

## Research Article

# Physical and Economic Valuation for Nontimber Forest Products (NTFPs) of Surra Government Plantation in the Upper Hare-Baso Rivers Catchment, Southwestern Ethiopia

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The study aimed to estimate the physical and monetary values for nontimber forest products (NTFP) of the Surra government plantation in the upper Hare-Baso rivers catchment of Gamo highlands, southwestern Ethiopia. The Surra government plantation was established in the mid-1980s and consisted of *C. lusitanica*, *E. globulus*, and *P. radiata* tree species, which were planted side by side. Because of food insecurity, forest proximity communities/inhabitants relied on extracting NTFP such as litter and fodder for income and livestock feed despite none of them being physically and monetarily accounted for. The plot method and stock change approach were applied to determine sample plots and collect litter data, respectively, while the active market price was used to account for monetary correspondences. Fodder data were acquired via integration of animal unit month (AUM), livestock carrying capacity, animal unit equivalent (AUE/TLU), quality of pasture (poor), and proper use factor (30%). Its monetary price data were collected from the local market. The gross total production of litter and grass/fodder was 158,614.90 kg and 284,076 kg per/year, respectively, while the corresponding monetary values were ETB 206,169.40 and ETB 255,669, respectively. However, the “proper use factor”-based physical value of fodder/grass was 85,224 kg per/year, and its corresponding monetary value was ETB 76,701. The average physical value (volume) of grass production/year during the wet and dry seasons was 56.67 kg and 96.67 kg, and its mean monetary price/kg was ETB 1.4 and 1.2, respectively. It was concluded that the fodder/grass data collected via the integrated approach reduced the accounting errors, and the data were more precise. Accounting for the economic values of litter and fodder embedded in the market price upscaled the accounting quality and was more indicative of ground facts. Therefore, this study contributed a fresh accounting approach to the field of NTFP accounting.

## 1. Introduction

Forests with other land uses are considered for poverty alleviation and food security, mainly in developing countries [1]. Specifically, nontimber forest products (NTFPs) contribute to livelihood diversification, job opportunities, and sources of income and are believed to be *safety nets* during periods of crisis [2, 3]. NTFPs contribute significantly not only to the livelihood of rural residents but also to the livelihood of migrants, residents of urban areas, national treasuries, and the global economy [4]. The term NTFP is

defined as all biological materials of forests other than timber that is extracted for human benefits [5, 6]. For example, fuelwood, litter, medicinal plants, fodder/grass, wild edible fruits, and house-building materials such as lianas are some of the major NTFPs [7–9]. The flow of a given NTFP to final consumption and data on value creation help to clarify the dynamics in the valuation of NTFPs [10]. This concept, in many contexts, is equated to a conservation-through utilization and increasing cash income to local communities and simultaneously creating incentives for the conservation of trees and forested ecosystems [11].

Forests play an important role in rural livelihoods and the national economy of Ethiopia [12–14]. For instance, plantation and natural forests provide 15% of the total livestock feed requirements for approximately 35 million TLU (tropical livestock units) (70–80 million herds) [15], whereas 15,000 women of Addis Ababa relied on the raking of litter from the Addis Ababa peri-urban eucalyptus energy plantation on a daily basis [16–18]. Many studies have demonstrated that a large number of NTFPs are important for national and local economies in Ethiopia [19–22]. Hence, accounting for the economic value of NTFPs has an advantage since it helps to ascertain the true value of the standing forest, leading to more rational decisions about the alternative uses of the forest to lessen consumption pressures [23, 24]; helps to reduce extraction that contributes to forest degradation and associated emission; enables sustainable exploitation of NTFPs that can contribute to reducing degradation and deforestation, increasing values of forests and reducing consumption pressures on them, and last, providing alternative sources of income to those highly relied on the forest and caused for severe depletion. However, only a few NTFPs are accounted for in detail in Ethiopia, such as forest coffee, honey, beeswax, spices, gums, and resins [25, 26], although many nontimber forest products require further investigation.

The degraded farmland, infertile acid soil, rain-fed subsistence agriculture, and dense population [27, 28] of the upper Hare-Baso rivers catchment initiated the community to rely on nonagricultural economic activities such as petty trade, weaving, and raking of litter [27, 29, 30]. In particular, grazing under the plantation and collecting of BLT (litter) for house consumption and market were considerable economic activities in the catchment but less overwhelmingly accounted for [31]. Different research conducted in the catchment demonstrates that none of them studied the physical and economic values of NTFPs from any forest, particularly grasses and litter/BLTs from plantations. In other words, the studies were conducted on woody vegetation, plant species diversity and composition, comparative analysis between sacred and nonsacred forests [32], and land-use dynamics [33]. Therefore, the focus of this study was on two valuable NTFP valuations, namely, fodder/grass and litter/BLTs. Because these two NTFPs were integral parts of economic goods for the Surra government plantation fringe community.

The Surra government plantation was one of the largest government plantations in the upper Hare-Baso river catchment that was established in the mid-1980s [34]. It was one of highly exploited and less managed government plantations in the catchment and beyond [35]. Accounting for the NTFP benefits obtained from plantations enhances livelihood options for users depending on a number of factors: the products concerned, the market in which they are sold, the demand of users, and the economic background of users [7, 36]. Moreover, the potential for increasing the sustainability of NTFP benefits is dependent on accounting for the extraction rate and characteristics of the tree species [6, 11, 24]. For instance, harvesting dead wood, litter, grasses, and fruits has been shown to have high potential for

sustainability because of users' positive attitudes [37]. Thus, the study aimed to account for the physical and economic values of the specific NTFPs from the Surra government plantation in the upper Hare-Baso rivers catchment, southwest highlands of Ethiopia. It is limited to accounting for the physical and monetary values of grass/fodder and BLTs/litter of the eucalyptus tree species of the Surra government plantation.

## 2. Materials and Methods

**2.1. Study Area Description.** The astronomical location is between 6°15'0" N–6°22'0" N and 37°28'0" E–37°38'0" E (Figure 1) while the relative location is between Chenchura, Dita, and Qogota districts.

The topography of the study area is part of the rugged terrain of the Gamo highlands that extends north to south with rising elevations up to 4200 masl (Mt. Gughe), which is the highest peak in the southwestern highlands of Ethiopia [38]. Altitudinally, the upper Hare-Baso river catchment is confined between 2,329 masl and 3,442 masl (survey data).

The study area is a part of the tropical highland climate (mountain climate type) that is represented by the capital letter "H" [39] and locally named *dega* to *wurch* [38]. The area receives bimodal rainfall, and the mean annual rainfall varies from 1100 to 1300 mm. The first rainfall season is from March to April, while the second season is from June to August [29]. The average minimum and maximum temperatures are 18°C and 23°C, respectively [30, 33].

