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APPLICATION OF GEOSPATIAL TECHNIQUES TO EVALUATE FEEDING PATTERNS FOR MILK PRODUCTION OF *BUBALUS BUBALIS* (BUFFALOES) IN DISTRICT KASUR, PAKISTAN.

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ABSTRACT: The aim of the present study was to explore relationship between feeding patterns and milk production of *Bubalus bubalis* (Buffaloes) using Geographic Information System (GIS). A total of 919 buffaloes from 38 dairy farms of Kasur, Punjab, Pakistan were included in this study. Milk production per annum for grazing, non-grazing and partial grazing feeding category of *B. bubalis* was recorded with a minimum value of 1808, 1856 and 1780 liters, respectively, while with a maximum of 2455, 2334 and 2902 liters, respectively. Availability of water lines and using both the land cover classes 1 and 3 with partial grazing feeding category significantly enhanced the milk production. Comparison among the feeding patterns was determined by one way Anova. The results also revealed a positive correlation of partial grazing feeding pattern with *B. bubalis* milk production. In conclusion, partial grazing feeding category attained high milk yield with existing resources than grazing and non-grazing feeding category.

Keywords: Feeding Patterns, *Bubalus bubalis*, Geographic Information System (GIS), Welch Test and Games-Howell Test.

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INTRODUCTION

The domestic animals contribute 58.3% milk and meat to the people and 11.4% to the total GDP. *B. bubalis* is the primary domestic animal of Pakistan with the aggregate population of 37.7 million having a milk production of 34,12 tons (Anonymous, 2016-17).

Over the last few years, variation in milk production has been noticed. The increase is not due to increase in production of milk but is due to increase in the number of milk producing animals (Shabbir, 2014) and there are several reasons for the decline in milk production including genetic potential, delayed puberty, different feed resources, green feed, lactation number, diseases, improper marketing system and outdated farming system (Ahmad *et al*., 2012 and Hussain *et al*., 2010). In Pakistan's dairy production systems, two types of feeding practices are followed. In rural households, animals are fed on growing fodders in the form of cut-and-carry livestock feed. In intensive and semi-intensive dairy farming, the animals are fed on crop cuts and other byproducts. Farmers use green fodder on its availability (Zia *et al*., 2011).

Most of the buffaloes' productivity level is dependent on water availability. In hot and dry areas the production is generally low. On the other hand, in cold and wet areas production from buffaloes is high due to their tendency of reducing heat load and thermal stress (Marai and Haeeb, 2010 and Borghese, 2005). *B. bubalis* (Water buffaloes) have good immune system (Sivakumar *et al*., 2006), well appropriate for pastures (Thomas, 2004) and mostly feed upon different types of riverside plants (Czerniawska-Piatkowska *et al*., 2010). Limited knowledge is available till to date regarding the comparison of the feeding patterns with the milk production using a statistical approach.

Therefore, this study was aimed at to draw a comparison between the feeding patterns and milk production along with the evaluation of best feeding pattern and its impacts on increasing milk production using GIS tools and statistical analysis.

MATERIALS AND METHODS

This study was conducted on *B.bubalis*, in District Kasur, Pakistan. It covers a total area of 4,768 Km2, at latitude and longitude of 31.118 and 74.463, respectively. Kasur region is characterized by three climatic seasons: i.e Winter (Dec –Mar), typically by mild temperatures and very few rainy days. Summer (Apr–Jun), a dry period during which hottest temperature is experienced and Rainy season (Jul–Sep) during which it typically rains for half of the day. The temperature ranges between 2˚C to a maximum of 48˚C (Stenek *et al.*, 2011).

Primary data collection: Primary data collection was done through field survey by fixed –effects model (Beg,

2005) in Kasur District. Milk production record of one year was collected through field survey. Total 38 farms were selected randomly, collectively having 919 buffaloes. The study area of District Kasur including 38 milk farms is illustrated in Fig-1. The data comprised of morning and evening milk records averaged per month, and the estimated milk yield was calculated for 305 days using the same strategy as applied by Ahmad *et al.*, (2008).

