Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

WOOD-BASED MARKET IN RIO GRANDE DO NORTE BETWEEN 1999 AND 2019

Luciélia Lacerda da Silva[1*], Pompeu Paes Guimarães[2], Vinicius Gomes de Castro [3], Flavio Cipriano de Assis do Carmo[4], Natalia Isabel Lopes Quirino[5], Edyla Maria Alves Nobrega[6]

[1*]Universidade Federal Rural do Semi-Árido, Centro de Ciências Agrárias, Departamento de Ciências Agronômicas e Florestais, Mossoró, Rio Grande do Norte, Brasil - * lucielialacerda@gmail.com
[2]Universidade Federal Rural do Semi-Árido, Centro de Ciências Agrárias, Departamento de Ciências Agronômicas e Florestais, Mossoró, Rio Grande do Norte, Brasil – pompeu.guimaraes@ufersa.edu.br
[3]Universidade Federal Rural do Semi-Árido, Centro de Ciências Agrárias, Departamento de Ciências Agronômicas e Florestais, Mossoró, Rio Grande do Norte, Brasil – vinicius.castro@ufersa.edu.br
[4]Universidade Federal de Campina Grande, Unidade Acadêmica de Engenharia Florestal, Patos, PB, Brasil – flavio.carmo@ufcg.edu.br
[5]Universidade Federal de Campina Grande, Unidade Acadêmica de Engenharia Florestal, Patos, PB, Brasil – isabelnataliaquirino@gmail.com
[5]Universidade Federal de Campina Grande, Unidade Acadêmica de Engenharia Florestal, Patos, PB, Brasil – edyla-maria@hotmail.com

Received for publication: 02/09/2022 – Accepted for publication: 07/06/2023

Resumo

Mercado dos produtos madeireiros praticados no Rio Grande do Norte entre 1999 e 2019. O objetivo do trabalho foi analisar o mercado de lenha, carvão e madeira em tora no estado do Rio Grande do Norte no período de 1999-2019. Foram utilizados dados disponibilizados pelo Instituto Brasileiro de Geografia e Estatística (IBGE) referentes à quantidade produzida, valor unitário (VU) e o valor bruto de produção (VBP), subdivididos conforme as mesorregiões Agreste, Central, Leste e Oeste potiguar. Essas variáveis foram apresentadas na forma de estatísticas descritivas, sendo o VU e VBT deflacionados com ano base em 1999. Ademais, foram analisados os produtos explorados, a área total explorada, o tipo de corte e a situação referente aos planos de manejo florestal sustentável - PMFS, conforme disponibilizado pelo Centro Nordestino de Informações Sobre Plantas - CNIP. Os resultados gerados permitiram que fosse observado que a região Oeste se destacou na produção de lenha, sendo a segunda maior produtora de carvão e a única produtora de madeira em tora. O maior VU por tonelada de carvão ocorreu em 2016 nas mesorregiões Agreste e Oeste; em 2018, na mesorregião Central e, em 2013, na Leste. O maior VU por metro cúbico de lenha ocorreu em 2017 para as mesorregiões Agreste e Central, e em 2019, na Leste e Oeste potiguar, respectivamente. A mesorregião Central apresentou o maior número de PMFS do estado, sendo a maioria dos planos que estão ativos atualmente utilizados para a exploração de lenha. A mesorregião Oeste potiguar apresentou apenas dois ativos.
Palavras-chave: lenha, carvão e madeira em tora.

Abstract

The objective of this work was to analyze the firewood, charcoal and roundwood market in the state of Rio Grande do Norte (RN) in the period 1999-2019. Data provided by the Brazilian Institute of Geography and Statistics (IBGE) were used referring to the quantity produced, unit value (UV) and gross production value (GPV), subdivided according to Agreste, Central, East and West mesoregions in RN. These variables were simplified in the form of descriptive statistics, with the UV and GPV deflated with a base year of 1999. In addition, the exploration products, the total area explored, the type of cut and the situation regarding the plans of sustainable forest management - PMFS, were analyzed, as provided by the Northeastern Plant Information Center (Centro Nordestino de Informações Sobre Plantas, CNIP). The results generated allowed us note that the West mesoregion stood out in the production of firewood, being the second largest producer of charcoal and the only producer of roundwood logs. The highest UV per ton of coal occurred in 2016 in the Agreste and West mesoregions; in 2018, in the Central mesoregion and, in 2013, in the East. The highest UV per cubic meter of firewood occurred in 2017 for the Agreste and Central regions, and in 2019, in the East and West mesoregions, respectively. The Central mesoregion had the highest number of PMFS in the state, with most of the plans that are currently active being used for the exploitation of firewood. West mesoregion presented only two assets.
Keywords: firewood, charcoal and roundwood logs.

INTRODUCTION

The use of wood diversification has gained increasing importance in the world (LONGUE JÚNIOR and COLODETTE, 2013). For the northeast region of Brazil, there has been great energy dependence on forest resources, especially from Caatinga biome. Firewood is used for both domestic and industrial consumption. This practice puts the biome at risk when carried out in a predatory manner (LIMA JÚNIOR *et al.*, 2015). This threat becomes bigger as the northeastern semi-arid region presents characteristics that make it vulnerable to desertification processes, which has been already noticed in a large part of its area (ESTEVES and CRUZ, 2022).

In addition, this situation can be related to the lack of studies to support the technical and economic planning of activities for the sustainable exploitation of Caatinga products (LOPES and CANTO, 2018).

Besides being dependent on firewood, the state of Rio Grande do Norte (RN) is characterized by its highly dependence on charcoal, both in the domestic sector and in the industrial and commercial sectors (CARNEIRO *et al.* 2013). In this state, the red ceramic industry is well-consolidated and plays a great socioeconomic role (RAMOS *et al.*, 2019). According to Almeida *et al.* (2020), one of the main characteristics of this type of industry is its production energy matrix, as it is primarily firewood or wood residues, which can cause large deforestation for production to take place. Carneiro *et al.* (2013) reported that the use of firewood as an energy source provides ceramics with a more competitive value, however, systematic deforestation constitutes a threat of desertification in the state. There is not enough Caatinga forest management in the state of RN, which means that a good part of the firewood consumed by the sectors is from questionable origin and, especially, with equally unknown technological characteristics (SANTOS *et al.*, 2013).