The natural forests of the upper Hare-Baso rivers catchment were depleted because of old and historic settlements of people in the area [40]. However, small patches of remaining natural forests, such as graveyards, meeting places (*Dubusha*), and other sacred sites, are found here and there in the pocket areas [32]. Hilltops of mountains are covered by Afromontane grasses and permanently grazed [29]. In contrast to natural forests, the coverage of plantation forests, namely, woodlots of *Eucalyptus globulus*, *Pinus radiata*, and *Cupressus lusitanica*, community plantations, and government plantations, have increased. The Surra government plantation was a part of government plantation that was established during the military government regime as a part of "Ethiopian highland plantation expansion projects" [34, 41]. The Surra government plantation was a mixture of *Eucalyptus globulus* (locally *Nech-bahirzaf*), *Cupressus lusitanica* (locally *Yeferenj tid*), and *Pinus radiata* (locally *Radiata*) tree species that were planted side by side [35].

The economic conditions of the people in the upper Hare-Baso rivers catchment were food insecure [42]. Farming was intensively practiced using hoe; oxen ploughing was insignificant due to the scarcity of grazing lands [29]. Therefore, mixed highland subsistence and rain-fed farming on fragmented small farms were a dominant economic activity, although it was not sufficient to feed the dense population [42]. Raising livestock is an integral part of the economy practiced by tethering and open grazing at homestead and communal grazing lands, respectively. The common livestock reared were sheep, horses, and cattle,

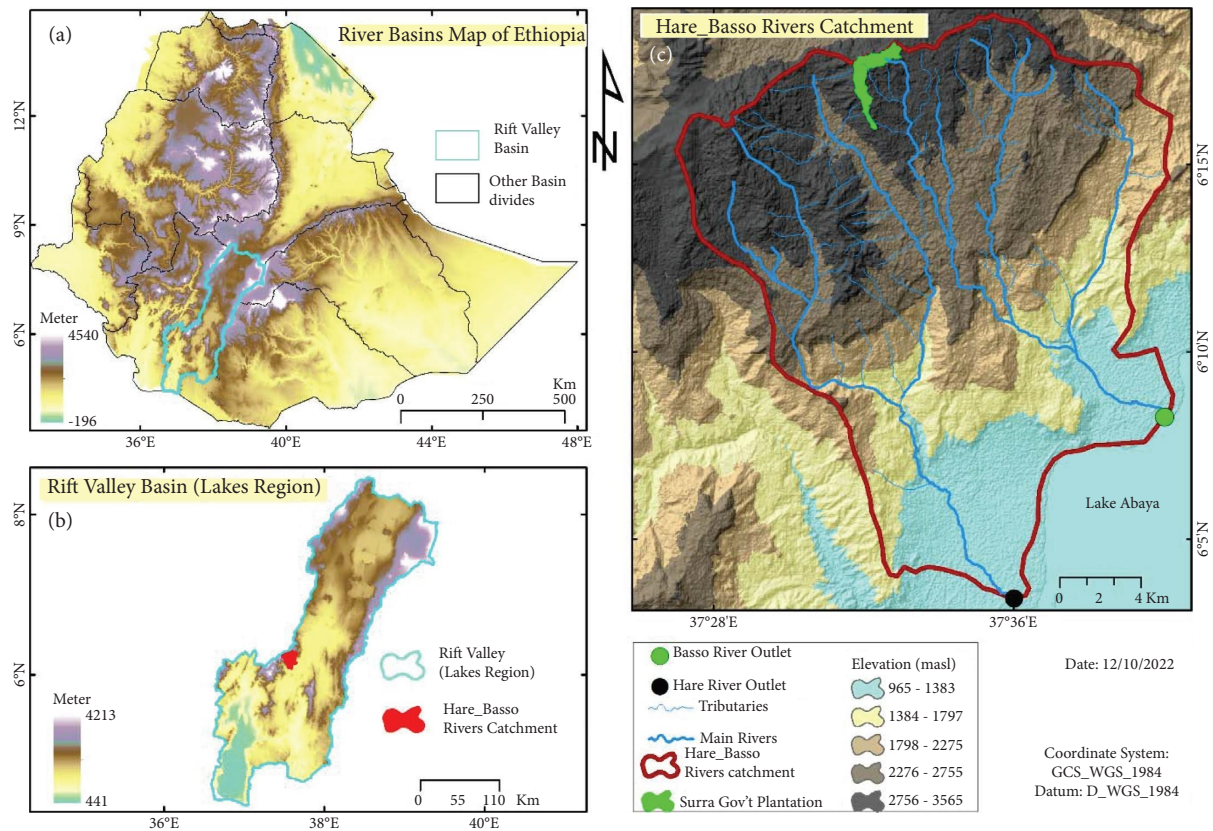


FIGURE 1: The river basins of Ethiopia (a), rift valley basin (b), and upper Hare-Baso rivers catchment (c) (source: own design, 2022).

despite being insignificant in number [43]. The petty trade, weaving, and collecting (raking) of BLTs are nonagricultural economic activities that diversify their livelihoods [29, 44, 45]. However, the adoption of apple trees has given hope to enhance the income of people [46, 47].).

## 2.2. Sampling Techniques

**2.2.1. Plot Sampling Techniques (Litter/BLTs).** The ground-based sampling method was implemented to measure litter/BLTs from the Surra government plantation. Because the ground survey method is more precise and effective than GPS (geographic positioning system)-based accounting in small areas and tree-dominated vegetation covers [48].

Initially, the total area of the forest was delineated using Garmin GPS 72H (GPS: global positioning system) with an accuracy of  $\pm 3$  m in the open space, dense canopy, and cloudy sky [49]. As depicted in Figure 2, the sample plots of the subforest patch (eucalyptus) were delineated following the determination of size, shape, and area [50]. The shapes of the three plots (major, minor, and small) were square since it is versatile and robust as well as the most commonly used in a ground-based survey of biomass investigation in most vegetation types [48, 51].

The areas of subforest patches (e.g., *E. globulus*) were redelineated and converted into a grid map using ArcGIS version 10.5 (Figure 2) [49, 52]. The sizes of major, minor, and small plots were determined purposively by considering the recommendations of different studies [50, 51]. Hence,

the areas of major, minor, and small plots were 100 \* 100 m, 10 \* 10 m, and 1 \* 10 m, respectively (Figure 2). Major sample plots were drawn out using a computer-based simple random sampling procedure via ArcGIS version 10.5 [49, 52].

