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Protecting Milk in a Changing Climate: Silvopasture as a Food Security Strategy in Kenya

In November 2021, during Kenya's severe drought, many rural families looked into their breakfast cups and saw no milk. For these families, milk is both a primary source of child nutrition and daily income, so when seasonal rains fail and pastures dry out, milk production declines. About 74 percent of Kenyans face moderate to severe food insecurity, especially in arid and semi-arid lands (ASAL) counties ("FAOSTAT: Kenya"; "Kenya IPC"). When milk disappears, it means a child starts school hungry and a parent loses the day's income.

As Kenya experiences rising temperatures, shifting rainfall patterns, and more frequent extreme weather events, one national response to climate change has been the plan to plant 15 billion trees by 2032 (Kinyanjui). While expanding tree cover can provide environmental benefits and livestock shade, the type of tree planted in grazing areas can affect whether reforestation efforts increase milk production. This paper argues that integrating fodder-based silvopasture into Kenya's national tree initiative can protect dairy stability and strengthen food security for families in ASAL regions. If Kenya continues to measure success only by trees planted, it may ignore whether those trees protect household nutrition.

Background on Kenya

Kenya is an East African country of approximately 56 million people (World Bank, "Kenya"). Although cities such as Nairobi and Mombasa are economic hubs, nearly 70 percent of the population lives in rural areas, where livelihoods depend on small-scale farming and livestock production (World Bank, "Kenya"). Kenya operates as a democratic republic with an elected president and parliament ("FAOSTAT: Kenya"), and access to services varies widely across its 47 counties.

A typical rural Kenyan household includes four to five family members, and nearly half of the population lives on less than three US dollars per day (UNICEF; World Bank, "Kenya"). Families grow maize, beans, pigeon peas, and sorghum for daily meals, and cook with charcoal and firewood. They also keep one to five cows or goats for daily milk, with surplus sold in markets often managed by women. Milk income often covers school transport, fuel, veterinary care, and food purchases. When drought reduces milk production, families must either consume or sell less, reducing both nutrition levels and income.

Agriculture contributes about 20 percent of Kenya's GDP, and milk represents about 17 percent of agricultural GDP (World Bank; USDA). Women also play a central role, making up 42–65 percent of the agricultural labor force (Onyalo). More than 80 percent of Kenya's land is classified as arid or semi-arid (ASAL), where climate conditions are harsh and rainfall is unpredictable (World Bank, "Kenya"). Since only about 11 percent of total land area is arable, livestock often become the most reliable source of food and income in regions that experience drought (World Bank, "Arable Land")

Challenge: How Climate Change Affects Dairy Production in Kenya

In Kenya's ASAL regions, livestock systems are highly vulnerable to drought, and rainfall variability has been shown to decrease household milk supply, reduce herd size, and lower income (Stavi et al.). During the 2021 drought, pasture conditions in many ASAL counties were reported as poor or depleted, leading to weakened livestock. As a result, average milk yield per household fell by about 75 percent compared to long-term averages. A decline of that size can turn four cups of milk into one. For a family that depends on one or two cows, that kind of loss changes what is eaten that day and what can be afforded that week. At the same time, milk prices rose by 30 to 40 percent due to reduced supply and sustained demand, placing milk even harder to afford. Several ASAL counties reported some of the highest levels of food insecurity during this period ("Kenya ASAL"). Together, these trends show that climate change in ASAL regions directly affects milk production causing both nutrition and household income decline with it.

The loss of milk due to climate change affects all four pillars of food security defined by the FAO: When pasture fails, milk *availability* declines. When milk declines, household income falls, limiting *access* to other foods. Reduced milk consumption weakens dietary *utilization*, especially for children. Increasing rainfall variability challenges milk supply *stability* from season to season. For this reason, protecting milk production in ASAL regions is essential to improving overall food security.

In many rural households, women manage around 60 percent of smallholder dairy farms and oversee milk sales in local markets (Kenbe). When household milk supply decreases, women lose a key source of household income, and children lose access to a primary source of dietary protein. This makes climate-driven milk instability a critical gender and child nutrition issue.

Additionally, Kenya's geography limits alternative strategies. Since so little land is suitable for growing crops, farmers cannot simply replace lost milk by growing more food. Crop farming depends on reliable rainfall and soil, so expanding crop planting is not a realistic solution in dry ASAL regions. Therefore, livestock must still serve as both a food and income source during a changing climate.

Solution: Exploring Climate Adaptation Strategy for Dairy Stability

In Kenya's ASAL regions, climate solutions must protect dairy stability during drought, not just restore degraded land. Milk-protective reforestation does this by choosing tree species that purposely support pasture and livestock. The goal should be to plant the right trees in the right places so rural families can survive the next drought.

