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Agriculture and Greenhouse Gas Emissions

K.K.G.L. Chathumini, N.P. Dassanayake,D.D.P.Preethika,R.T.Wadanambi,L.S.Wandana, Udara S.P.R. Arachchige
Faculty of Technology, University of SriJayawardhenapura

Abstract: Greenhouse gas emissions occur due to agriculture's effect in several ways, which has a worldwide impact on the environment. The leading gases produced by agricultural activities are methane (CH4) and nitrous oxide(N2O). These gases have a much greater potential to create a greenhouse effect than carbon dioxide (CO2). This study discusses the impact of various aspects of agriculture on GHG emissions and mitigation measures for them.

Index Terms: Agriculture, Green House Gas Emissions, Methane, Nitrous Oxide

1 INTRODUCTION

Agriculture contributes a variety of 0-98% of country greenhouse gas emissions, with a mean of 30%. Sri Lankan agriculture contribution for the national emission is 25% while emitting 4.7-10.9 Mt CO_2 equivalent of greenhouse gases to the atmosphere [1]. Agriculture emission includes methane (CH_4) and Nitrous Oxide (N_2O) emissions from livestock, manure management, flooded rice cultivation, agricultural soils, fertilizers, and burning of crop residues savannas, also as CO_2 from liming and urea applications. CO_2 emissions and up stakes related to agrarian soils, biomass, and land-use change.

Sri Lanka featured a long history in the agriculture industry Sri Lanka and was one of the world's foremost agrarian societies during the traditional kingdoms. Initially, agriculture activities are limited to domestic consumption. During the colonial era, the agriculture industry in Sri Lanka faced an exciting change by introducing commercial trading like coffee, rubber, and coconut and tea plantation. As of today, agriculture has been converted into trading and international markets. The agriculture industry consisted of 4 significant categories like plantation, fisheries, livestock, and forestry. They are again divided into 16 sub-components. 1-growing of cereals, 2- growing of rice, 3-growing of vegetables, 4-growing of sugar cane, tobacco, 5-growing of fruits, 6-growing of oleaginous products (coconut, king coconut, oil palm), 7-growing of tea, 8-growing of other beverage crops (coffee, cocoa), 9-growing of pharmaceutical crops and spices, 10-growing of rubber, 11-growing of other perennial crops, 12-animal production, 13-plant propagation, and support activities to agriculture, 14-forestry and logging, 15-Marine fishing and marine agriculture and 16-Fresh water fishing and water agriculture. 30% of the total population engages in the agriculture industry. Sri Lanka is moving towards organic agriculture, which is more health positive [2].

2 IMPACT OF FOREST

Global climate change is among our time's best scientific, environmental, economic, and social challenges. The typical global surface temperature has risen by 0.74°C since the late 1800s. Therefore the best estimates from model projections show that the surface air temperature could increase another 1.8–4.0°C within the 21st century [3]. The present warming trend is predicted to possess severe global effects like water level rise, higher frequency of utmost weather events, freshwater shortages, changes in agricultural yields, and negative impacts on forest ecosystems.

As a developing island nation, Sri Lanka is susceptible to the possible impacts of global climate change. The land use and forestry sector account for an outsized part of Sri Lanka's greenhouse emission emissions. Forests have a crucial role in the global carbon cycle. Sri Lanka has lost quite 60% of its forest cover, from about 80% within the late 1800s to 25% in early 2000. Eighty-five percent of the natural forests contain dry-zone forests [3]. Lowland rainforests and montane forests with higher biological diversity and better endemism levels are confined to small patches. The land use and forestry sector accounts for an outsized part of Sri Lanka's GHG emissions and may play a severe amount in Sri Lanka's strategy to mitigate and adapt to global climate change.