The grid map of major plots of eucalyptus tree species (Figure 2 right) was shifted onto ground using GPS coordinate points and threads [35]. While shifting the grid map of all plots of eucalyptus trees onto the ground, the vertices and center of major plots were purposively identified depending on the northing and easting of the grid map (Figure 2 left) and coded with white metallic paint [50]. The coded vertices of each major plot of eucalyptus tree species were encircled with threads and Squadra (*Squadra*: angle measuring instrument). Squadra was used to stabilize the shape (squared shape) while encircling sample plots using threads [51]. Hence, five minor plots were acquired from four vertices and a center of major plots of the eucalyptus trees (Figure 2 middle). Finally, two small plots (1 m \* 1 m) were sampled from opposite corners of each minor plot of eucalyptus subforest purposively based on the recommendations [48] (Figure 2 bottom left).

## 2.3. Data Acquisition Techniques

**2.3.1. Litter/BLTs.** Procedures recommended by Ravindranath and Ostwald [48] were implemented to collect BLT/litter data using the *stock change method*. The stock change approach is "collecting of litter/BLTs data from two different

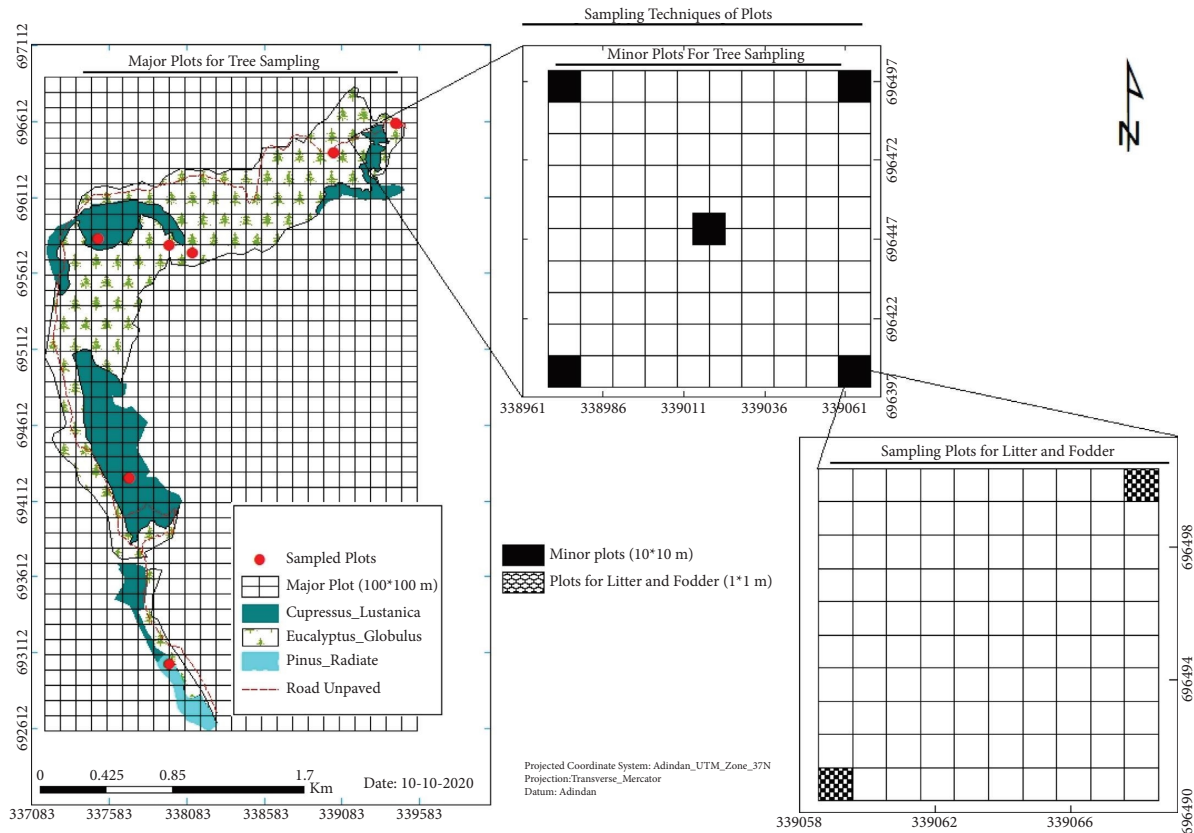


FIGURE 2: Sampling design of major plots (above left), minor plots (above middle), and small plots (below right) designed for collecting litter data (source: own survey map, 2021).

seasons, one from dry and other from wet seasons per year.” Before collecting litter data, four pieces of wood were erected at an angle of 90° in four vertices of minor plots (10 m\*10 m) and encircled with thread (Figure 2). Each 1 m<sup>2</sup> plot (small plot) was re-encircled at the opposite angle of minor plots (Figure 2 bottom right). Therefore, the BLT data of different seasons were collected from each sampled small plot using a plastic bag, weighed before summation (equation (1)), extrapolated into litter/ha (equation (2)), and extrapolated into the entire eucalyptus forest area (172.5 ha)/kg (equation (1)).

- (i) The average production potential of litter/BLTs in the two seasons was mathematically theorized as follows:

$$ALS = \frac{L_w + L_d}{2}, \quad (1)$$

where ALPS = average litter production of two seasons from small sample plots per annum

$L_w$  = litter of the wet season;  $L_d$  = litter of dry season; 2 = represents two seasons (wet & dry)

- (ii) Litter (BLTs) data collected from the small sample plots converted into hectares/month are theorized as follows:

$$\frac{ALPS}{ha} = \left( Eq.1 * \frac{0.004}{ha} \right), \quad (2)$$

where  $ALPS/ha$  = average litter production of two seasons from a hectare of two months (seasons); 0.004 = conversion unit of sample plots into hectares.

- (iii) Conversion of litter (BLTs) production from small sample plots (1 m \* 1 m) into entire forest/yr is mathematically theorized as follows:

$$ALP_t = (Eq. 2) * 12 * 172.5, \quad (3)$$

where  $ALP_t$  = total annual litter production; 12 represents months of a year; 172.5 represents the area of eucalyptus forest in *hectares*.

**2.3.2. Grass/Fodder/Grazing.** The common animal kinds were arranged into animal classes based on standard animal unit equivalent (AUE) guides/conversion factors [53]. The animal unit equivalent (AUE) is the coefficient or conversion factor of each animal kind into an animal class [54]. Therefore, TLU is a conversion factor for tropical livestock and/or the converted livestock numbers to a common unit [53, 55] (Table 1).

The daily, monthly, and annual DM (dry matter) intake data of grazing/fodder of animal classes were acquired by quantifying the average weight of livestock classes proportional to the tropical livestock unit (TLU) and quality of pasture [56] and/or multiplying AUE by 2% [58]. 2% is a single animal DM intake per day of its weight in poor



TABLE 1: Tropical livestock unit (TLU) and its signifying weights of livestock.

