Project ID: 781

Competitive Research Grant (CRG)

Sub-Project Completion Report

on

Assessment of methane emission in dairy production systems based on existing feed resources through GLEAM model under different climatic zones of Bangladesh and their mitigation options

Project Duration

May 2017 to September 2018

Animal Production Research Division, Bangladesh Livestock Research Institute
Savar, Dhaka-1341]

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Published in: September 2018

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Acronyms

CP	: Crude protein
CH_4	: Methane
CPR	: Crude protein requirement
CC	: Climate change
CRD	: Completely randomized design
DPA	: Drought prone area
DM	: Dry matter
DMI	:Dry matter intake
FPA	: Flood plane area
FCM	: Fat corrected milk
FAO	: Food and Agriculture Organization of the United Nations
GLEAM	: The Global Livestock Environmental Assessment Model
GHG	: Green house gas
kg	: kilogram
ME	: Metabolizable energy
M_f	: Maize indices
NI	: Nutrient intake
RBA	: River basin area
SNF	: Solid not fat
SPA	: Saline prone area
TMR	: Total mixed ration
UN	: United Nations

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Executive Summary

Global warming and depletion of the ozone layer because of the increased GHG emission is a major concern that impact on human health, crop and livestock production and environment. Methane is an important component of GHG in the atmosphere, and a significant proportion is produced by anaerobic decomposition of organic matter. In Bangladesh, 82% of CH_4 production comes from rice field and 43% from livestock production through enteric fermentation and manure breakdown. Keeping the above facts in view, the present research work was undertaken to assess the enteric methane emissions from dairy cattle and to demonstrate the mitigation options by adaptation of feeding interventions. *GLEAM* model was used for calculating the enteric methane emission from dairy animals. For the study a total of forty (40) farmers from four districts namely Sathkhira (saline prone area), Pabna (river basin area), Chapainobabganj (drought prone area) and Nilphamari (flood plain area) were interviewed. Two lactating cows from each farmer were selected for collecting the necessary information. Data were collected for seven days in each of the dry (November – February) and wet (June- October) seasons. The study revealed that the consumption of rice straw in drought prone areas was the lowest (45%) compared to the amount of rice straw consumed in poor Feed based flood plain areas which was 75%. On the other hand, the cows in the Drought prone areas were supplied with the highest amount of Napier grass (40%) that was, nearly double compared to the other climatic zones. Crude protein (CP) and metabolizable energy (ME) requirements among the different areas did not differ significantly ($P>0.05$). But the dairy cows in the river basin areas were found to consume significant ($P<0.05$) amount of dry matter (DM) compared to other zones under study. The highest amount of dry matter intake was found in the river basin areas (16.5 kg/day) whereas dairy cows in the flood plain areas consumed the lowest amount of dry matter (12.8 kg/day). The dairy cows from river basin areas were found to emit significantly higher amount of methane (565.01g) per day compared to the cows from saline prone areas (448.54g/day) or flood plain areas (440.78g/day). The dairy cows reared under flood plain areas was fond to produce significant ($p<0.05$) amount of methane from DMI and per kg milk production that was 34.28 g and 99.0 g respectively, compared to river basin areas that was 34.21g and 77.0g respectively. The average daily milk production of the dairy cows under saline prone areas was significantly ($p<0.05$) higher (11.8 kg/day) than that of the drought prone and flood plain areas (7.74 kg/day and 7.40 kg/day, respectively). From the current study it could be concluded that balanced feed may be the option, irrespective of climatic zones, to reduce the enteric methane emission that in turn will create positive impact on livestock production in Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:**
   Assessment of methane emission in dairy production systems based on existing feed resources through GLEAM model under different climatic zones of Bangladesh and their mitigation options.

2. **Implementing organization:**
   Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka-1341, Bangladesh

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk.):**
   a. Total: Tk. 20,46410.00
   b. Revised (if any): Not applicable

5. **Duration of the sub-project:**
   a. Start date (based on LoA signed): 15 May 2017
   b. End date : 30 September 2018

6. **Justification of undertaking the sub-project:**

The Global Livestock Environmental Assessment Model (*GLEAM*) is a modeling framework that simulates the environmental impacts of the livestock sector. Ruminants are essential to the livelihoods of millions of farmers and critical to human health, global food & nutritional security. Enteric CH_4 generated in the gastrointestinal tract of livestock is the single largest source of anthropogenic CH_4 which is responsible for Green House Gas (GHG) effect. GHG resulting global warming is one of the burning issues that impact on human health, crop and livestock production and environmental pollution. Anthropogenic sources account for approximately 58% of total global CH_4 emissions (EPA, 2010, 2011a). According to "Livestock's Long Shadow," the Food and Agriculture Organization (FAO) of the United Nations (Steinfeld *et. al*. 2006), global livestock agriculture is responsible for 18% of the anthropogenic GHG emissions annually.

Tackling climate change by 2030 is one of the important UN declared Sustainable Development Goals (SDGs). Livestock has been included to tackle climate change as well as other goals e.g. end poverty, zero hunger and responsible consumption.

