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Mapping the Density and Distribution of Indigenous Cattle Population Using Geographic Information System (GIS) Tools

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Authors' contributions

This work was carried out in collaboration among all authors. Author BG designed the study, performed the survey, data collection, compilation, data processing, map generation and wrote the first draft of the manuscript. Author MPS managed the literature searches, manuscript improvement and supervised the overall work. Author BK handled the data processing, map preparation and manuscript improvement. Authors MT and VD reviewed the work and provided critical comments for improvement. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The current research aims to map the density and distribution of indigenous cattle population using GIS technique.
Study Design: Survey research - Cross-sectional.
Place and Duration of Study: Thondamuthur Block, Coimbatore District, Tamil Nadu State, India. September 2018 to January 2019.

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Methodology: A house to house survey was conducted and the locations of farms and households with the indigenous cattle population were geocoded using a handheld Global Positioning System (GPS) device. The points generated were used to create density and distribution maps using QGIS 3.4 software and the information collected from the survey.
Results: The study revealed that a total of 21 indigenous breeds were found in the study area out of which 15 breeds were under the descript category and 6 breeds under the non-descript category. In the adult category, the Kangayam breed (descript) was found to be dominant compared to other breeds, occupying 25% of the total indigenous cattle population followed by the non-descript Kongu cattle (19%). Breeds like Hallikar, Kankrej, Umblachery, Tharparkar, and Sahiwal (all descript) occupied 7%, 5%, 4%, 2%, and 2% of the total indigenous cattle population, respectively. The results were similar in the calves category (including heifers) as well, with the Kangayam breed dominating the category with 8% of the total population, followed by the Kongu cattle (7%), Kankrej (2%), Hallikar (1%), Umblachery (1%), Sahiwal (1%), and Gir (1%). The distribution was found to be more concentrated towards the settlements and lower in the individual farms outside the settlements. The reverse scenario was observed with regard to density. Both the density and distribution were found to be least along the village boundaries adjoining the hilly areas.
Conclusion: Spatial distribution and density related information can be effectively utilized in cattle management, policy-making and decision support systems.

Keywords: Cattle management; decision support system; GPS and GIS; spatial distribution; survey.

1. INTRODUCTION

In India, cattle rearing forms an integral part of the farming system, acting as a risk reduction component and helps in achieving a balanced and sustainable return from agricultural operations. Among the various livestock species, the contribution of cattle is significant in terms of livelihood support and food security by supporting the sustenance of 67% of the rural community [1]. Cattle have long been considered as the most beneficial and income-generating livestock species, acting as a status symbol for many farmers. There is no change in the regional population of livestock in the past ten years, but there is a clear indication of variation in the density of various livestock species. The livestock composition of a particular area decides the livelihood it can support, market demand, and its adaptability to several economic and environmental fluctuations [2]. Factors like awareness, experience, availability of land, and veterinary facilities play a vital role in deciding the cattle breeds adopted by the farmers [3].

The State of Tamil Nadu has the highest crossbred cattle adoption, which is evident from the presence of the largest crossbred cattle population in the country [4]. This scenario has led to a massive reduction in the indigenous cattle population in the state by 35.38% between 2007 and 2011 [5]. The indigenous cattle population has reduced in most of the states in the country due to the rapid decline in the population of bulls, whose function in agricultural activity has decreased owing to the increased mechanisation in farming operations [6]. Indigenous cattle are crossbred with exotic cattle to increase the overall productivity [7]. However, excessive crossbreeding or exotic replacement may result in the loss of genetic resources of the native stock [8]. The conservation of indigenous cattle should be encouraged, owing to the fact that many of the breeds are close to extinction or in a critically endangered state and necessary steps have to be taken to exploit their genetic traits like the high quality of products and high feed utilisation efficiency [9].

With regard to cattle management, valid and real-time data on the spatial distribution of cattle is essential for planning, decision making [10] and to provide solution to various problems [11]. Very few industrialised countries have the provision for maintaining a comprehensive and up to date database with regard to cattle. The information collected during the census regarding cattle was little since agricultural crops were given prime importance in the developing countries [12]. In India, GIS techniques were not fully employed for managing the information gathered during livestock surveys due to the proprietary nature of the collected data. GIS-based implementation usually involves studying the various factors at the regional or global scale and not at the local scale [13]. Hence, the information gathered from livestock surveys should be given a geospatial approach which will

aid in analysing, interpreting, and disseminating information regarding cattle at a local level [14].

