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ESTIMATE OF GREENHOUSE GAS EMISSIONS FROM GOAT AND SHEEP HERD

In the Caatinga biome, Brazilian Semiarid, in IFAD action scenarios

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Estimation of greenhouse gas emissions from goat and sheep herds in the Caatinga biome, Brazilian Semiarid, in IFAD action scenarios

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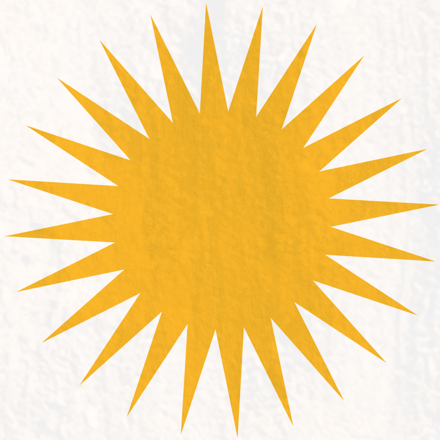

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The Caatinga biome

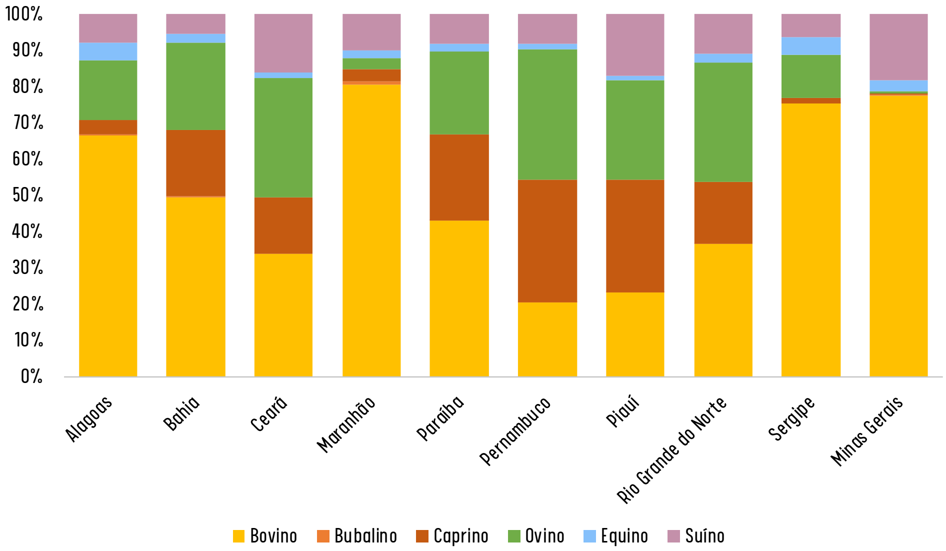
The Caatinga is part of a region with unique features regarding Brazilian biomes. Very peculiar, due to the semi-arid climate - being compared to other regions of the world with the same characteristics (such as the Savannas) -, it has its own native vegetation, developed in conditions of low rainfall and relative humidity, also presenting high temperatures during most of the year. As a result, it is also known as a seasonally dry tropical forest.

Figure 1 **–** Delimited territory to determine the semiarid region of Brazil, covering states in the Northeast and part of the state of Minas Gerais

Source: IBGE, 2018.

Livestock is a widespread activity in the Caatinga, being the birthplace of the Brazilian breeds of small ruminants. The raising of goats and sheep carries extremely relevant socioeconomic value and importance with regard to the livelihood and source of income for small family farms, in addition to preserving the culture of the region when it comes to the consumption of products from these animals. Therefore, it is the direct object of IFAD's activities in specific states of the region.

Figure 2 - Percentage distribution of livestock in the regions that make up the Brazilian semi-arid region, in each of the component states



Source: PPM - Municipal Livestock Survey, (IBGE, 2020). IBGE, 2017 (Resolution No. 115 of the Ministry of National Integration, of November 23, 2017).

