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# Fodder trees for improving livestock productivity and smallholder livelihoods in Africa

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Fodder trees are important feed sources for livestock in a wide range of farming systems in Africa. Researchers, extension services and farmers have developed and promoted fodder tree practices in many different countries and contexts. Fodder trees are particularly important in the highlands of Eastern Africa, where over 200 000 smallholders plant them, mainly to feed dairy cows. They can meet production shortages in times of extreme climatic conditions such as droughts. Fodder trees are easy to grow, require little land, labor or capital, have numerous by-products and often supply feed within a year after planting. Key challenges constraining the uptake of fodder trees include limited species appropriate to different agro-ecological zones, shortages in seed and that farmers lack knowledge and skills needed to grow them.

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## Introduction

Livestock are key components of African farming systems and are increasingly viewed as important pathways for rural households to escape poverty [1]. Low quality and quantity of feeds are a major constraint limiting livestock productivity among smallholder farmers [2]. This paper reviews the role of fodder trees and shrubs[a] to improve smallholders' livestock productivity, incomes and livelihoods. We highlight the highlands of Eastern Africa, where over 200 000 smallholders plant them to feed their livestock, particularly dairy cows and goats. First we assess fodder tree practices. Next, we review benefits and impacts. Finally, we present challenges for enhancing their contributions to improved productivity and livelihoods.

## Fodder tree practices

African farmers have fed tree foliage to their livestock for centuries, using wild browse or trees that grow naturally on their farms [3]. New agroforestry systems for feeding livestock have emerged over the last three decades, involving the planting of mostly exotic species, grown most frequently in hedges along field boundaries or along the contours to limit soil erosion. Fodder trees are widely grown in the East African highlands, including Kenya, Uganda, Tanzania and Rwanda, primarily among dairy farmers [4••]. *Calliandra calothyrsus* is the most commonly planted species. It is fast growing, tolerant to frequent pruning and droughts, but is not as nutritious as many other species [4••,5]; *Leucaena diversifolia*, *Leucaena trichandra*, *Chamaecytisus palmensis* and *Sesbania sesban* are also important (Table 1). Fodder trees are also planted in other countries, such as Ethiopia, Malawi and Zimbabwe [6,7]. In the Sahel, farmers do not plant fodder trees but purposely allow emerging seedlings to grow on their farms so as to harvest fodder from them [8]. Most fodder trees are multi-purpose, providing products such as firewood and services such as soil erosion control. In many instances fodder may not be the tree's primary use.

Seeds are planted in nurseries, either bare-rooted or in polythene pots, and then transplanted on farm three months later at the onset of the rains. Others plant seed directly in their fields. An evaluation of bare-rooted *Calliandra* seedlings in western Kenya reported 34% higher survival rates than direct seeding but the cost per surviving seedling was 24% higher, due to nursery labor costs [9]. Bare-rooted seedlings cost less to produce than potted seedlings but are more susceptible to drought after transplanting. The choice among alternative techniques depends on the species involved, the available resources and farmers' skills.

In the East African highlands, trees are first pruned 9–12 months after transplanting to a height of about 80 cm. In East Africa, farmers usually plant trees in neglected niches, such as in hedges around the homestead, along field boundaries or along the contours. They therefore do

[a] The terms 'trees' and 'shrubs' are used interchangeably.

**Table 1**

**Characteristics of selected fodder trees that farmers plant in Africa**

| Species | Indigenous (I), exotic (E) or naturalized (N) | Countries planted* | Altitude range (m) | Mean annual rainfall (mm) | Frost tolerance** | Tolerance to poor drainage** | Tolerance to acidity** | Feed quality*** |
|---|---|---|---|---|---|---|---|---|
| *Acacia angustissima* | E | Tanzania, Zimbabwe | 0–2600 | 900–2800 | M | NT | T | M |
| *Calliandra calothyrsus* | E | Kenya, Uganda, Tanzania, Rwanda, Burundi | 0–2200 | >800 | NT | NT | M | M |
| *Chamaecytisus palmensis* | E | Ethiopia, Kenya, South Africa | 1500–3000 | 600–1600 | T | NT | NT | H |
| *Gliricidia sepium* | E | Mali | 0–1600 | 600–3500 | NT | NT | M | H |
| *Leucaena diversifolia* | E | Uganda, Rwanda, Burundi, Tanzania | <2000 | 1500–3500 | NT | NT | NT | H |
| *Leucaena leucocephala* | E | Kenya, Tanzania, Malawi | 0–1900 | 650–1,500 | NT | NT | NT | H |
| *Leucaena pallida* | E | Tanzania | 1000–2000 | 500–2000 | M | NT | NT | M |
| *Leucaena trichandra* | E | Kenya | 700–2000 | 1000–1800 | NT | M | M | H |
| *Morus alba* | N | Kenya, Uganda | 1000–3000 | 1500–2500 | T | M | M | H |
| *Sesbania sesban* | I | Ethiopia, Kenya | 100–2500 | >500 | M | T | T | H |

*Source*: [25,40–43].

