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# Livestock Production Interventions, Pastoral Resilience, and Sustainable Livelihoods in Arid and Semi-Arid Areas: A Technical Review of Literature

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**Abstract:** Arid and semi-arid areas (ASALs) are highly vulnerable to drought, water and forage scarcity, land degradation, and socioeconomic shocks, threatening livestock assets and pastoral livelihoods. This review synthesizes literature published between 2020 and 2026 on livestock production, resilience, and sustainable livelihoods, with a focus on Kenya and the wider Horn of Africa. It examines feed and fodder systems, climate-resilient breeding, animal health, rangeland management, pastoral mobility, livestock marketing and value addition, climate information, insurance, livelihood diversification, and inclusive institutions. The evidence confirms that livestock remain central to food security, income, savings, employment, and household resilience, but recurrent droughts can erode herds and prolong recovery. Building resilience therefore requires integrated interventions that strengthen feed and animal health, promote locally adapted breeds and climate-resilient husbandry, restore rangelands, and support sustainable grazing and mobility. Improved markets, value addition, financial and climate-risk services, and livelihood diversification can further increase returns and reduce vulnerability, while gender-responsive approaches, local knowledge, social networks, and inclusive governance support adoption and sustainability. Overall, the literature suggests that isolated interventions are unlikely to deliver durable resilience. Sustainable pastoral development requires context-specific packages that increase productivity and value per animal while protecting rangelands and strengthening adaptive capacity. Future policy, investment, and research should therefore integrate feed security, breeding, animal health, rangeland governance, mobility, market development, climate-risk financing, livelihood diversification, and social inclusion to strengthen pastoral livelihoods and sustain dryland ecosystems.

**Keywords:** *Pastoralism; Livestock production; Pastoral resilience; Sustainable livelihoods; Climate change adaptation; Arid and semi-arid areas (ASALs).*

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## Introduction

Arid and semi-arid areas (ASALs) are characterized by rainfall variability, recurrent drought, high temperatures, seasonal shortages of forage and water, land degradation, and limited potential for reliable rain-fed crop production. In these environments, pastoralism is an economically viable and ecologically adapted livelihood system, with livestock mobility, herd diversification, livestock marketing, social networks, and communal resource management helping households manage climatic and economic shocks. Livestock provide food, income, employment, savings, productive assets, and liquidity during periods of stress, while contributing to wider economies through meat, milk, hides and skins, transport, veterinary services, and livestock markets.

These functions are particularly important in Kenya's northern and eastern ASALs and the wider Horn of Africa, where recurrent droughts can erode livestock assets and delay household recovery. Evidence from Marsabit indicates that pastoral households may require three to four years to rebuild herds after major droughts, while studies in southeastern Ethiopia report declining rainfall, increasing drought intensity, feed shortages, and livestock mortality. Such evidence also highlights differences in species' tolerance to climatic stress, with camels and goats often more drought-tolerant than cattle, reinforcing the importance of species diversification and locally adapted production strategies.

Livestock development is therefore shifting from isolated productivity-oriented interventions toward integrated approaches combining feed and fodder security, breeding and genetics, animal health, rangeland management, mobility, markets, finance, climate information, institutions, gender inclusion, and livelihood diversification. Productivity gains alone may not produce sustainable livelihood benefits where households face limited access to resources, markets, services, finance, and supportive institutions. Adaptation must consequently be understood not only as a technical process but also in social, institutional, economic, and environmental terms.

Against this background, this review examines how livestock production interventions contribute to pastoral resilience and sustainable livelihoods in ASALs. It synthesizes evidence on feed and fodder systems, pasture development, breeding, animal health, rangeland management, livestock marketing and value addition, climate information, insurance, and livelihood diversification, with emphasis on productivity, income, food security, asset protection, and resilience to climatic and economic shocks. It also examines the technical, environmental,

socioeconomic, and institutional factors influencing adoption and sustainability, and identifies integrated, scalable pathways that promote sustainable grazing, rangeland restoration, inclusive value chains, climate-risk management, and diversified livelihoods.

## Methodology

This study employed a technical literature review and qualitative thematic synthesis to examine evidence on livestock production interventions, pastoral resilience, and sustainable livelihoods in Kenya and the wider Horn of Africa. The review focused primarily on studies published between 2020 and 2026, with emphasis on Africa. Literature was searched through 43 sources across ProQuest, Scopus, Google Scholar, and ResearchGate using the search string "livestock production interventions" AND "pastoral resilience" AND "sustainable livelihoods." The review examined evidence on feed and fodder systems, pasture development, climate-resilient breeding, animal health, rangeland management, pastoral mobility, livestock marketing and value addition, climate information and insurance, livelihood diversification, and inclusive institutions. It also considered technical, environmental, socioeconomic, and institutional factors influencing intervention adoption, effectiveness, and sustainability.

Studies were selected using predefined inclusion and exclusion criteria, with priority given to publications from 2020-2026 that addressed livestock production, pastoral resilience, sustainable livelihoods, or related interventions in Africa. From the identified literature, 20 studies were retained for detailed synthesis. The quality of the selected studies was appraised based on the clarity of objectives, appropriateness of research design, sampling procedures, data collection and analysis, validity and reliability, transparency of reporting, and consistency between findings and conclusions. This process helped ensure that the synthesis was based on relevant and methodologically credible evidence.

