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GIS-based approach for mapping the density and distribution of crossbred cattle

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ABSTRACT

The current study was carried out to map the crossbred cattle density and distribution in the Thondamuthur block of Coimbatore district in Tamil Nadu. A house to house survey was carried out and information about the number of cattle per farm or household, breed, class, age, etc. were collected. The coordinates of households and farms with cattle were recorded using a GPS device and the locations were used to generate maps in QGIS software. The classes of crossbred cattle found in the study area were Holstein-Friesian crossbred (CBHF), Jersey crossbred (CBJ) and Mixed (Jersey-HF) class (CBJH). In the adult category, CBHF contributed about 28% of the total crossbred population followed by CBJ (20%) and CBJH (14%). In the calves category, including heifers, CBJ was marginally higher at 16% than CBHF (15%) followed by CBJH (7%). The cattle density and distribution were higher in the settlements and sparse in the farms located away from the settlements and least in the areas situated close to the hills. This information can aid in various policy and decision-making process regarding cattle management.

Keywords: Cattle management, Cross-sectional survey, Decision support, GIS, GPS, Policymaking, Spatial distribution

Traditionally, Indian agriculture adopts a mixed farming system with a symmetric balance between livestock and agriculture crops. Livestock rearing is an important income-generating operation, ensuring the livelihood of two-third of the rural population (Roy and Singh 2013). In India, there is a shift in the composition of livestock favouring milch cattle, thereby increasing the percentage of crossbred cattle. Non-descript or native cattle are crossbred with exotic cattle to improve the performance of the native stock (Singh and Kumar 2008). Various factors like expertise, awareness, land availability and veterinary services play a major role in crossbred cattle adoption. Tamil Nadu tops the country in terms of crossbred cattle population (BAHS 2019). Though the male population of crossbred cattle in the country decreased by 42% between 2012 and 2019, there is an increase in the overall crossbred cattle population by 26.9% (GOI 2019).

With the current population of cattle at 1.92 billion, authentic, reliable and updated information on the spatial distribution and abundance of animals is required for various decision making process (Hollings *et al.* 2017). In most of the developing countries, the quantity of data compiled with regard to cattle is meagre, since more importance is given to crops (Kruska *et al.* 2003). Though diverse information was collected during the livestock census, GIS tools were not used owing to the proprietary nature of the information and involvement of high cost and manpower. Further, the current GIS based application consider various parameters at the regional level and not at the local level (Singh *et al.* 2012). Hence, the data generated through livestock census should be given a geoinformatics approach, which will be convenient for visualising, analysing and disseminating various cattle related information (Senapati *et al.* 2016). The combination of GPS and GIS has been progressively used in animal husbandry to monitor the spatial distribution of animals, tracking routes and frequently used with data loggers for continuous monitoring (Kawamura and Akiyama 2010). Hence, a novel approach was made to integrate the GPS and GIS technique in the field of animal husbandry for exploring its potential application.

MATERIALS AND METHODS

Study area: Thondamuthur block is situated in Coimbatore south Taluk of Coimbatore district in the state of Tamil Nadu, India (Fig. 1). It comprises ten village Panchayats extending between 10° 54′ 42.57″ N, 76° 55′ 12.4″ E and 11° 1′ 20.33″ N, 76° 41′ 14.46″ E. There are about 52 hamlets present within the ten village Panchayats. The total number of households is 18,346 and the total

