Evaluation of Street Dog Population Management and Sterilization Impact in Mumbai

A Ten-Year Review (2014-2024)

Brihanmumbai Municipal Corporation
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Submitted By
Humane Society International/India

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Executive summary

The Brihanmumbai Municipal Corporation (BMC) partnered with Humane Society International/India (HSI/India) in 2022-23 to conduct a baseline survey of stray dogs in Mumbai City and Suburbs. This collaboration was made possible through an agreement and approval from the Administrator, Standing Committee Resolution. Humane Society International/India (HSI/India) is a non-profit organization dedicated to protecting animals through hands-on programs, policy change initiatives and education and awareness campaigns, guided by data-driven approaches, ensuring effective and impactful solutions for animal welfare.

In 2014, Humane Society International/India (HSI/India) conducted a baseline street dog survey in Mumbai, estimating a population of 95,172 dogs, or approximately 10.54 dogs per km. A decade later, a follow-up survey was carried out to evaluate the trends and the impact of the Animal Birth Control (ABC) programs. The 2024 survey estimated the dog population at 90,757 roaming across Mumbai (BMC Area). Approximately 930 km of Mumbai's streets were surveyed, which translates to about 8.01 dogs per km where as in the slums, we found 224 dogs per one kilometre square area in 2024.   Despite the growth in the human population, we have observed reduction of 21.8% and 27.4% in dog density in streets and slums respectively across the Mumbai area over the past ten years.

While dog density decreased by 31.6% across 19 of the wards, there were some exceptions. In four wards (Wards E, N, RS, and T), dog density increased by 19.9% and in Ward D, the density remained stable. The overall sterilization rate was 62.9%, with females having a slightly lower rate of 61.7%. The proportion of lactating females dropped to 7.1%, yet the number of pups rose to 4.3%. Despite a general decrease, the increase in dog density in four wards could be due and migration of dogs from outside Mumbai specially in bordering wards RS and Ward T or dog migration between the wards or due to human interactions such as feeding might influence these figures by boosting pup survival rates and impacting sterilization effectiveness. Although we are assuming multiple influencing factors, further research is needed to substantiate or refute these hypotheses.

Additionally, since their first recording in 1997, dog-related complaints and bite incidents have generally declined, according to data from the BMC. Nevertheless, there was an uptick in both complaints and incidents following the pandemic in 2022. The data indicates that dog-related complaints peak during the monsoon season of July and August, a period coinciding with the breeding season when dogs tend to be more territorial and aggressive. Despite the mating season, reports of dog bites decrease during the July and August months but increase during the late winter and spring, indicating a relationship between bite cases and the whelping season over the mating season.

The analysis of complaints and bites suggests a clear seasonal pattern that aligns with canine behaviour, although annual fluctuations indicate that various factors influence the timing and frequency of these incidents. The number of complaints has reduced by about fourfold by 2018 compared to 1994, although we are seeing some increase in recent years. This comprehensive survey not only provides insights into the effectiveness of ongoing ABC efforts but also highlights the need for targeted strategies to manage the free-roaming dog population more effectively in Mumbai.

About Humane Society International/India

Humane Society International/India (HSI/India) is a not-for-profit animal protection organization which works for the protection of animals through hands on programs, policy change and education. We are proud to be associated with Humane Society International, of which we are an affiliate. Humane Society International (HSI), the global arm of The Humane Society of the United States (HSUS), has worked with government agencies and local groups around the world for about two decades to safeguard public health through street dog sterilization and vaccination programmes. HSI/India has collected and analysed data in towns and cities across India and has the capacity and experience to advise national and local government authorities on the humane and effective management of both street and controlled (pet) dogs. Our programmes across the world have shown that it is necessary to generate reliable estimates of the dog population size and understand the human-dog relationship to create sustainable programmes. Recently, HSI/India has successfully carried out baseline dog surveys in several cities in Gujarat, including Ahmedabad, Gandhinagar, Vadodara and Jamnagar, several towns in Uttarakhand, including Dehradun, as well as other cities in India, e.g., Mumbai, South Delhi, Ranchi, Jamshedpur (Jharkhand), Kodaikanal and Dindigul (Tamil Nadu).

Brihanmumbai Municipal Corporation's (BMC) Efforts to Control Stray Dog Population

The Brihanmumbai Municipal Corporation (BMC) has launched a comprehensive initiative to control the stray dog population in Mumbai. As part of this effort, the BMC's Veterinary Health Department has conducted a thorough survey of stray dogs across the city.

Stray Dog Survey

The stray dog survey was conducted in 2024 to gather accurate data on the number of stray dogs in Mumbai, their distribution, and their health status. This data will enable the BMC to develop effective strategies for population control and animal welfare.

Dog Population Control Measures

The BMC's population control measures are focused on humane and sustainable methods, including:

1. Animal Birth Control (ABC) Program: The BMC is implementing a large-scale ABC program, which involves sterilizing stray dogs to prevent unwanted breeding, in collaboration with 10 animal welfare organizations. This collaboration with animal welfare organizations to implement its stray dog population control measures aims to leverage the expertise and resources of these organizations to achieve a common goal.
2. Anti-Rabies Vaccination: The BMC is conducting annual mass anti-rabies vaccination drives to immunize stray dogs against rabies.
3. Rehabilitation: The BMC is working with animal welfare organizations to rehabilitate sick and injured stray dogs.
4. Independent Veterinary Department: Established in 2018, BMC's Veterinary Health Department has Senior Veterinary Officers, Veterinary Officers, Dog Control Officer and staff dedicated towards the effective implementation of this initiative.
5. Collaboration with stray dog feeders and caretakers: The department has been in close contact with feeders and caretakers to help maximum sterilizations.

Objectives

The BMC's stray dog population control measures aim to:

- Reduce the number of stray dogs in Mumbai.
- Prevent the spread of rabies and other diseases.
- Improve animal welfare and promote compassion towards stray animals.
- Enhance public health and safety.

