source of revenue and to some extent food. Meat and milk are often thought as the most important mainstays in the diet but they are in fact the most desired and the least consumed (Crandall, 1992).

On top of this, people in Kunene have historically included a various range of wild products in their diets including fruits, berries, tuber and game meat. Since the instauration of conservancies and decrease of wildlife numbers and change in vegetation since the 80s, they seem to play a rather limited role in household's consumption. The only fruits still widely encountered and cited as important source of nutrition for children and smallstock was the dried palm fruits (omurunga) consumed during dry season.

PRODUCTION SYSTEMS AND THEIR PERFORMANCES

This chapter explores the diverse production systems that characterize the agricultural landscape, focusing on their performance metrics and underlying dynamics. It begins by examining the key actors involved, identifying who participates in these systems and what combinations of livestock systems (LS) and cropping systems (CS) are prevalent. This could not be done without giving attention to the operational aspects by outlining the working calendar of these production systems, providing insight into the timing of activities and seasonal variations that impact both livestock and crop management. Understanding the intricate relationships between these components allows for a detailed analysis of the performances and sustainability of the different agricultural practices.

A critical aspect of the analysis centres on the productivity of these systems, particularly farm income and the percentage of external revenue derived from activities such as employment or other pensions schemes. These factors are essential for assessing the economic viability and resilience of farming households.

To provide a representative overview of the diversity of agricultural practices and to evaluate their technico-economic performances, this study draws on several case studies (see Appendix 5). These case studies were used to model the various household and production systems present in the study area, categorized as "farm types".

Table 3: Farm types found in Ongongo and Ombujokanguindi and their main characteristics.

Type	Household	Familial labour	Livestock	Seasonal mobility	Crop field	External labour	External revenue	Drought relief
A	Single-headed or young (11)	4	Only smallstock (60)	1 flock Late DS outpost	0,35ha	none	Old age/child pension	2
A'	Head with small job (9)	2,5	Only smallstock (100)	1 flock Late DS outpost	0,7ha	Workers for cropping	Salary (NAD2'000)	2
B	Young or two households (11)	6	Smallstock (115) and few cattle (<10)	2 flocks 1 or 2 DS outpost	0,6ha	none	None or child pension	2
C	Large homestead (19)	9	Cattle (30) and smallstock (350)	3 to 4 flocks 2 to 3 outposts 2nd settlement	2x1ha	none	None or old age pension	3
D	Head with important salary	2,5	Cattle (50) and smallstock (500)	4 to 5 flocks 2 to 3 DS outposts	0,9ha	3 herders & workers for cropping	Salary (NAD20'000)	None
Ea	Single household (8)	3	Smallstock only (30)	Very limited or inexistant	0,5ha 0,15ha irr.	Workers for cropping	none	2
Ce	Large homestead (19)	9	Cattle (30) and smallstock (350)	3 to 4 flocks 2 to 3 outposts 2nd settlement	2x 1ha 0,05ha irr.	none	None or old age pension	3
X	absent	none	Mainly smallstock	None or DS outpost	None	1 or 2 herders	Salary	?

These farm types were modelled based on a comprehensive set of technical and socio-economic criteria. Key criteria include household characteristics, such as the number of people, their activities, age groups as well as eventual revenues from extra-agricultural activities. For livestock systems (LS), the analysis considers species, herd sizes, seasonal migration patterns, management practices, and outputs, including milk production, sales, and slaughtering.

The cropping systems (CS) examined include both rainfed and irrigated practices, as well as levels of mechanization and commercial engagement. Furthermore, the study considered the food security of household based on the number of people registered for drought relief as well as the strategies of procurement of maize, whether through purchase or exchanges. This thorough approach enables a detailed understanding of the different farm types and their respective performances within the study area.

C. Large historical homestead

Historically, Himba and Herero traditionally have settled in large homestead consisting of numerous household all organised around one single kraal. These household traditionally owned large herds of several hundreds of cattle.

Today, large homestead are often remanent of those ancient newcomers wealthy families dating back to the 1920s or 1930s. They inherited equipment such as cars and ploughs from prosperous times and managed to maintain a minimum cattle herd after the droughts of the last decade.

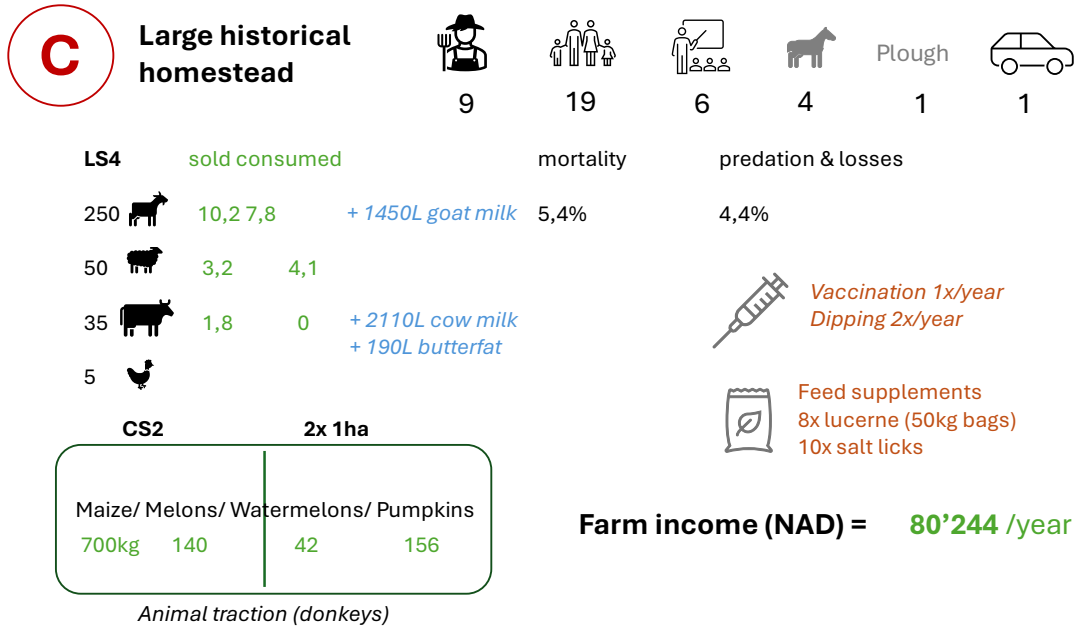

Figure 29: Operational diagram of production system C (red = inputs; green and/or blue = outputs).

Large families, often consisting of multiple wives, allow for the splitting of livestock herds into two to three flocks, particularly during the dry season (LS3). Sometimes, herds are even divided between the main homestead and a secondary settlement managed by a son and his family for several years (LS4). Livestock are then shifted back and forth between these locations. The ample household members facilitate the combination of herd mobility and cropping activities, allowing part of the cattle to benefit from temporary pastures also during the rainy season, coming back only after the last rains or after harvest. Lactating cows are usually brought back to the main homestead during rainy season when calving but the rest can stay at the outpost all year round. The ability to split the herd in several flocks throughout the year works as an important strategy to limit the impact of regular diseases outbreaks, thus mortality of goats rates below 6%. Given the important number of livestock, off-take rates applied to sustain the family are quite low (5% for goats) and this allows to engage in re-stocking of the goat herd (18%) in prevision of climatic or epidemic hazards, socio-cultural uses (e.g. inheritance) or to purchase cattle in the near future.

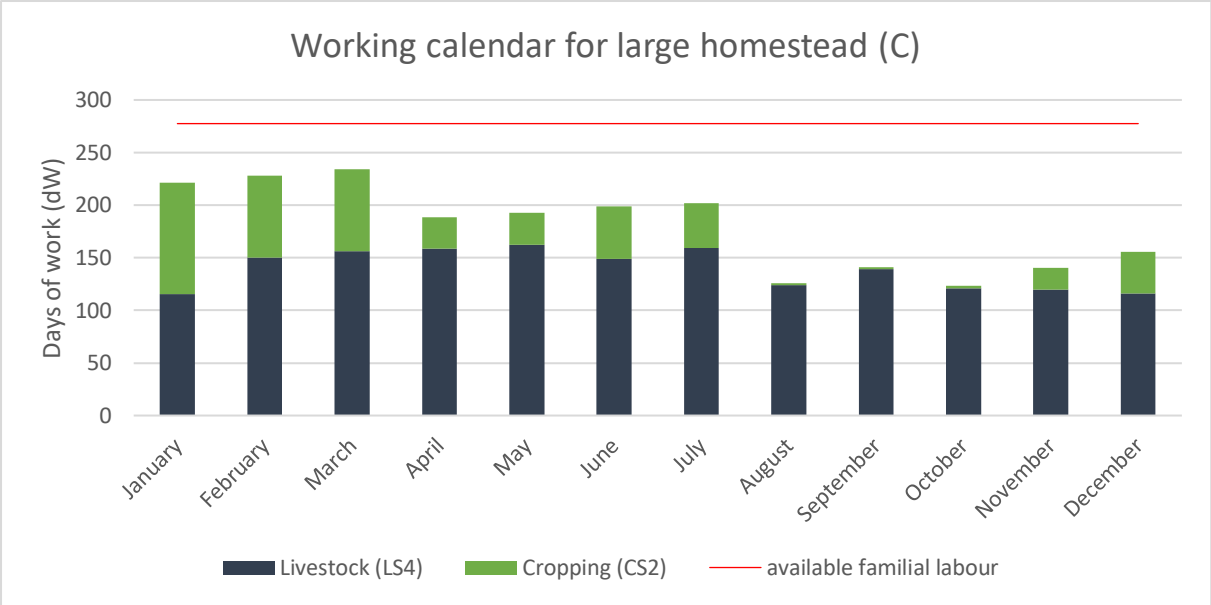

Figure 30: Working calendar of production system C.

The various flocks require numerous herders, amounting to more than 120 herding days per month, equivalent to about four persons. Herding goats, particularly during the dry season, can be exhausting, leading to two herders (often young children) taking turns for herding smallstock or assisting with watering at boreholes and wells. Typically, two herders are assigned to each smallstock herd. Cattle, requiring less daily attention, may go unguarded or be escorted only occasionally to water points.

The workload increases during the milking season for cattle, but the large family structure helps absorb this demand, allowing them to engage in additional activities such as transformation of cow milk into butterfat (*omaze*) or collection and trading wild products for bags of maize meal (e.g. stones, palm fruits = *omarunga* or pounded wood = *otjizumba*). Trading of wild products, however, seem very limited. Out of thirty, only three families mentioned exploiting wild products for commercial exchanges, others mostly citing them as livestock disease treatment or prevention as well as cosmetics (pounded wood) and complementary diets during rainy season (fruits and berry) or dry season (palm fruit) for humans and livestock.

As wealthy and influential first newcomers, those families often secured access to prime cropping grounds around the main settlements where part of the family stays to cultivate during rainy season. However, with the new generations and the wider uptake of rainfed cropping of maize to respond to difficult climatic conditions and sedentarization, those cropping grounds have been subdivided among the different households within the homestead or with the broader community. Those large homestead therefore function around the management of a common livestock herd, but cropping is mostly divided amongst the households. Each wife or son with his own family will therefore have its own crop field to cultivate. Fields are usually ploughed with the help of donkeys and sometimes with oxen. The latter seem to have been a very common practices that have almost ceased today with the decrease of cattle numbers across Kunene.

Over time, large family homesteads often split into smaller settlements, especially following the death of the family patriarch. The younger generation may choose to remain unified or divide into several households, each managing distinct herds. Even though one of the sons might decide to settle at his father's place with his own household later on, the splitting of the homestead and the herd is usually definitive. This doesn't exclude that tights of solidarity exists between families members and that they may help each other out and occasionally share resources.

B. Individual or young homestead

When the sons of a diseased patriarch decide to establish their own homesteads they generally settle at a new location with part of their inherited livestock. Those average households typically have a few cattle and smallstock on which a smaller number of relatives survive, often one or two households of two brothers and their respective families or a brother with his underaged siblings or divorced sister and her family.

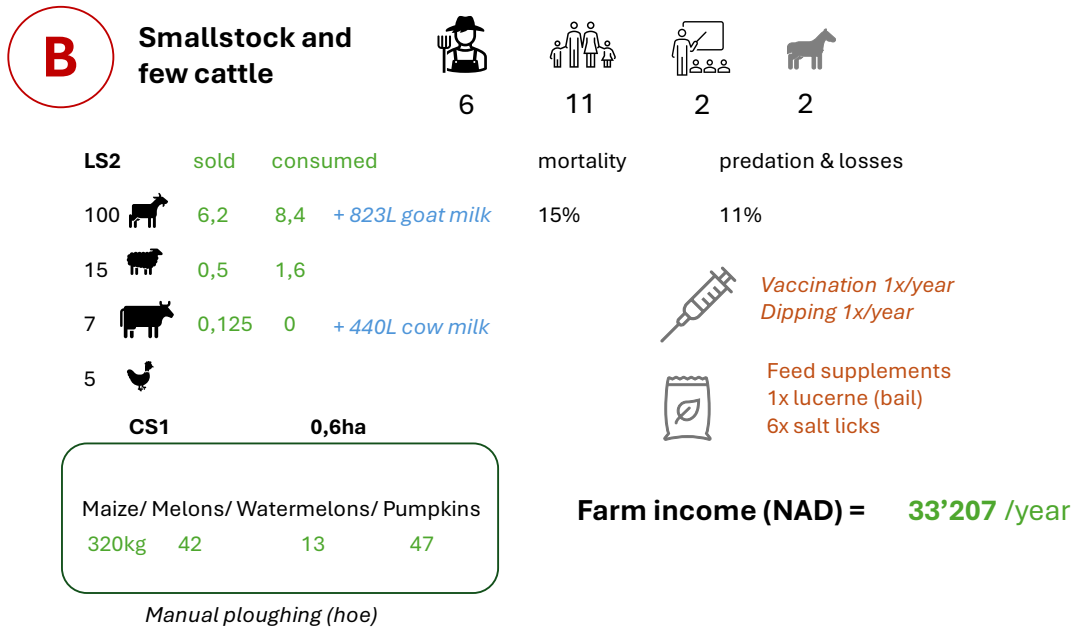

Figure 31: Operational diagram of production system B (red = inputs; green and/or blue = outputs).

With a constrained labour force, these households usually gather all livestock and family members at the main settlement during the rainy season for cropping. Livestock is generally kept in a single flock, occasionally divided into two for brief periods, with no hiring of external services for cropping due to financial limitations. As a result, ploughing and sowing is often done manually and resort to inputs for livestock system is very limited. Cattle numbers being very low, there is no production of butterfat, and the milk is mainly used as protein source for the family or left for the offsprings.

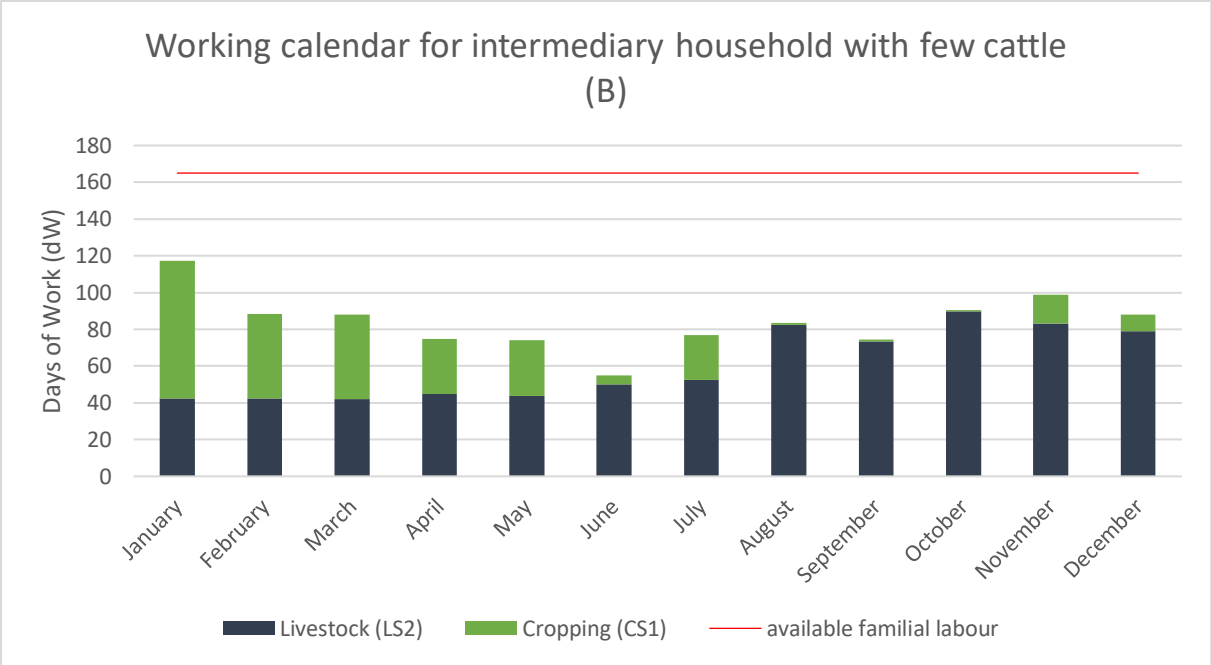

Figure 32: Working calendar for production system B.

In theory, those households can count on a sufficient available familial labour. However, the latter is mostly composed by young children of school age and boys herding livestock. With limited means, families can only afford education for few of them.

Here, the major labour requirements are represented by cropping activities such as weeding and surveillance of crop fields from January to May and livestock herding. As herds move to outposts form August, more time is often required for watering animals at waterpoints.

Those households are in "fragile" situations especially when lacking access to good crop fields or repeated crop failure due to difficult climatic conditions. Low crop harvest pushes those households to decapitalize severely in order feed an important household and therefore impeding on proper preventive management (e.g. vaccination, dipping, dosing). In an average year, off-take rates of goats account for 7,4%. Coupled to important losses to diseases and predation (26,5%), there is no possible increase of the herd size, thus suggesting a high vulnerability to hazards. Drought and diseases outbreaks can provoke a rapid and drastic loss of livestock pushing those households into serious food insecurity and further de-capitalisation.

This is particularly true for households settled westwards of both study areas, where low rainfall makes cropping very difficult or impossible pushing them to travel long distances of several dozen kilometres eastwards to cultivate, often where other relatives are settled.

A. Household owning only smallstock

Households having lost their cattle to the recent droughts or important part of their livestock herd to disease outbreaks are often left only with a herd of goats and very few sheep. Nonetheless, this can also be the case for single-headed households led by widows or divorced women of advanced age being stripped form many of their assets that, traditionally, belong to

the husband's family. As they were the second or third wife, those women and their children have to find new places to settle after a divorce or the death of the husband. They are therefore often moving back to settlements occupied by relatives. This type therefore regroups households with different individual trajectories but who all went through important decapitalisation of their livestock herd and are struggling to restock because of difficult conditions.

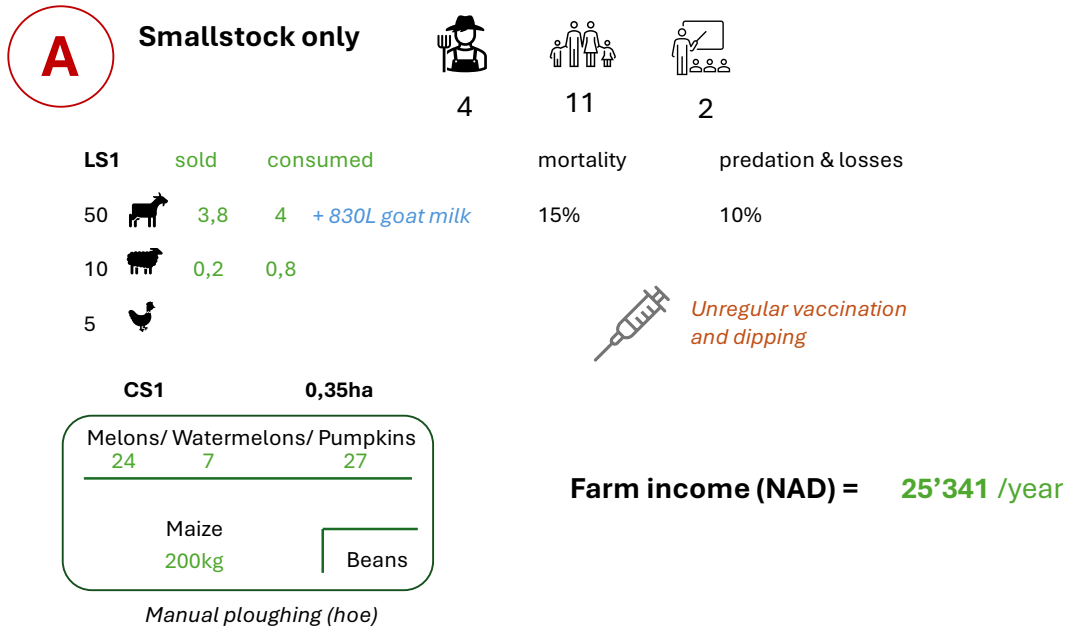

Figure 33: Operational diagram of production system A (red = inputs; green and/or blue = outputs).

