

## Spatio-temporal analysis of local dairy farming along the Indira Gandhi canal in Rajasthan, India

### Análisis espacio-temporal de la granja lechera local a lo largo del Canal Indira Gandhi en Rajasthan, India

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#### ABSTRACT

India is a country with the highest milk production and the consumption of dairy products is also at its high in India. In India by the year 2020, the contribution of Dairy products in the Gross Domestic Product (GDP) of India was 4.2 per cent. The dairy sector is one of the most important sectors in any country as it can provide the citizen of the country with nourishment and in a country like India, that is the second-largest (in terms of population), nutrition plays an important role in sustaining the country and its people because healthy people make a healthy nation. The dairy sector also provides livelihood to a very large population who are still residing in the rural parts of India. Therefore, analysis of the dairy sector, its growth and distribution become an important process to develop the nutritional and economical status of both farmers and consumers. The objective of the study was to analyse and comprehend the growth and geographical distribution of milk-producing animals in the study area and how with time their growth in the targeted area was got influenced. The study was conducted to understand the Spatio-temporal distribution of dairy farming along the Indira Gandhi Canal by analysing the secondary source of data of 15 years of the span between 1997-2012 were obtained from the Census Department of India and websites maintained by the Rajasthan Government. The Spatio-temporal analysis has been done using simple statistical methods using MS Excel and choropleth maps were designed using geospatial software Arc GIS 10.1 and Advanced MS Excel Geospatial Techniques. It was found that the study area is doing well with the production and addition of animals in the dairy sector and there is a need for the government to look towards the development of the infrastructure to survive the increasing population of milk-producing animals as well as the demand of the increasing population what we know as consumers.

Keywords: Dairy Sector, Spatio-Temporal, Rajasthan, Choropleth Techniques, Ms Excel, Arc GIS

#### RESUMEN

India es un país con la producción de leche más alta y el consumo de productos lácteos también está en su punto más alto en India. En India para el año 2020, la contribución de los productos lácteos en el Producto Interno Bruto (PIB) de India fue del 4,2 por ciento. El sector lácteo es uno de los sectores más importantes en cualquier país, ya que puede proporcionar alimento a los ciudadanos del país y en un país como India, que es el segundo más grande (en términos de población), la nutrición juega un papel importante en sostener al país y a su gente porque la gente sana hace una nación sana. El sector lácteo también proporciona sustento a una población muy grande que todavía reside en las zonas rurales de la India. Por lo tanto, el análisis del sector lácteo, su crecimiento y distribución se convierte en un proceso importante para desarrollar el estado nutricional y económico tanto de los productores como de los consumidores. El objetivo del estudio fue analizar y comprender el crecimiento y la distribución geográfica de los animales productores de leche en el área de estudio y cómo se influyó con el tiempo en su crecimiento en el área objetivo. El estudio se realizó para comprender la distribución espacio-temporal de la producción lechera a lo largo del Canal Indira Gandhi mediante el análisis de la fuente secundaria de datos de 15 años del período comprendido entre 1997 y 2012 que se obtuvieron del Departamento del Censo de la India y los sitios web mantenidos por Rajasthan. Gobierno. El análisis espacio-temporal se realizó utilizando métodos estadísticos simples utilizando MS Excel y los mapas de coropletas se diseñaron utilizando el software geoespacial Arc GIS 10.1 y Advanced MS Excel Geospatial Techniques. Se encontró que al área de estudio le está yendo bien con la producción y la adición de animales en el sector lechero y existe la necesidad de que el gobierno mire hacia el desarrollo de la infraestructura para sobrevivir a la creciente población de animales productores de leche, así como la demanda de la creciente población de lo que conocemos como consumidores.