The retained studies were analyzed through a qualitative thematic synthesis involving the sequence: study findings, coding, grouping of codes, descriptive themes, comparison across studies, analytical themes, overall synthesis and conclusions. Comparative analysis was used to identify intervention outcomes, enabling conditions, constraints, context-specific differences, and opportunities for integration and scaling. Particular attention was given to effects on livestock productivity, household income, food security, asset protection, adaptive capacity, and resilience to climatic and economic shocks. The findings were subsequently integrated to identify context-specific pathways for strengthening sustainable pastoral livelihoods while maintaining rangeland health. Overall, the methodology supports a systems-based understanding of sustainable livestock development, linking productivity-enhancing interventions with climate-risk management, market development, livelihood diversification, and inclusive local institutions.

## Evidence from Literature

### Livestock Feeds, Fodder Systems, and Pasture Development

Feed availability is a major determinant of livestock productivity, health, reproduction, and profitability in dryland systems. Natural rangelands remain the main feed source, but seasonal and drought-related fluctuations often cause poor body condition, reduced reproduction, livestock mortality, distress sales, increased mobility, and household income losses. Strengthening feed systems is therefore fundamental to pastoral resilience.

Commercial fodder markets can provide feed during shortages while generating income opportunities, although participation depends on access to credit, weather and market information, land tenure, shock exposure, off-farm income, gender, and proximity to markets (Sala et al., 2020; Mauerman et al., 2023). Similarly, pasture reseeding can improve feed availability, protect herds during drought, and rehabilitate rangelands, as demonstrated around Lake Baringo (Githu et al., 2022). Cultivated and conserved fodder, including improved pasture crops, hay, sorghum, perennial grasses, fodder trees, and strategic grazing reserves, can further reduce seasonal feed deficits and pressure on natural grazing areas (Mganga et al., 2024; Joseph et al., 2025).

However, adoption is constrained by water scarcity, recurrent drought, limited technical knowledge, inadequate finance and extension, insecure land access, weak grazing institutions, and poor transport and market infrastructure. Anno (2026) emphasizes that market-oriented livestock production and marketing can improve the viability, competitiveness, and profitability of pastoral economies. Feed interventions should therefore be integrated with land and water access, drought-tolerant forages, extension, finance, conservation facilities, market information, producer organizations, and collective grazing management. Feed intensification must also remain consistent with carrying capacity and appropriate stocking rates to avoid further land degradation (Habte et al., 2022).

### Livestock Breeding and Climate-Resilient Genetic Improvement

Genetic improvement can raise livestock productivity through better growth, reproduction, milk and meat production, disease resistance, and adaptation. In drylands, however, breeding should balance productivity with resilience to heat, feed and water scarcity, disease, and climatic variability. Evidence from Kenyan indigenous goats shows the importance of conserving genetic diversity: Kichamu et al. (2024) found low effective population sizes and concentrated genetic contributions among relatively few ancestors in Galla and Small East African goats, indicating risks of genetic bottlenecks under poorly managed breeding programmes.

Breeding should therefore prioritize locally adapted genetic resources through selection and controlled crossbreeding rather than indiscriminate replacement with exotic genetics. Indigenous breeds possess valuable traits such as heat tolerance, disease resistance, and ability to utilize poor-quality feed, while modernization can improve their productivity, market appeal, and product value (Anno, 2025). Ojango et al. (2023) similarly demonstrate the value of combining improved animal management with community knowledge and participation in Isiolo, Marsabit, and Turkana. Effective breeding programmes should integrate performance recording, genetic evaluation, artificial insemination where appropriate, extension, farmer participation, nutrition, animal health, markets, and sound husbandry. The emerging priority is therefore climate-resilient productivity per animal, combining genetic improvement with conservation of adaptive traits, farmer-defined breeding objectives, community participation, reliable records, and market demand (Kihoro et al., 2025).

**Rangeland Management, Pastoral Mobility, and Environmental Sustainability**

Rangelands are the ecological foundation of pastoral systems, supporting livestock nutrition, household income, food security, biodiversity, soil health, and water resources. Degradation results from interacting pressures including drought, overgrazing, land-use change, invasive species, restricted mobility, and weak governance. Sustainable management therefore requires integrated ecological restoration, livestock productivity, and local institutions. Key measures include rotational grazing, reseeding, appropriate stocking, species diversification, livestock-number management, and timely grazing (Odhong et al., 2025).

Strong institutions, collective action, and pastoral mobility are critical for effective resource governance and adaptation. Weak enforcement, unmanaged access, limited destocking incentives, and fragmentation of communal rangelands can undermine ecological and livelihood outcomes. In northern Kenya, resilience is also grounded in local knowledge, social solidarity, trust, and community institutions, highlighting the limitations of externally driven technical solutions (Hassan et al., 2026). Sustainable rangeland management should therefore balance livestock production with conservation of vegetation, soil, water, biodiversity, and wildlife, while improving productivity and returns per animal rather than promoting herd expansion beyond ecological carrying capacity. This aligns with Anno et al. (2024), who emphasize the links between livestock systems, agroecological conditions, and growing demand for quality, traceability, and sustainability.