Those households are often left with very few goats and sheep (<100) to feed an important household and not enough resources for proper management (preventive treatments). This results in higher mortality rates due to predation (not properly herded) and diseases (less treatments, limited seasonal migration in space and time because of water and labour availability).

Recent displacement of single-headed or young households complicate access to quality outposts and crop fields, leading to low yields. Indeed, many of those households had to move recently and so had to find new grazing outposts (usually limited in water sources) not too far from the settlement as well as new cropping grounds. This further impede on the management

of livestock and the cropping performances as pastures (mainly access to water) and soils can be of poor quality.

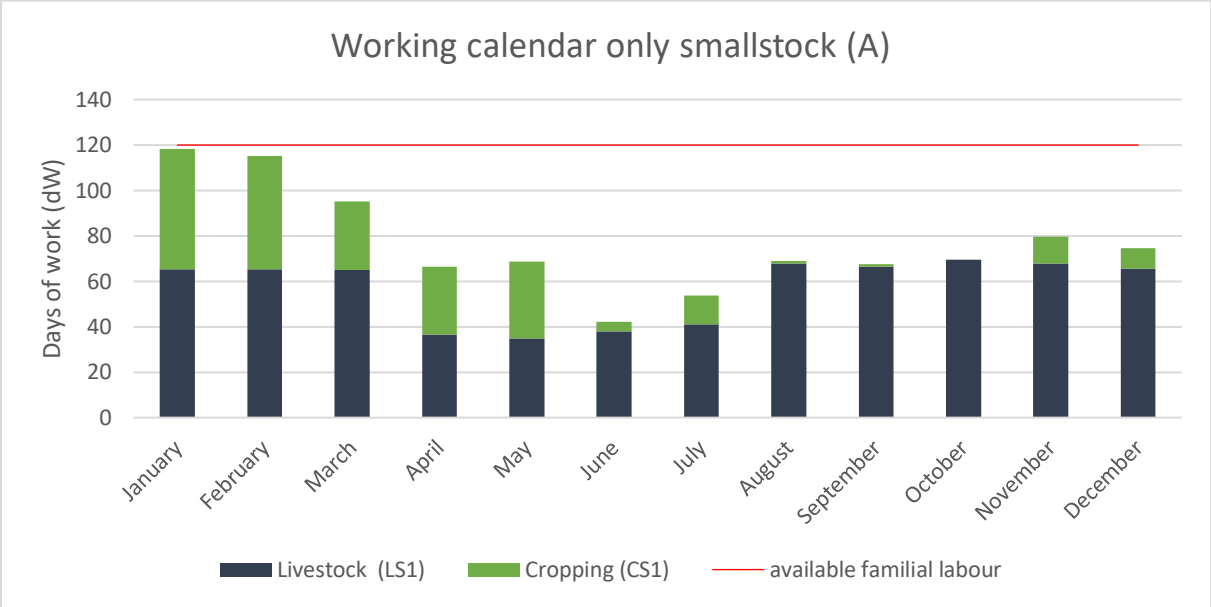

Figure 34: Working calendar of production system A.

Small harvests of crops due to lack of seeds, low yields or crop losses pushes to sell an important number of livestock to buy food and other necessities. Many families now have fewer goats than when they moved, suggesting important de-capitalization due to important losses (over 25% for goats) and the highest off-take rates amongst the study areas (8 to 10% for goats).

Single-headed households with an elder adult son might have better chances to degage a larger herd of livestock able to maintain the household with a larger herd of livestock from borrowings or inheritance to the son from the uncle or father. This might also provide a larger labour force to engage in serious cropping activities. This type of household might be a "transitional" type in response to severe climatic events and familial history until the kids take over and are able to stock bigger herds (type B). However, with the recent climatic difficulties and HWC it seems that many of those households have difficulties to harvest good yields and grow larger herds of goats in order to re-capitalize and eventually acquire cattle. This pushes many to look for alternative livelihoods and engage in non-agricultural activities.

A' Household with small external revenue

On of the ways to engage in non-agricultural activities and earn an additional income is by taking up unqualified paid jobs in the community (e.g. security guard of clinic or school) or within the conservancy structure (e.g. game-guards or other staff). Household with one of the parents earning a small salary (up to NAD 2,000 per month) can afford to take proper care of a somehow bigger livestock herd (disease management and supplement feeding). For an average year, an off-take rate of 7,42% for goats with somehow fewer losses (20%) enables a slight increase of the herd (7%). This is however not enough in prevision of potential hazards and a part of the additional income is invested in purchasing young animals (two female goats per

year).

The additional revenue also allows to send most of the kids to school. However, this restricts the household's mobility and labour availability, and the additional income is often not sufficient to hire full time herders.

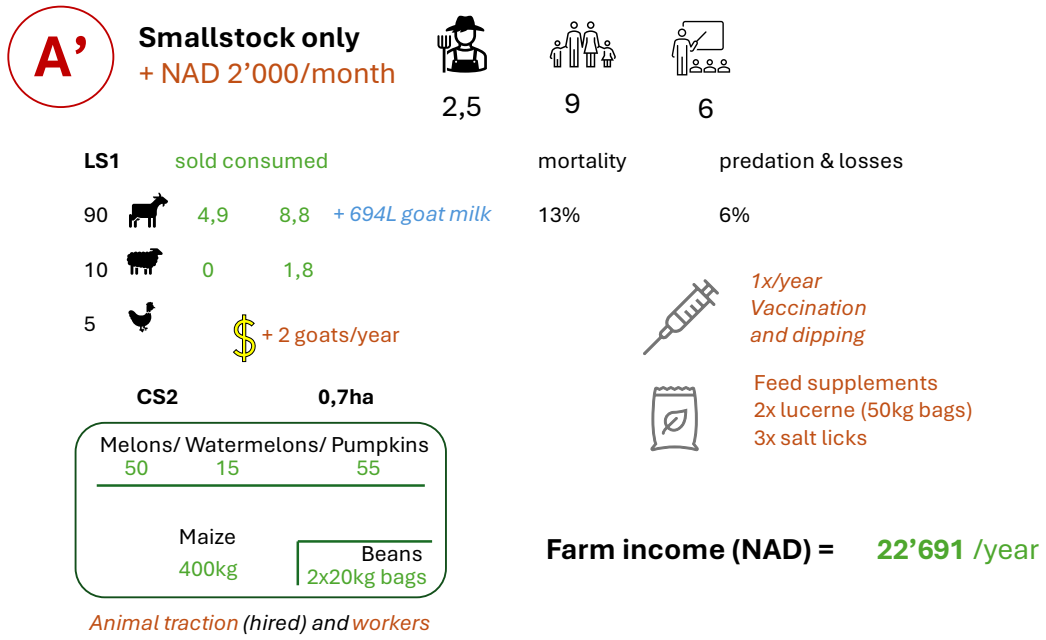

Figure 35: Operational diagram of production system A' (red = inputs; green and/or blue = outputs).

Being somehow "sedentarized" by the uptake of a full-time job, those household are keen to invest time and effort into cropping activities. Part of the additional income is therefore invested into hiring punctual services for cropping activities (e.g. animal traction and weeding), thus making cropping of an important surface area possible.

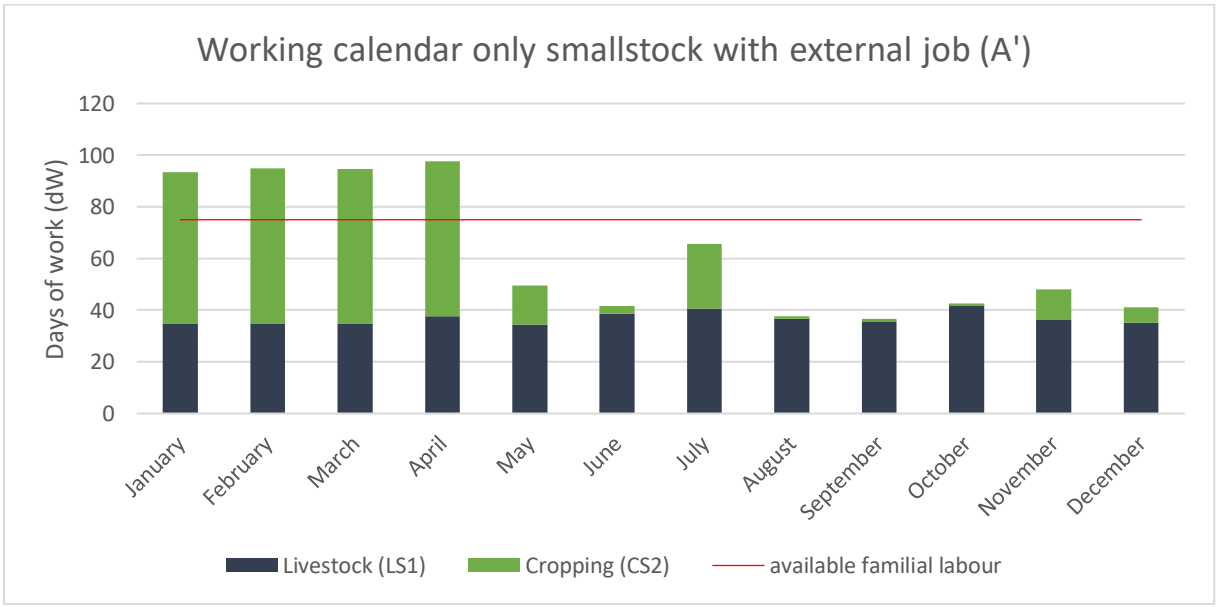

Figure 36: Working calendar of production system A'.

Altogether, while the little revenue is not sufficient to cover the family needs, it can be properly invested into intensifying livestock and cropping practices and avoid severe decapitalisation during bad years. If conditions are met it can even allow the small household to engage in commercialisation of part of its crop production and purchase cattle in the near future.

D. Household with important external revenue

Other households with one or several members recipient of a good education can sometimes access qualified jobs in government institutions (e.g. school teachers, nurses, military or police officers) who represent important additional incomes (up to NAD 20,000 per month). These wealthy household can therefore count on an external revenue from jobs contracted by one of the head of the household or sometimes even both. While those jobs are keeping the head of the household away from home most of the time, they allow the latter to "invest" livestock herds taking care of by the rest of the household that stays at the farm. Those households also employ external workers as herders and sometimes engage in small side businesses (e.g. tuck shop in the community) which allow them to maintain important numbers of livestock. The external revenue even facilitates, even though in very limited fashion, infrastructure investment such as direct water supply systems from boreholes or fenced-up livestock "camps" to keep enhanced breeds such as Boer goats, dorper sheep or brahman bulls.

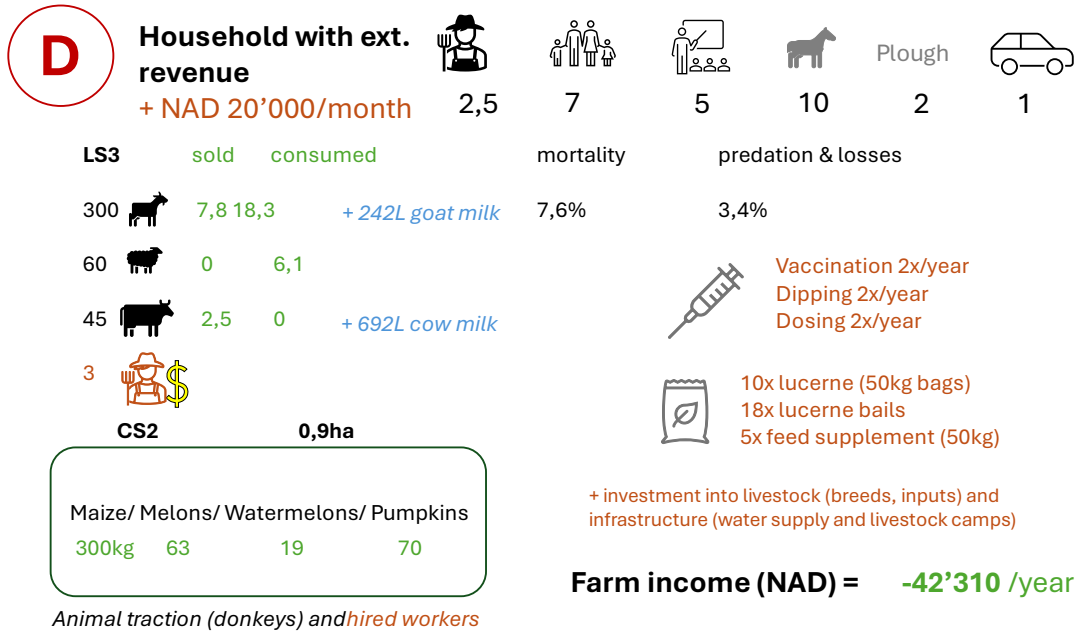

Figure 37: Operational diagram of production system D (red = inputs; green and/or blue = outputs).

Despite high livestock numbers, these households often engage minimally in marketing as livestock serves primarily self-consumption purposes and represent an important capital for sociocultural uses (e.g. weddings, funerals, etc…), rather than a living capital sold to access

cash. As a result, off-take rates do not surpass the 5%.

In the same vein, limited familial labour and presence of an important salary covering for everyday expenses is limiting the utilisation of goat milk or cow milk to produce butterfat despite important potential. With proper attention given to preventive treatments for livestock diseases as well as important amounts of capital invested in herding and supplement feeding, losses are also limited (11% for goats) and allows for an important increase of the herd on a yearly basis (up to 16%) to prevent future potential hazards or for other socio-cultural uses.

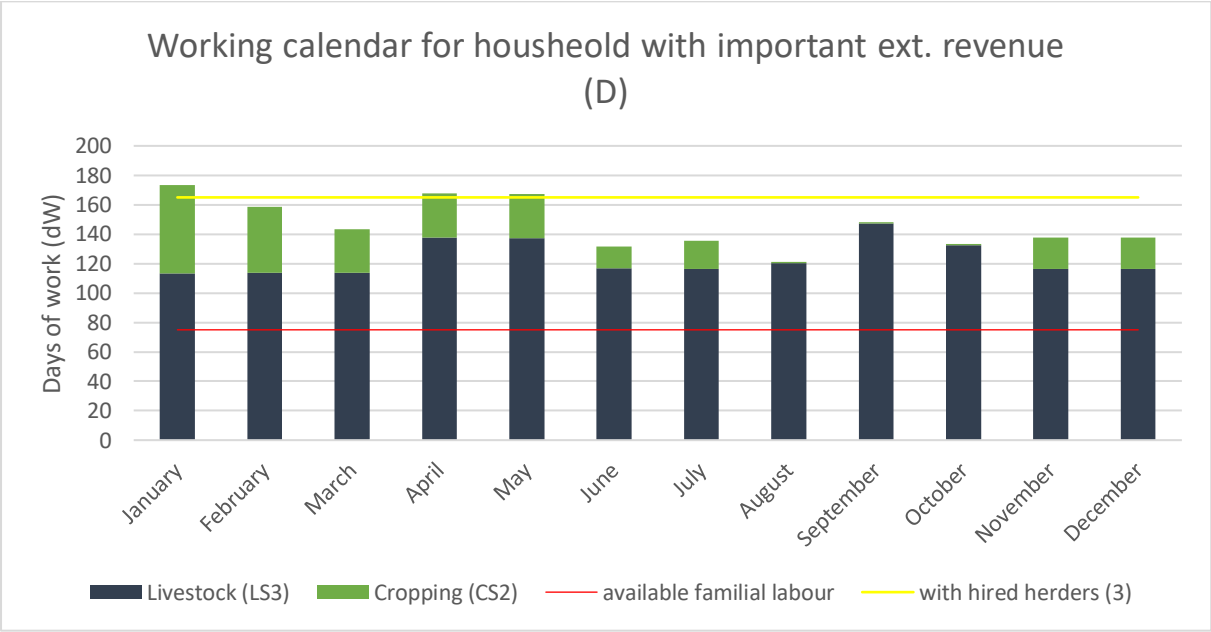

Figure 38: Working calendar of production system D.

The earlier recipients of those external jobs in the 1990s did not seem to engage much in cropping practices as they could benefit from large herds where selling of animals to meet the households needs was not provoking a de-capitalisation. However, those households seem to have started cropping more recently, motivated by difficult climatic conditions, job insecurity due to the COVID epidemic and rapidly approaching retirement.

While herders are hired to guard livestock spread out between distinct locations, the important number of animals implies important workload for operations such as vaccinations, treatments, watering or castration in April, May and September/October. Coupled with newly started cropping activities, this implies to punctually hire workers for cropping or livestock operations or count on the help from neighbours or relatives in exchange of goods or services (usually food or alcohol). As they own important numbers of donkeys and tools such as plough, these households also engage in lending material or services to others.

Beneficiaries of important external revenues might therefore not see farming as their primary occupation but being the owners of the biggest livestock herds and having a significant socio-economic influence, they have an important impact on the management of natural resources and development of livelihoods.

X. Small “absent” owner

Some households are compelled to take low-revenue jobs in distant locations, leading them to become “absent” owners of their livestock. In these situations, they leave their animals in the care of family members or with hired herders, if they can afford to pay for such services. Consequently, cropping activities are either absent or severely limited.

This phenomenon of “absent” livestock ownership is not confined to single-headed households; it is also common among families residing in towns. These families may keep their livestock at relatives' settlements or in separate posts managed by hired herders. Typically, the entire household does not live in the area and does not engage in agricultural practices.

Since farming is not their primary activity and due to the limited number of livestock they own, this type of household has not been extensively characterized in the study. However, for families living in urban areas, livestock can serve as an important safety net and a form of savings during emergencies or times of need, such as unexpected expenses or a temporary job loss.

E. Households with access to irrigation

Finally, when having access to an important water source (usually spring water), some households resigned themselves to develop other agricultural production instead of looking for alternative livelihoods outside of agriculture.

Those households have been historically present in places where good cropping soils were coupled with the presence of natural springs with sufficient water throughout the year allowing to grow maize, wheat and few other vegetables (cabbage) under furrow-irrigated gardens in addition to the more usual rainfed cropping fields. Irrigation practices seem to have spread across the landscape since the las drought period that started in the 2012/13 season, with more farmers engaging in irrigation at those initial locations but also around other springs in different locations where the soils are less optimal for copping practices (shallow stoney soils with no regular flooding or riverbeds) but were they started to grow vegetables, sugarcane and even lucerne for own consumption and commercial purposes.

Those smaller gardens in size demand a higher labour investment that large homesteads with several household members can afford beside management of large herds with cattle (production system Ce) or that forces smaller households looking for alternative livelihoods to a very limited seasonal mobility and keep only small herds of smallstock (production system Ea).