Low quality of feed resources and poor physiological systems considered to be responsible for enteric methane production that leads to GHG emission and environmental pollution. Methane emission in the rumen is also energetically wasteful process and is responsible for the loss of 6-10% of gross energy intake (GEI) or 8-14% of digestible energy intake of ruminants (Johnson *et al.* 1993; Okine *et al.* 2004). A recent report (Algas, 1998) found that 82% of the CH_4 production in Bangladesh came from rice and livestock production sheared 43% through enteric fermentation and manure breakdown. Therefore, if the digestibility of fibrous feedstuffs in ruminant animals could be increased, that would lead to decreased methane production and the combined effect would reduce environmental pollution as well as improve the livestock productivity towards improving overall livelihood of the livestock farmers. In Bangladesh, research work in relation to amounting enteric methane production from ruminant is very scanty and with the above mentioned facts the current research was undertaken to assess the enteric methane emissions from dairy cattle through *GLEAM* model and to demonstrate the mitigation options by adaptation of feeding interventions.

7. Sub-project goal:

Development of a dairy feeding system model for reducing enteric methane and intensify the productivity.

8. Sub-project objective (s):

a) To assess the existing feed resources based feeding systems for dairy (cattle & buffaloes) production in the different regions of Bangladesh.

b) To calculate the enteric methane emission from dairy animals based on existing feeding practices available in the different regions of Bangladesh through *GLEAM* model.

c) To develop existing feed resources based suitable feeding systems/methods and to demonstrate selected feeding interventions to mitigate enteric emission and environmental pollution from dairy animals under different regions of Bangladesh.

9. Implementing location (s):

The experiment was conducted at BLRI, Savar, Dhaka (on station) and at the different agro-climatic zones of Bangladesh, namely Saline Prone areas (Sathkhira), River basin areas (Pabna), Drought Prone areas (Chapainobabganj) and Flood Plain areas (Nilphamari). To achieve the stated objectives of the project series of experiments were conducted during the 18 months study periods.

10. Methodology in brief:

10.1. Assessing the existing feed resources based feeding systems for dairy (cattle & buffaloes) production in the different regions of Bangladesh:

Type of Survey

To achieve the first objective, a survey was conducted in the selected research areas based on herd size, production, utilization and management of feed resources and reproductive performance of dairy cows. So, it was a purposive survey which may not reflect the overall circumstances of methane production from livestock in Bangladesh.

Formation of Questionnaire

Based on the purpose of the study alone with secondary information a semi-structured questionnaire was formulated including some demographic information, livestock population, major feed resources and their utilization, seasonal variations, production and reproduction performances, manure management and associated constraints in relation to livestock production in the respective areas. In the prepared questionnaire, there were both close ended (yes or no) questions and open questions with single and multiple responses. Before going to formal survey, the semi-structured questionnaire was also pre-tested by interviewing some households and was subsequently refined.

Selection of farmers

A total of 40 farmers (having at least two dairy cows), 10 from each of the 4 districts under study were selected, on the basis of livestock density, for household survey and data were collected by direct interviewing the respondents. Among the selected farmers, there were at least 5 cross bred dairy farmers, 5 native dairy farmers and 5 buffalo dairy farmers from each of the selected locations. Different necessary information (e.g. existing feeding practices, feed resources, feed intake both roughages & concentrate, water intake, productive and reproductive data, etc.) were collected from each site, taking 7 days, considering two seasons dry (November – February) and wet (June- October) for setting up with *GLEM* model.

10.2. Estimation of enteric methane emissions through GLEAM model:

The Global Livestock Environmental Assessment Model (*GLEAM*) represents the bio-physical processes and activities along livestock production chains under a life cycle assessment (LCA) approach.

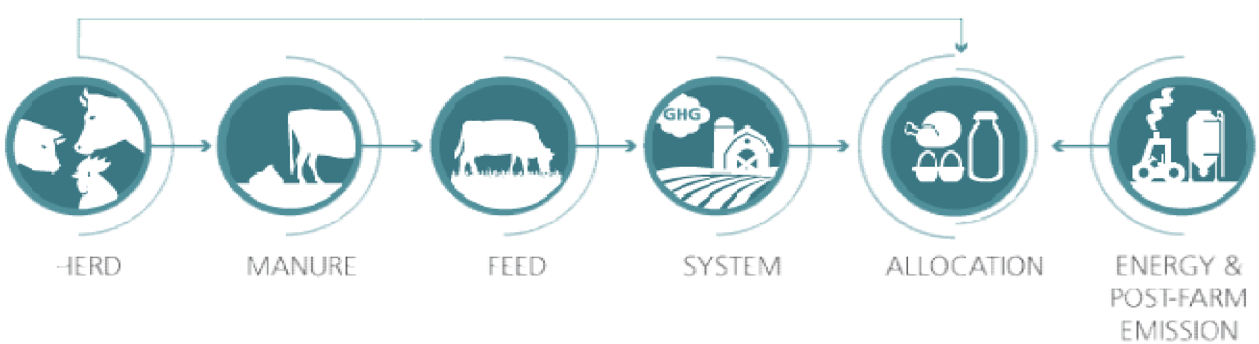


Figure 1: The structure of GLEAM

As shown in Figure 1 the structure of GLEAM consists of five main modules i.e., herd, manure, feed, system and allocation along with two additional modules for the calculation of direct and indirect on-farm energy use and post farm impacts. Primary data collected through questionnaire survey such as intake, feed type, total dry matter intake (DMI), productive and reproductive parameters were used for estimating the enteric methane emissions through GLEAM model by considering region and category of dairy species (cattle and buffalo) available in the selected areas. In addition to the above primary data, secondary information (Temperature, Humidity, Cattle population, etc.) also were collected for supporting the GLEAM model.