Animal classes	TLU	Weight (kg)
Camel	1	250
Cow, dry	0.7	175
Cow, with calf	0.76	190
Sheep, dry	0.1	25
Sheep, with lamb	0.13	33
Horse	0.8	200
<b>Total =</b>	<b>2.49</b>	<b>623</b>

Source: adapted from different studies [56, 57]. 2.49 is the mean TLU (tropical livestock unit) and 623 is the total corresponding weight for the average TLU (2.49). In other words, 2.49 TLU = 623 kg of livestock classes in tropical region. For instance, 1 TLU=250 kg, which is for camel in tropical region. Its weight may vary in different regions (for e.g., temperate).

pastures [54, 55]. The Surra government plantation, therefore, was allocated under poor pasture.

The TLU of the study area was quantified by the “standard forage-consuming domesticated live animal for the tropical region” [55]. For example, the camel has the largest average live weight in a tropical region with an average weight of 250 kg and is represented by 1 TLU (1AUE) (Table 1). The average live weight of cattle in the tropical region was 175 kg [56], and its corresponding TLU (AUE) was 0.7. Thus, the TLU and corresponding weight of livestock in the study area were calculated accordingly (Table 2).

The carrying capacity (CC) is the capability of grazing land to feed a class of livestock for a given time [53, 59]. The CC is computed using “the estimated relative production values method” for rangelands of all grass types [60]. In other words, the CC of the rangeland is a division of AUM by the total area of the rangeland and divided by the AUE [61], which gives us AUM/ha or AUEM/ha (equation (4)) [58].

- (i) The carrying capacity (CC) of the Surra government plantation was mathematically computed as follows:

$$CC = AUM \div TA \div AUE, \quad (4)$$

where CC = carrying capacity; AUM = animal unit month (DM intake per month); TA (ha); AUE = animal unit equivalent (the conversion factor

of the mass of a single animal class to the TLU standard).

The animal unit day (AUD), animal unit month (AUM), and/or animal dry matter (DM) intake per day, #/month, and #/annual for animal classes were important to account for the fodder/grass production potential of the Surra government plantation. Each aforementioned DM intake of #/day, #/month, and #/annual is mathematically theorized as follows:

- (i) The animal unit per day (AUD) was theorized as follows:

$$AUD = \text{Weight of animal class (WAC)} * 2\%, \quad (5)$$

where AUD = animal unit day (DM intake per day per weight); 2% indicates that the DM intake in a dry pasture is two percent of its body weight.

- (ii) The animal unit month (AUM) of a single animal class was theorized as follows:

$$AUM = WAC * 2\% * 30, \quad (6)$$

where AUM = animal unit month (DM intake of a single animal class per month); WAC = weight of an animal class; 2% = DM intake of animal classes per day per weight in poor pasture; 30 = days of a month.

- (iii) The animal unit annual (AUA) of a single animal class was theorized as follows:

$$AUA = WAC * 2\% * AUM, \quad (7)$$

where AUA = animal unit annual (a single animal class per year); WAC = weight of an animal class; 2% = DM intake of animal classes per day per weight in a poor pasture; AUM = animal unit month (DM intake of a single animal class per month)

- (iv) The total forage/fodder production potential of the Surra government plantation or the total forage intake of different animal classes with multiple sizes (AUE/TLU) of “a year” was theorized as follows:

$$TADFI = \left( \left( \sum_{1-n}^n X1 + X2 + \dots Xn \right) + \left( \sum_{1-n}^n Y1 + Y2 + \dots Yn \right) + \left( \sum_{1-n}^n Z1 + Z2 + \dots Zn \right) + \dots An \right), \quad (8)$$

where TADFI = total annual dry forage intake of all animal types (species), X = one of the animal species that owned different animal classes (cattle), Y = one of the animal species that owned different animal classes (horses), and Z = one of the animal species that owned different animal classes (sheep).

Note that all plants in the rangeland are not eaten by livestock [62]. Because some of them are not accessible to animals [54], others are unpalatable [63], whereas further losses occur due to animal trampling [61]. In this study, therefore, the correct proper use factor (excluding factor) should be used to deduct the supposed uneaten grasses

TABLE 2: Weight of livestock stocking at the Surra government plantation.

Animal classes	TLU	Weight/kg/tropical	Kinds/animal class of Surra	Amount/Surra	Weight/kg/Surra	=#kg
Camel	1	250	—	—	—	—
Cow, dry	0.7	175	Cow, dry	49	49 * 175	8575
Cow, with calf	0.76	190	Cow & calf	12	12 * 190	2280
Cattle bull, mature	1.40	42.5	Bull matures	9	9 * 42.5	382.5
Sheep, dry	0.1	25	Sheep, dry	301	301 * 25	7525
Sheep, with lamb	0.13	33	Sheep, with lamb	58	58 * 33	1914
Horse	0.8	200	Horse, mature	27	27 * 200	5400
<b>Total =</b>	<b>2.49</b>	<b>623</b>		<b>456</b>		<b>26076.5</b>

Source: adapted from different studies and converted using TLU into study area [53, 56, 57]. 2.49 is the average TLU while 623 kg is the corresponding weight of livestock in tropical region. 456 is the total amount of animal classes (for e.g., cow; dry=49 in number) that are stocking at the Surra government plantation and adapted from the TLU of tropical region. 26076.5 kg is the total corresponding weight for the 456 livestock classes.

[64, 65]. However, the proper use factor varies from region to region based on grass types, agroclimatic variation, and topography in Ethiopia [64, 66]. For instance, the *proper factor value* of southern Ethiopia was 30%, while in the Somalia region, it was different [65]. Therefore, to account for the grass/fodder production of the Surra government plantation, 30% was preferred since the study area is a part of southern Ethiopia [65]. Consequently, the grass production

potential data were collected through an indirect approach by combining a stocking rate [53], carrying capacity [56], conversion factors [57], and the *proper use factor* (30%) to deduct wastes (equation (9)).

- (i) Total DM intake based on the correct use factor of different animal classes was theorized as follows:

$$\text{TADFI} = \left( \left( \sum_{1-n}^n X1 + X2 + \dots Xn \right) + \left( \sum_{1-n}^n Y1 + Y2 + \dots Yn \right) + \left( \sum_{1-n}^n Z1 + Z2 + \dots Zn \right) + \dots An \right) * 30\%. \quad (9)$$

#### 2.4. Monetary Valuation

**2.4.1. Valuing Litter (BLTs).** For monetary valuation of litter production from the Surra government plantation, the *market price value method* was applied [4, 8, 67]. Before valuing the bales (bundles) of litter, it was weighed in kilograms (kg) for both seasons (Table 3). Consequently, the physical and monetary value data were collected concurrently (Chencha town), and their average price (per/kg) was quantified.