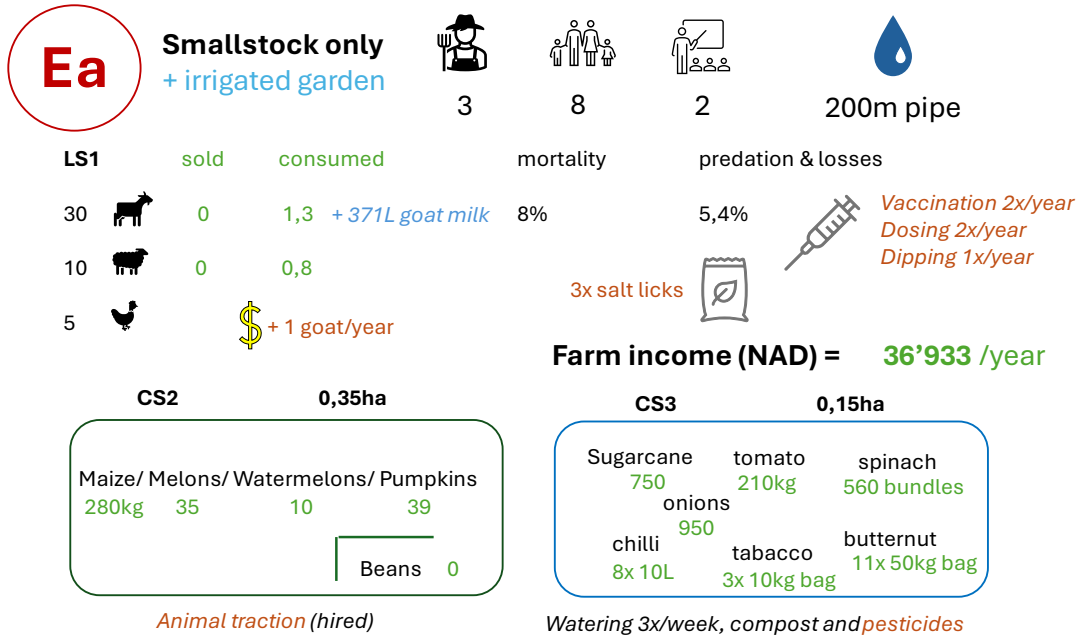

Figure 39: Operational diagram of production system Ea (red = inputs; green and/or blue = outputs).

For a small household owning a small herd of smallstock, commercialisation of the products from irrigated gardens (mainly vegetables) combined with a care-intensive rainfed crop production ensures food security without de-capitalisation. The revenue generated allows to limit off-take rates to a minimum and take proper care of, and somehow invest in, their herd of smallstock through preventive treatments, supplement feeding, limited milking during rainy season and purchase of young animals to compensate for losses (annual losses of goats of 12% and 23% annual herd increase).

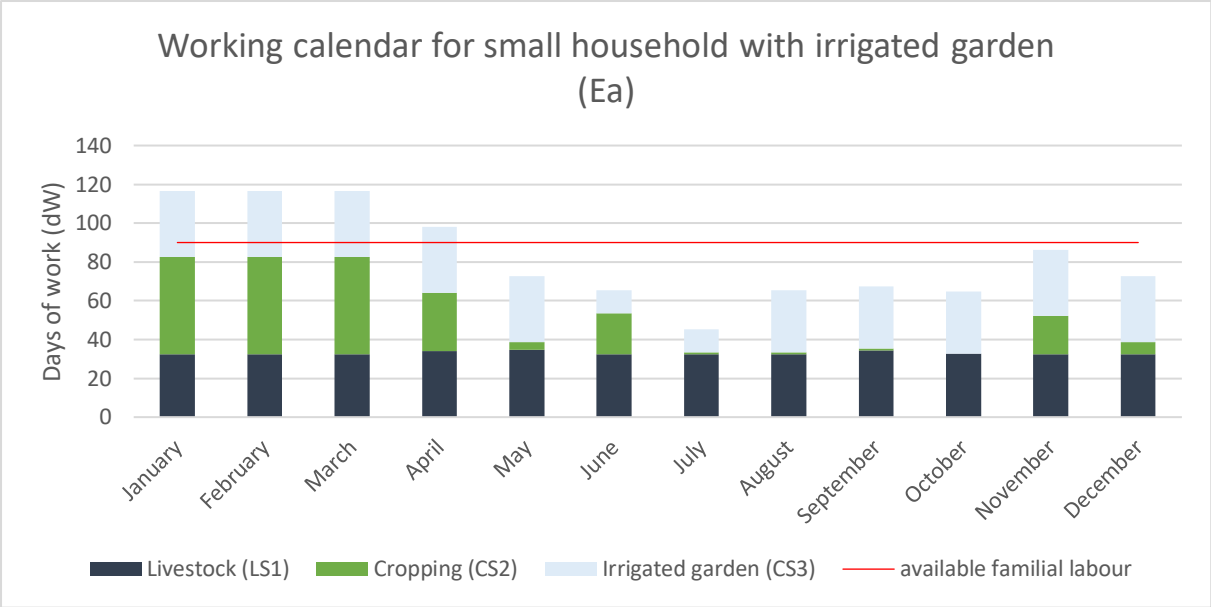

Figure 40: Working calendar of production system Ea.

However, vegetable production under irrigation doesn't come without effort. Indeed, watering, weeding, plating, harvesting and marketing operations for a limited surface area (0,15ha) represent an important workload occupying one person all year round. Even though livestock numbers are low and seasonal migration is almost inexistent, this implies to find arrangements during cropping season. Household will therefore count on external help for rainfed cropping during surveillance or by building one single fence around several crop fields owned by different households. or relatives.

For a large homestead with sufficient familial labour, engaging in irrigated cropping isn't as problematic. Nonetheless, has their primary motivation and production practices remains with the management of considerable number or livestock, vegetable is often done on smaller surface and part of the irrigated field can be dedicated to growing lucerne to provide supplement feeding for young or weak animals.

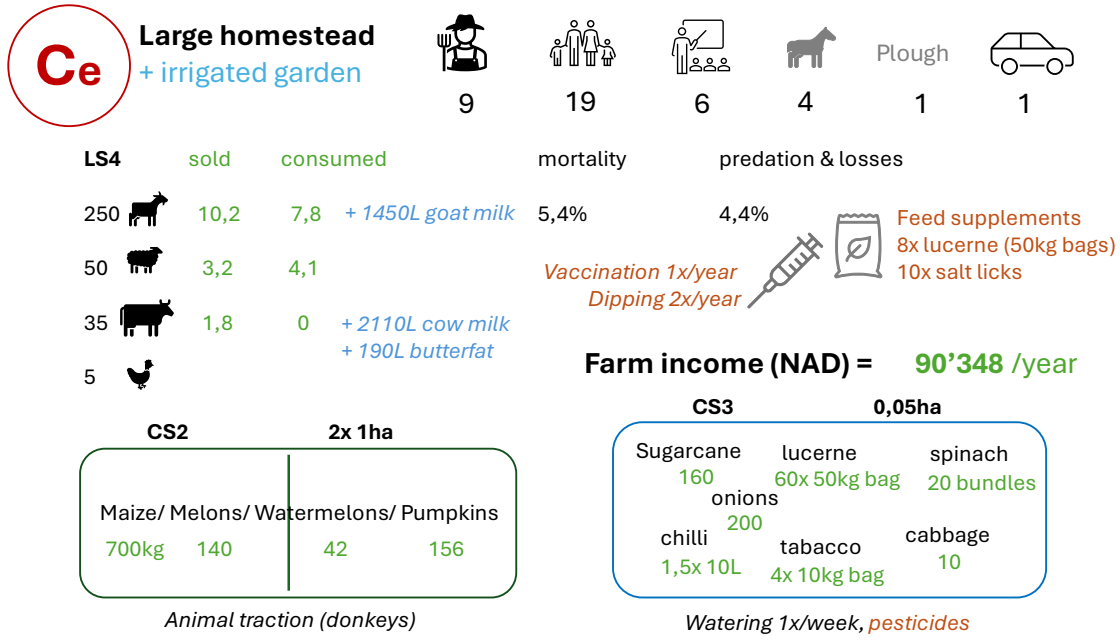

Figure 41: Operational diagram of production system Ce (red = inputs; green and/or blue = outputs).

Here, irrigated cropping represents a far smaller part of the households activities throughout the year. The production of vegetables is somehow more a seasonal activity than full year operation and beside more intensive times during planting (August) and harvesting season (December March) irrigated cropping represents a far smaller part of the households activities. During cropping season less care is given to production under irrigation as the focus shifts towards rainfed cropping of maize.

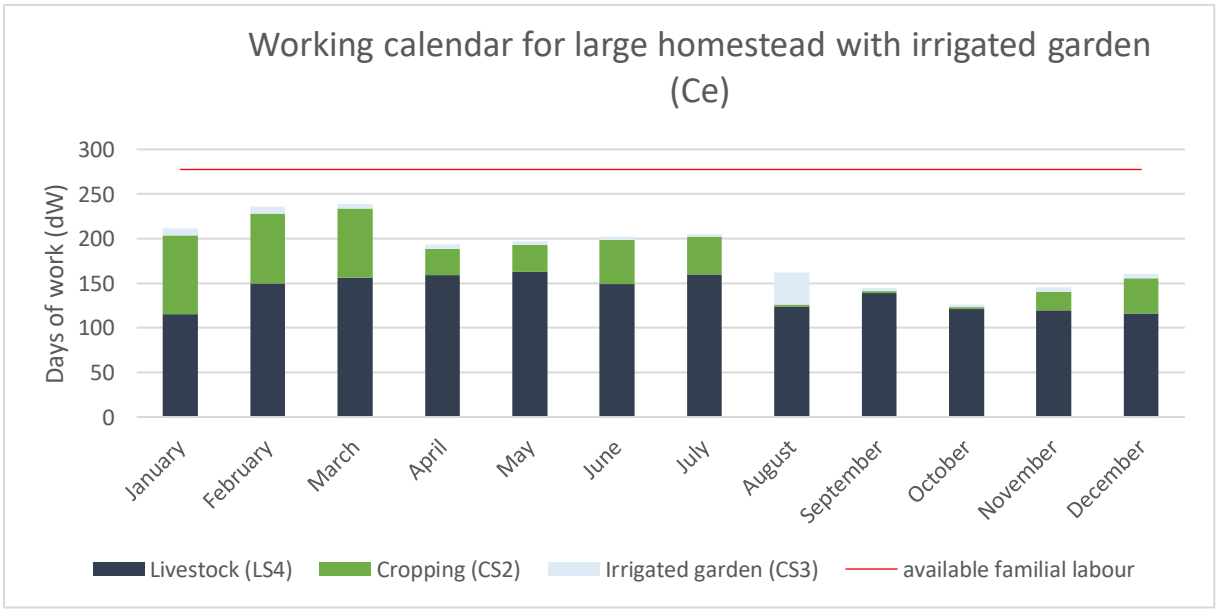

Figure 42: Working calendar of production system Ce.

PRODUCTIVITY OF FARMING PRACTICES

The analysis of farming types and their economic performances reveals significant insights into productivity and value addition in agro-pastoral systems. Performances of the different farm types was done through calculation of the annual gross value added of each livestock and cropping system. The gross value-added (GVA) is calculated as follows:

GVA = gross output (products x price) – intermediate inputs

All figures used for calculation of the economic performances were retrieved from the modelling of production systems presented above. Gross outputs of livestock systems include average animals sold and consumed, the annual milk and butterfat production. For cropping systems, gross outputs are determined by the average annual yields for maize and other crops such as vegetables or fodder. Typical intermediate inputs are purchased vaccines, treatments or supplement feed for livestock or seeds and milling of maize corns for cropping systems. A detailed overview of the calculation of economic performances of the different production systems can be found in Appendix 7. Table 4 provides an overview of the gross value-added of livestock and cropping systems for each farm type.

Table 4: Gross value-added of livestock and cropping systems per farm types.

Type	Household	Familial labour	Livestock system	GVA (NAD)	Rainfed cropping	GVA (NAD)	Irrigated cropping	GVA (NAD)	Total GVA (NAD)
A	Single-headed or young (11)	4	LS1	23,193	CS1 (manual) on 0,35ha	2,480	-	-	25,672
A'	Head with small job (9)	2,5	LS1	19,218	CS2 (animal traction) on 0,7ha	5,996	-	-	25,214
B	Young or two households (11)	6	LS2	28,458	CS1 on 0,6ha	5,131	-	-	33,589
C	Large homestead (19)	9	LS4	73,018	CS2 on 2x1ha	12,611	-	-	85,629
D	Head with important salary (7)	2,5	LS3	10,384	CS2 on 0,9ha	5,614	-	-	15,998
Ea	Single household (8)	3	LS1	6,923	CS2 on 0,5ha	3,980	CS3 (furrow irrigation) on 0,15ha	28,101	39,004
Ce	Large homestead (19)	9	LS4	73,018	CS2 on 2x1ha	12,611	CS3 on 0,05ha	17,826	103,455
X	Small absent "owner"	none	LS1	*Not evaluated*	-	-	-	-	-

When considering the performances of livestock systems summarized in Table 4, one of the logical key findings is that as the number of livestock and the size of the household increases, the gross value-added improves. For instance, in case of type C, the substantial number of cattle results in significant value addition, allowing for higher outputs through the sale of oxen and higher added value through production of butterfat from cow milk. This highlights the

importance of cattle value in enhancing productivity.

However, households engaging in alternative livelihoods such as paid jobs or irrigated commercial vegetable production show a reverse tendency with lower gross value-added despite higher livestock numbers. A good example of this observation is type D who, despite having higher number of livestock than type C, demonstrates a much lower GVA. This can be attributed to high inputs, such as feed supplements and medical treatments. Such households also tend to stock livestock rather than market them, viewing them as cultural and financial assets rather than as a source of livelihood.

When comparing GVA from livestock and cropping systems as presented in Figure 43, it is evident that livestock practices contribute significantly more to value addition compared to crop cultivation. However, as explained before and looking at the widespread of cropping practices, crops still hold considerable importance in the overall agricultural landscape. Furthermore, the total absence of market for milk products means that fermented milk (*omaere*) and butterfat (*omaze*) are neither sold nor bought. They are rather consumed on-site and sometimes offered to "nurture" social relationships. Animals are generally milked solely to meet household needs and not for "production". Therefore, the value creation shown here for livestock systems should be taken with caution.

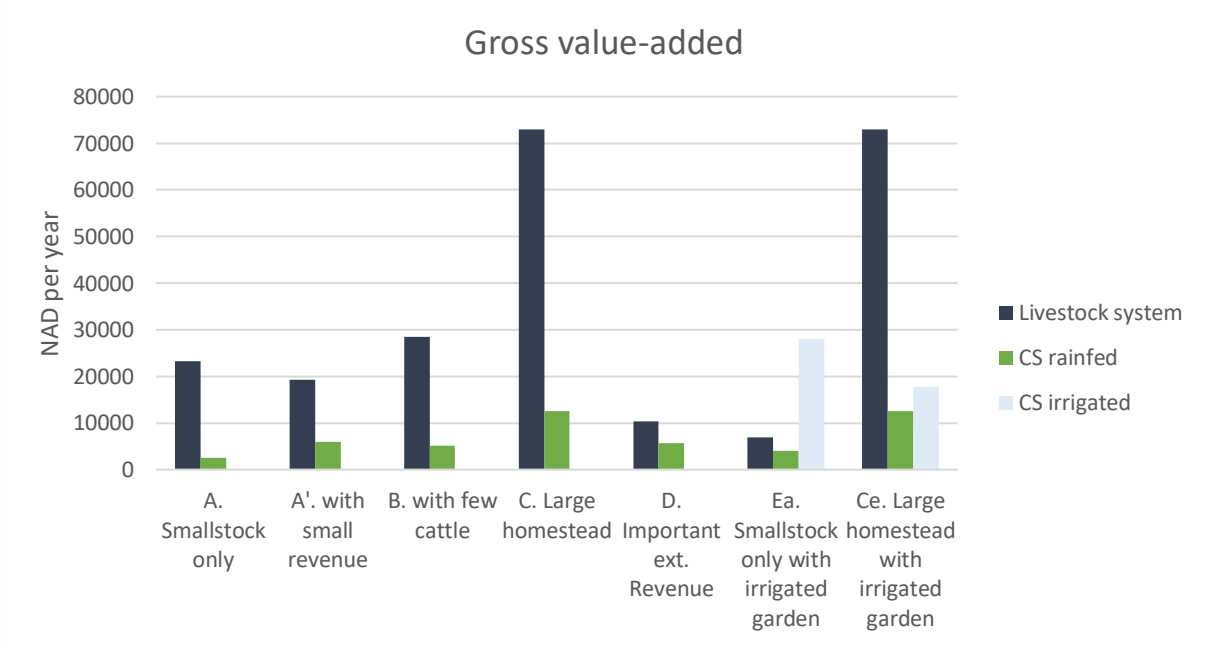

Figure 43: Comparison of the gross value-added of livestock and cropping systems (CS) between farm types.

GVA of rainfed cropping systems seem to vary primarily according to the sizes of the cultivated fields. For example, type A representing a newly settled household, often comprised of widows or young families, with limited access to prime land and means of cultivating a bigger area. In contrast, type A' and D can afford to pay for ploughing and weeding services in order to cultivate larger fields. Type B with a slightly larger familial labour force can afford a slightly bigger field and type C, who counts several households, operates two crop fields, effectively

doubling its GVA. Type Ea also has a more restricted familial labour force, resulting in smaller fields.

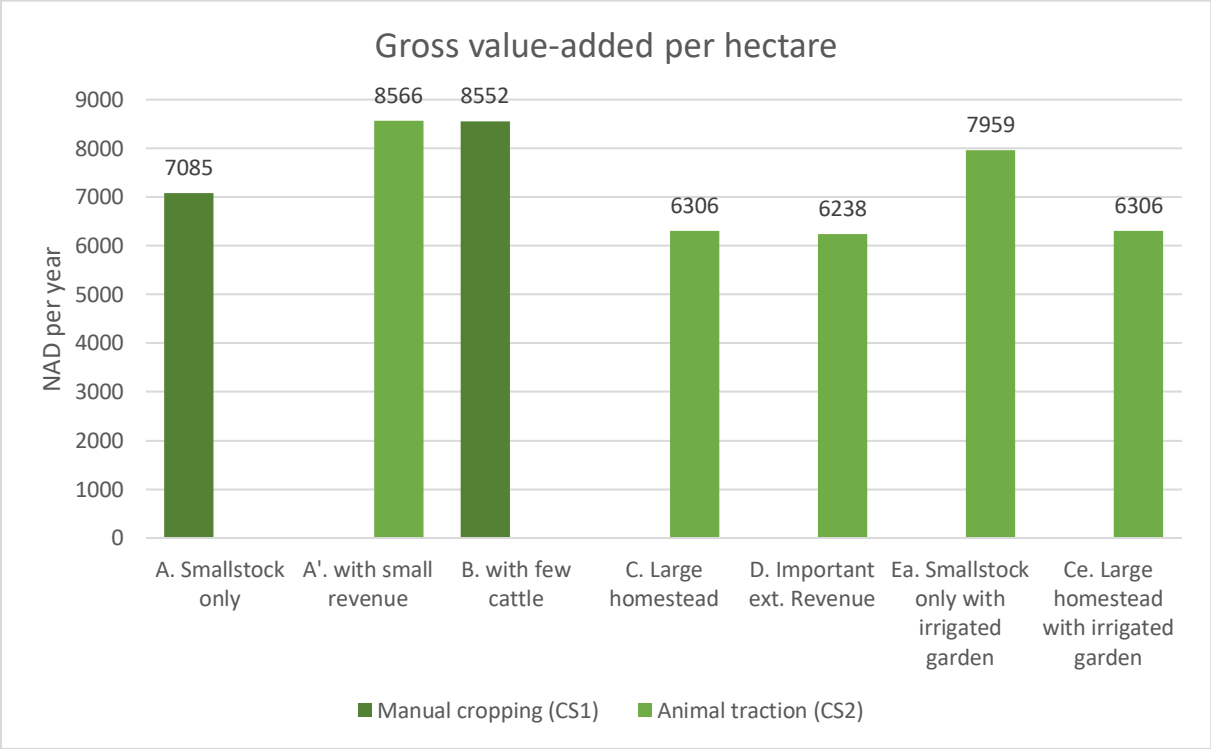

Figure 44: Productivity of cropping systems per surface area between farm types.

As illustrated by Figure 44, productivity of rainfed cropping systems per surface area seem to be influenced by the ability and motivation of households to "invest" into cultivation rather than the cropping techniques themselves (e.g. manual ploughing vs. animal traction). This can be explained by operations that require a significant amount of time, such as surveillance and weeding, which are essential but can be somewhat 'neglected' by households that depend less on crops (e.g. types C and D). As a result, it is likely that households with limited amount of additional income or limited number of livestock are investing more time and work to cultivate than "wealthier" households who regard livestock rearing or their job as a primary livelihood. For example, type A' invest part of its external income (salary) into intensification of crop production by paying workers to weed up to five times. Type Ea typically invests time and some amount of money to give proper care to crop fields but is limited by a small familial labour force occupied by irrigated cropping. On the other hand, productivity of type A seem to be limited due to more difficult access to fertile soils but also frequent lack of seeds by the time of planting.