GIS tools have the capacity to handle a large volume of spatial information and are flexible to various environmental and economic conditions [15]. GIS can deal with complex geocoded GPS data and provide the processing space for handling and interpreting huge geospatial information within a short period of time and at a lower cost [16]. GPS can be effectively used in cattle management to observe the distribution of grazing animals [17], track the animal routes [18], and with integrated data loggers for real-time monitoring [19]. Integrating GIS and GPS techniques can help in visualising the spatial distribution of animals by considering factors like preferred vegetation for grazing and real-time tracking [20]. In recent times, GIS tools have been increasingly used in the agriculture sector for crop monitoring and related decision support systems. However, their adoption in the field of animal husbandry which is closely associated with crop production system is still at a nascent stage. Hence, the current study was carried out to utilise the GPS and GIS techniques and investigate its potential application in animal husbandry.

2. MATERIALS AND METHODS

2.1 Study Area

Thondamuthur Panchayat Union (Block) is situated in the Coimbatore South Taluk of Coimbatore District (Tamil Nadu State, India) (Fig. 1). It has ten villages extending between 10.911825° N, 76.920110° E and 11.022314° N, 76.687349° E. The ten villages comprise 52 hamlets. The total household unit in the study area is 18346 and the total human population is 66080 [21]. The average temperature in the region varies from 21ºC to 32ºC. The altitude of the study area ranges between 400 and 600 m. The average annual precipitation is between 550 and 900 mm. The current land use includes residential areas, rainfed and irrigated agriculture, horticulture plantations, barren and wastelands.

2.2 Survey

Livestock census is usually carried out through field surveys and questionnaires by choosing a fixed number of household units that represent the entire area under survey. Based on the existing economic condition of a country, the methodology adopted for surveys is altered to suit the local needs. Methods like the house to house survey, total count, dip tank count, market count, road count, and extrapolation from vaccination records are usually followed for livestock census [2]. A house to house survey was conducted in the study area and various data regarding the number of indigenous cattle per household/ farm, age, sex, breed, etc., were documented. The locations with the indigenous cattle population were geocoded using a GPS device.

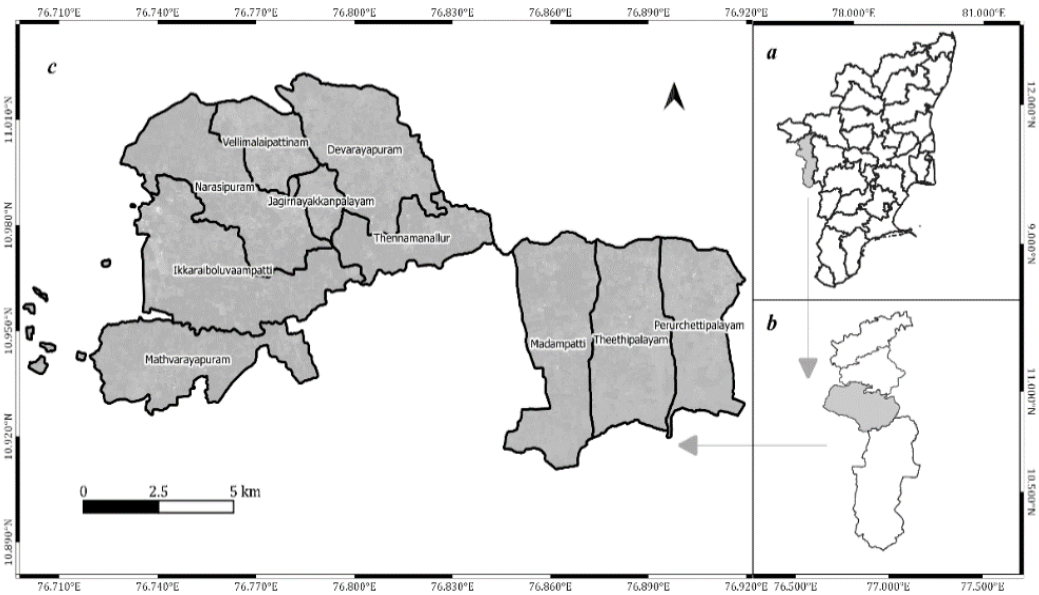

Fig. 1. a) The State of Tamil Nadu b) Coimbatore District c) Thondamuthur Block (Study area)

2.3 Cattle Density and Distribution

The geocoded points recorded in the cattle locations were imported and processed in QGIS 3.4 for creating density and distribution maps. The indigenous cattle density was calculated by parting the total number of indigenous cattle recorded in each village with the total area of that particular village. The cattle distribution was mapped using the data collected during the survey.