**Livestock Marketing, Value Addition, and Economic Opportunities**

Livestock contribute to sustainable livelihoods only when households can convert animals and livestock products into food, income, savings, and other forms of capital. Market access is therefore a central component of pastoral resilience. Northern Kenya's livestock markets remain characterized by substantial informality, but opportunities exist for improving animal condition, market timing, market information, aggregation, and value addition. Ndiritu (2020) found that pastoral beef value chains remain relatively informal and extensive, while livestock fattening provides an opportunity to increase animal weight and improve the quality and value of beef entering higher-value markets.

Evidence from the 2021–2023 drought period demonstrates the importance of flexible marketing systems. Using data from 1,053 pastoral households across five Kenyan ASAL counties, Ndiritu and Gichuki (2025) found that drought, conflict, herd characteristics, and access to market information influenced pastoralists' marketing decisions. Informal information networks involving neighbours, family members, and local traders were particularly important. This suggests that interventions should strengthen both community-based information systems and emerging digital livestock-market platforms.

Producer organizations, cooperatives, market infrastructure, aggregation systems, transport, and timely market information can help pastoralists make more strategic decisions about when and where to sell livestock. Such measures may reduce distress sales during drought and enable households to capture greater returns when market conditions are favourable.

**Value Addition and the Leather Industry**

Value addition beyond live-animal sales provides another important pathway for increasing returns without expanding herd size. Hides and skins connect pastoral livestock producers to collectors, traders, slaughter facilities, tanneries, manufacturers, and exporters. Kenya's leather industry demonstrates both the potential and the limitations of this value chain. Recent policy research identifies opportunities to integrate micro- and small enterprises into leather value chains through technology, skills development, improved linkages, and stronger market coordination (KIPPRA, 2024). Research supported by the National Research Fund has also emphasized capacity building among slaughter operators, flayers, and traders to improve hide and skin quality (National Research Fund, 2024).

Poor handling during slaughter, flaying, collection, and storage can reduce the quality and value of hides and skins. Strengthening these practices, together with investments in tanning, manufacturing, standards, infrastructure, finance, and market access, can enhance value addition and retain more benefits within livestock-producing regions. Livestock value chains should also diversify beyond meat and milk to include hides and skins, leather products, manure, breeding, transport, veterinary, feed, and other related enterprises, creating employment and income while reducing dependence on live-animal sales. Consistent with Anno et al. (2023), this requires forward-looking and well-defined interventions that prioritize long-term, sustainable growth over short-term gains.

**Climate Risk, Climate Information, Insurance, and Pastoral Resilience**

Climate change is increasingly interacting with existing socioeconomic vulnerabilities in pastoral areas. Rising temperatures, changing rainfall patterns, recurrent drought, declining forage availability, and water scarcity directly affect livestock productivity and household assets. The long-term consequences of repeated droughts are particularly important. Mauerman et al. (2023) demonstrate that drought impacts in Marsabit extend well beyond the immediate shock period. Repeated droughts reduce livestock holdings and income, increase expenditure on water, and delay herd recovery. This suggests that drought should be treated as a recurring structural risk rather than an isolated emergency.

Climate information can support anticipatory decision-making concerning livestock movement, destocking, feed conservation, water management, breeding, and marketing. However, information is valuable only when households have the resources and institutions required to act on it. Kihoro et al. (2025) therefore caution against approaches that treat climate adaptation primarily as a technical information problem while neglecting land tenure, markets, finance, political economy, and social institutions.

Index-based livestock insurance offers another mechanism for protecting livestock assets. Bostedt et al. (2025) found that uptake in the studied Kenyan counties remained very low, with only approximately 4.5% of surveyed households holding insurance. Lack of awareness and affordability were important barriers, while insurance adoption was also associated with fodder-management practices and exposure to limited alternative grazing opportunities. Insurance should therefore complement rather than replace other adaptation measures.

A resilience-oriented climate-risk strategy should combine early-warning and seasonal climate information with strategic fodder reserves and feed conservation, livestock insurance, flexible livestock marketing, appropriate destocking and restocking mechanisms, veterinary services, water development, pastoral mobility, and livelihood diversification. The objective should be to reduce asset losses before crises become severe, rather than relying predominantly on post-disaster relief.

**Pastoral Livelihood Diversification, Gender, and Inclusive Institutions**

Pastoral systems are undergoing rapid transformation due to climate variability, population growth, urbanization, changing markets, land-use change, infrastructure development, conservation policies, and expanding crop cultivation. Although livelihood diversification can reduce dependence on livestock, its sustainability depends on ecological conditions, land availability, market opportunities, and household capacity. For example, poorly planned crop expansion can reduce grazing resources and constrain pastoral mobility.

Recent literature therefore views resilience as depending on a diversified portfolio of assets, including livestock, education, social networks, financial resources, market access, employment, information, and community institutions. Livestock can support this diversification by providing capital for education, business, crop production, and other income-generating activities.