<u>Why General Tree-Planting and Monoculture Reforestation is Not Enough</u>

One major national response to climate change has already begun. Kenya's plan to plant 15 billion trees by 2032 aims to restore degraded land and increase tree cover (Kinyanjui). Tree plantings can provide environmental recovery benefits such as improved soil fertility, carbon sequestration, reduced erosion, enhanced water retention, and better wind protection (Ministry of Agriculture, Livestock and Fisheries). For grazing animals, trees provide an added benefit of providing shade, which reduces heat stress to keep them eating and producing milk. A study in the southeastern United States showed that without shade, milk yield was about 10 percent lower than with shade (West). For these reasons, expanding tree cover can improve the environment and livestock health at the same time. However, in grazing systems, not all trees function the same way.

In some cases, poorly selected tree species for meeting reforestation goals have reduced pasture conditions instead of supporting it. For example, *Prosopis juliflora,* locally known as mathenge, has spread widely across Kenya's ASAL regions. In Baringo County alone, mathenge invaded nearly 19 thousand hectares and continues to expand each year (CIFOR-ICRAF). Dense monoculture thickets block grass growth and reduce grazing space, forcing livestock to travel farther for forage or go without it, resulting in milk declines. As one report described it, reforestation without considering grazing systems became a "toxic, thorny nightmare" for pastoralists and worsened food insecurity in rural communities (Reynés). Tree planting should be judged not only by the number of trees planted, but by whether those trees protect a cow's health and milk to drink.

Fodder-Based Silvopasture Systems as an Advantageous Solution

To address both climate and food security goals, Kenya should adopt silvopasture, an agroforestry approach that purposely integrates trees, forage, and livestock. Using silvopasture restores degraded land, strengthens rural households, and enhances food security in dry regions (Haddad et al.). Intentionally planting fodder trees such as *Calliandra calothyrsus* and *Leucaena leucocephala* provides high-protein leaves that supplement natural pasture, especially during dry seasons. In well-designed silvopastoral systems, these trees also contribute shade, helping reduce heat stress while providing quality feed.

Research in East Africa shows that supplementing dairy cows with access to about one kilogram of *Calliandra calothyrsus* increased milk yield by 0.6 to 0.8 liters per cow per day (Place et al.)[1]. For smallholder farmers, who own between one to five cows producing on average 7 liters per cow per day through open grazing, this change is significant because milk yields increase between 8 to 11 percent per day (USDA)[2]. Additionally, farmers could earn more income due to the milk surplus. Over time, adoption of fodder trees generated 20 to 30 million US dollars in additional net income in Kenya (Place et al.).

Silvopasture also improves herd stability, which is critical during drought. A 2023 study in West Africa found that silvopastoral systems reduced calf mortality from over 18 percent to 5 percent and increased fertility rates to above 90 percent (Assani Seidou et al.). While this study was conducted in the country of Benin, the findings show how planting fodder trees improves herd survival and long-term milk yield.

Woody fodder species are less sensitive to rainfall variability than grasses alone because their deeper root systems allow them to access moisture stored below the soil surface (Balehegn). This means that even when surface pasture dries out, fodder trees can continue producing leaves that livestock can consume. This reduces the need to purchase expensive feed during the dry season. By integrating drought-tolerant fodder trees directly into pasture systems, silvopasture strengthens both environmental recovery and livestock feed availability during drought.

Kenya's informal sector of smallholder dairy farmers produces 80 percent of Kenya's 5.76 billion liters of milk annually (USDA). A single farmer could increase milk yield by about 8 percent, and, even if only 25 percent of smallholder dairy farmers adopted fodder trees, the impact could increase milk yield by an estimated 90 million liters annually. (Place et al.; USDA)[3]. This increase could supply millions of additional cups of milk for rural families. Small per-cow gains, added across thousands of households, could reduce price variations

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[1] Assumed milk density of 1.03 kilograms per liter to convert 0.6 to 0.8 kilograms to 0.6 to 0.8 liters.

[2] If fodder tree-planting can increase milk production by 0.8 liters per cow per day and an open grazing cow produces approximately 7 liters of milk on average per day, then milk yield can increase by about 11 percent. For increased milk yield of 0.6 liters per cow per day, milk yield increases by 8 percent (Place et al.; USDA).

[3] Calculation: 5.67 billion liters x 80 percent x 8 percent increase x 25 percent adoption rate.

during drought and improve overall milk availability in food-insecure counties. When many farmers adopt small changes, the combined impact can stabilize milk supply during future droughts.

Moreover, women are vital in smallholder dairy production and milk sales in rural Kenya. When cows continue producing milk during drought, women are better able to maintain household nutrition and daily income. In many communities, women manage milk sales and use that income to pay for food, school fees, and health expenses. By helping stabilize milk production, silvopasture supports both child nutrition and women's influence over household financial decisions.

In areas where milk determines what families eat each day, silvopasture protects both the land and what will be poured into cups tomorrow.