The BMC's initiative to control the stray dog population in Mumbai is a significant step towards promoting animal welfare, public health, and safety. By conducting a comprehensive survey and implementing humane population control measures, the BMC aims to create a more compassionate and sustainable urban ecosystem.
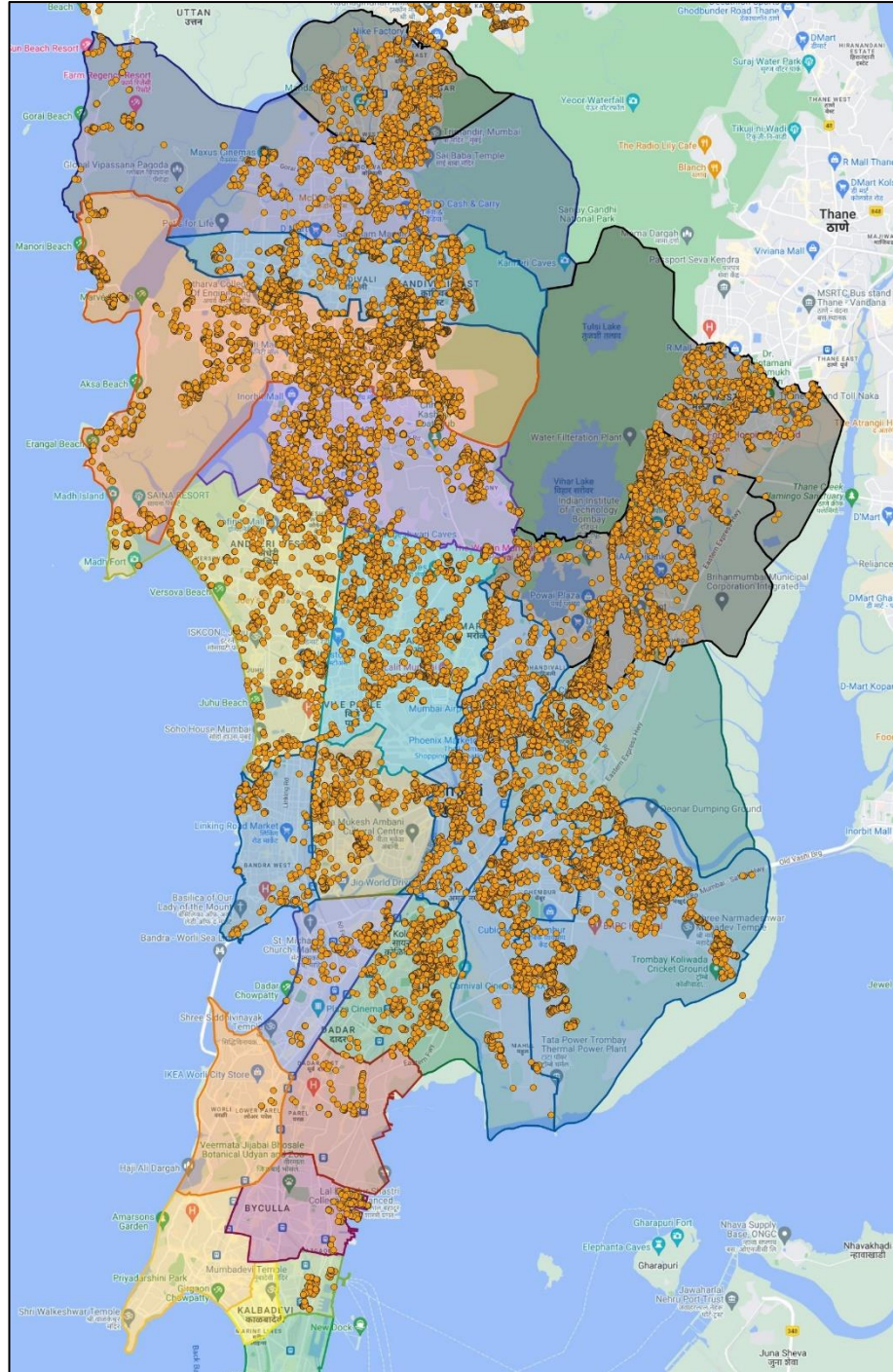
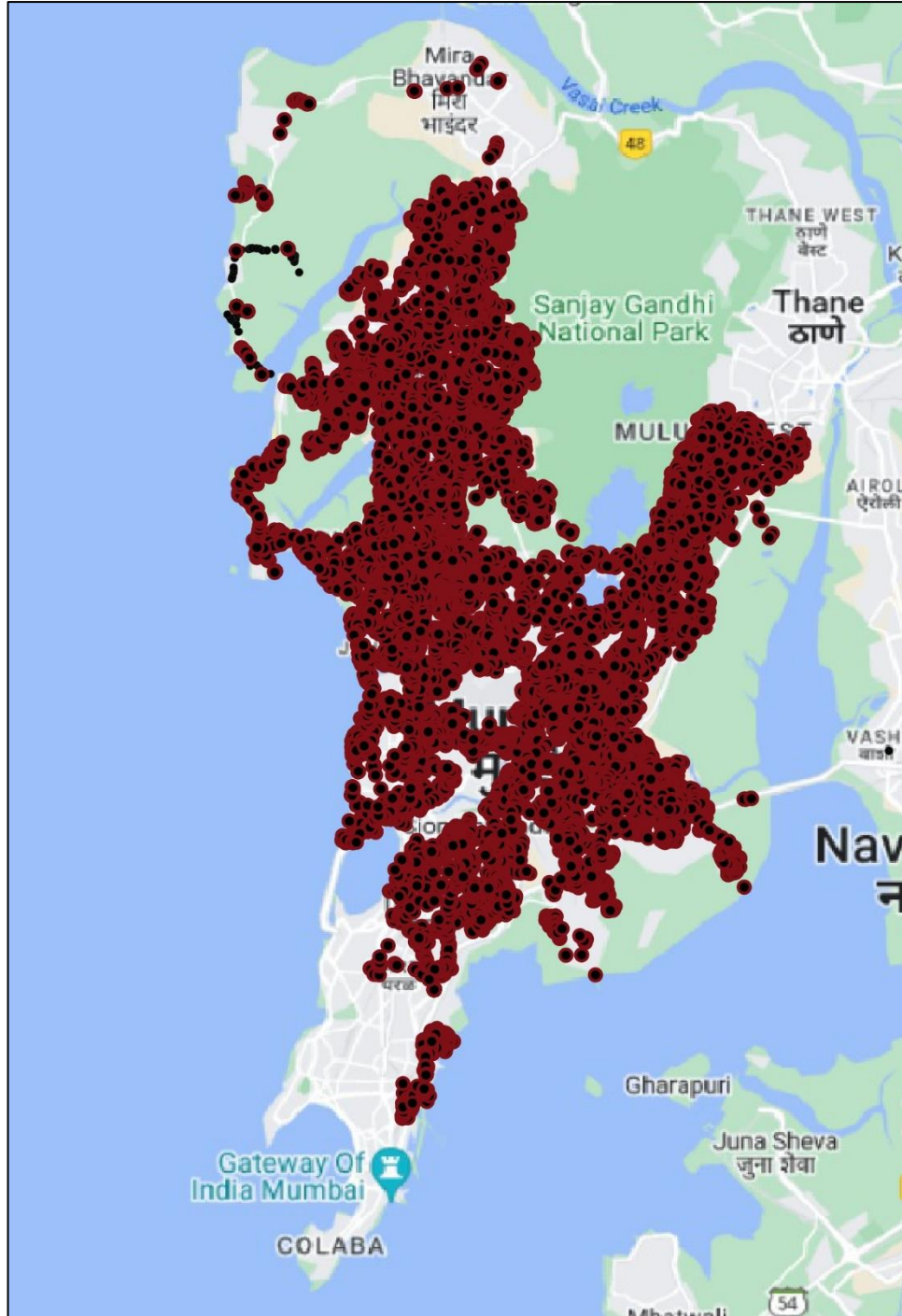Sterilization Program monitored by BMC Veterinary Officer