Project objectives

Since there are different scenarios in the Caatinga and different ways of carrying out these activities, the aim of evaluating and describing these realities of family production was to seek the best adaptation of technological levels, associating animal production and preservation of the environment, thus enabling the transfer of technology to other places with the same features as the successful cases studied by IFAD.

Figure 3 - Map of the Brazilian state of Paraíba - PB and its respective territorial regions

Regions of Cariri, Seridó and Curimataú receive actions from the Procase project, financed by IFAD.
Source: Procase.

Productive scenarios in the Caatinga biome - IFAD Projects

The Caatinga biome, typical of the semi-arid region of Brazil, was the application site for the calculations. This scenario was studied for estimates of enteric methane emission and waste management, which were described according to the adherence standards of technologies used for each of the production systems.

Scenario 1 – High technological adherence

The treatment designated as positive was represented by an integrated crop-livestock-forestry system (ICLF), with the implantation of cultivated pastures in an area of native Caatinga vegetation, at Embrapa Goats & Sheep in Sobral - CE.

Figure 4 - Aerial view of the Integrated Crop-livestock-forestry System at the Embrapa Goats & Sheep experimental unit

Photo: Márcio Landim.

Figura 5 - Dimensioned aerial view of the Integrated Crop-livestock-forestry System at the Embrapa Goats & Sheep experimental unit

Photo: Márcio Landim.

Figure 6 - Crop rotation of the Integrated Crop-livestock-forestry System at the Embrapa Goats & Sheep experimental unit

Photos: Rafael Tonucci.

Scenario 2 - Medium technological adherence in the Municipality of Coxixola and Sumé - PB IFAD Projects

The treatment, called medium technological adherence, was specified for areas undergoing transformation, that is, areas that are going through the intensification process in relation to the improvement of feeding with the use of food banks for the driest periods, or for animals with greater demands, and implementation of the integrated production system.

Figure 7 - Dairy goat production system in the Caatinga biome under open vegetation conditions

Photo: Fábio Henrique - IFAD Coxixola Project, PB.

The property has 10.5 ha, 3 ha of which are for grazing and 7.5 ha of natural caatinga.

In addition to the natural vegetation of the Caatinga, the animals are supplemented with food grown on the property, in irrigated (9,000 L well) and dryland systems, such as forage palm intercropped with grasses, corn, sorghum and a mixture of concentrated feeds that is composed of corn bran, soy bran, wheat bran and mineral salt.

The palm is also intercropped with leguminous forages, such as leucena, moringa and gliricidia.

Figure 8 - Area under transformation for planting supplementary foods and pasture formation of Buffel grass (Cenchrus ciliares), grasses, such as corn and sorghum, and legumes, such as leucena, moringa and gliricidia.

Photo: Fábio Henrique - IFAD Coxixola Project, PB.

Figure 9 - Crop area for food bank, containing forage palm, corn and leucaena, moringa and gliricidia (protein bank)

Photo: Fábio Henrique- IFAD/Embrapa Coxixola Project, PB.

Figure 10 - Facilities for supplementary feeding of animals

Photo: Fábio Henrique- IFAD/Embrapa Coxixola Project, PB.

Figure 11 - Crop area for food bank, containing forage palm, corn and/or sorghum and leucaena, moringa and gliricidia (protein bank)

Photo: Fábio Henrique- IFAD/Embrapa Coxixola Project, PB.

With 28 goats in total, the herd consists of 17 adult animals (males and females), with an annual lactation peak of 35 L of milk and an average of 10 lactating goats. The supply of roughage plus concentrate for supplementation of lactating animals is twice a day, which corresponds to approximately 14 kg of roughage (chopped palm, corn straw and/or sorghum and 5 kg of concentrate).

Figure 12 - Facilities for supplementary animal feeding

Photo: Fábio Henrique - IFAD/Embrapa Project Sumé, PB.

The property has 50 ha. In addition to the natural vegetation of the Caatinga, the animals are supplemented with food grown on the property, such as forage palm intercropped with grasses, forage sorghum and corn for silage (silage process between 2 and 3 months) and a mixture of concentrated feed.