The price of litter (ETB/kg) is influenced by the variation in seasons [16, 17]. For example, the market value of 966 kg of BLTs (branch, litter, and twigs) in Chencha town during January was ETB 1,159, and its average price (per/kg) was ETB 1.20 in the same month. However, 847 kg of litter during August was ETB 1,196, and its corresponding average monetary value was ETB 1.41 in the same month (Table 3). This demonstrates that the average price of litter product during the dry (January) season was 14.9% cheaper than its corresponding average price in August (wet season). Due to price discrepancies, most litter (BLT)-dependent women do not supply litter to the markets during the dry season and are accustomed to storing it at home to sell during the wet (summer) season while the price rises. There were similar experiences of women who depended on the raking of BLTs from Addis Ababa peri-urban eucalyptus plantation [17].

- (i) The total annual monetary value of litter from the entire forest was theorized as follows:

$$\text{TMVL}_{(\text{BLTs})} = \frac{\text{TAPL}_{(\text{BLTs})}}{\text{kg}} * \frac{\text{MVL}_{(\text{BLTs})}}{\text{kg}}, \quad (10)$$

where  $\text{TMVL}_{(\text{BLTs})}$  = total monetary value of litter or BLTs obtained from the forest,  $\text{TAPL}_{(\text{BLTs})}/\text{kg}$  = total annual production of litter per kg, and  $\text{MVL}_{(\text{BLTs})}/\text{kg}$  = monetary value of a single kg of litter (BLTs) in the local market.

**2.4.2. Valuing Grazing (Grass/Fodder).** The monetary valuation of grass (fodder) production was computed according to the *market price value approach* [4, 8]. The transect-walk data show that a bundle of grass carrying women were found here and there on the roads of Chencha town, particularly during the autumn season. It was assumed that the autumn season is a time when weeds are removed manually from cereal crops and sold as fodder for urban livestock owners. Therefore, the autumn season (partially wet season) was preferred to collect monetary value data of grass/fodder. The weight of each bale and its corresponding monetary value were acquired concurrently using a checklist [68].

The average monetary value/kg of grasses was acquired by dividing the summation of monetary prices by the total weight of wet grasses (equation (11)). The total weight of fodder (grass) was summed, and the average weights were calculated (equations (11) and (12)).

- (i) The average monetary value of grass per kg was mathematically theorized as follows:

TABLE 3: The mean and total weight of litter (BLTs) production from 30 m<sup>2</sup> sample plots of eucalyptus plantation during dry (January) and wet (August) seasons/kg/ha and #/year.

Litter weight (kg/30 m <sup>2</sup> )			Litter weight (kg/ha)			Total litter weight	
Wet (Aug)	Dry (Jan)	Mean	Wet (Aug)	Dry (Jan)	Mean	kg/ha/year	kg/year
0.17	0.29	0.23	56.67	96.67	76.67	920	158,608

Source: computed from field data, 2021.

$$\frac{\text{AMV}(\text{grass})}{\text{kg}} = \sum \frac{V1 + V2 + V3 + \dots + Vn}{wg}, \quad (11)$$

where (AMV<sub>(grass)</sub>/kg) = average monetary value grass/kg;  $\sum V1 + V2 + \dots + Vn$  = summation of monetary price per bale of grasses; and  $W_g$  = weight of grasses (summation of bales/kg).

- (ii) The total monetary value of grass/kg was theorized as follows:

$$\frac{\text{TMV}}{\text{kg}} = \left( \frac{\text{AMV}(\text{grass})}{\text{kg}} \right) * (235.5), \quad (12)$$

where TMV/kg = total monetary value/kg/ha; (AMV<sub>(grass)</sub>/kg) = equation (11) (above); and 235.5 = area of plantation (ha).

The dry mass (DM) and its corresponding monetary value were considered, and thus, 1/2 kg of wet mass is a dry mass (air-dried grasses) [69]. However, to compute the monetary value of grasses (grazing) from the Surra plantation, wet masses were implemented, and if it is interesting to convert into DM, the possibility is multiplying the wet mass by half [60] and/or vice versa (equations (13) and (14)).

- (iii) The conversion of wet biomass (WM) into dry biomass (DM) was theorized as follows:

$$\text{DM}_{(\text{kg})} = \text{WM}_{(\text{kg})} * 0.5, \quad (13)$$

where DM<sub>(kg)</sub> = dry matter per kg; WM = wet matter; and 0.5 = represents “half of wet matter is dry.”

- (iv) The conversion of dry biomass (DM) into wet biomass (WM) was theorized as follows:

$$\text{WM}_{(\text{kg})} = 2 * \text{DM}_{(\text{kg})}, \quad (14)$$

where WM<sub>(kg)</sub> = wet forage/kg; DM<sub>(kg)</sub> = dry forage/kg; and 2 = represents “twice the dry matter.”

The annual total grass production and its corresponding monetary price (value) accounting were the central themes of this study. Thus, based on physical and corresponding market price data, the total monetary value/annual of the Surra government plantation was investigated (equation (15)).

- (v) The total annual monetary value of grazing was theorized as follows:

$$\text{TAMV}_{(\text{fodder})} = \frac{\text{TAI}_{(\text{fodder})}}{\text{kg}} * \frac{\text{MV}_{(\text{grass})}}{\text{kg}}, \quad (15)$$

where TAMV<sub>(fodder)</sub> = total annual monetary value of grazing (fodder) (ETB), TAI<sub>(fodder)</sub>/kg = total annual DM intake (total animal unit year), and MV<sub>(grass)</sub>/kg = monetary value of a kilogram of grass in the local market.

### 3. Results and Discussion

#### 3.1. Physical Values

**3.1.1. Litter/BLTs.** The BLT production potentials (kg/ha/month) of dry (January) and wet (August) seasons were directly collected from the field and were 96.67 and 56.67, respectively (Table 3). The results demonstrate that the litter production potential during winter is greater than that during summer (Table 3). The seasonal variation in litter production potential between dry and wet seasons might have emanated from the physiological reaction of trees to weather conditions [70, 71].

The total (kg/year) and #/ha/month of BLTs from the same plantation were 158,608 kg and 920 kg, respectively. Similar studies conducted on the Addis Ababa peri-urban eucalyptus plantation demonstrated that BLT production potential/kg/ha/month and kg/ha/year were 35,708 ton/ha and 428,500, respectively [17]. When comparing the litter/BLT production potential of the Surra government plantation with that of the Addis Ababa peri-urban eucalyptus plantation, the peri Addis litter/BLT production potential [17] was 99.2% greater than that of Surra (Table 3), and the difference was insignificant.