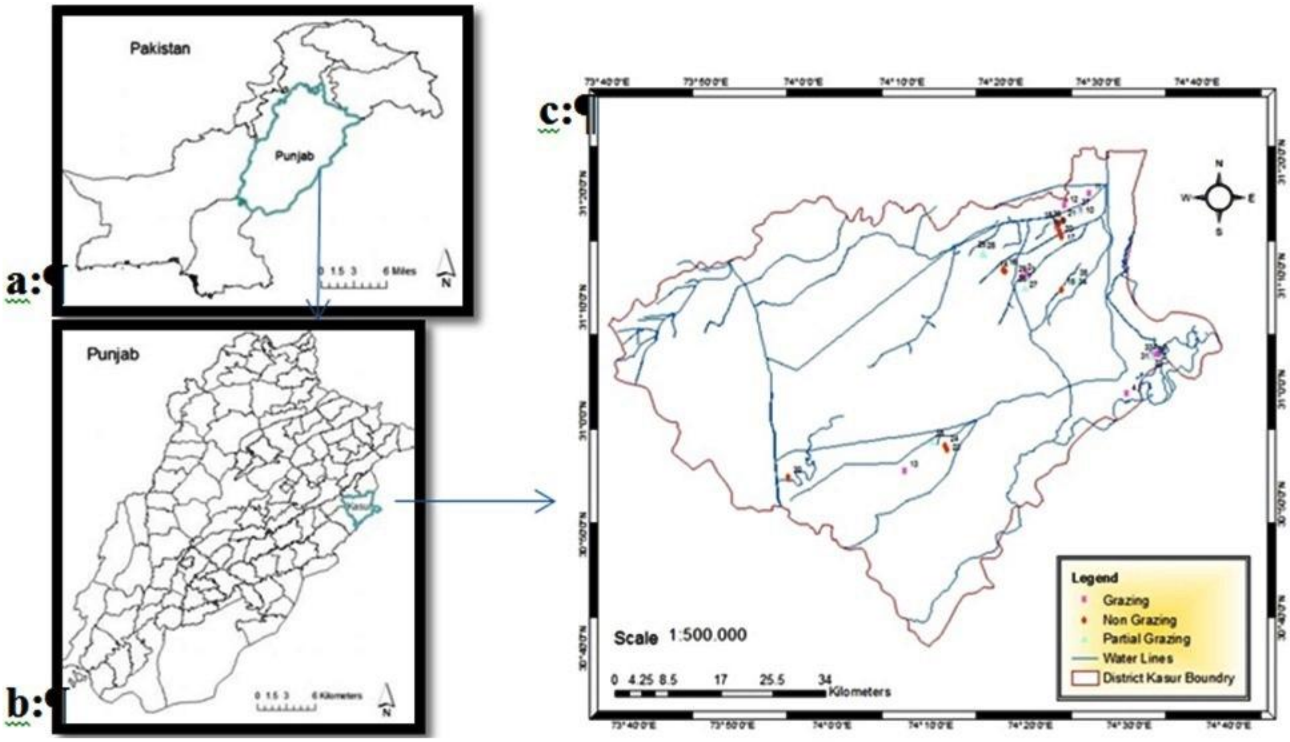


Figure 1: **Study area map of District Kasur showing locations of 38 milk farms and feeding patterns of *B. bubalis* categorized as grazing, non-grazing and partial grazing along with the nearly available water lines.**

Data about aborted, sick buffaloes or of any other reasons were eliminated as they were assumed to affect the data on overall milk production. The average distance covered by grazing and partial grazing buffaloes ranged from 0 to 2.5 Km. Feeding pattern of buffaloes was categorized into three classes: 1) Grazing buffaloes i.e feeding directly on green fodder available on land all day, Non-grazing buffaloes i.e feeding on the diet comprising of silage, green fodder cuts or Wanda provided by the farmer and held at the farm all day and Partial grazing buffaloes i.e feeding pattern lies between that of grazing and non-grazing buffaloes *i.e.* they fed on land as well as by farmers. During the survey, it was observed that in each feeding pattern different compositions of green fodder or wanda were fed to the buffaloes by the farm owners. The GPS points of each farm were also noted during the survey.

Secondary data collection: A classified land cover map having 300 m resolution was used to demonstrate different socioeconomic factors, for example; cropland, grassland and so forth. Land cover map (2009) was downloaded from ESA, DUE web site. Digital Elevation Model (DEM) at 90-meter resolution was also used to find out the extension of available water lines (e.g. rivers, lakes, etc.).