Vaccination of Stray Dogs

Use of Technology to record Data

Brihanmumbai Municipal Corporation

Neutering Coverage in Mumbai

Vaccination Coverage in Mumbai

Introduction

In India, the ABC Rules 2001, (amended in 2010, 2023) marked a significant shift in the approach to street dog welfare, mandating sterilization as the only permissible method for managing street dog populations. This legislation was a response to the historical use of non-humane methods for controlling street dog populations, which included culling through poisoning and other lethal methods. Prior to these reforms, cities like Chennai and Jaipur saw early initiatives by organizations like Blue Cross of India and Help in Suffering, which began sterilization and vaccination programs in the mid-1990s.

In urban India, the prevalence of street dogs was traditionally attributed to their scavenging from leftover garbage. However, recent studies suggest that a more significant factor is the direct provision of food by people and households. It appears that garbage and leftovers do not provide sufficient nutritional value to sustain such large populations of street dogs in urban areas. This interaction fosters a complex ecosystem where dogs are in close contact with human populations, leading to various public health concerns. Aggressive behaviors in dogs are often triggered by territorial instincts, which can escalate into dangerous encounters involving chasing, aggression, and biting, especially when dogs face unfamiliar individuals. Additionally, the dynamics of this interaction are further complicated by seasonal breeding patterns, which are associated with increases in dog bite incidents, adding another layer of complexity to managing these populations.

India faces a substantial challenge with its free-roaming dog population, estimated at 62.1 million street dogs and 13.9 million owned dogs that frequently roam (WellBeing International, 2022). The country reports about 17.4 million dog bites annually (Gongal & Wright, 2011), contributing significantly to its public health challenges. Dogs living on the streets, whether owned or unowned, are typically unsupervised and contribute to India's high rabies burden, which accounts for one-third of global rabies cases in humans. Rabies remains endemic, with 18,000–20,000 human cases annually, primarily transmitted through dog bites. Beyond rabies, dogs can also transmit other zoonoses like visceral leishmaniasis, echinococcosis, and toxocariasis, posing further risks to public health.

The Brihanmumbai Municipal Corporation (BMC) has been one of the pioneers in humane street dog population management in India, adopting sterilization as its primary strategy since 1994. By December 2023, BMC had successfully sterilized 403,374 dogs, demonstrating its commitment to humanely managing the free-roaming dog population. About eight to ten NGOs actively participates in the street dog sterilization program, each contributing in varying capacities and with differing levels of resources. From 2014 to 2023, these organizations collectively achieved the sterilization of 148,084 dogs, with the annual figures reaching a peak of 24,290 in 2017 and a low of 6,414 in 2015, averaging 14,808 sterilizations per year over the decade. This recent effort, however, represents a decrease from the period between 2008 and 2013, during which a total of 122,120 dogs were sterilized. The earlier period saw a significantly higher annual average of 26,016 sterilizations per year, with the highest single-year total reaching 36,990 in 2009 and the lowest at 9,722 in 2013.

In January 2014, Humane Society International/India conducted its first comprehensive survey of the street dog population in Mumbai with the support from BMC. The results from this survey estimated a roaming dog population of 66,087 on the streets and 29,085 in the slum areas, for a combined total of 95,172 dogs. Over 914 km of street length were surveyed with repetition of pre-defined randomly drawn survey routes on Google maps, averaging 10.54 dogs per km. Additionally, survival estimates were generated from clinic sterilization data, and a sight-resight experiment provided a detectability of street dogs of 0.4, indicating the probability that a roaming dog would be seen during morning surveys. A decade later, in January 2024, HSI/India conducted its second survey to assess current trends and evaluate the ongoing ABC and dog welfare activities in Mumbai. This survey aims to compare and analyze the developments in street dog population management over the past ten years, informing future strategies and initiatives for improving urban animal welfare.