Data analysis:
The collected household data were summarized and analyzed through Statistical package for the social Sciences, (SPSS, version 11.5). The design of the experiment was 5 X 3 X 2 factorial experiment and data were analyzed through Randomized Block Design (RBD) to evaluate the enteric methane emission considering the species, location and season.

10.3. Development of suitable feeding systems to mitigate enteric methane emission:

Ranking of roughage:

$$M_f = \frac{\frac{y\,(\boldsymbol{FodderDDM})}{\boldsymbol{MaizeDDM}} + \frac{y\,(KgLWofFodder)}{Kg\ LW\ of\ Maize} + \frac{\frac{\mathbf{KgCH_4}}{\mathbf{KgLWgain}}\mathbf{ofMaize}}{y} + \frac{y}{\frac{GR_f}{GC_f}\boldsymbol{ofMaize}}}{\mathbf{4}}$$

For the development of existing feed resources based suitable feeding systems to mitigate enteric emission and environmental pollution from dairy animals the Maize Index (M_f) of different fodders was calculated using the formula shown above and all the data were statistically tested described by Huque *et al.* (2017). All the significant ($p<0.01$) relations of M_f with different attributes of fodder crops and their combination may signify the effectiveness of M_f in ranking of fodder crops at least in terms of efficiencies of production of biomass, benefit to cost, animal performances; and reduction of enteric methane in the rumen.

11. Results and discussion:

11.1. Results:

11.1.1. Assessing the existing feed resources based feeding systems for dairy (cattle & buffaloes) production:

General Information of dairy herd
General information of dairy herd in the different climatic zones of Bangladesh is shown in Table 1. It was found that, farmers in the areas under survey were keeping dairy cattle in the range between 6 and 65. The highest number of cattle was observed in the drought prone areas (7 to 65) whereas the flood plain area contained the lowest in number (6-18). The birth weight of calves was more or less same in the different climatic zones and the conception rate of cows was surprisingly very low all over the

research areas (between 40 and 65%) that might have some effect on reproductive performances of dairy cows in the areas.

Table 1: General information of dairy herd under different climatic zones of Bangladesh

Parameters	Different Climatic Zones			
	River basin area	Drought prone area	Flood plain area	Saline Prone area
Heard Size (no. of cattle)	7-58	7-65	6-18	9-40
No. of milking cows	4-25	4-35	3-9	2-20
Birth weight of calves (kg)	27-37	25-35	25-35	25-35
Conception rate (%)	40-50	50-55	45-65	45-60
Mortality rate (%)	7-13	10-15	5-10	5-10
Age at 1st Heat (months)	14-27	15-21	14-21	14-17

Feed ration in the different climatic zone

The farm practice of roughage feeding and their actual amount is presented in Figure 2. The study revealed that the consumption of rice straw in the flood plain areas was the highest (75%) whereas the lowest amount of rice straw was consumed in the drought prone areas, which was 45%. However, the farmers in the drought prone areas supplied the highest amount of Napier and cut and carry grass to their cows that were 40% and 15% respectively, which were double compared to the other climatic zones. The farmers' practice of supplying different concentrate mixed items in the different climatic zones is given in Figure 3.

