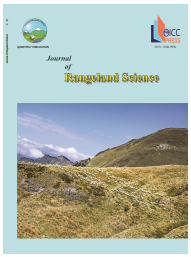

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Economic value of Morocco Oued Beht Watershed rangeland habitats in terms of forage production

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Abstract:
Rangelands represent a potential resource with a high socio-economic value. This value remains unmonetarized and therefore, not taken into account in public policies, which does not reflect the real value of this Ecosystem Services (ES) and negatively affects the sustainable management of rangelands. This study was carried out in 2019; it aims to estimate the economic value of the supply service of the rangelands and to demonstrate its place in the local economy. The result reflects the socio-economic importance of this service, offering an average of 22.65 million forage units (FU/year = 1 kg barely grain), with the gross economic value of 6.79 million USD/year. The study also illustrates the degree of pressure on these pastoral ecosystems, represented by high overgrazing rates and negative net economic value. The comparison between the supply and demand of forage units shows an average cost of degradation of 760 USD/ha in forests and 209 USD/ha out of forests, which negatively affects the sustainable management of these resources. To this end, the strategies adopted must respond to all environmental and socio-economic challenges, based on the preservation of the fragile environment to benefit the socio-economic development of local populations. These strategies must give users a sense of responsibility in the process of setting up, monitoring, and eventually adapting the management systems practiced.

Keywords: Rangeland; Economic value; Overgrazing; Sustainable management

1. Introduction

Ecosystem Services (ES) have always played a fundamental role in socio-economic development in different countries in the world and in sustaining human well-being [1–3]. However, ES is considered as the backbone of economic development for developing countries where these resources represent the capital of production. The rangeland is one of the most important ES, playing an important socio-economic and environmental role. According to Donald et al., in many developing countries, rangelands are vital to the subsistence of a significant proportion of the population [4]. It supports 2.0 billion people and 50% of the world's livestock [5]. Pastoral livestock provides income to more than 1.2 billion people living on less than 1 a day [4, 6, 7].

In Morocco, rangelands have a privileged position in the economy of rural populations [8–10]. These ecosystems are the main source of income for poor livestock keepers who usually graze on communal and/or public land free access, constituting a reserve of resources on which the reproduction of the pastoral system is based. Livestock farming represents an important part of agricultural gross domestic product, and it is carried out in rangelands where small ruminants graze in a traditional extensive way. This extensive livestock farming has a considerable advantage, especially in the steppe and mountain regions, where improving this activity is the best option for resource development and management.

Rangelands represent a national heritage both in terms of the space they cover and the wealth they contain [11]. Offering large quantities of forage reflecting all the above-ground biomass palatable to livestock, rangelands contribute to the supply of livestock through their contribution to phytomass capital [12].

In Morocco, pastoral ecosystems cover an area of 53 million ha. Silvopastoral areas cover 9 million ha representing 12.7% of the national rangeland areas [7]. The forest rangelands cover 17% of the herd's. However, the application of this partnership reveals some flaws in the text's provisions,