The study of the wood-based market in Rio Grande do Norte is necessary to understand the real situation of the state regarding the production and use of these products, in addition to providing a basis for discussion about the particularities of each mesoregion, as well as the demands presented. (OLIVEIRA *et al.*, 2017). The objective of this work was to analyze the firewood, charcoal and roundwood market in RN, from 1999 to 2019.

MATERIAL AND METHODS

In each RN mesoregion, the quantity produced and the gross value of the production of wood products charcoal, firewood and roundwood were analyzed, as provided by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, IBGE) (2022). According to these data, the unit value of the referred products was calculated. For practical purposes, IBGE (2022) subdivided the state of Rio Grande do Norte according to its mesoregions in Agreste, Central, East, and West (Figure 1).

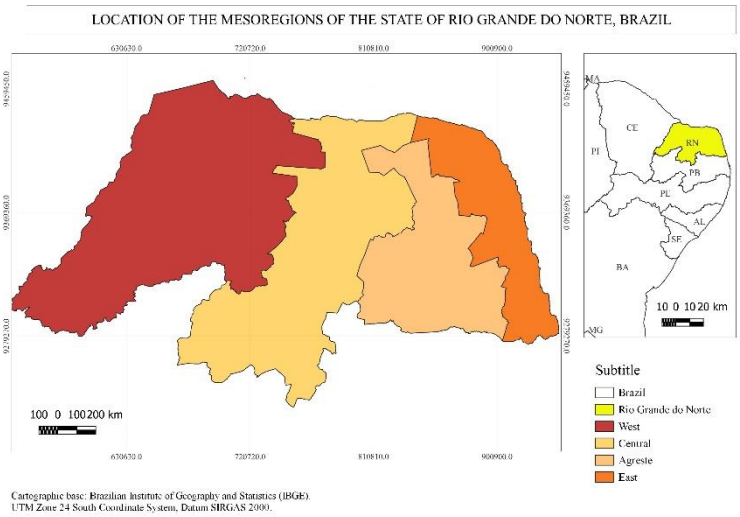


Figure 1. Location of the mesoregions of Rio Grande do Norte.
Figura 1. Localização das mesorregiões do Rio Grande do Norte.
Source: The authors (2022).

Data regarding the produced quantity and gross production value (GPV) of charcoal, firewood and roundwood analyzed were obtained by the Brazilian Institute of Geography and Statistics (IBGE) for the years 1999 to 2019. Furthermore, data analysis was based on methodology adopted by Guimarães *et al.* (2018), the quantity produced refers to the total of each product obtained during the reference year. Also, the unit value (UV) corresponds to the weighted average of the price per product, over the reference years (Equation 1).

$$UV = \frac{GPV}{Quantity\ produced} \quad (1)$$

Where: GPV is the Gross production value, in R$, Quantity produced is the total of each product obtained during the reference year.

Furthermore, the gross value of production is the quantity produced multiplied by the average unit price. Finally, UV and GPV data were deflated by the Extended Consumer Price Index (Índice de Preço ao Consumidor Amplo, IPCA), base year 1999.

Data referring to the quantity produced, Unitary Value (UV) and Gross Production Value (GPV) were presented in the form of average and coefficient of variation considering each year studied and the mesoregions.

Therefore, they were submitted to analysis of variance in a completely randomized design and compared using Tukey's test at 5% significance. Also, it should be noted that the GPV was divided by a thousand in order to facilitate visualization and presentation.

In addition, data were collected, regarding the Sustainable Forest Management Plans (Planos de Manejo Florestal Sustentáveis, PMFS), which include the product exploited, the year in which the exploration began, the total area explored, the type of harvest and its current situation, data provided by the Northwest Center of Plant Information (Centro Nordestino de Informações Sobre Plantas, CNIP) (2022), corresponding to wood-based products from the state of Rio Grande do Norte and subdivided according to the mesoregion of occurrence (West, Agreste, Central and East).

RESULTS

Descriptive statistics referring to the produced quantity of charcoal, firewood and roundwood for Rio Grande do Norte were shown according to the mesoregions (Table 1).

Table 1. Descriptive statistics on the quantity of charcoal (t), firewood (m³) and roundwood (m³) produced by mesoregions.
Tabela 1. Estatísticas descritivas da quantidade produzida de carvão (t), lenha (m³) e madeira (m³) por mesorregiões.

	Charcoal					Firewood					RW
	Ag	Ce	E	W	Av (CV%)	Ag	Ce	E	W	Av (CV%)	W
99	711	1,285	448	1,075	879.8 (42.4)	352,460	252,347	334,446	831,641	442,723.5 (59.4)	20,153
00	643	1,191	442	1,031	826.8 (41.7)	329,378	248,297	332,041	846,995	439,177.8 (62.5)	17,375
01	584	1,166	331	1,021	775.5 (49.8)	296,002	259,863	229,998	841,312	406,793.8 (71.5)	15,689
02	622	1,133	280	1,023	764.5 (51.1)	320,353	249,022	198,155	946,235	428,441.3 (81.4)	15,870
03	566	994	253	929	685.5 (50.2)	278,052	236,019	180,354	932,011	406,609.0 (86.7)	7,516
04	507	933	207	914	640.3 (54.6)	241,648	235,838	145,717	934,277	389,370.0 (94.0)	7,867
05	471	876	183	955	621.3 (58.1)	226,070	257,129	94,359	1,001,658	394,804.0 (104.0)	8,240
06	415	824	152	862	563.3 (60.5)	201,188	257,733	74,333	953,955	371,802.3 (106.4)	7,666
07	389	819	128	829	541.3 (63.5)	190,697	252,807	60,562	759,295	315,840.3 (97.0)	7,607
08	363	802	98	829	523.0 (67.9)	182,351	233,326	50,687	773,169	309,883.3 (102.7)	6,775
09	337	791	77	794	499.8 (70.9)	170,669	227,300	39,561	818,820	314,086.5 (110.0)	6,573
10	302	770	52	834	489.5 (76.8)	158,777	228,245	26,146	796,618	302,446.5 (112.4)	6,672
11	41	763	298	822	481.0 (78.1)	151,401	226,139	18,199	799,756	298,873.8 (15.4)	6,974
12	298	795	37	690	455.0 (77.2)	152,099	308,323	14,460	746,389	305,317.8 (104.0)	5,290
13	295	844	32	705	469.0	153,224	279,658	12,016	777,164	305,515.5	4,532