2.3.1 Dot density

Dot density maps are a type of thematic maps which indicate the numerical count of the collected data using dots. It does not project the exact location, but randomly distribute the total population within a particular area. Dot density map was created using the *Dot Map* plugin in QGIS 3.4 [22]. A single dot in the map indicates a specific number of cattle. If the number of dots is less, it indicates a lower cattle count within that particular village and vice versa.

2.3.2 Grid density

The areas under all the villages were parted into grids of 0.5 sq.km. by using the *Create Grid* algorithm in QGIS 3.4. The total number of locations falling under each grid was counted and the corresponding number of cattle in each location was summed up using the *Count Points in Polygon* algorithm in QGIS 3.4 [22]. This data was used to render the density map which indicates the cattle density within each grid.

2.3.3 Proportional distribution

The number of animals in each geocoded point was depicted by scaling the size of the symbol (circle) proportionally. If the size of the symbol is small, it indicates a smaller cattle count in that particular location and vice versa. The distribution map was prepared using the *Graduated Symbols* option from *Symbology* in QGIS 3.4 [22]. This map clearly indicates the indigenous cattle distribution and variation between the villages.

3. RESULTS AND DISCUSSION

The study revealed that a total of 21 indigenous breeds were found in the study area out of which 15 breeds were under the descript category and 6 breeds were under the non-descript category. In the adult category, the Kangayam breed (descript) was found to be dominant compared to other breeds, occupying 25% of the total indigenous cattle population followed by the non-descript Kongu cattle (19%). Breeds like Hallikar, Kankrej, Umblachery, Tharparkar, and Sahiwal (all descript) occupied 7%, 5%, 4%, 2%, and 2% of the total indigenous cattle population, respectively. The results were similar in the calves category (including heifers) as well, with the Kangayam breed dominating the category with 8% of the total population followed by the Kongu cattle (7%), Kankrej (2%), Hallikar (1%), Umblachery (1%), Sahiwal (1%), and Gir (1%). The overall cattle density is given in (Table 1).

3.1 Indigenous Cattle Density

The dot density of indigenous cattle in the study area is presented in Fig. 2. More dots were present in the villages with a higher cattle count and vice versa. A single dot in the map indicates ten indigenous cattle population.

The density of indigenous cattle present in each grid is shown in Fig. 3. The number of grids that contain cattle varied between the villages, depending upon the density and distribution prevailing in that village. Each grid was found to have variable cattle densities depending upon their proximity to settlements. Four hot spots with a higher density of indigenous cattle were observed in the study area, which is revealed by the grid density map.

Table 1. Indigenous cattle density in the study area

Villages	Total area (sq.km)	Indigenous cattle count	Density (cattle/sq.km.)
Devarayapuram	14.6	396	27
Ikkaraiboluvaampatti	18.6	412	22
Jagirnayakkanpalayam	2.6	19	7
Madampatti	15.7	94	6
Mathvarayapuram	13.8	372	27
Narasipuram	15.4	983	64
Perurchettipalayam	11.4	65	6
Theethipalayam	14.5	42	3
Thennamanallur	8.2	148	18
Vellimalaipattinam	6.3	327	52