Quite remarkable is the value-added enabled by vegetable and crop production under irrigation even for very small surfaces (0,05ha and 0,2ha) as illustrated by Figure 43. Irrigation typically facilitates a very important intensification, boosting the productivity per surface area (see Figure 45).

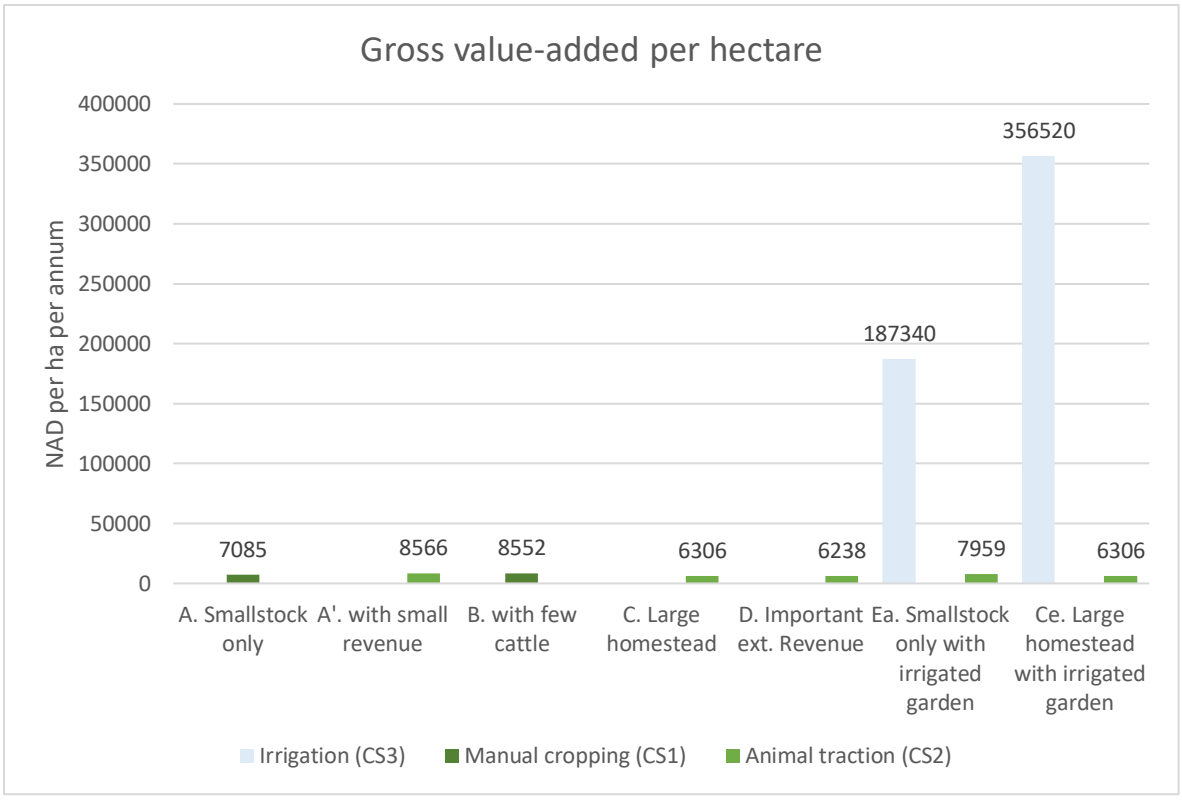

Figure 45: Productivity of cropping systems per surface area for each farm type.

In such a hot and arid environment, irrigation enables a year-round production. Beside a few weeks of standby during winter (June-July), vegetables (tomatoes, chilis, butternuts, etc.) and fodder such as lucerne can be harvested continuously during more than eight month. Here, the productivity can be almost doubled by investing in cultivation of fodder which can be harvested several times a month during many years without interruption (NAD 176'520/ha per annum). As a result, almost half of the GVA of type Ce is represented by the marketing or self-consumption of lucerne.

As irrigation is mostly practice by channelling natural spring water into the gardens with the help of furrow or old plastic pipes, intermediate inputs are very limited apart from qualitative seeds and occasional treatments against pests. Nonetheless, furrow irrigation can induce high water consumption that can have significant impact on the management and utilization of this scarce resource. Beside the regularity or watering (usually two to three times per week), water consumption was not quantified.

Nonetheless, given the high labour requirement of irrigated cropping, only small surfaces are usually cultivated. Irrigation as practiced in the study areas is rather a labour-intensive production rather than a high input enterprise. The increase of productivity per days of work facilitated by irrigation in comparison to rainfed systems is therefore less significant, even though still important (see Figure 46). Here again, the cultivation of a perennial fodder crop such as lucerne can significantly increase the value added by reducing the labour requirements compared to vegetable production.

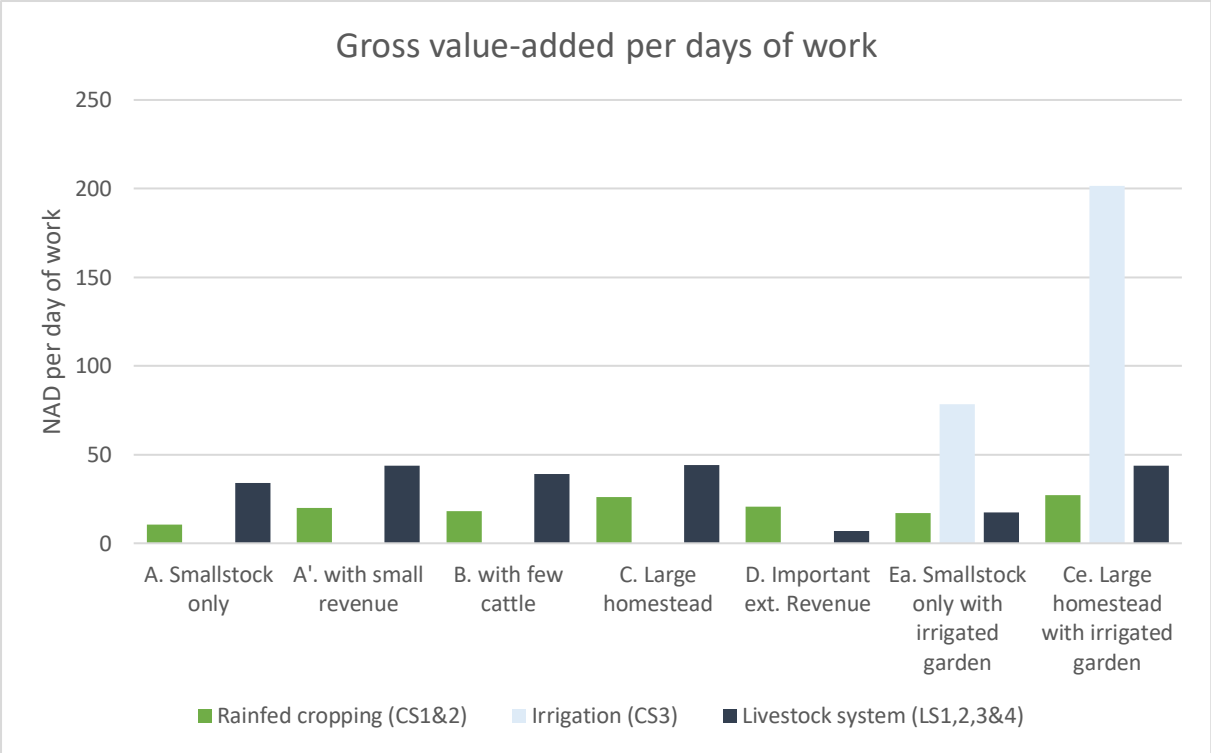

Figure 46: Gross value-added of livestock and cropping system per day of work for each farm type.

In contrast to the gross value-added per surface are, figure on the labour productivity of rainfed systems seem to indicate that animal traction and the ability to cultivate larger areas leads to improved productivity. The effect of the latter is probably enhanced by the important workload of field surveillance which is rarely doubled when two plots are cultivated close to each other as for type C.

Interestingly, analysis of Figure 46 suggests that an increasing herd size and having more cattle does not necessarily enhance labour productivity. Rearing cattle may require less daily work, such as herding but larger cattle herds often coincides with larger herds of small ruminants that require more labour. Overall, while figures on the total gross value-added underline the importance of livestock systems, the productivity of labour in livestock is not markedly higher than in crop cultivation. This may be due to the high labour demands for small ruminant systems (principally herding, breastfeeding and milking), which in turn have low off-take rates and are sensitive to climatic or epidemic hazards. This underscores the importance of investing considerable labour into apparently low output rainfed cropping that can, in fact, help save substantial capital.

Household revenues: Food security on a drip

While the gross value-added gives a good picture of the performances of the different livestock and cropping system, it does not account for the required investments into eventual

infrastructure, material or paid labourer nor the household composition and thus the needs of the various farm types. Calculating the farm income gives an appreciation of how much wealth each and every production system can actually produce every year. Farm income is calculated as follows:

Farm income = gross value-added – investments – wages

In order to balance the annual production of wealth according to the household composition and household needs, farm income is usually calculated per unit of familial labour working on the farm. In Figure xx, the farm income per familial labour for each farm type is then compared to the annual capital needed to cover basic food and material needs for a typical household to survive (see Appendix 8 for details on the calculation of the survival threshold) as well as the comparative advantage of engaging in other activities (represented here by the minimum wage in the agricultural sector)[13].

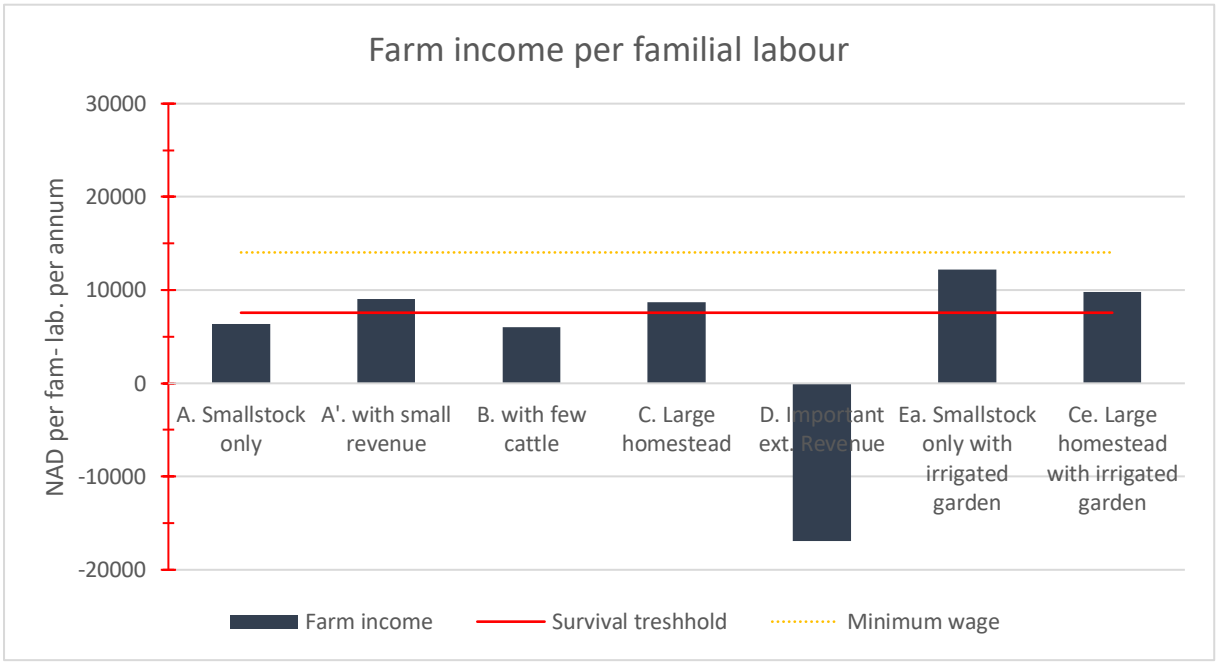

Figure 47: Farm income per familial labour for each farm type or production system.

As illustrated in Figure 47, when it comes to household revenues, the picture is quite concerning for most families who struggle to meet their basic needs. In case of type A, for instance, a small herd and low crop production do not meet the family's needs. Similarly, type B faces challenges, despite slightly larger livestock herd and crop fields. With a large family and numerous dependents to feed, type C is barely managing despite having a greater number of animals,

[13] Following common agreement between the Ministry of Labour, Industrial Relations and Employment Creation and the Agricultural Employers' Association (AEA), the minimum cash wage in the agricultural sector is currently set at NAD 6 per hour, or NAD 1,170 per month, for workers who work 45 hours per week. See https://archive.gazettes.africa/archive/na/2024/na-government-gazette-dated-2024-05-21-no-8369.pdf

particularly cattle, which theoretically should increase productivity. In reality, they have to feed a large number of dependents (elderly people, many children), and the shared ownership of the herd complicates decision-making, often resulting in little sale or consumption of animal products beyond meeting basic needs.

Conversely, the addition of an external revenue or secondary activities focused on commercialisation, such as vegetable gardening under irrigation, seem to have a positive impact on the farm income. Increased financial resources enable households to enhance productivity in both livestock and cropping systems (e.g. with type A' or Ea) and earn an income exceeding the survival threshold. However, despite the important gross value-added from irrigated gardens, small areas are insufficient to generate a farm income competing with the minimum wage household members could found when looking for jobs in the agricultural sector.

In households with substantial external income (type D), significant investments are made in agricultural activities, particularly livestock, primarily for capitalisation rather than commercial purposes. This leads to a negative farm income, indicating a reliance of the production system on external income for survival. The high expenses associated with the need for hired herders (wages), inputs, such as vaccines and supplement feeds, further exacerbate this situation.

As a result of low generally low productivity of livestock and cropping system result in insufficient farm incomes and most households in the study area today are dependent on external revenues as well as food aid in form of drought relief.

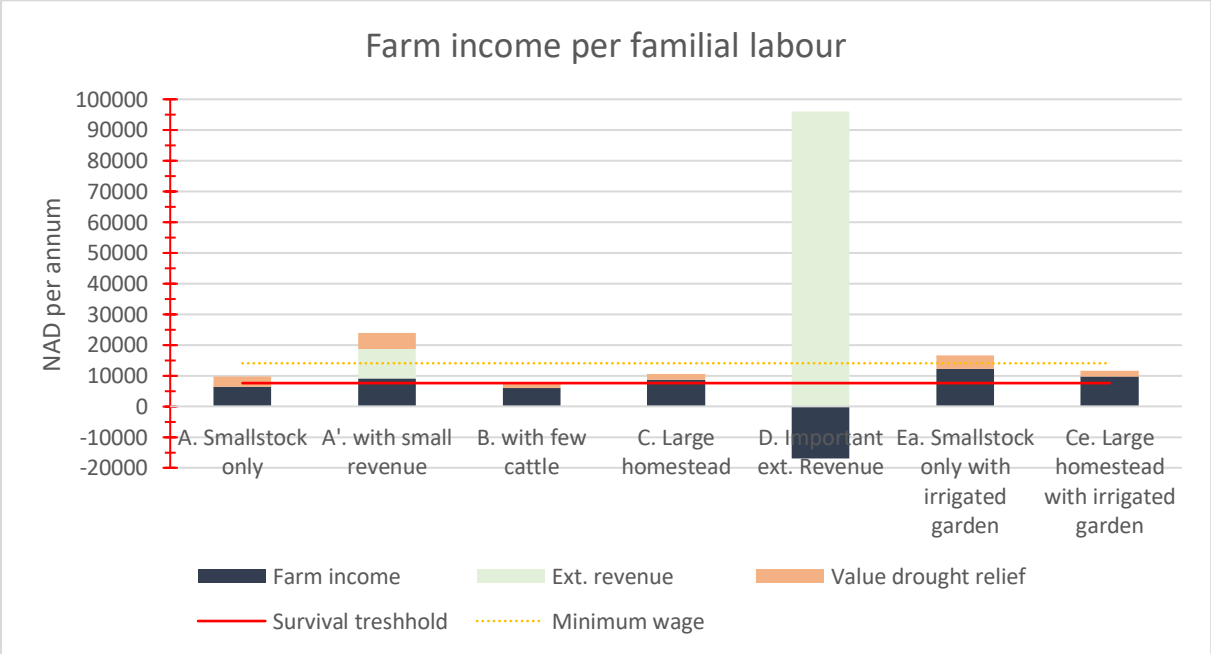

Figure 48: Farm income and value of external revenues for each farm type.

Drought relief is crucial for many households, and it has recently been doubled from one 20-kilogram bag (as calculated here) to two per month per registered person beside distribution of cooking oil and canned fish. However, at the beginning of the year, this relief scheme often

faces delays, forcing many households to de-capitalize by selling goats to buy bags of maize meal, as crop fields have not yet been harvested. Livestock prices typically drop during this period due to increased market supply from families needing cash for expenses, such as school fees or food. This further increases the challenges to feed families while trying to minimise livestock off-takes.

Note that many household also receive pensions that were not quantified here such as old age pensions (NAD 1,400 per month) or child money for single mothers or household with very small amounts of livestock (NAD 300 per children per month). Those pensions schemes are administrated by the Ministry of Gender Equality and Social Welfare, often after endorsement from traditional authorities.

Considering that the calculation of the productivity of livestock systems was based on the actual off-take rates, figures presented here do not include the yearly potential increase of the number of animals in cattle or smallstock herds. “Wealthier” households counting larger herds such as type C and Ce or type D take advantage of external revenues in form of salaries or pensions and drought relief to limit off-take rates to a minimum in order to increase the number of goats they own by nearly 20% for a year with good conditions. However, as presented previously, livestock systems in Kunene are very sensitive to natural hazards such as severe droughts and disease outbreaks and as the latter are quite recurrent, it can be considered as necessary re-stocking measure to maintain livestock numbers on the long-term. Note to forget other uses of livestock such as inheritance or borrowings and offerings that wealthier households engage in to indulge their socio-cultural position.

In conclusion, agro pastoral systems in Kunene produce relatively little, largely due to high sensitivity to climatic and epidemic hazards and a lack of technical resources to overcome these challenges, as the agricultural development in other regions of Namibia has permitted. Current analyses of productivity and farm incomes indicate that these systems predominantly depend on external activities and revenues such as pensions, salaries, and food aid to maintain their existence. However, where conditions are met, it exists promising practices enhancing productivity and provide potential solutions for improvement such as irrigated agriculture.

DISCUSSION AND PERSPECTIVES

The present study highlights how agro pastoralist production systems in Kunene today are largely shaped by historical factors. The political agendas of colonization and apartheid played a significant role. Apartheid aimed to render a substantial portion of the population strangers in their own country by forcibly relocating them to designated areas. This was a structurally racist initiative designed to create a dependent labour force that could be exploited as and when needed. Over the past fifty years, pastoralists who had diversified their assets and engaged in early commercial activities were ultimately pushed back into subsistence herding (Bollig, 1998). Additionally, these populations were often situated in conflict-prone border zones, facing tensions with neighbouring communities, such as those along Namibia's border with Angola and the regions in South Africa adjacent to Mozambique. These areas were strategically designed to rely on external production systems, ensuring that apartheid maintained a pool of cheap labour for its enterprises. While the apartheid project may have failed to achieve its long-term goals, its effects remain profoundly felt. Consequently, the agro pastoral systems in northern Namibia and Kunene today exhibit high hazard sensitivity and very low competitiveness.

Droughts and their impacts are structural in Kunene, however due to poverty, whose root causes are historical and socio-political, populations are severely affected by climatic fluctuations. If the trend of acidification caused by climate change and witnessed in the last decade continues, the situation for the situation of agro-pastoralists in Kunene is likely to become even more critical. This is particularly true for those who cannot find solutions in terms of alternative income outside of agriculture. Looking forward, it seem evident that a true de-encapsulation is necessary.

To address what some perceive as a "lack of development" in these regions, many advocate for market homogenization to enable communities to benefit and improve their livelihoods. Proponents suggest that people should organize themselves, pool resources, and create new sectors and value chains. However, under structural disadvantages, such policies rarely yield effective results. Current farming practices and productivity are highly sensitive not only to natural hazards but also to market fluctuations and price volatility.