					(79.6)					(109.0)	
14	324	804	24	623	443.8 (77.2)	172,449	270,948	9,261	672,957	281,403.8 (100.4)	3,826
15	308	801	20	689	454.5 (78.9)	165,043	238,146	7,310	568,699	244,799.5 (96.6)	3,346
16	275	731	20	720	436.5 (80.1)	146,885	187,807	7,060	520,556	215,577.0 (100.9)	2,956
17	273	697	53	714	434.3 (75.1)	145,466	171,566	15,700	444,790	194,380.5 (92.8)	2,773
18	264	717	40	780	450.3 (79.4)	145,364	165,258	12,964	409,171	183,189.3 (90.2)	2,883
19	621	1,093	36	842	648.0 (69.6)	216,208	184,555	12,660	386,087	199,877.5 (76.6)	2,947
Av	410.0 .c	896.6 a	152.9 d	842.0 b		209,323.1 c	236,682.2 B	89,332.8 d	750,550.4a		7,787.1

PS.: Average values followed by the same letter in a column do not differ from each other at the 5% significance level by Tukey test. Where: Ag = Agreste; Ce = Central; E = East and W = west. Also, RW = roundwood, CV = coefficient of variation, and Av = average

When considering the period from 1999 to 2019, the Central mesoregion, followed by the West, was one of the largest charcoal producers in the state. When it comes to firewood production, the West mesoregion was more representative, followed by the Central (Table 1). Still, regarding roundwood, the West region was the only producing mesoregion.

Furthermore, in Table 2, the unit values of production for charcoal, firewood and roundwood per mesoregion were indicated.

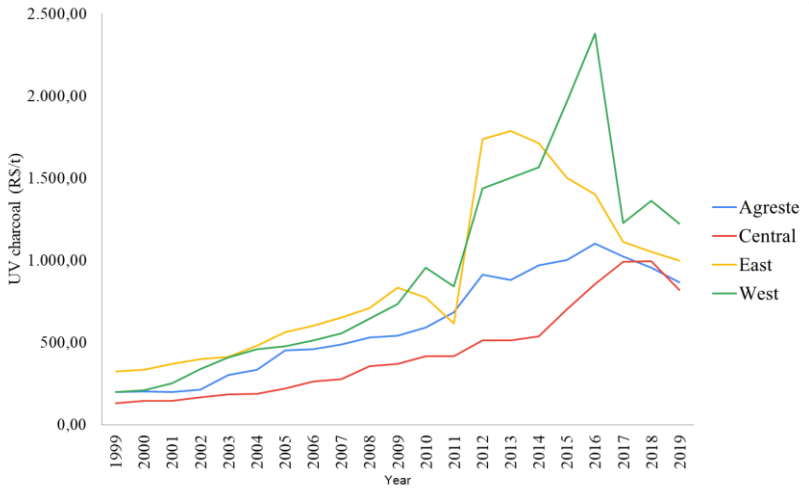
Table 2. Descriptive statistics on the quantity of charcoal (R$/t), firewood (R$/m³) and roundwood (R$/m³) produced by mesoregion.
Tabela 2. Estatística descritiva do valor unitário de carvão (R$/t), lenha (R$/m³) e madeira (R$/m³) por mesorregião.

	Charcoal					Firewood					RW
	Ag	Ce	E	W	Av (CV%)	Ag	Ce	E	W	Av (CV%)	W
99	197.9	131.6	325.4	199.6	213.6 f (37.9)	3.5	3.3	4.2	3.8	3.7 f (10.3)	49.0
00	203.0	146.9	334.2	209.0	223.3 f (35.4)	3.4	4.2	4.2	4.0	3.9 f (9.8)	42.0
01	197.3	146.5	369.6	252.5	241.5 f (39.6)	3.3	4.4	4.3	4.3	4.1 f (12.4)	44.0
02	212.8	165.8	400.5	337.7	279.2 ef (38.9)	3.8	4.8	4.9	4.5	4.5 ef (10.9)	47.0
03	303.0	183.7	414.7	408.3	327.4 ef (33.2)	4.7	5.2	5.0	4.8	4.9 ef (4.6)	54.0
04	334.1	188.0	482.1	458.8	365.8 def (37.0)	5.0	5.6	5.3	5.5	5.4 ef (4.9)	58.0
05	451.3	218.5	561.5	476.8	427.0 cdef (34.4)	8.7	7.1	6.7	5.3	7.0 def (19.7)	60.0
06	461.1	264.0	602.9	514.0	460.5 cdef (31.2)	9.0	7.6	6.8	5.9	7.3 cdef (18.4)	56.0
07	486,.5	276.6	652.8	555.0	492.7 bcdef (32.4)	10.5	8.0	7.0	6.5	8.0 cdef (22.3)	58.0
08	532.2	357.5	708.4	644.5	560.6 bcdef (27.4)	11.0	14.2	7.8	7.1	10.0 bcdef (32.9)	62.0
09	540.1	370.0	835.9	733.3	619.8 abcdef (33.4)	11.2	13.7	7.8	7.6	10.1 abcdef (28.8)	64.0
10	592.4	417.7	773.2	955.7	684.8 abcdef (33.8)	13.3	21.2	7.7	9.8	13.0 abcdef (45.7)	78.0
11	686.0	416.0	616.9	840.8	639.9 abcdef (27.5)	13.7	21.1	7.7	10.3	13.2 abcdef (44.0)	75.0