There is a protein bank composed by leguminous forages, such as moringa and gliricidia.

With 30 animals in total, the herd has 15 lactating goats and an average production of 20 kg/day for 12 months. About 3kg of supplementary feed is provided twice a day to the herd.

Figure 13 - Production system of dairy goats and beef sheep in the Caatinga biome under open vegetation conditions.

Photo: Fábio Henrique - IFAD/Embrapa Project Sumé, PB.

Figure 14 - Crop area for the food bank, focused on the cultivation of grasses and legumes

Photo: Fábio Henrique - IFAD/Embrapa Project Sumé, PB.

Figure 15 - Area for the production of corn silage

Photo: Fábio Henrique - IFAD/Embrapa Project Sumé, PB.

Figure 16 - Area under transformation for the implementation of an Integrated Livestock and Forest (ILF) system and area destined for the planting of pasture to start an integrated production system with crop rotation in the Caatinga biome.

Photo: Fábio Henrique - IFAD/Embrapa Project Sumé, PB.

Scenario 3 – Low technological adherence

The scenario of low technological adherence concerns a degraded area, with low mitigation capacity and carbon stock, which results in a lower quality of food for goats and sheep and in a smaller amount of cover vegetation acting in soil conservation and accumulation of organic matter. The absence of trees also disadvantages the environment, both in terms of animal feed and woody or shrubby vegetation, which could offer a milder environment in terms of thermal comfort for goats and sheep in the production system.

NOTE: Specific locations were not chosen for the estimates in the scenario of low technological adherence

Results of carbon emission and sequestration estimates

The development of the calculation tool resulted in the possibility of generating estimated values for the scenarios proposed for the study

Figure 17 **–** Presentation interface of the introduction tab of the GHG Small Ruminants Calculation tool.

Source: GHG_Small Ruminants_Calc.

The basis used to calculate the estimates of greenhouse gas emissions from small ruminants in the Caatinga came from the equations described by the IPCC Guidelines for National Greenhouse Gas Inventories (2019), with information directed specifically to sheep and goats.

Estimates for sheep (non-lactating ewes, lactating ewes, lambs and rams) and goats (non-lactating goats, lactating goats, kids and goats) were structured for the calculation base.

Figure 18 - Presentation interface of the introduction tab of the GHG Small Ruminants Calculation tool regarding its ability to estimate the emissions from goats and sheep and the carbon stock of the scenarios

The tabs and a summary of their contente are as folliwing:

Equations_Calc: Information and equations used to estimate greenhouse gas emissions from small ruminants, following the methodology of the Guidelines IPCC, 2019.

Data Farm_Sheep: Collection of sheep farm production data evaluated in the calculations.

Ewes_Emissions: Mathematical model to calculate emission estimates for the sheep species category: Ewes.

Lamb_Emissions: Mathematical model to calculate emission estimates for the sheep species category: Lamb.

Ram_Emissions: Mathematical model to calculate emission estimates for the sheep species category: Ram.

Total Emissions_Sheep: Sum of emissions, referring to enteric methane and methane from manure management, from all categories of sheep species.

Data Farm_Goats: Collection of sheep farm production data evaluated in the calculations.

Does_Emissions: Mathematical model to calculate emission estimates for the goats species category: Does.

Kids_Emissions: Mathematical model to calculate emission estimates for the goatsspecies category: Kids/Yearlings.

Bucks_Emissions: Mathematical model to calculate emission estimates for the goats species category: Bucks.

Total Emissions_Goats: Sum of emissions, referring to enteric methane and methane from manure management, from all categories of goats species.

Carbon Stock: Estimation of carbon stock in different scenarios in the Caatinga biome (based in: Sampaio and Silva, 2005; Sampaio and Costa, 2011).

Source: GHG_Small Ruminants_Calc.

Input data into the calculation tool

The input data for the calculation estimate are nothing more than the real data of the property in relation to the size and type of area, the quality of animal feed in the production system and detailed description of the number of animals and zootechnical indices of the herds.