Gender and social inclusion are central to this process. Women contribute significantly to livestock production, processing, and marketing but often have limited access to livestock ownership, land, credit, extension, information, technology, and decision-making. Inclusive interventions should therefore improve access to productive assets and services for women, youth, poorer households, and other marginalized groups through gender-responsive finance, extension, producer organizations, market information, training, and value addition.

Local institutions and social capital including trust, customary governance, collective action, conflict-resolution mechanisms, and local ecological knowledge strongly influence whether interventions are adopted and sustained. Hassan et al. (2026) therefore emphasize resilience approaches grounded in local institutions and collective action rather than relying solely on externally designed interventions.

## Summary of findings

**Livestock as the Foundation of Pastoral Livelihoods**

The review finds that livestock remain the primary foundation of livelihoods among pastoral and agro-pastoral households in arid and semi-arid areas (ASALs) of Kenya and the wider Horn of Africa. Livestock provide food, income, employment, savings, productive assets, and an important buffer against drought and other economic shocks. However, recurrent and prolonged droughts can cause substantial herd losses, reduce household assets, and leave affected households requiring several years to recover. The evidence therefore suggests that strengthening livestock productivity and protecting livestock assets are central to improving household food security and long-term pastoral resilience.

**Feed Security, Breeding and Rangeland Management**

Feed and fodder security is identified as a fundamental requirement for resilient livestock production. Pasture reseeding, cultivated fodder, hay conservation, strategic feed reserves, improved forage crops, and commercial fodder markets can reduce feed shortages, livestock mortality, and distress sales during droughts. At the same time, climate-resilient breeding should combine improved productivity with adaptation to harsh environments by conserving locally adapted genetic resources while improving traits such as growth, reproduction, disease resistance, and overall productivity. Healthy rangelands are equally important. Rotational grazing, reseeding, grazing reserves, appropriate stocking levels, and community-based rangeland management can improve resource conditions, while protecting pastoral mobility enables livestock keepers to respond to changing availability of pasture and water.

**Markets, Climate-Risk Management and Finance**

The review demonstrates that improved livestock markets can convert livestock production into greater household income. Access to market information, producer organizations, aggregation, livestock fattening, improved transport, appropriate market timing, and value addition in meat, milk, hides, skins, and leather can improve returns while reducing the need to maintain increasingly large herds. Climate-risk management should also shift from reactive responses to anticipatory action. Climate information and early-warning systems can guide decisions on livestock movement, destocking, feed conservation, water management, breeding, and marketing. Livestock insurance and other financial mechanisms can protect productive assets against climate shocks, although uptake remains very low, with the reviewed evidence reporting approximately 4.5% uptake among the households studied.

**Livelihood Diversification, Gender and Local Institutions**

Livelihood diversification can further strengthen resilience by reducing excessive dependence on livestock. Education, employment, small businesses, financial services, and other income-generating activities can provide alternative sources of income during periods of livestock stress. However, diversification must be carefully adapted to local conditions because activities such as crop expansion may compete with grazing resources and restrict pastoral mobility.

The review also highlights the importance of gender, youth, social inclusion, and local institutions. Women and young people may make substantial contributions to livestock production while having limited access to livestock ownership, finance, information, extension services, markets, and decision-making. Consequently, effective interventions require inclusive institutions, recognition of local knowledge, strong social networks, customary governance, and collective action.

**Integrated Approach to Sustainable Pastoral Resilience**

The central finding of the review is that no single livestock intervention is sufficient to create lasting pastoral resilience. Sustainable resilience in ASALs requires an integrated, context-specific approach that links feed and fodder security, climate-resilient breeding, animal health, rangeland restoration, pastoral mobility, markets and value addition, climate information, insurance and finance, livelihood diversification, and inclusive local institutions. Importantly, the evidence supports a shift away

from the traditional objective of simply increasing herd size toward increasing productivity, resilience, and value per animal**.**

This approach can improve household income and food security while reducing pressure on fragile ASAL ecosystems. Overall, the study concludes that sustainable pastoral resilience is best achieved through integrated livestock and livelihood systems that strengthen productive capacity, protect natural resources, manage climate risks, improve market opportunities, and ensure equitable participation in local decision-making.

## Discussion

### Livestock Productivity, Feed Security and Climate-Resilient Production

The reviewed literature shows that livestock production is central to pastoral livelihoods in ASALs, providing food, income, employment, savings, insurance, and assets that support households during shocks. However, recurrent droughts progressively reduce livestock assets and prolong recovery, highlighting the need to strengthen pastoral resilience through mobility, herd diversification, social networks, local knowledge, and flexible resource use.

Feed and fodder security is critical for sustaining livestock productivity and protecting household assets, as shortages reduce animal condition, reproduction, and survival and increase distress sales. Evidence from northern Kenya supports fodder markets, pasture reseeding, cultivated pastures, hay conservation, and improved forage crops, although their adoption depends on access to land, water, finance, extension, markets, transport, and grazing resources. Similarly, breeding strategies should combine productivity with adaptation to heat, feed and water scarcity, and disease. Overall, sustainable livestock development requires an integrated approach linking feed security, climate-resilient genetics, animal health, husbandry, and rangeland management.