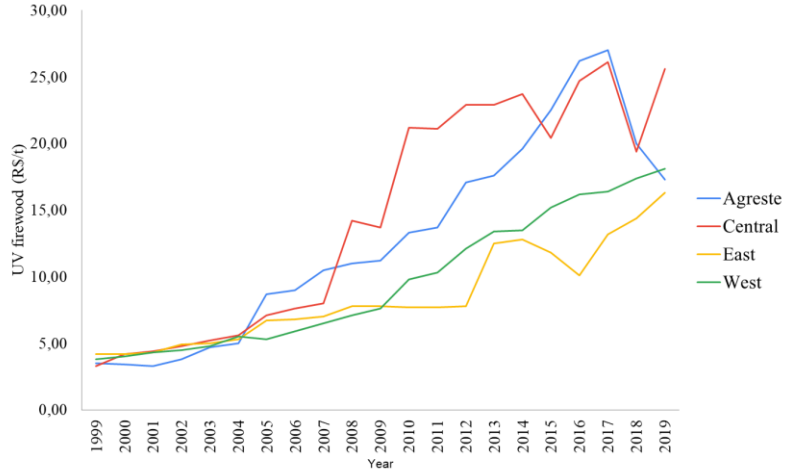
12	913.0	514.0	1,736.6	1,436.1	1,149.9 abcd (49.7)	17.1	22.9	7.8	12.1	15.0 abcde (43.5)	67.0
13	880.9	513.6	1,787.3	1,500.1	1,170.5 abcd (49.4)	17.6	22.9	12.5	13.4	16.6 abcd (28.7)	84.0
14	968.7	538.8	1,713.1	1,566.1	1,196.7 abc (45.5)	19.6	23.7	12.8	13.5	17.4 abcd (30.0)	87.0
15	1,002	703.0	1,502.9	1,966.0	1,293.5 ab (43.0)	22.5	20.4	11.8	15.2	17.5 abcd (27.9)	87.0
16	1,103	854.5	1,401.5	2,381.7	1,435.2 a (46.6)	26.2	24.7	10.1	16.2	19.3 ab (39.2)	94.0
17	1,023	990.7	1,114.0	1,227.8	1,088.8 abcde (9.8)	27.0	26.1	13.2	16.4	20.7 a (33.2)	95.0
18	954.9	993.4	1,050.4	1,362.0	1,090.2 abcde (17.0)	20.0	19.4	14.4	17.4	17.8 abc (14.1)	97.0
19	866.3	820.7	1,000.0	1,222.1	977.3 abcdef (18.4)	17.3	25.6	16.3	18.1	19.3 a (22.1)	99.0
Av	614.7 c	438.6 d	875.4 b	916,6 A		12.8 B	14.6 a	8.5 d	9.6 c		69.4

PS.: Average values followed by the same letter in a column do not differ from each other at the 5% significance level by Tukey test. Where: Ag = Agreste; Ce = Central; E = East and W = west. Also, RW = roundwood, CV = coefficient of variation, and Av = average

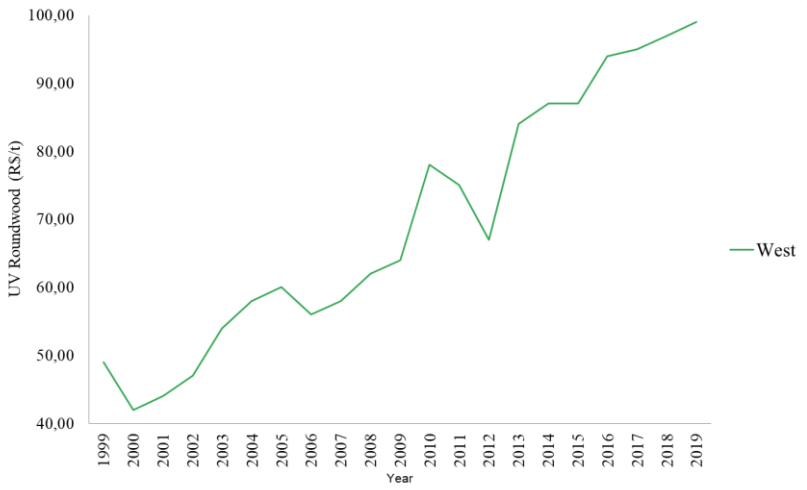
Figure 2 shows UV behavior of charcoal, firewood and roundwood between 1999 and 2019 in the state of Rio Grande do Norte.



(a) Charcoal



(b) Firewood



(c) Roundwood

Figure 2. UV of (a) charcoal, (b) firewood and (c) roundwood for Rio Grande do Norte between 1999 and 2019.
Figura 2. UV do (a) carvão, (b) lenha e (c) madeira para o Rio Grande do Norte entre 1999 e 2019.

Table 3 shows the gross production value for charcoal, firewood and roundwood products in each RN mesoregion.

Table 3. Descriptive statistics regarding the GVP of charcoal (1.000,0 R$/t), firewood (1.000,0 R$/m³) and roundwood (1.000,0 R$/m³) in each mesoregion.
Tabela 3. Estatística descritiva referente ao VBP de carvão (1.000,0 R$/t), lenha (1.000,0 R$/m³) e madeira (1.000,0 R$/m³) por mesorregião.

