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Greenhouse gas emissions from livestock production in rural area of Algeria, the case of Chemini (Kabylie)

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Abstract

The Algerian agricultural sector faces the challenge to meet the food needs of its population despite low agricultural capacity, resulting in increasing pressure on natural resources. This paper aims to inventory the greenhouse gas (GHG) emissions related to livestock sector in the rural area of Chemini (province of Bejaia), taking into account the emissions due to enteric fermentation, in the form of methane, and manure management, in the form of methane and nitrous oxide. Emissions intensity, expressed in CO_2-equivalents (CO_2-eq) per kg of edible protein, was included in the study. Ruminants contribute to 94% of livestock GHG emissions and to 53% of protein production, with a large share due to cattle. The main part of emissions is related to enteric fermentation. High-producing cattle present the lowest emission intensity of the ruminant category with 24 kg CO_2-eq per kg protein. Chickens produce 2.7% of livestock related emissions but provide 47% of animal protein. It results in low emission intensities whereas important difference is noticed between backyard and industrialized systems (around 21 versus 1 kg CO_2-eq per kg protein, respectively). Improvement of animal performance should contribute to mitigate the environmental impact of livestock production in Algeria.

Keywords: edible proteins, emission intensity, enteric fermentation, manure management, methane, nitrous oxide.

Introduction

In Algeria, agriculture sector contributes to about 10% of gross domestic product and employs 14% of the workforce. However, it fails to meet the food needs of the country’s population since domestic production covers only 15% of the needs (Benbekhti 2008). With 0.20 ha of utilized agricultural area per capita (8 million ha for a population of 38.7 million inhabitants), the agricultural capacity of Algeria is low and essentially limited to a narrow fringe situated in the North of the country (Abbas 2012). In the next decades, food demand for livestock products is expected to increase owing to the demographic growth and the changes in food preferences. Presently, livestock products provide one-third of humanity’s protein intake (Steinfeld et al 2006). In rural area, a large number of poor people depend on livestock for their daily survival, and extra income and food. Backyard animal production systems have a huge cultural, social and economic importance for smallholders, but come under increasing pressure resulting from competition over resources (FAO 2011; Moula et al 2009; Moula et al 2012a).

The impact of animal agriculture on natural resources includes the reduction of the biodiversity, the degradation of land, soil and water, and the air pollution (Steinfeld et al 2006). Globally, livestock production accounts for 18% of anthropogenic emissions of greenhouse gases (GHGs) involved in climate change and global warming (Steinfeld et al 2006). In Algeria, the livestock sector is estimated to contribute to about 6% of national emission of GHGs (UNFCCC 2014). The latter figures only include the emissions due to enteric fermentation (in form of methane, CH_4) and manure management (in form of CH_4 and nitrous oxide, N_2O). These two gases are important contributors because their global warming potential (GWP) over a 100-year period are 34 and 298 times that of CO_2, respectively (IPCC 2013). The GWP is used to calculate cumulative emissions of GHG by converting the various GHG emissions into comparable CO_2-equivalents (CO_2-eq.).

Emission intensity reflects the emission level per unit of animal product (i.e. kg of carcass weight, milk or protein). It may greatly differ between production systems. By example, live cycle analyses performed for cattle milk production (including all the supply chain, from feed production to transportation of the final products to the retail points) showed that industrialized regions of the world exhibit the lowest emission intensities, around 1.7 kg CO_2-eq per kg milk, while in developing regions it ranges from 2.0 to 9.0 kg CO_2-eq per kg milk (FAO 2013a). In some rural area, it is common that industrialized and backyard production systems coexist.

The aim of this study is to evaluate the GHG emissions and emission intensities related to livestock production in such area in Algeria, taken into account enteric fermentation and manure management. Emissions associated with feed production, land use and land use change, energy consumption, manure spreading, transportation and food processing are not included in this discussion.

Material and methods

The region of Chemini was chosen as representative example of agricultural area of Algeria. Chemini is located in the Western of the Wilaya (province) of Bejaia, at 140 km West of Algiers (Figure 1). The surface area of Chemini is 39.04 km². In 2008, the population was 15,274 inhabitants distributed amongst 25 villages (Office National de Statistiques 2014).

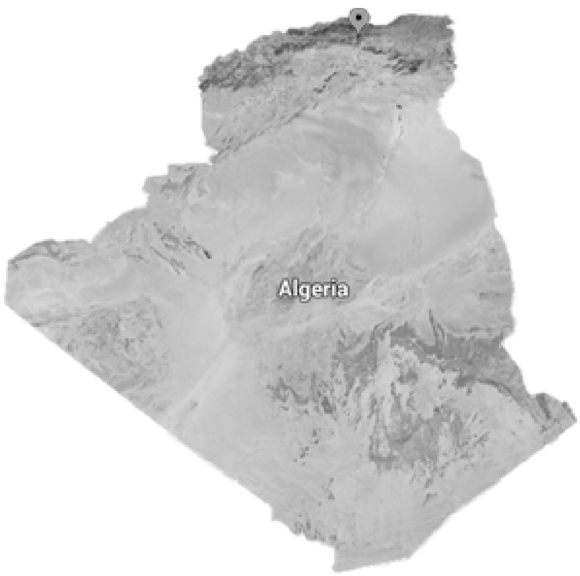

Figure 1. Location of the region of Chemini, Algeria.