Palabras clave: sector lácteo, espacio-temporal, Rajasthan, técnicas de coropletas, MS Excel, Arc GIS

## INTRODUCTION

Dairy farming is one of the most important economic activities in a country like India. The development of the dairy sector involving the small income groups of people could play a key role in poverty alleviation and better nutrition for any country (Mihret, et. al. 2017). India is a country with the highest milk production and the consumption of dairy products is also at its high in India. In India by the year 2020, the contribution of Dairy products in the Gross Domestic Product (GDP) of India was 4.2 per cent (Yadav, & Naagar. 2021). Being an activity that is mostly associated with the rural parts of India, dairy farming is highly dependent upon livestock. As in India, the population growth, urbanization and growth of income is trending on an upward scale; therefore, it is now becoming very important to monitor the development of the dairy sector of the country to prevent it from overexploitation in an unmanaged way. In India, a mostly agrarian country, monitoring the growth and sustainable development of dairy-based economic activities is very important because many times these dairy farmers are small-holders supporting the livelihood of the people of the particular area associated with them. The sustainability of the small-holders is important in securing the vital nutritional resource and livelihood to the masses (Chand, et. al. 2015). Since

the establishment of the National Dairy Development Board in 1965 in India, things have changed a lot and India, from a milk deficit country became a milk surplus country, leaving the USA behind in milk production in 1998 is just being an example after 28 years of the launch of Operation flood (Yadav, 2020, June 1). It is very important to estimate the productivities and monitoring of the various factors that affect the production of milk and other dairy-related products to help farmers in optimum utilization of their available on-farm resources (Sharma & Singh. 1993). In the dairy sector the size of the farms, the number of livestock and technological progress plays an important role in increasing milk production (Ahmad & Ureta. 1995). Indian socio-cultural configuration also plays an important sector in the consumption of dairy products. Indian religious and socio-cultural practices hurt the domestic output from dairy products but they also increase the consumption of the dairy products demanding an increase in the number of dairy farms (Bhaskaran. 1996). Dairy animals, especially buffalo also play an important role in the contribution of dairy to the gross national product of India. India has the 19 best breeds of buffaloes contributing 15 per cent to the GNP of India along with other castles (Kulkarni, et.al 2000). Goat also plays an important role in the configuration of dairy farms and the demand for dairy products. Goats' milk is 11 times more nutritious than that of the cow in less space and acceptance towards a large variety of fooder (Maity & Das. 2000). Here, we need to understand that to fulfil the need of the growing population and maintain the health of the consumer as well as the income of the dairy farmers the central and state government need to work hand in hand towards the investment in infrastructure, research and development in the dairy sector and development of more agricultural universities (Mathur. 2000). Some biggest challenges of the dairy sector are lack of infrastructure and less power to the producer to bargain because most of the farms are regulated by the unorganized sectors and developing an infrastructure ideal to the dairy farms and farmers so that they can stand on a global market is the challenge to be fulfilled in the future (Rajendran & Mohanty. 2004). Large scale commercial dairy sectors also need a large scale investment in the form of capital, labour and technology or else it becomes difficult to withstand the increasing demand both a domestic as well as at international platform (Ngongoni, et., al. 2006). Linking local needs with the expectations of the farmers could help in boosting the innovations and implementation of the policies in the dairy sector (Schulze, et., al. 2006).

#### STATEMENT OF PROBLEM

The dairy sector is one of the most important sectors in any country (Jesse, 2006) as it can provide the citizen of the country with nourishment and in a country like India, that is the second-largest (in terms of population), nutrition plays an important role in sustaining the country and its people because healthy people make a healthy nation. In Rajasthan, along Indira Gandhi Canal the existence of dairy farming can be seen and it is very important to analyse the Spatio-temporal pattern of the growth of the dairy farms to plan mitigation strategies to prevent the dairy sectors from the variety of shocks that keep occurring in the environment including the demand and supply chain of the day to day market (Kale, 2016). The dairy sector also provides livelihood to a very large population who are still residing in the rural parts of India. Therefore, analysis of the dairy sector, its growth and distribution become

an important process to develop the nutritional and economical status of both farmers and consumers. India's share is 16 per cent of the total milk production around the world (Deshmukh, 2014). Dairy infrastructure needs assessment so that it could stand with the competition, both at domestic and international platforms. Sustainable development of the Dairy sector is also very important in maintaining the uniform development of the dairy sector along with the maintenance of hygiene and keeping in view the need of the increasing population (Sirohi, & Michaelowa, 2004).

#### THE OBJECTIVE OF THE STUDY

The study's goal was to examine and understand the growth and geographical distribution of milk-producing animals in the study region, as well as how their growth in the targeted area was influenced over time.

