



Working with variability – Pastoral systems' climate resilience and contributions to ecosystem conservation

GIZ Background Paper

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List of Abbreviations

CO₂	Carbon Dioxide
FAO	Food and Agriculture Organization
GHG	Greenhouse gases
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
NDCs	Nationally Determined Contributions
GIZ	Background Paper

Executive Summary

As global temperatures continue to increase, agriculture and food systems are facing a double burden: while contributing to climate change, biodiversity loss, and land degradation, these same pressures in turn undermine food production through shifting climates, depleted soils, and collapsing ecosystems. Increasing fossil-based energy inputs to stabilize production systems from rising insecurities reinforce these global crises.

A fundamental overhaul of global agriculture and food systems is needed with an alternative, low-emission strategy to climate resilience.

In this context, integrated production systems like pastoralism – with high adaptive capacity to variable environments and uncertainty relying on little external inputs – play an increasingly important role for climate resilience and food system sustainability.

Pastoralists are experts in dealing with high resource variability in rangelands and in providing food and nutrition security while not relying on energy-inten-

sive processes and inputs that have accelerated climate change and biodiversity loss in the first place. Rooted in the use of locally adopted and diverse livestock breeds, strategic mobility, and collective decision making, pastoralism embraces ecological, economic and social resilience principles at the same time. Such ecologically integrated approaches, which are in many respects consistent with principles now articulated under agroecology, are increasingly recognized for their potential to bridge the objectives of the so-called Rio-Conventions on climate change, biodiversity conservation and combating desertification¹.

Based on a vast diversity of research and with the help of case studies from different geographical contexts, this paper highlights the role of pastoralism in the food systems context and why pastoralists' livelihood systems are essential for climate resilience and food system sustainability in rangelands. It highlights core principles of pastoralist systems' resilience in climate variable environments and generates key-take aways on factors limiting or enhancing pastoralist systems' contribution to food system sustainability and the synergistic implementation of the three Rio-Conventions:

- 1. **Pastoral systems play an important part for rural economies.** Particularly in dryland regions they are an inherent part of rangeland socio-ecological systems. Through their specialisation in livestock management, they make important contributions to rural economies and food security.
- 2. **Pastoralists have developed strategies that support their resilience to climate variability.** Key factors supporting pastoralists' resilience include strategic mobility, a diversity of livestock and non-livestock assets, access to markets, adaptive resource management strategies, often based on Indigenous knowledge systems, and strong customary institutions.
- 3. **Pastoralists' resilience is under pressure by diverse non-climate stressors.** Policies of sedentarisation, barriers to strategic mobility, the reduction and fragmentation of traditional pastoral areas, and inappropriate land-tenure systems are heavily impacting pastoralists. This leads to unsustainable pressures on natural resources, damage to range land ecosystems and increased conflict.

¹ The Rio-Conventions include the → United Nations (UN) Framework Convention on Climate Change, (UNFCCC), the → Convention on Biological Diversity (CBD) and the → UN Convention to Combat Desertification (UNCCD).

- 4. **Rapidly increasing climate change mitigation adds additional stress factors to pastoralism.** Land-based climate change mitigation schemes by national climate policies and international carbon markets are increasing land competition and often neglect negative effects on pastoralists.
- 5. **Strengthening pastoralists' resilience to climate change depends on an appropriate enabling environment.** Good governance and regulations should allow for mobility, guarantee access to vital resources such as land and water, access to climate information, appropriate infrastructure, and reliable and accessible basic services.
- 6. **Pastoralism support rangeland health and biodiversity conservation.** If pastoralists are enabled to practice their specialized management systems, they contribute to maintaining and strengthening biodiversity and ecosystem processes that underpin carbon storage and green water flows.

The paper synthesises the following recommendations to increase the political integration of pastoralists in the implementation of the three Rio Conventions:

- The **Rio Conventions** need to strengthen the recognition of the role of pastoral systems as constitutive elements of rangeland ecosystems with inherent rights, valuable Indigenous knowledge and local management systems. Pastoralism is part of an agroecological approach to food system transformation.
- **National plans for the implementation of the Rio Conventions** need to integrate pastoralists' perspectives, to strengthen their role and participation in rangeland management and to avoid non-intended negative outcomes. Pastoralists, men, women and youth, need to be included in the process of elaborating these plans and the plans need to protect the basis for pastoralist livelihoods.
- **National policies need to respect and enable pastoralism to function**, supporting pastoral mobility, enabling access to adapted basic services, and securing inclusive and collaborative land tenure systems. In particular, land-based climate change mitigation activities need to ensure respect for pastoralist management systems, accountability as well as co-designed mechanisms securing broad community ownership and intersectionality.
- **Research** needs to enhance the understanding for pastoralist livelihood systems by updating assessment methodologies for pastoralist systems and generating relevant disaggregated data. Participatory research co-designed and conducted with pastoralists should document pastoralism's ecological integration and the effects on rangeland's health.
- **Climate change and biodiversity related projects and programmes** need to actively strengthen the role of pastoralists in rangeland and ecosystem management and support their inclusion in decision-making at local, regional and national level.

1. The role of pastoralism in rural economies and food systems

Since the industrial revolution, global average temperature has increased by over 1°C. The Intergovernmental Panel on Climate Change (IPCC, 2021) predicts that global warming will reach plus 1.5°C by 2040 or earlier. Higher average temperatures and more frequent weather extremes expose millions of people worldwide to acute food and nutrition insecurity and reduced water security. Beyond 1.5°C there is a sharp increase in the risk of triggering the tipping points in Earth's natural systems. In that case, their capacity to adapt to climate change and to provide critical ecosystem services may be substantially lowered or even lost (Lenton et al., 2023). This bears high potential for conflicts on land and water resources. Dryland areas – characterised by high uncertainty, water scarcity and food insecurity, affecting millions of small-scale food producers – are particularly vulnerable to such changes, especially in sub-Saharan Africa (IPCC, 2021).

Global agri-food systems are a major driver of climate change with a contribution of about 32% to total anthropogenic greenhouse gas (GHG) emissions (FAO, 2025). Within this framework, the livestock sector is estimated to contribute between 16% and 28% (Lima, 2025). At the same time, agriculture and food systems suffer significantly from climate change as well as elevated levels of carbon dioxide (CO₂): increased weather

extremes and pest and disease outbreaks destroy harvests, increase livestock mortality, reduce areas suitable to crop cultivation, and foster water scarcity – factors predominantly affecting smallholder-based production systems (Bezner et al 2022).