* List of countries is not exhaustive.

** NT = not tolerant, M = moderate tolerance, T = tolerant.

*** M = medium, H = high.

not take up land otherwise allocated for annual crops. Few find that the trees compete with adjacent crops; experiments have shown that calliandra intercropped with Napier grass (*Pennisetum purpureum*) does not depress grass yields [10].

Farmers in other areas plant in different arrangements. In Ethiopia, *Sesbania sesban* is the most important planted fodder tree and is generally grown in home gardens [5]. In East and Central Mashonaland Provinces of Zimbabwe, farmers plant *Leucaena leucocephala*, *Acacia angustissima*, *Leucaena diversifolia* and *Leucaena pallida* in pure stands while others intercrop them with food crops or other fodder crops [11,12].

Not much information is available on the yield of fodder trees. Calliandra yields 1.5 kg dry matter per tree per year on farms in central Kenya, grown in hedges pruned at 0.6 m to 1 m height, five times per year [4••,13]. In Zimbabwe, where many farmers plant in pure stands, calliandra yields range from 2.5 to 5.6 tons $ha^{-1}$ $year^{-1}$and *A. angustissima*, *L. leucocephala* and *Gliricidia sepium* produce more than 3 tons $ha^{-1}$ $year^{-1}$ when cut a single time at the end of the wet season [14]. In the semi-arid areas around Segou, Mali, *G. sepium* yields 2 tons $ha^{-1}$ $year^{-1}$ and *Pterocarpus* spp yields 0.5 tons $ha^{-1}$ $year^{-1}$. Neither is widely planted by farmers [15].

Much less is known about the farmer-managed natural regeneration of fodder trees and how these trees are managed once mature. In an area of eastern Kenya ranging from sub-humid to semi-arid, researchers identified 160 such species that farmers used for fodder. Farmers most preferred species were *Triumfetta tomentosa*, *Aspilia mossambicensis* and *Melia volkensii*. Among the 15 that farmers ranked highest in importance, only one, *Commiphora zimmmermanii*, was planted and its main use appeared to be as a live fence. Most were scattered in crop land. Harvesting methods varied included coppicing, pruning branches, cutting soft twigs only or allowing animals to browse [16]. Twenty-nine indigenous fodder tree species used by farmers were identified in Dendi and Jeldu Districts, West Shewa Zone, central Ethiopia [17]. In Burkina Faso, farmers were found to use 70 tree species for fodder across three land use systems [18].