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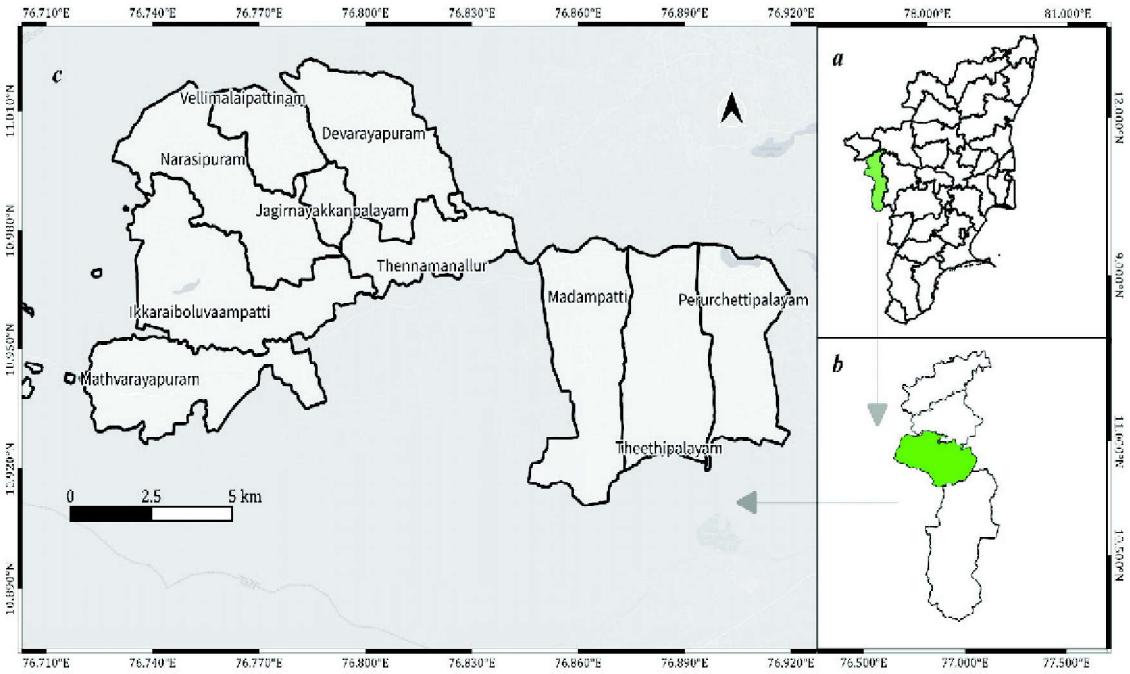

Fig. 1. (a) Tamil Nadu State, (b) Coimbatore District, (c) Thondamuthur Block (Study area).

population of the block is 66080 (COI 2011). The altitude of the region varies from 400 m to 600 m. The average temperature ranges between 21°C and 32°C. The average annual precipitation varies between 550 mm and 900 mm. The current land use in the study area includes rainfed and irrigated agriculture, horticulture farms, residential areas and wastelands.

Field survey: Cattle census are generally executed through questionnaires and field surveys by selecting representative households. Techniques like total count, market count, house to house survey, road count, dip tank count and extrapolation from vaccination records are usually adopted (Wint *et al.* 2002). A comprehensive hamlet wise survey was conducted in the ten village panchayats and information about the number of crossbred cattle per household/ farm, breed, class, age, sex, etc. were collected. The coordinates of households and farms with cattle were recorded using a GPS device (GARMIN® eTrex® 30x with Software Ver. 3.00) in all the hamlets in each village. The survey was initiated in the first week of September 2018 and concluded in the last week of January 2019 spanning a period of five months.

Age class: In crossbred cattle, the male population > 1.5 years were classified as adult and < 1.5 years as calves. The female population > 2.5 years were classified as adult and < 2.5 years as calves (BAHS 2019). The calves and heifers in the female population of crossbred cattle were combined and placed under a single category (calves) to maintain consistency between the male and female population.

Density and distribution: The coordinates were transferred from the GPS device and converted to point shape files using the DNRGPS application (6.1.0.6). The shape files were processed in QGIS 3.4 software for generating maps. The overall crossbred cattle density in each village was calculated by dividing the total number of crossbred cattle in each village by the total area of the village in km^2. Class wise cattle distribution was also mapped for the study area using the information gathered during the field survey.

Density map: The study area was divided into hexagonal grids of 0.1 km^2 area using *Create Grid* function from Vector Research Tools and the number of geocoded points falling under each hexagon was counted using *Count Points in Polygon* function from Vector Analysis Tools in QGIS 3.4. The number of cattle present in each geocoded point was added to the hex grid by using the *Join Attributes by Location* function in QGIS 3.4 and the total number of cattle per hexagon was calculated (QGISDT 2018).

Distribution map: These maps increase the size and colour of the marker (usually a circle) proportionally, to depict the number of cattle in each geocoded location. The larger the size of the marker, the larger the individual count will be at that location and vice versa. The class wise proportional distribution map was developed by using the Graduated Symbols function from *Symbology* in QGIS 3.4 (QGISDT 2018). This gives a clear visual of the cattle distribution and abundance within each village boundary.