To enhance food and nutrition security, improve rural livelihoods and maintain life-supporting ecosystem functions, a fundamental overhaul of global agriculture and food systems towards climate-resilient and low-emissions systems is critically needed (FAO 2018; Dury et al 2019).

In this process it is important to challenge the current perception of climate resilience in agriculture. Agricultural systems that rely on high and fossil-based energy inputs to sustain artificially stable environments appear more resilient to current levels of manifold insecurities, including climate variability. Yet, besides increasing global warming, they are in fact more prone to stress in the long run as they are contributing to further degradation of soil and water resources, thus contributing to depleting their own resource base. In recent years, agroecology has increasingly been recognized as a promising approach that adopts a systemic

FACTS AND FIGURES

- In 2023, global agri-food systems emissions were 16.5 billion tons of carbon dioxide equivalent (Gt CO₂eq), a 21 percent increase since 2001. This represents 32% of the total global GHG emissions.
- Of the global agri-food systems emissions:
 - Crop and livestock activities within the farm gate (49 %)
 - Emissions from pre- and post-production, due to activities along the supply chain, (32%)
 - Emissions from land-use change (19 %)

These emissions do not come from traditional pastoralist systems. (FAO, 2025)

lens. Agroecological principles as defined i.a. by the Food and Agriculture Organisation (FAO) build on elements like participation, low external inputs, biodiversity conservation, connectivity, participation and synergies between its different elements (GIZ 2025). In this context, ecologically integrated production systems like pastoralism – with high adaptive capacity to variable environments and uncertainty relying on little external inputs – provide valuable insights.

Rangelands represent an often overlooked social-ecological system that can be used economically and sustainably for food production only through grazing (Briske and Coppock, 2023). Over half of the global land surface consists of rangelands with diverse biomes like deserts, grasslands, shrub steppe, savannas, and open wood lands, which are dominated by grasses, forbs, shrubs, and scattered trees as vegetation. A large share of rangelands is classified as drylands that are particularly prone to climate change impacts, especially drought (ILRI et al 2021). Within rangelands and drylands, **pastoralists** represent an important socio-cultural group which is an inherent part of rangeland socio-ecological systems. Pastoralism refers to a wide and diverse family of livelihood and agri-food systems sharing a specialization in making a living in variable climatic conditions through livestock. Based on their Indigenous knowledge, pastoralists have created formal and informal systems which are essential for rangeland management in the context of climate change (FAO 2021).

Pastoralist systems support an estimated 2 billion people globally, particularly in marginalised and vulnerable communities. Particularly women play a central role in providing resource management, biodiversity conservation, and food and nutrition security (IYRP 2024).

By making use of vast rangeland areas that are not suited to crop production unless supported by high levels of external inputs, often derived from fossil fuels, pastoralist systems generate substantial economic value. Despite chronic under-investment, pastoralism makes important contributions to agricultural gross domestic product (GDP) particularly in sub-Saharan African countries, often providing the bulk of meat and dairy for both domestic markets and exports (African Union 2010, FAO 2021). As pastoralist systems make only negligible use of external inputs, they are among the most efficient producers of sustainable human-edible proteins. Data on the economic value of pastoralism, even when limited, points to its considerable significance of their economic importance. One of the key aspects of pastoral production is its tendency to provide multiple products rather than a single output, with a particular emphasis on products from live animals (Hatfield & Davies 2006). In sub-Saharan Africa, pastoralists supply over 60% of beef, 40% of shoaat meat and 70% of milk consumed (Waters-Bayer et al, 2015). In India, the economic value of pastoral manure has been calculated as equiva-

FACTS AND FIGURES

- 50% of global land surface are rangelands where grazing is the only sustainable food production. Of these, 78% are classified as drylands (ILRI et al, 2021).
- Estimates of the number of pastoralists worldwide vary between 200 and 600 million people (IUCN 2015) of whom many live in Sub-Saharan Africa.
- 70% of livestock-derived foods consumed in lower- and middle-income countries are sourced in informal markets (Unger et al. 2025).
- Pastoralism contributes nearly 15% to the GDP of Sahelian countries (Jenane et al, 2025).

lent to about USD 45 billion per year (FAO 2021). Furthermore, they provide hides, blood, firewood, wool, honey, fruits and medicine to individuals, families and communities, contributing to domestic and international markets (FAO 2021). Yet, lacking

knowledge and acceptance of rangelands and pastoral systems and their role in safeguarding ecosystem services are amongst the factors constraining investments in rangelands (Davies et al, 2025).

CASE STUDY

Strengthened pasture user groups in Mongolia as co-investors in rangelands

Shuranga bagh, located in Uyanga soum of Uvurkhangai aimag, represents a Hangai mountain pastoral system in Mongolia where herder households depend on seasonal mobility and collective pasture use. To strengthen local governance, herders established a Primary Herder Household Association at the bagh level (local administrative unit in Mongolia), organized into six sub-groups based on rangeland use patterns and community.

The Primary Herder Household Association introduced community-based management tools, including Rangeland Use Agreements, Rangeland Use Regulations, and a Rangeland Use Plan, enabling coordinated grazing and restoration practices. Herders actively invest in forage cultivation to increase feed availability and reduce pressure on natural pastures, particularly during critical seasons. Through the Responsible Nomads certification system, they collectively market livestock products with improved quality and traceability, allowing access to higher-value markets. In 2026, the association began working together to develop a local dairy value chain, adding value to milk production, and strengthening local processing capacity.

These efforts have improved rangeland health, enhanced fodder security, and strengthened collective action among herders. Certified production has increased household incomes and market access, while sustainable grazing practices contribute to biodiversity conservation and soil carbon sequestration, supporting climate resilience (Green Gold – Mongolian Rangeland Research Center).



2. Variability in processes and diversity of assets – The key elements of pastoralist resilience

Resilience to climate variability is at the core of pastoralist livelihood systems. The concept of ‘resilience’ describes the capacity of intricately linked social and ecological systems to withstand sudden shocks and to adapt or even transform in the face of unexpected change. This understanding of resilience emphasises adaptability and transformability in light of uncertainty, while recognizing the interconnectedness between ecological and social dimensions.

Pastoralists are experts in managing uncertainty – pastoralism achieves a relative stability of food production under extreme and variable natural conditions → **Figure 1**. This is realised by working with nature and adapting to environmental circumstances rather than by creating artificially controlled environments, i.e. separating production from nature. Pastoralists’ specialization to benefit from climate variability while managing its risks makes pastoralism the most suitable agricultural land use system in drylands as well as highly relevant in the face of climate change.