	Charcoal					Firewood					RW
	Ag	Ce	E	W	Av (CV%)	Ag	Ce	E	W	Av (CV%)	W
99	139.0	167.0	144.0	212.0	165.5 (20.1)	1,214.0	822.0	1,394.0	3,125.0	1,638.8 (62.5)	967.0
00	129.0	173.0	146.0	213.0	165.3 (22.2)	1,104.0	1,042.0	1,365.0	3,328.0	1,709.8 (63.6)	721.0
01	114.0	169.0	146.0	255.0	171.0 (39.4)	977.0	1,142.0	971.0	3,574.0	1,663.0 (76.5)	678.0
02	131.0	186.0	111.0	342.0	192.5 (54.3)	1,202.0	1,182.0	951.0	4,221.0	1,889.0 (82.5)	744.0
03	170.0	181.0	104.0	376.0	207.8 (56.4)	1,304.0	1,227.0	887.0	4,451.0	1,967.3 (84.7)	404.0
04	168.0	174.0	99.0	416.0	214.3 (64.8)	1,201.0	1,304.0	762.0	5,119.0	2,096.5 (96.8)	450.0
05	211.0	190.0	102.0	452.0	238.5 (62.7)	1,944.0	1,817.0	624.0	5,308.0	2,423.3 (83.1)	490.0
06	190.0	216.0	91.0	440.0	234.3 (62.9)	1,804.0	1,945.0	498.0	5,561.0	2,452.0 (88.6)	423.0
07	188.0	225.0	83.0	457.0	238.3 (66.2)	1,984.0	2,021.0	419.0	4,875.0	2,324.8 (79.9)	437.0
08	192.0	285.0	69.0	531.0	269.3 (72.7)	1,986.0	3,302.0	392.0	5,416.0	2,774.0 (76.6)	415.0
09	181.0	291.0	64.0	579.0	278.8 (79.1)	1,895.0	3,087.0	307.0	6,202.0	2,872.8 (86.8)	417.0
10	178.0	320.0	40.0	793.0	332.8 (98.4)	2,096.0	4,810.0	201.0	7,730.0	3,709.3 (88.5)	517.0
11	183.0	316.0	28.0	668.0	298.8 (92.8)	2,067.0	4,744.0	140.0	8,157.0	3,777.0 (92.1)	518.0
12	271.0	407.0	64.0	987.0	432.3 (91.6)	2,597.0	7,018.0	112.0	8,997.0	4,681.0 (86.6)	352.0
13	259.0	432.0	57.0	1,054.0	450.5 (95.6)	2,688.0	6,391.0	118.0	10,338.0	4,883.8 (90.9)	380.0
14	313.0	432.0	41.0	973.0	439.8 (89.0)	3,377.0	6,413.0	118.0	9,045.0	4,738.3 (81.3)	332.0

15	308.0	562.0	30.0	1,352.0	563.0 (101.1)	3,711.0	4,844.0	86.0	8,644.0	4,321.2 (71.4)	290.0
16	303.0	624.0	28.0	1,713.0	667.0 (101.7)	3,842.0	4,629.0	71.0	8,398.0	4,235.0 (71.9)	277.0
17	279.0	690.0	59.0	876.0	476.0 (78.5)	3,925.0	4,473.0	207.0	7,274.0	3,969.3 (73.2)	262.0
18	252.0	712.0	42.0	1,062.0	517.0 (88.0)	2,906.0	3,200.0	187.0	7,111.0	3,351.0 (85.1)	280.0
19	538.0	897.0	36.0	1,029.0	625.0 (71.1)	3,750.0	4,732.0	206.0	6,968.0	3,914.0 (71.9)	293.0
Av	223.7 c	364.2 b	75.4 d	703.8 a		2,265.4 c	3,340.2 b	476.9 d	6,373.4 a		459.4

PS.: Average values followed by the same letter in a column do not differ from each other at the 5% significance level by Tukey test. Where: Ag = Agreste; Ce = Central; E = East and W = west. Also, RW = roundwood, CV = coefficient of variation, and Av = average.

The details of the sustainable forest management plans in Rio Grande do Norte, according to the mesoregion, are shown in Table 4.

Table 4. Absolute description of forest management plans in Rio Grande do Norte in each mesoregion.
Tabela 4. Descrição absoluta dos planos de manejo florestal no Rio Grande do Norte por mesorregiões.

Year	Product	Area (ha)	Cycle	Type	Situation	Year	Product	Area (ha)	Cycle	Type	Situation
CENTRAL						**AGRESTE**					
95	Firewood	2,044.0	10	SL	Inactive	89	Charcoal	3,859.4	12	CC	Inactive
		755.6	10	SL	Inactive	95	Firewood	3,774.9	10	SLAT	Not det.
07	FW, Ch.	1,151.0	12	CC	Inactive			2,294.5	10	SLAT	Inactive
08	FW, Ch.	1,151.0	12	CC	Inactive	03	FW, Ch.	3,334.3	12	CC	Active
09	FW, Ch.	1,977.4	15	CC	Inactive	12	Firewood	1,399.1	15	CC	Active
	Firewood	117.2	15	CC	Inactive			948.5	15	CC	Inactive
		419.2	15	CC	Under review			832.4	15	CC	Inactive
		1,223.3	13	CC	Inactive	13	Firewood	3,294.8	15	CC	Inactive
		2,384.0	15	CC	Active	14	Firewood	1,542.5	15	CC	Inactive
		1,969.8	15	CC	Inactive			2,415.1	15	CC	Active
10	Firewood	4,332.1	15	SL	Inactive			901.2	15	CC	Active
		2,338.8	0	CC	Inactive			1,305.0	15	CC	Active
11	Firewood	780.7	15	CC	Inactive	15	Firewood	473.5	15	CC	Active
12	Firewood	917.4	15	CC	Active			725.9	15	CC	Active
		3,606.5	15	CC	Inactive	18	Firewood	975.9	15	CC	No inf.
		3,626.4	15	CC	Inactive	**Total**		**28,076.9**			
		3,588.3	15	CC	Inactive	**EAST**					
		1,697.5	15	CC	Active	10	Firewood	1,364.5	15	CC	Inactive
		1,364.4	15	CC	Inactive			1,651.7	15	CC	Active
13	FW, stakes, FP.	0.0	15	-	Inactive	14	-	166.5	-	-	Inactive
							Firewood	1,144.7	15	CC	Active