Many NGOs and development actors are focused on promoting food security. In the short term, from a consumer perspective food security is linked to the availability and access to low-priced food products, such as those from supermarkets. However, this dynamic undermines the local agricultural production intended to meet community needs, especially considering that in this part of the world consumers are very often and primarily producers. A long-term development strategy must therefore prioritize the protection of producers from the adverse effects of low prices. The challenge for policymakers and development actors lies in reconciling short-term and long-term objectives.

As previously noted, farming practices in Kunene are deeply influenced by historical factors that over-determine current practices. Additionally, these systems are inherently vulnerable to

significant climatic and epidemic hazards, which have intensified in frequency and severity due to climate change. Following repeated droughts in the 2010s, agro pastoralists in Kunene are cautiously beginning to replenish their herds. While the number of smallstock, particularly goats, is on the rise, the situation is more complex for cattle, historically a crucial economic and socio-cultural asset for the Himba and Herero communities. Low breeding numbers and hesitance to reinvest in cattle due to uncertain climatic conditions complicate recovery. Farmers have cited challenges in replenishing their herds compared to the period following the severe droughts of the 1980s, particularly due to unfavourable price dynamics with southern and eastern regions of Namibia, where they used to purchase cattle. As a result, many are reluctant to invest additional money and labour into livestock activities, opting instead to resort to drought relief assistance as a short or mid-term strategy.

CBNRM BETWEEN OPPORTUNITIES AND COMMUNITY "FATIGUE"

The development of conservancies and community-based natural resource management (CBNRM) initiatives aims to provide new alternatives in response to these challenges by empowering communities to take ownership of their resources and develop new livelihoods. However, a critical question remains: do conservancies merely represent a new form of "reserve," or are they genuinely instruments of development? In other words, has CBNRM improved people's lives?

The answer to this question is complex and sensitive. While CBNRM has indeed provided communities with jobs and income in areas where tourism has developed, these communities still rely on livestock and agricultural practices. The livelihoods offered by conservancies do not replace agriculture; rather, they provide supplementary income to offset a poorly rewarding and inefficient agriculture facing regular hazards. In areas where tourism has not yet penetrated, such as those examined in this study, small salaries for conservancy staffs, like game guards or committee members, provide a welcome additional source of income, with demonstrated positive impacts on productivity of livestock and cropping systems (as seen in economic productivity of type A'). Nevertheless, this income rarely enables households to achieve food security. Additionally, CBNRM activities such as funded development projects offer indirect benefits branded as the "meet and meat" benefits, providing opportunities for short-term gains, such as access to food, temporary jobs, livestock sales, transport, and opportunities to build social capital.

Overall, outside a few areas with established tourism, conservancies have not created sustainable employment or market opportunities for local populations. Many conservancies struggle to generate their own income and often rely on project funding from external partners to cover operational costs, including staff salaries and logistical expenses. Moreover, CBNRM initiatives also bring challenges related to cohabitation with wildlife, leading to negative impacts on infrastructure and livestock due to predation and crop damage. With limited benefits generated over time, communities are experiencing a growing sense of "fatigue," focusing more on the negative impacts than on the opportunities offered by these initiatives.

This study contends that human-wildlife conflicts, while challenging, are not the primary cause of poverty in Kunene. Instead, they compound existing vulnerabilities. It is crucial to recognize that poverty in this region is historically rooted, and the sensitivity of communities and agriculture to these hazards is primarily a result of systemic denial of access to resources that could mitigate such vulnerabilities.

Consequently, households and communities in Kunene today engage in a diverse array of activities, including agricultural production and alternative livelihoods, since no single strategy suffices to meet their needs. Nonetheless, despite this combination of activities and as demonstrated by low farm incomes and household revenues, the context of poverty persists.

TOWARDS WATER-CENTRED SOLUTIONS

Despite these challenges, promising practices worthy of further study do exist. Here, access to water emerges as a key factor. Economic performances of production systems presented in the previous chapter clearly indicate that irrigation can enhance food security and income for households. Local communities and institutions recognize this, as most development projects in the region focus on rehabilitating boreholes or drilling new ones to implement irrigated agriculture, particularly using drip irrigation.

However, community management of production systems has often proven to be a challenge, as a lack of ownership over time can lead to project abandonment. Furthermore, equitable access to water resources and infrastructure is unlikely to be guaranteed for every household in Kunene due to logistical and environmental constraints. Additionally, groundwater resources are finite, and increasing population pressures, infrastructure development, and below-average rainfall over the past decades will inevitably have an impact on water reserves. Relying solely on irrigated agriculture as a catch-all solution for food security in Kunene is risky. While, more research is needed to assess whether current water reserves and their renewal can meet the growing demand under prevailing rainfall trends, the sustainable management of water resource and its handover to communities is a complex task that will not succeed without serious investments and implication of government institutions (Menestrey Schwieger et al., 2024).

In Kunene, farmers with access to irrigation are focusing on three primary types of production: market gardening for vegetables, lucerne cultivation for livestock fodder or for sale, and maize cultivation, which appears to be an already established practice since several generations. The irrigated practices identified in this study emphasize vegetable and cash crop production, such as sugar cane and lucerne, intended for both marketing and self-consumption. This can positively impact productivity and, indirectly, household food security. Given the limited availability of such products in remote areas, local producers may find it easier to secure buyers for their annual harvests, encountering less competition from supermarkets or other regions. In remote regions of Kunene, perishable products offer a competitive advantage over non-perishables, such as sugar cane and dried lucerne, which face higher competition from imported goods with lower production costs. Given transportation costs to the nearest towns, locally

produced goods will always hold an advantage when they can be directly consumed by both humans and livestock. However, if such production expands, market absorption may be limited, particularly since a significant portion of the population has low purchasing power and a pressing need for calorie-rich staples rather than less nutritious vegetables.

On the other end, the cultivation of lucerne as fodder raises critical questions about market demand. While local availability of fodder could mitigate the effects of natural hazards on livestock mortality and enhance productivity, it is essential to consider whether there is a genuine demand for increased meat and dairy products. It is likely that livestock owners may prefer to retain their animals as assets for future emergencies rather than slaughter them, especially given the availability of free, ready-to-cook maize flour through drought relief programs. Current practices also suggest that farmers with more livestock, are likely to sell them to purchase bags maize meal to feed their families rather than slaughter and consume more animals.

Complicated market dynamics, characterized by costly access for livestock producers and power imbalances that favour buyers, create economic risks, leaving producers uncertain about the prices they can expect for their livestock. Demand does exist from more urbanised areas of northern Namibia (Ovamboland), but the informal market appears saturated, driving prices down and structurally reluctant to the commercialisation of larger numbers of animals. Initiatives by government institutions and farmer unions to establish more formal marketing platforms, such as regular auctions to ensure transparent pricing, have often faltered. Some producers have reported difficulties attracting buyers, and the growing proportion of sales diverted by auction organizers has deterred them from participating.

On top of that, livestock, particularly goats, serve as a safety net for households, providing assets that can be sold in times of need. Fixed-date auctions may not align with farmers' urgent needs for cash, meaning desperate sellers may inadvertently benefit buyers. Studies on the characterization of the main factors determining cattle marketing of communal farmers in Kunene have A critical analysis of previous initiatives aimed at improving livestock marketing, especially for smallstock in Kunene, could yield valuable insights for future interventions designed to support farmers in their livestock enterprises. Previous studies on the main factors influencing cattle marketing of communal farmers in Kunene exist but many were conducted before the last FMD outbreak and the recent decrease in cattle numbers. Very few have taken interest in the marketing of smallstock, which, however, is the main commodity traded by farmers nowadays.

Moreover, current off-take rates applied by wealthier households demonstrate the necessity, for structurally sensitive livestock systems in Kunene and for socio-cultural reasons, to engage in strategies of high stocking rates to prevent recurrent and severe losses provoked by climatic and epidemic hazards. It would therefore be hazardous to estimate that with a more developed formal market, farmers would be encouraged to sell more animals and thereby improve their productivity and reduce the pressure on grass and water resources. Moreover, looking at current herd demographics with very little herds allowing greater off takes, especially for cattle, as well

as the state of food security across households in Kunene, there seem to be too little potential for a more developed formal livestock market.

FOCUS ON THE POTENTIAL OF SUBSISTENCE CROPPING

Complicated marketing dynamics and recurrent drought years drive the demand for maize, a staple that has been cultivated in Kunene at least since the very return of agro pastoralists in the region. Despite the inherent challenges of cropping, farmers persist in their efforts year after year, seemingly reaping some benefits from maize production. Historically, having a stockpile of maize flour has provided farmers with greater negotiating power, allowing them to wait for better prices from merchants before selling their livestock (Bollig, 2002). During this study, many participants emphasized the importance of cropping to restock their herds and build wealth. Today households in Kunene continue to rely on maize from their own production, as well as food aid from drought relief schemes or purchases made through the sale or exchange of livestock for their survival.

When conditions are met, farmers strive to enhance their cropping productivity, sometimes traveling over thirty kilometres to harvest a few bags of maize. This raises the question of whether the focus should shift from cash cropping and livestock to subsistence cropping and cereal production. Many countries have built food security around cereal production; as many arguments that supporting farmers in improving their maize yields through irrigation could be a viable strategy.

Some farmers have practiced irrigated maize production for generations in areas with reliable water sources and suitable cropping grounds. In these regions, households often cultivate a traditional rainfed crop field, followed by an irrigated field with maize and vegetables later in the year. While these systems were not included in this study, farmers who practice irrigated maize cultivation reported yields that were significantly lower than those from rainfed maize. Their assertion that "maize likes to be watered from above" (interview no. 25) suggests that furrow irrigation from springs during the dry season does not fully compensate for higher evapotranspiration and reduced rainfall compared to the main cropping season. However, it is very likely that, in semi-arid regions with erratic rainfall, well-managed and timed irrigation during the main cropping season could provide an insurance against crop failures and yield tangible benefits. Studies have already demonstrated the high water use efficiency (WUE) for maize under furrow irrigation in such environment (Bayisa et al., 2021). Even with lower yields than in rainfed systems, irrigated maize could therefore potentially still produce more biomass and calories than vegetables and other crops per amount of water used for irrigation.

It is important to distinguish between motivations and approaches: those who wish to produce to meet their basic needs (i.e., to eat) versus those who aim to generate wealth. Attention must be paid to the biases introduced by conservancies, historically created to generate alternative revenues, and the rent-seeking economy that encourages the pursuit of livelihoods generating income rather than focusing on meet the direct household needs.

The development of crops and productivity also encounters obstacles due to agricultural practices focused on increasing "goat" (or rather, cattle) production for obvious socio-cultural reasons (living capital and social capital). Nevertheless, some households are showing interest in self-improvement and increasing productivity through cultivation. And historical crises have demonstrated a similar trend, with a tendency to cultivate more during drought periods. Today's hesitation to invest in herds, coupled with challenges posed by climatic and economic factors, may signify a shift toward a more crop-centred approach.

Looking at the precarious state of food security in the region, where many households rely on drought relief to meet their nutritional needs and malnutrition among children is not uncommon[14], this study argues that investing in the potential improvement of cereal production in Kunene, focusing on water access and soil fertility, merits serious consideration.

[14] According to figures published by the Demographic and Health Surveys Program in 2013, stunting prevalence in children aged under five in Kunene accounts for 19.3% and underweight prevalence 11.5%. See https://apps.who.int/gho/data/node.searo.NODESUBREGchildmalnutrition-NAM?lang=en. A health officer interviewed in Ongango (Ombujokanguindi conservancy) during the present study cited three to four cases of malnutrition per annum for a community counting 70 children under five (approx. 5%).

CONCLUSION

Overall, the present study has shown that Human-wildlife conflict (HWC) and low rainfall present significant hazards for communities in Kunene, but these challenges are deeply rooted in a difficult historical context. The legacy of colonialism and apartheid has left livestock systems particularly vulnerable, as the expected development of veterinary services and herd health management was largely neglected. Livestock diseases and outbreaks remain major causes of losses, often overshadowing predation. Furthermore, erratic rainfall has led to crop losses, resulting in a phenomenon known as "cropping migration", where farmers seek more favourable conditions for cultivation.

Despite these adversities, small job opportunities can create substantial impacts. Conservancies, often introduce alternative livelihoods such as roles for game guards and committee members where even modest earnings can significantly improve lives. However, these projects do not guarantee structural change that effectively lifts communities out of poverty. Many conservancies struggle to cover operational costs and face governance challenges, leading to a sense of "fatigue" among local populations, who increasingly focus on the negative effects of community-based natural resource management (CBNRM) rather than potential benefits.

Mobilizing resources to help communities "survive" through pensions and food aid is essential, but this approach should not overshadow the need for sustainable living strategies. Currently, households heavily rely on external income and assistance, and the present study has highlighted the importance of smallstock, particularly goats, and crops for enhancing the resilience of agro pastoral systems. Historical marginalization has impeded the development of veterinary services, making livestock systems susceptible to shocks. While some initiatives, such as cattle vaccination programs, have shown success, much more is required to bridge the existing gaps in services for smallstock owners.

Market development is similarly crucial, as the informal meat market suffers from a lack of regulation, fair trading conditions for producers, and infrastructure. Although initiatives like "controlled" auctions have been attempted, their success has been limited, necessitating a thorough understanding of the underlying reasons.

Irrigation has gained growing attention as a means to enhance agricultural productivity in Kunene. It offers the potential for intensifying production while remaining compatible with conservation efforts. To maximize its benefits, further study is needed to determine the appropriate types of irrigation, the crops to produce, and the target markets. While horticulture has advantages in isolated areas, the demand among a population facing caloric scarcity may be limited, underscoring the need for a focus on subsistence crops.

Given the region’s history of agricultural challenges, attention should shift toward subsistence cropping and cereal production rather than cash crops. Although farmers persist in cultivating despite low yields, the historical importance of grain production must not be underestimated. Furthermore, the risks associated with increased market exposure such as price volatility could

exacerbate existing vulnerabilities of production systems.

Ultimately, interventions should prioritize meeting the immediate needs of families and the local market, fostering independence from external market fluctuations. The present study therefore argues that, before pursuing wealth creation, the emphasis should be on enhancing local agricultural production and food security with subsistence cropping based as the main focus.

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APPENDICES

Appendix 1 Interview questionnaires

Interview guide: Historical evolution of agriculture

Note: these are open-ended questions aimed at helping the interviewers guide the discussion during the semi-structured interviews, this should not be taken as closed questionnaire.

The current study is conducted by students under the supervision from IRDNC and AVSF, a French organisation implementing projects in agriculture in the conservancies of Ongongo and Ombujokanguindi. The objective of the study is to better understand farming practices and challenges that farmers face to better inform future projects. The present interview aims at better understanding the recent evolution of agriculture in the region.

☐ Are you ok with taking part in the study?

Any information from the interviews will be made anonyme and final results of the study will be presented and discussed with participants later this year.

☐ In which village are you born? Where did you grow up?

[mapping exercise] *Present a schematic mapping or satellite image of the conservancy and try to locate the features while discussing the following questions:*

- Was the vegetation and forest (bush and tree cover, annual/perennial grasses) similar to nowadays?
- Were the rivers similar to nowadays?
- Was there a lot of wildlife?
- How many settlements and where?
- Where there any roads? Electricity? School? Clinic? Boreholes?
- Where were the permanent water points?
- Where did people drink water from? And livestock?
- What were the best grazing areas (for cattle and for smallstock)?
- What were the best areas for crop fields?

☐ How many family members lived together with you?

☐ How many people/family lived in each village? Where did they come from?

☐ How were the families constituted?

- Who did what on the farms?
- Was external labour employed? For what tasks? At what cost?

☐ What did people consume and eat?

- ☐ What other non-farming activities were practised in the village (hunting, gathering, crafts, local industries, others)?

- ☐ How was land managed?
  - Who owned the land or settlements? *(oveni vehi)*
  - How much land was farmed by a family (number of gardens and size)?
  - Where were the gardens situated in the ecosystem (refer to agro-ecological zoning)?
  - What were the different plots and areas that a family farmed?
  - Did people grow crops together in community fields or only on individual fields?

- ☐ What plant species were used?
  - What were the spontaneous species?
  - How were they distributed in space?
  - What were the cultivated pants?
  - How were the different crops grown, and how were they rotated?
  - How was the fertility of the different types of land maintained?
  - Would the location of crop fields and garden change over the years? For what reason?
  - Were there any commercial seeds varieties, fertilizers, pesticides provided from merchants or institutions?

- ☐ What tools and equipment were used?

- ☐ What species and breeds of animal were farmed?
  - What were the fodder resources?
  - How were the herds managed?
  - Did you migrate with the livestock to better grazing areas during the year? Where and when?
  - Did people and families manage their livestock together?
  - Did households also move to other areas during the year?
  - Where there any “rules of good grazing”?
  - Were violations punished? How?

- ☐ What were the products from livestock?
  - What were the products used for?
  - Was livestock sold, slaughtered, exchanged, borrowed or gifted?
  - How much livestock had to be sold for a bag of maize? What were the price relationships (relative prices between agricultural products, inputs, consumer goods)?

- ☐ What were the products from crops and gardens?
  - What were the products used for?
  - What were the price relationships (relative prices between agricultural products, inputs, consumer goods)?

- ☐ What wild products were harvested?
    - What were the products used for?
    - What were the price relationships (relative prices between agricultural products, inputs, consumer goods)?

- ☐ What was the diversity of farms, in terms of land and livestock ownership, equipment, labour, farming, processing and non-farming activities?

- ☐ What was the nature of the exchanges of land, labour, water and capital (equipment or other) between the different types of farmer?

Continue the interview by discussing the evolution of the career/life of the respondent while trying to identify phases of transformation of agriculture until saturation. Specific questions arising from the first landscape and historical analyses can also be addressed if judged appropriate/relevant.

Thank the respondent for its time when closing out the interview and ask for his consent to share contacts to be informed in case of focus groups or restitutions.

- ☐ Are you ok with sharing your contact details for the invitation to following discussions or the final restitution?

Interview guide: Production systems

Note: these are open-ended questions aimed at helping the interviewers guide the discussion during the semi-structured interviews, this should not be taken as closed questionnaire.

The current study is conducted by students under the supervision from IRDNC and AVSF, a French organisation implementing projects in agriculture in the conservancies of Ongongo and Ombujokanguindi. The objective of the study is to better understand farming practices and challenges that farmers face to better inform future projects. The present interview aims at better understanding the recent farming practices and their respective productivity.

☐ Are you ok with taking part in the study?

Any information from the interviews will be made anonyme and final results of the study will be presented and discussed with participants later this year.

General information on the household

☐ How many family live with you? How old are they? What is their occupation and contribution to the household?
☐ Who is responsible for which operations on the farm? Who is managing cattle, goats, sheep, crop fields and gardens? Who is managing the processing and selling of products?
☐ Are there other people working on the farm? Do other relatives come and help with some activities? Do you employ and pay workers? Do these people work here temporarily or permanently?
☐ Did you establish your own homestead, or did you inherit from your elders? When did you start to farm and where?

Livestock rearing system

Composition of herd

☐ What livestock species do you rear? What breeds? How do you describe those breeds and their advantages/disadvantages?
☐ Do you have a bull and oxen? How many cows do you have and how many calves are born each year?
☐ Do you also own sheep and goat ram? How many? How good are they reproducing?
☐ What other animals are you roaring (chicken, pigs, ..)?
☐ Do the animals belong to one or several owners?
☐ Who watches the animals? What type of contract for herders?
☐ Are the animals penned in at night or certain time in the year? When? Why?
☐ Do you have any building for the animals? Building to store fodder or feed?
☐ Do you separate adults from offspring?

Breeding

☐ Which breeding method do you use? Do you control the mating?

- ☐ At what age are young females first breeding? What is interval between two parturitions for any one female? Average number of live young born per litter (portée)? What is the mortality rate of the young before weaning (sevrage)?
- ☐ Are births being grouped together? What periods do they take place? Do any difficulties occur?
- ☐ How long is the breeding career of one female?
- ☐ When are females being culled (éliminées)? And the males?