Pastoralists’ underlying logic of integrating and adapting food production within highly variable natural environments is at the core of their resilience. Their ability to use unpredictable environments and to benefit from variability is based on keeping the production system itself highly flexible. They adopt production strategies and operational processes flexible enough to match the variability of inputs from the natural environment (IUCN 2014).

Pastoralists specialize in operating with unpredictable variability rather than externalizing it.

The high levels of **process variability** in pastoralism can be seen as a way of being ‘better prepared to be surprised’ – a strategy that becomes increasingly a key prerequisite to dealing with accelerating climate change (FAO 2021).

The most obvious example of this systemic variability in pastoralism is **strategic mobility** – a strategy that increases livestock productivity by optimising the use of short-lived and unpredictable grazing opportunities. Strategic mobility enables pastoralists to arrive on the forage at the time when nutrients peak, and do so for months on end, although in every location they visit, this opportunity only lasts for a few days. But mobility also allows pastoralist households to minimise their exposure to drought and other stressors, climate-related and not – for example, social and political insecurity – as well as taking advantage of distant market opportunities. The importance of pastoral mobility for both productivity and resilience, including in the face of climate change, is widely recognized albeit with little follow-up in practice (African Union 2010; IFAD 2018; FAO 2021; FAO 2022; Cervigni and Morris 2016; IPCC 2014b).

– FIGURE 1 –

Achieving relative stability by matching highly variable inputs with equally variable strategies

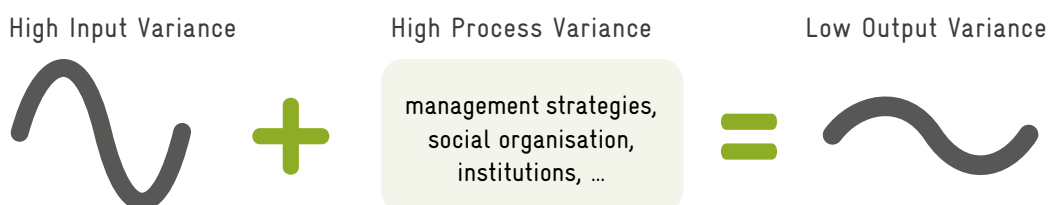


Figure taken from Krätli et al (2023), adapted from Roe E. 2020. A New Policy Narrative for Pastoralism? Pastoralists as Reliability Professionals and Pastoralist Systems as Infrastructure, STEPS Working Paper 113, IDS, Brighton, United Kingdom.

FACTS AND FIGURES

→ For almost 20 million people in the Sahel, seasonal migration following shifting grazing opportunities underpins and sustains their livelihoods (Turner and Schlecht 2019).

CASE STUDY

Pastoral mobility as a vital economic driver and pillar of resilience in Sahelian Countries

The practice of pastoralists' seasonal migration regionally connects several Sahelian countries, such as Mali, Niger, and Burkina Faso, with coastal nations like Nigeria, Senegal, and Côte d'Ivoire, through three important yet unstable cross-border corridors. These migratory routes last about 200 days and pass through five main hosting areas.

Financially, pastoral mobility generates tens of millions of US-dollars each year. A typical household spends around \$2,000 per year to meet its needs, with about 44% of this amount spent on animal feed and 22% for human consumption. The sale of live animals (cattle, sheep, and goats) helps cover these costs and directly supports local economies through taxes and community services.

Beyond its financial importance, mobility is crucial for maintaining a steady supply of milk, meat, hides, and skins, promoting grassland regeneration, and significantly lowering livestock drought-related losses. However, there are several obstacles to this traditional practice, including health hazards, thievery, and land conflicts. To sustain pastoral mobility, it is imperative to secure migration corridors, enhance the management of water resources and rangelands, improve animal health delivery, and, most importantly, reinforce cross-border cooperation among the countries involved (Thebaud et al 2018; Corniaux et al 2018; Jahel et al 2020; Turner and Schlecht 2019; Wane et al 2023).

Variability is also embedded in other areas of pastoral livelihood strategies.

Pastoralists' livestock breeding systems result in populations able to make use of constantly changing landscapes.

Thus, those breeding systems are designed to include genetic diversity as well as multiple, complex and rapidly adaptable combinations of animal learned behaviour and performance (Kaufmann et al 2018; FAO 2021; Krätli 2023). Having a variety of assets reduces sensitivity to individual hazards. A **diverse herd composition** – from a variety of species with different

→ p 11:

feeding requirements to a diversity of feeding skills and behaviours amongst the linkages of the same breed—enables pastoralists to take advantage of complex and dynamic environmental conditions. Local breeds that have been developed by pastoralists over centuries and that are well adapted to the local climatic conditions play an important role in these herds. A mixed species approach enables the mimicking of wild herbivores and hence can even restore ecosystem functions while maximizing the food output of such systems. In addition, pastoralists have multiple livelihood strategies that aim at enhancing variability. Resources such as honey, firewood or medicinal plants can be easily converted into cash. Large networks of kin and friends spanning rural and urban contexts in often distant locations contribute to bonding and bridging ties within and outside communities and support pastoralists in their mobility on their routine routes and during exceptional migrations (FAO 2021).

Customary social organisation and institutions

in drylands have evolved to keep options open. Such institutions exist in many forms and can encompass pastoral assemblies, in which common decisions on resource allocation or access, customary rules, and institutionalised practices are taken (Barrow et al 2007). They are usually based on inclusionary principles and a combination of individual and collective decision-making on natural resource governance, e.g. in terms of access to grazing land and water. For instance, **communal land tenure systems** are based on intrinsic principles such as local recognition, strong relationships, community cohesion, long-term use and control over resources, and respected leadership. They have been developed as customary law over generations and tailored to the needs of natural resource users in drylands, allowing multiple and overlapping access rights to grazing opportunities. They facilitate seasonal patterns of crop-livestock integration, with specialist farmers and specialist pastoralists using the same space for their purposes at different times of the year. Or they can decide upon a complete or partial

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limitation of access to a space of resource during a certain period, as for example for protecting dry-season grazing reserves (FAO 2021; SPARC 2024).

Within pastoral societies, women play an important role with their knowledge and expertise on livestock, plants and waters as well as the care work and for strengthening social relationships within and beyond their communities.

Since women often face restrictive social norms, gender-based violence and restricted access to resources, their role needs to be better acknowledged and strengthened within pastoralist communities, and their voices integrated in local to global decision-making (Fernández-Giménez et al 2024).

By applying the above-described strategies, pastoralists provide important contributions to resilient rural areas.

Synergies between pastoralists and farmers bring multiple benefits to the rural economy. For example, pastoralists breed animals that farmers can use for draught (oxen) and transportation (donkeys, camels and oxen).