If planned and implemented correctly, carbon mitigation activities from the land use and forestry sector can bring adaptive components like the continuity of forest ecosystems, biodiversity, watershed conservation, and poverty alleviation. Deforestation and forest degradation account for about 6–18% of all GHG emissions [3]. The leading causes of forest degradation in Sri Lanka comprise illicit felling of trees, shifting cultivation, cattle damage – livestock grazing, illegal cultivation, encroachment, and extraction of gravel, minerals, and metals. It's difficult to estimate the actual emissions associated with these causes, and no proxy estimates are available. GHG emissions causes due to the conversion of forest land to another land. Timber harvesting, after which the plantation is again planted, causes losing lanes. The annual area clear-felled and replanted during the same year amounts to 800 to 1000ha [4]. The felled areas are generally replanted due to the high demand for fuelwood for estate operations**.**

During photosynthesis, trees assimilate CO_2 from the atmosphere and convert it to carbohydrates. A number of the carbohydrates are respired back to the atmosphere. Therefore the rest forms the biomass of the trees. When the material gets dried, the carbohydrates are decomposed or are burnt, and therefore the carbon is released back to the atmosphere as CO_2.

2.1 Mitigation Measures

- Reducing emissions from Deforestation
- Afforestation and reforestation for the enhancement of forest carbon stocks

In the future, when large scale forest type maps are available with the forest department in Sri Lanka.

- Sustainable management of forests
  - ✓ Activities that replace formerly unsustainable forest management strategies lead to the reduction of forest carbon stocks, during which case the Degradation activity covers it.
  - ✓ Activities that are introduced to extend carbon stocks in formerly unmanaged forest areas, during which the Restoration activity covers it.
- Conservation of forest carbon stocks
  - ✓ Activities that ensure that forest lands are not converted to other land use categories, during which case the Deforestation activity covers it
  - ✓ Activities that ensure that carbon stocks in forest lands are not reduced over time, during which case the Degradation activity covers it
  - ✓ Activities that enhance forest carbon stocks in protected areas are covered by the Restoration activity [4].

3 IMPACT OF SYNTHETIC FERTILIZER

Synthetic and organic crop residues left after harvesting, and animal manure deposited during grazing are the most sources that contribute to N_2O emission. N_2O emissions from cropping systems are strongly correlated to increased N fertilization. With the doubling of the N use in South-Asia since 1990, there is an excellent potential for enhanced N_2O emissions from the Asian region [6]. The overuse of synthetic N fertilizer generates significant environmental threats. Nitrogen fertilizer, which is not taken by the crop, is either lost as N gas, including the greenhouse emission (GHG) nitrous oxide gas (N_2O).

Nitrous oxide (N_2O) is liable for 6% of worldwide anthropogenic GHG emissions; 90% of those emissions are associated with agriculture. The very best increase is predicted from developing countries under the Kyoto protocol, including Sri Lanka, with increases of over 65% in 2050 unless mitigation strategies are implemented. Increased N fertilizer usage and animal production are the most sources of the projected increase in N_2O. Agricultural soils are the key anthropogenic sources of N_2O and contribute around 60% of human-derived N_2O emissions [6].

Nitrogen oxides are identified as a severe air pollutant in Sri Lankan cities. The contribution of N_2O to the entire GHG emissions in Sri Lanka in 2010 was 18.1%. The Third National Communication (TNC) to the UNFCCC by Sri Lanka, which is currently being prepared by the global climate change Secretariat of the Ministry of Mahaweli Development and Environment, indicates that the agriculture sector in Sri Lanka contributed to about 82% of the entire N_2O emission [6]. Ammonium (NH_4^+) and Nitrate (NO_3^-) are the most sorts of nitrogen nutrients that plants may absorb from soils. The nitrate ion is the most common inorganic nitrogen in the soil, and it is the most vital nutrient that higher plants require. N deficiency in soil resulting in significant reductions in plant growth, especially during the vegetative stage. Nitrogen, converted to ammonia by the Haber process, is employed within the industry to form fertilizers. Plants are unable to use gaseous sort of N in the atmosphere. It must be fixed naturally through abiotic lightning and volcanic actions, the biological organic process by symbiotic bacteria within the root and stem nodules of legume plants.