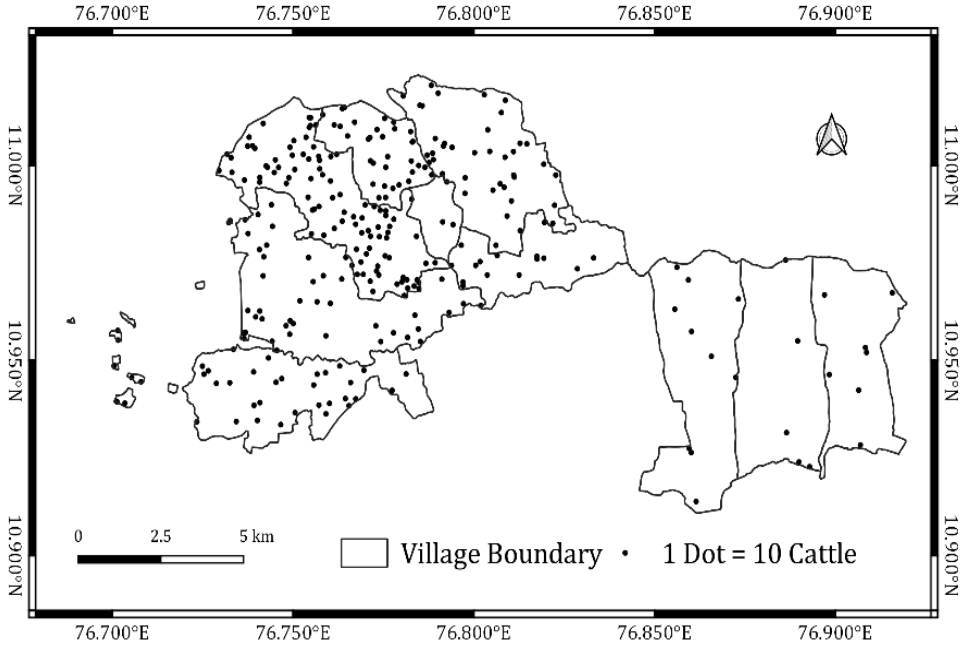

Fig. 2. Dot density of indigenous cattle in the study area

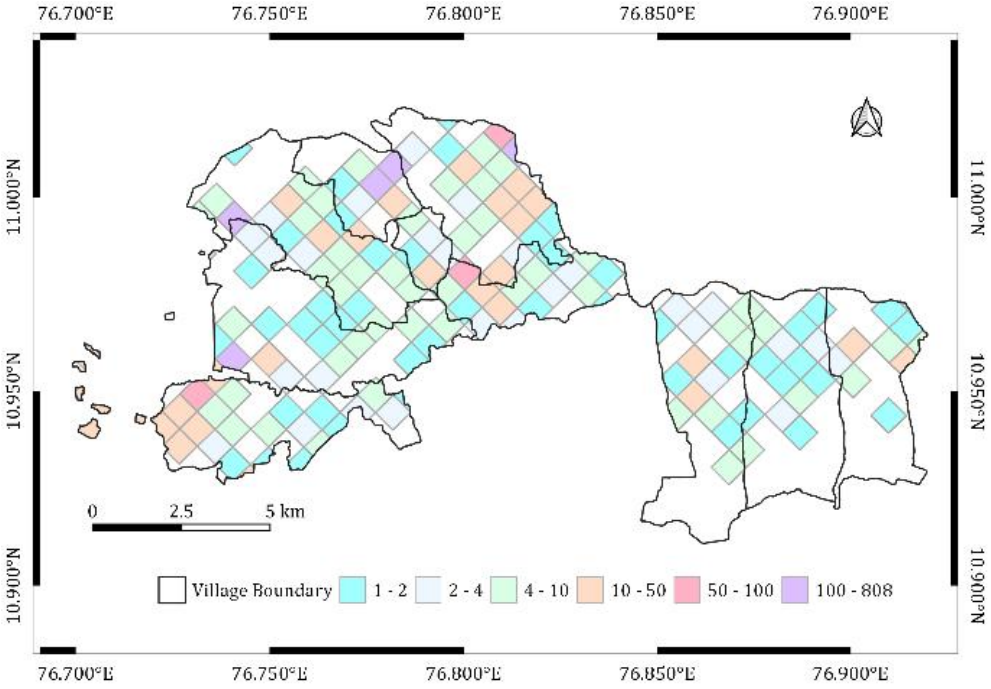

Fig. 3. Grid density of indigenous cattle in the study area

The population of Kangayam breed and Kongu cattle was found to be high in all the ten villages under both the adult and calves category. A small per cent of other native breeds like Hallikar, Umblachery, Kankrej, Tharparkar, Sahiwal, etc., were maintained by few farmers for breeding purpose and to meet their personal dietary requirement. The higher density of Kangayam

and Kongu cattle is due to the fact that the study area comes under the natural breeding tract of both the breeds [23] and also the adoption of native breeds by the farmers has increased in the past five-year period. This is due to the increased awareness among the farmers about the importance of conserving native breeds [24]. The native breeds have better disease resistance compared to crossbreds and adapt well to the prevailing climatic conditions with a low dietary requirement and a high feed conversion efficiency [9] which motivate the farmers to raise indigenous cattle.

Native breeds are preferred for their low maintenance which in turn reduces the expenditure incurred for their rearing compared to crossbreds [25]. The milk from native breeds fetches a higher market price due to their increased demand in recent times. The higher demand is due to the consumer preference shifting towards A2 milk, which prompts the farmers to adopt native breeds [7]. In the current study, it was observed that many farmers have shown renowned interest in rearing indigenous cattle which was reflected by the increased purchase of indigenous cattle calves in the past five years. However, the calf population is still significantly lower compared to the adult population with a ratio of 1:3 indicating unstable dynamics in the population (Fig. 4).