Recommendation: Implementing Fodder-Based Silvopasture in Kenya

Climate and hunger challenges connect to two United Nations Sustainable Development Goals (SDG), Climate Action (SDG 13) and Zero Hunger (SDG 2) that urge countries to strengthen both climate resilience and food systems (United Nations). Kenya should implement milk-protective reforestation by adding fodder-based silvopasture within its national tree initiative, especially in ASAL regions that depend on livestock. This integration could be coordinated through the Kenya Forest Service, which oversees national tree-planting implementation and species guidance under Kenya's forest and tree cover strategies (Kenya Forest Service).

Since smallholder dairy production is often managed at the household level, especially by women, extension services and seedling distribution should prioritize rural smallholder farms where dairy income supports family nutrition. Based on the evidence presented, Kenya should prioritize expanding fodder-based silvopasture within existing grazing areas rather than relying only on new, large-scale tree planting.

First, county governments in ASAL regions should prioritize the distribution of drought-resistant fodder trees such as *Calliandra calothyrsus* and *Leucaena leucocephala*. These species have already been tested in East Africa and shown to increase milk yields (Place et al.). The Ministry of Agriculture and Livestock Development, established in 2023, can lead the distribution effort through traditional, existing extension services that already support rural smallholder dairy farms in ASAL regions. Additionally, Kenya can use farmer-to-farmer extension programs such as Volunteer Farmer Trainers, Village Based Advisor, and Peer Farmer Trainers, to reach rural communities and share silvopasture practices. Research shows extension services work best when respected local farmers serve as trainers and when women are intentionally included (Morrison et al.). Funding could come from redirecting a portion of national tree-planting funds toward species that protect milk yield and household nutrition. Prioritizing smallholder households targets support toward families most vulnerable to milk losses due to drought.

Second, extension services must include hands-on training. Research shows that fodder trees improve milk yield when they are properly spaced, pruned, and fed consistently (Place et al.). Without guidance, farmers may plant trees incorrectly or abandon them. Extension services like ASAL eXtension help ensure smallholder farming communities become self reliant. County livestock officers and local agricultural trainers should provide demonstrations on pruning cycles, cut-and-carry feeding methods, and integration with grazing routines.

Third, the Kenyan government should strengthen monitoring systems that track food security outcomes, not just tree-planting numbers. This could prove to be challenging, the Kenyan government should designate a

singular organization that collects data, allowing for consistent long term data analysis on the effectiveness of silvopasture solutions. However, in livestock-dependent counties, success should also be measured by milk yield per cow, calf survival rates, and months of milk availability during dry seasons.

There are limitations to consider. Some farmers may hesitate to adopt new species due to uncertainty about land tenure or fear of invasive spread, especially given past experiences with mathenge. To address this, county governments should provide clear guidance on approved fodder species and ensure that invasive trees are not included in reforestation programs. In addition, since water access remains a constraint, fodder seedlings should be established during the rainy seasons. Moreover, farmers may be reluctant to adopt silvopastoral systems due to the higher initial cost and long term management of tree systems in addition to livestock. To mitigate these concerns, farmers should receive government stipends and extension service training for tree management.

Despite these challenges, silvopasture expansion is realistic and achievable. Long-term research across Kenya and neighboring East African countries, Tanzania and Uganda, found that more than 200,000 smallholder dairy farmers adopted fodder trees such as *Calliandra calothyrsus* and *Leucaena leucocephala* (Place et al.). Farmers reported that these trees provided reliable, high-protein feed during dry periods, reduced the need to buy expensive commercial feeds, and helped keep cows healthier and more productive over time. This research demonstrates that silvopasture is practical for smallholder farmers and can be expanded further with continued extension support.

A pilot program in a few ASAL counties could begin within two planting seasons. If just 10,000 out of 1.8 million smallholder farmers received 200 seedlings each, Kenya could integrate 2 million fodder trees into active dairy systems within three years (Kiplagat el al.). Since fodder trees can be grown from locally sourced seedlings and require limited irrigation after establishment, this strategy remains economically possible for smallholder households. By focusing on drought-resistant tree fodder, Kenya can reduce sharp dairy declines like those seen during the 2021 drought.

Improving food security in rural Kenya requires climate strategies that directly protect milk. By prioritizing fodder-based silvopasture, strengthening extension training, and measuring dairy-related outcomes, Kenya can align environmental recovery with household nutrition.

Conclusion

Climate change is already reducing milk yield in Kenya’s ASAL regions, threatening household nutrition and income. The 2021 drought showed how quickly milk supply can collapse when pasture fails. Since livestock are central to rural food security, protecting dairy stability must be a national priority. For many families, protecting dairy stability means protecting tomorrow’s breakfast. Expanding tree cover alone will not fully solve this problem. The type of tree planted determines whether restoration supports grazing systems. By prioritizing fodder-based silvopasture, Kenya can align environmental recovery with dairy stability. For millions of rural Kenyan families, climate resilience will be measured in whether a child in rural Kenya still wakes up to a cup of milk each morning.

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