Figure 19 - Presentation interface of the proposed scenario data entry tab in the Small Ruminants GHG Calculation tool

Description of data farm - Sheep	
Name	Vista bela
State	Paraíba
City	Coxixola
Biome	Caatinga
Average Stocking rate (Animal Units/hectare)	1
Area all farm (hectare)	53
Pasture area (hectare)	50
Type of production system	1
Type of diets	2
Digestibility (DE% - pasture)	58
Digestibility (DE% - feedlot)	0
Number of mature Ewes (head)	25
Number of mature Ewes non-lactanting (head)	6
Number of mature Ewes lactanting (head)	19
Average body weight of Ewes (BW, kg)	50
Preganancy rate (%)	75%
Number of Lambs (head)	26
Average born weight of Lambs (BW, kg)	3.5
Average weaning weight of Lambs (BW, kg)	15
Mortality rate 0 to 2 months (%)	8%
Mortality rate 3 to 12 months (%)	0%
Number of Ram (head)	1
Average body weight of Ram (BW, kg)	90
Discard rate (%)	10%

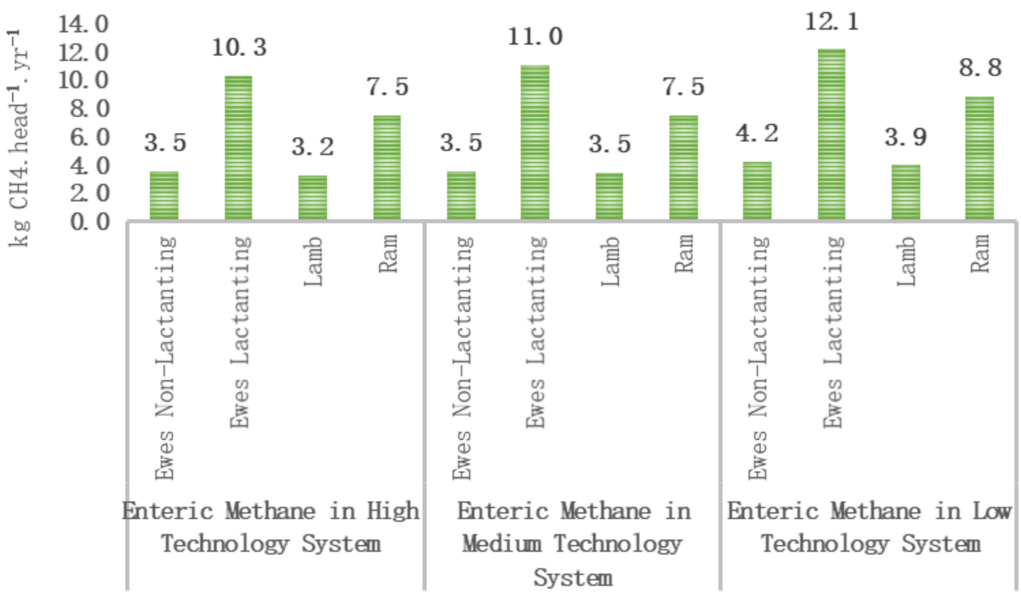
Source: GHG_Small Ruminants_Calc.

Results of enteric CH_4 emission calculation

With the dynamism proposal of the calculation tool, it is possible to estimate several emission scenarios for different herds, types of vegetation, and soil, thus characterizing the production systems with greater use of technologies, medium and low adhesions.