		0.0	15	-	Inactive			3,928.7	15	CC	Active
		0.0	15	-	Inactive	17	Firewood	556.5	15	CC	Active
		0.0	15	-	Inactive			325.5	15	CC	Active
		0.0	15	-	Inactive	**Total**		**9,138.1**			
		0.0	15	-	Inactive			**WEST**			
		0.0	15	-	Inactive	88	Charcoal	10,236.6	10	SL	Inactive
	Firewood	188.5	15	CC	Inactive	08	Firewood	428.5	10	CC	Inactive
		1,067.2	15								
		406.7	15	CC	Inactive			248.9	0	CC	Inactive
		709.4	15	CC	Inactive	09	Firewood	8,397.6	15	CC	Inactive
		11,403.7	15	CC	Inactive	10	Firewood	583.3	10	SL	Inactive
		11,403.7	15	CC	Active			2,514.8	15	CC	Inactive
14	FW, stakes, FP.	0.0	15	-	Inactive			2,341.7	15	CC	Active
		0.0	15	-	Inactive	11	Firewood	1,853.5	12	CC	Inactive
	Charcoal	272.8	15	CC	Inactive	12	Firewood	2,642.0	15	CC	Inactive
	Firewood	5,100.0	15	CC	Active	13	Firewood	1,820.6	15	CC	Active
17	Firewood	1,377.6	15	CC	Active			1,214.9	15	CC	Inactive
		1,377.6	15	CC	Active			3,882.2	15	CC	Inactive
	FW, stakes, FP.	2,554.4	15	CC	Active			1,111.8	15	CC	Inactive
18	Firewood	1,159.7	15	CC	No inf.	14	Firewood	0.0	15	-	Inactive
		650.3	15	CC	Under review			0.0	15	-	Inactive
Total		**73,116.2**						3,059.2	15	CC	Inactive
								538.8	15		
							FW, stakes, FP.	0.0	15	-	Inactive
								0.0	15	-	Inactive
						Total		**40,874.1**			

PS: CC = Clear cut; SL: Selective logging; SLAT = Selective logging in alternative tracks; CCAT = Clear cut in alternative tracks, Not det. = Not detailed, No inf. = No information, FW, ch. = Firewood and charcoal, FW, post, FP. = Firewood, stakes and fence post.

Table 5 presents the sustainable forest management plans (PMFS) of Rio Grande do Norte, currently, in 2022, in progress and their relative characteristics.

Table 5. Relative description of forest management plans in Rio Grande do Norte in each mesoregion.
Tabela 5. Descrição relativa dos planos de manejo florestal no Rio Grande do Norte por mesorregiões.

Mesoregions	Products	PMFS	Explored area (ha)	Total
Agreste	Firewood	6.0	13,837.9	17,172.2 b
	Firewood and Charcoal	1.0	3,334.3	
Central	Firewood	7.0	59,913.1	62,467.5 a
	rewood, stakes and fence po	1.0	2,554.4	
East	Firewood	5.0		7,773.6 d
West	Firewood	2.0		8,657.7 c
TOTAL		**22.0**		**96,071.0**

DISCUSSION

Considering the period between 1999-2019, the West mesoregion produced 15,761,555 m³ of firewood and obtained an annual average production corresponding to 788,077.8 m³. The Central mesoregion, which covers Seridó region, produced 4,970,326 m³, with an annual average production of 248,516.3 m³ (Table 1). The prominence that the West mesoregion had in the production of firewood and roundwood, besides being the second largest production of charcoal, may be related to the fact that it has the largest territorial extension, among the other mesoregions, since it has an area of 21,179.573 km², while the Agreste has an area of 9,297.796 km², the Central mesoregion has an area of 15,831.629 km² and, finally, the territorial extension of the East is 6,500.604 km² (IBGE, 2019).

RN's amount of firewood, charcoal and roundwood produced between 1999 and 2019 decreased (Table 1). Regarding firewood, Coelho *et al.* (2018) highlighted that this behavior may be related to the increase in income of the local population, as there is a direct relationship between residential firewood consumption and low human development index and high social inequality.

Since the red ceramic industry is a supplier of materials used in civil engineering (bricks, tiles, expanded clay, among others) (ALMEIDA *et al.*, 2020), their performances may be correlated, as there is a chain reaction in the market, because once civil construction was affected, the ceramics industry also suffered its effects, as well as the wood based products market, considering its use to feed the ceramic kilns.

The prominence of the West mesoregion as a producer does not necessarily indicate that the production came from that mesoregion. According to Sousa Júnior *et al.* (2021), RN received wood products from 24 Brazilian states, with the North region being the most active and the main products being sawn wood, firewood and wood residues. In addition, the same authors reported that most of the products sold and transported in the state came from the state of Pará.

Considering that the Document of Forest Origin (Documento de Origem Florestal, DOF) is related to the control and monitoring of the transport and of products and by-products of native forest origin, Sousa Júnior *et al.* (2021) highlighted that the number of DOF's had an average growth of 22% between 2011 and 2014 and a reduction between 2015 and 2016 in RN. In this sense, the amount of charcoal, firewood and roundwood produced during the analyzed period did not present a significant difference between the studied period (Table 1). This could indicate that the transport and commercialization of wood products occurred without DOF issuance, since, according to Carneiro *et al.*, (2013), there is a historical dependence of the northeastern semi-arid region on the illegal cutting of native vegetation.

Furthermore, the average of charcoal produced in 2008 increased from 523.0 to 454.5 tons in 2015. In the same period, the portion of charcoal consumed in final energy in Brazil decreased from 3.2% to 1.5%, as cited by Ministry of Mines and Energy (Ministério de Minas e Energia, MME) (2015). Thus, there is a tendency to replace charcoal with other energy sources and this has contributed to the reduction of production in RN.