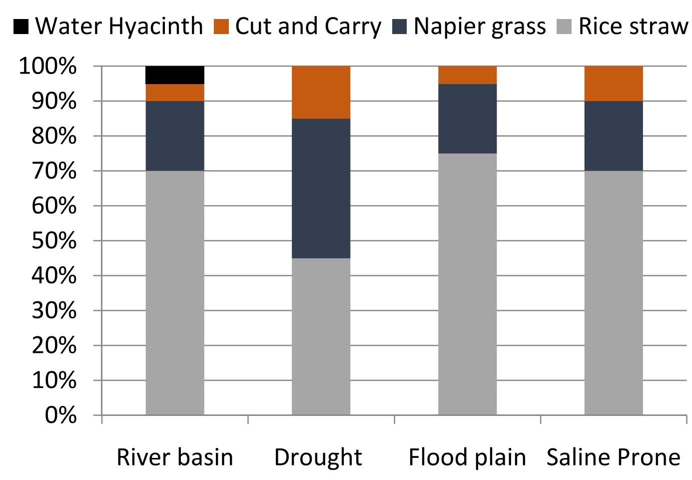


Figure 2: Available roughages in the different climatic zones

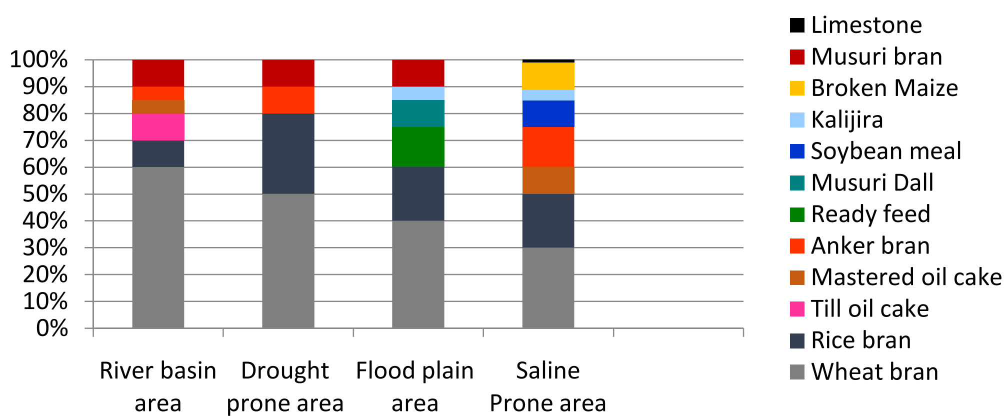


Figure 3: Available concentrate items in the diferent climatic zones

It was observed that, the dairy cows of river basin areas consumed the highest amount of wheat bran that was 60% whereas the lowest amount of wheat bran was supplied to the dairy cows in the saline prone areas which was 30%. It was also found that wheat bran supply to the cows gradually increased by 10% from saline prone area to river basin area. The rice bran was found to be the common feed ingredient all over the climatic zones with the drought prone areas to be the highest user amounting to about 30%. The farmers from the saline prone areas was found to use the highest number (8) of feed ingredients namely mastered oil cake, anker bran, soybean meal, kalijira, broken maize and limestone compared to the others. It may be the balanced ration that had a positive impact on milk production as shown in Table 4.

Nutrient intake

Feeds and nutrient intake of dairy cows from different climatic zones of Bangladesh are shown in Table 2. CP and ME requirements among the cows from the different climatic zones did not differ significantly (P>0.05). But the dairy cows from river basin areas consumed significant (P<0.05) amount of DM compared to the cows from the other three areas. The highest amount of dry matter intake was observed in the cows from river basin areas (16.5 kg/day), whereas dairy cows from the flood plain areas consumed the lowest amount that was 12.8 kg/day. There was no significant difference on total CP intake from roughage and concentrate among the cows from the different climatic zones.

Table 2. Nutrient intake of crossbred dairy cows under different climatic zones (means ± SE)

Parameters	Different Climatic Zones					
	River basin area	Drought prone area	Flood plain area	Saline Prone area	Overall SE	Significance Level
CPR (gm/day)	832.01±59.3	733.03±23.8	703.81±17.3	1025±62.0	50.34	P=0.09
MER (MJ/kg)	76.6±4.3	69.73±4.3	65.63±25.1	88.69±4.3	3.56	P=0.10
DMI from Rau (kg/day)	8.90±0.71	7.76±0.08	7.47±0.72	6.68±0.2	0.32	P=0.10
DMI from Con. (kg/day)	7.59±0.71	7.65±1.12	5.39±0.58	6.41±0.2	0.38	P=0.11
Total DMI (kg/day)	16.5^{a}±0.6	15.4^{ab}±1.4	12.8^{b}±1.3	13.1^{b}±0.26	0.55	P=0.04
CPI from Rau (g/day)	483.0^{a}±4.9	405.8^{ab}±1.8	440.3^{ab}±8.6	288.3^{b}±17.1	28.5	P=0.08
CPI from Con. (g/day)	1268.0^{a}±31.4	1057.9±86.4	930.7±13.9	1100.7±67.3	66.2	P=0.35
Total CP intake(g/day)	1751.0±31.5	1463.7±23.6	1370.9±81.3	1388.8±73.4	81.7	P=0.33

CPR, crude protein requirement; MER, metabolizable energy requirement; DMI, dry matter intake; CPI, crude protein intake; Figures with different superscript in the same row differ significantly

Quality of milk

Milk constituents of different climate zones of Bangladesh are presented in Table 3. The fat percent of milk among the cows from the different climatic zones did not differ significantly (P>0.05). The other milk constituents like protein and lactose in the milk from flood prone areas (4.05% and 5.91% respectively) were significantly (p<0.05) higher than that of river basin area (3.60% and 5.37% respectively). The SNF (Solid not fat) of milk did not differ significantly between the two climatic zones of drought (10.63%) and flood plain (10.81%) areas but the values differed significantly with the values from the river basin (9.83%) and saline prone (9.90) areas.

Table 3: Milk composition of crossbred cows in different climatic zones of Bangladesh (means ± SE)

Milk constituents (%)	Different Climatic Zones					
	River basin area	Drought prone area	Flood plain area	Saline Prone area	Overall SE	Significance Level
Fat	3.20±0.08	3.70±0.26	4.1±0.38	3.59±0.14	0.13	P=0.16
Protein	3.60^{b}±0.02	3.90^{b}±0.02	4.05^{b}±0.11	4.5^{a}±0.2	0.10	P=0.01
Lactose	5.37^{b}±0.03	5.75^{a}±0.02	5.91^{a}±0.15	5.67^{a}±0.14	0.07	P=0.02
SNF	9.83^{b}±0.06	10.63^{a}±0.06	10.81^{a}±0.28	9.90^{b}±0.1	0.13	P=0.001

Figures with different superscript in the same row differ significantly

11.1.2. Estimation of the enteric methane emission and production performance:

Production performances and their methane production of crossbred dairy cows in different climatic zones of Bangladesh are shown in Table 4. The average live weight, 4% fat corrected milk (FCM) production, fat yield and average void production of the cows under different climatic zones of Bangladesh had no significant variation. The average daily milk production of the cows from the saline prone areas was significantly ($p<0.05$) higher (11.8 kg/day) than that of the cows from the drought prone and flood plain areas (7.74 kg/day and 7.40 kg/day, respectively).