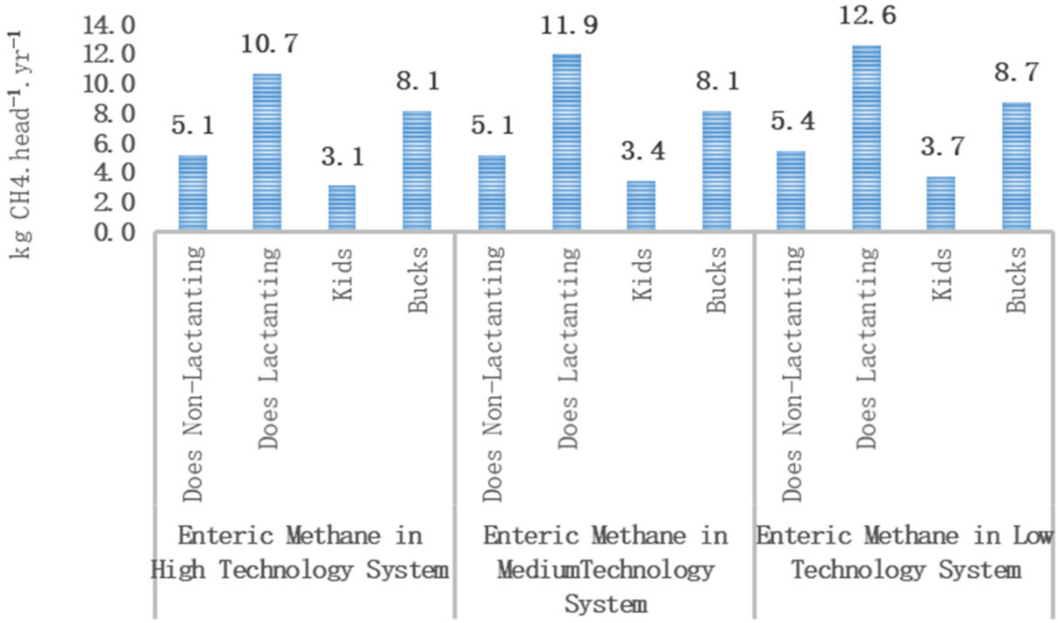
In this opportunity, there is even the possibility of understanding which categories of animals in a flock of beef sheep can best contribute to the total emission of the property.

Figure 20 -Simulation of the estimate calculation of enteric methane emission ($kg.CH_4.animal^{-1}.ano^{-1}$) for a flock of sheep for the proposed scenarios



Source: GHG_Small Ruminants_Calc.

Figure 21 - Simulation of the estimate calculation of enteric methane emission ($kg.CH_4.animal^{-1}.ano^{-1}$) for a herd of goats for the proposed scenarios.