ADMINISTRATIVE AND DEMOGRAPHIC PROFILE OF BRIHANMUMBAI MUNICIPAL CORPORATION (BMC):

The Brihanmumbai Municipal Corporation (BMC) serves as the primary governing body for Mumbai, the capital city of Maharashtra. Mumbai is recognized as one of India's most densely populated cities, undergoing rapid developmental transformations. It is administratively divided into 24 wards, which are grouped into seven zones to facilitate efficient urban management and address the diverse needs of its expansive population.
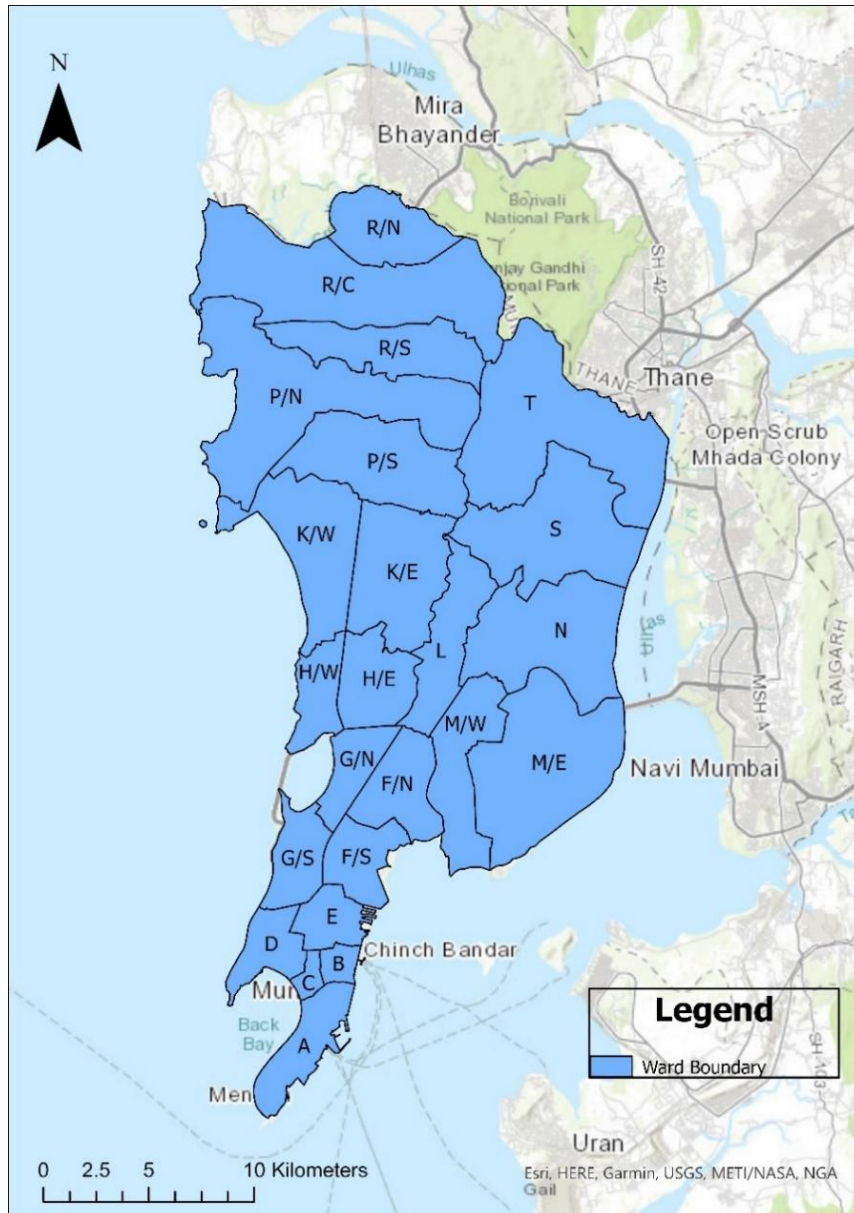
Historical census data from 2011 recorded Mumbai's population at 12,442,373. Due to the absence of more recent census data, the population for 2023 is estimated at 21,297,000 using online resources. This projection indicates considerable growth, highlighting the ongoing urban expansion and the increasing complexities of municipal administration. The boundary remained same for BMC for last ten years, but human population grew about 11% as per the population growth estimates.

BMC is notable for being India's richest municipal corporation, with an annual budget that exceeds that of several smaller states within the country. Established by the Bombay Municipal Corporation Act of 1888, BMC's responsibilities extend beyond civic administration to include the management of civic infrastructure and various suburban areas. The corporation's commitment to improving Mumbai's infrastructure is crucial for sustaining Mumbai's dynamic growth and addressing the challenges posed by such a densely populated urban environment.

Figure 1. ArcGIS Map of BMC Administrative Wards - Division of BMC Wards

SURVEY OBJECTIVES:

1. **Determine the Current Population of Free Roaming Dogs in Mumbai:** To estimate the number of free roaming dogs across Mumbai, providing updated data to assess changes since the 2014 survey.

2. **Measure Dog Density and Demographic Changes:** To calculate current dog density per km of road and analyze shifts in demographic ratios such as male-to-female dog ratios and dogs per 100 humans, offering insights into changes in dog ecology and demographics over the last decade.
3. **Assess the Impact of Sterilization Programs in Each Ward:** To determine the sterilization rates achieved in each ward of BMC since the last survey and evaluate their effectiveness in controlling the dog population.
4. **Analyze the Effects of Sterilization on Reproductive Dynamics:** To estimate how sterilization efforts have influenced the reproductive dynamics of the street dog population, focusing on changes in breeding patterns and population growth.
5. **Compare Changes Over Time with 2014 Baseline Data:** To conduct a longitudinal analysis by comparing the current survey results with those from the 2014 baseline to identify trends, measure progress, and assess the impact of interventions over the past ten years.
6. **Evaluate Street Dog Welfare Indicators:** To record and analyze street dog welfare based on body condition scores and skin conditions as proxy measures of general health and well-being.
7. **Provide Recommendations for Future Sterilization Strategies:** Based on the analysis of impact indicators and survey findings, to make informed recommendations aimed at enhancing the effectiveness of BMC's ongoing sterilization program.