Products

- ☐ What products are obtained from animals? For what use?
- ☐ Milk:
    - Are lactation periods the same for all females or are they spread out? How many month does the lactation period for each female last? During what month does it begin and when does it end?
    - What is the average quantity of milk obtained per day and per female? How is the trend of milk production over the whole lactation period (draw a line)?
    - How is the milking done? By whom? When? How often?
    - How is the milk transformed? Used? Sold? For what price?
- ☐ Do you sell or slaughter animals?
    - Which animals? What age? At what period in the year or animal growth? For what price?
- ☐ Do you borrow or exchange animals?
- ☐ Other products? Eggs? Wools? Leather?
- ☐ Animal dung? Manure or litter? Usage?

Animal feeding and health

- ☐ Are they health difficulties or risks? What kind?
- ☐ What is the average mortality? How many animals do you lose to illness, parasites or predators per year?
- ☐ How do you take care of sick animals?
- ☐ Do you practice any preventive treatments? Do you have a treatment schedule?
- ☐ Do you vaccinate animals?
- ☐ How are you feeding your animals? Do you buy any feed or fodder? When? How much?

[mapping exercise] *Present a schematic mapping or satellite image of the conservancy and try to locate the features while discussing the following questions:*

- Where do you bring your livestock to graze? When in the year? For how long? Do you create various flocks or keep them together? Are the animals herded?
- Where do people drink water from? And livestock? Who brings livestock to drink? When? How many times?
- How is the access to those grazing areas and water managed or organised with the other households?

- ☐ Are you limited by available forage resources? Do you like space to keep the animals?

- ☐ Is there too much of a need of labour at on particular period? Which tasks is the limiting one?
- ☐ Do the health risk that the animals face prevents you from developing your herd? Or any other factor?

Cropping system

- ☐ Do you cultivate in crop fields or gardens? How many? Are they your own fields or from someone else? How big are those fields?

[mapping exercise] *Present a schematic mapping or satellite image of the conservancy and try to locate the features while discussing the following questions:*

  - Where are the crop fields situated?
  - Does the location of the plots change over the years?
- ☐ Do you build fences? With which material? When do you fix them?
- ☐ What crops and varieties are grown? Where do you get the seeds from?
- ☐ Where in the plots are the crops cultivated? Are they cultivated together? Why? In which proportion?
- ☐ When are the crops cultivated? Are there several successive cycles per year on the same plot? What is the crops succession over several years?
- ☐ What are the cropping practices during the year? When do they take place? How often? Who does the work?
- ☐ What are the most intensive periods and how do you manage the workforce?
- ☐ What tools and equipment do you use?
- ☐ How do you ensure that soil fertility is maintained? Do you apply fertilizers, manure or compost?
- ☐ What are the main products and by-products for each crop?
- ☐ What are the average yields of good or bad years for each crop? Do you suffer any crop loss during cultivation? During harvest? During processing or transportation?
- ☐ What were the products used for?
- ☐ What are the processing steps for each by-products?
- ☐ Do you sell any crop products? To whom? For which price?

Additional activities and revenues

- ☐ What other non-farming activities do you practise in your household (hunting, gathering, crafts, local industries, others)?
- ☐ What wild products are harvested?
  - How often? How much?
  - What are the products used for?
- ☐ Do someone in your household have a formal job? What type? Where?
- ☐ Do you have any other sources of additional revenue?
- ☐ Do you have to purchase any food products to sustain your family? What type of products? When in the year?
- ☐ Do you have any other sources of additional food (drought relief)

- ☐ Finally, what do you think are the main constraints you face in sustaining your household?

Thank the respondent for its time when closing out the interview and ask for his consent to share contacts to be informed in case of focus groups or the final restitution.

- ☐ Are you ok with sharing your contact details for the invitation to following discussions or the final restitution?

'Dangi tjinene munene koruveze roye' (sing.)

'Dangi tjinene vanene koruveze rweni' (pl.)

Interview guide: MAWLR – Directorate of Veterinary Services, Opuwo

Note: these are open-ended questions aimed at helping the interviewers guide the discussion during the semi-structured interviews, this should not be taken as closed questionnaire.

The current study is conducted by students under the supervision from IRDNC and AVSF, a French NGO implementing projects in agriculture in the conservancies of Ongongo and Ombujokanguindi. The objective of the study is to better understand farming practices and challenges that farmers face to better inform future projects. The present interview aims at better understanding the activities of the veterinary services in the region as well as collect data on local breeds and the evolution pf livestock demographics and prices over the last century.

☐ Are you ok with taking part in the study?
Any information from the interviews will be made anonyme and final results of the study will be presented and discussed with participants later this year.

1. Can you present us the main missions of the veterinary services and its annual activities?

2. How is the service organised and what resources does it benefit from?

3. What support does the veterinary services offer to farmers in terms of vaccination and other preventive disease management?

4. What are the DVS recommendations to farmers in terms of disease management of the different livestock species in Kunene? Type, regularity and quantity of preventive treatments?

5. I understand that the veterinary services provide a once a year free of charge vaccination for cattle across Kunene. Under which conditions can farmer access this service?

6. How did this program start and why? Are similar services available for smallstock? If not why cattle and not smallstock?

7. Do you collect any additional data on the health of animals or status of herds during those vaccination campaigns? If yes, are those data available?

8. How has the livestock population in Kunene change over the last 20 years? Do you have any official data or figures on the number of livestock in Kunene?

9. How has the spread of diseases and overall health status of livestock herds in Kunene change over the last century and what are the main factors of this evolution?

10. During the study, farmers mentioned rearing mainly local goats with some Boer goat crossing, Himba (Nguni) cattle as well as some brahman and bonsmara breeds. Can you confirm that? Can you explain us when and how have those breeds been introduced in Kunene?

11. Are there any other breeds encountered in Kunene? Which one?

12. Farmers have usually mentioned rearing fat-tail and twisted-tail sheep. What are the breeds of sheep encountered in Kunene?

13. Can you explain us the main characteristics (advantages and disadvantages) of those different livestock breeds in regard to the rearing conditions in Kunene?

14. Do you have any documentation on herd demographics and productivity of the different breeds (1st mating, reproduction rate, longevity, milk production and lactation period)?

15. Otherwise, can you confirm the follow figures collected from farmers declarations during our study?

16. [notes on livestock demographics and productivity]
17. *Present the different figures for each livestock specie and breed and ask the respondent to give his thought on whether the figures are accurate or not.*

18. Do you have any figure representing the relative distribution and importance of the different livestock breeds in Kunene?

19. Farmers mostly mention selling their animals to private buyers in Opuwo or from other parts of northern Namibia for resell. What are the main commercialisation strategies of farmers in Namibia?

20. What are the prices of livestock in Kunene? How do the different commercialisation strategies influence producers prices?

21. Do you have any data of figures of the evolution of livestock prices in Kunene over the last century?

22. Finaly, what do you think are the main challenges that farmers in Kunene face to sustain their activities?

23. Do you see any influence or link between cropping practices implemented by farmers and the status of their livestock herds?

24. Do you think that CBNRM has influenced farming practices in Kunene by bringing new challenges or solution for farmers to sustain their livelihood? How and why?

Thank the respondent for its time when closing out the interview and ask for his consent to share contacts to be informed in case of focus groups or restitutions.

- ☐ Are you ok with sharing your contact details for the invitation to following discussions or the final restitution beginning of September?

Interview guide: validation of typology of production systems

Note: these are open-ended questions aimed at helping the interviewers guide the discussion during the semi-structured interviews, this should not be taken as closed questionnaire.

The current study is conducted by students under the supervision from IRDNC and AVSF, a French organisation implementing projects in agriculture in the conservancies of Ongongo and Ombujokanguindi. The objective of the study is to better understand farming practices and challenges that farmers face to better inform future projects. The present interview aims at better understanding the recent evolution of the different farming practices and agriculture in the region

- ☐ Are you ok with taking part in the study?
  Any information from the interviews will be made anonyme and final results of the study will be presented and discussed with participants later this year.

- ☐ Where were you born? Where did you grow up?

- ☐ Can you explain us how people were farming back then and what were the main difference between the households?
  - Cattle and smallstock?
  - Cropping?

- ☐ Were Homestead bigger or smaller than today? Were there homestead with one single household?

- ☐ How was land managed?
  - Who owned the crop fields, waterpoints or settlements? *(oveni vehi)*
  - What were the different plots and areas that a family farmed? Where were the gardens and outposts situated in the ecosystem (refer to agro-ecological zonation)?
  - How much land was farmed by a family (number of gardens, size, number of outposts)?
  - Did people grow crops together in community fields or only on individual fields?

- ☐ How were families settled at the same location interacting, exchanging goods or working together?

- ☐ How are farming practices different nowadays and how did it change over time?

- ☐ In your opinion, what are the major historical event or factor that influenced farming practices in Kunene over the last 100 years?

- ☐ Do you think that CBNRM has changed farming practices in Kunene? Why?

- ☐ Do all households own cattle in you conservancy? Was it always like this?

☐ Do all households grow crops in your conservancy? Was it always like this?

☐ Do households also employ workers for their farms? Which operations in specific? When did people start to use external labour and why?

☐ Are there a lot of households with at least one member working for job and benefitting from a salary?

☐ During our study in Ongongo and Ombujokanguindi, we have found different cropping and livestock farming practices summarized as follow:

Livestock System 1	smallstock only with limited mobility (time and distance)
LS2	cattle and smallstock kept at one single location and migration to oupost from late DS to rainy season
LS3	cattle and smallstock divided into several herds and temporary outposts throughout the DS
LS4	cattle and smallstock divided between main settlement and secondary settlement
Cropping System 1	manual rainfed cropping
CS2	rainfed cropping with animal power for ploughing
CS3	crop and vegetable fields with springwater irrigation

☐ As a result, we have categorized farming practices into 7 different type of farms:

[*present the typology and its historical evolution*]

A. Single-headed household (female)
- Recent displacement
- Smallstock only
- No external revenue
- Crop failure leading to de-capitalisation

B. Household with low external revenue
- Job in the community (clinic or school security, game-guard, ...)
- Majority of smallstock (as savings)
- Limited mobility leading to investment in cropping activities
- Limited familial labour (school and job)

C. Large homestead with secondary settlement
- Historically wealthy
- Herd and household divided in two different location
- No cropping or cropping in main homestead divided into numerous households
- No external revenue or external labour

D. Average household (in transition?)
- Usually young head of household
- Smallstock and few cattle
- Seasonal outposts and division of herds
- No or occasional external labour
- No external revenue

E. Household with important external revenue
- External job leading to partially or totally absent owner
- Large number of livestock (as investment)
- External labour and multiple herds
- No cropping or as a "bonus" activity

F. Commercial crop farming household
- Revenue from vegetables or fodder production
- Irrigated crop fields
- Smallstock and few cattle

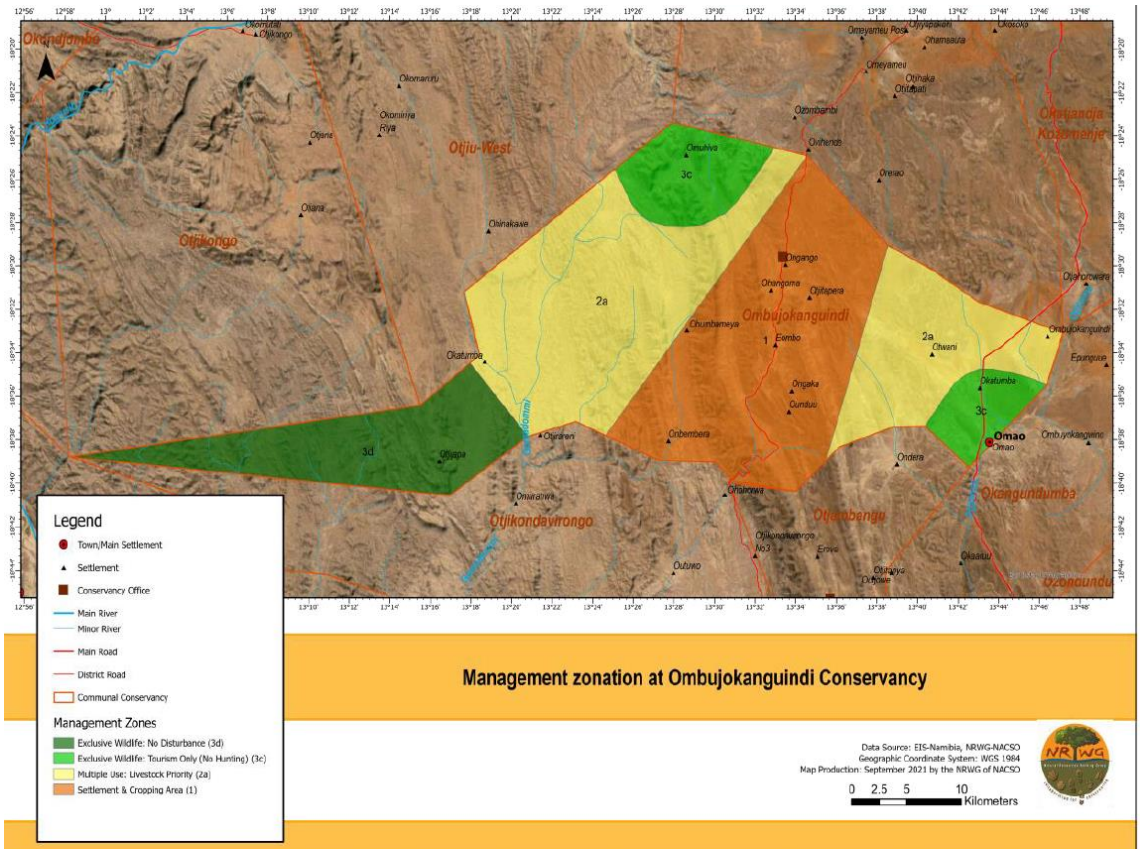
X. "absent" owner (mainly smallstock)

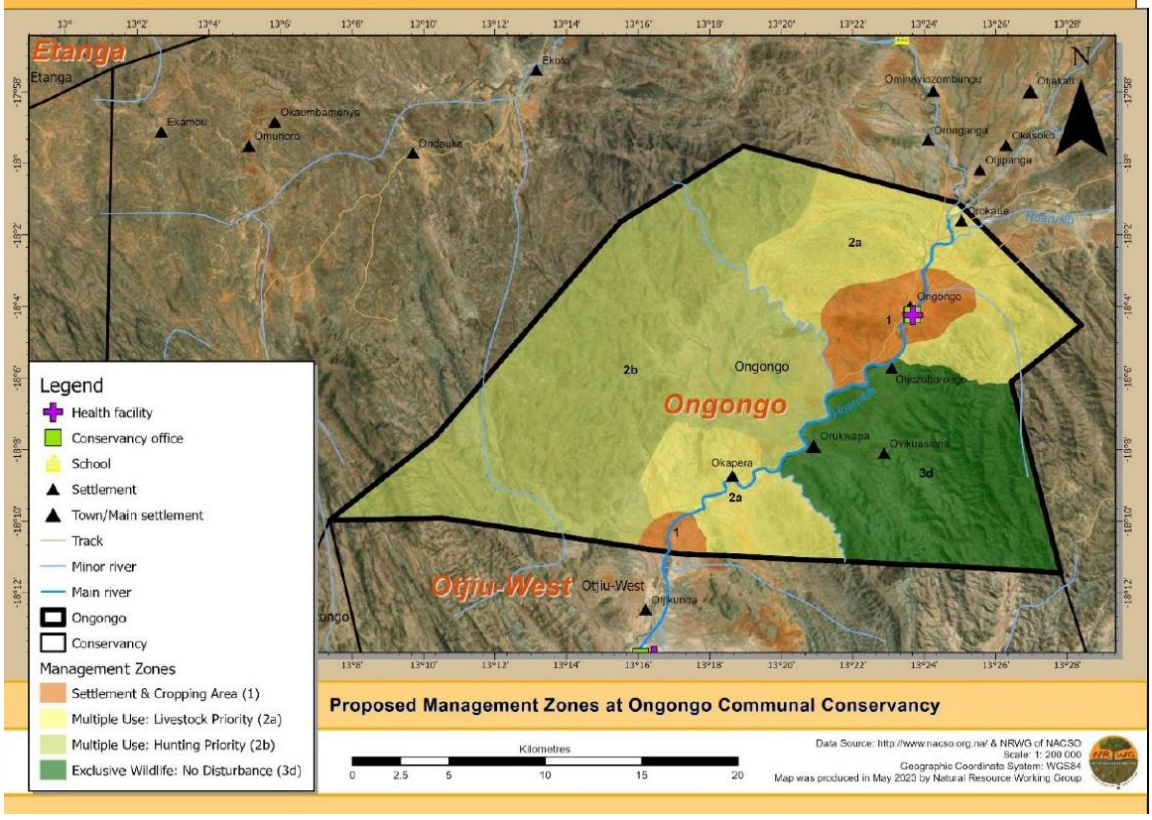
Can you identify those distinct types of farming in your conservancy? Do you think it represents well how people are farming today or is there any type of farm or household that is not represented here?

Thank the respondent for its time when closing out the interview and ask for his consent to share contacts to be informed in case of focus groups or restitutions.

- ☐ Are you ok with sharing your contact details for the invitation to following discussions or the final restitution?

Appendix 2 Zonation plans of Ongongo and Ombujokanguindi





Appendix 3 The five main agroecological zones

1

Floodplains

Where : riverbeds of ephemeral rivers and tributaries

Soils : silty, loamy regosols (alluvial sediments, salty)

Vegetation : Hyphaene petersiana (*omurunga*), Faidherbia albida (*omue*), Ziziphus mucronate (*omukaru*), and indicators of cropping soils such as Cenchrus clandestinum (*ondombora*)

RS Rainfed cropping (maize, watermelons, melons, pumpkins, sorghum)
DS Cattle (and smallstock) grazing / dugwells and waterpoints (natural or earth dams)

Ongongo 2024 – Léon Bickel-Pasche

2

Settlements

Where : hills along riverbeds or valley foothills

Soils : shallow sandy and stoney leptosols/calcisols

Vegetation : Colosphospermum mopane (*omutati*), Senegalia mellifera (*omusaona*), Terminalia prunoides (*omuhama*), annual grasses

all year Permanent settlements, springs, boreholes
Irrigated gardens (if spring)

Ekongo 2024 – Léon Bickel-Pasche

Ongongo 2024 – Léon Bickel-Pasche

3

Alluvial grasslands

Where : intramountainous valleys with intramountainous river tributaries and flat alluvial plains

Soils : silty and sandy regosols or leptosols

Vegetation : Colosphospermum mopane (*omutati*), annual *"omupito"* grasses *(ohungue, omurondji, orwejo*)

RS	Grazing areas during rainy season around settlements
DS	Early dry-season cattle posts around waterpoints (*erindi, rivers*)

Okapera 2024 – Léon Bickel-Pasche

4

Mountainous rangelands

Where : smaller intramountainous valleys, summit of mountains or hills

Soils : shallow stoney leptosols with rocky outcrops

Vegetation : Catophractes alexandri (*omukaravize*), Rhigozum virgatum (*omumbuti*), Grewia bicolor (*omuvapu*), standing perennial grasses (*ongumba, ongangahozu, otjimbere, ondoni)*