RESULTS AND DISCUSSION

The major classes of crossbred cattle found in the study area were Holstein-Friesian crossbred (CBHF), Jersey crossbred (CBJ) and Mixed (Jersey-HF) class (CBJH). In the adult category (>2.5 years), CBHF contributes about 28% of the total crossbred cattle population followed by CBJ (20%) and CBJH (14%). In the calves category,

Table 1. Crossbred cattle density in Thondamuthur block

Village	Total area (km^2)	Crossbred cattle count	Density (cattle/km^2)
Devarayapuram	14.6	1148	79
Ikkaraiboluvaampatti	18.6	973	52
Jagirnayakkanpalayam	2.6	269	104
Madampatti	15.7	770	49
Mathvarayapuram	13.8	942	68
Narasipuram	15.4	1547	100
Perurchettipalayam	11.4	675	59
Theethipalayam	14.5	552	38
Thennamanallur	8.2	873	107
Vellimalaipattinam	6.3	344	54

including heifers, (<2.5 years of age), the CBJ population was marginally higher at 16% than CBHF (15%) followed by CBJH (7%). The overall crossbred cattle density is given in Table 1.

Crossbred cattle density: The hex bin map indicates the density of cattle in each grid. The number of crossbred cattle within each grid is shown in Fig. 2. Each village in the study area was found to have varying number of grids, some with no cattle and some with variable cattle density. The number of grids in each village that have cattle depends on the cattle density and distribution in that particular village.

The population of adult CBHF was higher in 80% of the villages compared to other classes. This is due to the fact that HF crossbreds have better milk yield (Madhuri *et al.* 2009) and adapts well to the slightly colder weather regime (Fanta 2017) that prevails in the study area and hence the adaptation by farmers is high compared to other classes of crossbred cattle. The village where the CBJ cattle was higher was due to the higher population of abandoned cattle owing to lower productivity, bull calf and other reasons. CBJH has the lowest population in the adult category.

The scenario with regard to calves was slightly different with the CBJ having a higher share (60%) compared to CBHF (40%) among the villages. This shows an increase in the CBJ calf population compared to the CBJ adult population. The results indicate that there is a shift in the farmers preference towards CBJ cattle in recent times owing to the fact that they have better tropical disease resistance (Jonsson *et al.* 2000) and provide milk with better fat content (Hussain *et al.* 2011) thereby having an advantage over CBHF. Further CBJ cattle are easier to handle and demand less space due to their smaller body size. Susceptibility to various tropical diseases and the associated medical expenditure was found to influence the class preference by cattle farmers. CBJH has the lowest population in the calf category as well.

Crossbred cattle distribution: The class wise distribution of crossbred cattle in the study area is depicted in Fig. 3. Significant variation was observed in the distribution of cattle with regard to various classes. The calves population was found to have a better distribution compared to the adult population. The difference between the adult and calves population was narrow, indicating healthy population dynamics. Irrespective of the class, the distribution of cattle was more concentrated towards the settlements and very sparse in the individual farms. The reason is that the majority of cattle owners are landless labourers or marginal farmers who maintain cattle in their respective households as they