Poverty and the loss of natural capital are not correlated with the modernization of productive systems. In fact, according to Tabarelli *et al.* (2018), this is a characteristic of the rural world based on the predatory use of natural resources. In addition, the energy matrix is highly dependent on native vegetation for industrial activities, consuming millions of cubic meters of native firewood every year.

Firewood reduced its portion in final energy consumption in Brazil from 8.2% in 2005 to 6.3% in 2014. The total consumption of firewood increased, in the period from 2005 to 2014, from 91,676 thousand to 79,768 thousand tons, with transformation into charcoal and final consumption in homes accounting for 31.1% and 24.7% of total firewood consumption, respectively. While these two sectors reduced their percentage share, industrial consumption of firewood increased (BRASIL, 2015).

In relation to the price of firewood, in 2017, the Agreste mesoregion had the highest UV in the state, costing R$27.00/m³ of firewood, followed by the Central mesoregion with R$26.10/$m^3$. On the other hand, observing the twenty years analyzed, it was verified that the Central mesoregion had the highest UV of firewood, being R$ 15.30/m^3, on average (Figure 2).

Furthermore, the increase in charcoal UV, mainly from 2008 onwards (Table 2), was a recurrent scenario in most Brazilian states and is caused by a decrease in production. According to Brainer (2019), another relevant factor to explain the situation is the increase in environmental requirements, since the demand for charcoal from planted forests has grown.

The UV of charcoal, on average, in Rio Grande do Norte reached its peak in 2016 (R$ 1,435.20 per ton), showing a higher coefficient of variation between the mesoregions in the periods from 2012 to 2016 (Figure 1). Firewood had the highest coefficient of variation between 2010 and 2012. With regard to roundwood, the peak of prices also occurred in 2019, when it cost R$ 99.00 per m^3. According to Simoni *et al.* (2017), the increase in UV is related to higher demand than current supply.

Furthermore, the UV can be considered as the sum of legalization, exploration and transport costs. According to Lopes and Canto (2018), in the exploitation of firewood in the state, manual and semi-mechanized systems predominate, the latter being the most expensive, however, which provides a considerably shorter working day when compared to manual exploitation.

Additionally, in the West, the GPV of charcoal (R$ 14,780,000.00/t), considering the twenty years analyzed, was higher than in the other mesoregions, even though this is not the mesoregion with the highest charcoal production in the state (Table 3). It was noted, regarding the amount of charcoal, that the year 2016 had the highest coefficient of variation (80.1%). Still regarding charcoal, the highest UV, on average, also occurred in 2016, reaching R$1,435.20/t, thus being significantly different from other years.

The Central mesoregion had the highest amount of charcoal produced, considering the entire period analyzed, and the lowest charcoal UV among the other mesoregions. Also, the UV of charcoal in the Central mesoregion in 2016 was R$854,500.00/t, while in the West, R$2,381,700.00/t, which is a difference of R$1,527,200.00/t despite the difference of production is only 11 tons (Table 1).

Therefore, there is a possibility that charcoal in the West mesoregion was having a much higher demand than that of the Central, not only in 2016, but throughout the analyzed period, since the GPV in the West mesoregion was R$ 14,780,000.00 per t producing 17,681.00 t of charcoal while in the Central mesoregion it was R$ 7,649,000.00 per t producing 18,829.0 t of charcoal. Being the difference in production of 1,148.00 t and GPV of R$ 7,131,000.00 per ton.

The Central mesoregion presented UV per cubic meter of firewood lower than the Agreste in 1999, 2005, 2006, 2007, 2015, 2016, 2017 and in 2018 (Table 2), resulting in 8 of the 20 years analyzed, that is, 40% of the analyzed period (Figure 1 b). However, despite this, the GPV (Table 3) was higher than that of Agreste. This behavior may indicate that in RN Central region there was a considerable increase in the UV in the mentioned years. Furthermore, the average UV of firewood in the Central region was R$ 14.60 while in the Agreste mesoregion it was R$ 12.80 considering the entire period.

The Central mesoregion had the highest number of PMFS in the state, but most of them were inactive (Table 4). There was eight active PMFS, seven aimed at the exploitation of firewood and one of "firewood, stakes and fence posts" representing, in all, 62,467.52 ha of exploited area. This mesoregion was also the one that had the most PMFS, with the majority, in 2022, inactive. Thus, the high UV of firewood from the Central mesoregion may indicate that the product came from the aforementioned PMFS, considering the statement by Lopes and Cantos (2018) previously cited.

Concerning the charcoal exploration, the Central mesoregion had three PMFS involving "firewood and charcoal" (Table 4). Considering that this was the mesoregion that most produced charcoal in the state (18,829.0 t produced, Table 1), the number of PMFS involving this product may be insufficient. This fact corroborates the information in Table 2, in which the Central mesoregion had an average UV of R$ 438.60 per ton of charcoal, significantly differing from the other mesoregions and this being the lowest, on average, UV per ton of charcoal in the state.

In addition, the West mesoregion, as the second largest charcoal producer (17,681.0 t), had only one charcoal PMFS started in 1988, with 10,236.61 ha of exploited area and inactive. It is important to mention that the West mesoregion was the largest producer of firewood in the state of Rio Grande do Norte (15,761,555.0 m3), but it was noted that it was also where there were less active firewood PMFS, with only two plans totaling 8,657, 67 ha of logged area (Table 5).

Furthermore, as the West mesoregion was the only mesoregion that produced roundwood, this fact may be related to the production of fence posts, but, when observing Table 4, it was noted that the referred mesoregion only had two management plans involving fence posts and that, in these, the total area exploited is not included

because they are classified as inactive. It was also observed that the Central was the only one that had an active PMFS involving fence post.