By moving with their herds, pastoralists take affordable high-value proteins and natural fertiliser to crop-farming communities. Pastoral herds deposit manure directly to fields and reduce the need for mineral fertilizers. Yet, many of the benefits pastoralists offer in relation to the ecosystems they naturally manage are still too often neglected and underappreciated. Instead of forming synergies, pastoralists often find themselves combatting over resources with other resource user-groups such as farmers, conservationists, but also raw material conveyors (FAO, 2021).

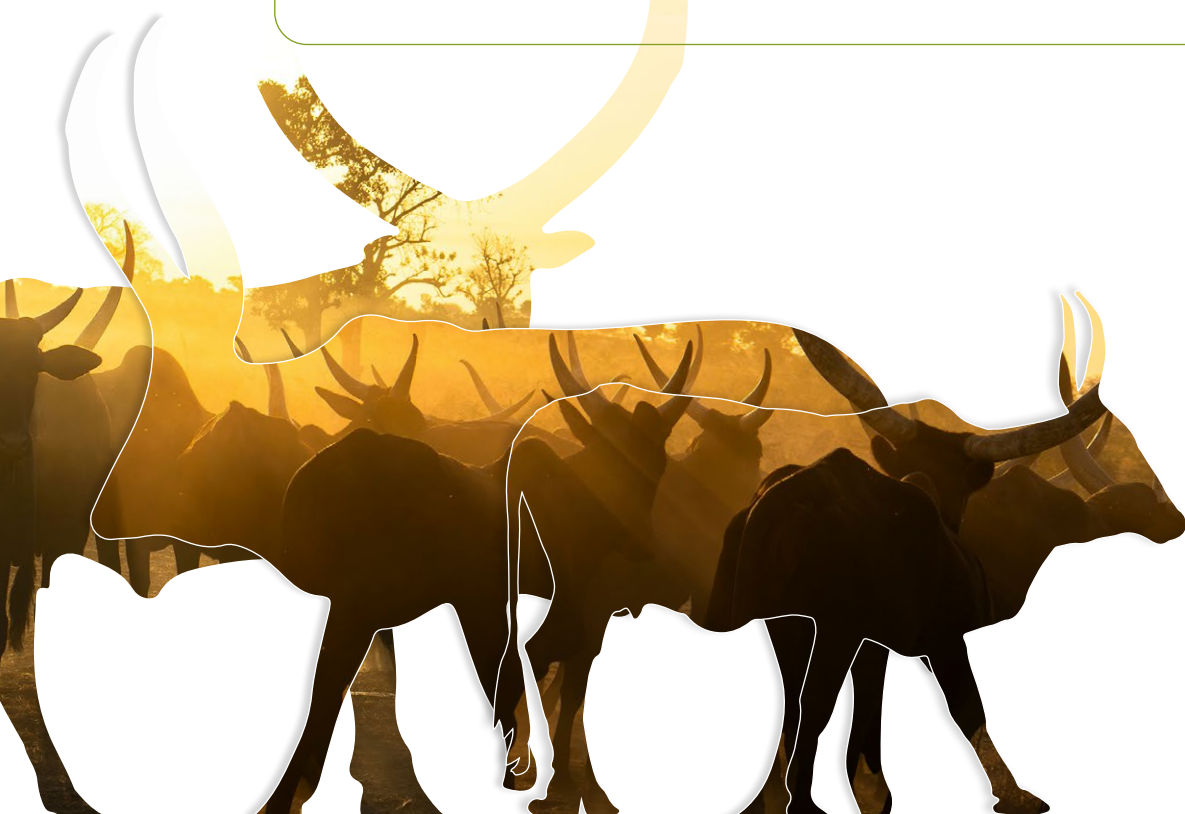
CASE STUDY

Effective common land rights and collective decision making in Burkina Faso

In Burkina Faso, pressures on traditional grazing lands and related conflicts have increased due to agricultural expansion and weak enforcement of national laws recognizing pastoral land rights. Climate change exacerbates these challenges through shifting rainfall patterns and shorter rainy seasons, contributing to resource scarcity and unpredictability. It intensifies the need for mobility, as pastoralists move longer distances to access adequate resources.

In Zoundweogo Province, the Wakilé Allah pastoral group's land tenure system, particularly in the wet season grazing areas, aligns with the Land and Rural Orientation Plan of the national government which designates these lands as reserved for grazing. These areas are a vital part of the pastoral lifestyle, traditionally dedicated to livestock activities. These lands are informally held by the Bissa farmer host community but managed by the Wakilé Allah group based on collective customary rights, which safeguard pastoral mobility and flexibility – key adaptations to climate stress.

While the customary system for managing pastoral land is widely accepted and functioning, concerns linger regarding its security. Threats to tenure security include agricultural encroachment, inadequate law enforcement, loss of group cohesion, and unmarked pastoral spaces. Addressing the current threats to the pastoral group's land tenure system requires a balanced approach that safeguards traditional practice, while providing the system formal protection through land management and registration. Formally securing the land tenure system entails two main aspects: (1) development of rules and a local land charter; and (2) registration of pastoral land and community benefit (SPARC 2024).



3. The impact of non-climate stressors on pastoralist resilience

For decades, pastoralists have been affected by the intended and unintended outcomes from a long history of interventions and policies based on a view of pastoralism as a barrier to development.

These outcomes have led to non-climate stressors that deeply affect the socio-economic and political conditions in which pastoralists live and operate. Most prominently, they include the **promotion of sedentarisation** and related measures. This includes for example, the creation of permanent water sources in seasonal rangelands, the provision of basic services only to settled populations or tolerating arbitrary taxation of herders crossing administrative boundaries. Greater market integration among pastoral societies can also incentivize shifts towards more sedentary, ranching-type systems, including the promotion of the use of livestock as collateral. Changing lifestyle expectations, such as cash needs to support education, may also encourage herd accumulation, increasing pressure on land where mobility is limited (WWF, 2025).

For many years, **inappropriate land policies**, the privatisation of natural resources, and exclusionary conservation programmes have led to the fragmentation of rangelands and the loss of crucial dry-season grazing reserves, competition with crop farming, and privatisation of the commons (Herrero et al 2016, Catley 2017). All of these measures restrict the mobility of pastoralists and increase the pressure on the existing resources e.g. through overgrazing from the resulting concentrations of livestock. In a growing number of contexts, combined with conflict dynamics reaching from local over national to regional scales, this is threatening the livelihood basis of pastoralists and small-scale farmers alike, and is at the root of violent confrontations between and within communities (Toulmin 2020). The frequent closing of borders

for pastoralists – caused by for example, security concerns, political dissent and as happened during the COVID-19 pandemic – also contributes to further **limiting the mobility** of herds and pastoralists' access to markets. During the COVID-19 pandemic and combined with the overstretching of already inadequate health services, this seems to have caused more harm to pastoralists than COVID-19 itself (Catley 2020).