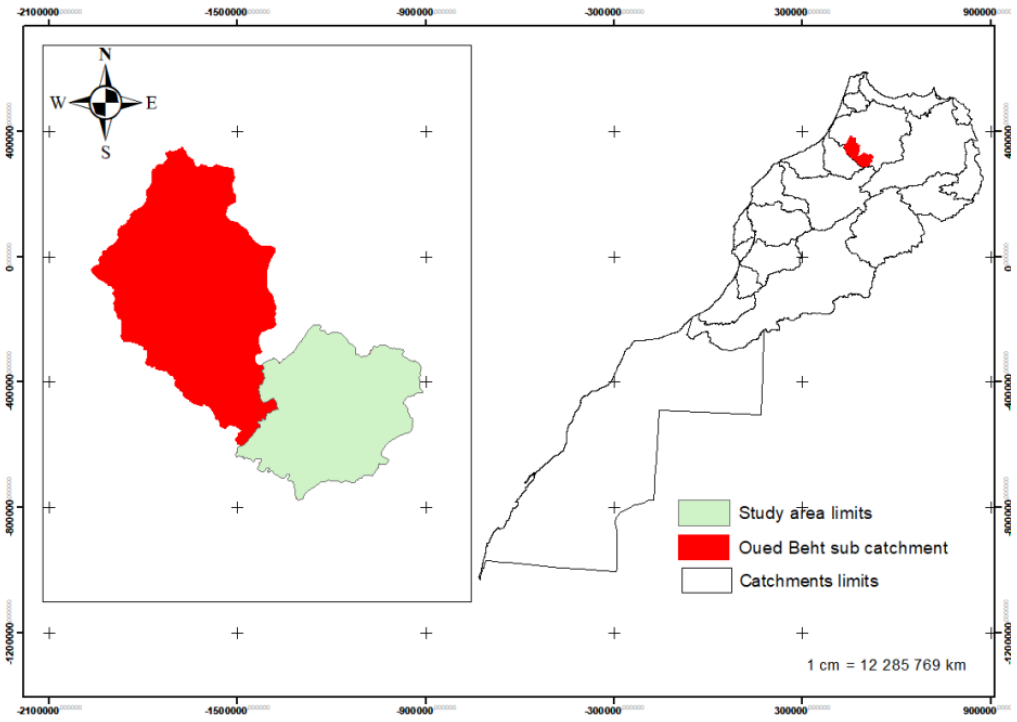

Figure 1. Location of the study area.

particularly concerning the amount of compensation (27.5 USD/ha), and the minimum area to be compensated, which are insufficient. The notion of those entitled to compensation also poses a problem for the mechanism's proper functioning. For this purpose, it is essential to conduct specific research to clarify these concerns and calculate the required willingness of the local population to purchase the use rights in each pastoral area based on sound science.

In addition, these studies should analyze the possibility of setting up a collective payment system for ES and choose the most suitable one for the Moroccan context that could influence the individual voluntary subscription of farmers within the community.

Certainly, the compensation mechanism for the defenses of forest land is one of the faces of the partnership and participatory approach to which the Moroccan Department of Water and Forests is committed to the sustainable management of natural resources. However, ownership of the compensation mechanism remains modest and needs to be improved and consolidated to achieve the conservation objectives.

Considering that rangeland is an ecological factor of the ecosystem providing many environmental, social, and economic services, an ecosystem approach combining socially and economically sustainable ways is a solution to ensure the maintenance of these ES on which human well-being depends on forage balance, which corresponds to 5 billion forage units per year, contributing to the satisfaction of 80% of the animals' food needs [13–21].

Nevertheless, the Moroccan rangelands are not enough to satisfy the forage needs of the livestock. The deficit is relatively pronounced depending on the region and explains the different situations of degradation of the vegetation cover and the soil. The rangelands are currently suffering a regression, as demonstrated by the significant decrease in communal areas accompanied by the impoverishment of the floristic procession. Aridity coupled with the overuse of resources and disruption of ecological and environmental balances also contribute to the fragility of these pastoral ecosystems to different degrees and negatively affect their sustainable management [22, 23].

It should also be noted that extensive livestock production is like most ES that are not traded in formal markets and whose financial values cannot be obtained directly. Given the degree of degradation of pastoral resources and its socio-economic consequences, it was important to know the economic value of the forage production of these rangelands and the threats faced by these resources. Certainly, the economic value of this ES is not limited to the appreciation of the market value. However, in this study, only this type of production that generates significant benefits for the local population is considered.

This study aims at understanding the state of pastoral areas in the Oued Beht watershed to characterize them in terms of range yield, grazing capacity, and economic value. This is essential to expose the situation and highlight the consequences of disconnecting economic and ecological aspects to alert decision-makers to the costs generated.

2. Materials and methods

2.1 Study area

Our study area is the upstream part of the Oued Beht watershed, which occupies the south-western part of the Sebou watershed with an area of 168350 ha (Fig.1).

Administratively, the watershed area extends over 3 provinces and 9 communes, the province of Ifrane rep-

