



Reducing dairy data inconsistency through Regional Modeling Approach (RMA): a case from North-Western part of Bangladesh

MM Uddin^{1*}, A Akter¹, M Tanzin^{1,2}, MN Sultana¹, ABM Khaleduzzaman³, MR Islam², MS Palash⁴ and BB Bruemmer⁵

¹Research group: Dairy Nutrition, Economics, Environment and Marketing, Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh; ²Rural Development Academy (RDA), Bogura; ³Department of Livestock Services (DLS), Ministry of Fisheries and Livestock (MoFL) Dhaka; ⁴ Department of Agribusiness and Marketing, Bangladesh Agricultural University, Mymensingh; ⁵Department of Agricultural Economics and Rural Development, University of Goettingen, Germany

Abstract

In Bangladesh, the transformation of dairy farming from livelihood-oriented to enterprise-driven farming system might require deeper understanding on the regional differences in terms of regional potential for further dairy development. This, however, entails detailed data on dairy farm at regional level. Since the data are relatively very scarce in one hand and on the other hand, even available, are contradicting among various sources in terms of data accuracy and precision, the application of the regional modeling on the data and extrapolates to the national data and vice-versa is one of the ways to identify the possible options to improve the data availability and quality. Considering this, the current study was undertaken to assess the data inconsistency by comparing the dairy herd structure and its milk production at regional level and propose a validation tool to arrive at the national data by using the regional findings. The International Farm Comparison Network (IFCN) Regional Modeling Approach (RMA) along with the locally developed Integrated Dairy Research Network (IDRN) farm model was used. The primary data was collected from three divisions (9 districts) from the North-Western part of the country. The results revealed that proportion of household farm dominates over family and business farm while considering the total dairy cow as unit for defining the farm type. The share of the cross bred cows to the local cows is 74.6% and 24.4%, respectively. However, the proportion of lactating cows over dry cows and heifer seems to be higher in local cows (48.8%) than cross breed cows (34.2%). The average milk production for all regions is 4.49 lit/day/cow while that for cross breed is 6.23 lit and local 1.71 lit/day/cow. Using regional model and its coefficient on average milk production, herd composition, proportion of lactating cows on total milk production of DLS and IDRN revealed that IDRN new model estimates 36.5% lower milk than the DLS in 2019 and 33.5% lower in 2018. The IDRN version 1.0 and 2.0 model difference was found to 15.4% and 18.3% lower for 2018 and 2019, respectively. The model setup, calibration and validation are time-demanding and challenging tasks for these large set of data, given the scale intensive data requirements, and the need to ensure the reliability data from multiple regions. This study concludes that regional modeling is quite useful for validating the regional share of the milk production and national milk production. However, this study would recommend for using standardized for data collection, validation and thus conducting further study on the other regions and finally including all regions of the country.

Keywords: milk production, local and cross bred cows, data inconsistency, regional model. IDRN networking

Introduction

Globally there is an increasing consolidation into fewer but larger herd size, especially in the developed country (USA, EU, New Zealand) while this trend has also been happening in the developing country, but the form and magnitude is quite different (IFCN, 2019). The recent trend in the structural change of the dairy sector and

changing of the dairy farming from livelihood-oriented to enterprise-driven is taking place in Bangladesh (Uddin *et al.* 2020). This structural change might require reassessing the existing dairy farming situation along with herd structure, milk production and suitability with rural socio-economic condition. The study done by Uddin *et al.* (2013) showed that 34% of the surveyed dairy farmers (total 180 dairy farmers) from

Regional modeling approach for reducing dairy data inconsistency

different production systems were willing to exit from dairying given with the availability of alternative jobs for family livelihood. The main drivers were the higher cost per unit of milk production, lower return to variable costs, age of the farmers and lower profitability (Uddin *et al.* 2013). This situation has been changing from 2014 onward where dairy has been getting momentum due to changing focus to dairy by the government. Recently, the biggest project on Livestock and Dairy Development (LDDP) with the finance from the World Bank and government (approximately 500 million USD) might have positive change in increasing milk productivity (DLS, 2019).

Looking at the regional contribution to the national milk production, the North and Northwestern part of the country seem to be the highest milk producing areas as well as the highest milk collection network in Bangladesh (Mortensen *et al.* 2017). It is also reported that the district of Sirajgonj and Pabna and its aligned districts contributes more than 53% of the total milk production in the country (IDRN, 2020). On the other hand, there is an increasing trend in milk production in South-western (Sathkhira, Khulna, Jashore and Kushtia) and South-eastern (i.e., Chittagong) wherever milk production is outpaced than expected (IFCN, 2018 and Uddin *et al.* 2019). This implies that policy intervention should be based on the assessment of the regional dynamics in terms of herd composition and variation in milk production which would enhance the future replication of the production systems and dairy farm management practices to similar other areas.

To enhance the milk productivity, the genetic composition, herd structure and regional shares of the herd structure is quite important to consider. Application of regional modeling might be helpful to assess the structural change within and between the regions. The modeling of regional dairy farming system would require substantial input data sets which are quite scarce, even it is available, are subjected to the questions of authentic sources and inconsistency. The data mining on the dairy sector and dairy farm in Bangladesh revealed that there are only two sources who have been generating data as a part of their institutional and legal mandate such as: 1) Bangladesh Bureau of Statistics (BBS), and 2) Department of Livestock Services (DLS). In addition, there is agricultural census which has been done in every 10 years. Using local infrastructure and resources, the Food and Agricultural Organization (FAO) of the United Nations also report dairy data in the name of

“FAOSTAT”. Furthermore, the International Farm Comparison Network (IFCN) Dairy Research Centre of Kiel University of Germany is the most recognized dairy data sources worldwide which has 120 countries dairy sector data and 54 countries dairy farm data that represent 98% of the global milk production (IFCN, 2019). In Bangladesh, the Integrated Dairy Research Network (IDRN) which is a new and innovative dairy database development initiatives linked with dairy networking approach arises from the successful implementation two projects under the Department of Animal Nutrition of Bangladesh Agricultural University (BAU) has also been aiming to develop database based on the IFCN methods, models and utilizing the local dairy networking approach. Against this, there are no studies on the detailed dairy sector data assessment of the data except the study done by Jabbar *et al.* (1989) and Huque (2014). These studies have attempted to provide the overview of the dairy structure and its dataset, but still there might need to review how can the national dairy database be assessed which was not revealed from the existing studies and they did not take the regional perspectives as well as also not providing the options for updating data on regular basis converging real time farm data.