#### STUDY AREA

Rajasthan is the largest state of India by area, i.e., 3,42,239 square kilometres at 27.0238° N, 74.2179° E coordinates and is home to a rich cultural diversity. Rajasthan is divided into nine regions; namely, Ajmer State, Hadoti, Dhundhar, Gorwar, Shekhawati, Mewar, Marwar, Vagad and Mewat regions. With nearly two-thirds of the population living in the rural parts of Rajasthan, the state is one of the least populated states of India. Rajasthan has the longest canal system in India, Indira Gandhi Canal, formerly known as Rajasthan Canal. The canal covers a length of 650 km or 400 miles. The canal enters the Rajasthan state from Kharakhera village situated in the Tibbi Tehsil of Hanumangarh and covers a total of seven districts; namely, Barmer, Bikaner, Churu, Hanumangarh, Jaisalmer, Jodhpur, and Sriganganagar. The final construction of the canal was done in the year 2010. As mentioned above that the major portion of the Rajasthan population lives in a rural area engaged in the activities supported by livestock, therefore; it is very important to understand how Indira Gandhi Canal helped the distribution of dairy farmers of the Northwestern thorn scrub forests where temperature rises to more than 45 degrees Celcius in the summer season receiving less than 450 mm of the annual rainfall. The targeted areas for the study are Barmer, Bikaner, Churu, Ganganagar, Hanumangarh, Jaisalmer and Nagaur.

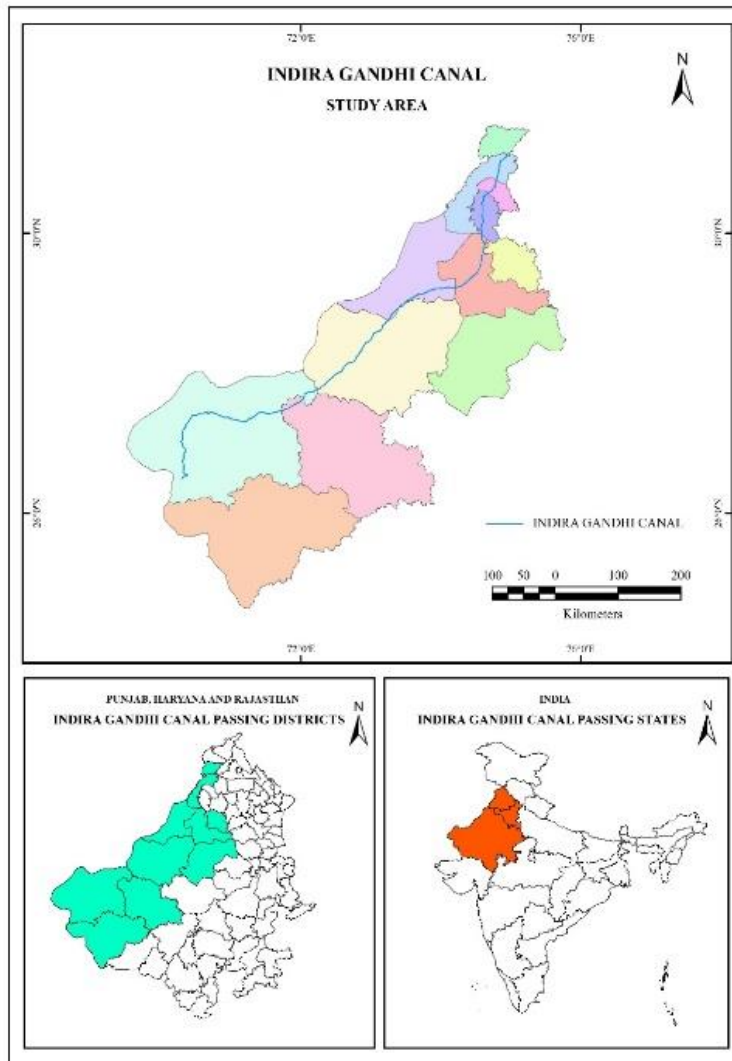


Figure 1. Map of the study area. Source: Prepared by the Research Scholar, 2021.