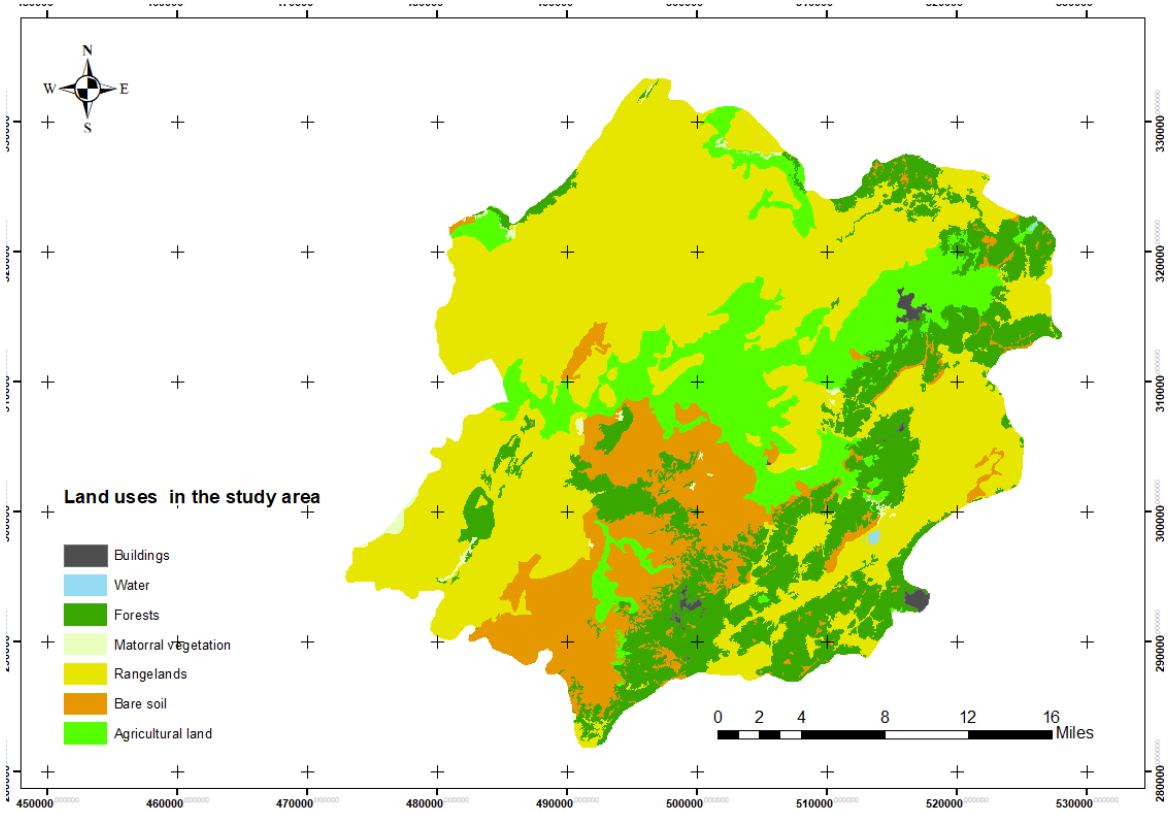

Figure 2. Land use map of the study area.

resents 76.76% of the total surface area, followed by the province of Khenifra with 17.32%. El Hajeb remains the least represented with a surface area not exceeding 6%.

Based on the results of the General Census of Population and Housing, the human population is 41647, the number of households is 9330, and the average size is 4.46 inhabitants per household, which is lower than the national average in 2014 (4.6 inhabitants/household). The number of households is shared between rural households representing 88.54%, and urban households representing only 16.46%, the unemployment rate is approximately 10.47% [24]. This rate is higher than the national average, which is 9.9%. These two indicators show the low income of the study area's population, which makes them very attached to the natural resources.

The area is characterized by extensive pastoral and silvopastoral areas, where livestock systems are generally of the extensive pastoral type based on forest and non-forest rangelands. This type of livestock farming represents the main activity of the local population in the area.

2.2 Research method

Land use mapping was the first step in this study. A Geographic Information System (GIS) was developed, and the land cover map was produced using a series of Landsat satellite images of the year 2018, with a spatial resolution of 30 m. For the classification of the images, a supervised classification was used [25].

To check the results obtained, we also rely on the analysis of cartographic documents already produced in the study area. Map in the paper format was also scanned and digitized. The objective is to map areas of each land use that will be used to determine the yield afterward.

After mapping the different pastoral and silvopastoral areas,

Table 1. Forage supply of forest-rangeland areas as Fodder unit (FU) equal to 1 kg of barley grain. (Total Fodder supply: 13.6 million FU/year. Fodder supply per hectare: 387.5 FU/ha/year.

Forests	Area (ha)	Fodder supply (FU/ha/year)*	Total fodder supply (FU/year)	Percentage (%)
Jaaba	2001	300	0.60 million	4.39%
Azrou	9933	350	3.47 million	25.43%
Sidi M/guild	11013	400	4.40 million	32.22%
Ain Leuh	10379	500	5.18 million	37.96%
Total	33326	387.5	13.67 million	100%