GIS tools: The study area land cover was clipped from the classified map and area of each class was calculated. This calculated area exhibited the variability and extent of the available grazing area. Watershed delineation was applied by Arc Hydro tools at 90 meter DEM to find out the extension of available water lines e.g. rivers and lakes. Buffering technique, based on proximity analysis was also applied that created a zone around a map feature to measure distance or time in their respective units. A single ring buffer of 2.5 Km distance was applied on water lines to see water lines near milk farms (Sarfraz *et al*., 2012 and Cringoli *et al*., 2007) and single ring buffer of 2.5 Km distance was also applied on milk farms to calculate grazing land around the milk farms (Amiri, 2012). The shortest possible distance between milk farms and water lines was calculated by using Measure tool (Chang, 2006). A map of average annual milk production with natural breaks classification was created to show maximum annual milk production per feeding category. The natural breaks classification was suitable when breaks were typically uneven and were selected to separate values, where large changes in value occured (De Smith *et al*., 2007). Arc GIS 10.2 was used to integrate the surveyed data with land cover and DEM.

Statistical analysis: One-way-Anova was selected as there were three categories for comparison (Field, 2012). Kolmogorov-Smirnov test was applied to check the normality of data. Levene's test checked the homogeneity of variance. The assumption of homogeneity of variance was not violated where the P- value was >0.05. Alternatively, Welch and Brown-Forsythe tests were also applied to check the variance between the groups. The Games-Howell test was also used to check which one, was better than the other category with unequal sample size and unequal variance between the groups. To see the effect size of feeding patterns, Eta Squared was calculated as follows.

$$\text{Eta Squared} = \frac{Sum\ of\ Suares\ between\ groups}{Total\ sum\ of\ squares}$$

According to the Cohen, 0.01 = small effect, 0.06 = effect and 0.14 = large effect (Cohen, 1988).

RESULTS AND DISCUSSIONS

Geospatial interpretation of the data: The classified land cover map of study Area in District Kasur with eight information classes viz; Irrigated croplands or aquatic, Rainfed croplands, Mosaic cropland/ vegetation, Mosaic vegetation/cropland, Closed to open grassland, Artificial areas, Bare areas and Water bodies is shown in Fig-2. Among these 4312170 Km (97.8% of the total study area) land was available for grazing. The area of each class was also calculated for detailed examination of study area regarding grazing land and the calculated values are shown in Table-1. The calculated values showed that Post-flooding or Irrigated croplands were 93.3 % and Closed to open (>15%) herbaceous vegetation (grassland, savannas) was only 0.1 % of the total study area, but *B. bubalis* only used 1395.6Km (0.032%) land for grazing (Table-2). Table-2 further showed that large portion of grazing land used by *B.bubalis* was based on Post-flooding or irrigated croplands (or aquatic).