Table 4: Production performances of crossbred dairy cows and their methane production under different climatic zones of Bangladesh (means ± SE)

Parameters	**Different Climatic Zones**					
	River basin area	Drought prone area	Flood plain area	Saline Prone area	Overall SE	Significance Level
Ave. live weight (kg)	283.8±13.0	276.3±26.3	248.8±11.2	282.3±7.7	8.09	P=0.39
Ave. milk prods. (kg/day)	9.06^{ab}±0.83	7.74^{b}±1.64	7.40^{b}±1.56	11.8^{a}±0.8	0.67	P=0.09
4% FCM yield(kg/day)	8.08±0.74	7.41±1.57	7.54±1.59	10.95±0.7	0.64	P=0.16
Fat yield(kg/day)	0.29±0.02	0.28±0.19	0.30±0.20	0.41±0.09	0.15	P=0.22
Ave. void prod. (DM; kg/day)	3.2±0.21	3.32±0.43	3.49±0.12	3.64±0.07	0.12	P=0.63
Methane production						
*CH_4 production (g/day)	565.01^{a}±21.6	527.75^{ab}±50.1	440.78^{b}±42.9	448.54^{b}±8.9	18.8	P=0.04
*CH_4 prod. (g/kg DMI)	34.21^{b}±0.09	34.24^{ab}±0.02	34.29^{a}±0.02	34.26^{ab}±0.05	0.01	P=0.05
g CH_4/kg milk prod.	77.0^{b}±0.003	88.0^{ab}±0.005	99.0^{a}±0.003	91.0^{a}±0.001	0.002	P=0.003

*Figures with different superscript in the same row differ significantly*Author's calculation as per Purnomoadi (2013).*

The dairy cows from river basin areas were found to emit significantly ($p<0.05$) higher amount of methane (565.01g) per day compared to the cows from saline prone areas (448.54g/day) or flood plain areas (440.78g/day). The dairy cows reared under flood plain areas were found to produce higher amount of methane for per kg DM intake (34.29g) and for per kg milk production that was 99.0g, compared to river basin areas which were 34.21g and 77.0g for DM intake and milk production respectively and the values differed significantly ($p<0.05$). For the other two groups like drought prone and saline prone areas there was no significant ($p>0.05$) difference of methane production for per kg DM intake but the values differed significantly for per kg milk production (88.0g and 91.0g respectively).

Table 5: Effect of season on enteric methane emission in dairy cows in the different climatic zones of Bangladesh

Parameters	RBA		Sig	DPA		Sig	FPA		Sig	SPA		Sig
	Wet	Dry		Wet	Dry		Wet	Dry		Wet	Dry	
CH_4 production (g/day)	565.0	561.0	NS	527.7	522.2	NS	440.7	441.2	NS	448.5	445.3	NS
CH_4 prod. (g/kg DMI)	34.21	34.20	NS	34.24	34.23	NS	34.29	24.26	NS	34.26	24.25	NS
g CH_4/kg milk prod.	77.0	75.0	NS	88.0	87.3	NS	99.0	97.3	NS	91.0	89.2	NS

RBA, river basin area; DPA, drought prone area; FPA, flood plain area; SPA, saline prone area; Sig, Significant or not.

Seasonal effect on enteric methane emission in dairy cows in the different climatic zones is shown in Table 5. The table shows that seasonal variation of roughage and concentrate had no significant impact on g/day CH_4 production, g/kg DM intake CH_4 production and g CH_4/kg milk production, irrespective of the climatic zones studied.

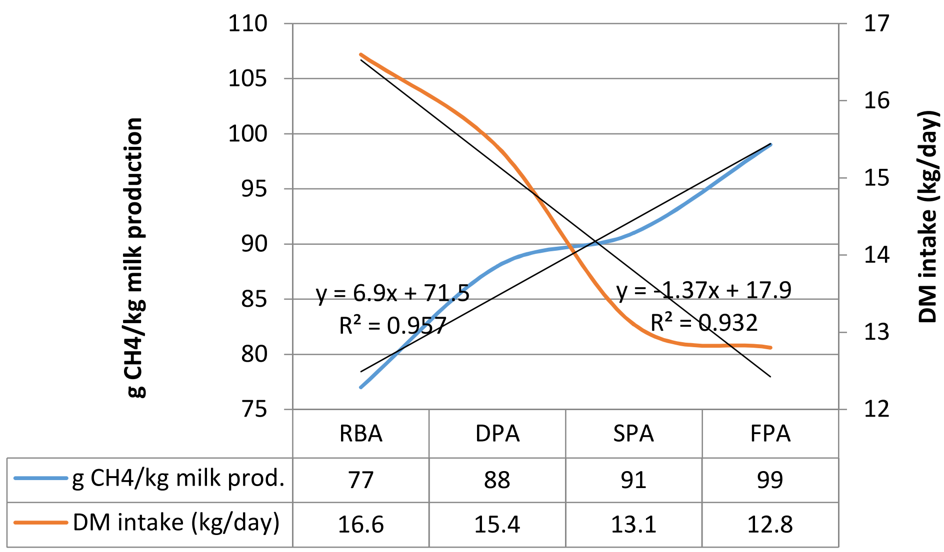


Figure 4: Relationship between DM intake and methane production for per kg milk production