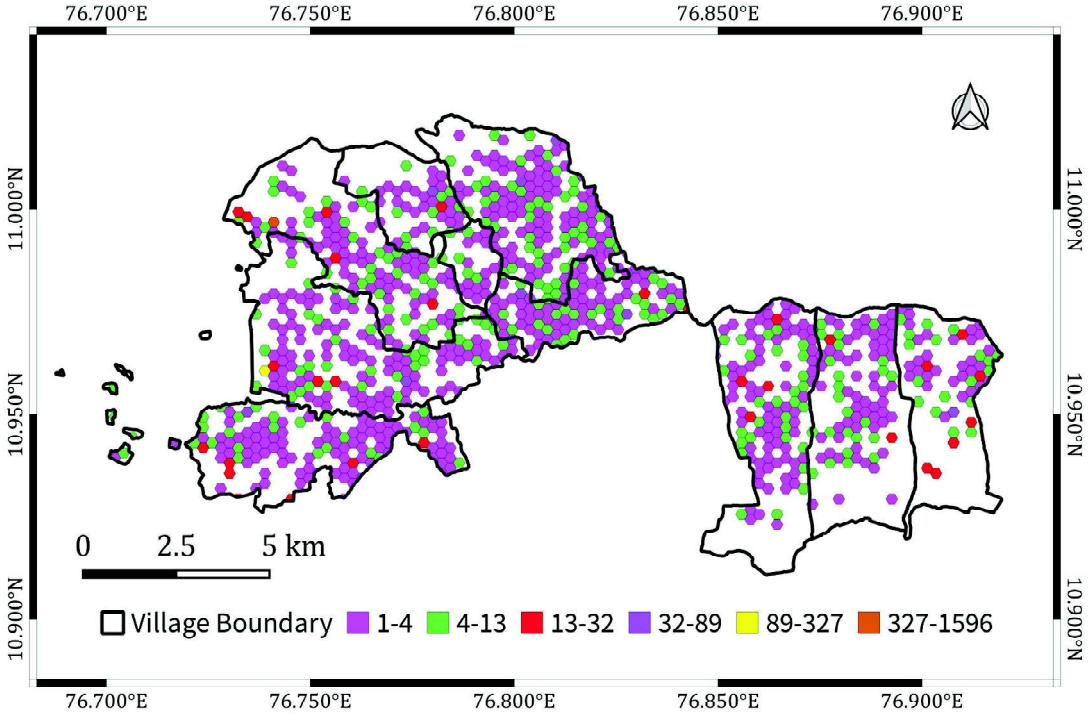

Fig. 2. Hex bin density of crossbred cattle in the study area.