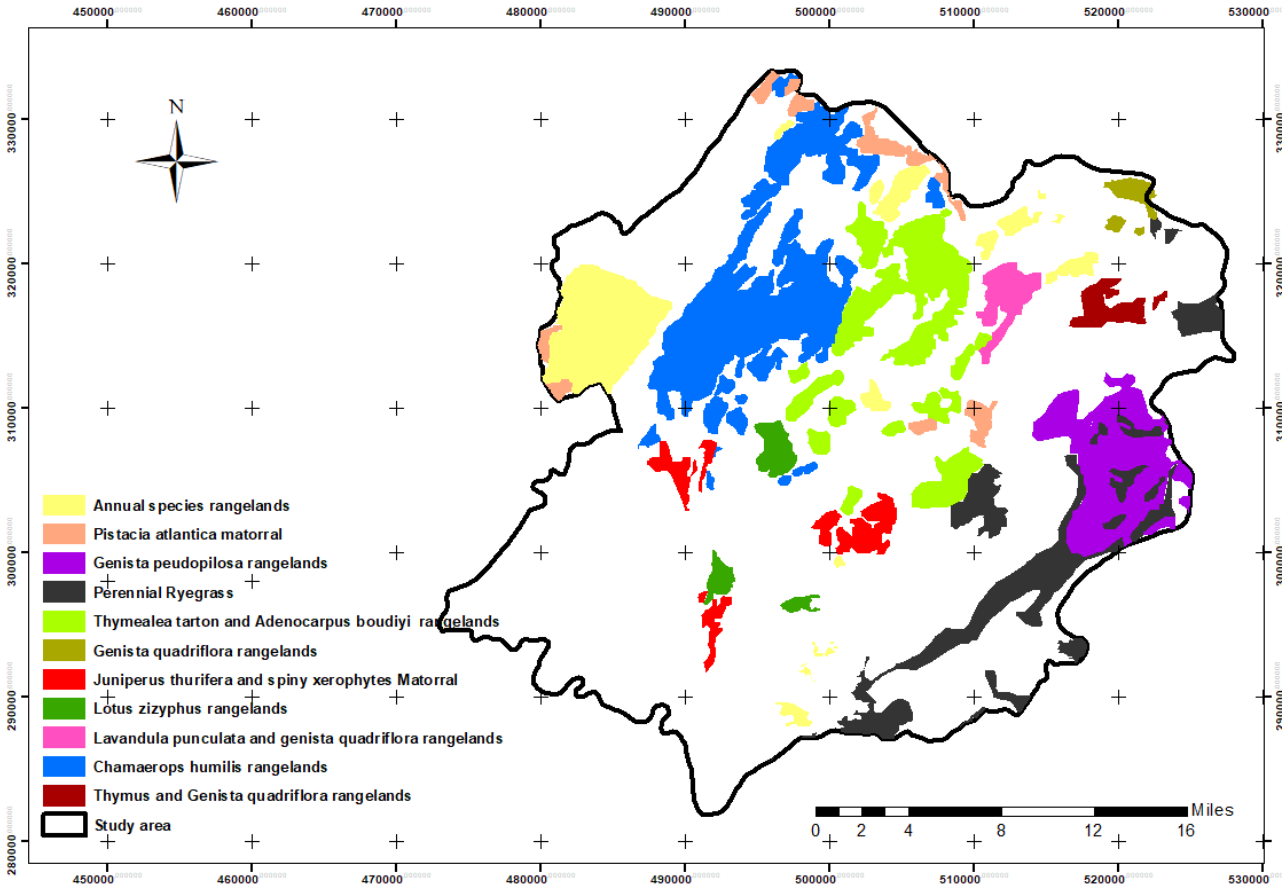

Figure 3. Distribution of pastoral rangelands out of forest.

we quantify forage production from rangelands forests and out of forests based on:

Forest rangelands: To obtain the total forage supply of forest rangelands, we multiply the forage supply as a Fodder unit (FU/ha) of each forest in our study area by its area included in our study area. Forage supply of non-forest rangelands: We multiply the average annual quantity of forage offered by each pastoral rangeland (FU/ha) by its actual area included in the study area.

The data of forest forage production were recovered from the forest management plans and the study of concerted management of forests and collective rangelands in the province of Ifrane forage supplemented by field surveys [26].