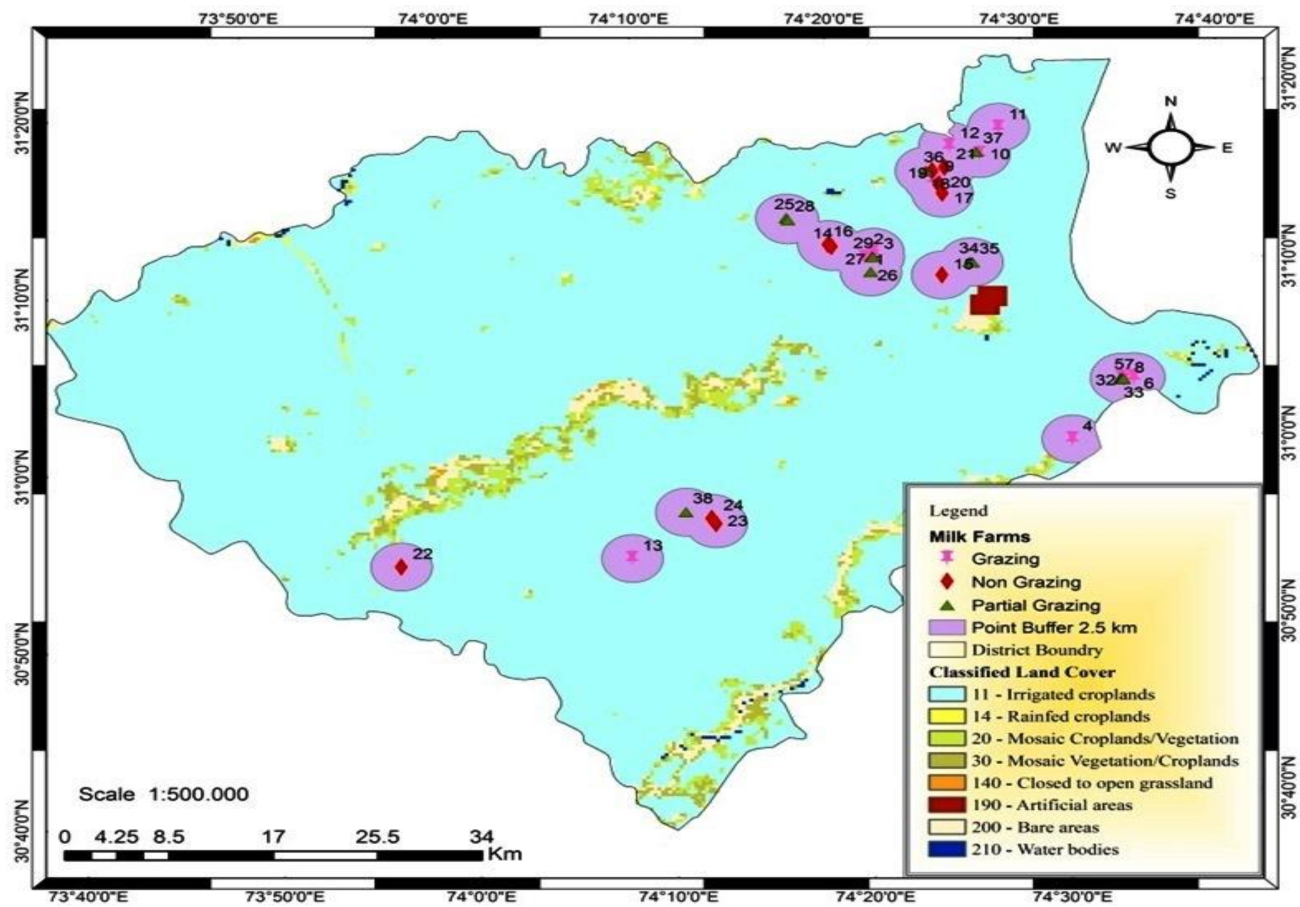


Figure 2: Classified land cover map of study area in District Kasur showing a): Category wise milk farms as grazing, non-grazing and partial grazing, b): Point buffer of 2.5 Km, c): District boundary, d):Eight land cover classes. Data extracted from ESA DUE website (Source: http://due. esrin.esa. int/ page_globcover.php).

Table 1: Area calculation in square kilometer (Km^2) and percentage (%) of individual classes of classified land cover.

Land cover class No.	Land cover classes names	Area (Km^2)	Percentage
1	Post-flooding or Irrigated croplands (or aquatic)	4112.82	93.3%
2	Rainfed croplands	6.3	0.1%
3	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	119.52	2.7%
4	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	70.56	1.6%
5	Closed to open (>15%) herbaceous vegetation (grassland, savannas)	2.97	0.1%
6	Artificial surfaces and associated areas (Urban areas >50%)	9.180	0.2%
7	Bare areas	80.010	1.8%
8	Water bodies	7.290	0.2%
	Total	4408.650	100%

Table-2 shows land cover classes, the land cover area under each class. Out of total land cover, area used by *B. bubalis* for different classes is as following: 1) Post-flooding or Irrigated croplands are 66.8%, 2) Rainfed croplands are 0.1%, c): Mosaic croplands (50-70%) / vegetation (grassland/shrubland/forest) (20-50%) are 0.8%, d): Mosaic vegetation (grassland/shrubland/forest) (50-70%) / croplands (20-50%) are 32.2% and e): Closed to open (>15%) herbaceous vegetations (grassland, savannas) are 0%. It was depicted from the table that Post-flooding or Irrigated croplands (or aquatic) and Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%) with 66.8% and 32.2% were used majorly for grazing around milk farms.

Table 2: Area calculation in a square kilometer (Km^2) and percentage (%) of individual classes of classified land cover used by *B. bubalis* for grazing at a distance of 2.5 Km around each milk farm.