Synthetic fertilizer is one of the primary artificial processes that add nitrogen to the soil. Synthetic fertilizer is often partly lost or unavailable for plants: the leaching, DE nitrification, and NH_3 volatilization cause that. Because nitrogen is very mobile, certain soil bacteria that thrive in saturated (anaerobic) soil conditions convert NO_3^-nitrogen to O_2 and nitrogen gases as a result of DE nitrification. Volatilization of the nitrogen as NH_3 gas may result in N losses of the maximum amount as 5% of nitrogen per day. Urease enzymes within the soil and crop residues convert the urea component to $NH4^+$ ion. Suppose this conversion occurs at the soil surface and is related to warm sunny days. In that case, the maximum amount as 15-20% of the urea-based N fertilizer may volatilize as NH_3 gas within per week after application [6]. Urea because the primary source of supply of nitrogen to crop production in Sri Lanka. Imported urea to Sri Lanka during 2015-2017 is for agricultural use is represented by Fig. 1.

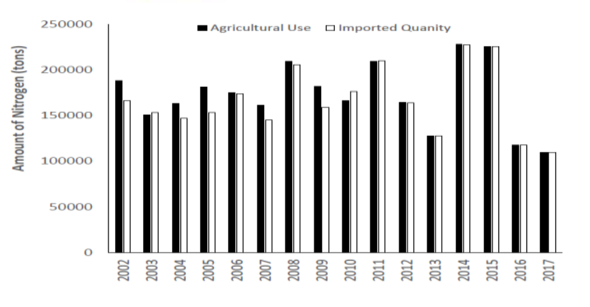

Fig. 1. Imported urea in Sri Lanka [6]

Around 64% of the imported urea, with a nitrogen content of 46%, is employed in paddy cultivation in Sri Lanka. The recovery of applied nitrogen to wetland paddy is around 20-40%. It is estimated that 1.0 kg of N is required to supply 50.0 kg of grains of rice. Nitrogen utilization in the tea sector in 2018 includes 100.4 million kg of urea and 27.7 million kg of ammonium sulfate, totaling about 51.88 million kg of nitrogen. The entire losses are estimated as 40% of the applied nitrogen[6]. The fertilizer usage for various crops in Sri Lanka is represented by Fig. 2.

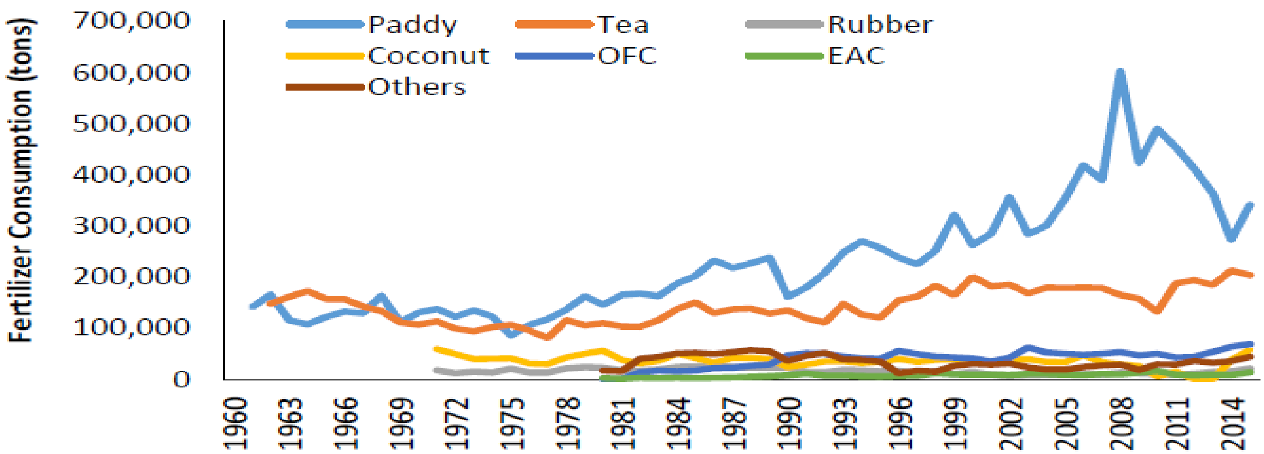

Fig. 2. Fertilizer use in Sri Lanka various crops[6]