DS	Livestock outposts (late-DS)
RS, all year	Collection of wild fruits, wood

Okozombandje 2024 – Léon Bickel-Pasche

Omuhiva 2024 – Léon Bickel-Pasche

5

Wildlife only zones

Where : remote mountainous and hilly areas often with limited water resources

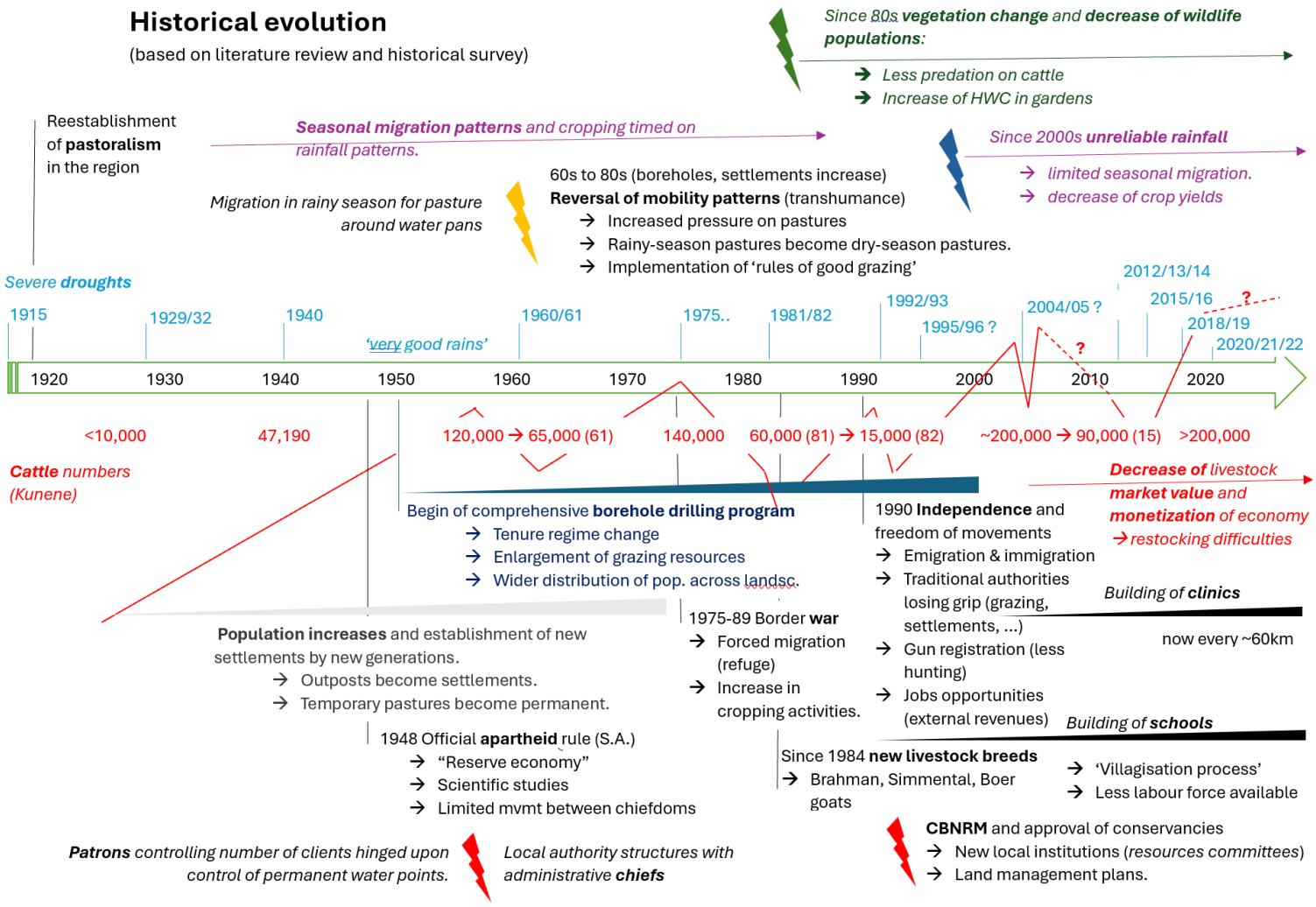
Soils : shallow rocky leptosols

Vegetation : Catophractes alexandri (*omukaravize*), Boscia albitrunca (*omungwindi*), Cyphostemma juttae (*omutindi*), Stipagrostis uniplumis (*ongumba*)

all year	No disturbance
DS	Reserve grazing areas for drought years

Omuhiva 2024 – Léon Bickel-Pasche

Appendix 4 Historical timeline of influencing factors for agriculture in Kunene



Appendix 5 Table summarizing interviews conducted during the study

Livestock System 1	smallstock only with limited mobility (time and distance)
LS2	cattle and smallstock kept at one single location and migration to oupost from late DS to rainy season
LS3	cattle and smallstock divided into several herds and temporary outposts throughout the DS
LS4	cattle and smallstock divided between main settlement and secondary settlement
Cropping System 1	manual rainfed cropping
CS2	rainfed cropping with animal power for ploughing
CS3	crop and vegetable fields with springwater irrigation

	interview n°	conservancy	location	LS1	LS2	LS3	LS4	CS1	CS2	CS3	Type
historical	1	Ongongo	Ongongo		?			?			A'/X
	2	Ongongo	Ongongo		▬						?
	3	Ongongo	Otjikunda								?
	4	Ongongo	Otjikunda		▬			?			B/C
	5	Ongongo	Otjipanga	?				?			?
	6	Ongongo	Otjipanga	▬							A
	7	Ombujokangu	Orukune			▬			?		B
	8	Ombujokangu	Otjinanua			▬					B
	9	Ombujokangu	Ongango				?		?		C
	10	Ombujokangu	Omuhiva	▬				?		?	A
	11	Ombujokangu	Otuani		?				?		?
production systems	12	Ongongo	Otjipanga	▬				?			A
	13	Ongongo	Otjipanga	▬				▬			A
	14	Ongongo	Ongongo			▬		?			C
	15	Ongongo	Otjikunda			▬		▬			B/C
	16	Ongongo	Otjikunda		▬						B/C
	17	Ongongo	Okatuo	▬				▬	▬		A'
	18	Ombujokangu	Orukune				▬				C
	19	Ombujokangu	Okakuara			▬			▬		D
	20	Ombujokangu	Okakuara	▬					▬		A
	21	Ombujokangu	Ongango	▬				?			A'
	22	Ombujokangu	Omuhiva				▬		▬	▬	Ce
	23	Ombujokangu	Ondera			▬	?		?		D
	24	Otjiu-West	Otjiu-West		▬						B/A
	25	Okajandja	Okorosave				▬		▬	▬	Ec
	26	-	Ozombambi	▬					▬	▬	Ea
socio-economic	27	*follow-up of interview 26*		"					"	"	Ea
	28	*follow-up of interview 22*					"		"	"	Ce
	29	Ombujokangu	Omuhiva		▬				▬		B/A'
	30	*follow-up of interview 17*		"				"	"		A'
	31	Ongongo	Ongongo			▬		▬			C
	32	Ongongo	Otjikunda		▬			▬	▬		B
	33	*follow-up of interview 25*					"		"	"	Ec
	29	**number of case studies:**		**9**	**8**	**7**	**5**	**12**	**12**	**3**	

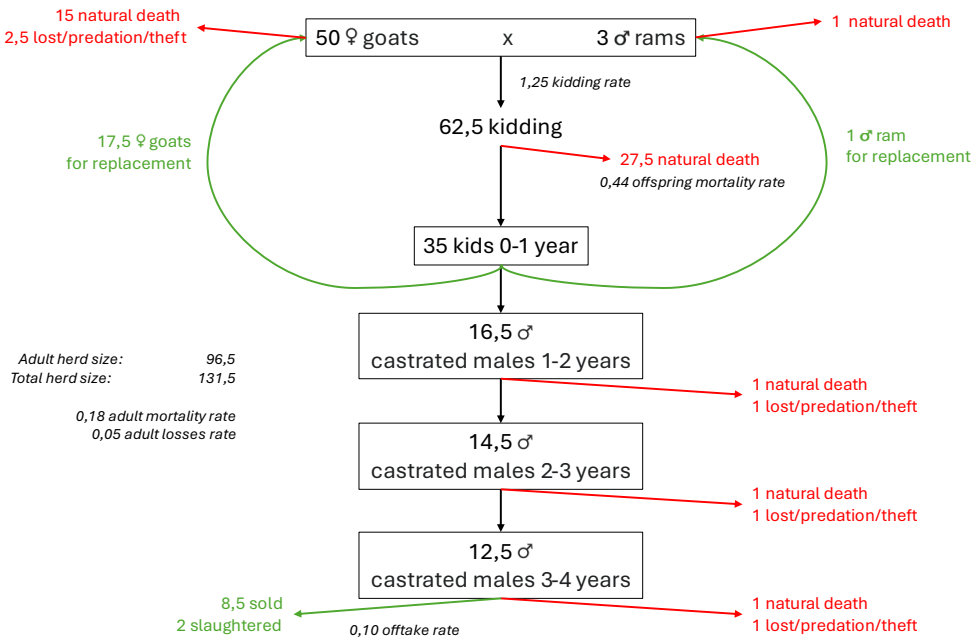
nb of case studies per type:

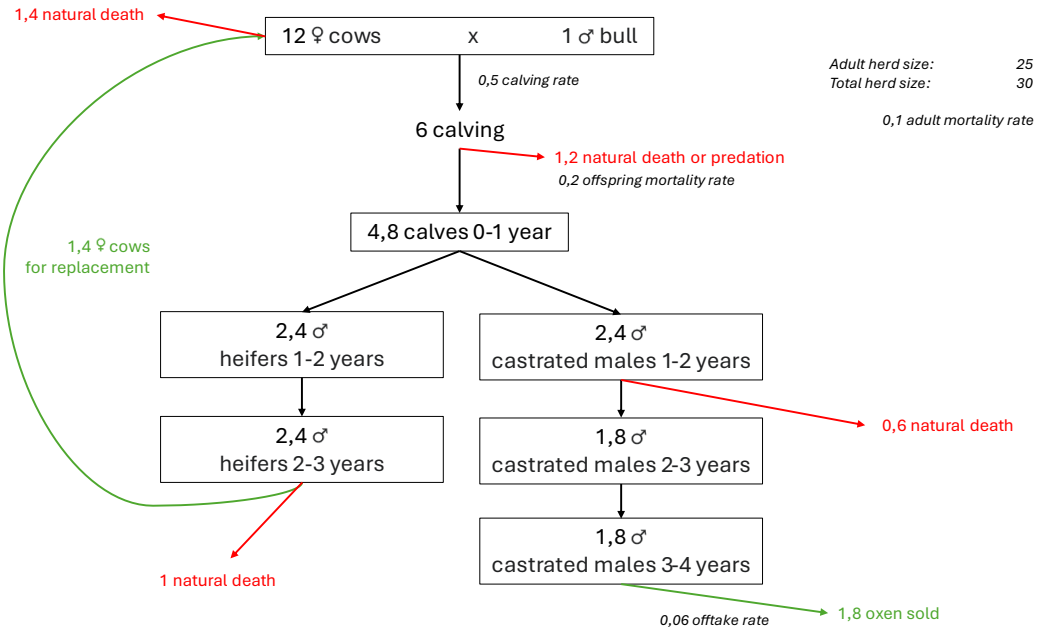
A	5
A'	4
X	1
B	7
C	5
D	2
E	3

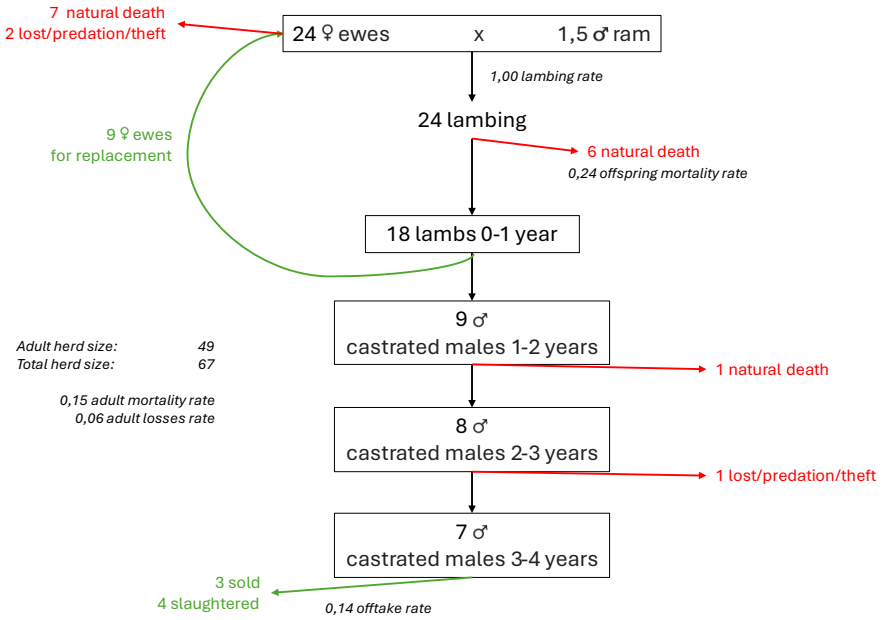
additionnal interviews:

2 historical interviews with IRDNC Facilitator and Rural Water Supply extensionist
3 interviews on livelihoods development projects with NACSO Director, IRDNC Senior Projects Manager and IRDNC Landscape Coordinator
1 interview on livestock management practices and marketing with a veterinarian from the Directorate of Veterinary Services (MAWLR)

Appendix 6 Livestock systems demographics






7 natural death
2 lost/predation/theft
24 ♀ ewes
x
1,5 ♂ ram
1,00 lambing rate
24 lambing
9 ♀ ewes
for replacement
6 natural death
0,24 offspring mortality rate
18 lambs 0-1 year
9 ♂
castrated males 1-2 years
Adult herd size: 49
Total herd size: 67
0,15 adult mortality rate
0,06 adult losses rate
1 natural death
8 ♂
castrated males 2-3 years
1 lost/predation/theft
7 ♂
castrated males 3-4 years
3 sold
4 slaughtered
0,14 offtake rate

Appendix 7 Calculation of economic performances of production systems

Economic performances	**type A**								
LS1									
GROSS PRODUCT	nombre	prix	total						
omaere goat in L	830,22	25,00	20755,62						
goats sold or slaughtered	4,55	800,00	3640,00						
sheep sold or slaughtered	0,20	1000,00	200,00						
TOTAL			24595,62						
INTERMEDIARY INPUTS	quantité	prix	total						
preventive vaccination DISULFOX L.A. 100ml	1,53333333	345	529	unregularly: 2 times over last 3 years; 1ml per 10kg biomass; goat = 40kg; 1 goat = 4ml					
dipping as treatment AGRAPOR 1L	0,092	485	44,62	unregularly: 2 times over last 5 years; sheep = 30kg; 1 sheep = 3ml					
transport to Opuwo and back for selling livestock	3,95	210	829,5						
TOTAL			1403,12						
GVA LS1			**23192,50**						
CS1	surface area	0,35	ha						
GROSS PRODUCT	nombre	prix	total						
50kg maize meal sack	4,0	550	2174,54						
melons	24	30	733,92						
watermelons	7	50	366,12						
pumpkins	27	30	819,33						
beans per tin (big ones)	0	10	0	no harvest					
TOTAL			4093,90						
INTERMEDIARY INPUTS	quantité	prix	total						
milling of 50kg maize corns	4,0	60	237,22						
transport to Opuwo and back	4,0	280	1107,04						
maize seeds	1	250	250,00	have to buy them in Opuwo; 250 NAD for 4'600m2 = 2/3 of the field					
withe beans seeds	2	10	20,00						
TOTAL			1614,26						
GVA CS1			**2479,65**						
GVA Type A			**25672,15**						
number of familial labour			4						
INVESTMENTS	quantité	prix	années	total					
hoe head	1	130	5	26					
hoe handle	1	65	1	65					
workers for ploughing (per bottle of 350ml)	6	20	1	120	buy traditionnal brew to pay labourers				
TOTAL				211					
SALARIES	quantité	prix	total						
workers for ploughing (per bottle of 350ml)	6	20	120	buy traditionnal brew to pay labourers					
TOTAL			120						
NVA Type A			25461,15						
GVA/familial labour Type A			6418,04						
GVA/dW Type A			27,88						
NVA/familial labour Type A			6365,29						
NVA/dW Type A			27,65						
Farm income			**25341,15**						
GVA/dW CS1 Type A			10,47						
GVA/dW LS1 Type A			33,96						

Economic performances	**type A'**					
LS1						
GROSS PRODUCT	nombre	prix	total			
omahere goat in L	694,34665	25	17358,67			
goats sold or slaughtered	7,5	800	6000			
sheep sold or slaughtered	0,0	1000	0			
TOTAL			23358,67			
INTERMEDIARY INPUTS	quantité	prix	total			
small goats bought in 2022	8	250	666,67	/ 3 (3 years ago); 4 sacks of 50kg for 8 small goats		
salt blocks (the small ones)	3	200	600,00			
preventive vaccination DISULFOX L.A. 100ml	3,5	345	1207,50	1x/year	1 goat = 4ml	
preventive dipping AGRAPOR 1L	0,35	485	169,75	1x/year	1 sheep = 3ml	
luzerne supplement in 50kg sack	2	150	300,00			
transport to Opuwo and back for selling livestock	4,875	210	1023,75			
feed supplement VM ECO - Grasveld lick 50kg	2	419,99	839,98			
watering of goats at outpost	14	100	1400,00	1x/week form sept to 1st rains (3,5 month)		
TOTAL			4140,98			
GVA LS1			**19217,69**			
CS2	surface area	0,7	ha			
GROSS PORDUCT	nombre	prix	total			
50kg maize meal sack	8,0	550	4417,37			
melons	49	30	1467,84			
watermelons	15	50	732,23			
pumpkins	55	30	1638,66			
beans 20kg sacks	2	200	400,00	20kg sack = 20 big tin		
TOTAL			8656,10			
INTERMEDIARY INPUTS	quantité	prix	total			
milling of 50kg maize corns	7,5	60	450			
transport to Opuwo and back	7	280	1960	7 times		
maize seeds 20kg sack	1	230	230	keep them from harvest		
beans seeds big tins	2	10	20			
TOTAL			2660			
GVA CS2			**5996**			
GVA Type A'			**25214**			
external revenue from job		NAD	24000			
number of familial labour			2,5	head of household partially absent counted as 0.5		
INVESTMENTS	quantité	prix	années	total		
hoe head	2	130	5	52		
hoe handle	2	65	1	130		
TOTAL				182		
SALARIES	quantité	prix	total			
workers for ploughing	6	100	600			
workers for weeding	4	60	240			
worker for fencing	1	1000	1000			
oxen + plough	1	500	500			
TOTAL			2340			
NVA Type A'			25031,79			
GVA/familial labour Type A'			10085,52			
GVA/dW Type A'			33,93			
NVA/familial labour Type A'			10012,72			
NVA/dW Type A'			33,69			
Farm income			**22691,79**			
GVA/dW CS2 Type A'			19,85			
GVA/dW LS1 Type A'			43,58			

Economic performances	**Type B**					
LS2						
GROSS PRODUCT	nombre	prix	total			
milk cow in L	440,1	15,0	6601,7			
butterfat from cowmilk (L)	0,0	25,0	0,0			
omaere goat in L	823,9	25,0	20598,7			
goats sold or slaughtered	7,3	800,0	5840,0			
oxen sold or slaughtered	0,1	6500,0	812,5			
sheep sold or slaughtered	0,8	1000,0	833,3			
TOTAL			34686,3			
INTERMEDIARY INPUTS	quantité	prix	total			
salt blocks	6	200	1200			
preventive vaccination DISULFOX L.A. 100ml	8,6	345	2967	1x/year	1 goat = 4ml	
preventive vaccination cattle	1	0	0	free (provided by veterinary services 1X/year)		
preventive dipping AGRAPOR 1L	0,86	485	417,1	1x/year	1 sheep = 3ml	
transport to Opuwo and back for selling livestock	6,825	210	1433,25			
luzerne bails for goats	1	210,99	210,99			
TOTAL			6228,34			
GVA LS2			**28457,92**			
CS1	surface area	0,6	ha			
GROSS PRODUCT	nombre	prix	total			
50kg maize meal sack	6,5	550	3581,11			
melons	49	30	1470,00			
watermelons	14	50	700,00			
pumpkins	55	30	1650,00			
TOTAL			7401,11			
INTERMEDIARY INPUTS	quantité	prix	total			
milling of 50kg maize corns	6	60	360			
transport to Opuwo and back	6	280	1680	3 times		
maize seeds	1	230	230	keeps a 20kg bag		
TOTAL			2270			
GVA CS1			**5131,11**			
GVA Type B			**33589,03**			
number of familial labour			5,5			
INVESTMENT	quantité	prix	années	total		
Donkey	2	2000	20	200	life expectancy of 20 years	
hoe head	2	130	5	52		
hoe handle	2	65	1	130		
TOTAL				382		
SALARIES	quantité	prix	total			
	0					
TOTAL			0			
NVA Type B			33207,03			
GVA/familial labour Type B			6107,10			
GVA/dW Type B			33,26			
NVA/familial labour Type B			6037,64			
NVA/dW Type B			32,88			
Farm income			**33207,03**			
NVA/dW CS1 Type B			18,03			
NVA/dW LS2 Type B			39,23			