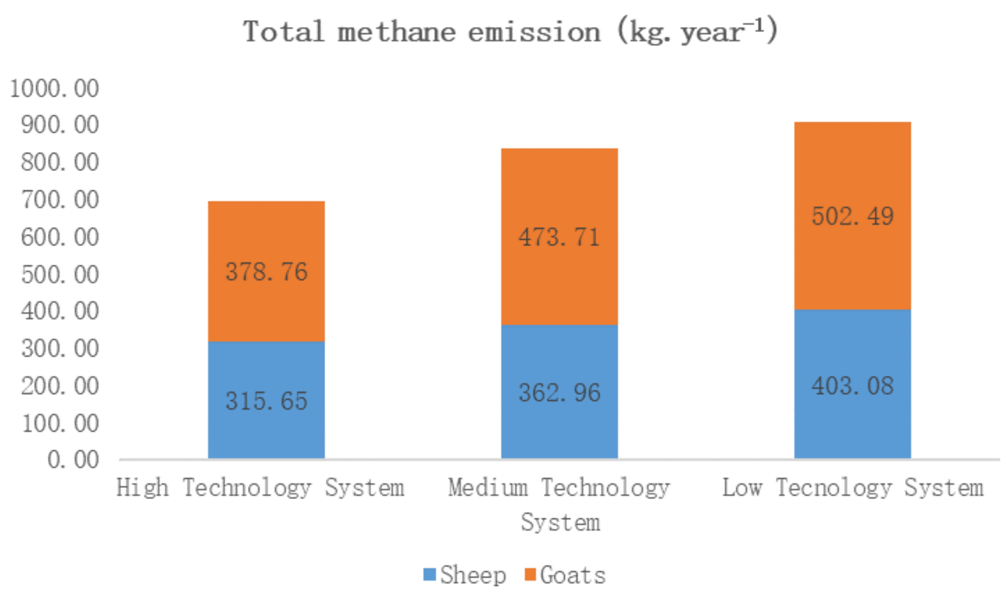
Source: GHG_Small Ruminants_Calc

Results of enteric CH_4 emission calculations

Factors such as the number of animals per category within the goat and sheep herd, the production system and, consequently, the quality of food and body weight of each one influence the total emissions for each one of them. This is possible to observe in the previous figures, paying attention to the values of lactating females (greater number of animals) and of reproducers (usually housed in systems with more limited feeding and higher body weight - kg).

It is possible to add the enteric CH_4 values and the CH_4 from the manure management of goat and sheep herds, resulting in the total sum of emissions for each studied property.

Figure 22 - Simulation of the estimated calculation of the total emission of enteric methane and methane from manure management ($kg.CH_4.animal^{-1}.ano^{-1}$) for sheep and goat herds for the proposed scenarios



Source: GHG_Small Ruminants_Calc

Results of enteric CH_4 emission calculations

The calculation tool can also generate emission data in units of g $CH_4.head^{-1}.d^{-1}$, which are presented in the following tables. This is a very important point so that the values can be compared with other studies that present emissions numbers for small ruminants in other biomes and other production systems.

Table 1 -Simulation of the estimate calculation of enteric methane emission ($g.CH_4.animal^{-1}.ano^{-1}$) for a flock of sheep for the proposed scenarios

Ewes Non-Lactanting	Ewes Lactanting	Lamb	Ram
Enteric Methane in High Technology System			
9.6	28.1	8.9	20.5
Enteric Methane in Medium Technology System			
9.6	30.2	9.5	20.5
Enteric Methane in Low Technology System			
11.6	33.3	10.8	24.2

Source: GHG_Small Ruminants_Calc

Table 2 - Simulation of the estimate calculation of enteric methane emission ($g.CH_4.animal^{-1}.ano^{-1}$) for a herd of goats for the proposed scenarios

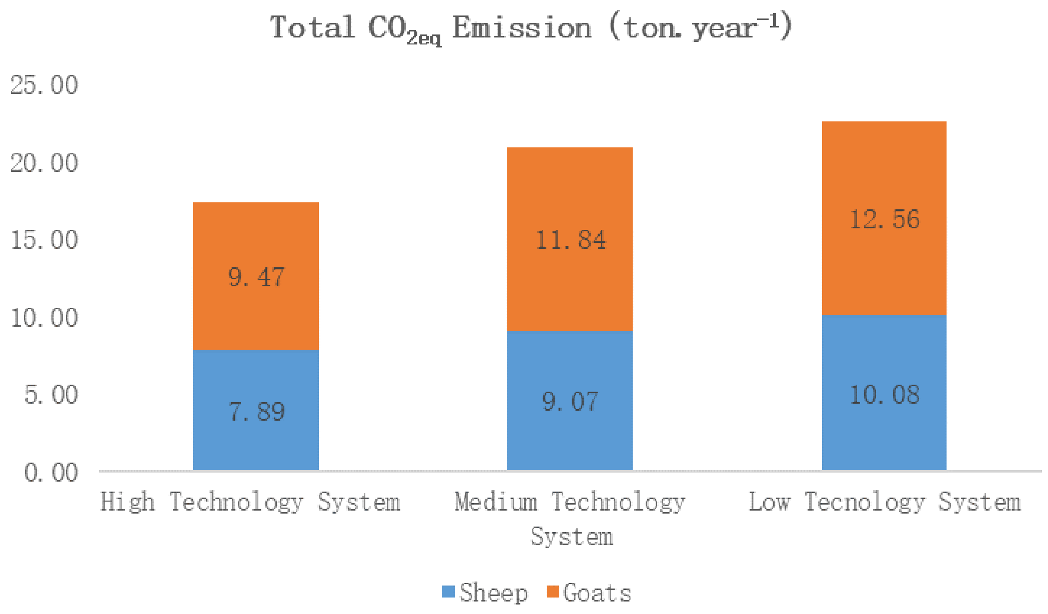
Does Non-Lactanting	Does Lactanting	Kids	Bucks
Enteric Methane in High Technology System			
14.0	29.2	8.4	22.2
Enteric Methane in Medium Technology System			
14.0	32.7	9.4	22.2
Enteric Methane in Low Technology System			
14.8	34.5	10.1	23.9