3.1 Reasons for emissions

- Use Synthetic fertilizer
- Crop residues left after harvesting
- Animal manure deposited during grazing
- Excessive use of fertilizers

The efficient use of fertilizer without polluting the environment is one of the challenges of sustainable agriculture. Unsustainable agricultural practices have substantial, negative environmental impacts. That will be achieved by understanding the N requirements during a given cropping system.

3.2Mitigation Measures

- Integration with organic fertilizers (Organic Farming)

Composting may be a preferred and environmentally sound method whereby organic waste is reduced to organic and soil conditioners through biological processes. When composting, the ammonium nitrogen component in farmyard manure is converted to organic nitrogen. Vermicomposting may be a method of preparing enriched compost with the utilization of earthworms. It is one of the simplest ways to recycle organic wastes. Vermicompost is stable, excellent granular organic manure. It has the power to enhance soil quality by improving its physicochemical and biological properties.

- Use alternatives
- Agriculture may be a source of chemical pollution from the utilization of nitrogenous and phosphorous fertilizers and agro-chemicals. N fertilization dependency is often minimized by using alternatives like farmyard manure, manure, and compost. Introduction of a canopy crop Mucunabracteata to substitute 50% of N fertilizer requirement of young crops would scale back the value of N by Rs 31,300 per ha[6].
- Promote slow/controlled N releasing fertilizers and increasing their effectiveness
- Deep placement and reduction of frequency of application of N fertilizer,
- Use of N transformation inhibitors to scale back the hydrolysis of urea to ammonium by soil urease enzyme.
- Use of nitrification inhibitors to scale back accumulation of nitrate also will help to reduce GHG emissions.

4 IMPACT OF MANURE

Total emissions of emission sources such as manure management, enteric fermentation, crop residue decomposition, fertilizer, manure applied to feed, manure deposited on pasture, and also feed production, transport, and processing are represented by Fig. 3. The absolute emission of the above emission sources in different regions in Sri Lanka is represented by Fig. 4.