### Rangeland Management, Pastoral Mobility and Environmental Resilience

Rangeland management and pastoral mobility are central to pastoral resilience and environmental sustainability because natural rangelands support livestock production, household welfare, biodiversity, soil health, and water resources. Sustainable management should promote rotational grazing, reseeding, grazing reserves, appropriate stocking levels, species diversification, and improved grazing timing. At the same time, pastoral mobility enables livestock to access seasonally variable pasture and water, while restrictions on movement, land fragmentation, and inappropriate land-use changes can undermine this key adaptation strategy. Community-based rangeland management is most effective when supported by legitimate institutions, locally appropriate grazing rules, conflict-resolution mechanisms, participation, and incentives. Sustainable livestock development should therefore combine productivity improvements with mobility, rangeland restoration, controlled stocking pressure, and protection of ecological functions.

### Markets, Climate-Risk Management, Diversification and Inclusive Institutions

Livestock marketing, value addition, climate-risk management, and livelihood diversification are critical for converting production gains into sustainable livelihoods. Improved market information, producer organizations, aggregation, transport, fattening, and timely sales can reduce distress selling and improve returns, while value addition in meat, milk, hides and skins, leather, and breeding services can raise incomes without increasing herd sizes. Climate information and livestock insurance can strengthen anticipatory action and protect assets, although affordability, awareness, and institutional capacity remain challenges. Diversification into education, employment, small businesses, and suitable crop production can reduce dependence on livestock, while gender and social inclusion ensure equitable access to resources, services, finance, markets, and decision-making.

Overall, the 2020–2026 literature supports a shift from fragmented interventions to integrated, context-specific pastoral development that prioritizes productivity, resilience, and value per animal over herd expansion. This requires coordinated investment in feed security, climate-resilient breeding, animal health, rangeland restoration, mobility, markets, value addition, climate information, insurance, livelihood diversification, and inclusive institutions. Sustainable pastoral livelihoods ultimately depend on healthy rangelands, functioning markets, effective institutions, social inclusion, and continuous adaptation to climate and economic change.

### Livestock Development Aspects in ASALs

#### *Livestock Production Interventions diagram*

The diagram presents an integrated framework for strengthening livestock production, pastoral resilience, and sustainable livelihoods in ASALs. At its centre is livestock production, supported by feed and fodder systems, climate-resilient breeding, animal health, rangeland and pasture management, pastoral mobility, livestock marketing and value addition, climate information and risk management, livelihood diversification, and inclusive institutions and social capital.

These interconnected interventions address key challenges including drought, feed shortages, disease, land degradation, limited market access, climate variability, and socioeconomic vulnerability. Improved feeding, breeding, animal health, and rangeland management enhance productivity; market access and value addition improve incomes; while climate information, insurance, preparedness, mobility, and diversification strengthen resilience to shocks. Inclusive governance, gender responsiveness, local knowledge, and social networks promote equitable participation and resource access.

Overall, the framework integrates technical, environmental, economic, institutional, and social interventions to improve livestock productivity, food and nutrition security, household incomes, employment, climate adaptation, rangeland sustainability, and resilient, inclusive pastoral livelihoods.

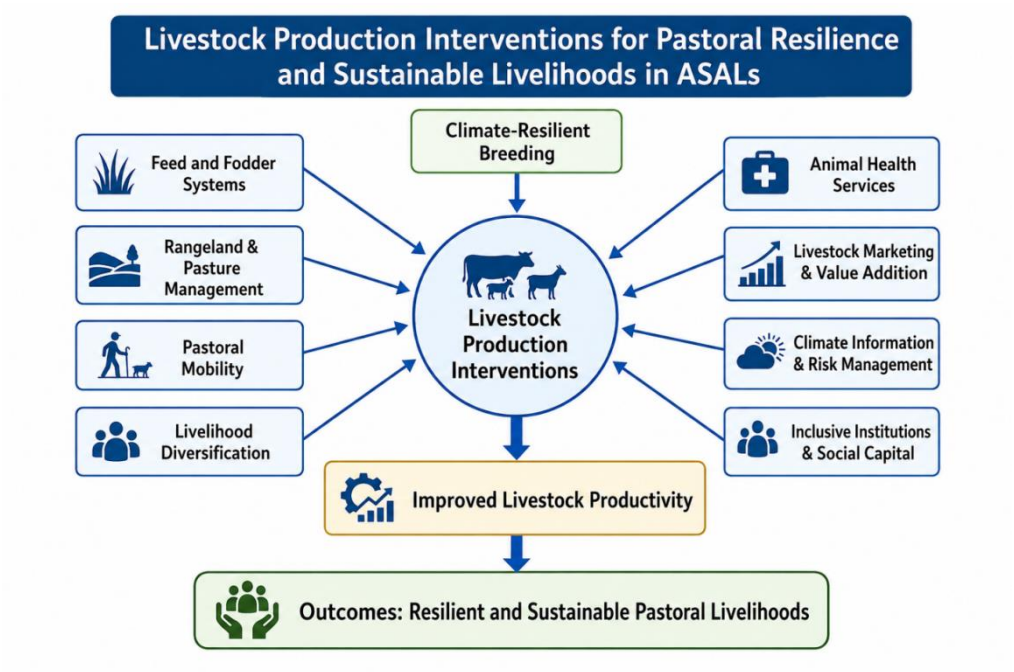


*Figure 1: Interventions for Resilience and Sustainability of Pastoral Livelihoods. Source: Researcher made.*

