Greenhouse gas emission and mitigation measures of agriculture in Sri Lanka

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Abstract: Sri Lanka is a developing country whose agricultural contribution to the economic sector is 11 per cent, and Greenhouse gas emission from the agricultural sector is 25.1 per cent. In reducing GHG emissions, it is essential to consider maintaining fertile soil and restoring degraded land. As a developing country, it is complicated to implement some of the agricultural sector's advanced techniques. But this article is beneficial to understand simple ways to reduce GHG emissions in the agricultural sector. Adaptation to climate change is also an important part to identify the available GHG emitting sources.

Index Terms: Crops & Livestock, Degraded land, Fertile soil, GHG emission, GHG mitigation, Manure management.

1 INTRODUCTION

Sri Lanka is a developing country which mainly depends on the agricultural sector in the past. However, the fact has been changed over time by the agricultural sector's contribution to gross domestic product changed to 46% in 1950 to 11% in 2012 [1]. For the agricultural purpose, 36.4 per cent of the total land area in Sri Lanka is used. The total extent cultivated in Sri Lanka is revealed as 5,643,277 acres (2,283,803 hectare) [2]. The main cultivation crop in Sri Lanka is Paddy rice. The total land as weddumized for paddy was 1,706,410 acres (690,560 hectares) of the small-holding sector in 2013/2014. Other crops are Tea, Rubber, Coconut, and other perennial crops (Pepper, Coffee, Cinnamon, Cocoa, etc.) [2].

In the past, agricultural behaviour is mostly combined with the environment. The traditional agriculture has been practiced in Sri Lanka for nearly 2000 years. It was organic farming because they did not use any artificial pesticide, fertilizers, etc. Chena cultivation was practiced in traditional agriculture; it is practiced by cleaning the forest and cultivate for 1 or 2 seasons then fallow for a period again forest regenerate. Also, a home garden is practiced in the past; it still practicing is some people [3]. Due to eco-friendly traditional agriculture practice, GHG emission is not highly affected by the past environment. After industrialization, the new technologies, machines, chemicals, fertilizers and pesticides were used for agriculture. Also, fossil fuel usage increased. Because of that, the agriculture sector also becomes a contributor to GHG emission. As shown in Fig.1, the agriculture sector is responsible for 25% of GHG [4].

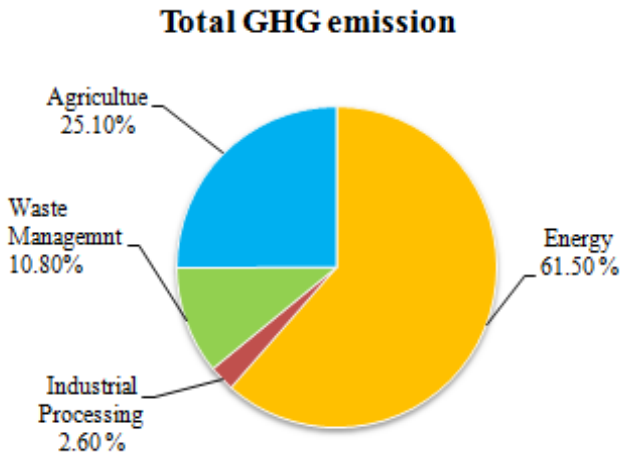

Fig. 1. Total GHG emission by sectors in Sri Lanka [4].

As shown in Fig.2, GHG emissions from the agriculture sector, mainly in Crops and livestock.There are 69.5% of GHG emissions from crops including Cultivation of organic soils, Rice cultivation, and Burning of crop residues. 30.5% is emitting from livestock, including Enteric Fermentation and Manure management [4].