The transition of the dairy sector toward achieving self-sufficiency and making dairy for young and dedicated new potential entrepreneurs requires their historical development in the past and the outlook for the future (Uddin *et al.* 2020). This could be done once there is a good database available and accessible for all stakeholders. However, the current data flow and its availability is not persistent and have substantial variation in cattle population, milk production and milk self-sufficiency (Jabbar *et al.* 1989; Uddin *et al.* 2020). Recognizing this, the government has been emphasizing the need for the development of dairy data, however, the accuracy of the data would require suitable modeling approach which is the key focus of this study. Therefore, this study has been aiming at assessment of the dairy data inconsistency by comparing the dairy herd structure and its milk production at cow level on regional level and proposes a validation tool to arrive at the national data by using the regional findings.

Materials and Methods

Modeling the regional dynamics and dairy networking approach

This study was carried out using the International Farm Comparison Network (IFCN) RMA which is, however, calibrated with locally developed

Integrated Dairy Research Network (IDRN) farm model. The IFCN model is based on the real time farm econometrics, dynamic, multi-country and multi-stakeholder model for global dairy sector and dairy farm while the IDRN is focused more to the regional and local dairy sector. The combination of both models provides an outstanding opportunity to make in-depth analysis on the targeted research issues, especially in the case where the data are scarce. To make comprehensive overview of the regional dynamics in the herd structure and milk productivity, it is also important to adopt the concept of dairy networking (Hemme et al. 2014).

The IFCN is a global network that connects 80 research partners from 120 countries and 110 dairy companies under the auspices of university of Kiel, Germany (IFCN, 2019). This network has strong tools and models for analyzing complete picture of dairy sector, dairy market, dairy farm, production systems, feeding system, market integration, forecasting production, demand, and market outlook (Hagemann et al. 2011; Hemme et al. 2014; Uddin et al. 2017; Sultana et al. 2014; Sultana et al. 2015). This model clustering

on herd structure, dairy farm within herd size class, milk production at global and regional level. However, the regional data from different country is on aggregate level (DLS, 2020), and for Bangladesh only to Divisional level (IFCN 2018). This limitation is, however, can be overcome by using the IDRN farm model (2020) where the model is extended to district and sub-district level with a possibility to extend the model to Union and Village level. This requires the IDRN to be adopt from project-based model to more institutional model similar like IFCN. Since IDRN is still under development, validation and testing phase, therefore further attempt is needed to be executed to be endorsed by institutional level. As the data is scarce from the formal sources, the IDRN farm model can make a bridge between the formal data government agency and academic agency as this network is well connected with global IFCN (IDRN, 2020) network. The IFCN model is already used in several studies (Ndambi et al. 2008; Uddin et al. 2010; Uddin et al. 2012; Hemme et al. 2014 and Sultana et al. 2014 and 2015).

Table 1: Overview of samples in the study area

Division	Total district	No. of district covered	% representative	Sample size (n)
Mymensingh	4	2	50.0%	356
Rajshahi	8	5	62.5%	753
Rangpur	8	2	25.0%	254
Total	20	9	45.8%	1363

Table 2: Coding of the various regions as unique code in the IDRN farm model

SL No	Name of the District	Two digits Alphabetic code*	Numeric code**	IDRN farm model code***
1	Jamalpur	JP	41	JP-41
2	Mymensingh	MM	42	MM-42
3	Bogura	BG	45	BG-45
4	Joypurhat	JT	46	JT-46
5	Pabna	PB	50	PB-50
6	Sirajgonj	SG	51	SG-51
7	Rajshahi	RJ	52	RJ-52
8	Kurigram	KG	55	KG-55
9	Lalmonirhat	LM	56	LM-56

*For each district has two digit unique Alphabetic code, **For each district a number is assigned from 1 to 64 and ***IDRN farm model code combines both Alphabetic and Numeric code. All of this coding is done following the principles of IFCN global model for different countries and keeping the Alphabetic order for both divisions and districts. District's serial is taken from the www.wikipedia.org (not based on the year of establishment)

Array of the inputs and output variables to the regional modeling

Selection of the regions, sample and sample size

For this study, we have selected three divisions out of 8 divisions and nine districts out of total 20 districts under three divisions which represent 37.5% divisional data and 45.8% district data. The overview of the selected regions and sample size under three divisions is depicted in the Table 1.

Since it is evident that Rajshahi division is the highest milk producing region in the country producing 36% of milk of the total milk production (IFCN, 2019), our selection represents the most promising milk producing regions of the country. The sampling was done with unbiased and proportionate to the regional dairy farming practices. The selection of the sample dairy farm was stratified and purposive where the type of farm (based on the total livestock unit and dairy unit) was considered as Strata and the sample unit must be a dairy farm where milk production is the key focus although beef and other enterprise could be as secondary options. The name of the districts was extended with numeric code and alphabetic code and assigned in the model which is used to interpret in tables and graphs which are shown in the table 2.

Herd structure: total livestock unit versus total dairy unit

The herd structure is a function of the two factors, i) per total livestock unit which includes lactating cows, dry cows, heifers, bulls, male calves and female calves; and ii) per total dairy cattle which includes only dry and lactating cows. This is extremely important to represent the existing farming system. In addition, this herd structure was also segregated between local and cross bred cows. The milk production and farm types were substantially varied between cross and local cows (Huque, 2014).