Source: GHG_Small Ruminants_Calc

Results of CO_{2eq} emission calculations

Emission calculations can be transformed from CH_4 para CO_{2eq}, a universal unit that can even be compared to other greenhouse gases, as shown in the figure below.

Figure 23 - Simulation of the calculation of the estimated total emission in CO_{2eq} (ton.CH_4.animal^{-1}.ano^{-1}) for sheep and goat herds for the proposed scenarios



CH_4 conversion (kg.ano^{-1}) to CO_{2eq} (ton.ano^{-1}) AR4 (25) IPCC, 2007
Source: GHG_Small Ruminants_Calc

Variation in emissions between production systems and herds (%)

When comparing the adoption of technology within production systems in relation to the variation in emissions (%), it is possible to observe the drop in values emitted given the increase in the technology applied. There is, therefore, an inversely proportional variation, since the higher the technological level applied, the lower the values of greenhouse gases within the production system. This information is shown in the following table.

Table 3 - Variation in emissions between production systems and goat and sheep herds (%)

	Variation (%) Low - Medium	Variation (%) Medium - High	Variation (%) Low - High
Sheep	-11%	-15%	-28%
Goat	-6%	-25%	-33%

Source: GHG_Small Ruminants_Calc

Carbon stock results (C)

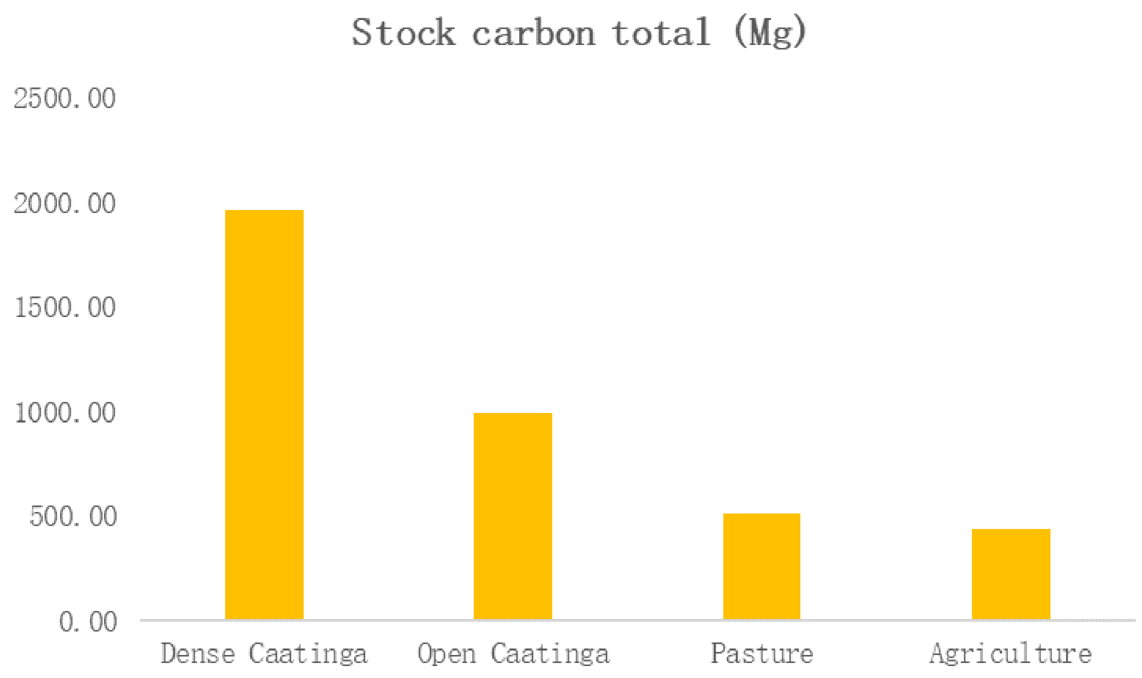
For the description of the carbon stock calculations in the tool, two scientific articles developed on the Caatinga biome were used, which regard different types of vegetation and soil cover and also different types of soil (SAMPAIO; SILVA, 2005; SAMPAIO ; COSTA, 2011).