Economic performances	**Type C**							
LS4								
GROSS PRODUCT	nombre	prix	total					
milk cow in L	2110,1	15,0	31651,6					
butterfat from cowmilk (L)	190,2	25,0	4755,3					
omaere goat in L	1450,6	25,0	36265,5					
goats sold or slaughtered	14,7	800,0	11733,3					
oxen sold or slaughtered	1,8	6500,0	11700,0					
sheep sold or slaughtered	6,2	1000,0	6200,0					
TOTAL			102305,7					
INTERMEDIARY INPUTS	quantité	prix	total					
salt blocks	10,0	300,0	3000,0					
preventive vaccination DISULFOX L.A. 100ml	27,0	345,0	9315,0	2x/year	1 goat = 4ml	1 sheep = 3ml		
preventive vaccination cattle	1,0	0,0	0,0	1x/year provided by veterinary service for free				
preventive dosing VALBAZEN sheep&goat	2,7	215,0	580,4	2x/year	1 goat = 0,5ml*4 = 2ml		1 sheep = 0,5ml*3 = 1,5ml	
preventive dipping AGRAPOR 1L	0,0	485,0	0,0	0x/year	1 sheep = 3ml			
L of fuel for transport for selling livestock	276,6	22,2	6141,4	own car 80km one way, 0,114L/1km				
feed supplement VM P12 Veefos 50kg	1,0	831,0	831,0					
feed supplement VM ECO - Grasveld lick 50kg	1,0	420,0	420,0					
luzerne for old and young goats and sheep in 50kg sacks	60,0	150,0	9000,0					
TOTAL			29287,8					
GVA LS4			**73018,0**					
CS2	surface area	2	ha	*2 fields of 1ha*				
GROSS PRODUCT	nombre	prix	total					
50kg maize meal sack	14,1	550,0	7761,1					
melons	139,8	30,0	4193,8	for both fields				
watermelons	41,8	50,0	2092,1					
pumpkins	156,1	30,0	4681,9	for both fields				
TOTAL			18728,9					
INTERMEDIARY INPUTS	quantité	prix	total					
milling of 50kg maize corns	12,1	60,0	726,7					
transport to Opuwo and back in km	193,3	22,2	4291,1	own car 70km one way, 0,114L/1km				
maize seeds	2,0	550,0	1100,0					
TOTAL			6117,8					
GVA CS2			**12611,1**					
GVA Type C			**85629,1**					
number of familial labour			9,3					
INVESTMENTS	quantité	prix	années	total				
Donkey	4	3200,0	90,0	142,2	whole life of farmer as they multiply			
plough for animal traction	1	1800,0	30,0	60,0				
hoe head	2	130,0	5,0	52,0				
hoe handle	2	65,0	1,0	130,0				
car	1	150000,0	30,0	5000,0				
TOTAL				5384,2				
NVA Type C			80244,89					
GVA/familial labour Type C			9257,20					
GVA/dW Type C			39,96					
NVA/familial labour Type C			8675,12					
NVA/dW Type C			37,45					
Farm income			**80244,89**					
GVA/dW CS2 Type C			26,20					
GVA/dW LS4 Type C			43,95					

Economic performances	**Type D**							
LS3								
GROSS PRODUCT	nombre	prix	total					
milk cow in L	692,88	15	10393,20					
butterfat from cowmilk (L)	0	25	0,00					
omaere goat in L	242,22	25	6055,50					
goats sold or slaughtered	14,75	800	11800,00					
oxen sold or slaughtered	2,5	6500	16250,00					
sheep sold or slaughtered	6,2	1000	6200,00					
TOTAL			50698,70					
INTERMEDIARY INPUTS	quantité	prix	total					
salt blocks	14	300	4200,00					
preventive vaccination DISULFOX L.A. 100ml	38	345	13110,00	2x/year	1 goat = 4ml	1 sheep = 3ml		
preventive vaccination of cattle	17,5	345	6037,50	2x/year (1 being provided by veterinary services for free)			cow = 350kg	1 cow = 35ml
preventive dosing VALBAZEN Sheep&goat 500mL	3,8	214,95	816,81	2x/year	1 goat = 0,5ml*4 = 2ml		1 sheep = 0,5ml*3 = 1,5ml	
preventive dipping AGRAPOR 1L	3,8	485	1843,00	2x/year	1 goat = 4ml	1 sheep = 3ml		
feed supplement VM ECO - Grasveld lick 50kg	2,5	419,99	1049,98	2,5 bag every month in winter and spring (July to December)				
feed supplement VM P12 Veefos 50kg	3	830,99	2492,97	3 bag every month in winter and spring (July to December)				
luzerne 50kg sack for goats	10	150	1500,00					
luzerne bails for cattle	18	210,99	3797,82	3 bails every month in winter and spring (July to December)				
L of fuel for transport for selling livestock	186,96	22,2	4150,51	own car 80km one way, 0,114L/1km				
L of fuel for transport of water for small goats	59,28	22,2	1316,02	one transport (2x200L) per week with own car for 2x5km; 11,4L/100km; 22,20 NAD/L				
TOTAL			40314,60					
GVA LS3			**10384,09**					
CS2	surface area	0,9	ha					
GROSS PRODUCT	nombre	prix	total					
50kg maize meal sack	6	550	3300,00					
melons	63	30	1887,22					
watermelons	19	50	941,44					
pumpkins	70	30	2106,85					
TOTAL			8235,52					
INTERMEDIARY INPUTS	quantité	prix	total					
milling of 50kg maize corns	5	60	300,00					
fuel for transport to Opuwo and back in L	79,8	22,2	1771,56	own car 80km one way, 0,114L/1km				
maize seeds	1	550	550,00	keeps 1x 50kg maize corn every year				
TOTAL			2621,56					
GVA CS2			**5613,96**					
GVA Type D			**15998,05**					
external revenue from job		NAD	240000					
number of familial labour			2,5	head of household partially absent counted as 0.5				
INVESTMENTS	quantité	prix	années	total				
Donkey	3	3200	90	106,67	whole life of farmer as they multiply			
plough for animal traction	2	1800	30	120,00				
car	1	150000	30	5000,00				
hoe head	2	130	5	52,00				
hoe handle	2	65	1	130,00				
TOTAL				5408,67				
SALARIES	quantité	prix	total					
workers for ploughing	3	266,666667	800					
workers for clearing and fencing crop field	1	4500	4500					
neighbours for weeding the field	1	800	800	1 goat killed				
workers for second weeding	1	2000	2000					
helpers to dip smallstock	2	800	1600	1 goat killed 2x/year				
external labour (herders)	3	14400	43200					
TOTAL			52900					
NVA Type D			10589,38					
GVA/familial labour Type D			6399,22					
GVA/dW Type D			9,11					
NVA/familial labour Type D			4235,75					
GVA/dW Type D			6,03					
Farm income			**-42310,62**					
GVA/dW CS2 Type D			20,49					
GVA/dW LS3 Type D			7,01					

Economic performances	**Type Ea**							
LS1								
GROSS PRODUCT	nombre	prix	total					
omaere goat in L	371,518902	25	9287,97	don't milk goats from july to december				
goats sold or slaughtered	0	800	0,00					
sheep sold or slaughtered	0	1000	0,00					
TOTAL			9287,97					
INTERMEDIARY INPUTS	quantité	prix	total					
salt blocks (the small ones)	3	300	900,00					
preventive vaccination DISULFOX L.A. 100ml	2	345	690,00	2x/year	1 goat = 4ml	1 sheep = 3ml		
preventive dosing VALBAZEN sheep&goat 500mL	0,15	214,95	32,24	2x/year	1 goat = 0,5ml *4 = 2ml			
dipping as treatment AGRAPOR 1L	0,5	485	242,50	1x/year?	1 goat = 4ml	1 sheep = 3ml		
small females goats bought	5	500	500,00	over last 5 years				
TOTAL			2364,74					
GVA LS1			**6923,23**					
CS2	surface area	0,5	ha					
GROSS PRODUCT	nombre	prix	total					
50kg maize meal sack	5,6	550	3106,48					
melons	35	30	1048,46					
watermelons	10	50	523,02					
pumpkins	39	30	1170,47					
TOTAL			5848,43					
INTERMEDIARY INPUTS	quantité	prix	total					
milling of 50kg maize corns	4,6	60	278,89					
transport to Opuwo and back	4	260	1040,00					
maize seeds 50kg	1	550	550,00					
TOTAL			1868,89					
GVA CS2			**3979,55**					
CS3	surface area	0,15	ha					
GROSS PRODUCT	nombre	prix	total					
eggplant			0					
butternut per 50kg bag	11,5	700	8050	50kg bag = 40 buternuts; 23 blocks of 20 butternuts = 460				
tomatoes 300g	700	10	7000					
chillis in 10L jerricane	8	360	2880					
onions pack of 5	190	10	1900	19 blocks of each ~50 onions				
sugarcane	500	10	5000	25 blocks of each 20 canes				
tabacco dry in 10kg bag	3	300	900					
spinach in bundles	560	10	5600					
TOTAL			31330					
INTEMEDIARY INPUTS	quantité	prix	total	harvest 2x50kg bags every two weeks form october to may (7 month); 50kg bag = 20 bundles				
pesticide for butternuts KNOX WORM	2	200	400					
pesticide for tomatoes Malazol	1	119	119					
vegetable seeds	6	40	240					
transport to Opuwo and back for selling	14	160	2240					
plastic bags to sell chillis	1	100	100					
net for onions in rolls	1	130	130	spinach, onions, chillis, tomatoes				
TOTAL			3229	2 times per month from October to May (7month) = 14 times				
GVA CS3			**28101**					
GVA Type Ea			**39003,78**					
number of familial labour			3					
INVESTMENTS	quantité	prix	années	Total				
50mm pipe for irrigation 250m	1	1500	10	150				
hoe head	2	130	5	52				
hoe handle	2	65	1	130				
spade	1	300	5	60				
rake	1	144	5	28,8				
pick	1	175	5	35				
pick handle	1	65	1	65				
water buckets	5	100	2	250				
TOTAL				770,8				
SALARIES	quantité	prix	total					
Donkeys + plough	1	500	500					
workers for ploughing	3	266,67	800					
TOTAL			1300					
NVA Type Ea			38232,98					
GVA/familial labour Type Ea			13001,26					
GVA/dW Type Ea			39,51					
NVA/familial labour Type Ea			12744,33					
NVA/dW Type Ea			38,73					
Farm income			**36932,98**					
GVA/dW CS2 Type Ea			17,01					
GVA/dW LS1 Type Ea			17,52					
GVA/dW CS3 Type Ea			78,49					

Economic performances	**Type Ce**							
LS4								
GROSS PRODUCT	nombre	prix	total					
milk cow in L	2110,1	15,0	31651,6					
butterfat from cowmilk (L)	190,2	25,0	4755,3					
goat omaere in L	1450,6	25,0	36265,5					
goats sold or consumed	14,7	800,0	11733,3					
oxen sold or consumed	1,8	6500,0	11700,0					
sheep sold or consumed	6,2	1000,0	6200,0					
TOTAL			102305,7					
INTERMEDIARY INPUTS	quantité	prix	total					
salt blocks	10,0	300,0	3000,0					
preventive vaccination DISULFOX L.A. 100ml	27,0	345,0	9315,0	2x/year	1 goat = 4ml	1 sheep = 3ml		
preventive vaccination cattle	1,0	0,0	0,0	1x/year provided by veterinary service for free				
preventive dosing VALBAZEN sheep&goat	2,7	215,0	580,4	2x/year	1 goat = 0,5ml*4 = 2ml		1 sheep = 0,5ml*3 = 1,5ml	
preventive dipping AGRAPOR 1L	0,0	485,0	0,0	0x/year	1 sheep = 3ml			
L of fuel for transport for selling livestock	276,6	22,2	6141,4	own car 80km one way, 0,114L/1km				
feed supplement VM P12 Veefos 50kg	1,0	831,0	831,0					
feed supplement VM ECO - Grasveld lick 50kg	1,0	420,0	420,0					
luzerne for old and young goats and sheep in 50kg sacks	60,0	150,0	9000,0					
TOTAL			29287,8					
GVA LS4			**73017,97**					
CS2	surface area	2	ha	*2 fields of 1ha*				
GROSS PRODUCT	nombre	prix	total					
50kg maize meal sack	14,1	550,0	7761,1	two times 3,5 50 kg bags (both fields together) for an average year				
melons	139,8	30,0	4193,8	for both fields				
watermelons	41,8	50,0	2092,1					
pumpkins	156,1	30,0	4681,9	for both fields				
TOTAL			18728,9					
INTERMEDIARY INPUTS	quantité	prix	total					
milling of 50kg maize corns	12,1	60,0	726,7					
transport to Opuwo and back in km	193,3	22,2	4291,1	own car 70km one way, 0,114L/1km				
maize seeds	2,0	550,0	1100,0					
TOTAL			6117,8					
GVA CS2			**12611,1**					
CS3	surface area	0,05	ha					
GROSS PRODUCT	nombre	prix	total					
Lucerne 50kg bags	60	150	9000					
cabbage	10	35	350	pests problems				
Sugarcane	160	10	1600	10 blocks = 8x10L jerricane; 2 blocks = 1,6x10L jerricane				
sweet potatoes		0	0	4 blocks of each ~50 onions				
chillis in 10L jerricane	1,6	360	576					
onions pack of 5	40	10	400					
sugarcane	160	10	1600					
tabacco dry in 10kg bags	4	900	3600					
spinach in bundles	20	10	200	pests problems				
maize seeds for rainfed 50kg	2	550	1100					
TOTAL			18426					
INTERMEDIARY INPUTS	quantité	prix	total					
vegetable seeds	5	40	200	spinach, onions, chillis, tomatoes				
plastic bags to sell chillis	1	100	100					
bottles of pesticide for cabbage and maize	3	100	300					
TOTAL			600					
GVA CS3			**17826,0**					
GVA Type Ce			**103455,1**					
number of familial labour			9,3					
INVESTMENTS	quantité	prix	années	total				
Donkey	5,0	3200,0	90,0	177,8	whole life of farmer as they multiply			
plough for animal traction	1,0	1800,0	30,0	60,0				
hoe head	5,0	130,0	5,0	130,0				
hoe handle	5,0	65,0	1,0	325,0				
spade	4,0	300,0	5,0	240,0				
rake	4,0	144,0	5,0	115,2				
pick	4,0	175,0	5,0	140,0				
pick handle	4,0	65,0	1,0	260,0				
car	1,0	150000,0	30,0	5000,0				
lucerne seeds	3,0	281,0	8,0	105,4				
TOTAL				6553,3				
NVA Type Ce			96901,78					
GVA/familial labour Type Ce			11184,34					
GVA/dW Type Ce			35,05					
NVA/familial labour Type Ce			10475,87					
NVA/dW Type Ce			32,83					
Farm income			**90348,45**					
GVA/dW CS2 Type Ce			27,1889594					
GVA/dW LS4 Type Ce			43,7142216					
GVA/dW CS3 Type Ce			201,423729					

Appendix 8 Calculation of the survival threshold

interview n°	**26**					**32**					
	adults	kids	fam. Lab.	adult equ.		adults	kids	fam. Lab.	adult equ.		
n° of household members	3	5	4	5,5		2	5	3	4,5		
morning meal	quantity	unit price	costs (NAD)			quantity	unit price	costs (NAD)			
tea (bags)	1,00	1,00	1,00	*10 tea bags = 9,99NAD*	porridge (cups of maize meal)	4,00	2,09	8,37	*2 cups for husband, 6 cups for wife and*		
sugar (500g)	0,50	11,49	5,75		omaere (L)	0,66	25,00	16,50	*2 cups; 1 cup = 0,33L; 500g = 11,49 NA*		
ozopa (cup of maize meal)	1,50	2,09	3,14	*1L = 634g; 1 cup = 0,3L; 50kg = 78,864L = 262,88 cups = 550NAD*							
afternoon meal											
maize mil porridge (cups)	6,00	2,09	12,55		porridge (cups of maize meal)	4,00	2,09	8,37			
onion	1,00	2,00	2,00	*5 onions = 10NAD*	omaere (L)	0,66	25,00	16,50	*2 cups; 1 cup = 0,33L*		
spices for soup (50g)	0,50	6,99	3,50								
annual consumption of maize meal	520,67	kg/year				555,39	kg/year				
extras during rainy season (7 month)	per week										
omaere for kids (L)	3,5	25	2450								
extras during harvest (3 month)	per week					per week					
melons	1	30	360			7	30	2520			
pumpkins	1	40	480			7	40	3360			
Total annual costs of extras (in NAD)			**3290**					**5880**			
annual consumption											
maize meal (kg)	520,67	11,00	5727,42			555,39	11,00	6109,25			
cooking oil (L)	60,00	39,99	2399,40	*5L/month*		45,00	39,99	1799,55	*5x0,75L*		
salt (kg)	6,00	22,98	137,88	*500g/month*		6,00	22,98	137,88	*500g/month*		
sugar (kg)	91,25	*22,98*	2096,93	*250g/day; 500g = 10NAD*		24,00	22,98	551,52	*2kg/month; 500g = 11,49NAD*		
tea bags	365,00	1,00	364,64				1,00	0,00			
onions	365,00	2,00	730,00				2,00	0,00			
cooking spices	182,50	6,99	1275,68				6,99	0,00			
goat omaere (L)	98,00	*25,00*	2450,00			481,80	25,00	12045,00	*4 cups/day; 1 cup = 0,33L*		
Total annual consumption (NAD)			**15181,94**					**20643,20**			
kitchen material											
fire pot	1,00	400,00	133,33	*/3 years*		1	400	133,33	*/3 years*		
20L waterbucket	1,00	100,00	33,33	*/3 years*		1	100	33,33	*/3 years*		
cup	3,00	15,00	45,00			2	15	30,00			
plate	3,00	30,00	90,00			2	30	60			
hygiene											
soap	48,00	5,00	240,00	*2/week*		48	5	240	*2/week*		
clothing											
pair of flip-flops	3,00	50,00	150,00			2	50	100			
Himba sheep skin	0,00	400,00	0,00			1	400	400			
t-shirt adult	3,00	150,00	450,00			1	150	150			
trousers adult	3,00	350,00	1050,00			1	350	350			
fabric piece	0,00	175,00	0,00			2	175	350			
housing											
blanket	8	600	2400,00			7	450	1575,00			
	usage (in years)	2				usage (in years)	2				
metal sheet for roof	1	850	85,00			10	140	186,67			
	usage (in years)	10				usage (in years)	7,5				
Total annual material costs (NAD)			**4676,67**					**3608,33**			
Total annual costs			**23148,60**	NAD				**30131,53**	NAD		
Total annual costs/ adult equ.			4208,84	NAD				6695,90	NAD		
Total annual costs/ familial active			5787,15	NAD				10043,84	NAD		
				AVERAGE							
		Total annual costs		**26640,07**							
		Total annual costs/ adult equ.		**5452,37**							
		Total annual costs/ familial active		**7915,50**							

Abstract

This study investigates the agrarian systems of the Ongongo and Ombujokanguindi conservancies in northwestern Namibia. Conducted in collaboration with Agronomes et Vétérinaires sans Frontières (AVSF) as part of a broader initiative to strengthen community rights and enhance livelihood resilience, this research aims to inform interventions that address the challenges posed by climate change and human-wildlife conflicts (HWC) to agricultural livelihoods. Using a mixed-methods agrarian diagnosis approach, the study characterizes the socio-economic and ecological dynamics of local farming systems as well as their technical and economic performances. It highlights the historical context of marginalization, particularly under colonial and apartheid rules, which has left livestock and crop production vulnerable. Key findings reveal that HWC and erratic rainfall significantly increase this vulnerability. Today, food security in Kunene is in an exceedingly fragile state and a majority of farmers rely on alternative incomes, pensions or food aid to feed their families. In contrast, practices focusing on irrigated agriculture show promising potential even though the type of cropping and purposes of cultivation must be carefully contemplated. Recommendations emphasize enhancing local agricultural practices, prioritizing subsistence cropping, and improving veterinary services to bolster resilience against climate shocks and market fluctuations. This study advocates for a shift in focus from state-organized safety nets in form of aid and pensions to sustainable, community-driven agricultural livelihoods strategies that ensure food security and economic sovereignty.

Key words

Agriculture, farming systems, Kunene, climate change, conservation, pastoralists, livelihoods, food security, Community-based natural resource management

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