Herd simulation and milk production and milk composition

The herd simulation variables, e.g., breeding parameters are strongly correlated with milk productivity and profitability. For herd simulation, lactation length and dry period were the key variable to define the total milk production per cow and per lactation. From the point of annual economic analysis, which is the key for the dairy farmers, the milk production needs to be converted to production per cow per year. For this, specific gravity of 1.028 to 1.033 widely used and for this study, we use 1.033 is following

the conversion of liter to kilogram (kg) (Uddin et al. 2010)

Data and data analysis

The total number of dairy farms in this study for primary data collection was 1363 (n) as shown in table 3 which covers the time horizon from Last Quarter (Q4/2018) of 2018 to the First Quarter 2020 (Q1/2020). A well trained and having well background knowledge on livestock, particularly dairy farming, herewith called "Database Team" was assigned to collect data which was consecutively pass through a number of quality check by the research team, expert panel and national workshop. This is the uniqueness of the IDRN data and model compared with traditional data collection method. A very strong quality check tool is employed in every steps of the data collection starting from the study design to the result publication. A pre-defined and pre-tested questionnaire was used to collect the pertinent data for this study. A total of 25 variables which has at least 1 to 10 i.e., sub variables called "**Transect Study**" were used for this study. In order to cross check and validation of the collected data and assessing the regions, the IDRN check tool (following the IFCN principle) and comparing with a total of eight sources were applied for this study: i) Department of Livestock Services (DLS), ii) Bangladesh Bureau of Statistics (BBS) iii) Bangladesh Economic Review (BER) iv) Food and Agricultural Organizations (FAO) v) Integrated Dairy Research Network (IDRN) Farm Database vi) IDRN Sector Database vii) International Farm Comparison Network (IFCN) sector database (2019 and 2020) and viii) Reviewing various data generated in the Animal Nutrition Analytical Laboratory and research articles on structural change and milk production. The data was analyzed using the IDRN farm model version 1.0 and MS Excel (Microsoft Office 365) was used to manage the data.

Results and Discussion

IFCN farm classification approach has defined three types of dairy farms: i) Household Farms (HF), ii) Family Farms (FF), and Business Farms (BF), which is depicted in Table 4. It might be logical to adopt to the dairy farming context in Bangladesh. The characteristics of the farm types as explained in the Table 3 which reflects both herd size and objective of the dairy farming along with economics of the dairy farming. Hence, the proposed farm type is expected to fit well to the existing socio-economic condition as well as the prevailing farming practices.

Regional modeling approach for reducing dairy data inconsistency

Until today, there is no specific farm type which is established by national authority, the prevailing farm type, hence, varies from the viewpoint of the researchers (Khan *et al.* 2009; Uddin *et al.*, 2010; Uddin *et al.* 2012, Sultana *et al.* 2015; Huque 2014; BBS, 2018; Islam *et al.* 2019,). For livestock, more specifically dairy, farm is generally classified based on total livestock per farm which are small, medium and large but the number of the livestock per farm is not same and varies in different study (Khan *et al.* 2009; Datta *et al.* 2018 and Islam *et al.* 2019). The different classification is proposed by Huque (2014) who virtually classified livestock based on the vicinity of the location (urban is considered as the center) and Saadullah (2001) who classified livestock farm based on land ownership.

Following the IFCN regional modeling and farm classification, the farm type based on total livestock unit per farm and dairy cows per unit is depicted in Table 4 and 5, respectively which shows three types of farm, there are HF, FF and BF).

Until today, there are no specific farm type which is established by national authority, the prevailing farm type, hence, varies from the viewpoint of the researchers (Khan *et al.* 2009; Huque 2014; BBS, 2018; Islam *et al.* 2019). For livestock, more specifically dairy, farm is generally classified based on total livestock per farm which are small, medium and large but the number of the livestock per farm is not same and varies in different study (Khan *et al.* 2009; Datta *et al.* 2018 and Islam *et al.* 2019). The different classification is proposed by Huque (2014) who virtually classified livestock based on the vicinity of the location (urban is considered as the center) and Saadullah (2001) who classified livestock farm based on land ownership.

Following the IFCN regional modeling and farm classification, the farm type based on total livestock unit per farm and dairy cows per unit is depicted in Table 4 and 5, respectively which shows three types of farm: Household Farm (HF), Family Farm (FF) and Business Farm (BF).

Table 3: Farm type classification at national level in Bangladesh

Farm types*	Household farm (HF)	Family farm (FF)	Business farm (BF)
Farm description	Household Farm (HF) is defined as one the income source for livelihoods, mainly consumed at household level and sells the surplus milk.	Family Farm (FF) is defined as the farm that operates the farm with goal to earn main source of income for sustaining family	Business Farm (BF) is defined as the farm that operates their business based on Return on Investment (ROI).
Herd size/farm			
Bangladesh	1-3 cows	4-16 cows	>16 cows
Global	1-30 cows	31-300 cows	>300 cows
Comparison with traditional classification	Small	Medium	Large
Labour use	Mainly family labour	Combination of both family and hired labour	Mainly hired labour

**This classification can be compared with traditional classification of small, medium and large (Khan *et al.* 2009) but IFCN classification is more reflective to the farming activities and farm objective as well as economies of scale. In our study, we proposed IFCN classification for the future research.*

Table 4: Regional share of the farm types to the total farm based on total livestock unit

Division	Unit	Avg.	Mymensingh					Rangpur			
Districts with Code	Total (average)		JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Household Farm (HF) %	39.3	29.3	57.4	33.6	32.7	23.8	33.5	45.7	44.6	41.5	
Family Farm (FF) %	56.1	68.4	40.8	62.5	63.6	66.7	59.6	52.1	47.0	52.0	
Business Farm (BF) %	4.5	2.3	1.8	3.9	3.6	9.5	7.0	2.1	8.4*	6.4	

**Sample for Business Farm (BF) in Kurigram has slightly selection biased. HF, FF, and BF represents the small farm, medium farm and large farm with a herd size of 1-3 cows, 4-16 cows and >16 cows respectively.*

Considering the total livestock unit (as shown in table 4), the main dominant farm type in the region is FF (56.1% to the total farm type). However, a strong interregional variation exists among the farms analyzed in this study however substantial differences are also observed within region. The lowest HF is observed in JP-41 (29.3%) and the highest in MM-42 (57.4%). The lowest FF is observed in MM-42 (40.8%) while the highest is JP-41 (68.4%). In relation to BF, it is found that Pabna has the biggest share of BF (9.5%) which is to some extent justified as because the key driver for the dairy development in Bangladesh has been initiated in Lahiri Mohonpur Pabna (presently Sirajganj) following the cooperative model of Amul from India. This region has strong history of dairy farming. The next region is Sirajganj (7%) which is also justified as the most dairy interventions are taking place in this region and also the major milk processing companies are operating their milk collection center in this region.