The transect-walk data indicate that the Surra government plantation was permanently grazed (Figure 3), illegally logged (Figure 4), and encroached upon by plantation fringe dwellers, and thus, it was highly disturbed. For example, the wood stand density of Surra government plantations (e.g., eucalyptus) was twofold less than that of other counterpart government plantations in Ethiopia [35]. Moreover, the data acquisition approach of the Surra government was ground survey (stock change method) [48, 50], while the peri Addis's was APR (participatory rural appraisal) [17]. The APR information collection techniques encompass semistructured interviews with individuals or groups, transect walking or field observation and experts' opinion data [72], and are subjective.

#### 3.2. Monetary Values

**3.2.1. BLTs/Litter.** The valuing for some NTFPs is not as easy as that for commercial goods due to the absence of market prices [4, 5, 8]. However, the availability of market prices for some NTFPs, such as BLTs and fodder, in the local market of





FIGURE 3: Grazing under the plantation forest (upper left: cowboys) (source: filmed from the field, 2021).



FIGURE 4: Illegally logged boles (source: field photo, 2021).

the study area enabled us to account for using active market prices. Consequently, the market price data in Table 4 demonstrate that the average weight of a bundle/kg of BLTs/litter and its corresponding monetary values for dry and wet seasons are ETB 1.20 and 1.41, respectively. However, the average price (ETB/kg) of BLT products for both seasons was 1.31.

The results in Table 4 depict that the monetary value of litres/BLTs (ETB/kg) is influenced by the variation in seasons. For example, the market price (MP) of 966 kg of litter (BLTs) product at Chenchä town during January (dry season) was ETB 1,159, whereas its average price (per/kg) in the same month was ETB 1.20. The monetary value during August 847 kg of litter (BLTs) was ETB 1,196, and its corresponding average price (per/kg) was ETB 1.41 (Table 4).

Hereby, comparing the prices of the two seasons, the monetary value/kg during the dry season was 14.9% cheaper than its corresponding average price during the wet (August) season. Due to price differences, most litter (BLT) harvesters in the upper Hare-Baso river catchments do not supply their products to markets during the dry season and/or are accustomed to storing and selling during the wet season (summer). Similarly, women who depended on the raking of BLTs from the peri-urban Addis Ababa eucalyptus plantation did the same [17].

The price difference between dry and wet seasons is assumed from the excess production potential of BLTs during dry, windy, and sunny seasons (Figure 5); ease of foot walking (Figure 5) and availability of fuelwood biomasses from



TABLE 4: Physical value/bundles/kg of litter (BLTs) and its corresponding monetary market price (MP) and average price (AP)/ETB/kg.

Seller (code)	During the dry (January) season				During the wet (August) season			
	BLT (kg)	MP (ETB)	ETB/kg	AP (ETB)	BLT (kg)	MP (ETB)	ETB/kg	AP (ETB)
1	63	72	72/63	1.14	67	95	95/67	1.42
2	28	34	34/28	1.21	53	82	82/53	1.55
3	70	83	83/70	1.19	33	47	47/33	1.42
4	57	81	81/57	1.42	46	73	73/47	1.55
5	54	67	67/54	1.24	46	71	71/49	1.45
6	48	62	62/48	1.29	48	67	67/48	1.40
7	65	82	82/65	1.26	51	68	68/51	1.33
8	68	70	70/68	1.03	40	66	66/40	1.65
9	58	65	65/58	1.12	62	78	78/62	1.26
10	58	69	69/58	1.19	70	89	89/70	1.27
11	50	67	67/50	1.34	49	64	64/46	1.39
12	62	77	77/62	1.24	44	63	63/44	1.43
13	53	66	66/53	1.25	42	60	60/42	1.43
14	41	55	55/41	1.34	58	84	84/58	1.45
15	69	74	74/69	1.07	39	64	64/39	1.64
16	54	65	65/54	1.20	52	65	65/52	1.25
17	68	70	70/68	1.03	47	60	60/47	1.28
Total/AP	966	1,159		1.20 847		1,196		1.41
Average price (ETB/kg) of BLTs product for both seasons = ETB 1.31								

Source: field data (2021) (USD = ETB 53.53 at current exchange rate of Ethiopia).



FIGURE 5: Women carrying bundles/bales of litter to Chenchu town during the dry season (source: photo filmed with their consent in December 2021).

different sources such as cow dungs [15, 18]. In contrast, during the wet season, leaf shedding decreases [70]; barefoot walking is difficult due to dirty and muddy roads and cloudy and rainy weather (Figure 6) [45]. However, less access to different sources of fuelwood (despite being easily available in the dry season) increases the demand for BLTs during the wet season that depends on fuelwood for their energy sources.

The total BLTs/litter production potential of the Surra government plantation and its corresponding monetary value were 158,608 and ETB 207,776.50, respectively. The BLTs/kg/ha and its equivalent monetary price were 920 and ETB 1205.2, respectively (Table 5). The physical value/ha/year of BLTs from the Surra government plantation was less than counterpart government plantations around Addis Ababa [16, 17].

The expert opinion and pieces of unstructured interview information triangulate that approximately 40 to 60 women were dependent on the raking of BLTs on a daily basis for only income, whereas 1500 to 2100 women visit the plantation annually for income and household consumption expenses. Similar studies by Olsson [17] demonstrate that 2000 women were dependent on the raking of BLTs from the Addis Ababa peri-urban eucalyptus energy plantation as the sole source of income.

Although the litter/BLTs production potential of the Surra government plantation, particularly eucalyptus, is the most exploited and disturbed government plantation in the upper Hare-Baso rivers catchment and beyond, this was due to the economic reliance of the proximity community (Figures 3, 4, and 7).



FIGURE 6: The “split wood” (a) and the bale of litter (b) probably from an illegally logged Surra government plantation during the semiwet season (sources: photo filmed from field by their consent, 2021).

TABLE 5: The total production potential of BLTs/kg/ha and kg/year and its corresponding monetary values of the Surra subeucalyptus plantation.

The production potential of BLTs/kg			The monetary equivalent/ETB		
Total area/ha	kg/ha/yr	Total kg/yr	Price/kg	Price/ha/yr	Price/total/yr
172.4	920	158,608	1.31	1,205.20	207,776.50

Source: field survey, 2021.



FIGURE 7: Raking of litter/BLTs from the Surra government plantation (source: field survey, 2021).

### 3.3. Physical Values

**3.3.1. Grass/Grazing.** The animal weight proportional DM intake (2% of its mass) per a single animal class/day, #/mon, and #/annual data was adopted from different sources [53, 56]

and adapted to the fodder production of the Surra government plantation (Table 6). Hence, DM intake for a single class of different animal types, such as animal unit (AUD)/day, animal unit month (AUM), and animal unit annual (AUA)/kg, was 12.5, 375, and 4347 kg, respectively (Table 6).

TABLE 6: An animal class, animal unit equivalent (TLU), the average weight of an animal class, and DM intake per day (AUD), per month (AUM), and per annual (AUA) of an animal class.