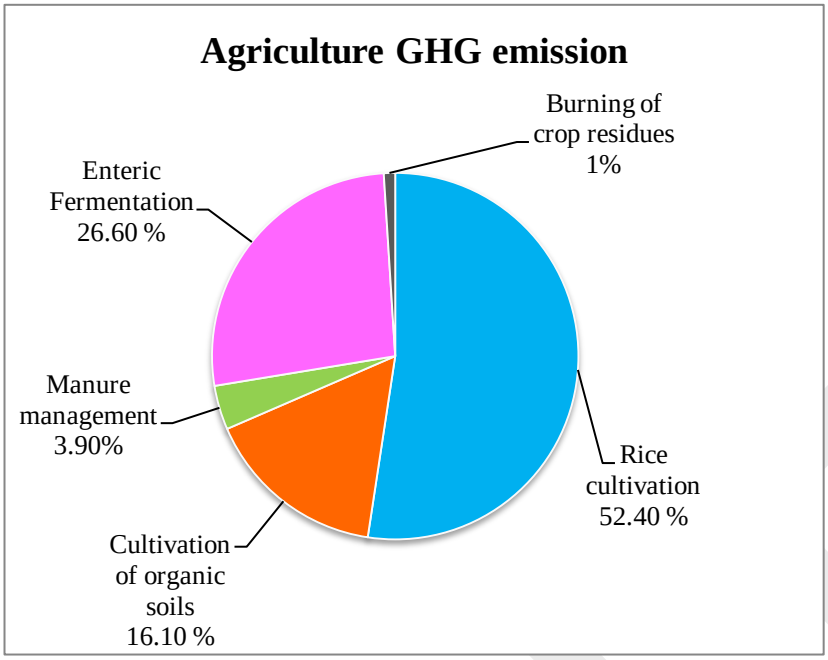

Fig. 2. Agriculture GHG emission [4].

Mitigation of GHG emissions from the agriculture sector is important because it plays a major role in GHG emissions in Sri Lanka [5].

2 MANURE MANAGEMENT

2.1 Emission from manure

Main GHG emission from manure is a Nitrous oxide (N_2O) and Methane (CH_4). An organic compound contains in manure convert to methane and Nitrogen convert to Nitrous oxide. Methane generates from manure by anaerobic decomposition. Nitrification and Denitrification are lead to generate Nitrous oxide. Storage of solid manure provides the condition for anaerobic and aerobic microorganisms to active. That leads to N_2O emission [6].

2.2 Mitigation of emission from manure

Emission of methane from manure storage tanks can be reduce using solid covers, by separating slurry and solid from manure and cooling as well as capturing the methane emitted from the storage tank. Also, use the manure for biogas production will make it as renewable energy. Sometimes, manure can use for composting under controlling emission. Modifying the feeding strategy will also help to prevent methane and N_2O emissions [7]. This can be done using the animal which has high productivity that will reduce the numbers of animals on the farm and manure production. For that gene characteristics of animal has to change [8].

3 LIVESTOCKS AND CROP MANAGEMENT

One of the major sub-economic sectors in agriculture in Sri Lanka is crop and livestock. According to the population growth land use for crop cultivation and livestock also increase. The GHG emission increases due to the increase in agricultural production. There are three major agricultural productions in Sri Lanka. They are Food crops, Plantation crops and Dairy cattle. Sri Lanka has 42% of the area under agricultural land. The prominent food crop is paddy rice and vegetable cultivation. Around 46.1% of the harvested area is covered by paddy rice. Also, Coconut and Tea is the main plantation crop in the agricultural sector. The pie chart in Fig.3 shows the harvested area of main crops in Sri Lanka [4].

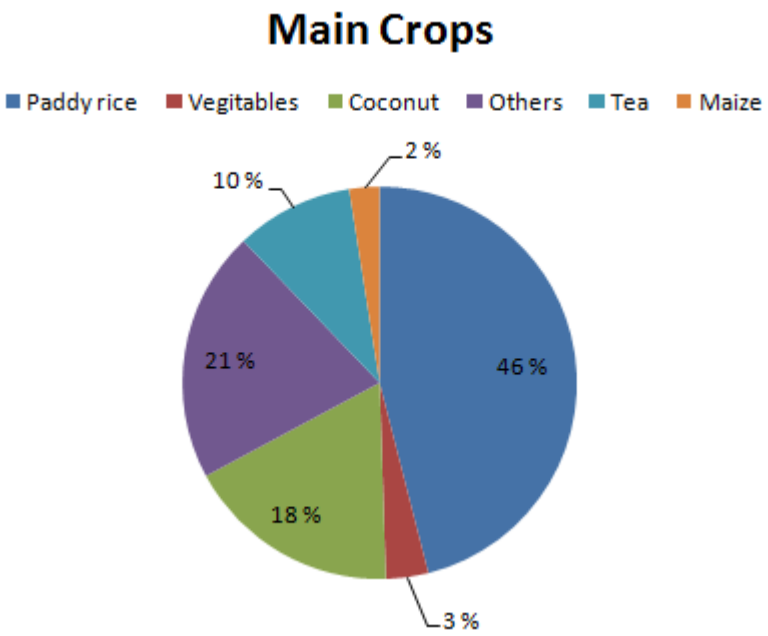

Fig. 3. Main crop harvested area in Sri Lanka [4].