Adding to this, **public knowledge and data** about pastoralism is confused and highly politicized (Johnsen et al, 2019), while standard methods for generating national and global statistics are generally inadequate to represent pastoral systems (Pica-Ciamarra et al 2014; Krätli et al 2015; Zezza et al 2016; Scoones 2022). Modelling, including of risk, is becoming more and more sophisticated, yet is often pre-empted in the case of pastoralism by its dependence on data that is scanty, rarely at the relevant scale, and often misleading because it is generated from inadequate or false assumptions. Innovative data collection methodologies, e.g. satellite technology or participatory mapping techniques present new opportunities and there have been recent initiatives, e.g. by the InterAfrican Bureau for Animal Resources for the development of an African Pastoral Markets Development Platform (AU-IBAR, 2025). Yet efforts need to be increased to collect relevant data on pastoralism and need to be developed together with pastoralists themselves.

Most non-climate stressors limit or undermine the mobility of pastoralists and therefore their capacity to produce value from their variable environments. This also **negatively affects the health of rangelands**. The less mobile pastoralists become, the more they become exposed and vulnerable to the environment they specialize in using. The lack of mobility can lead to overgrazing of the accessible rangeland areas, negatively affecting productivity, and consequently herders' assets.

CASE STUDY

The impact of non-climate stressors in Uganda

In Karamoja, northeastern Uganda, pastoralists face a dense set of pressures unrelated to climate change. Decades of marginalization and negative narratives have shaped policy responses that consistently misunderstand the logic and livelihood needs of a mobility-based system. As a result, pastoralists confront a drastic reduction in essential assets such as land and livestock – with a sharply increased dependence on waged labour – reduced voice in decision-making, and fragmented mobility routes.

Land-use change is one of the most visible pressures. The expansion of mining sites, commercial agriculture and game reserves has disrupted seasonal movements, carved up communal grazing lands, and intensified competition over water and pasture. Alongside this, the influx of neighboring pastoralists – particularly Turkana – during dry periods increases pressure on resources and can heighten local tensions.

Security-centered interventions have further compounded these pressures. Past disarmament operations, the confinement of herds in so-called “protected kraals,” and some enforcement practices have resulted in rights abuses, livestock theft, disease transmission from crowding, and the weakening of customary management systems. In parallel, lawlessness around mining sites has caused an upsurge of child labour, exploitation, and gender-based violence. Weak public services, including limited veterinary and human health systems, leave communities more vulnerable to endemic and transboundary diseases.

Policy and governance constraints reinforce these problems. Long-standing under-investment, restrictive administrative boundaries, and the lack of a functional rangeland policy (pending since 2009) continue to undermine traditional mobility and the mapping and recognition of migratory corridors. The result is increased conflict between herders and farmers, loss of dry-season grazing reserves, and rising food insecurity.

Taken together, these non-climate stressors sharply limit pastoralists' ability to deploy their core resilience strategies – strategic mobility, flexible herd management, and adaptive use of dryland resources. As in other dryland regions, the erosion of these adaptive mechanisms increases vulnerability to climate extremes and undermines the long-term sustainability of the pastoral system (Ateker Cultural Center 2025, IIED 2025).

→ p 15:

It can also increase conflicts with other land users, e.g. if pastoralists compete with settled farmers around access to land and water. Pastoralists who have to change their routes due to climate conditions or restrictions on land access might end up traversing protected areas leading to problems with the authorities. The collection of wild fruits and herbs as a critical livelihood strategy may lead to overexploitation if the mobility of pastoralists is restricted. Changes in population

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dynamics, tenure systems, livelihoods, and livestock husbandry that have been actively promoted by policies – including shifts in herd composition, and conversion of natural grasslands to intensive monocultures – can also compromise ecosystem health (WWF 2025). This leads to a vicious cycle because the more vulnerable pastoralists appear, the more they are subjected to standard interventions such as sedentarisation and exit from pastoralism (FAO 2021).

4. Impacts on pastoralists through land-based climate change mitigation

More recently, efforts to mitigate climate change have also begun to impact access to land in the Global South.

Land is increasingly being considered by governments to use for achieving climate change targets set in the Nationally Determined Contributions (NDCs), particularly through afforestation and restoration efforts (Dooley et al 2023). To enhance these efforts, rangelands are being increasingly targeted for large-scale tree planting as part of mitigation efforts while traditional land use conversion for industrialisation and mining continue unabated or indeed increases at unprecedented speed. Around 448 million hectares of the world's rangelands have been identified as being suitable for **afforestation** and the carbon sequestration potential is estimated at 32.2 billion tons by 2100 (Rohatyn et al 2022). However, recent estimates show that approximately 50% of the global land area which is considered suitable for tree planting does not have enough precipitation to provide sufficient water for trees to grow, especially in Africa and parts of South Asia (Ricciardi et al 2022). Recent analysis also shows that estimates of the potential of carbon sequestration from afforestation in rangelands tend to overestimate the positive effects while neglecting risks linked to the vulnerability of above-ground carbon storage in trees, the reduction of biodiversity in rangelands and its impacts on water

and the carbon cycle, and the time it takes for carbon storage to build up (Briske et al 2024). In addition, negative effects on communities are often neglected. Many projects do not sufficiently implement measures to ensure free, prior and informed consent (FPIC) of the affected communities as communities may not be fully informed, population groups such as pastoralists may not be included or the communities feel pressured to give their consent to the projects (CIDSE 2025; Survival International 2023).

Negative impacts of land-based climate change mitigation include increased water scarcity, reduced access to grazing and communal land. As they disrupt traditional systems of stewardship of natural resources, they can also have negative effects on biodiversity and carbon storage (Briske et al 2024).

In addition, **land-based carbon projects** are raising increasing concerns as they impact pastoralists way of life by privatizing communal land and altering grazing patterns and access rights with the aim of increasing carbon sequestration and off-setting. Soil carbon projects risk repeating historical patterns of land dispos-

session and restriction of pastoral mobility which is the basis of pastoralists' livelihood strategy and ability to adapt to climate change. Many projects are weak on assuring that communities can make informed decisions and are able to know and protect their rights. Land-based carbon credits represent a large share in the voluntary carbon market, and an exponential increase

is predicted for the future (Business Research Company 2025; CIDSE 2025). These trends are increasingly leading to the loss or fragmentation of rangelands, the loss of crucial dry season grazing reserves, competition with crop farming, mining, urbanisation, and (violent) conflicts between herders and farmers or competing herder groups.