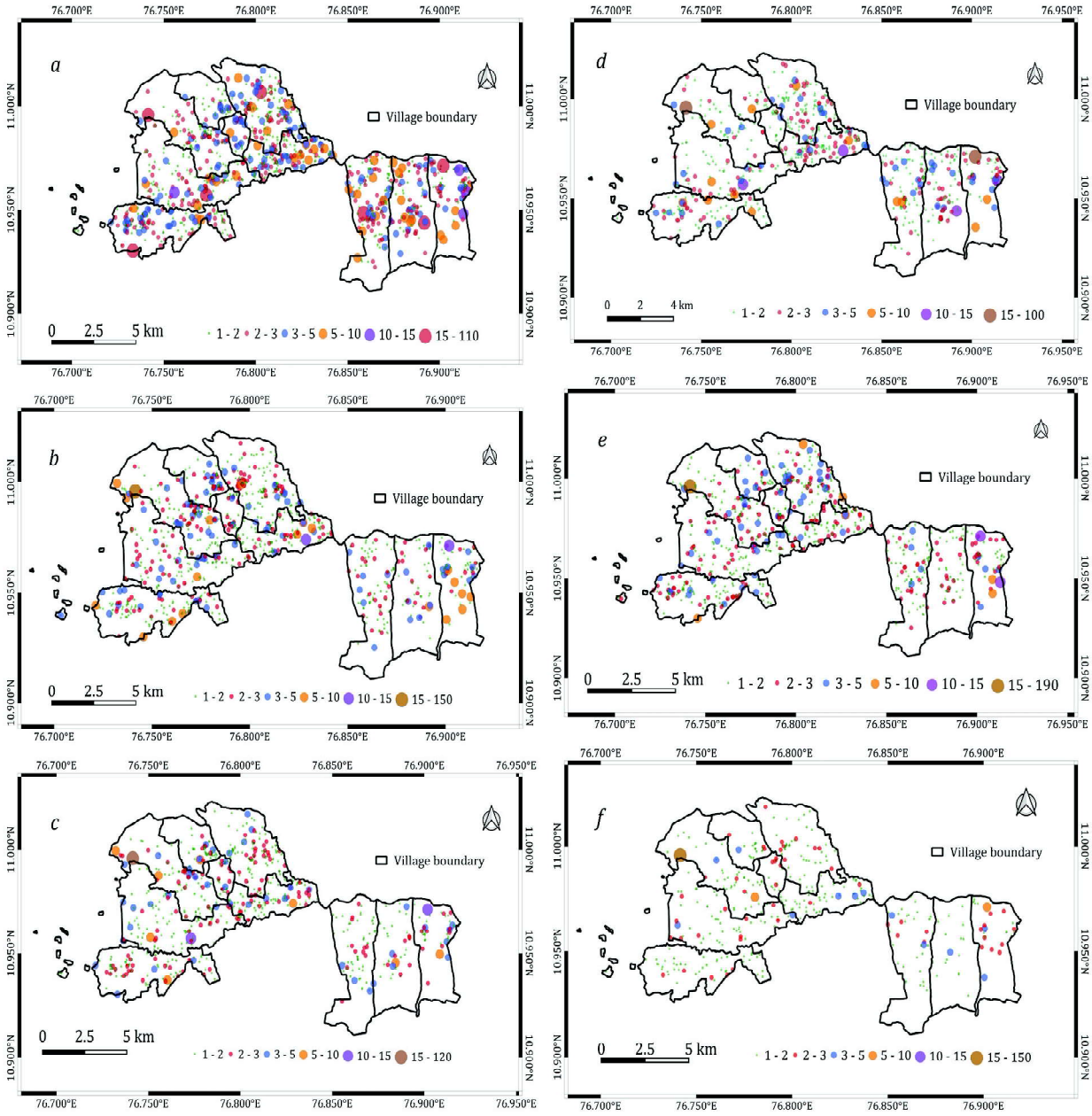

Fig. 3. Class wise distribution of crossbred cattle population (a) CBHF adult, (b) CBJ adult, (c) CBJH adult, (d) CBHF calf, (e) CBJ calf and (f) CBJH calf.

do not possess any separate land or farm. Also, the cattle distribution was very low towards the village boundaries adjoining the hilly areas due to reasons like low water availability, wild animal conflict, distance from village centres and veterinary dispensaries, etc. Various factors like human population, availability of feedstock, urbanisation, roads, availability of veterinary establishments were found to have a profound influence on the distribution of crossbred cattle (Rao 1993). Livestock distribution in the form of classified maps, with regard to various field data like village boundaries, roads, settlement, topography, drainage, etc. can provide valuable information on the adoption of various livestock species (Ranad and Mishra 2015).

Scientific validation: The total crossbred cattle population derived through the current study was validated by comparing it with the population from vaccination records maintained at the government veterinary dispensaries under the department of animal husbandry. The population comparison and the cumulative distribution is shown in Fig. 4. The comparison revealed that the crossbred cattle population recorded through the current study was slightly higher than those present in the vaccination records in the majority of the villages. The lower population in the records is due to the reason that vaccination was not done for calves less than four months of age and cattle under medication for other clinical symptoms. Further, the current GPS based population assessment tend to produce better results compared to the conventional method of enumeration due to

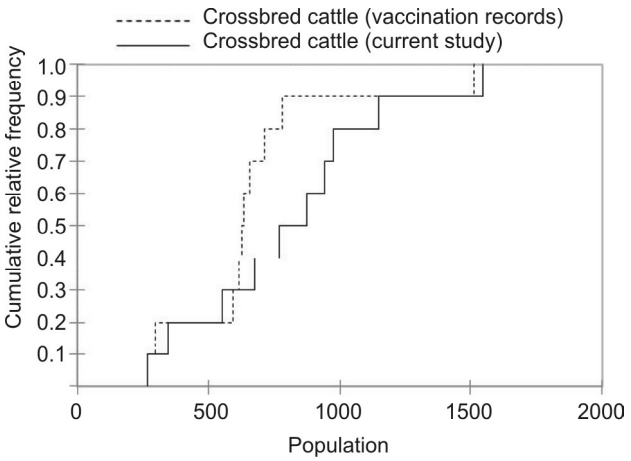

Fig. 4. Population distribution (K-S test).

the total count method adopted in the study.

The current study integrated the GPS and GIS techniques for assessing the crossbred cattle density and distribution in the study area. GIS is a powerful decision support tool aiding the decision makers in planning, structuring policy framework and making an informed decision. In India, the implementation of GPS and GIS in the field of animal husbandry has not been explored to its full potential. The census information that is currently available in the form of raw data is difficult to interpret and arrives at a conclusion due to the huge volume of information generated from field surveys. With an increasing cattle population and a huge geographical area, GIS based cattle management will be an effective tool for monitoring, data management (analysis and interpretation) and information dissemination. Integrating GIS, GPS and remote sensing technologies have the advantage of saving time and cost and also provide a more comprehensive and integrated approach towards cattle management in an agrarian country like India.

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