The inventory of GHG emissions was performed in accordance with the guidelines of the IPPC for emissions from livestock, manure management and managed soils (IPCC 2006). The tier 1 approach was used for this assessment. Livestock species and categories retained were: high-producing cattle (ameliorated breeds, average milk production of the herd around 20 L day^{-1}), low-producing cattle (local breeds, average milk production around 5 L day^{-1} $head^{-1}$), sheep, goats, mules, asses, horses, rabbits, backyard chicken, backyard turkey, industrialized layers, industrialized broilers, and industrialized turkey. Animal population was estimated by conducting a field survey of animal keepers in the villages of Chemini in August 2014. This method was preferred to official statistics that may underestimate animal population. Average annual population for each category was estimated by balancing the measured population by the specific lifespan of the category and the number of series over the period of one year. Default emissions factors were used for calculations of CH_4 emission from enteric fermentation taking into account the region of interest and the animal performance. Methane emissions factors from manure take into account the manure management system allocation for each category and the average annual temperature. Calculations of N_2O emissions from manure management use default values for nitrogen excretion, manure management system allocations, and N_2O emission factors for direct emissions, and fractions of volatilised nitrogen in forms of NH_3 and NO_x for indirect emissions. N_2O emissions associated with pasture and grazing operations were calculated according to the recommendation for managed soils (IPCC 2006). Table 1 summarises the emission factors used for each animal category.

Table 1. Emission factors by source and by animal category used for the calculation of greenhouse gases emissions (IPCC 2006).

Animal categories	**CH_4 Enteric (kg CH_4 $head^{-1}$ $year^{-1}$)**	**CH_4 Manure (kg CH_4 $head^{-1}$ $year^{-1}$)**	**N_2O Manure (kg N_2O $head^{-1}$ $year^{-1}$)**
High-producing cattle	109	1.00	2.31
Low-producing cattle	61.0	1.00	1.82
Sheep	5.00	0.150	0.302
Goats	5.00	0.170	0.314
Asses	10.0	0.900	0.343
Mules	10.0	0.900	0.343
Horses	18.0	1.64	0.628
Rabbits	0.0542	0.0800	0.127
Backyard chicken	-	0.0200	0.0137
Backyard turkey	-	0.0200	0.0577
Industrialized broilers	-	0.0200	0.00124
Industrialized layers	-	0.0200	0.00339
Industrialized turkey	-	0.0200	0.0115

Emission intensity was calculated for the main species contributing to GHG emissions and protein supply, i.e. cattle, sheep, goats and chicken. The functional unit was expressed as kg CO_2^{-eq} per kg of protein. Estimation of the protein production by animals was based on specific zootechnical performance for each animal category in the region of interest, as reported by FAO (2013a 2013b and 2014). It takes into account herd parameters (fertility, mortality, replacement rate, growth rate), slaughter parameters (weight and age at slaughter, carcass yield, meat and protein shares), milk yield and/or laying parameters (egg weight, number of eggs per hen per year, number of laying cycle). For milking and laying animals, the assessment includes the protein production originating both from milk/eggs and meat production since culled animals can be slaughtered for meat consumption.

Results

High-producing cattle account for 2/3 of total livestock emissions, followed by low-producing cattle with 1/5 of the total emissions (Table 2). Small ruminants contribute to 6.33% of the emissions. Poultry sector produces 2.72% of the emissions, essentially due to laying hens. Methane emissions from enteric fermentation are the main contributor. It represents around 80% of the emissions for cattle, and around 2/3 of the emissions for small ruminants, while enteric CH_4 emissions from poultry are considered negligible. Methane from manure is the main part of emission for broilers (around 2/3 of the emissions). For backyard chicken and industrialized laying hens, the main share is represented by N_2O from manure management, with 85.8% and 59.7% of the emissions respectively.

Table 2. Annual greenhouse gas emissions by source and by animal category, in tons of CO_2^{-eq}, in the region of Chemini, Algeria.