Land cover class No.	Land cover classes names	Area (Km^2)	Percentage
1	Post-flooding or Irrigated croplands (or aquatic)	932.4	66.8%
2	Rainfed croplands	1.8	0.1%
3	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	11.4	0.8%
4	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	450	32.2%
5	Closed to open (>15%) herbaceous vegetation (grassland, savannas)	0	0%
	Total	1396	100%

In a study Joshi *et al*., (1968) described previously that the buffaloes have fewer sweat glands than cattle (*Bos taurus*), *i.e.* 1.07 per cm^2 compared to domestic cattle's 3.08 per cm^2. Therefore, for the effective working of the thermoregulation system, water baths must be required especially during hot days. This becomes essential for the animals to approach to ponds, flowing rivers or artificial pools with clean water. Showers with cool water may also serve the purpose as well. This shows that the availability of water lines near the grazing area is critical.

Application of Buffer tool of 2.5 Km distance at water lines showed that all milk farms are near water lines within the range of 2.5 Km (Fig-3). The shortest possible distance calculation between water lines and milk farms showed that all milk farms are in the range of 0.025 – 2.037 Km (Fig-3).

All the information collected both from Table-2 also from the Fig. 2, 3 and 4 shows the data of three feeding categories in reference to the milk production. Grazing feeding category of *B. bubalis* showed milk production per annum with a minimum of 1808 of liters milk using land cover class number 1 for grazing at a distance of 0.687 Km from milk farm while the maximum milk production of 2455 liters using land cover class number 1 and 3 for grazing at a distance of 0.237 Km from milk farm. It illustrates that the grazing *B. bubalis* near to water lines and feeding both land cover class number 1 and 3 produced more milk than *B. bubalis* far from water lines and feeding just land cover class number 1 only.

Non-grazing feeding category of *B. bubalis* annually produced minimum of 1856 liters milk and maximum of 2334 liters of milk and comparison cannot be made for the land cover and water line with milk production as this category held on the farm all the day.

Partial grazing feeding category of *B. bubalis* showed milk production per annum with a minimum of 1780 liters using land cover class number 1 and 3 for grazing at a distance of 1.190 Km from milk farm while the maximum milk production of 2902 liters milk using land cover class number 1 and 3 for grazing at a distance of 0.664 Km from milk farm. It was depicted that availability of water lines and using both the land cover classes, played positive role in enhancing milk production.

Maximum averaged annual milk production from partial grazing farms = 2902 liters, non grazing farms = 2334 liters and grazing farms = 2455 liters (Fig-4). Natural Breaks classification was applied on partial grazing, non-grazing and grazing milk farms to show the peak annual milk production with respect to land cover classes and water lines.