## DATABASE AND METHODOLOGY

The study was undertaken to analyse the Spatio-temporal distribution of dairy farming along the Indira Gandhi Canal by analysing secondary source data from the Census Department of India, National Dairy Development Board and websites maintained by the Rajasthan Government over a 15-year period from 1997 to 2012. Barmer, Bikaner, Churu, Ganganagar, Hanumangarh, Jaisalmer, and Nagaur are the districts targeted along the Indira Gandhi Canal in Rajasthan. Spatio-temporal analysis was performed with MS Excel using simple statistical methods, and choropleth maps were created with Arc GIS 10.1 and Advanced MS Excel Geospatial Techniques. To achieve variance

in the units of the intended data, the percentage technique was also used. To compute a percentage, divide the value by the entire amount and multiply the result by 100. The formula used to calculate percentage is:

$$(value/total\ value)\times 100\%.$$

## RESULT AND DISCUSSION

The geographical condition of any area determines the distribution of economic activities and in the selected study area geography plays an important role in deciding the distribution of the dairy farms and farmers and their socio-economic well-being. The development of dairy farms is very important because it can regulate the consumption of nutrition by the locals as well as by the people of the urban area (Kumar, 2013).

The pattern of Livestock in the study area:

The geographical distribution of the milch animals in the year 1997 compared to the year 2012 is shown with the help of table 1 and 2 and figure 2, 3, 4 and 5. The distribution of the milch animals is divided into three sections namely Indigenous cattle, crossbred cattle and Buffalo. Here, in 1997 Bikaner recorded the highest 2,71,000 Indigenous cattle followed by Barmer and Nagaur having 2,52,000 and 2,43,000 Indigenous cattle. Churu had 1,65,000 indigenous cattle and Ganganagar had 1,63,000 indigenous cattle. Hanumangarh and Jaisalmer had 1,38,000 Indigenous cattle each in the year 1997. Similarly, the crossbred cattle in the Barmer district of Rajasthan was negligible and only around 1,000 crossbred cattle were available in the Churu and Nagaur each. Bikaner had 2,000 crossbred cattle in the year 1997 and Ganganagar and Hanumangarh had 14,000 and 6,000 crossbred cattle in the year 1997.



Plate 1. Rearing of cows and buffaloes in the research area.

Source. Primary Survey, 2021

Buffalo population is also very important as a provider of milk. The Barmer district of the Rajasthan had 45,000 buffaloes in the year 1997. Bikaner and Churu had 50,000 and 95,000 population of buffaloes. Ganganagar and Hanuangerh had 1,53,000 buffaloes each. Jaisalmer had 1,000 and Nagaur district had 2,10,000 population of buffaloes in the year 1997.

Growth of the Dairy Sector along Indira Gandhi Canal:

The growth of the dairy sector is shown with the help of the geographical distribution of milk-producing animals in the selected study area. To achieve the purpose choropleth maps and graphs were taken into consideration to show the pattern of the distribution of animals in the year 2012 to compare the same in the year 1997. This gave the account of 15 years of development of the sector. In figure 2 with the help of a choropleth map of the selected study area, the distribution of indigenous cattle ('000) is shown. Barmer district had 3,71,000 indigenous cattle in the year 2012. Bikaner was having 3,96,000 indigenous cattle in the year 2012. Churu had 1,55,000 indigenous cattle in the same year. Ganganagar and Hanumangarh had 2,05,000 and 1,82,000 indigenous cattle in the year 2012. Jaisalmer and Nagaur had 2,04,000 and 2,25,000 indigenous cattle in the same year. (Table 2)

The distribution of crossbred cattle ('000) has been shown in figure 3 using the choropleth style of mapping. The map depicts the data of crossbred cattle for the year 2012 to compare it with the distribution of crossbred cattle ('000) in the year 1997. Barmer district had 1,000 crossbred cattle in the year 2012. Bikaner was having 27,000 crossbred cattle in the year 2012. Churu had 16,000 crossbred cattle in the same year. Ganganagar and Hanumangarh had 81,000 and 44,000 crossbred cattle in the year 2012. Jaisalmer and Nagaur had 1,000 and 36,000 crossbred cattle in the same year. (Table 2)

The study area along Indira Gandhi Canal shows a significant growth of the dairy sector within 15 years. The change shows an upward trend in the percentage growth (table 3). After analysis, it was found that Barmer showed 47 per cent growth in terms of the addition of Indigenous cattle ('000) in its dairy sector between 1997-2012. Bikaner showed positive growth of 46 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012. Churu district showed a negative growth rate of -6 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012. Ganganagar showed positive growth of 26 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012. Hanumangarh showed positive growth of 32 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012. Jaisalmer showed positive growth of 48 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012. Nagaur showed negative growth of -7 per cent of Indigenous cattle ('000) in its dairy sector between 1997-2012.