The farm type based on the dairy cows per farm as shown in table 5 shows substantial differences in farm type. The dairy farm is defined as the total number of dry and lactating cows (IFCN, 2019). If this is applied to the IDRN farm classification database, a significant number of farm types fall under the HF category (74.7%), only 23.0% is FF and 2.3% is BF. But the trend of farm type found in the table 4 is also same for the farm type found in table 5 as because PB-50 and SG-51 has the highest BF representing 4.8% and 5.1%, respectively. The same is true for FF which once again revealed that dairy is the major business for maintaining the livelihood.

The farm type and scale of production is extremely important to undertake any

intervention on the management as well as policy for increasing milk production. Until recent time, there is no specific farm type that is well established in dairy sector in Bangladesh although there is quite common approach based on the land holdings and total livestock holdings. The stocking rate for dairy in Bangladesh is the highest at global level which makes relatively insignificant to the land-based classification. The land-based classification is more suitable for agriculture, particularly for crop sector. From the economic perspectives, the classification proposed in this study might be taken into account while devising any intervention for improving the dairy sector in Bangladesh.

Since the data are extremely scarce and non-availability of the established farm types poses the challenges for making decision on the real need of the dairy farmers. The policy decisions on farm management and farm productivity enhancement could be well harmonized once the farm types along with herd size are well established. This study results, in this regard, could contribute to the dairy farmers, input suppliers and policy makers.

Herd structure and its composition

The milk production at the national or regional level is highly dependent on the milk productivity at the cow or herd or farm level. This is again depending on the genetic merit and its composition at herd and/or farm level. The proportion of the genetic merit as expressed by percentage of local and cross bred in the herd in the analyzed region is shown in Figure 1.

Table 5: Regional share of farm type based on total dairy cows' unit

Division	Unit	Avg. Total (average)	Mymensingh			Rajshahi			Rangpur		
			JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Household Farm (HF)	%	74.7	82.7	91.9	78.5	78.2	42.9	48.2	87.2	75.9	76.6
Family Farm (FF)	%	23.0	15.8	7.6	20.3	20.9	52.4	46.7	11.7	20.5	19.9
Business Farm (BF)	%	2.3	1.5	0.4	1.2	0.9	4.8	5.1	1.1	3.6	3.5

HF, FF, and BF represents the small farm, medium farm and large farm with a herd size of 1-3 cows, 4-16 cows and >16 cows respectively.

Regional modeling approach for reducing dairy data inconsistency

The figure shows that the mixed results on the proportion of cross bred and local cows in the herd in our analyzed regions. The BG-45 has the highest share of cross bred cows (88.9%) followed by PB-50 (82.7%), KG-55 (76.7%) and RJ-55 (76.4%). The interesting to note that proportion of cross bred cows in SG-51 is to some extent similar to JP-41 which implies that the milk production potential is increasing in JP-41 as like SG-51. Since the SG-51 is well recognized for the biggest dairy region, this analysis shows that SG-51 might be losing its competitiveness in terms of genetic merit. On the other hand, there are other promising regions which were not yet explored (i.e., JP-41) but could be make as point of intervention for deeper analysis using multiple variables.

The other findings are quite different compared to the study is done by Huque (2014) who found the average of 70% local and 30% cross bred cows, while our study revealed 74.6% cross bred and 25.4% local (average of the all regions) that is reflected to. the study (Uddin *et al.* 2020) stated the structural change of the dairy sector and changing of the dairy farming from livelihood-oriented to enterprise-driven with higher milk producing crossbred cows. This is also implies that milk production in Bangladesh might be increasing and dairy development is progressing.

In contrast, it might be also evident that our results are not true reflection of the national level but more to the highly milk producing regions, which however, again require extending this study to other regions of the country and even at the national scale including all 64 regions.

Considering the detailed herd structure within different farm types and genetic merit is shown in Table 6 and 7. From the table 6 and 7, it is revealed that overall percentage of lactating cows is substantially higher in local dairy cows (48.8%) than cross bred (34.2%). For the case of dry cows, the cross bred has higher dry cows (17.9%) than local (14.8%) as crossbred milking cows number are higher than local . In relation to interregional variation, the district of Lalmonirhat has the highest share of lactating cows for local cattle which might be due to the fact that the dairy production in Lalmonirhat is dominated by the local cattle, whereas, the share of lactating cows for crossbred cattle is highest for Jamalpur which implies that Jamalpur is the promising region for uplifting dairy. But the Sirajgonj and Pabna has the highest average share of lactating cows both for local and cross bred (53.7% and 35.8%) compared to the other regions (49.8% and 32.7%) which implies that dairy farms in those two regions are well managed compared to other regions.

Figure 1: The proportion of the local and cross bred in different regions of Bangladesh