3.1 GHG Emission

The agricultural sector accounts for 25.1% of the country's total GHG emission and GHG emission from the livestock sector accounts for 30.5% of total emission [4]. Dairy cattle and buffaloes are the main livestock special for meat and milk production. The number of livestock in Sri Lanka is shown in Table 1.

Table 1. Number of livestock by the type – 2014 [2]

Type	No
Cattle	1,124,097
Buffaloes	327,909
Goats and sheep	391,656

Emission from livestock and crop consists of non-CO_2 emission and produce GHGs from the following sources:

- Livestock related processes such as enteric fermentation and manure management
- Applications of croplands and pastures
- Burning of agriculture crop residue

3.1.1 Emission from enteric fermentation

Animals like cattle and buffaloes have produced methane as part of their digestive process. In their rumen, enteric fermentation is breaking down carbohydrate molecules into soluble particles. Thus, methane is produced as a by-product. The amount of methane produce depends on body size, metabolism and feed quality. Feed quality is the major reason for CH_4 production. If the feed contains a high amount of cellulose, the high amount of methane will produce [9]. In Sri Lanka, 26.6% of total agricultural emission comes from enteric fermentation [4].

3.1.2 Emission from rice cultivation

The anaerobic breakdown of organic matter in paddy fields is the key reason for methane production. Most of the rural farmers are used residues in their field as manure. Rice cultivation accounts for 52% of total agricultural GHG emissions [4].

3.1.3 Burning agriculture crop residue

Crop residue from paddy rice and maize cultivation are burnt in the filed in many rural areas. It causes the emission of CO_2 and N_2O. Emission of open field burning of crop residue accounts for 1% of total agricultural GHG emission [4]. The other sources of GHG emissions related to crop and livestock are feed production, processing, on-farm fossil fuel use, post-harvest emission, and energy consumption. In the feed production, CO_2 and N_2O emit fertilizer on pasture, process and feed transportation. As well as Energy consumption for machinery, harvesting and production is emitting carbon dioxide [10]. Apart from that, agricultural activities emit a considerable amount of GHGs indirectly. Agricultural irrigation, energy used for the construction of buildings and equipment, and natural resources for product transport, storage and processing are related to indirect emission [11].

3.2 Mitigation options for crop and livestock emission

3.2.1 Prevent methane emission from manure heaps and tanks

A considerable amount of animal manure and organic waste is generated as waste or by-product. Typically, animal manure is store and composting. But it causes to emit GHGs to the environment. If the compost production is done by covering and processing while preventing leaching and N_2O emission, it reduces the emission of GHGs [5].

3.2.2 Utilize biogas as a resource

Feedstock that collected on the farm can be used to produce biogas to reduce methane emission. They allow degrading in an oxygen-free environment and organic materials are degraded by involving microbial degradation. Feedstocks for biogas production include livestock manure, crop residues, industrial processing by-products, and organic waste. Biogas can be used as renewable energy to minimize fossil fuel and the sludge left after the process can be used as bio fertilizer.

3.2.3 Utilize crop residues as fuel

Around 3.8 million tons of paddy rice is produced annually in Sri Lanka, and 656,730 tons of rice husks are produced from paddy [12]. Rice has low nutrient properties, low bulk density and not suitable fertilizer due to a high C: N ratio. Because of that, rice husk does not use for any useful thing. But, improving combustion characteristic, it can be used as fuel by preparing husk blocks [13].

3.2.4 Organic Agriculture

Organic farming is a cultivation method that avoids using chemical such as pesticide and herbicide and fertilizers. Animal manure, compost and crop residues can be used for the requirement of nutrient. As well as, plant extracts can be used as pest control for plant and crop protection [3].