3.2 Indigenous Cattle Distribution

The proportional distribution of indigenous cattle in the study area is depicted in Fig. 5. The distribution of cattle showed significant variation between the villages and also between various breeds. Both the adult and calf distribution were found to be uneven as the indigenous cattle population was very less compared to the crossbred population which was dominant in the study area.

The distribution of indigenous cattle was high towards the settlements and very low in the farms outside the settlements. Such a trend was observed due to the reason that most of the cattle farmers are small farmers or landless labourers who raise their cattle in their own houses as they do not hold a separate farm for cattle maintenance. The distribution was observed to be very sparse near the village boundaries bordering the hilly areas, due to wildlife interference, water unavailability, long distance from veterinary establishments and villages, etc. Human population, urbanisation, feedstock availability, veterinary services, etc., influence the distribution of cattle population [26]. Information on the adoption of various types of livestock can be obtained through classified distribution maps with supplementary data like topography, village extents, drainage, roads, etc. [13].

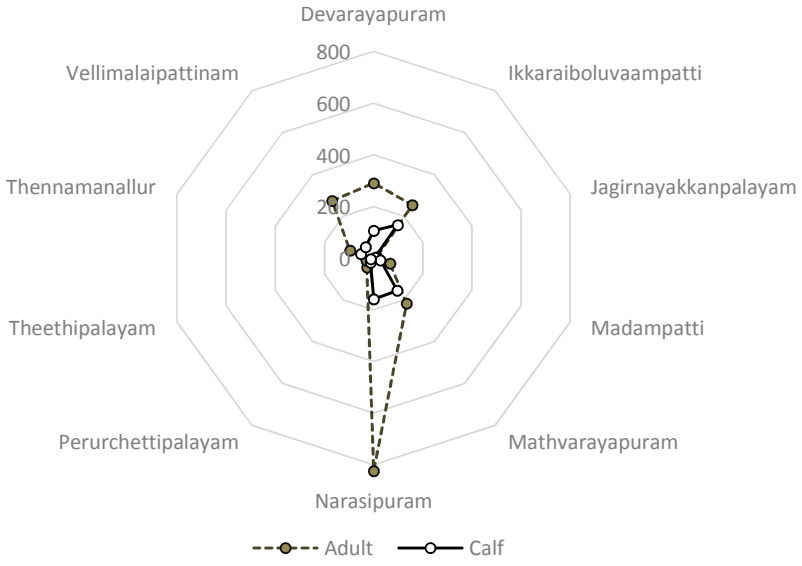

Fig. 4. Comparison of adult and calf population of indigenous cattle at the village level