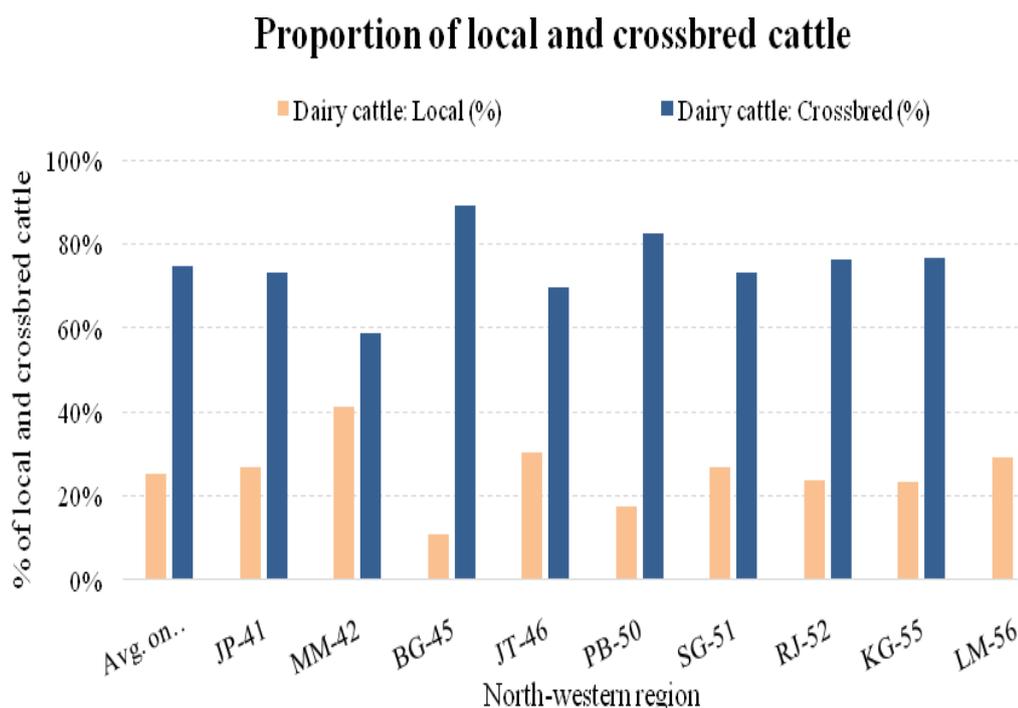


Table 6: Herd structure based on local cows in the north-western region

Division	Unit	Avg. Total (average)	Mymensingh		Rajshahi				Rangpur		
			JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Lactating cow	%	48.8	34.9	54.1	70.1	26.9	55.6	51.8	53.9	41.8	66.8
Dry cow	%	14.8	13.5	14.5	13.4	15.7	7.4	22.9	11.8	9.6	8.2
Heifer	%	28.3	17.9	14.1	7.2	14.3	22.2	9.1	18.4	13.0	6.4
Female calf	%	10.2	16.2	1.2	3.1	18.8	3.7	8.2	10.5	14.4	10.0
Male calf	%	13.9	17.5	16.1	6.2	24.2	11.1	7.9	5.3	21.2	8.6

Table 7: Herd structure based on crossbred cows in the north-western region

Division	Unit	Avg. Total (average)	Mymensingh		Rajshahi				Rangpur		
			JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Lactating cow	%	34.2	37.6	35.6	32.3	34.2	36.1	35.5	32.4	26.7	30.6
Dry cow	%	17.9	15.8	12.2	23.6	27.1	11.1	15.4	24.6	21.4	18.2
Heifer	%	14.6	12.8	11.6	12.8	14.2	19.7	11.5	13.4	22.6	19.7
Female calf	%	17.1	19.7	16.8	16.8	12.1	16.2	20.8	4.6	13.8	18.2
Male calf	%	16.2	14.1	23.8	14.6	12.4	16.9	16.8	25.0	15.6	13.3

The percentage share of the dry cows to the total herd is lower in PB-50 and the percentage of heifer is also higher in PB-50. Since the percentage of heifer and its quality as well as its availability at the farm level makes the dairy farmers enable to replace the cull cows at the rate of higher than those who does not have access to heifer. The higher replacement rate is trade off with culling rate. The higher replacement rate, the higher the culling rate which creates the opportunity for culling relatively less productive and less efficient cows from the herd. Apart from the main dairy regions, JP-41 is another promising region for dairy which is not yet explored and less research have done, therefore, a detail research can be a way to find out the potentiality of dairy production in Jamalpur.

Milk productivity

The milk production as a key output from the regional model is depicted in the table 8. The PB-50 and SG-51 has the highest amount of milk production (6.62 lit/cow/day and 6.18 lit/cow/day) per cow per day when compared with other regions which is the known fact of better farm management in those regions than other regions. The lowest amount of milk production is found in LM-56 (2.19 lit/cow/day, since the Lalmonirhat is dominated by local cows and the milk production from local cows is substantially lower than the crossbred cows. The aggregate average milk yield in the north-western regions is found 4.49 lit/cow/day wherein the milk yield from local cows is 1.71 lit/cow/day and milk yield from crossbred cows is 6.23 lit/cow/day. Whereas, the statistics of Banglapedia (2015) is recorded that milk production from local and crossbred cows is 1.5 and 5.5 lit/cow/day, respectively in registered dairy farms in Bangladesh.

Table 8: Milk yield in north-western region

Division	Unit	Avg. Total (average)	Mymensingh		Rajshahi				Rangpur		
			JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Milk yield	lit/cow/day	4.49	5.70	3.08	4.61	4.82	6.26	6.18	5.54	2.93	2.19
Milk yield: local	lit/cow/day	1.71	2.13	1.55	1.63	2.12	1.54	2.05	1.81	1.56	1.30
Milk yield: cross	lit/cow/day	6.23	8.12	4.55	5.41	6.37	6.76	7.72	7.58	5.17	4.08

Regional modeling approach for reducing dairy data inconsistency

Driver for milk productivity

The herd simulation is the key driver for milk production which is a function of lactation length and dry period (e.g., calving interval). The lactation length and dry period for local and cross bred cows are depicted in table 9. It is evident from this study that the PB-50 and SG-51 has the highest lactation length of 261.90 and 260.26 days, respectively which also has the highest milk production, whereas the LM-56 has the lowest lactation length of 216.43 days with the lowest amount of milk production in the north-western region. While the simulated aggregate average lactation length is found 243.12 days. On the other hand, the highest dry period was found in MM-42 which is 145.12 and also the average milk production in Mymensingh is much lower 3.08 lit/cow/day.

Regional modeling approach: way forward for minimizing data inconsistency.

Regional data modeling versus national dairy data

For sustainable dairy development, it is necessary to take holistic approach where the decisions should be based on the real time data, the accurate assessment of the need of the farmers, the participation of all dairy stakeholders and the outlook of the country as well as the linkage with international dairy development perspectives. However, the intervention that is taken based on the national level might not fit to the regional level. Therefore, the application of the regional

modeling approach in our study clearly revealed that Bangladesh dairy has been undergoing a structural change where the proportion of the HF is decreasing, and proportion of the FF is increasing (IFCN, 2019). The north western part is considered as the major dairy region in Bangladesh (Mortensen *et al.* 2017) which contribute the largest share of milk production in total national milk production. The output from the regional modelling such as the proportion of local and crossbred cows, share of lactating cows to the total herd and the variability of milk productivity between the local and crossbred cows would be worthwhile to estimate the aggregate milk production at the national level following the principle of IFCN regional farm simulation approach which is depicted in Table 10.