The relationship between DM intake (kg/day) and (g) methane production for per kg milk production under the different climatic zones of Bangladesh is shown in Figure 4. It was observed that the methane production for per kg milk linearly (R^2= 0.95) decreased with the increase of dry matter intake. The dairy cows from flood plain areas consumed the lowest amount of DM that was 12.8 kg/day but the methane production for each kg milk production was the highest which was 99.0 g whereas the lowest methane production was observed in the cows from river basin areas that was 77.0 g but their DM intake was the highest which was 16.6 kg/day. Considering the DM intake and their methane production per kg milk, the feeding system used in the saline prone areas may be accepted as the suitable practice for production and creating the friendly environment than the feeding system practiced by the farmers from other climatic zones. It could be seen in Figure 5 that the overall methane production in the different climatic zones was not up to the mark that may have direct impact on the environment. The Figure shows that, with the increase of milk production methane production decreased linearly (R^2=1). So, it could be concluded that balance feed may be one of the options in the different climatic zones to reduce the enteric methane emission that converted to energy.

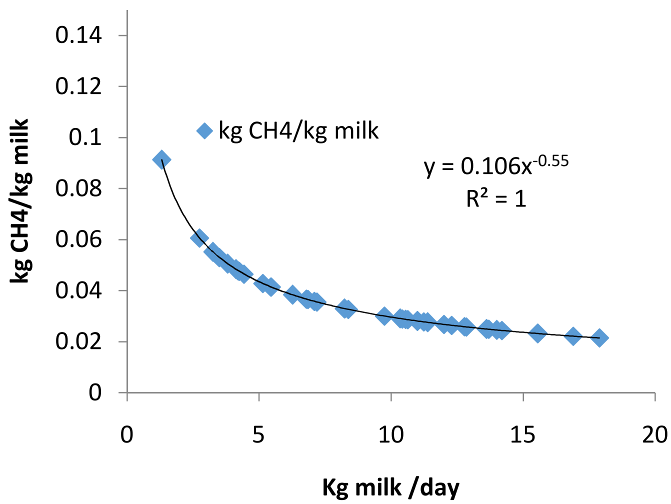


Figure 5: Relation between enteric methane production and daily milk yield of cows of Bangladesh

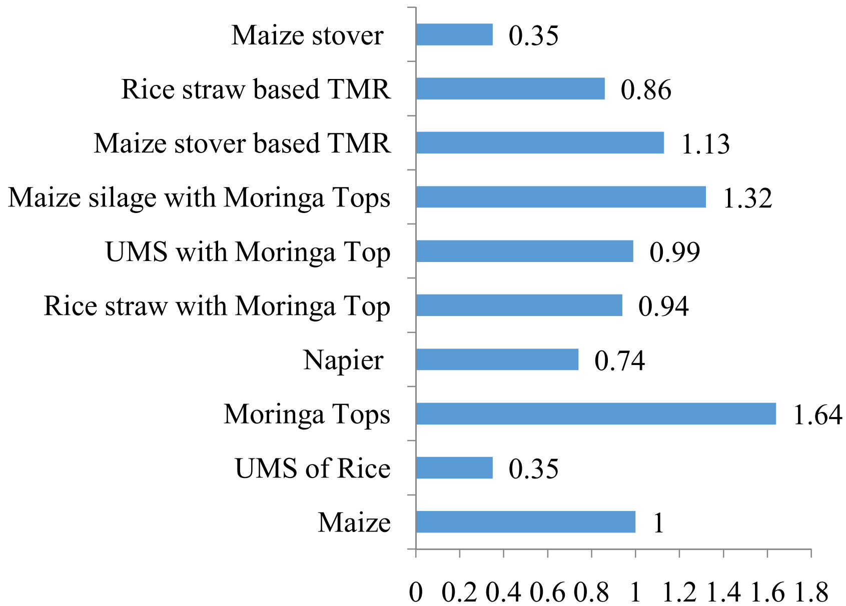
11.1.3. Development of existing feed resources based suitable feeding systems to mitigate enteric emission:

Ranking of roughage:

$$M_f = \frac{\frac{y\,(FodderDDM)}{MaizeDDM} + \frac{y\,(KgLWofFodder)}{Kg\ LW\ of\ Maize} + \frac{\frac{KgCH_4}{KgLWgain}ofMaize}{y} + \frac{y}{\frac{GR_f}{GC_f}ofMaize}}{4}$$

The Maize indices (M_f) of available fodder crops was developed using the above mentioned formula and statistically tested according to Huque *et al.* (2017). The ranking of roughages are shown in Figure 6. Maize stover, Uria molasses straw (UMS) of rice straw, Napier, rice straw based total mixed ration (TMR), rice straw with moringa top and UMS with moringa top had the M_f value of 0.35 to 0.99 indicating that all the roughages mentioned was of poorer quality compared to the fodder maize (M_f = 1). The moringa top, maize silage with moringa top and maize stover based TMR however had the M_f value of 1.64, 1.32 and 1.13 respectively indicating that the roughages are of better quality compared to the fodder maize considering the efficiencies of production of biomass, benefit to cost, animal performance; and reduction of enteric methane in the rumen.

Figure 6. Maize indices (M_f) of different fodders



A strong relation of M_f with an increasing DM yield per hectare or a Kg LW yield or an increasing live weight gain of animals, and a lower emission of CH_4 in the rumen with increasing live weight gain ($y=0.068*\text{daily gain}^{-0.928}$, r=0.97, p<0.01) signifies that the biometric system of determining Maize Index (M_f) may be considered for ranking the available fodder crops for the development of cost effective and environmentally friendly feeding systems in the country.