***Factors influencing performance of livestock production interventions***

The diagram shows that successful livestock interventions in ASALs depend on the integration of technical, institutional, socioeconomic, and environmental factors. Technical measures include feed and fodder security, climate-resilient breeding, animal health, rangeland management, market development, and climate-risk services, supported by effective governance, pastoral mobility, extension and veterinary services, finance, policies, and local knowledge. Socioeconomic conditions such as income, market access, asset ownership, gender inclusion, and capacity building, together with climate variability, water availability, rangeland condition, and ecosystem health, shape intervention outcomes.

An integrated approach can increase livestock productivity and survival, protect assets, improve household income and food security, reduce distress sales, and strengthen resilience to drought and climate shocks. Sustainable grazing, rangeland restoration, and improved water management also reduce land degradation and protect ecosystem services. Overall, combining technical improvements with strong institutions, socioeconomic empowerment, and environmental sustainability provides a foundation for resilient pastoral systems and sustainable livestock-based livelihoods in ASALs.

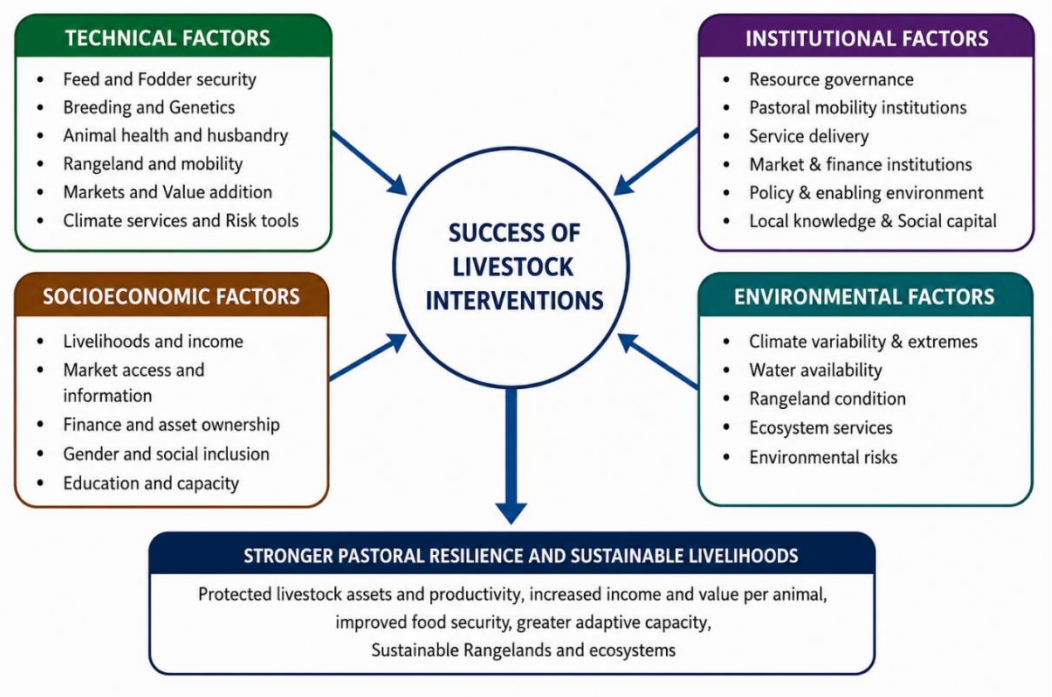


*Figure 2: Success of Livestock Interventions Framework. Source: Researcher made.*

***Integrated and scalable pathways for achieving livestock interventions***

The diagram presents an integrated framework for strengthening livestock-based livelihoods and sustainable dryland management in ASALs. It responds to climate variability, recurrent droughts, feed and water shortages, rangeland degradation, animal diseases, weak markets, limited finance, and social inequality through seven interconnected pathways: feed and fodder security; breeding and genetic improvement; animal health and husbandry; rangeland management and mobility; markets and value addition; climate-risk management and finance; and livelihood diversification and social inclusion.

These pathways are supported by cross-cutting principles of pastoral participation and knowledge, gender and social inclusion, adaptive management, ecosystem conservation, and increased productivity and value per animal. Enabling conditions including supportive policies, extension, infrastructure, finance, and strong institutions facilitate implementation and scaling from household to community, landscape, and regional levels.

The integrated approach simultaneously improves livestock productivity and resilience, household income and food security, and environmental sustainability. Better feed, breeding, health, and rangeland management enhance livestock survival and productivity, while markets, value addition, financial services, and diversification reduce vulnerability to shocks. Sustainable grazing, restoration, mobility, and ecosystem planning support healthy rangelands and biodiversity. Overall, the framework promotes resilient pastoral communities, inclusive livelihoods, and sustainable dryland ecosystems through continuous learning and adaptation.