Table 11 clearly shows that the total milk production reported by the DLS in 2018 is quite different than IDRN model version 1.0 and 2.0. The DLS milk production is 20.71% and 42.73% higher than IDRN model version 1.0 and 2.0, respectively. These differences might be due to the fact that IDRN data relies more on the simulation of the farm data with real time monthly survey while the DLS data is based on more on the aggregate annual data. However, to arrive at the consensus on the data at national level, it might be worth to estimate the herd structure and milk production at regional level and therefore, the output of the current RMA should be extended to other regions covering all 64 districts of Bangladesh.

Table 9: Lactation length and dry period in the north-western regions

Division	Average	Mymensingh		Rajshahi			Rangpur			
		JP-41	MM-42	BG-45	JT-46	PB-50	SG-51	RJ-52	KG-55	LM-56
Lactation length (days)										
Avg. Lactation length	243.12	246.05	242.69	250.99	242.58	261.90	260.26	241.70	225.49	216.43
local	213.60	212.98	228.57	207.87	223.76	210.00	227.81	214.26	194.53	202.64
cross	261.41	269.44	256.97	261.91	254.68	267.37	272.16	256.94	270.17	243.05
Dry period (days)										
Avg. Dry period	126.77	122.59	145.12	109.68	119.60	111.52	111.59	144.47	135.12	141.21
local	143.02	148.82	160.94	142.87	131.49	120.00	125.96	138.09	166.79	152.21
cross	113.61	103.40	129.52	101.06	113.41	110.63	106.32	147.58	89.43	121.15

Table 10: Validation of Milk yield at national level using IFCN regional farm simulation approach (DLS data Vs IDRN/IFCN data)*

Simulation variables	Unit	2018
No. of Dairy farm	million	1.47
No. of Dairy cow	million	4.76
Number of dairy cows: local	million	1.21
Number of dairy cows: cross	million	3.55
Milk yield: local	million ton/year	0.46
Milk yield: cross	million ton/year	5.82
BD milk production (IDRN model version 1.0 - based on the regional approach)	million ton	6.60
IDRN milk production (IDRN model version 2.0 - based on the national aggregate approach)	million ton	7.80
DLS milk production	million ton	9.42
Difference between DLS and IDRN model version 1.0	%	20.77%
Difference between DLS and IDRN model version 2.0	%	42.73%

Table 11: Inconsistency in the dairy data (cattle population and milk production) among various source

Source	1984			1996			2008			2018		
	TC	DC	MProd	TC	DC	MProd	TC	DC	MProd	TC	DC	MProd
	mil.	mil.	mil.t	mil.	mil.	mil.t	mil.	mil	mil.t	mil.	mil.	mil.t
Agr. census	21.50	-	-	21.57	-	-	25.68	-	-	28.49	-	-
FAO*	21.92	3.40	0.70	22.02	3.73	0.77	22.90	4.02	0.83	24.09	4.05	0.83
BBS	22.1						22.9		2.65	24.08		9.41
DLS	21.40			21.50			22.9		2.65	24.08		9.41
IFCN/IDRN	-	-	-	-	4.15	1.8	-	4.47	2.96	-	4.75	7.80

*TC, Total cattle; DC, Dairy cows; MProd. Milk Production; mil, million and mil.t., million ton; - no data. *FAO data for total milk production might need signification validation steps as this data shows substantial differences than available sources.*

This difference can also be explained by assessing the inconsistency of the dairy data among various sources which are shown in Table 11. Comparing the time series data among various organizations and agricultural census data, with the exception of IFCN data showed consistency and to some extent implausible data (BBS 2008, BBS 2018, DLS 2010, and DLS 2019). From the Table 11, it is clearly revealed that challenges to compare all the sources as each of the sources have different data. Using the total cattle, a substantial variation has been observed among DLS, BBS and Agriculture census. Considering the number of dairy cows and milk production, each of the sources report quite different number which implies that there might need strong coordination among all the sources to generate the data on dairy sector. The marked differences are observed between the annual sources and agricultural census data in 2010 and 2018. However, the data availability and data authenticity remain important aspects of future research strategy for dairy uplifting.

In addition, there is a substantial inconsistency in the data both at primary data obtained from various researchers and institute of data generation. The data and research findings is done by Islam *et al.* (2019) revealed some inconsistency in price data for feed ingredients which are important especially for the rice straw where they showed the average of rice straw price by 1.7 BDT/kg and grass is 1.2 BDT/kg based on four district data. In contrast, the IDRN monthly dairy market update showed that average rice straw price for July -December, 2018 was 11.8 BDT/kg, January-December 2019 was 8.96 BDT/kg and January-December 2020 was 10.16 which seems our price were substantially higher (IDRN, 2020) than Islam *et al.* (2019). We also claim that our data is based substantially higher region and also have time series data and having more consistent than other sources. The price shown in Islam *et al.* (2019) could be either underestimated or might have sampled bias where those farms (265) analyzed might get subsidy in one or another form. This would certainly lead to the point of notion that data must be validated with more than one sources which is difficult in the case of Bangladesh. The RMA of IDRN could be a way forward to validate data, hence, the IDRN database would serve more intensively on farm data collection and has scope to include more districts.

At the same pace, the milk production data reported by FAO and UNIDO (2019) stated that Bangladesh produces 9.4 million tons of which

only half of the milk is produced by bovine where goat produces the highest share (54.2% of the total milk production). The milk production from buffalo and sheep was 1.8% and 1.5%, respectively. Our analysis from the IDRN Farm database and also from the data published by the DLS (Uddin *et al.* 2020), the data from International Farm Comparison Network (IFCN) and the personal experiences from the field survey clearly evident that share of cows milk to the national milk production is 97%. The estimation of goat milk by FAO and UNIDO is unrealistic which might compel to review the data reported by 2019 with some more logical tools and cross check with other statistical sources.