After analysis, it was found that Barmer showed 100 per cent growth in terms of the addition of crossbred cattle ('000) in its dairy sector between 1997-2012. Bikaner showed positive growth of 1250 per cent of crossbred cattle ('000) in its dairy sector between 1997-2012. Churu district showed a growth rate of 1500 per cent of crossbred cattle ('000) in its dairy sector between 1997-2012. Ganganagar showed positive growth of 479 per cent of Crossbred cattle ('000) in its dairy sector between 1997-2012. Hanumangarh showed positive growth of 633 per cent of crossbred cattle ('000) in its dairy sector between 1997-2012. Jaisalmer showed positive growth of 100 per cent of crossbred cattle ('000) in its dairy sector between 1997-2012. Nagaur showed growth of 3500 per cent of crossbred cattle ('000) in its dairy sector between 1997-2012. (Table 4).

After analysis, it was found that Barmer showed 122 per cent growth in terms of the addition of buffalo ('000) in its dairy sector between 1997-2012. Bikaner showed positive growth of 72 per cent of buffalo ('000) in its dairy sector between 1997-2012. Churu district showed a growth rate of 43 per cent of buffalo ('000) in its dairy sector between 1997-2012. Ganganagar showed negative growth of -19 per cent of Buffalo ('000) in its dairy sector between 1997-2012. Hanumangarh showed positive growth of 16 per cent of Buffalo ('000) in its dairy sector between 1997-2012. Jaisalmer showed positive growth of 100 per cent of Buffalo ('000) in its dairy sector between 1997-2012. Nagaur showed growth of 29 per cent of Buffalo ('000) in its dairy sector between 1997-2012 (Table 5).

## CONCLUSION

The dairy sector of Rajasthan is providing livelihood to a large population that still depends on the rural aspects of sustainability. These people are highly dependent on their milk-producing animals for a secure livelihood. On the other hand, the increasing population of India is also demanding more nutrition and looking forward to dairy sectors from a socio-cultural aspect as well. The dairy sector in the selected study area along Indira Gandhi Canal showed growth in terms of Dairy sectors between 1997-2012, i.e., 15 years of the span. It is clear from the discussion that the dairy sector is getting attention in the study area Barmer and Bikaner are getting their maximum benefit from the development of the dairy sector. The inclination towards the crossbred cattle in the study area is least compared to the Indigenous breed and buffalo. The local people in the study area are very much inclined towards the domestication of the local or in the local terms pure breeding techniques rather than going for the cross-breeding of two different purebred individuals. Overall, the study area is doing well with the production and addition of animals in the dairy sector and there is a need for the government to look towards the development of the infrastructure to survive the increasing population of the milk-producing animals as well as the demand of the increasing population what we know as consumers.



Table 1. District-wise population of Milch animals in the study area in 1997

District	Indigenous Cattle (‘000)	Crossbred Cattle (‘000)	Buffalo (‘000)
Barmer	252	0	45
Bikaner	271	2	50
Churu	165	1	95
Ganganagar	163	14	153
Hanumangarh	138	6	153
Jaisalmer	138	0	1
Nagaur	243	1	210

Source: National Dairy Development Board, 1997.