The phytomass assessment method used in this study was based on the measurement of the total aerial phytomass in situ (sites in pastoral zones), done by double sampling technique, i.e. by cutting and visual estimation. The methodol-

Table 2. Fodder supply of pastoral rangelands outside forests as Fodder unit (FU) equal to 1 kg of barley grain. (Total fodder supply (FU/year): 8,986,573. Fodder supply per hectare (FU/ha): 156.58)

Pastoral rangelands	Area (ha)	Area (%)	fodder resources		
			FU/ha/year	FU/year	Percentage
Genista quadriflora	642	0.38%	171	109,782	1.22%
Thymus and Genista quadriflora	170	0.10%	217	36,890	0.41%
Pistacia atlantica matorral	2,411	1.43%	112	270;032	3.00%
Chamaerops humilis	13,769	8.18%	111	1,528,359	17.01%
Lavandula punculata and genista quadriflora	1,418	0.84%	128	181,504	2.02%
Zizyphus and lotus	1,412	0.84%	86	121,432	1.35%
Thymealea tarton and Adenocarpus boudiyi	8,733	5.19%	163	1,423,479	15.84%
Juniperus thurifera and spiny xerophytes Matorral	2,532	1.50%	173	438,036	4.87%
Annual species	7,663	4.55%	142	1,088,146	12.11%
Genista peudopilosa	8,278	4.92%	186	1,539,708	17.13%
Lolium perenne	10,365	6.16%	217	2,249,205	25.03%
Total	57,393	34.09%	8,986,573	100.00%	

Table 3. Distribution of livestock by province and commune in the study area.
(* is a territorial authority under public law, with legal personality and financial autonomy.
[1] The weight of the reference sheep is 25 kg.
[2] The weight of the reference cattle is 250 kg.
[3] The weight of the reference goat is 20 kg.)

Province	Commune*	Sheep No.[1]	Cattle No.[2]	Goat No.[3]	Total
El Hajeb	Ait Bourzouine	1,583	85	395	2,063
	Tamchachate	1,575	113	355	2,043
Ifrane	Tigrigra	25,000	1,875	2,000	28,875
	Ben Smim	76,500	1,710	5,400	83,610
	Sidi El Makhfi	90,000	1,300	10,000	101,300
	Timahdite	81,000	975	6,000	87,975
	Oued Ifrane	4,200	113	800	5,113
	Ain Leuh	41,360	616	4,400	46,376
Khenifra	El Hammam	32,808	11,850	14,496	59,154
Total		354,026	18,637	43,846	416,509
Percentage		85.00%	4.47%	10.53%	100%
head/ha		3.9	0.20	0.48	4.59

ogy adopted is essentially stand-based on measurement of total dry matter production using a standard method.
Other data were collected in 2019 through agricultural and livestock statistics available from the 'Regional Directorate of Agriculture of Fez Mekneś, the National Inter professional Office for Cereals and Pulses. The monetary value of rangelands was calculated based on the use-value of this ecosystem service. Two methods can be used: one based on the actual market behaviour of users of ES described by revealing preference methods, and another one based on users' stated preferences for ES that are not traded on the market [27, 28].
In this work, an approximation of the use-value which reflects the value of secondary production from rangelands has been determined by the market price of similar or substitute products called substitute price. This method is a category of revealed preference methods where the substitution cost can be used to estimate the value of rangelands based on the analysis of substitute markets. Substitute products provide the same types of benefits as natural resources [29, 30].

3. Results

3.1 Land use of the study area

Based on the results of land use, seven land-use classes were identified (Fig. 2). Rangelands are the most representative, it occupies 50.83% of the total surface of the study area. Forests come in second place with 19.79%. In third place, we find bare land with 13.64%, then, agricultural land with a share of 12.10%. That demonstrates the importance of ES related to forests and rangelands.
The results show that within the study area, there are four managed forests with a total area of 33326 ha (Table 1). The Sidi Mguild forest with a total surface area of 11013 ha (33.05%) followed by the Ain Leuh forest (31.14%), in the third-place, one finds the Azrou forest (29.81%) and in the last position, the Jaaba forest with a percentage of 6%.
For pastoral rangelands out of the forest, Fig. 3 shows their distribution in the study area. The main pastoral plant formations found are the rangelands based on Thymus and Genista quadriflora, Chamaerops humilis, Lavandula punculata, Lotus zizyphus, Thymealea tarton and Adenocarpus

Table 4. Type of livestock demands based on standard Livestock Small Unit (SLU) in forest and non forests area.

Type of livestock	Livestock No.	LSU	Demand (FU)	Percentage	Demand in Forests (FU)	Demand in non Forests (FU)
Sheep (1 SLU)	354,026	354,026	106.20 million	72.09%	70.80 million	35.40 million
Cattle (5 SLU)	18,637	93,185	27.95 million	18.98%	18.63 million	9.31 million
Goat1 (1 SLU)	43,846	43,846	13.15 million	8.93%	8.76 million	4.38 million
Total	416,509	491,057	147.31 million	100%	98.21 million	49.10 million

Table 5. Forage supply indicators, including Equilibrium Load (EL) and Grazing coefficient.
(The percentage of habitat, forage production which can be harvested each year is 13,92%
*1 FU is equivalent to 1,760 Kcal or 7,36 Mj.
1 sheep needs 300 units of fodder, which is equivalent to 2208 Mj.
1 goat needs 300 units of fodder, which is equivalent to 2208 Mj.
1 cattle needs 15000 units of fodder, which is equivalent to 11040 Mj.)