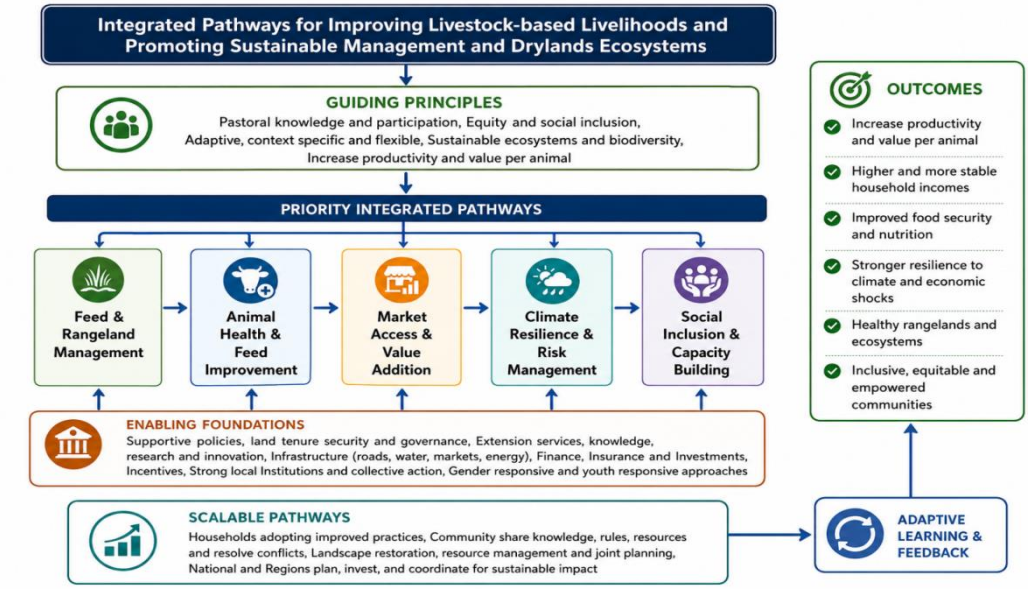


*Figure 3: Integrated Livestock Development Pathways. Source: Researcher made.*

**Integrated Discussion and Policy Implications**

***Feed security is foundational***

The 2020-2026 literature demonstrates that livestock development in ASALs cannot be effectively addressed through isolated interventions. Livestock productivity is generated by an interconnected system involving genetics, nutrition, animal health, water, rangelands, markets, infrastructure, finance, institutions, gender relations, mobility, and climate. Feed shortages are a major pathway through which climate shocks become livestock and livelihood losses. Pasture reseeding, fodder cultivation, hay conservation, improved forage crops, feed formulation, strategic reserves, and commercial fodder markets can reduce seasonal deficits. However, their sustainability depends on land and water access, finance, extension, markets, and appropriate grazing institutions.

***Unit Productivity and Herd replacement and expansion***

Increasing herd size is not always compatible with rangeland carrying capacity. Improved genetics, nutrition, animal health, husbandry, fattening, and value addition can increase household returns without requiring proportional increases in livestock numbers. This approach can simultaneously support livelihoods and reduce pressure on ecosystems. Genetic improvement programmes should prioritize locally appropriate traits rather than indiscriminate introduction of high-performing breeds. Community-based breeding, performance recording, reproductive technologies, genetic diversity conservation, extension, and farmer participation are central to achieving sustainable genetic improvement.

***Rangeland governance and market value addition***

Rangeland restoration cannot be separated from pastoral institutions and mobility. Grazing plans, reseeding, rotational grazing, restoration, livestock-number management, conflict resolution, and secure land-use arrangements should be combined with recognition of mobility as a legitimate adaptation strategy. Livestock producers can increase returns through better market information, aggregation, cooperatives, fattening, meat processing, hides and skins quality improvement, leather manufacturing, and other forms of value addition. Strengthening these systems can improve incomes without increasing livestock numbers.

***Climate adaptation and finance***

Early-warning systems and climate information should be connected to practical decisions about livestock movement, destocking, feed conservation, water management, breeding, and marketing. Insurance and financial services can strengthen this

system by protecting productive assets and reducing distress sales. Many livestock technologies fail to achieve their potential because households lack finance, land, water, information, or institutional support. Credit, savings, insurance, extension, producer organizations, and community institutions should therefore be considered enabling components of livestock-development interventions rather than separate sectors.

***Gender, social inclusion and systems integration***

Interventions should examine who owns livestock, who controls income, who has access to finance and information, and who participates in decisions. Women and youth should be explicitly included in breeding, fodder production, livestock marketing, processing, finance, training, and value-addition programmes. The strongest policy implication from the literature is the need to move from isolated projects toward bundled interventions. A fodder programme, for example, should be connected to water, finance, climate information, extension, markets, and rangeland governance. Breeding programmes should be connected to nutrition, animal health, performance recording, extension, and market demand. Rangeland restoration should be linked to appropriate stocking strategies, mobility, conflict management, and livestock marketing.