METHODOLOGY

Survey Design, Methods, and Protocols An unbiased survey design was retained for the BMC survey by reutilizing the transect routes established in all 24 wards during the 2014 survey. This approach ensures continuity and comparability of data over time. A comprehensive database was maintained to store and process the collected data efficiently. These established routes, also referred to as index or standard routes, were originally drawn in Google Maps along residential roads and highways, avoiding expressways where dogs tend to be less frequent.

Survey routes, averaging 20-30 km in distance, were drawn using the "draw a line along roads" option in Google Maps. This tool accounts for one-way systems, allowing the route to be easily navigated using the Maps app on a GPS-enabled mobile phone synchronized with the Google account used for the survey. Routes are marked with a starting (Flag) and endpoint (House) for clarity. For accessibility, the routes were saved as KML files and stored in Google My Places, accessible from smartphones both online and offline.

The survey was conducted early in the morning, starting at dawn. The survey team comprised a driver and an observer on a motorcycle. The observer, seated on the pillion, used Google Maps to guide the driver along the predetermined route, maintaining an average speed of about 10-15 km/hr. Concurrently, the observer utilized the OSM Tracker app (Figure 2 & 3 below), which was adapted specifically for the survey, enabling the observer to efficiently record sighted dogs and collect detailed information about each. Categories recorded included sterilized female, unsterilized female, lactating female, sterilized male, unsterilized male, and unknown adult dogs. Pups were also noted, defined as dogs too young to be sterilized, though their sex was not recorded.

Welfare indicators such as skin problems and body condition scores (BCS1 to BCS5) were also recorded alongside the GPS coordinates of each sighted dog. OSM Tracker provided a track record of all sighted dogs and their specifics along the route followed during the survey. Each route was surveyed at least twice to estimate the day-to-day variance in dog count and composition along the routes.
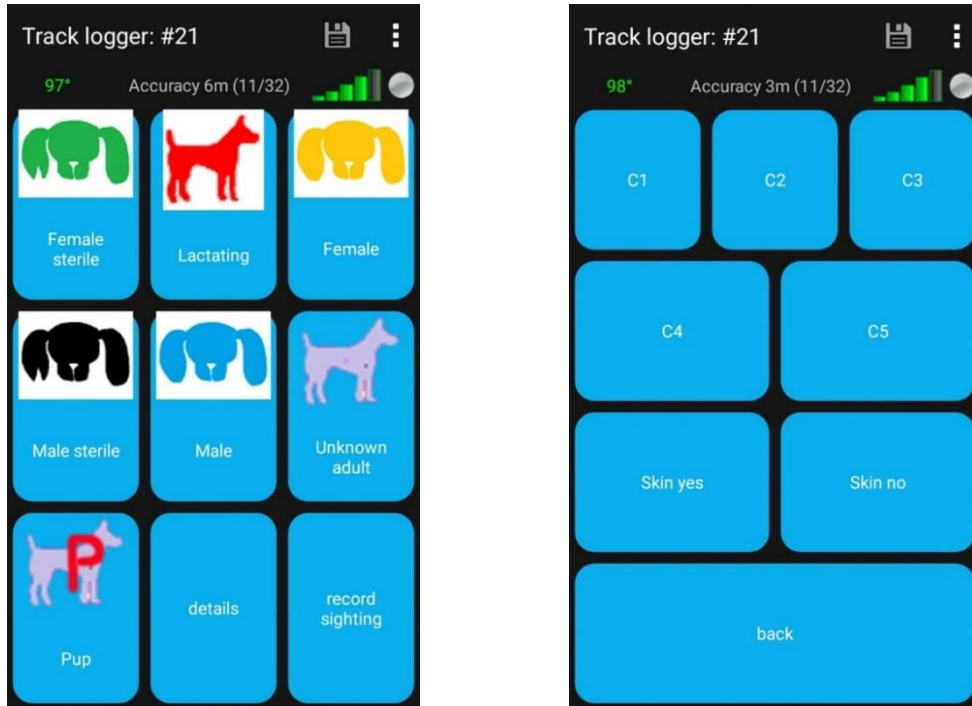
Figure 2 & 3: OSM Tracker Application Layout – Dog Type Recording Screen (left) & Welfare Detail Recording Screen (right).

After completion of the survey, the recorded data was uploaded to a database, where the recorded dogs could be displayed along the survey-route, as each record is geo-tagged at the time of data collection. The visualization of encountered dogs provided a straightforward summary of the data. The routes are archived, and the average survey speed and protocol are documented to ensure that the survey can be repeated annually to monitor changes in the roaming dog population.

The slum area survey mirrored the 2014 survey design, covering four distinct locations: Dharavi, Bhatia Nagar, Raval Pada (Wadala East), and Jogeshwari East (Southeast of Mahakali Caves Road). Before the survey, we mapped each location's boundaries using Google Maps. Without predefined routes and street lengths in the slums, surveyors navigated all accessible passageways. They conducted dog counts in both narrow and wide passages throughout the slum areas. We used the OSM Tracker to track dogs and My Tracker to record routes. Surveyors documented specific details for each dog, including Female, Female Sterile, Lactating Female, Male, Male Sterile, Pups, Unknown Adults, Body Condition Score (C1 or C2), and Visible Skin Conditions.