4 MAINTAINING FERTILE SOILS AND RESTORING DEGRADED LAND

The agriculture sector directly depends on the soil and land in any country. In Sri Lanka 65 610 km^2 area land is used for the agricultural sector. The idea about the Sri Lanka land use can be taken by Fig. 1 [14].

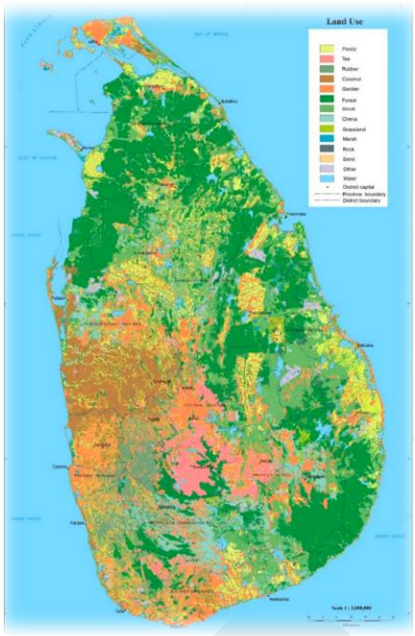

Fig. 4. Land use map of Sri Lanka [14]

When considering soil and atmosphere, the soil contains a carbon amount of 3 times as atmosphere [15]. Overall, 20% of GHG emissions are from land-use activities in the 1990s [16]. It shows that our country is agriculture-based and it is essential to pay attention to GHG emissions due to unavailability and usage of unfertile soils and land degradation. Several steps can be proposed to mitigate the GHG emission by maintaining fertile soils and restoring lands.

4.1 Improve fertility by soil amendment

Fig. 5. Biochar

Soil fertility is essential for agriculture, and it is essential to consider the reduce GHG emission by improving soil fertility. For that purpose, biochar is a very suitable soil amendment that can increase soil fertility. Biomass waste is subjected to pyrolysis process to produce the biochar. This biochar product can reduce CH4 emissions as it reduces the methanogens to methanotrophs ration, especially in paddy soil. As well as N2o emission reduces by sewage sludge biochar [17].

4.2 Soil conservation techniques to carbon mineralization and to prevent soil erosion

Carbon mineralization is very important as it can be used to predict the emission of CO_2 and nutrient availability. And the carbon mineralization rate can quantify the impaction from inorganic and organic materials to the soil [18]. When talking about the carbon emission of the soil, it can be happened due to various reasons. They are the composition of the organic materials added to the soil, environmental conditions, soil processes, etc. The micro-organisms lead to decomposing organic materials in soil, and it causes to emit different gasses with CO_2. Therefore carbon mineralization prediction is very helpful to reduce GHG emissions in agriculture [19].

In soil erosion, upper layer of the soil is subjected displacement. This incident involves emitting the light soil organic carbon, clay, and silt particles in the soil [20]. So soil organic carbon erosion cause to emit greenhouse gasses like CH_4, CO_2, and N_2O to the atmosphere.

Considering all these facts, it shows that soil conservation techniques need to mitigate GHG emissions in the agricultural sector. Some of the soil techniques reduce tillage, contour farming, terracing, and no-tillage [21]. One method will discuss in here.

Reduce tillage

Fig. 6. Tillage

Tillage is the soil preparation method in agriculture by overturning, digging, and stirring. Tillage reduction is an essential one of the methods to conserve the soil while reducing the GHG emissions. In agriculture, cultivation practices like brake soil aggregates, ploughing, and exposing soil organic carbon in the soil to the microorganisms' attacks lead to increase CO_2 emissions to the atmosphere. Tillage is directly affected by the soil carbon emissions, and it reduces the soil organic stock. Tillage can be directly and indirectly affect the GHG emission [21].

Direct impact

Total carbon content reduction, breaking of soil organic matter and CO_2 emissions can be seen in continuous soil cultivation. Then tillage directly affects to increase organic carbon oxidation. Another one is tillage directly impact to emit the nitrous oxide in agriculture. This causes to increase nitrification rates and soil water content.

Indirect impact

Dissolved organic carbon and nitrogen losses is a one way that indirectly impact for GHG emissions because of the tillage. The variation in dissolved organic carbon and dissolved organic nitrogen that is essential to micro-organisms also causes to emit the greenhouse gasses. Another indirect impact is inorganic nitrogen leaching that also affects GHG emissions.