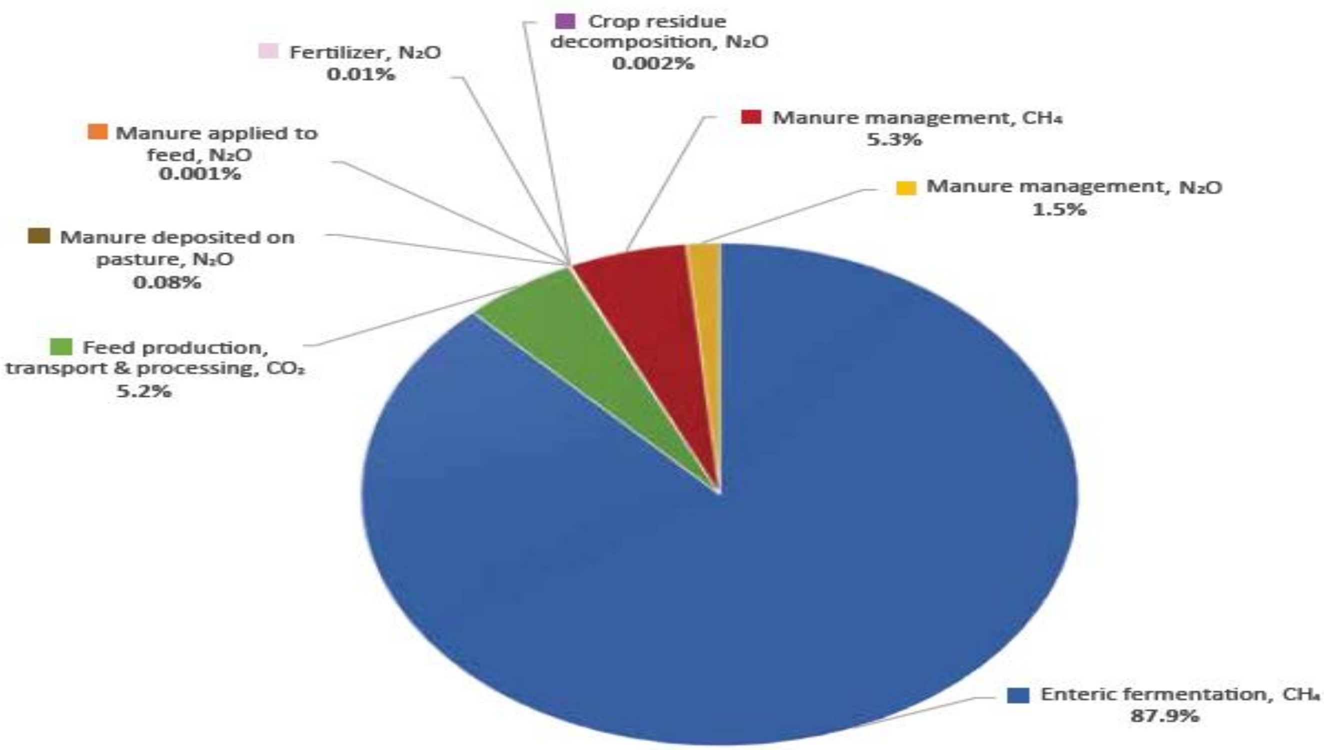

Fig. 3. Total emissions by emission sources[5]