Although the carbon stock data do not represent the same studied scenarios, since there is no C balance calculation from the tool, the values are representative in terms of carbon stock (Mg C) and CO_2 removal (Mg CO_2) regarding the different vegetation and soil covers and types of soil in the Caatinga.

In this case, there are higher stock and removal values, respectively, for dense Caatinga, open Caatinga, pasture and agriculture (crops).

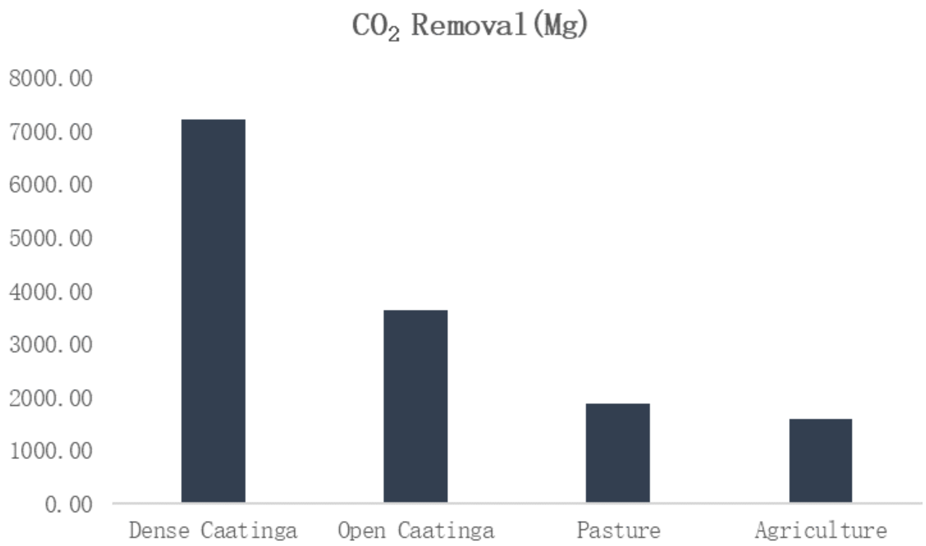
The simulated areas for the scenario that generated the results presented below were: area of dense Caatinga = 20 ha; area of open Caatinga = 15 ha; area of pasture = 7.5 ha; and area of agriculture = 7.5 ha.

Figure 24 - Simulation of the calculation of carbon stock (Mg) for scenarios of dense Caatinga vegetation, open Caatinga, pastures and agriculture



Source: GHG_Small Ruminants_Calc

Figure 25 - Simulation of CO_2 (Mg) removal calculation for scenarios of dense Caatinga vegetation, open Caatinga, pastures and agriculture



Source: GHG_Small Ruminants_Calc CO_2 removal= SOC x 44/12 (C-Sequ - FAO, 2021).

The improvement of the stock and removal calculations needs to be better established within each of the studied scenarios, so that it is possible to estimate the carbon balance numbers.

This approximation influences the entry of real property data, which turns out to be not so simple with regard to stock numbers and removal, considering: type of soil cover vegetation; type and density of species that cover the soils (aerial and root biomass); and type of soil in which the systems and animals are inserted.

Final Remarks

It was possible to create a calculation tool with a dynamic profile, as well as generate enteric methane emission values and the management of goat and sheep manure in the proposed scenarios. In addition, it was possible to generate preliminary values of carbon sequestration in the proposed scenarios.

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