So by considering all these factors it can be concluded that tillage in the agriculture sector need to be reduced and alternative methods needs to introduce to reduce GHG emissions.

4.3 Sequester of CO_2

This method is very useful in the context of reducing GHG emissions. This can be done by increasing soil organic matter content and by introducing biomass for fossil fuel in agriculture. Further, the carbon sequestration in the soil can be enhanced by different methods, such as plant residue management on the soil surface, complex cropping system adaptation, and carbon-rich substrates.

4.4 Apply substrates like composts

Compost plays a major role in the agriculture sector as it improves soil fertility. So composts can be used for agriculture than other chemical fertilizers. When talking about the GHG emissions methane and nitrous oxide is also very important in agriculture. The composting method is very useful to reduce this methane and nitrous oxide from the field of agriculture. These emissions can be reduced in making composts by supplying enough oxygen by different aeration methods. As well as compost helps to increase the soil organic matter content. Another main point is composting directly affects CO_2 reduction [22].

4.5 Retain crop residues as covers

Fig. 7. Crop residue management

A large number of crop residues are harvested by thousands of agricultural lands in Sri Lanka. In this article, rise residue management will discuss farming as one of the greatest fields in agriculture when rice residue is returned to the agricultural fields, some carbon in rice residue deposits as organic matter in the soil. And other portions will emit as CH_4 and CO_2. Here, rice straw can be used as a mulch to other crop cultivations like maize, sugarcane etc. This helps to improve dry lands with crop yields and to improve soil moisture. In addition to that, it immobilizes the available nitrogen in the soil. An important fact is that N_2O emission has not happened from this method [23].

4.6 Revegetation

In this method, disturbed land is used to rebuild the soil and to do replanting. Revegetation helps to reduce CO_2.

4.7 Water management

Water is essential for the irrigational activities and continuous supply is essential for it. Then the expansion of water reserve allowing areas can develop carbon storage in the soil. But the attempt that needs to distribute this water can affect to emit CO_2, which is the energy required for the distribution. As well as N_2O emissions due to the high moisture in the soil [15]. So it is essential to introduce a water management system to agriculture and some of them describe as follows [24].

- In-Situ moisture conservation – Using cowpea, paddy husk, and paddy straw to reduce the requirement of water.
- Rainwater harvesting.
- Surface water management- By canal, tanks and ponds.

- Groundwater management- By improving foot valves propeller pumps and using rigid PVC tubes.

5 ADAPTION TO CLIMATE CHANGE

Sri Lanka is a country that subjected to different climatic changes in different periods. Then it is greatly affecting the agriculture sector as it is not possible to deal with this sudden climate change. For that reason following actions can be taken to adapt to climate change for ecologically managed farms [5]. Then it further helps to reduce GHG emissions.

5.1 Improving soil

Soil fertility is an important factor in the agricultural sector. Climate changes cause to have floods, erratic rainfalls and droughts. Then it leads to destroy not even the cultivation but also the soil composition and fertility. But there are some soils with high organic matter content that can retain more rainwater. Otherwise, we have to introduce a method to lower the decay rates of organic matter in the soil. In addition to that high amount of biomass alsoprevents soil erosion. If the soil management is done properly, then it further helps to reduce GHG emissions in the agricultural sector.

5.2 Farmer knowledge

In our country, most of the farmers have the proper knowledge of these agro-systems from their practical knowledge and skills. They used to have traditional agricultural systems from generation to generation. So as a developing country we have the opportunity to build up advanced agro-systems that minimize GHG emissions that can be adapted to climatic changes. As an example it can be started up with using the inexpensive nature derives pesticides. Then these methods help in GHG mitigations and adaptations to climate change.

6 CONCLUSIONS

The agriculture sector is responsible for a considerable amount of GHG emissions in Sri Lanka. Approximately 25% of the total greenhouse gas emissions agricultural activities. The agriculture sector consists of non-CO_2 emissions emitted directly by crop and livestock activities within the farm gate. Besides agricultural activities such as land use, fertilizer use, energy use, and product transportation cause CO_2 emission. To reduce emissions from these activities, modern emission reduction methods can be used. Manure management to mitigate methane and N_2O, use waste for energy production, compost manure, and retain crop residues as covers are the methods that can be used to mitigate GHG emission.

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