Table 2. District-wise population of Milch animals in the study area in 2012

Districts	Indigenous Cattle (‘000)	Crossbred Cattle (‘000)	Buffalo (‘000)
Barmer	371	1	100
Bikaner	396	27	86
Churu	155	16	136
Ganganagar	205	81	124
Hanumangarh	182	44	177
Jaisalmer	204	1	2
Nagaur	225	36	270

Source: National Dairy Development Board, 2012

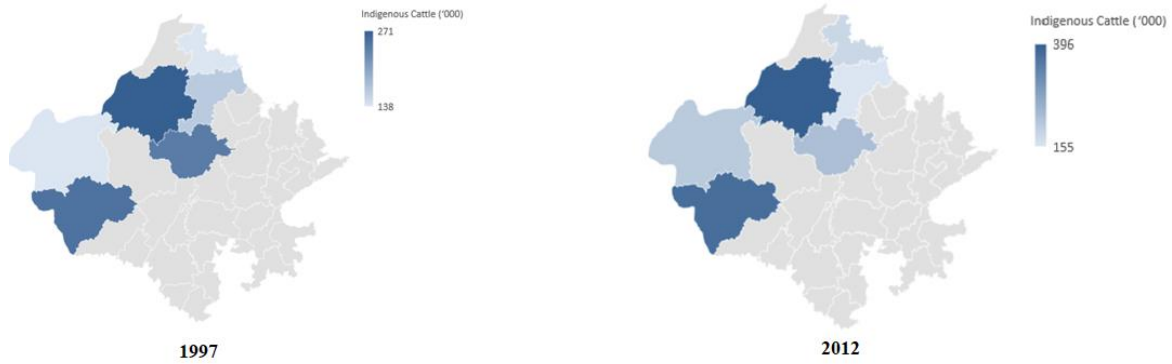


Figure 2. Choropleth Map of Indigenous Cattle in the Study area ('000) in 1997 and 2012. Source: District Census Handbook of Rajasthan State and National Dairy Development Board, 1997 and 2012, Map Prepared by the Authors, 2021.

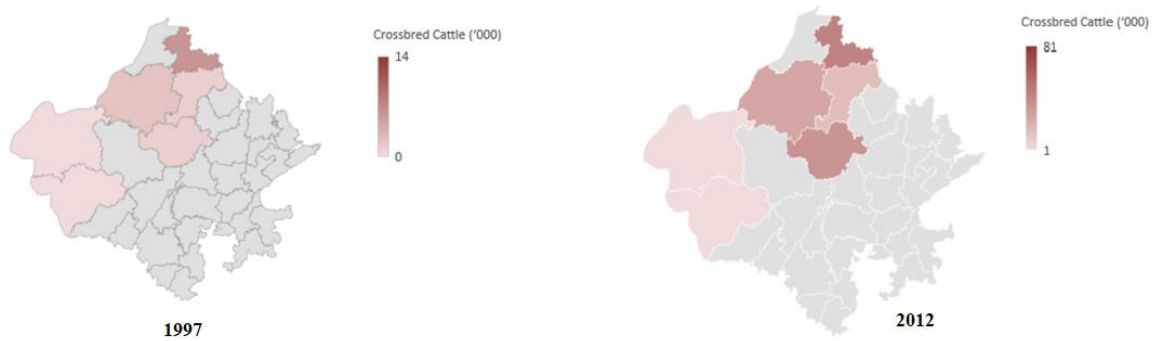


Figure 3. Choropleth Map of Crossbred Cattle in the Study Area ('000) in 1997 and 2012. Source: District Census Handbook of Rajasthan State and National Dairy Development Board, 1997 and 2012, Map Prepared by the Authors, 2021