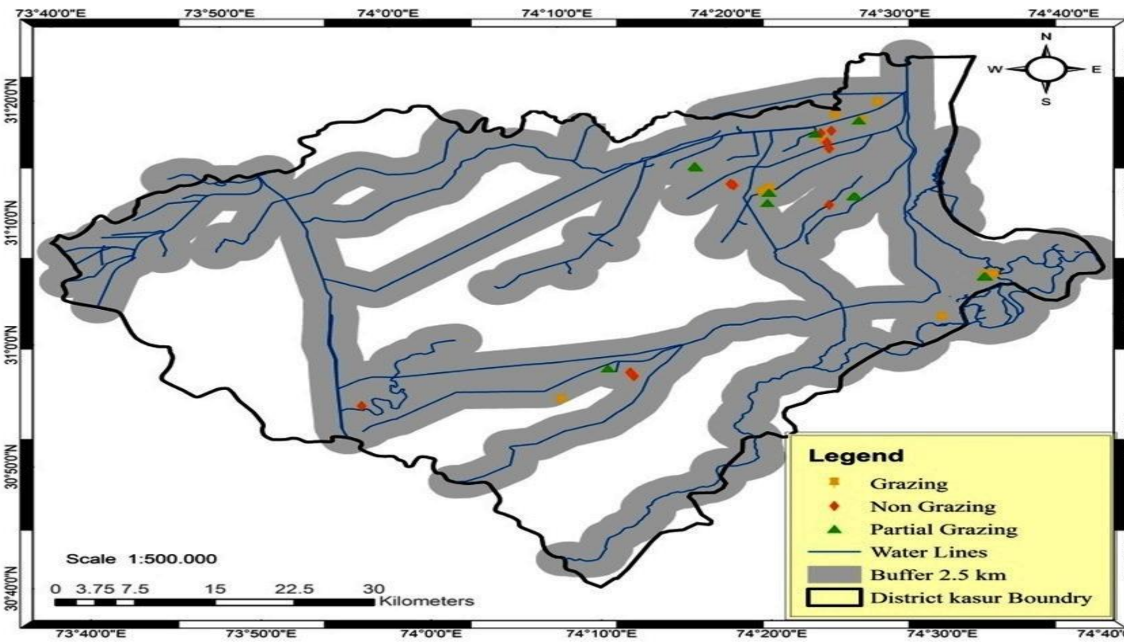


Figure-3: Water lines map of the study area in District Kasur showing a): Category wise milk farms as grazing, non-grazing and partial grazing, b): Water lines, c): Ring buffer of 2.5-kilometer distance applied at water lines and d): District boundary of the study area.

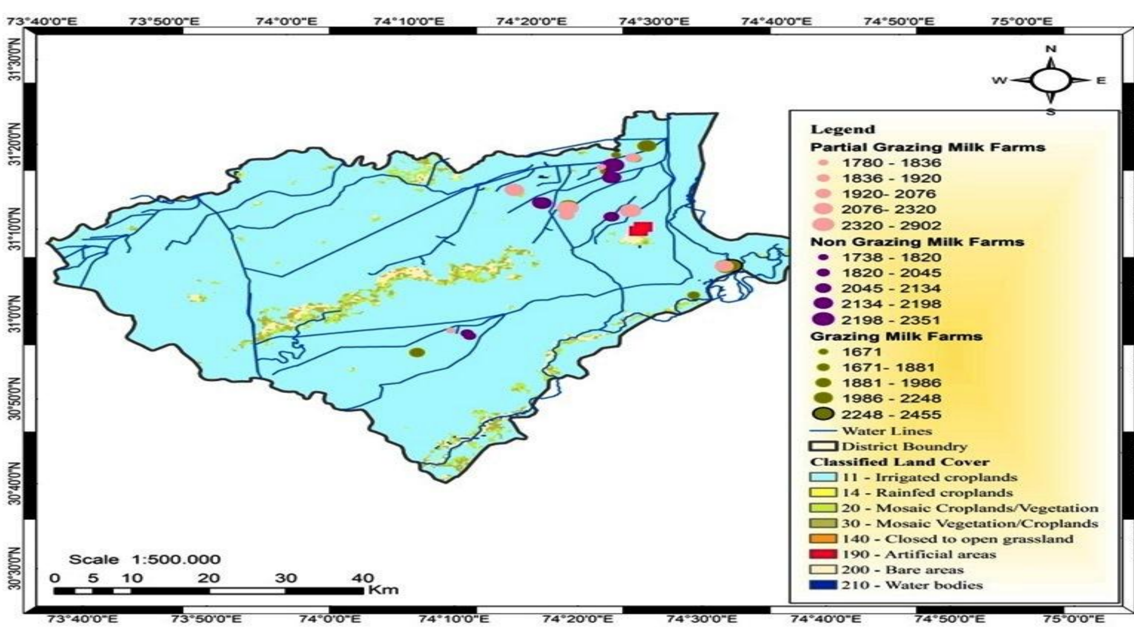
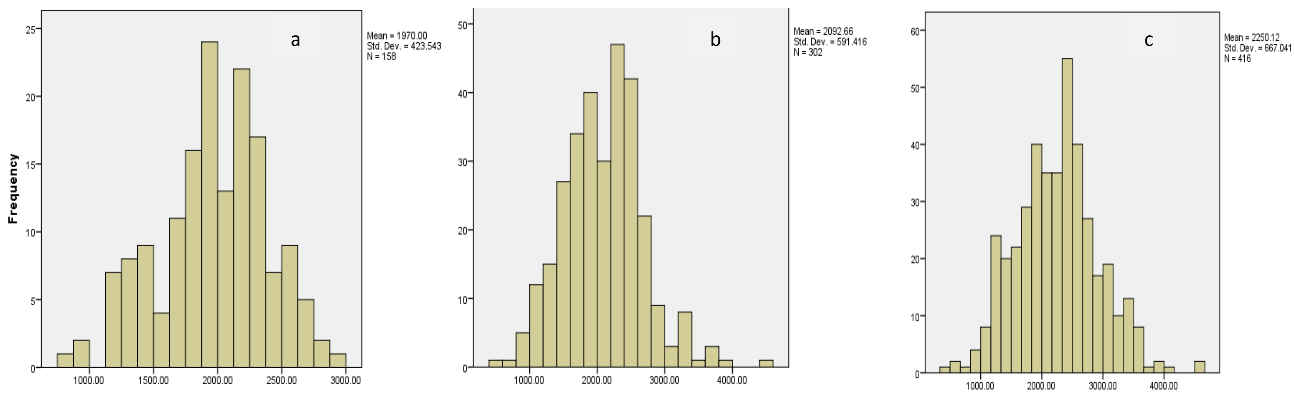