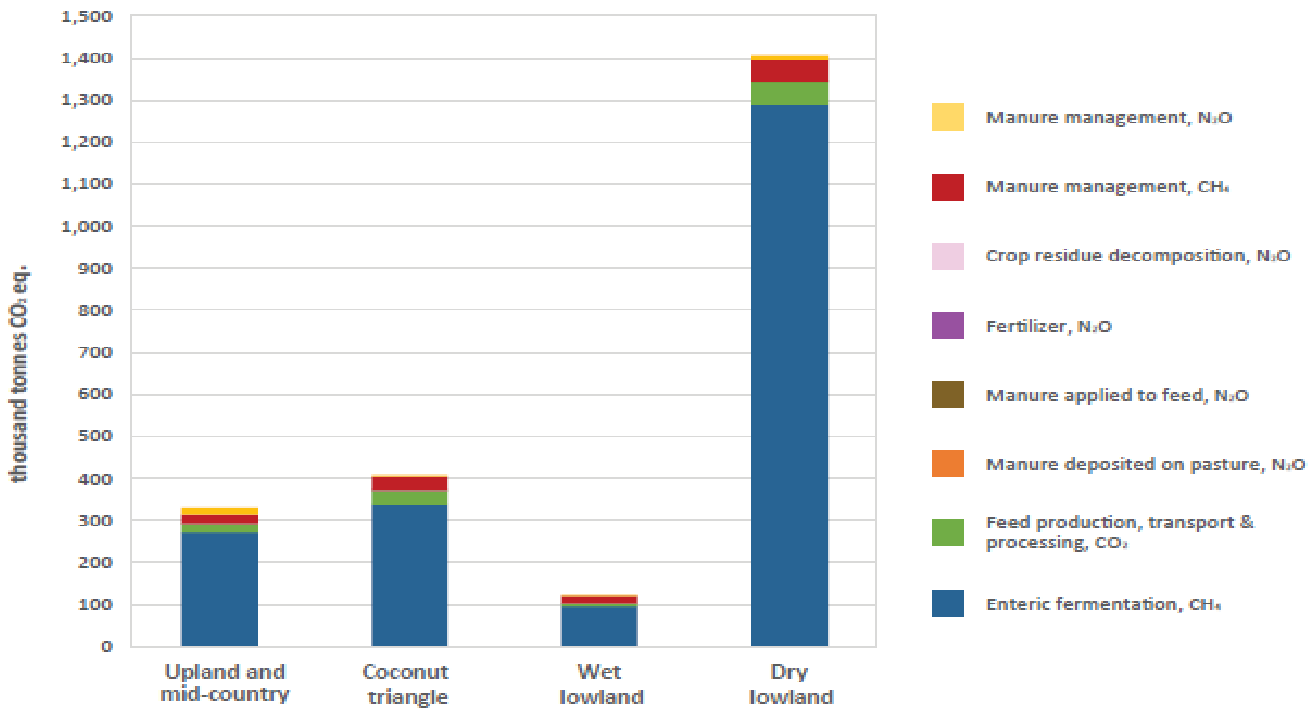

Fig. 4. Absolute emission in different regions of the country [5]

5 ORGANIC FARMING

Since the past, manuring has been considered together of the foremost vital techniques to extend and maintain soil fertility. Soil organic matter plays a crucial role in soil fertility. Rice straw might be considered as a precious organic material for rice grown in Sri Lanka. Since many rice soils in Sri Lanka are low in soil fertility, it should be noted that straw is often successfully wont to improve the long-term soil fertility in many parts of the country. The majority of Sri Lankan farmers are entirely unaware of the worth of rice straw as a fertilizer material, and an outsized quantity of rice straw is wasted. Generally, rice straw may be a valuable source of such as carbon, potassium, and silicon. It is also a convenient source of organic manure in Sri Lanka, apart from being considered the most cost-effective. Rice straw, thereby, might be considered as a significant organic material for rice grown in Sri Lanka. Sources of animal manure feature a high demand for vegetable and potato growers within the country. A unique feature observed within the up-country of Sri Lanka in potato and vegetable cultivation is animal manure like cattle and poultry manure. Within the up-country, it might be considered more as farmyard manure than pure cattle manure because it contains large quantities of grass, straw, and leftovers of bedding materials. However, farmers within the up-country like better to use farmyard manure than pure cattle manure. The addition of manure often reduces chemical fertilizer [7].

6 IMPACT OF LIVESTOCK

Livestock production has increased in Sri Lanka in recent years. The same trend would continue within the future. While providing vital protein for the human population, livestock farming contributes to the greenhouse emission (GHG) emissions. Methane is that the primary GHG emitted by livestock. Livestock populations with ruminants emit methane due to the anaerobic digestive process in the forestomachs (fermentation). In Sri Lanka, the livestock sector contribute to about 0.6% of the gross domestic product. However, this might increase in the future. Milk production has increased by 4% within the year 2014 and has shown an increasing trend over recent years. That is mainly due to the rise in the productivity of an animal and the number of animals. for instance, the cattle population has increased by 10% while the buffalo population by 2% in 2015 compared to 2014 [8].

Milk production from the dairy cow sector in Sri Lanka emits about 2.3 million tonnes CO_2 eq. The emission's profile of milk is dominated by methane (93.2 %), while the nitrous oxide (N_2O) and CO_2 contribute 1.6 % and 5.2 % of the entire emissions, respectively. Approximately 88% of the emissions from the management of stored manure arise from methane produced by the rumination of cows and 5%. CO_2 emissions related to feed production, transport, and processing contribute a further 5% to total emissions [5].

The three leading greenhouse gases (GHGs) are CO_2, methane (CH_4), and nitrous oxide (N_2O). The animal agriculture sector accounts for about 9% of the entire CO_2 emissions, of which animal material processing and transport accounts mainly for livestock-related CO_2emission, while the remainder is from the crop agriculture sector. The livestock sector is liable for about 35-40% of the annual global anthropogenic methane emissions, which are the results of enteric fermentation and livestock manure. Ruminants could produce 250 to 500 liters of methane per day counting on various animal and feed-related factors. That would cause about a 12% loss of the dietary energy within the ration as methane [8]. In Sri Lanka, cattle and buffaloes are the most livestock groups by numbers, while sheep, goat, and swine remain as minors. Sri Lanka total cattlevariation, total buffalo variation, and minor livestock variation from 2015 to 2019 are given in Table 1, Table 2, and Table 3 respectively.