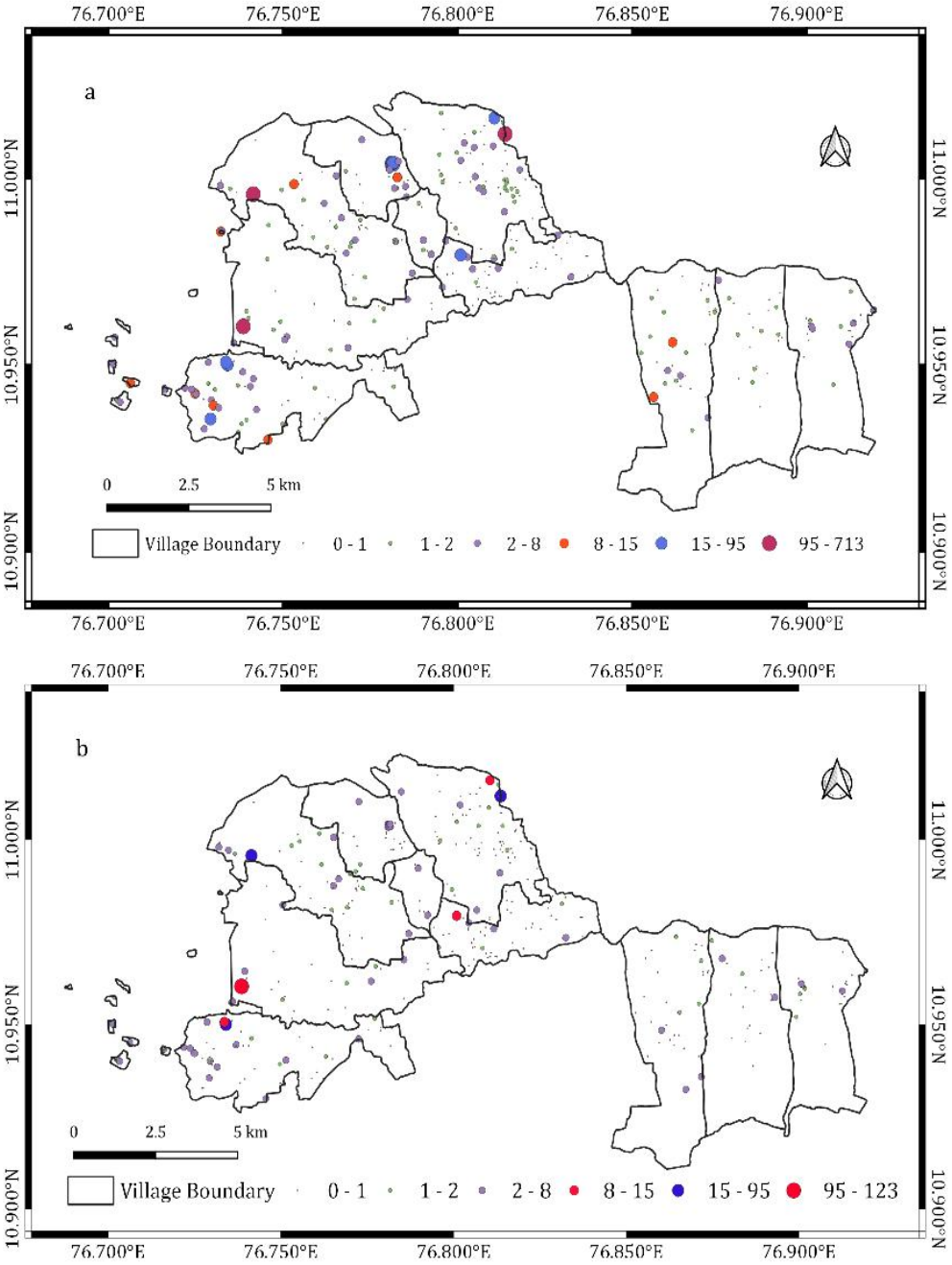

Fig. 5. Proportional distribution of indigenous cattle population a) Adult b) Calf

3.3 Comparative Histogram

The human and indigenous cattle population were compared and the ratio between the two was calculated to know the per capita cattle availability in individual villages (Fig. 6). The results revealed that the per capita availability was far less than one, indicating a skewed indigenous cattle population. The highest per capita availability matched with the village having the highest indigenous cattle count and the lowest per capita availability corresponded with the village having the largest human population. Urbanisation coupled with a higher human population exerts a huge demand on the available natural resources thereby limiting the

support for cattle rearing. The productivity of livestock depends mainly on the existing human population [12]. In the long run, higher human population along with a lower cattle count will raise the demand for animal-based products, thereby increasing their prices to unaffordable levels. The human to livestock population ratio was found to vary with the geographical location [6].

3.4 Validation

The indigenous cattle population assessed through the current investigation was corroborated with the government vaccination records available in the veterinary dispensaries. The comparative graph and the distribution test are depicted in Fig. 7a and Fig. 7b, respectively. The indigenous cattle population assessed through the current work was found to be marginally higher in majority of the villages when compared to the count in the vaccination register. Vaccination is usually avoided for calves with age less than four months and for cattle undergoing treatment for other diseases, resulting in a slightly lower population count in the records. Further, the total count method followed in the current investigation coupled with the GPS based enumeration provides a more accurate output compared to the mainstream method of population assessment.