Animal classes	TLU	Weight (kg)	AUD/kg * 0.02	AUM/kg	AUA/kg	CC/ha/yr	CC/TLU/yr	CC/TLU * 30%
Camel	1	250	—	—	—	—	—	—
Cow, dry	0.7	175	3.5	105	1260	0.73	63	44
Cow, with calf	0.76	190	3.8	114	1368	0.79	70	49
Sheep, dry	0.1	25	0.5	15	27	0.1	9	6
Sheep, with lamb	0.13	33	0.7	21	252	0.15	11	8
Horse	0.8	200	4	120	1440	0.83	72	50
<b>Total =</b>	<b>2.49</b>	<b>623</b>	<b>12.5</b>	<b>375</b>	<b>4347</b>	<b>2.6</b>	<b>225</b>	<b>158</b>

Source: adapted from different studies [53, 57]. (1) 2.49= average TLU (tropical livestock unit; 623 = the corresponding weight for the average TLU (2.49); 12.5 = animal unit per day (per day intake of dry matter for an animal class (0.02% kg intake of their weights)). Here, the assumed dry matter intake per day of the animal classes from the Surra government plantation was 0.02% of their weight. (2) AUM/kg (375) = total dry matter intake per kg of different animal classes per month from the Surra government plantation. (3) AUA (4347) = dry matter intake for animal classes from the Surra government plantation per annual. (4) The 2.6 is the carrying capacity of the Surra government plantation for the total animal classes per hectare. (5) 225 represents the total animal classes/TLU that are stocking at the entire Surra government or/and the carrying capacity of the entire Surra government plantation (235.5ha) annually. (6) 158 = carrying capacity/TLU of the animal classes, but the proper use factor (30%) is deducted. Proper use factor (unpalatable grasses) is 30% of the total grass /fodder production.

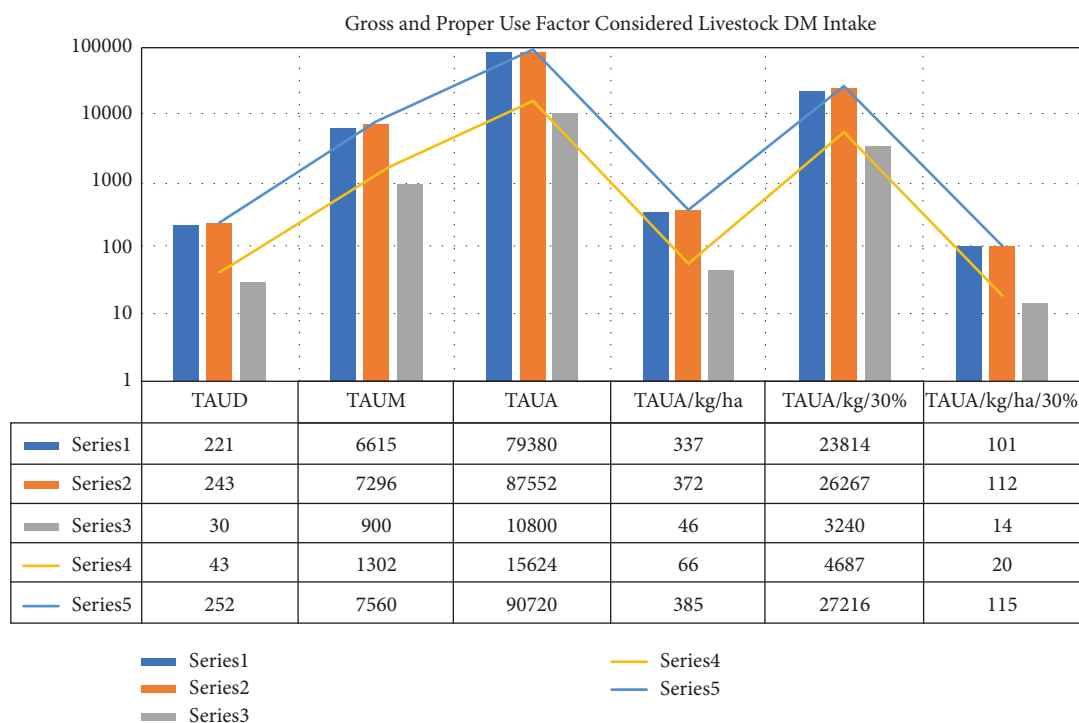


FIGURE 8: Total livestock gross and proper use factor considered DM intake from the Surra mountain government plantation (source: adapted from different types of literature).

The carrying capacity per TLU per year of the Surra government plantation for animal classes such as cow dry, cow with calf, sheep dry, sheep with lamb, and horse was 63, 70, 9, 11, and 72, respectively. The carrying capacity of the total area (235.5 ha) of the Surra government plantation was 225TLU, while the *proper use factor* considered was 158 (Table 6).

The TAUD, TAUM, TAUA, and TAUA/kg \* 30% of the grazing from the Surra government plantation were 789.1, 23673, 1042380, and 312,714 kg, respectively (Figure 8/ Table 7). However, the physical value differences between the gross and *proper use factor* values were due to the deduction

of uneaten grasses (30% of total production) [61, 66]. In other words, approximately 30% of the total grass production of the Surra government plantation was not accessed by livestock.

However, the physical and monetary values of grass/ fodder production from Ethiopian plantation forests were not accounted for [73]. For example, the Ethiopian government estimated that grass/fodder production from plantation forests was 860,993,000 kg (860,933 ton)/year, while the grass/fodder production/kg/ha/yr was 947 [15]. The corresponding fodder production potential of the Surra government plantation was 385 kg (Figure 8). The physical

TABLE 7: The calculated total animal unit (TAU)/day, #/month, #/annual and correct proper use factor (30%) considered grazing of the Surra government plantation.

Animal classes	TAUD/kg * 0.02	TAUM/kg	TAC	TAUA/kg	TAUA/kg * 30%
Cow, dry	220.5	6615	63	291,060	87,318
Cow, with calf	243.2	7296	64	357,504	107,251
Sheep, dry	30	900	60	5,400	1,620
Sheep, with lamb	43.4	1302	62	10,416	3,125
Horse	252	7560	63	378,000	113,400
<b>Total =</b>	<b>789.1</b>	<b>23673</b>	<b>312</b>	<b>1,042380</b>	<b>312,714</b>

Source: adapted from different types of literature [56, 57]. Note: TAC = total animal class; TAUA = total animal unit annual. Total animal unit (TAU)/day, #/month, #/annual and correct proper use factor (30%) considered grazing of the Surra government plantation. Note: Animal Unit (AU) represents the dry matter intake (DM intake). in other words, it is the grass/fodder taken (grazed) by different animal classes. for example, animal classes represents a given animal with its corresponding weight that given by FAO (TLU) and America animal unit equivalent (AUE). Hence, TAUD represents total animal unit per day (total animal grass (DM) intake per day; TAUM (total animal class DM intake per month); and TAUA (total animal classes DM intake per annual). These leads to the total fodder production of the Surra government plantation. However, an animal class in a poor pasture like the Surra intake 2% (0.02) of its weight. The second issue is 30%. 30% represents the assumed uneaten (unpalatable) grasses that the Surra government plantation produces. Therefore, based on these information and the carrying capacity (that tell as the amount/number of animal classes) the grass/fodder production podetial per hectare per annual and the entire forest were quantified. Hence, 789.1 is total single animal classes DM intake per day; for instance, cow dry + cow with calf + ...; 23673 represents the total single animal classes DM intake per month (789\*30 days); 312 represents a number of animal classes, for instance, animal class of cow dry is 63 in number, cow with calf is 64 in number, and so forth. 312, 714 is for example, total animal unit annual (total animal classes DM intake per annual, and deducted 30% of it in order to deduct the uneaten or unpalatable grasses).