Furthermore, the FAOSTAT data (FAO, 2018) published by the FAO clearly stated that Bangladesh has milk production of less than 1 million ton which is quite impossible. This data could be either arises from technical error in uploading the data or the source from where the data is taken is not authentic (DLS 2019; IDRN 2020). This once again prove the inconsistency of the data and might mislead the improvement of the dairy in Bangladesh. Milk production in Bangladesh is estimated as 9.92 million tons in 2018 while considering the simple average growth rate the milk production is estimated 10.47 million ton in 2019 (DLS, 2019 and Uddin *et al.* 2020). In contrast, IDRN has estimated milk production (both cows and buffalo) as 8.14 million tons (IDRN, 2020). The study done by Uddin *et al.* (2020) revealed that milk production in Bangladesh as reported by both sources (DLS, 2019 and IDRN, 2020) is over estimated and suggest to revise the milk production data backward considering the different phases of development and natural shock as well as global impact, at the same time it is also argued to apply holistic tools in order to increase the precision of the data. This instigates to dig deeper the existing dairy herd population, their genetic composition and milk productivity which in turn will determine the total milk production in the country.

Dairy data is scarce in Bangladesh not unlike in several many other developing countries globally. The application of the dairy networking is the promising way to minimize the data gap and helpful for creating strong knowledge pool. Considering this, this study has adopted the IDRN regional database and Farm model which is the output of the Dairy Networking in Bangladesh Funded by Ministry of Education (MoE 2017) that could add value to the existing database development activity by the DLS under the project of LDDP (DLS, 2019). The real time data

Regional modeling approach for reducing dairy data inconsistency

and updated information by using the network which is if then combined with various cross-sectional research would be way forward for accurate representation of the Bangladesh dairy and that can be a viable mode for Sustainable Dairy Development in Bangladesh.

Apart from this, there are no other institutions or organizations who might take the lead for the data generation using specific methods, tools and logical models. The exception is the IDRN which has been investing improved methods, models and tools in cooperation with the Department of Animal Nutrition, Bangladesh Agricultural University and the IFCN. The IDRN is attempting to develop different models and tools to identify the data gap, data inconsistency and ways to increase the efficiency and precision of the dataset on the dairy sector and dairy farm in Bangladesh (IDRN, 2020). The IDRN is also able to update the real time dairy sector and dairy farm data, however, has limited resources and is still working to have institutional endorsement. Using this dataset together with other sources, it would be highly relevant to integrate regional modeling in the case of Bangladesh dairy sector. Therefore, this study aims at the application of the regional modeling on assessing the regional variation in the herd structure and milk productivity by using the IDRN farm model (IDRN, 2020) and IFCN dairy sector model (IFCN, 2019). The outcome of this study would identify the regional dynamics of the existing dairy situation and also justify the use of regional data modeling developed by IDRN.

Conclusion

This study proposed three types of dairy farms which are different from the traditional farm types, but this farm type is claimed as close representation of the farming system of Bangladesh. The regional modeling results depicted that the proportion of family farm is higher while consider total livestock unit and household farm is higher while consider the total dairy cow unit. The average milk production is 4.49 lit/cow/day wherein for the local is 1.71 lit/cow/day and cross bred is 6.23 lit/cow/day. The top four milk producing region based on the average milk yield per cow per day are SG-51 (7.72 lit), RJ-52(7.58 lit), PB-50(6.37 lit) and JP-41 (6.12 lit), which is divergent from the existing literature as it is quite usual for the highest milk producing region for SG-51 and PB-50. The top position for SG-51 is reflecting the reality as this region is well developed and considered as the major dairy region in Bangladesh.

The inconsistency in the national level data on dairy sector might be considered as the key constraints for proper decision-making process, formulating policy and applying interventions on dairy development. The application of the regional modeling approach of IFCN and IDRN could provide broader scope for validation of the data for the dairy sector development. The regional model revealed that north western part of the country is well representative of dairy region especially the regions of Rajshahi division with the highest milk producing, such as Sirajganj and Pabna is located with higher percentage of business farms. This study further identified some inconsistency in the data among various sources which entail to take initiatives by the government affiliated respected data collection agency (e.g. BBS, DLS) to make coordination among them and also it would be worthy to use established methods, models and validation tools before publishing the data to represent fact-based situation better for Bangladesh Dairy so that real intervention can be made to reach the target to become self-sufficient in milk production in near future. The external organization like FAO, IFCN and IDRN could be well linked and endorsed with government for increasing the precision of the data with real time update. Even with the fact that regional model could provide more precise information on the regional level but does not necessarily allow to extrapolate to the national level. This would require the inclusion of all districts and more sample for farm level data, could make a step forward which also fits with the vision and mission of the IDRN which collaboration with IFCN and DLS can play role to support the Sustainable Dairy Development in Bangladesh.

Acknowledgment

The authors highly acknowledge the Ministry of Education (MoE 2017) for financial support for materializing this study. The authors also acknowledge the International Farm Comparison Network (IFCN) for access to data, methods and model.

IDRN stands for Integrated Dairy Research Network. IDRN is new and innovative methodological concept that uses the principles of networking for integrating dairy data, methods, models, people, and coordination among various dairy stakeholders.

IDRN data source refers to the data generated, compiled and validated through a series of activities (PhD project, academic project, external sources) and The stakeholders meeting nationally

and internationally through different phases of network development from 1996 till date.

Conflict of interest

There is no conflict of interest among the authors.