11.2. Discussion:

Agriculture contribute to climate change (CC), with the crop agriculture, forestry, livestock and other land use sectors contributing 24% of anthropogenic global greenhouse gas emission (Smith *et. al.* 2014). Livestock being one of them needs to adapt to this looming challenge to maintain food security, economic activities and the livelihoods of many, especially in the developing country like Bangladesh (Howden *et al*., 2007). Methane (CH_4) is the second most important greenhouse gas (GHG) that is emitted from the enteric fermentation of livestock which influenced by the level of feed intake, quality of feeds and fodder and their digestibility. Higher DMI and nutrient intake (NI) as manifested in the present study could be due to overfeeding of protein and energy to dairy cows in the different climatic zones of Bangladesh. Garg *et al.* (2013) also reported overfeeding of protein and metabolizable energy in 70% of the animal in various states of India. The milk production of dairy cows in saline prone areas was the highest (11.8 kg/day) whereas the lowest milk production was shown in the flood plain areas (7.40 kg/day). Overall milk production in the different climatic zones was found not to be up to the mark. The imbalance rations could be held responsible for reducing the rumen microbial protein synthesis that might have negative impact on milk production (Garg *et al.*, 2014). Imbalance feeding of dairy cows in the different climatic zones increased CH_4 emission; flood plain area produced the highest amount of CH_4 (99.0 g CH_4/day) compared to others. In the present study, unbalanced nutrients shifted the rumen fermentation pattern towards the lower microbial cell production which might have resulted in higher acetate and butyrate production on account of lower propionate production, thereby increasing CH_4 emission. This finding is also supported by Mohini and Singh (2010), who reported the lower enteric methane emission after the balancing the rations of the cows. The present study shows that smallholder dairy production system of Bangladesh, where the average productivity of dairy animals is low to medium, provide a good opportunity to reduce enteric methane emission with improving productivity through feeding a nutritionally balanced ration to dairy animals. Kebreab *et al.* (2001) and Rotz *et al.* (2010) also stated that there is considerable potential for improvement of milk production and reduction of GHG emission from dairy animals through dietary manipulation. Improved efficiency of nutrient utilization would increase productivity and reduce GHG emission from animals. In addition to increased productivity, improved feed conversion efficiency can be a highly effective way of reducing CO_2-eq emission per kilogram of milk (Vellinga *et al.,* 2011).

12. Research highlight/findings:

- Considering the feed intake and reduction of methane emission the feeding system practiced by the dairy farmers from saline prone areas was suitable than the others. The farmers from the saline prone areas was found to use the highest number of feed ingredients namely mastered oil cake, anker bran, soybean meal, kalijira, broken maize and limestone compared to the others.

- The average daily milk production of the cows from the saline prone areas was significantly higher (11.8 kg/day) than that of the cows from the drought prone and flood plain areas (7.74 kg/day and 7.40 kg/day, respectively).

- The dairy cows from river basin areas were found to emit significantly higher amount of methane (565.01g) per day compared to the cows from saline prone areas (448.54g/day) or flood plain areas (440.78g/day).

- On the basis of bio-mass production, animal performance, CH_4 reduction and benefit to cost ratio the roughages like Moringa tops (M_f = 1.64) > Maize silage with Moringa tops (M_f = 1.32) > Maize Stover based TMR (M_f = 1.13) were ranked to be the best.

- From the overall findings it could be concluded that the use of balanced feed may be one of the options to reduce the enteric methane emission from livestock in Bangladesh.

B. Implementation Position

1. **Procurement:**

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment		29,900.00		29,900.00	
(b) Lab &field equipment					
(c) Other capital items					

2. **Establishment/renovation facilities: Not applicable.**

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. **Training/study tour/ seminar/workshop/conference organized: Not applicable.**

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Femal e	Total		
(a) Training	-	-	-	-	-
(b) Workshop	-	-	-	-	-