	Forestry (8 Months)	Out of forest (4 Months)
Area of pastoral land	33,326	57,393
Total small livestock units	327,371	163,686
Fodder requirements (FU/year)	98.21 million	49.10 million
Potential in (FU/year)	13.67 million	8.98 million
Metabolic energy*(Mj)	100.62 million	66.14 million
Actual load (LSU/ha)	9.82	2.85
Equilibrium load (EL)	0.14	0.18
Overgrazing coefficient (%)	98.57%	93.68%

boudiyi, Genista peudopilosa and the matorral based on Pistacia atlantica and Juniperus thurifera and spiny xerophytes. The total area of these facies was estimated at 57393 ha. The plant productivity per hectare (FU/ha) differs according to the plant composition.

3.2 Production of forest rangelands

Based on the forage supply extracted from the management plans of each forest included in the study area, the annual production of forage in the forest is estimated at 13.6 million FU/year, or an average of 387.5 FU/ha/year (Table 1).
This offer was represented in Ain Leuh forest by 37.96%, then Sidi M'guild forest by a percentage of 32.22%, and followed by Azrou forest by 25.43%. With a proportion of 4.39%, the forest of Jaaba comes in the last position.
This average supply per hectare is comparable to the supply of the Tazeka National Park and the results of forage production in the provinces of Andalusia, estimated between 491 and 381 for hardwoods, and between 452 and 229 for shrublands [9, 31].

3.3 Production of pastoral areas out of forests

Estimating the forage supply of non-forest rangelands is presented in (Table 2). The annual supply is estimated at 8.98 million FU/ha, i.e. an average of 156.58 FU/ha. Grassland based on perennial ryegrass comes in first place in terms of forage units with a percentage of 25.03%, followed by rangelands with Genista peudopilosa (17.13%), rangelands with Chamaerops humilis (17.01%), and rangelands with Thymus and Genista quadriflora come in the last place with a percentage of 0.41% (Table 2).

3.4 Estimating the value of forage production

The annual contribution of the study area in forage units amounts to 22.65 million FU/year.
The supply from forest areas represents more than half (60.33%), followed by non-forest areas with a percentage (39.67%), which shows the importance of forests in the global forage production.
The quantities estimated above are valued using the substitute price method often used in low-monetarist economics. The value of forage is estimated at the price of the equivalent forage units (1FU $\sim$ 1kg of barley grain) calculated by taking the average of prices observed at the level of markets during the last six years between 2014 and 2019. This average price is 0.29 USD for 1 Kg. The revenues generated are estimated in (Fig. 4).
The annual forage value was of the order of 6.79 million USD/year, of which the forest contributes approximately with 4.09 million USD/year and the areas out of forests with 2.69 million USD/year. The average monetary value per unit area of forests is around 123 USD/ha whilst non forest areas are represented by a value of 47 USD/ha, which proves the importance of forests in the monetary supply of rangelands. The total forage value of one hectare in all types of area combined is 170 USD/ha.

3.5 Calendar of feed and livestock management

In the study area, the herds graze in the forest for eight months (in the mountains). They only start to move to non-forest rangelands during the four months of snow (November to February). The dependence on natural resources is mainly due to the high prices of supplements, the poverty of the herders, and the presence of forests for which the herders have a right to use [21].
Two geographical domains are distinct, namely Azghar and Jbel, where herds move in winter to graze on the plateau (Azghar) for approximately four months and stay in the forests (Jbel) in summer from melting of the snow until its reappearance for eight months [32]. During their time in the forests, the herds take in several forage units equal to almost 100% of their food needs.
This geographical complementarity expressed by reciprocal movements between the two regions through transhumance illustrates the role of natural resources for grazing [33].
Thus, the maintenance of animal grazing in mountain areas without any supplementation can only be ensured by adopt-

Table 6. The net economic value of fodder.