References

- Banglapedia (2015). Cattle. <http://en.banglapedia.org/index.php?title=Cattle>
- BBS, Bangladesh Bureau of Statistics (1984), Agricultural Census 1984. Statistical division, Ministry of Planning, Dhaka.
- BBS, Bangladesh Bureau of Statistics (1996), Agricultural Census 1996. Statistical division, Ministry of Planning, Dhaka.
- BBS, Bangladesh Bureau of Statistics (2008), Agricultural Census 2008. Statistical division, Ministry of Planning, Dhaka.
- BBS, Bangladesh Bureau of Statistics (2008). Statistical yearbook of Bangladesh. Statistical division, Ministry of Planning, Dhaka.
- BBS, Bangladesh Bureau of Statistics (2018), Agricultural Census 2018. Statistical division, Ministry of Planning, Dhaka.
- BBS, Bangladesh Bureau of Statistics (2018). Theatistical yearbook of Bangladesh. Statistical division, Ministry of Planning, Dhaka.
- Datta AK, MZ Haider and SK Ghosh (2018). Economic analysis of dairy farming in Bangladesh. *Tropical Animal Health and Production* 51: 55-64.
- DLS, Department of Livestock Services (2010). Livestock Economy at a glance. Ministry of Fisheries and Livestock (MoFL), Government of the People's Republic of Bangladesh, Dhaka. www.dls.gov.bd
- DLS, Department of Livestock Services (2019). Livestock Economy at a glance. Ministry of Fisheries and Livestock (MoFL), Government of the People's Republic of Bangladesh, Dhaka. www.dls.gov.bd
- FAO-UNIDO, Food and Agricultural Organization-United National Industrial Development Organization (2019). The dairy and beef value chain in Bangladesh. <https://www.unido.org/sites/default/files/files/2019-05/Bangladesh%20dairy%20and%20beef%20vc%20report%20%28Wei%27s%20final%20version%29%20.pdf>
- FAO, Food and Agricultural Organization (2020). FAOSTAT. <http://www.fao.org/faostat/en/#country>
- Hemme T, MM Uddin and OA Ndambi (2014). Benchmarking cost of milk production in 46 countries, *Journal of Reviews on Global Economics* 3:254-270.
- Huque K (2014). A performance profile of dairying in Bangladesh - programs, policies and way forwards. *Bangladesh Journal of Animal Science* 43 (2): 81-103.
- IDRN, Integrated Dairy Research Network (2020). Bangladesh monthly dairy market update. www.idrn-dairy.org.
- IFCN, International Farm Comparison Network, 2018. Dairy Report. IFCN Dairy Research Center, Schauenburger Str. 116, 24118 Kiel, Germany. www.ifcndairy.org.
- IFCN, International Farm Comparison Network, 2019. Dairy Report. IFCN Dairy Research Center, Schauenburger Str. 116, 24118 Kiel, Germany. www.ifcndairy.org.
- Islam MN, MS Bari, MR Habib, MM Sarker and MA Islam (2019). Comparative economic analysis of dairy characteristics focused on repeat breeding losses in selected milk pocket areas of Bangladesh. *Bangladesh Journal of Animal Science* 48(2):145 -154.
- Jabbar MA (1989). An assessment of the quality of livestock statistics in Bangladesh. *Bangladesh Journal of Agricultural Economics* XII (2):25-42.
- Khan MJ, KJ Peters and MM Uddin (2009). Feeding strategy for improved dairy cattle productivity in small holder farm in Bangladesh. *Bangladesh Journal of Animal Science* 38:67-85.
- Ministry of Education (MoE) (2017). Benchmarking Dairy farming system in major milk shed areas of Bangladesh: Implications for nutritional, economics and environment. A project report by MoE.
- Mortensen IQ, P Hallberg and T Brogger (2017). Milk, market and malnutrition-Human rights assessment of scaling -up affordable dairy nutrition in Bangladesh. Arla Foods Ltd. https://www.arla.com/494b79/globalassets/arla-global/company---overview/responsibility/human-rights/milk-market-and-malnutrition_-human-rights-assessment-of-scaling-up-affordable-dairy-nutrition-in-bangladesh_final.pdf
- Ndambi OA and T Hemme (2008). An economic comparison of typical dairy farming systems in South Africa, Morocco, Uganda, and Cameroon. *Tropical Animal Health and Production* 41(6): 979-994.
- Saadullah M (2001). Smallholder dairy production and marketing in Bangladesh. In: Smallholder dairy production and marketing-opportunities and constraints; *Proceedings of a South-South workshop* held at National Dairy Development Board. Anand, India, 13-16 March 2001.
- Sultana MN, MM Uddin, BG Riddout and KJ Peters (2014). Comparison of water use in global milk production for different typical farms. *Agricultural Systems* 129: 9-21.
- Sultana MN, MM Uddin, GB Riddout, T Hemme and KJ Peters (2015). Benchmarking Consumptive Water Use in dairy production system worldwide-implication for global food security. *Global Food Security* 4: 56-68.

Regional modeling approach for reducing dairy data inconsistency

- Uddin MM, A Akter, ABM Khaleduzzaman and MN Sultana (2020). Forecasting milk production in Bangladesh toward achieving self-sufficiency. *Livestock Research for Rural Development* 32, <http://www.lrrd.org/lrrd32/5/moham32081.html>.
- Uddin MM, ABM Khaleduzzaman and A Akter (2019). Impact of tax liberalization on dairy sector competitiveness in Bangladesh: Implications for dairy import policy. Abstract in: *20th IFCN Dairy Conference*, 15-19th June 2019, Berlin, Germany
- Uddin MM, MN Sultana and MJ Khan (2017). Impact of dairy support services and strategies on reduction of cost of milk production in different dairy production systems in Bangladesh: Implications for rural livelihood improvement. *Asian Journal of Poverty Studies* 3(2): 95 – 104.
- Uddin MM, B Brümmer and KJ Peters (2013). Modelling factors affecting the decision to exit dairy farming in Bangladesh: A Two-Stage Regression Analysis. In: *Agricultural development within the rural-urban continuum*. Tropentag, 17-19 September 2013, Stuttgart-Hohenheim, Germany.
- Uddin MM, MN Sultana, B Brümmer and KJ Peters (2012). Assessing the impact of dairy policies on farm-level profits in dairy farms in Bangladesh: Benchmarking for rural livelihoods improvement policy. *Journal of Reviews on Global Economics* 1: 124-138.
- Uddin MM, MN Sultana, OA Ndambi, T Hemme and KJ Peters (2010). A Farm Economic Analysis in different Dairy Production Systems in Bangladesh. *Livestock Research for Rural Development*, 22 (7) 2010, <http://www.lrrd.org/lrrd22/7/uddi22122.htm>.