## Recommendations

1. Adopt integrated livestock development interventions rather than isolated projects by combining feed and fodder security, breeding, animal health, rangeland management, markets, climate-risk management, finance, diversification, and social inclusion.
2. Strengthen feed and fodder security through pasture reseeding, fodder cultivation, hay conservation, strategic feed reserves, improved forage varieties, fodder-tree production, and commercial fodder markets, particularly to reduce drought-related feed shortages and livestock losses.
3. Promote climate-resilient breeding programmes that increase productivity while conserving locally adapted indigenous genetic resources. Breeding should prioritize traits such as heat tolerance, disease resistance, reproductive performance, and ability to perform under feed and water scarcity rather than indiscriminate replacement with exotic breeds.
4. Strengthen animal health and husbandry services by integrating veterinary services, extension, nutrition, breeding, water provision, and farmer knowledge into livestock development programmes. Improved genetic potential will have limited benefits where animals lack adequate feed, health care, water, and management.
5. Strengthen community-based rangeland governance and restoration through rotational grazing, reseeding, grazing reserves, appropriate stocking levels, restoration of degraded areas, conflict resolution, and enforcement of locally agreed grazing rules.
6. Protect and facilitate pastoral mobility by recognizing mobility as a legitimate climate-adaptation strategy and avoiding land-use policies that unnecessarily fragment communal rangelands or restrict access to seasonal grazing and water resources.
7. Shift livestock development from herd expansion toward productivity and value per animal. Improving nutrition, genetics, animal health, fattening, marketing, and value addition can increase household returns without increasing livestock numbers beyond rangeland carrying capacity.
8. Improve livestock market access and market information through producer organizations, cooperatives, aggregation, transport infrastructure, digital and community-based market information, and improved market timing to reduce distress sales and increase producer bargaining power.
9. Promote livestock value addition in meat, milk, hides and skins, leather, breeding services, manure, transport, veterinary services, and fodder enterprises. Improving handling, processing, quality, infrastructure, skills, finance, and market linkages can increase the share of value retained in livestock-producing areas.
10. Strengthen climate-risk management and anticipatory action by linking early-warning and seasonal climate information to practical decisions on livestock movement, destocking, feed conservation, water management, breeding, and marketing.
11. Expand access to livestock insurance and financial services including credit and savings, while addressing barriers such as low awareness and affordability. Insurance should complement, rather than replace, fodder management, mobility, marketing, veterinary services, and other adaptation measures.
12. Promote sustainable livelihood diversification through education, employment, small enterprises, and other income-generating activities that are compatible with local ecological conditions and do not unnecessarily reduce grazing resources or pastoral mobility.
13. Mainstream gender and social inclusion by ensuring women, youth, poorer households, and marginalized groups have equitable access to livestock ownership, finance, extension, information, training, markets, technology, and decision-making.
14. Build interventions around local institutions, knowledge, and participation. Customary governance, social networks, trust, collective action, conflict-resolution mechanisms, and local ecological knowledge should be incorporated into programme design and implementation rather than relying exclusively on externally designed technical solutions.
15. Improve enabling infrastructure and institutional support, including water systems, roads and transport, extension, veterinary services, finance, market infrastructure, and supportive policies, because technical interventions are unlikely to perform effectively without these complementary services.
16. Adopt context-specific and adaptive approaches to scaling**.** Interventions should be designed according to local ecological, socioeconomic, institutional, and market conditions and scaled from household to community,

landscape, and regional levels through continuous learning and adaptation.

## Conclusion

The reviewed literature (2020–2026) confirms that livestock remain central to livelihoods, food security, and local economies in ASALs, particularly in Kenya and the wider Horn of Africa. Livestock provide food, income, savings, employment, and protection against climatic and economic shocks, but recurrent drought, feed and water shortages, and environmental degradation continue to erode household assets. Pastoralism should therefore be recognized as an adaptive livelihood system based on mobility, herd diversification, local knowledge, social networks, and market access.

The evidence indicates that pastoral resilience is best strengthened through integrated and locally adapted interventions. Feed and fodder security, climate-resilient breeding, animal health, water access, rangeland restoration, mobility, extension, finance, infrastructure, and functioning markets should be addressed together. Community-based rangeland management, rotational grazing, strategic reserves, appropriate stocking, and conflict-resolution mechanisms can enhance both ecosystem health and livestock productivity. Development should prioritize productivity and value per animal rather than herd expansion alone.

Markets, value addition, climate-risk management, and livelihood diversification are also critical. Improved market information, producer organizations, aggregation, transport, livestock fattening, processing, insurance, savings, credit, and early-warning systems can improve incomes and strengthen households' capacity to withstand shocks. These interventions should be inclusive, ensuring equitable access for women, youth, poorer households, and other vulnerable groups.

Overall, sustainable pastoral development requires a shift from fragmented, technology-focused projects toward coordinated systems that strengthen productivity, resilience, market returns, and ecosystem sustainability. For Kenya and similar dryland economies, integrating feed security, resilient livestock production, rangeland management, mobility, markets, climate-risk financing, diversification, and inclusive governance offers the most promising pathway for strengthening pastoral livelihoods while conserving the ecological foundations of ASAL production.

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**Interest Conflicts**

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