CONCLUSIONS

- The West mesoregion stands out in the production of firewood and it is the only producer of roundwood. Besides that, it has the second largest number of Sustainable Forest Management Plans in Rio Grande do Norte.
- The Central mesoregion had the highest production of charcoal, the second highest production of firewood and has the highest number of Sustainable Forestry Management Plans in the state.
- The East mesoregion had the lowest wood-based productions and only seven Sustainable Forest Management Plans, five of which were active.
- The years 2016, 2017 and 2019 stood out in terms of Unit Value (UV) of charcoal, firewood and roundwood, respectively. Still, there were no significant differences in Gross Production Values (GPV) and produced quantities of any of the studied products.

REFERENCES

ALMEIDA, K. S. DE.; SOARES, R. A. L. e MATOS, J. M. E. DE. Efeito de resíduos de gesso e de granito em produtos da indústria de cerâmica vermelha: revisão bibliográfica. **Matéria**, Rio de Janeiro, v. 25, n. 1, p. e-12568, 2020.

BRAINER, M. S. C. P. Silvicultura: uma nova proposta para a área de atuação do Banco do Nordeste do Brasil (BNB). **Caderno Setorial ETENE**. Fortaleza: Banco do Nordeste do Brasil, v. 4, n. 68, 2019. (Série Caderno Setorial ETENE, n. 68). Disponível em: < https://www.bnb.gov.br/s482-dspace/handle/123456789/607>. Acesso em: 08 de fev.2022.

CARNEIRO, A. D. C. O.; SANTOS, R. C. D.; CASTRO, R. V. O.; CASTRO, A. F. N. M.; PIMENTA, A. S., PINTO, E. M. e ALVES, I. C. N. Estudo da decomposição térmica da madeira de oito espécies da Região do Seridó, Rio Grande do Norte. **Revista Árvore**, Viçosa, v. 37, n. 6, p.1153-1163, 2013.

CNIP. **Centro Nordestino de Informações Sobre Plantas**. Disponível em: <http://www.cnip.org.br/planos_manejo.html>. Acesso em: 03/05/22.

COELHO, S. T.; SANCHES-PEREIRA, A.; TUDESCHINI, L. G.; GOLDEMBERG, J. The energy transition history of fuelwood replacement for liquefied petroleum gas in Brazilian households from 1920 to 2016. **Energy Policy,** Londres, v. 123, p.41-62 2018.

ESTEVES, P. M. DA S. V. e CRUZ, F. S. Assessment of the impacts of the desertification process in the Western Seridó by biophysical and social indicators. **Research, Society and Development,** Vargem Grande Paulista, v. 11, n. 3, p. e1411326082, 2022.

IBGE. **Produção da Extração Vegetal e da Silvicultura.** Disponível em: <https://www.ibge.gov.br/estatisticas/economicas/agricultura-e-pecuaria/9105-producao-da-extracao-vegetal-e-da-silvicultura.html?=&t=downloads>. Acesso em: 14/02/2022.

LIMA JÚNIOR, C.; LIMA, R. L. F.; LIBERAL, B. G.; GUERRERO, J. R. H.; SAMPAIO, E. V. S. B. e MENEZES, R. S. C. Viabilidade econômica do uso energético de lenha da caatinga sob manejo sustentável. **Revista Brasileira de Geografia Física**, Recife, v. 8, n. 1, p.156-166, 2015.

LONGUE JÚNIOR, D.; COLODETTE, J. L. Importância e versatilidade de reflorestamento para produtos florestais. **Pesquisa Florestal Brasileira**, Colombo, v.33, n. 76, p.429-438, 2013.

LOPES, E. A. e DO CANTO, J. L. Produtividade e custos de dois sistemas de exploração e transporte de lenha na Caatinga. **Nativa**, Sinop, v.6, n. 2, p.207-212, 2018.

MME. Ministério de Minas e Energia. **Empresa de Pesquisa e Energia – EPE. Balanço Energético Nacional: Relatório final.** Rio de Janeiro: RJ, 2015. Disponível em: <https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-127/topico-97/Relat%C3%B3rio%20Final%202015.pdf>. Acesso em: 02/12/21.

OLIVEIRA, G.; CASTRO, V. G.; NOGUEIRA, N. W. GUIMARAES, P. P.; BISPO, D. A. Mercado da madeira: estudo de caso sobre aplicação da ferramenta swot e desenvolvimento de estratégias. **Nativa**, Sinop, v. 5, p. 601-605, 2017.

RAMOS, S. D. O.; DANTAS, G. C. B.; LIRA, H. D. L.; PIMENTEL, P. M.; MARCIANO, J. E. A. Caracterização de argilas de novos jazimentos situados em Parelhas/RN, Brasil, visando aplicação na indústria cerâmica. **Matéria,** Rio de Janeiro, v. 24, n. 2, p. e-12352, 2019.

SANTOS, R. C. D.; CARNEIRO, A. D. C. O.; PIMENTA, A. S.; CASTRO, R. V. O.; MARINHO, I. V; TRUGILHO, P. F.; CASTRO, A. F. N. M.; ALVES, I. C. N.; CASTRO, F. N. M. Potencial energético da madeira de espécies oriundas de plano de manejo florestal no estado do Rio Grande do Norte. **Ciência Florestal**, Santa Maria, v. 23, n. 2, p.491-512, 2013.

SOUSA JÚNIOR, A. D. DE.; CANTO, J. L.; COSTA, W. P. L. DA. Produtos florestais nativos, legalizados e comercializados no Rio Grande do Norte. **Cadernos de Ciência & Tecnologia,** Brasília, v. 38, n. 1, p. e26779, 2021.

TABARELLI, M.; LEAL, I. R.; SCARANO, F. R.; SILVA, J. Caatinga: legado, trajetória e desafios rumo à sustentabilidade. **Ciência e Cultura**, São Paulo, v. 70, n. 4, p. 25-29, 2018.