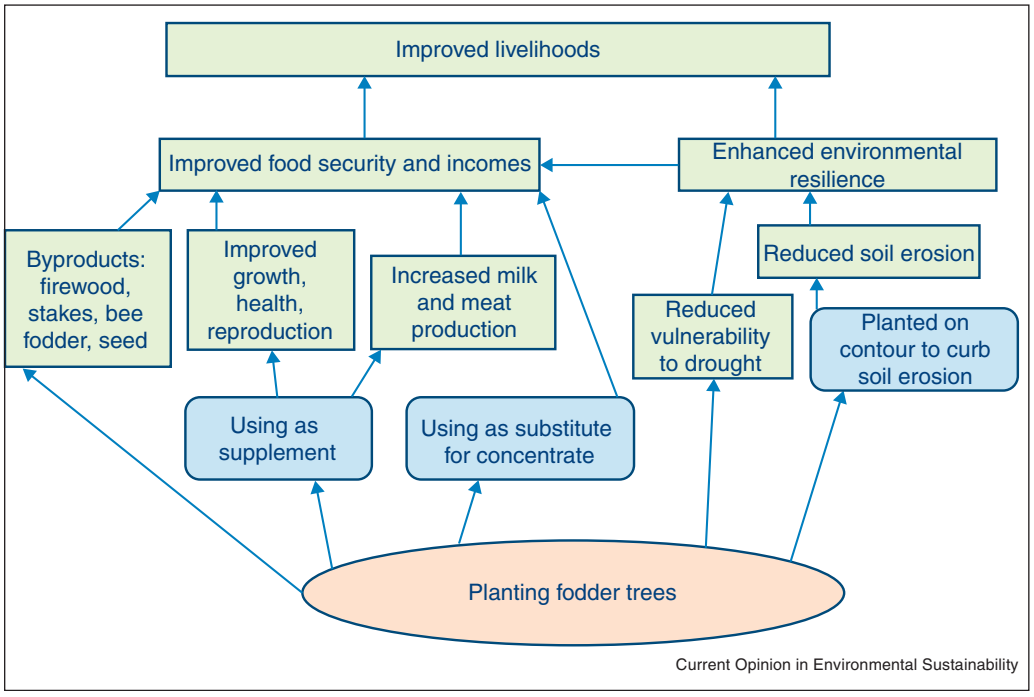
## Benefits and impacts

Fodder trees contribute to improved livelihoods in various ways, as discussed below (Figure 1).

### Increased production and income from cattle

Most of the evidence on milk yields involves calliandra. A farmer in East Africa needs about 500 calliandra trees to feed a dairy cow throughout the year at a rate of 2 kg dry matter per day. One kilogram of dried calliandra (24% crude protein and digestibility of 60% when fed fresh) has

**Figure 1**




Principal ways that fodder trees contribute to improved food security, incomes and livelihoods. Note. Food security and income are grouped together in this diagram but in fact contributing to one does not necessarily contribute to the other, as when an increase of cash income is taken by the male head of household for his own use.

about the same amount of digestible protein as 1 kg of dairy meal (16% crude protein and 80% digestibility) [19]. Two kilograms of dried calliandra provide an effective protein supplement to the basal feed of Napier grass and crop residues, according to on-farm feeding trials from Embu District, Kenya [13] and Masaka District, Uganda [20]. Under farmers' management, milk production increased by 0.6–0.75 kg milk $kg^{-1}$ dried calliandra. Surveys also reported farmers' estimates of the milk response to calliandra feedings. In one, farmers estimated the mean response was 0.80 kg milk $kg^{-1}$ dry calliandra [21] slightly above the range of the findings from the on-farm trials. In the other, in which farmers reported amounts of tree fodder fed and milk produced, the response was 0.35 kg milk $kg^{-1}$ dried calliandra [22]. One of the trials also investigated the effect of calliandra on butterfat and found a positive, but not statistically significant effect [23].

Most of the evidence on income from fodder shrubs also involves calliandra. Farmers use it both as a supplement to increase milk production and as a substitute for dairy meal. It can be fed fresh or stored and fed dry, which does not significantly reduce nutritive quality [24]. Net returns in 2002 and 2003 ranged from \$US 62 $year^{-1}$ to \$US 122 $year^{-1}$ across four sites in Kenya and Uganda for a farmer with 500 trees. Farmers' actual numbers of trees were usually fewer, ranging from means of 130 trees per farm in western Kenya to 560 trees per farm in south-western Uganda, resulting in net returns ranging from \$US 30 to \$US 114 $year^{-1}$ [25]. Net returns varied across sites primarily because of differences in numbers of trees and in milk prices. An estimate in 2009 found mean net returns to be \$35 $year^{-1}$ in central Kenya [22]. The lower amount was primarily due to lower estimates of amounts fed and response of milk yields.

An economic analysis from Chikwaka District, Zimbabwe found that the use of fodder tree (*L. leucocephala, A. angustissima, L. diversifolia and L. pallida*) in smallholder dairy had gross margins of \$US 13 to \$US 334 and benefit–cost ratios of 1.12–3.03. The margins and ratios varied depending mainly on the amount of tree fodder fed; higher use led to higher returns [26].

Only one study was found assessing the effect of fodder trees on non-dairy cattle, which confirmed the effectiveness of *L. leucocephala* as a dry season supplement for grazing steers in semi-arid western Tanzania [27].

### Increased production and income from small ruminants

Dairy goats are an important and rapidly growing smallholder enterprise in East Africa. Many farmers grow fodder trees to feed their goats [22] and studies confirm

**Table 2**

**Benefits of fodder shrubs according to farmers, aside from increased milk production**

| Type of benefit | % of farmers mentioning in | |
|---|---|---|
| | Embu area, Kenya ($N = 60$) | Kabale area, Uganda ($N = 93$) |
| Firewood | 50 | 72 |
| Soil fertility improvement | 48 | 72 |
| Improvement in animal health | 38 | 5 |
| Soil erosion control | 18 | 20 |
| Improved creaminess of milk (increase in butter fat) | 18 | 6 |
| Fencing | 18 | 76 |
| Revenue from sale of seedlings | 13 | 9 |
| Stakes | 9 | 70 |