Figure 4: Map of average annual milk production showing a: Category wise average annual milk production of 38 milk farms as partial grazing, non-grazing and grazing b: Water lines, c: District boundary, and d: Classified land cover classes.

Statistical interpretation of the data

Normality of the data: The normality was checked by both the Skewness and Kolmogorov-Smirnov test. Skewness value showed symmetry of the distribution, but a limitation lies with reasonable large sample size where skewness would not make a basic difference in the analysis (Weinberg, 2002). The Kolmogorov-Smirnov test p - value was 0.012 which showed that data was not normal as the sample size was large. Normality of the three groups was also assessed separately through Skewness and Kolmogorov- Smirnov[a] test. The hypothesis and numeric results of each category showed that the data was normally distributed (Fig-5). Kolmogorov-Smirnova test p – value = 0.200 for each feeding group showed that the data was normally distributed (Table-3).

By Levene's test, the p - value was 0.00 which was not significant. It means that the variance in scores was not same for each of the three groups. Alternatively, Welch and Brown-Forsythe tests were applied to check the variance. The p - values of Welch and Brown-Forsythe tests were highly significant. Therefore, the feeding patterns were significantly different from each other on the basis of milk production.



Average Annual Milk Production

Figure 5: Category wise average annual milk production of 38 milk farms as a) Hypothesis of average annual milk production of grazing *B. bubalis*, b) Hypothesis of average annual milk production of non-grazing *B. bubalis* and c) Hypothesis of average annual milk production of partial grazing *B. bubalis*.

Table 3: Normality of three feeding categories of *B. bubalis* through Skewness (range -1 to +1) and Kolmogorov-Smirnov[a-] test (Sig. value>.05).

Feeding Categories of *B. bubalis*	Skewness (range -1 to +1)	Kolmogorov-Smirnova (Sig. value>.05)
Grazing	-.345	.200
Non grazing	.330	.200
Partial grazing	.213	.200

Table 4: Multiple comparison of feeding categories (dependent variable is milk production).

	(I) Diet type	(J) Diet type	Mean Difference (I-J)	Std. Error
Games-Howell	Grazing	Non grazing	-131.13909*	45.88542
		Partial grazing	-288.27236*	44.97047
	Non grazing	Grazing	131.13909*	45.88542
		Partial grazing	-157.13327*	45.61536
	Partial grazing	Grazing	288.27236*	44.97047
		Non grazing	157.13327*	45.61536

*. The mean difference is significant at the 0.05 level.

The results of multiple compressions in Table-4 shows that group 3 with partial grazing was found significantly different from grazing and non-grazing groups in terms of milk production. The resulting Eta squared value was 0.02. This value showed that the effect size of feeding patterns on milk production was small.

Bilal and Sajid (2005) have shown a comparison of obtained milk yield with agricultural yield and it was evident that the economic value of milk was comparatively more than the combined value of major crops (e.g. wheat, cotton, sugar cane and rice).

Different studies were conducted to enhance milk yield by adopting different techniques by Wanapat, M., *et al.*, 2017; Morsy, T.A., *et al.*, 2016; Iqbal, M.A. *et al.*, 2015; Valsalan, J., *et al*., 2014) who supported the present study carried out by different researchers as it was carried out using limited resources.

In future, a detailed research is necessary at the dairy farm level and on dairy farm design for the new generation of partial grazing dairy production systems along with buffalo grazing activities and mixed pastures. The new available technologies and facts provide sufficient opportunities for improvement in this new area.

Conclusions: Farmers need to adapt and invoke partial grazing feeding strategy that will enhance the milk production instead of increasing number of buffaloes.

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