DATA METRICS

Data gathered during transect surveys were employed to generate essential metrics that support the objectives of this project. These metrics are structured to provide a comprehensive assessment of the dog population and its dynamics within the BMC:

- **Index of Dog Density:** This metric, calculated by dividing the total number of dogs sighted by the length of the transect, is expressed as "dogs per km." It serves as an indicator of the underlying dog density, which is crucial for analyzing spatial patterns and temporal changes in the dog population.
- **Dog Composition:** Each dog sighted was categorized based on several criteria, including sterilization status (sterilized or unsterilized), reproductive status (lactating females, for instance), and age (puppies under 6 months and adults). This classification helps in understanding the demographic structure and reproductive dynamics of the street dog population.

- **Observations of Collared Dogs:** Dogs wearing collars were specifically noted to assess the level of human-animal bonding. A collar often indicates recognition by people, suggesting that the dog, while free roaming, is known or owned by someone and lives on the street. This helps to differentiate between truly stray dogs and those that have some level of care from the community.
- **Health and Welfare Indicators:** The health status of each dog was evaluated using a simplified veterinary scale from C1 to C5, where C1 indicates malnourished and C5 indicates over-nourished. Additionally, visible skin conditions, such as mange, were recorded to assess the overall welfare and health risks associated with the street dog population.

These metrics are designed to provide a detailed snapshot of the street dog population, enabling the BMC survey team to assess changes since the 2014 survey accurately. This data is vital for planning effective management strategies and interventions to improve the welfare and control of the street dog population in Mumbai. The Table 1, below is about the ward-wise street length and survey coverage statistics, illustrating the extent of survey tracks within each ward's total road network.

Table 1 – Ward-wise Street Length and Survey Coverage

Ward	Total Street Length (km)	Survey Track Length (km)	% Ward Street Length Covered
A	74.76	21.7	29%
B	44.32	8.7	20%
C	33.28	14.9	45%
D	80.08	11.7	15%
E	60.08	15.1	25%
GS	61.08	14.5	24%
FS	70.8	17.3	24%
GN	75.6	16.3	22%
FN	91.16	25.3	28%
HW	85.84	20.1	23%
HE	82.8	22.2	27%
KW	175.6	24.7	14%
KE	158.76	27	17%
L	114.04	26.5	23%
ME	115.84	29.2	25%
MW	112.48	28.3	25%
N	119.76	21.5	18%
S	160	25.1	16%
T	68.72	20.2	29%
PS	133.76	25.1	19%
PN	132.8	22.5	17%
RS	105.17	19.8	19%
RC	137.42	25.8	19%
RN	59.81	11.2	19%
Total	**2353.96**	**494.7**	**21%**

Street length and composition in each wards provide a detailed overview of the total street lengths and their composition, categorized into residential areas and highways, across all 24 wards of the BMC (Table 1). It also outlines the lengths and compositions of the survey tracks used during the street dog population survey,

consistent with the routes established in the 2014 survey. By comparing track lengths and their respective environments, this table serves as a critical resource for understanding the geographic scope and context of the data collected during the survey. The consistency in track selection from the previous survey ensures comparability and accuracy in longitudinal data analysis.

Table 2 – Total street length and composition (residential vs highways) and track length and composition by ward (same as 2014 survey)

| Ward	Total km	% Residential Area Streets	Survey Track km	% Residential Area Streets in Survey Track
A	74.76	76	21.7	72
B	44.32	90	8.7	78
C	33.28	84	14.9	81
D	80.08	72	11.7	71
E	60.08	83	15.1	74
GS	61.08	70	14.5	70
FS	70.8	82	17.3	83
GN	75.6	71	16.3	69
FN	91.16	87	25.3	79
HW	85.84	82	20.1	74
HE	82.8	85	22.2	71
KW	175.6	76	24.7	72
KE	158.76	86	27	80
L	114.04	87	26.5	83
ME	115.84	88	29.2	84
MW	112.48	88	28.3	84
N	119.76	78	21.5	73
S	160	88	25.1	83
T	68.72	90	20.2	80
PS	133.76	87	25.1	82
PN	132.8	90	22.5	87
RS	105.17	90	19.8	81
RC	137.42	88	25.8	84
RN	59.81	86	11.2	88
Total	2353.96		494.7	
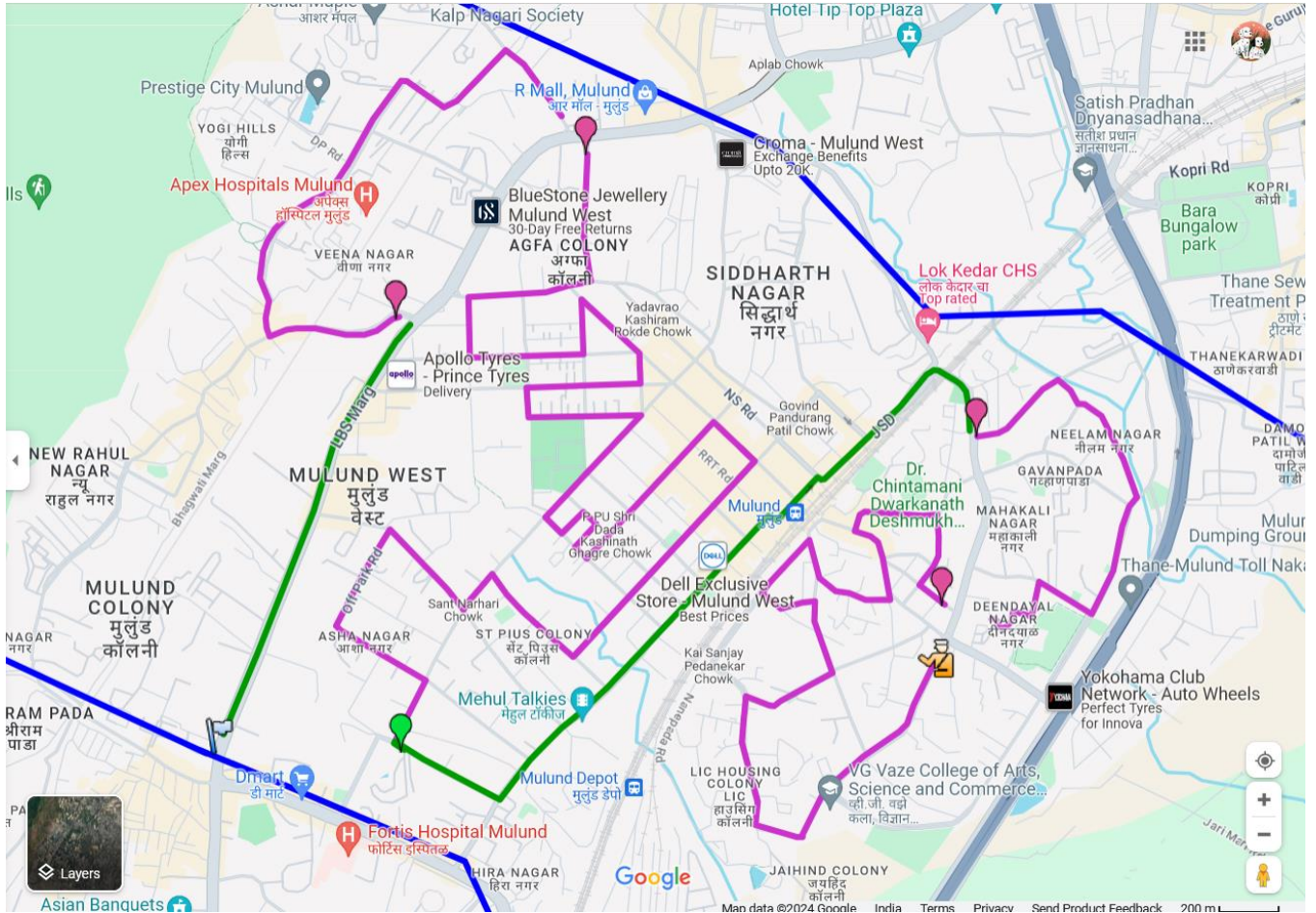
Figure 4. Google map of Wad T-Survey route layout. The ward boundary is shown with blue colour lines; green and pink colour lines are pre-defined routes for counting free roaming dogs. The flag icon indicates the start point, whereas the police icon indicates the end point.