	Forests	Out of forest	Total
Area of all pastoral rangelands (ha)	33,326	57,393	90,719
Supply of fodder units (FU)	13.67 million	8.98 million	22.65 million
Price of 1 Kg of barley (USD/Kg)	0.29$		
Value of fodder supply (USD/year) (1)	4.09$ million	2.69$ million	6.79$ million
Demand for fodder units (FU)	98.21 million	49.10 million	147.31 million
Fodder demand value (USD/year) (2)	29.44$ million	14.72$ million	44.16$ million
Net fodder value (USD/year) (1)-(2)	-25.34$ million	-12.02$ million	-37.37$ million
Average degradation cost (USD/ha)	760 $	209 $	412 $

ing efficient management capable of providing good quality of rangelands during all year seasons [34].

3.6 Forage demand

The number of livestock stands at 354,026 sheep, 43 846 goats, and 18,637 cattle (Table 3). From these Figures, and based on a total area of 90719 ha supporting the rangeland in the study area, it is clear that the average user livestock for all miles of the study area is about 3902 sheep, 483 goats and 204 cattle, sheep are the most representative with a percentage of 85%. We can conclude that our area is devoted to sheep farming.

Based on the definition of an animal unit, which reflects the herbivore's capacity to take grass, one livestock unit (LU) refers to 250 kg cattle, which is equivalent to 5 small livestock units (SLU) equivalent to a 25 kg sheep or 20 kg goat.

A small livestock unit (LSU) of goats or sheep has a feed requirement of about 300 (FU) than that for larger livestock unit (cattle), this is equal to 5 small livestock units (SLU), i.e. 1500 FU/year. Table 5 shows the results obtained.

The overall demand for livestock is estimated at more than 147.3 million FU divided between sheep, cattle, and goats in the following proportions: 72.09%, 18.98%, and 8.93%, respectively. The demand for forests, which is 98211400, is the most important with a percentage of 66.66%. Compared to the annual forage production of the study area, the available forage represents only 15.38% of the total forage demand per year (Table 4). To deepen the analysis and to compare the needs of the livestock with the exploited pastoral potential in the study area, an analysis of the following indicators is necessary:

1· The grazing livestock density (GLD): corresponds to the stock of grazing animals expressed in livestock standard units (LSU) per hectare of rangeland. GLD = Number of LSU/ study area rangelands in ha.

2· The Equilibrium Load (EL): based on the forage production compared to the livestock's need for LSU. This indicator corresponds to the load that a range can support without compromising its sustainability.

EL = SUPPLY(FU)/DEMAND(FU).

Grazing coefficient = (1-EL/ GLD) $*$ 100

These indicators provide a quantitative assessment of rangeland degradation in terms of impact and pastoral pressure [20]. Based on the total quantity of forage units taken by all the livestock in the study area, compared with the potential of the rangelands in terms of FU (Table 5), the study area is under high pastoral pressure. The forage deficit can be estimated at 84.53 million FU in forests and 40.11 million FU out of forests, or a total of 124.65 million FU represented by overgrazing percentages of around 98.57% in forests and 93.68% out of the forests.

The exploited pastoral potential in the area does not exceed an average of 4% of the annual livestock needs. This situation is in a state of opposition to the long-term objectives of sustainable use of the rangelands and the short-term needs of meeting the food requirements of the livestock [4]. It, therefore, causes a reduction in the biological and economic productivity of the land, which negatively affects hydrology, soil processes, and vegetation composition.

Overgrazing is considered as the main factor of degradation, affecting both soil and ecosystem components and is also a problem for forest regeneration [10, 35–37]. It contributes to rangeland degradation altering plant community composition and biodiversity [38].

The net economic value of forage is determined by multiplying the quantities in forage units by the unit price of the substitute, which is barley (0.29 USD/kg). The gross value of the forage supply is estimated at 6.79 million USD/year whereas the net value is minus 37.37 million USD/year (Table 6). This means that the costs of inefficient use of these resources are higher than the benefits.

As removals far exceed the forage supply, this constitutes overexploitation of natural resources, causing negative effects that can be assessed as negative externalities affecting the composition and structure of plant and soil communities by reducing biomass, nutrient enrichment, and overall regeneration [14, 39, 40].

The economic value of this negative externality is calculated by multiplying the number of forage units taken by oversupply (124.65 million UF) by the product substitute price. This value is estimated at 37.37 million USD/year (Table 6).