FACTS AND FIGURES

- An estimated 1.2 billion hectares of land are needed to achieve the current net-zero targets set by governments in the NDCs (Dooley et al 2023).
- In 2021, land-based carbon credits accounted for over 66% of transactions in the voluntary carbon market (Business Research Company, 2025).

CASE STUDY

The impacts of carbon markets on pastoralists in Kenya

In Kenya, soil carbon projects were started more than a decade ago to produce carbon credits through rangelands restoration and community-based development. One example is a recently established project aimed at removing 50 million tons of CO₂ by establishing 22 community conservancies. The area has more than 100,000 inhabitants and also includes land which has traditionally been managed by pastoralist communities. Despite being credited under acknowledged standards, the project design fell short to properly include the needs of pastoralist communities.

A major concern lies in the design and underlying logic of the carbon project. The project replaces the established traditional grazing systems with a centrally controlled system of rotational grazing on specifically defined geographical areas. This is seen to create new risks for food security of pastoralists because they will no longer be able to flexibly react during drought and adapt migratory routes according to changing conditions.

Additionally, the project has sparked controversy on its accounting methodologies. It is accused to lack a proper baseline and its ability to measure carbon 'leakage' to other areas is questioned. In January 2025, a Kenyan court ruled in favour of 165 pastoralists from Isiolo county who had filed a legal case for non-compliance with the Kenyan Community Land Act. The court declared the establishment of two conservancies as illegal as appropriate consultations with the communities were not conducted (Mongabay 2025, Survival International 2023, The Carbon Observer 2026).

5. Strengthening pastoralist resilience in the context of climate change

The IPCC states explicitly that 'addressing non-climate stressors facing pastoralists, including policy and governance features that perpetuate their marginalisation, is critical for reducing vulnerability' (IPCC 2014b, Table 22-6, p 1237). This highlights the strong influence of socio-economic conditions, and their institutional and governance context, on the resilience of pastoral systems. And it points out how non-climate stressors – especially those that limit mobility, reduce the diversity of assets, and undermine social organization and institutions – have increased pastoralists' vulnerability to climate change while explicitly analysing new challenges from climate change and corresponding measures to strengthen pastoralists' climate resilience. As climate change exacerbates existing challenges and resource conflicts in drylands it becomes increasingly important to protect and strengthen the resilience inherent in pastoral systems. Any efforts in this direction need to start from recognising and redressing the damaging legacy of past and ongoing development policies. Pastoralists need to be able to **use and restore their specialization**, operating with their logic of keeping options open, adapting to and making optimal use of

changing natural conditions. The **social-ecological resilience framework** in → **Figure 2** highlights four core intervention areas.

Strengthening good governance requires policy development at local, regional and national level and needs to be based on genuine participatory planning with stakeholders – farmers and pastoralists, men and women, young and old.

An enabling socio-political and legal environment for pastoral systems should avoid limiting pastoralists' operational options and allow them to operate flexibly instead. The protection of pastoralists' core resilience mechanisms – process variability and diversity of assets – needs to become a governance focus and reflected in the Nationally Determined Contributions, National Adaptation Plans, National Biodiversity Action Plans and national plans and goals under the UNCCD such as Land Degradation Neutrality targets or National Action Programmes.

CASE STUDIES

Mobile schools in Chad

In Chad, "*nomadic schools*" have been established to meet the educational needs of the children in pastoral systems. Around ten experimental schools have been set up in the provinces of Mandoul, Sila, Salamat, Guéra and Wadifira, Mao in Kanem, Assinet and Djedda in the Batha.

The aim of these mobile schools is to supplement the traditional education provided in the family and in camps to support the entry of young herders into Chadian national society without having to abandon pastoralism. These schools teach pastoralist children to read and write, which also helps in accessing and understanding information on climate change and can help to prevent conflicts between herders and farmers. The teacher, who receives an additional bonus, travels with the herders on horseback or donkey, equipped with teaching materials. Classes are held in the shade of a tree or under a tent. The timetables are flexible and adapt to the mobility of the pastoral society (Ferrini & Odjo, 2025).

Strengthened social organisation and adaptive institutions are important to support **sustainable livelihoods** of pastoralists. Land, water and tree tenure systems with multiple overlapping rights for different natural resource user groups can support rural livelihoods and peaceful co-management of resources. Land use planning also needs to account for customary and traditional institutions including land and natural resource tenure traditionally held by pastoralists. Embedding systemic variability in the provision of basic services and infrastructure is crucial. This could be

health-service and veterinary provision alongside the achieved by developing mobility compatible education, standard models. Promoting mobile water points or time-bound water access (e.g. as experimented in pastoral water development in Chad) would also be ways of embedding and supporting process variability to buffer shocks and stresses.

In the face of climate change, increasing **effective responses to shocks and stresses** – including by actively support pastoralists’ use of strategic mobility