Google map displays the boundary of Ward T in BMC, delineated by blue color lines. The predefined routes for counting free-roaming dogs are marked with green and pink lines, indicating residential and non-residential areas of the survey tracks. A flag icon at each route's starting point and a police icon at the end point help in navigating and demarcating the survey paths clearly. This visual representation aids in understanding the spatial planning and logistics of the street dog count survey conducted in this specific ward (Figure 4).
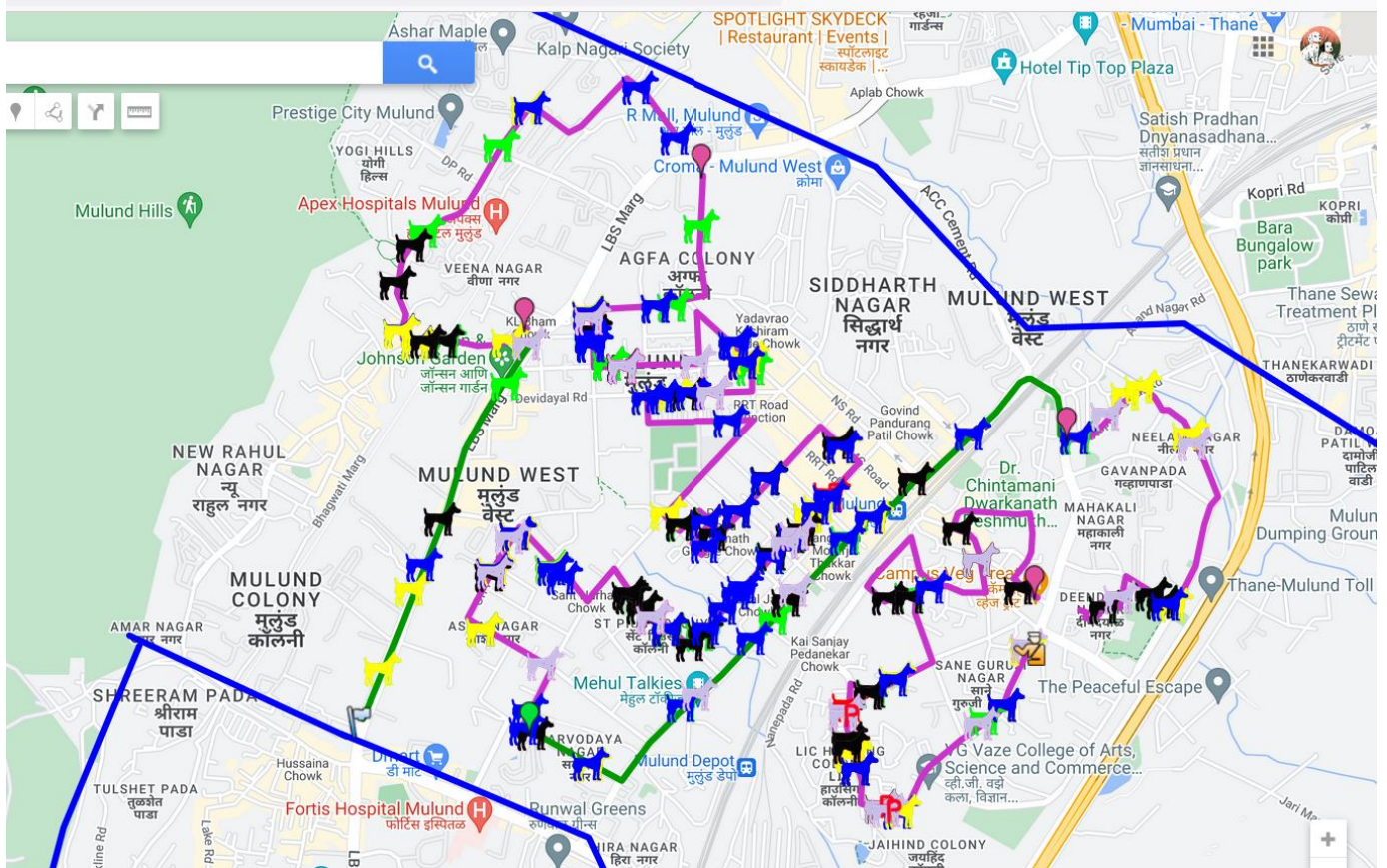
Figure 5. Google Map of Ward T with survey track: Dogs counted during the 2024 survey, with dogs' locations shown with a combination of various colours to indicate their reproductive status, gender, and sterilization status.