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	560424.00	560424.00	560424.00	0.00	100.00	
B. Field research/lab expenses and supplies	1005656.00	1000936.00	1000936.00	0.00	100.00	
C. Operating expenses	185428.00	185428.00	184398	1030.00	99.44	
D. Vehicle hire and fuel, oil & maintenance	54807.00	42100.00	41357.00	743.00	98.24	
E. Training/workshop/seminar etc.	100000.00	0.00	0.00	0.00	0.00	
F. Publications and printing	75000.00	8300.00	8000.00	300.00	96.39	
G. Miscellaneous	35195.00	34050.00	34050.00	0.00	100.00	
H. Capital expenses	29900.00	29900.00	29900.00	0.00	100.00	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
1. To assess the existing feed resources based dairy (cattle & buffaloes) production feeding systems in the different regions of Bangladesh	Study on feed resources and feeding practices of existing dairy production systems in the different agro-climatic zones (Saline Prone areas, River basin areas, Drought Prone areas and Flood Plain areas) of Bangladesh	Consumption of rice straw in the flood plain areas was the highest (75%) and the lowest amount of rice straw was consumed in the drought prone areas (45%). The farmers in the drought prone areas supplied the highest amount of Napier and cut and carry grass to their cows (40% and 15% respectively). The dairy cows of river basin areas consumed the highest amount of wheat bran (60%) and the lowest amount of wheat bran was supplied in the saline prone areas (30%). Wheat bran supply to the cows gradually increased by 10% from saline prone area to river basin area. The rice bran was found to be the common feed ingredient all over the climatic zones with the drought prone areas to be the highest user (30%). Farmers from the saline prone areas were found to use the highest number of feed ingredients compared to other areas. The average daily milk production of the cows from the saline prone areas was significantly higher (11.8 kg/day) than that of the cows from the drought prone and flood plain areas (7.74 kg/day and 7.40 kg/day, respectively).	The output of this project will hopefully help to reduce enteric methane emission through intervention of balanced diet formulating by existing feed resources with proper management. This will also increase the productivity of farm animals as well as more income generation for the farmers. The output of this project will also help the policy makers of the livestock sectors for future research planning with large scale of initiatives.
2. To calculate the enteric methane emission from dairy animal based on existing feeding practices available in different regions of Bangladesh through GLEAM model	Estimate the enteric methane emissions based on existing feeding practices of existing dairy production systems through GLEAM model	The dairy cows from river basin areas were found to emit significantly higher amount of methane (565.01g) per day compared to the cows from saline prone areas (448.54g/day) or flood plain areas (440.78g/day). The dairy cows reared under flood plain areas were found to produce higher amount of methane for per kg DM intake (34.29g) and for per kg milk production (99.0g) compared to river basin areas (34.21g and 77.0g for DM intake and milk production respectively). The methane production for per kg milk linearly (R^2= 0.95) decreased with the increase of dry matter intake. The dairy cows from flood plain areas consumed the lowest amount of DM (12.8 kg/day) but the methane production for each kg milk production was	

		the highest (99.0g).The lowest methane production was observed in the cows from river basin areas (77.0g) but their DM intake was the highest (16.6 kg/day). Considering the DM intake and their methane production for per kg milk, the feeding system used in the saline prone areas may be accepted as the suitable practice for production and creating the friendly environment. Again, with the increase of milk production methane production decreased linearly (R^2=1). So, it could be concluded that balance feed may be one of the options in the different climatic zones to reduce the enteric methane emission that converted to energy. Overall methane production in the different climatic zones was found not up to the mark that may have direct impact on the environment.	
3. To develop existing feed resources based suitable feeding practices/ methods and to demonstrate selected feeding interventions to mitigate enteric emission and environmental pollution from dairy animals under different regions of Bangladesh	Screening and development of suitable feeding methods to mitigate the enteric methane emissions in dairy cows under on-station	Maize stover, Uria molasses straw (UMS) of rice straw, Napier, rice straw based total mixed ration (TMR), rice straw with moringa top and UMS with moringa top had the M_f value of 0.35 to 0.99 indicating that all the roughages mentioned was of poorer quality compared to the fodder maize (M_f = 1). The moringa top, maize silage with moringa top and maize stover based TMR however had the M_f value of 1.64, 1.32 and 1.13 respectively indicating that the said roughages are of better quality compared to the fodder maize when the efficiencies of production of biomass, benefit to cost, animal performances and reduction of enteric methane in the rumen was considered. Biometric system of determining Maize Index (M_f) may be considered for ranking the available fodder crops for the development of cost effective and environmentally friendly feeding systems in the country.	

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication			
Information development			
Other publications, if any		1	International Seminar on Rice Bran as Animal Feed

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)
GLEAM model for assessing methane emission in dairy production system based on existing feed resources in Bangladesh was adopted through this project.

ii. **Generation of new knowledge that help in developing more technology in future**
Balanced feed for dairy cattle and buffalo in the different climatic zones may be the option of reducing the enteric methane emission from livestock in Bangladesh.

On the basis of biomass production, animal performance, reduction of methane emission and cost-benefit analysis, Moringa tops could be the best choice as roughage feed for feeding to cattle followed by maize silage with Moringa tops and maize stover based TMR (total mixed ration).

iii. Technology transferred that help increased agricultural productivity and farmers' income
None

iv. Policy Support
The output of this project will help the policy makers of the livestock sectors for future research planning with large scale of initiatives.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring:

Bangladesh livestock Research Institute regularly organize monthly meeting to evaluate different project activities implemented under Bangladesh Livestock Research Institute (BLRI) funded by GoB and other sources. The financial and technical progress of this project had also been evaluated during those meetings. The recommendation and suggestions came from those meetings helped much for implementation of the project. Beside this, Project implementation unit – PIU-BARC also organized following workshops to evaluate the project activities and progress.

Workshop	Date
Progress workshop	24-25 April, 2018
Monitoring workshop	15-16 May, 2018
Annual workshop	22-23 September, 2018

ii) Field Monitoring (time& No. of visit, Team visit and output):

Monitoring team	Date(s) of visit	Total visit till date (No.)	Output
Livestock Division, BARC	20/02/2018	01	Satisfactory
Internal team monitoring, BLRI	30 July, 2018	01	Satisfactory

H. Lesson Learned (if any)

i) Fund was not sufficient for successful implementation of the project goal
ii) Needed sophisticated lab equipments and facilities for assessing methane emission
iii) Needed lab based training

I. Challenges (if any)

i) Very limited timeframe to achieve project objectives successfully
ii) Insufficient field staff (only one field assistant for working in four locations)

Signature of the Principal Investigator
Date ……………………….
Seal

Counter signature of the Head of the organization/authorized representative
Date ………………………..
Seal