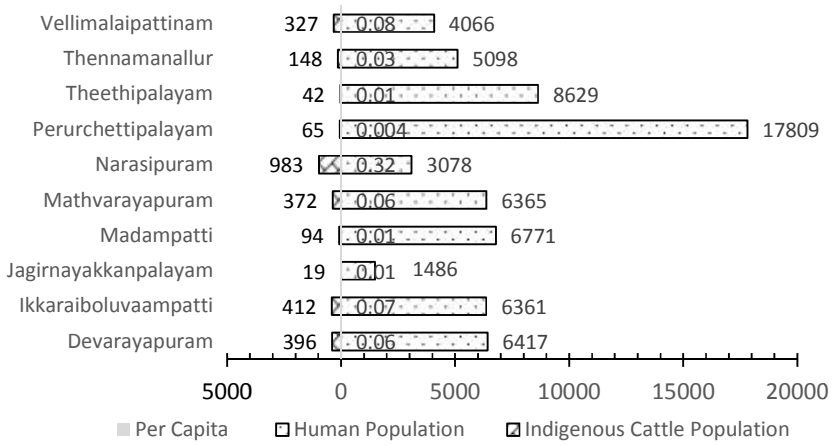

Fig. 6. Comparative histogram of the human and indigenous cattle population

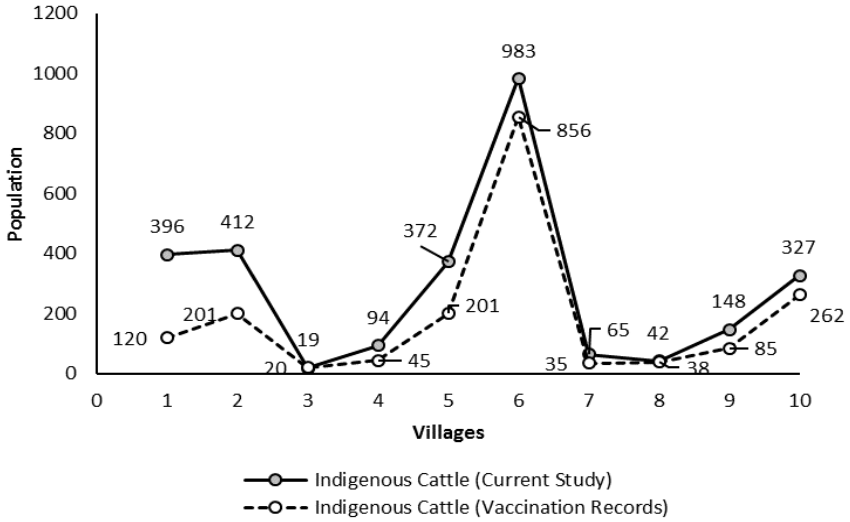

Fig. 7a. Comparison of the population from the current study with vaccination records

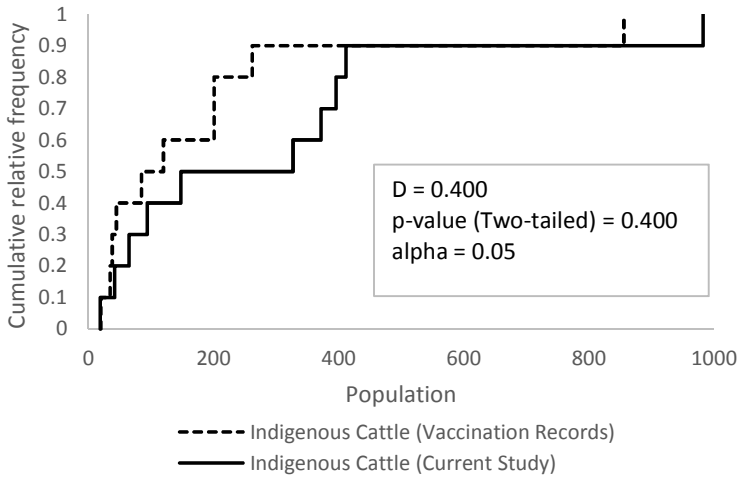

Fig. 7b. Cumulative distribution (Two-sample Kolmogorov-Smirnov test)

4. CONCLUSION

GPS and GIS techniques were employed in the current study to assess the density and distribution of indigenous cattle population. Location-based studies enable policymakers to manage cattle in an effective way by establishing a policy framework and aid in planning and implementing various conservation schemes related to cattle. In India, the integrated use of GIS and GPS in cattle management has not been implemented yet on a large scale. The information available through livestock census is hard to analyse and interpret owing to the enormous load of data gathered during surveys. For a large geographical area and cattle population, integrated GPS and GIS based management activity will be useful and effective for monitoring, analysing, interpreting, and transmitting the information related to cattle. Geospatial techniques can save time and cost and provide a structured and comprehensive approach to cattle management. Future research on the geospatial application in cattle management can consider implementation on a zonal or regional scale and study the possibility of integrating resource-related factors like fodder availability, feed resources and availability of medical services which are essential for cattle sustenance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Roy AK, Singh JP. Grasslands in India: Problems and perspectives for sustaining livestock and rural livelihoods. Trop Grasslands - Forrajes Trop. 2013;1(2): 240–3.
2. Wint W, Bourn D, Hendrickx G, Kruska R, Slingenbergh J, Tateishi ER. Livestock mapping: Present and future. Glob Environ Databases. 2002;2(15):2–14.
3. Mariam Y, Galaty J, Coffin G. Strategic decision-making: Adoption of agricultural technologies and risk in a peasant economy. Munich Pers RePEc Arch. 1993;387:1–29.
4. BAHFS. Basic animal husbandry and fisheries statistics. Gov India, Department Animal Husbandry, Dairy Fish Minist Agric. 2014;AHS Series(15):77.
5. GOI. Government of India (19th Livestock Census-2012). Department Animal Husbandry, Dairy Fish Minist Agric. All India Report:1–10; 2014.