Table 1. Sri Lanka total cattles [9]

Cattle		**Year**						
		2015	**2016**	**2017**	**2018**		**2019*****	
					Local	**Improved**	**Local**	**Improved**
Milk Cows	**Milking at Present**	301,140	284,400	296,250	229,700	99,680	230,850	92,640
	Milking not at Present	295,570	246,160	269,350	225,080	55,190	214,840	53,930
Other Cows		57,910	40,610	36,010	38,240	8,020	35,360	7,580
Bulls		87,100	80,340	75,460	80,180	16,370	78,140	16,380
Calves		346,390	293,640	323,810	263,380	94,900	264,700	91,590
Total Cattle		**1,088,110**	**945,150**	**1,000,880**	**836,580**	**274,160**	**823,890**	**262,120**

Table 2. Sri Lanka total buffallos [9]

Buffaloe		**Year**						
		2015	**2016**	**2017**	**2018**		**2019*****	
					Local	**Improved**	**Local**	**Improved**
Milk Cows	**Milking at Present**	91,570	83,150	86,490	83,500	10,700	81,180	10,610
	Milking not at Present	78,250	63,630	69,980	66,370	9,020	60,730	8,730
Other Cows		12,370	8,000	8,730	8,900	1,080	9,310	1,060
Bulls		33,920	24,960	25,250	25,250	4,990	23,800	2,930
Calves		106,970	87,010	93,100	93,100	11,260	88,440	11,640
Total Buffaloes		**323,080**	**266,750**	**283,550**	**271,740**	**37,050**	**263,460**	**34,970**

Table 3. Sri Lanka other minor livesstocks [9]

Species	Year				
	2015	2016	2017	2018	2019***
Goats	309,160	266,750	287,190	314,800	313,640
Sheep	7,700	8,300	10,389	11,382	11,554
Swine	69,680	81,420	95,120	97,990	91,200

Methane is that the primary GHG emitted by livestock. The quantity of methane emitted by livestock depends on the body size, metabolism, activity level of the animals, and their feed quality. Recently, FAO and therefore, the New Zealand government funded a project on “Reducing enteric methane emissions for food security and livelihoods” and estimated the methane and nitrous oxide emissions by cattle in Sri Lanka. The results indicated that GHG emission is the highest within the Dry Zone while lowest within the Wet Zone. The mid-country, which contributes to about 40% of the national milk production but had only but 10% of the cattle population. It has shown the second-lowest GHG emissions. Comparatively, the cattle production efficiency at Dry Zone is low, leading to the highest contribution to GHG emission. Several processes are conducted to enhance livestock productivity through better feeding and nutrition, which can ultimately function as a mitigation measure to reduce GHG emissions.

6.1Mitigation Measures

- Feeding efficiency improvement has been found to reduce methane emission and increase milk production.
- Exogenous fibrolytic enzymes cellulose and xylanase supplemented with Guinea grass and rice straw. From this, Enteric methane production as a percentage for rumen gas production reduced numerically.
- Adaptive measures on livestock housing, mainly to tackle high temperatures, are introduced and are successful operational within the country.

Warm climate does not allow temperate breeds to perform well, but the local breeds adapted to those conditions and produce less milk. Mid and upcountry of Sri Lanka have a favorable climate for top-producing animals, but land availability is low for livestock farming. Therefore, the dairying had to be moved to the Intermediate and Dry Zones of the country. Because more land is out there for livestock farming within the Intermediate and Dry Zones. As an answer to this matter;
There is a way to construct farmhouses by tackling high heat. To accommodate more air movement, most farms consider well-ventilated, high roof sheds, and a few have introduced cooling and fogging systems. These farms having temperate breeds are located in hot and humid places like Hambantotain, the southern province of the country, and have proven to achieve success. Improved cattle breeds are typically given higher quality, concentrate feed, mostly consisting of coconut cake and rice bran, and that they have higher digestive

efficiencies with reduced CH_4 emissions. Livestock housing method is represented by Fig. 5.