This externality generates a degradation cost of 760 USD/ha/year in forest area and 209 USD/ha/year out of forests, or an average cost of 412 USD/ha/year, causing a loss of productive capacity and accentuated soil erosion, the effects of which go beyond pastoral ecosystems. This result

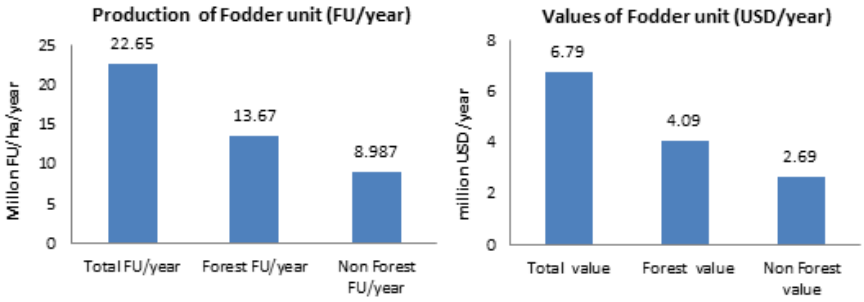

Figure 4. Estimating of forage production and thier values in forest and non-forest rangelands.

shows that rangeland degradation causes not only ecological losses, but also significant economic losses [41].

Thus, the ecosystem service of rangelands cannot continue to ensure these roles in the economic and social organization of the riparian populations that will take into consideration the current situation of degradation of the rangelands and contribute to the healthy and sustainable management of these spaces.

4. Discussion

In the study area, grazing constitutes a socio-economic balance factor, allowing cohesion and social solidarity through the collective use of pastoral resources. This practice generates an economic value for the rural population of 6.79 USD per year or 169 USA/ha/year.

Grazing is recognized as a right of use devolved to the local populations and consequently exercised without concern for the renewal of the pastoral resource, which leads to the over exploitation of rangeland resources caused by an imbalance between the actual herd load and the pastoral potential of these areas. This imbalance affects the sustainability of pastoral resources and generates an average annual degradation cost of around 412 USA/ha/year.

In the face of this situation and the erosion of the traditional management institutions that governed the common use of the pastoral area, regulated the use of rangelands, and resolved conflicts between herders and neighbouring communities, it is necessary to move to modern institutions that involve the users in the development process.

Given that grazing is an interaction between two components of humans and herds that interact on the same territory, any strategy converging from a partnership approach is unlikely to succeed [42, 43]. The human factor must be the cornerstone in inclusive partnership co-management policies for these rangelands, recognizing that the effectiveness and efficiency of natural resource conservation policies are largely dependent on their desirability by populations.

For this purpose, the forestry administration has set up a compensation mechanism to protect forest land, which underpins the temporary purchase of the rights use and the organization of right holders into institutions working in the rational management of rangelands. It consisted of establishing a contract under which grazing avoided by users is remunerated by the Department of Water and Forests considered as the buyer of the environmental service.

For this reason, several attempts have been made in the study area since 2008 to set up pastoral associations. Today, there are five associations in the study area, with around 1173 members and a surface area of 5387 ha. The benefits generated for the local population are in order of 148377 USD per hectare at a rate of (27.5 USD/ha). Managing grazing intensity using exclusion fencing indeed contributes to a significantly higher perennial vegetation cover [38]. Furthermore, associations played a mediating role in reducing the pressure on pastoral resources and contributed to providing financial support to small socio-economic projects of collective interest, promoting solidarity between groups of rights-holders in the forest.

However, the application of this partnership reveals some flaws in the text's provisions, particularly concerning the amount of compensation (27.5 USD/ha), and the minimum area to be compensated, which are insufficient. The notion of those entitled to compensation also poses a problem for the mechanism's proper functioning.

For this purpose, it is essential to conduct specific research to clarify these concerns and calculate the required willingness of the local population to purchase use rights in each pastoral area based on sound science.

In addition, these studies should analyze the possibility of setting up a collective payment system for ES and choose the most suitable one for the Moroccan context that could influence the individual voluntary subscription of farmers within the community.

Certainly, the compensation mechanism for the defenses of forest land is one of the faces of the partnership and participatory approach to which the Department of Water and Forests is committed to the sustainable management of natural resources. However, ownership of the compensation mechanism remains modest and needs to be improved and consolidated to achieve the conservation objectives.

Considering that rangeland is an ecological factor of the ecosystem providing many environmental, social, and economic services, an ecosystem approach combining socially and economically sustainable ways is a solution to ensure the maintenance of these ES on which human well-being depends [13–19].

5. Conclusion

This research has shown that natural resource conservation consists of choosing between several management compromises to balance benefits and costs.

Thus, in a socio-economic context dictated by the

production system practiced and socio-environmental constraints, it is imperative to opt for a participatory management system. This system will give users a sense of responsibility in the process of setting up, monitoring, and eventually, adapting the management systems practiced.

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The authors declare that they have no conflict of interest.

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