Percentages sum to greater than 100 because many farmers mentioned more than one benefit. *Source*: [21].

their significant impact on milk yields [28,29]. Supplementation with *Mimosa scabrella* in the highlands of Rwanda enabled goats to gain 50 g day$^{-1}$ compared with 31 g day$^{-1}$ for grass alone. Six other tree species also increased body weight [29]. Ewes supplemented with *S. sesban* in Ethiopia showed a 13% increase in milk production over ewes supplemented with concentrates [AK Mekoya, unpublished]. Numerous experiments have confirmed the effectiveness of fodder trees in increasing the productivity of sheep and goats for meat production. Sheep gained 79–90 g day$^{-1}$ in live weight from being fed calliandra in Kenya [28]. Ebong found that calliandra leaf meal is a potentially valuable substitute for soybean meal in compound feeds for feeding goats raised for meat production [30].

The only economic analysis involving fodder trees and small ruminants is from Segou, Mali. In on-farm trials, *G. sepium* and *Pterocarpus* spp were evaluated on their contributions to sheep growth and on the time they saved farmers from having to collect fodder off the farm. Fodder shrubs were found to be profitable only under conditions where alternative options were expensive [15]. While not conducting a formal economic analysis, a study from Ethiopia found that farmers in three land use systems made widespread use of *S. sesban* for feeding sheep, and had strong positive perceptions of the tree's effect on weight gain and reproductive performance in two of them [5,31].

### Other benefits

Few studies report on the marketing of fodder tree biomass or its use in commercial feeds.

In the Tanga area of northeastern Tanzania, *L. leucocephala* leaf meal is widely marketed, primarily to urban dairy producers. Most is from wild populations but some is cultivated on farms. Leaf meal is also an ingredient of one of the country's major mineral supplements [32]. Analyses of the use of leaf meal in mineral blocks for sheep in Nigeria have been conducted but use at the farm level is not reported [33]. Farmers in East Africa also report feeding tree biomass to other types of livestock, notably poultry, rabbits and fish [22,32].

The above analyses do not take into account several other benefits of fodder shrubs as cited by farmers in Kenya and Uganda (Table 2). These include the provision of products (firewood, stakes, bee forage and seeds, which are sometimes sold) and services (fencing, soil fertility improvement, soil erosion control, and improvement in animal health and reproduction) [21]. Few estimates of the quantities and values of these products and services were found. In Kenya, hedges combining Napier grass and calliandra or *L. trichandra* reduced runoff and soil erosion while not reducing adjacent maize yields [34,35]. Fodder trees can also help farmers adapt to and mitigate climate change [36••]. For adaptation, they are deep rooted, resistant to drought and they maintain high protein levels during the dry season, when high-quality feed is scarce [4••]. For mitigation, fodder trees improve livestock productivity, which helps reduce methane emissions per unit of output and helps reduce carbon emissions by substituting for commercially manufactured concentrates. But no studies were found that explicitly quantify the contributions of fodder trees to climate change adaptation or mitigation.

## Conclusions

It is difficult to estimate the numbers of farmers planting fodder trees. About 205 000 farmers were estimated to be planting them in East Africa (Kenya, Uganda, Rwanda and northern Tanzania) in 2006, based on a review of household surveys and reports from organizations promoting fodder trees. Numbers have likely increased since then, as a vibrant private seed market has emerged in Kenya [4••,37]. About 40–50% of the planters were women, indicating the appropriateness of the practice to their needs and that many of the organizations promoting the practice targeted women [38].

Key challenges for enhancing fodder trees' benefits include:

a. *Species diversification*. There is a lack of species appropriate to different agro-ecological zones, particularly high altitude (>2000 m) and semi-arid zones. In humid and sub-humid zones, species are needed that provide more nutritious biomass than that of calliandra [21].
b. *Lack of functioning seed supply systems*. An emerging seed market has facilitated adoption in Kenya but is yet to emerge in neighboring countries. Main constraints include policies of government seed centers, plant health regulatory agencies, and non-governmental organizations that distribute free seed [21]. Decentralized, commercial models provide greater potential than government or NGO-led models [39••].
c. *Weak extension support*. While fodder trees require relatively little land, labor or capital, they are a knowledge-intensive practice as farmers need to acquire new skills such as nursery establishment, tree pruning and seed collection. As weak as extension systems are in most countries, agroforestry extension is nearly non-existent. Promoting innovative approaches such as farmer to farmer extension, civil society campaigns and facilitative policies can help promote widespread adoption [4••].

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