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Fig. 5. Livestock housing method[7]

6.2 Factors that affects to Methane emission of livestocks

- Inadequate and poor feeding
  Feed resources are either not available in sufficient quantities due to fluctuating weather or, maybe when available, poor nutritional quality. Seasonal changes in pasture conditions compound that problem. With weak productivity during dry seasonsdiet is mainly made from low-quality feed products like crop residues and native pastures of poor nutritive value.
- Poor reproductive performance of the dairy herd
- High genetic potential animals

6.3 Mitigation measures of livestock Methane emission

- Supplementation with fodder trees, rice straw, and low-cost concentrate. – Here, lower CH_4 observed with legumes is attributed to lower fiber content and faster rate of passage of feed through the rumen; thus, intakes are higher with legume forages.
- Use of total mixed ration – improves productivity and reduces methane emissions
- Supplementation of forage diet with Gliricidia blocks- Promotes high dry matter intake and have a faster rate of passage through the rumen and reduction of CH_4
- Animal comfort (heat stress management)- Enhanced animal productivity and reduced GHG emission intensity.
- Low-quality forage including grasses causes higher amounts of CH_4 emission, and most of the indigenous/local cattle and buffaloes in Sri Lanka feed on low-quality grasses, straw, and other crop residues [5].

7 IMPACT OF COW-DUNG

According to the United Nations Food and Agriculture Organisation (FAO), the animal waste on this planet produces around 55–65 % methane. By releasing to the atmosphere can affect heating 21 times above the speed CO_2 does. Cow dung, an animal waste, maybe a cheap and merely available bioresource on our planet. Cow dung is often defined because of the undigested residue of consumed food material being excreted by herbivorous bovine animal species. A mix of feces and urine within the ratio of 3:1, it mainly consists of lignin, cellulose, and hemicelluloses. It also contains 24 different minerals [10].

7.1 Usages of cow-dung

- Cow dung is often used as a co-product in agriculture, like manure, biofertilizer, biopesticides, pest repellent, and energy sources.

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- As per Ayurveda, it also can act as a purifier for all the wastes within nature.
- Use within the field of energy production like biogas, pharmaceutical products.

A mixture of various gases produced by anaerobic fermentation of organic matter from methanogenic bacteria is defined as biogas. It mainly constitutes methane (50–65 %) and CO_2 (25–45 %). One kilogram of manure can produce 35–40 l of biogas. Here cow dung is mixed with an equal amount of water with hydraulic retention time (HRT) of 55–60 days maintained at an ambient temperature of 24–26 °C[10].

Green bacteria like Pseudomonas sp., Azotobacter sp. are known to supply the maximum amount of methane gas as compared to other photosynthetic bacteria present in cow dung[10]. Bacteria convert the solids in manure into biogas, primarily methane, which may then be wont to generate electricity. Biogas is captured and burned to power the farm and generate electricity to be sold back to the facility supplier. Capturing and using the methane prevents its discharge to the atmosphere, where it is 21 times more heating potential than CO_2[11].

8 CONCLUSION

Green house gas emissions occurs due to the effect of agriculture in several ways and it has a worldwide impact on the environment. Methane (CH_4) and nitrous oxide(N_2O) are the main gases produced by agricultural activities. Agriculture involves for the Green House Gas Emissions in different aspects. Forests, Synthetic Fertilizers, Manure, Livestock, and Cowdung are major GHG emissions in the agricultural field. We can apply different mitigation measures for all of these aspects and can mitigate the Green House Gas emissions to the environment. Reducing emissions from deforestation, afforestation and reforestation, sustainable management of forests, conservation of forest carbon stocks, organic farming, promote controlled N releasing fertilizers, feeding efficiency improvement for the livestock and efficient livestock housing are some of effective GHG mitigation measures in the agriculture sector.

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