Animal categories	Average annual animal number	CH_4 Enteric	CH_4 Manure	N_2O Manure	Cumulative emissions
High-producing cattle	1224	4536 (71.5%)	41.6 (22.7%)	844 (53.9%)	5421 (67.0%)
Low-producing cattle	618	1281 (20.2%)	21.0 (11.5%)	335 (21.4%)	1637 (20.2%)
Sheep	1543	262 (4.13%)	7.87 (4.30%)	139 (8.88%)	409 (5.05%)
Goats	385	65.5 (1.03%)	2.23 (1.22%)	36.1 (2.31%)	104 (1.28%)
Asses	389	132 (2.08%)	11.9 (6.50%)	39.8 (2.54%)	184 (2.27%)
Mules	83	28.2 (0.445%)	2.54 (1.39%)	8.48 (0.542%)	39.2 (0.485%)
Horses	66	40.4 (0.636%)	3.68 (2.01%)	12.4 (0.789%)	56.4 (0.697%)
Rabbits	563	1.04 (0.0163%)	1.53 (0.836%)	21.3 (1.36%)	23.9 (0.295%)
Backyard chicken	2550	-	1.73 (0.947%)	10.4 (0.668%)	12.2 (0.150%)
Backyard turkey	192	-	0.131 (0.0713%)	3.30 (0.211%)	3.43 (0.0424%)
Industrialized broilers	29104	-	19.8 (10.8%)	10.7 (0.687%)	30.5 (0.377%)
Industrialized layers	100427	-	68.3 (37.3%)	101 (6.48%)	170 (2.10%)
Industrialized turkey	1027	-	0.699 (0.382%)	3.53 (0.226%)	4.23 (0.0523%)
Total		6348 (100%)	183 (100%)	1564 (100%)	8095 (100%)

Concerning the protein production, high-producing cattle contribute to about 46% of the annual production, as well as the industrialized chicken, broilers and layers together (Table 3). The rest of the production is principally due to low-producing cattle, while the overall production by sheep, goats and backyard chicken is around 1%.

Table 3. Annual protein production, in tons year^{-1}, and

emissions intensity, in kg CO_2-eq (kg protein)$^{-1}$, by animal category in the region of Chemini, Algeria.

Animal categories	**Annual protein production (tonnes year^{-1})**	**Emission intensity (kg CO_2-eq kg protein^{-1})**
High-producing cattle	225 (45.8%)	24.1
Low-producing cattle	32.2 (6.55%)	50.9
Sheep	3.21 (0.653%)	127
Goats	1.48 (0.301%)	70.0
Backyard chicken	0.591 (0.120%)	20.6
Industrialized broilers	191 (38.8%)	0.890
Industrialized layers	38.2 (7.76%)	0.800
Total	492 (100%)	-

Emission intensity for sheep is the highest, with 127 kg CO_2-eq kg protein^{-1}, while high-producing cattle have the smallest value of the ruminant sector, with 24.1 kg CO_2-eq kg protein^{-1} (Table 3). Poultry production presents the lowest emission intensities, especially for the industrialized chicken, with less than 1 kg CO_2-eq kg protein^{-1} for both broilers and layers.

Discussion

In Chemini, ruminants contribute to 93.5% of livestock GHG emissions and to 53.3% of protein production, with a large share due to cattle. The main part of emissions is related to enteric fermentation. High-producing cattle present the lowest emission intensity of the ruminant category. This highlights the fact that, when the productivity of animals increases, the same amount of output can be produced while the herd size is reduced. With higher yields, there is a shift in the distribution of feed towards less feed for maintenance and more for production (Gerber et al 2011).

Small ruminants show the highest emissions intensity whereas their contribution to protein production is very weak. However, this sector should not be neglected because it plays a very important role for rural inhabitants. Indeed, small ruminants are well suited to the harsh conditions of the region thanks to their rusticity and low demand for input. Thus, they represent a relatively low-risk source of food and income for vulnerable households in this area (Kamuanga et al 2008; Moula et al 2014). Large efforts should be done to improve the productivity of these animals as regards on feed quality, genetic potential, animal health, fertility and herd management. In case of higher production combined with a lower proportion of non-producing animals (breeding herd and replacement stock), a more important part of the resources are used for the production of edible product with positive effects on environmental footprint as consequence.

The poultry sector is a low contributor to GHG in Chemini. Chickens produce less than 3% of livestock related emissions but provide 46.7% of animal protein, resulting in low emission intensities. However, an important difference is noticed between backyard and industrialized systems, to disadvantage of the first. Numerous factors can be proposed to explain this difference, as suggested by FAO (2013b). Backyard chickens are smaller, grow slowly and lay fewer eggs. They spend energy scavenging for feed and the feed quality of their ration is lower (digestibility, nitrogen content). The herd structure differ from commercial systems with higher death rate (due to disease and predation), and lower fertility rate, with higher proportion of un-productive breeding animals in the flock as a result. Manure deposition on the ground rather than collection and management like with intensive systems also leads to higher emissions in form of N_2O.

Nevertheless, the environmental efficiency of industrialized systems, as pointed out in this paper, should not hide the strong dependence of these systems regarding the incomes, especially for feed and commercial lines of animals. It must be remembered that this assessment does not include GHG emissions related to feed production. In industrialized systems, feed production can account for more than 75% of total emissions, including land use change (FAO 2013b). Local animal resources in the region of Chemini present a large range of species and breeds that are perfectly suited to their environment (Moula et al 2012b). Erosion of such biodiversity should have deleterious consequences on environmental, cultural, social and economic levels. Thus, the challenges for the livestock sector in Algeria are the research and promotion of locally-available feed of high quality, in combination with improvement of animal performance (with special attention to animal health and herd management). In this way, the sustainability of livestock production systems could be ensured.

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