TABLE 8: The monetary value of grass/fodder production from the Surra government plantation was priced according to the average price of grass/fodder in the local market.

Animal classes	DMI and corresponding monetary value							
	TAUA	ETB	TAUA/ha	ETB	TAUA * 30	ETB	TAUA/ha/ * 30%	ETB
Cow, dry	79380	71442	337	303	23814	21433	101	91
Cow, with calf	87552	78797	372	335	26267	23640	112	101
Sheep, dry	10800	9720	46	41	3240	2916	14	13
Sheep, with lamb	15624	14062	66	59	4687	4218	20	18
Horse	90720	81648	385	347	27216	24494	115	104
<b>Total (kg)</b>	<b>284076</b>	<b>255669</b>	<b>1206</b>	<b>1085</b>	<b>85224</b>	<b>76701</b>	<b>362</b>	<b>327</b>

Source: adapted to the study area from different studies, 2021. (1) = TAUA (total animal unit annual) represents total livestock stocking (grass production) at the entire Surra government plantation (total animal dry matter intake per annum), which per annum is 284076 kg, and its corresponding monetary value is ETB 255669 (a USD=ETB53.24). (2) TAUA/ha (total animal unit annual) represents the total animal dry matter intake per hectare, which per annum (grass production per hectare/annual) is 1206 kg, and its corresponding monetary value is ETB1085. (3) The 85224 kg represents total grass production potential of the Surra government plantation by deducting uneatable grasses (30%) and its corresponding monetary value is ETB76701. (4) The 362 kg represents the grass production (total animal unit per annual) per hectare by considering the unpalatable grasses and its corresponding monetary price was ETB 327. Note. AUA/month indicates the grass/fodder production potential of the Surra government plantation.

value of the fodder/grass production potential of the Surra government plantation was 38% of the Ethiopian (Figure 8), and/or the Ethiopian government is 62% greater than the Surra/kg/ha [14, 15]. The grass/fodder production potential kg/ha variation may be due to dissimilarity in accounting approaches and methodologies [18, 61], the absence of standardized and harmonized NTFP accounting methodologies [61], lack of active market price data [74], less availability of related (default) data [75], and agroecology differences [39] in growing grasses. Moreover, the *proper use factor* (30%) considered grass/fodder valuation is another factor [61, 65]. Canopy differences also affect the grass distribution in forests [76], whereas some types of grasses are unpalatable [64].

### 3.4. The Monetary Values

**3.4.1. Grass/Fodder.** One of the greatest challenges in monetary valuation for NTFPs is obtaining active market prices for each NTFP [9, 77]. However, for this study, the maximum efforts were made to obtain the maximum and minimum

surplus values for producers and consumers [4]. Therefore, the monetary equivalent of the annual production potential of NTFPs, particularly grasses/fodder, of the Surra government plantation was embedded in the active market prices.

The average monetary value of a kilogram of wet grass/fodder during autumn (better available season) and winter (rarely available season) in Chenchu town was ETB 0.90. Table 8 indicates that the gross total annual, total annual/ha, proper uses factor considered total annual monetary values of grasses/fodders were ETB 255669, 1085, 76701, and 327, respectively. The gross monetary value of grasses/ha/annual of the Surra government plantation and the proper use factor-based value were ETB 1206 and ETB 142, respectively, while the Ethiopian value was ETB 0.53 [15]. The monetary value of grass/ha/annual of the Surra government plantation was 99% (Table 8) of the Ethiopian government [15].

Monetary price differences between the Surra and Ethiopian government plantations were supposed to be a lack of updated monetary data of NTFPs in the forest databases of the Ethiopian government [75], the grass/fodder and its corresponding monetary value data



acquisition technique (methodology) variations [74], the devaluation of currency (rate of exchange) at the moment [78], and other factors.

#### 4. Conclusion and Recommendations

The total BLTs/litter production potential of the Surra government plantation and its corresponding monetary value were 158,608 kg and ETB 207,776.50; #/kg/ha/year and total/kg/year were 920 kg and 158,608 kg, and their equivalent monetary prices were 920 and ETB 1205.2, respectively. The average monetary values of litter/BLTs/kg per wet and dry season were ETB 1.40 and 1.20, respectively. The litter production during the dry season was greater, while the price/kg/ETB during the wet season was greater. The TAUD, TAUM, TAUA, and TAUA/kg \* 30% of the grazing from the Surra government plantation were 789.1, 23673, 1042380, and 312714 kg, respectively. Likewise, TAUA, TAUA/ha, TAUA \* 30, and TAUA/ha/ \* 30% per kg were 284076, 1206, 85224, and 362, whereas the representing monetary prices were ETB 255669, 1085, 76701, and 327, respectively.

The litter/BLT production potential of the Surra government plantation was lower than that of the other government plantations, which demonstrates a weak management system over the government plantations. The proper use factor considering the physical and monetary value of fodder was specific and represented the ground facts. The integrated grass data collection approach is applicable in permanently grazed and communal grazing lands. In other words, the integrated fodder data collection approach is suitable for collecting grass/fodder data from poor and permanently grazed pasture of plantation forests and is novel in this study. The market price-based monetary values of grasses and litter are more specific and representative than the default data-based results. However, multiple NTFPs are not valued physically and monetarily and seek further accounting and investigations. Since the management intensity was weaker, there should have been policy revisions and decisions.

#### Data Availability

The findings of this article are publicly available wherever necessary. Thus, the data are openly accessible and reusable. In other terms, all data created during this research are openly available for anybody and/or not restricted, and publicly can be used and shared. All figures and images are the researchers' own work and in text properly in the article. This publication is supported by multiple datasets and are openly available at public repository, and in text and cited in the reference section of the article.

#### Conflicts of Interest

The authors declare that they have no conflicts of interest.

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