– FIGURE 2 –

The social-ecological resilience framework strategies

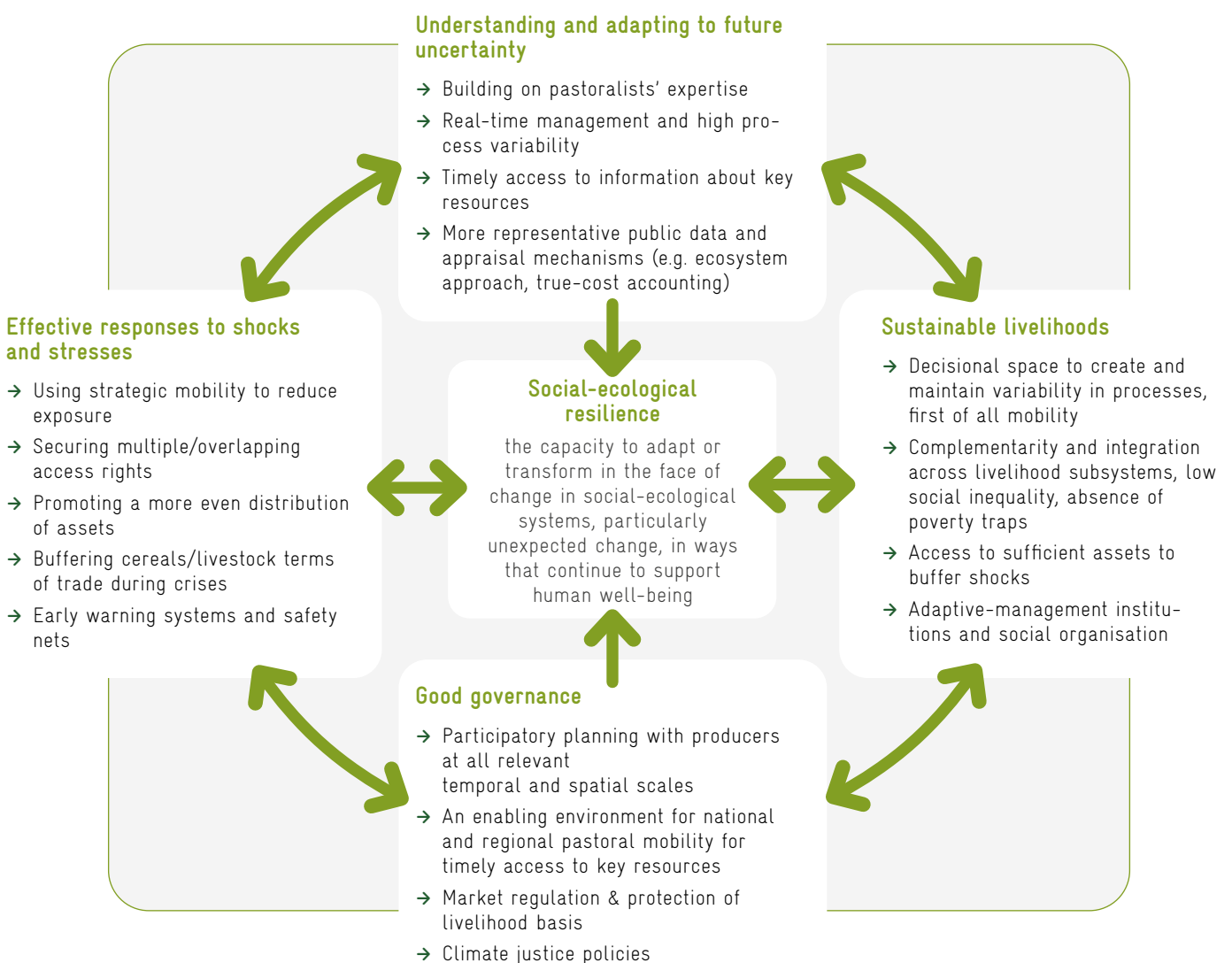


Figure taken from Krätli et al (2023), adapted from from Pasteur, K. 2010. From Vulnerability to Resilience, Practical Action, Rugby, United Kingdom.

economic and political factors and conflict – needs to reduce their exposure. This also includes access to warning systems, safety nets and humanitarian assistance that need to consider pastoral mobility strategies and migration routes. Mobile phone-based and community-based information systems should be used wherever possible.

Strengthening pastoralists' understanding of patterns of climate **uncertainty and supporting their adaptive knowledge** to manage the associated risks, also requires better access to climate-related information. These measures need to engage positively with the diversity and variability of pastoral systems and can be successful only in dialogue with pastoralists and by building on their expertise and traditional systems.

6. Pastoralist's contribution to biodiversity conservation and carbon sequestration – important but often neglect

FACTS AND FIGURES

- Rangelands account for approximately 30% of total terrestrial carbon storage (WRI, 2000)
- Livestock from conventional agricultural and food systems contribute to 14,5 % of global GHG emissions (Gerber et al 2013)
- When all elements of the pastoral livestock system are considered – not just the animal – the overall carbon balance is nearly neutral (Assouma et al 2019)

CASE STUDY

Green water management as a driver of dryland ecosystem restoration

In the Karamoja cross-border area between Kenya and Uganda, the Restore4More research project collaborates with pastoralist communities to restore degraded rangelands with the aim to improve water security, ecosystem functions and local livelihoods, with focus on managing the soil–water–biodiversity nexus.

A central innovation is the establishment of “Livestock Cafés”, where local agro-pastoralist communities, researchers, extension workers, NGO practitioners and local authorities jointly develop and test restoration and land management options. Interventions, e.g. half-moon structures combined with reseeded grasses, are implemented to enhance soil water recharge and increase the availability of green water, providing more water to support plant growth while also reducing surface runoff and erosion risk. Interventions are tailored to local contexts, integrating local and Indigenous knowledge with scientific knowledge. Through co-learning and peer-to-peer knowledge exchange, successful interventions and approaches are further scaled.

Initial studies indicate improvements in soil moisture, vegetation cover and species diversity, and reduced erosion in the restored areas. These gains strengthen pastoralist livelihoods by increasing water retention and fodder availability, reducing ecological drought and improving overall climate resilience. The case illustrates how locally driven and co-produced rangeland restoration can improve hydrological functioning, advance national restoration goals and enhance the long-term resilience of pastoral social-ecological systems (SLU Restore4More, 2026).

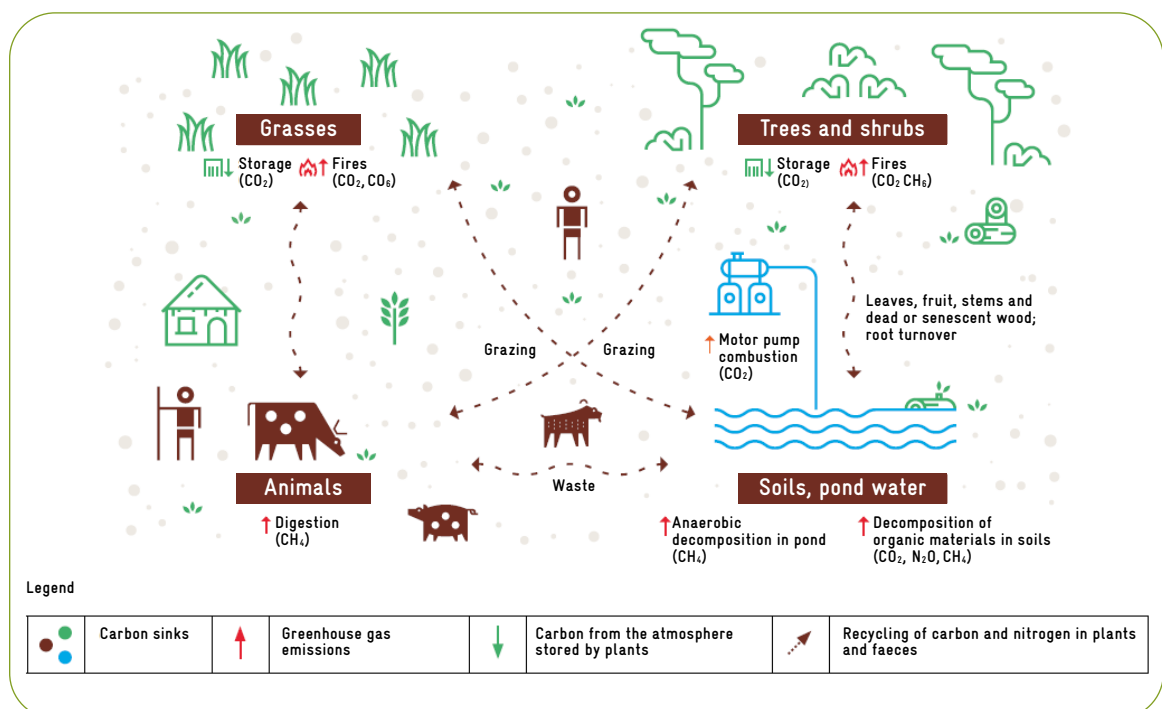
Compared to other land use systems, pastoralism is further characterised by the sustainable use of the available and naturally existing grazing and browsing resources, resulting in significant ecosystem benefits. Pastoralism not only benefits from well-functioning dryland ecosystems but typically **ensures ecosystem health** – an effective ecological integration which is increasingly acknowledged. Pastoralist systems allowed to operate according to their specialisation excel in **water use efficiency** and in the **provision of ecosystem services and biodiversity** (FAO 2021). This includes