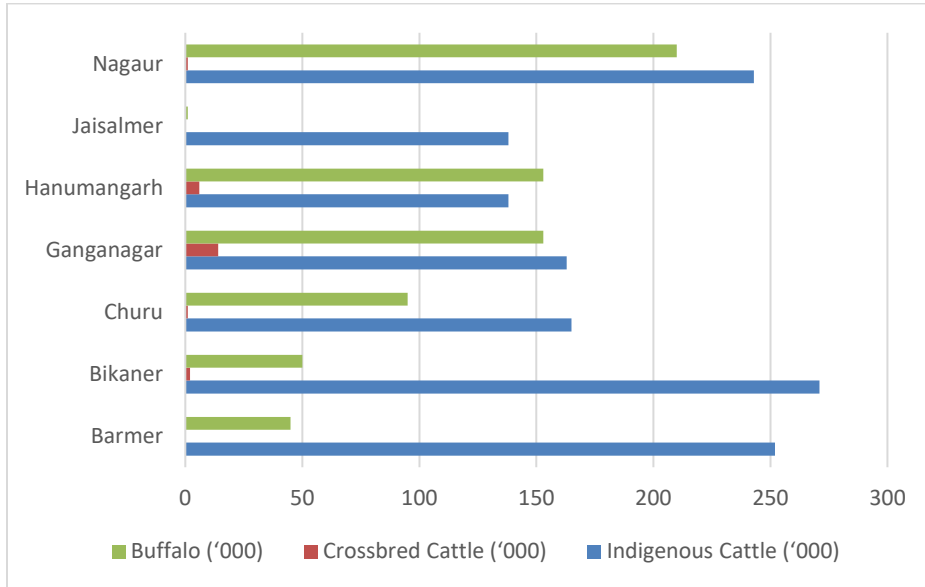


Figure 4. The district-wise population of Milch animals in the study area in 1997. Source: District Census Handbook of Rajasthan State and National Dairy Development Board, 1997, Chart Prepared by the Authors, 2021

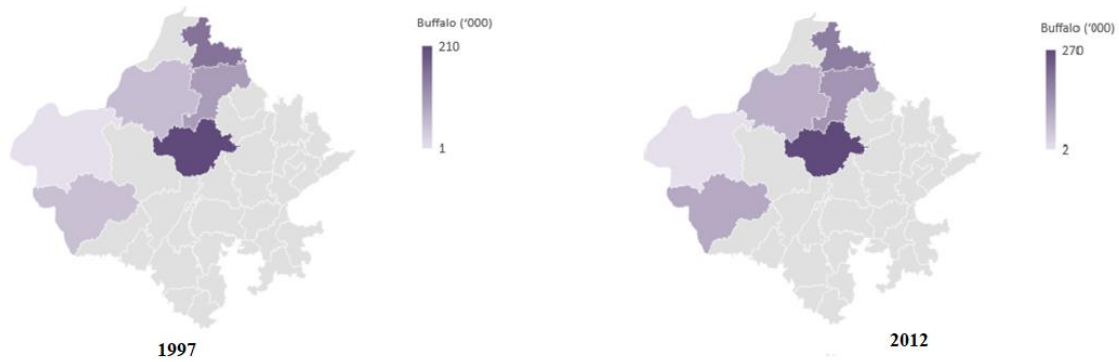


Figure 5. Choropleth Map of Buffalo Population in the Study Area ('000) in 1997 and 2012. Source: District Census Handbook of Rajasthan State and National Dairy Development Board, 1997 and 2012, Map Prepared by the Authors, 2021

Table 3. Growth of Dairy Sector in terms of Indigenous Cattle ('000) in Study Area within the Duration of 15 years, 1997-2012

Districts	2012		1997
	Indigenous Cattle ('000)	Percentage Change	Indigenous Cattle ('000)
Barmer	371	47%	252
Bikaner	396	46%	271
Churu	155	-6%	165
Ganganagar	205	26%	163
Hanumangarh	182	32%	138
Jaisalmer	204	48%	138
Nagaur	225	-7%	243

Source: National Dairy Development Board, 1997 and 2012, Computed by Authors, 2021

Table 4. Growth of Dairy Sector in terms of Crossbred Cattle ('000) in Study Area within the Duration of 15 years, 1997-2012

Districts	2012		1997
	Crossbred Cattle ('000)	Percentage Change	Crossbred Cattle ('000)
Barmer	1	100%	0
Bikaner	27	1250%	2
Churu	16	1500%	1
Ganganagar	81	479%	14
Hanumangarh	44	633%	6
Jaisalmer	1	100%	0
Nagaur	36	3500%	1

Source: National Dairy Development Board, 1997 and 2012, Computed by Authors, 2021

Table 5. Growth of Dairy Sector in terms of Buffalo ('000) in Study Area within the Duration of 15 years, 1997-2012

Districts	2012		1997
	Buffalo ('000)	Percentage Change	Buffalo ('000)
Barmer	100	122%	45
Bikaner	86	72%	50
Churu	136	43%	95
Ganganagar	124	-19%	153
Hanumangarh	177	16%	153
Jaisalmer	2	100%	1
Nagaur	270	29%	210

Source: National Dairy Development Board, 1997 and 2012, Computed by Authors, 2021

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