6. Singh DK, Kumar A. Livestock production systems in India: An appraisal across agro-ecological regions. Indian J Agric Econ. 2008;63(4):577–97.
7. Srivastava AK. Conservation of indigenous cattle breeds. J Anim Res. 2019;9(1):1–12.
8. Mwai O, Hanotte O, Kwon YJ, Cho S. Invited review - African indigenous cattle: Unique genetic resources in a rapidly changing world. Asian-Australasian J. Anim Sci. 2015;28(7):911–21.
9. Shabtay A. Adaptive traits of indigenous cattle breeds: The Mediterranean Baladi as a case study. Meat Sci. 2015;109:27–39.
10. Robinson TP, William Wint GR, Conchedda G, Van Boeckel TP, Ercoli V, Palamara E, et al. Mapping the global distribution of livestock. PLoS One. 2014;9(5):1–13.
11. Hollings T, Robinson A, Van Andel MV, Jewell C, Burgman M. Species distribution models: A comparison of statistical approaches for livestock and disease epidemics. PLoS One. 2017;12(8):1–19.
12. Kruska RL, Reid RS, Thornton PK, Henninger N, Kristjanson PM. Mapping livestock-oriented agricultural production systems for the developing world. Agric Syst. 2003;77(1):39–63.
13. Ranade P, Mishra A. Web-GIS based livestock information management system (WGLIMS): Review of Indian scenario. Int J Appl Sci Eng Res. 2015;4(2):209–13.
14. Senapati S, Paikaray A, Das BC, Swain P. Application of remote sensing in agriculture and animal husbandry, ICT programmes in livestock development problems and prospect of ICT in livestock development. Int J Environ Agric Biotechnol. 2016;1(4): 920–5.
15. Rasmussen MS, James R, Adiyasuren T, Khishigsuren P, Naranchimeg B, Gankhuyag R, et al. Supporting mongolian pastoralists by using GIS to identify grazing limitations and opportunities from livestock census and remote sensing data. GeoJournal. 1999;47(4):563–71.
16. Sajeevan G, Ranade P, Dutta U, Londhe S. GRIMMS Web - Connecting India. Geospatial Today. 2012;6:42–3.
17. Kawamura K, Akiyama T. Simultaneous monitoring of livestock distribution and desertification. Glob Environ Res. 2010;14:29–36.
18. Barbari M, Conti L, Koostra BK, Masi G, Guerri FS, Workman SR. The use of global positioning and geographical information systems in the management of extensive cattle grazing. Biosyst Eng. 2006;95(2): 271–80.
19. Champion RA, Rutter SM, Penning PD. An automatic system to monitor lying, standing and walking behaviour of grazing animals. Appl Anim Behav Sci. 1997;54(4):291–305.
20. Kawamura K, Akiyama T, Yokota HO, Tsutsumi M, Yasuda T, Watanabe O, et al. Quantifying grazing intensities using geographic information systems and satellite remote sensing in the Xilingol steppe region, Inner Mongolia, China. Agric Ecosyst Environ. 2005;107(1):83–93.
21. COI. Census of India. Dist census handbook, Coimbatore, Tamilnadu. 2011;Series-34(Part XII-B):232.
22. QGISDT. QGIS Development Team. QGIS 3.4 Geographic information system user guide. Open Source Geospatial Found Proj. 2018;161–73.
23. Karthickeyan S, Gajendran K. Traditional technologies in the improvement of breeds of livestock in Tamil Nadu. Indian J Tradit Knowl. 2005;04(3):303–6.
24. Hegde NG. Impact of crossbreeding and upgrading of nondescript cattle and buffaloes on livestock quality and income. Indian J Anim Sci. 2018;88(5):606–11.
25. Upadhyay RC, Singh SV. Future of draft breeds of livestock in India. VIII Natl Conf Anim Genet Breed. 2005;215.
26. Rao CHH. Agricultural growth and rural poverty in India: Emerging Trends and Perspectives. Indian Econ Rev. 1993;28(2):129–40.

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