seed transportation and dispersal. For example, up to 25 000 seeds per sheep are carried for hundreds of kilometres, along with small insects, enabling movement to new biotopes and adaptation to a changing climate. Pastoral herds also contribute to the **control of shrub growth** or the stimulation of grass tilling. The feeding selectivity often promoted in pastoral herds, and their mobility, also strengthen ecosystem functionality. **The moderate grazing** that results from herd mobility and selective feeding allow plants to regrow and recover in times of rest but also optimizes animal

– FIGURE 3

Carbon cycle in pastoralist systems

A simplified diagram of GHG emissions and carbon storage in a pastoral ecosystem in Senegal



nutrition in conditions where nutrients are unevenly distributed over the range. Trampling from moderate grazing can increase plant production and survival and thus help maintain dense grass cover and extensive deep-reaching root systems in grasslands. These prevent erosion by acting as a filter for groundwater and by preventing bare soils. They can also contribute to reduce the spreading of invasive species and of large wildfires by reducing biomass in risk-prone areas.

All these are important factors for maintaining biodiversity of grasslands, thus also contributing to the stabilization of water cycles (FAO 2021; Parra et al 2025, McGahey et al 2014).

These dynamics also influence the contribution of pastoralism to the benefits derived from healthy ecosystems for **carbon storage** and biodiversity conservation. Pastoral systems operate as part of rangeland ecosystems, which contain one third of global biodiversity hotspots and hold large carbon stocks (Davies et al 2012). Studies have estimated that rangelands account for up to 10–30% of global soil organic carbon (Mgalula et al 2021). This means that the GHG balance of pastoral systems cannot be assessed simply by looking at emissions from individual animals. An assessment of the carbon footprint of a maintained pastoral system in the Sahel found it to be carbon neutral (→ **Figure 3**). GHG emissions in pastoral systems are part of natural carbon cycles rather than adding to them.

CASE STUDY

Pastureland restoration by pastoralist women in India

Maldharis, the pastoralist communities in Gujarat, India, have historically adapted to challenges such as climate change, restricted grazing areas, and land use changes. However, the increasing scarcity of grazing lands due to pastureland degradation has forced them – especially women – to travel farther in search of fodder. To address these challenges, a women-led pastureland regeneration initiative was introduced in 10 villages, covering 100 acres of degraded rangelands. This effort aimed at empowering pastoralist women by restoring and managing these lands sustainably, ensuring access to grazing resources while promoting traditional knowledge, culture, biodiversity and climate resilience.

A structured approach was adopted starting with community mobilization and capacity building. Training sessions equipped women with skills in GPS-based land mapping, soil conservation, and sustainable grazing practices. Community Commons Advocacy promoted the recognition of common lands as community assets. Engagement with panchayats (village councils) and the revenue department facilitated formal recognition of women's governance over these lands. Land restoration efforts included soil treatment and water conservation, and seed and fodder banks were established to promote native grasses, ensuring year-round fodder availability.

This initiative has contributed to biodiversity restoration and improved groundwater recharge and enhanced climate resilience of pastoralist communities. Reduced deforestation through sustainable grazing practices and the regeneration of native grasses and trees are supporting ecosystem balance. Women-led governance of restored pasturelands also strengthened social cohesion and economic independence among pastoralist women. (Source: ILC (2024))

7. Promoting synergies for implementation of climate change, biodiversity and land management under the Rio Conventions

Livelihoods in rangeland ecosystems are weakened by various factors, directly or indirectly connected with socio-economic processes and their impacts at different scales, most notably climate change, which intensifies other pressures. Based on current ambition levels in global policy processes to mitigate and adapt to climate change, this situation will drastically worsen in the future and is likely to lead to a shift in areas suitable for staple food production, further straining local livelihoods and employment opportunities particularly in drylands. This, in turn, requires understanding how pastoralism works and the core elements of its resilience, especially process variability and diversity of assets, and involving pastoralists' voices in decision-making processes.

At the same time, pastoralism offers important lessons for the resilience of agri-food systems more broadly. As climate change increasingly affects agriculture beyond drylands, pastoralism provides an example of how to work with variability rather than against it, through flexibility, mobility, diversity, and adaptive management.

Pastoral systems make important contributions to food and nutrition security and need to be recognized for this. If not impacted by external restrictions, their livelihoods are highly resilient to climate variability, strengthen rangeland ecosystems and provide important benefits for the rural economy. By applying low-emission strategies rooted in local knowledge systems and natural resource availabilities, pastoralism can inform strategies to sustainably transform current agriculture and food systems which are exceeding the capacity of the social and ecological systems they are based on. Learning from pastoralists' livelihood strategies and the practices they demonstrate can help promote agroecological approaches and support inter-linked efforts to achieve the Rio Convention goals.

Yet, agri-food systems can achieve their full resilience potential only if backed by ambitious climate change policies integrated into development strategies, and by political and legal environments that enable adaptive co-management of natural resources, and the peaceful coexistence of different resource users. In rangeland ecosystems, this means better understanding, recognizing, and increasing policy support for it.



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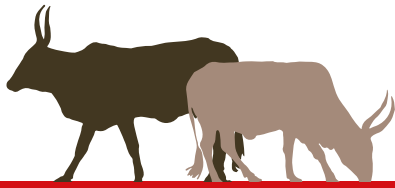
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