The above figure illustrates the survey route layout within Ward T, annotated with colored dog icons representing different categories of dogs counted during the 2024 survey. Each color signifies a specific type: blue icons for unsterilized male dogs, black for sterilized male dogs, green for sterilized female dogs, yellow for unsterilized female dogs, red for lactating females, grey for dogs of unknown status, and icons with a 'P' symbol for pups. This visual tool effectively demonstrates the distribution and demographic composition of the street dog population along the surveyed routes (Figure 5).

Findings

OVERVIEW

We conducted surveys in 24 wards in Mumbai, 930 km of the 2,354 km were covered during 2024 free-roaming dog population survey. Our survey found a total of 9,064 dogs including 176 pups and 325 cats. Using street dog sterilization data provided by BMC since 1994 and a population estimation method known as survival estimates, we estimate the dog population in Mumbai to be 90,757. This represents a decrease from our 2014 survey, which estimated a population of 95,172 free-roaming dogs, with 9,825 dogs (9,628 excluding pups) counted during the survey-on-survey routes. Our survey calculated a male-to-female ratio of 1.5 to 1 average

across the wards. Of all dogs surveyed, 62.9% were sterilized ward-wise. During our 2024 survey, we observed 7.1% lactating females and 4.3% pups. Lactating females decreased in our 2024 survey by 2% (9.1% in 2014); however, pups increased by 0.6% (3.7% in 2014). Cats were counted over 185 km of street length, with an average of 0.36 cats per km. Dogs were counted over 930 km of street length, with an average of 8.01 dogs per km. Slum dog counts were conducted later at the request of the BMC. Slum count showed a decrease in dog population and sterilization rates for males and females. An estimated population of 21,094 dogs in the slums, average of 5.2 dogs per km. Slum total sterilization rate was at 57.1% and we observed 4% lactating females and 10% pups.

DOG POPULATION DEMOGRAPHY

Our initial dog survey back in 2014 allowed for the comparison of dog population estimates and the success of sterilization efforts throughout Mumbai. We recorded the number of male and female dogs with ear notches (sterilized), without ear notches (intact males and females), lactating females, and pups. Dog density (dogs per km) and proportion of lactating females and pups are key indicators to measure ABC programs' effectiveness. Skin issues and body conditions were considered welfare indicators during counts. The long-term indicators that we will use for comparison are female dog sterilization rates and the number of dogs per kilometer.

Our survey results suggested an overall decrease in the dog population among the wards. However, some wards experienced an increase in dog populations. Comparison plots between the wards from 2014 and 2024 demonstrate the increase and decrease in street dog counts (Figure 6). We recorded an increase in total dog populations in 4 wards: Ward E, N, RS, and T (Figure 7). An increase in dog populations could be the result of immigration of dogs from outside Mumbai (adjoining geographical area, e.g., Thane), migration of dogs between wards, pet abandonment, and, with the increase in human population and settlements, an increase in more access to food and care by communities.
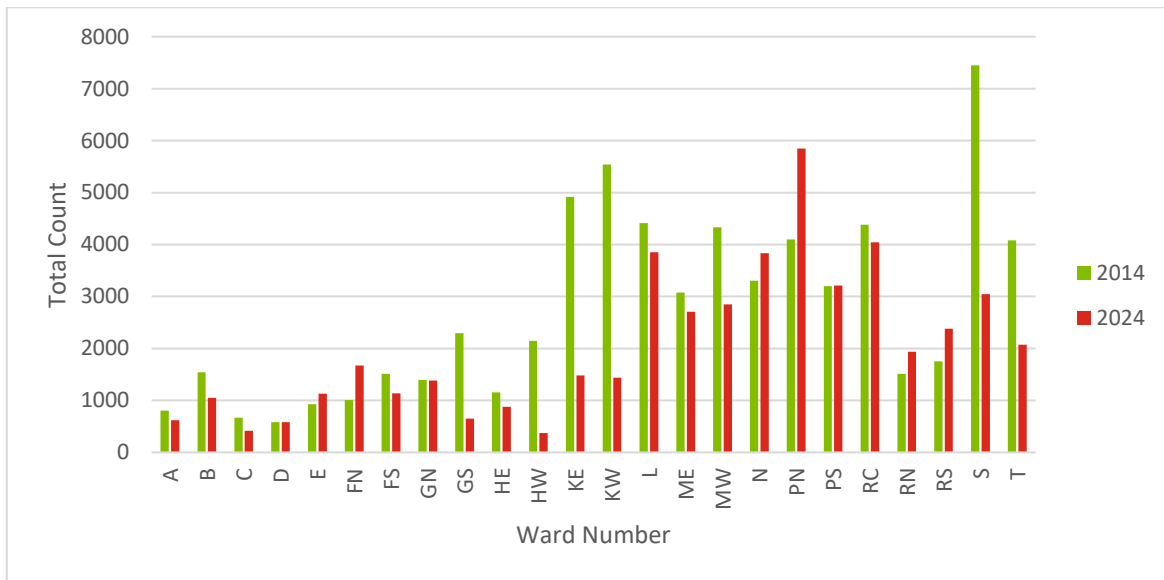

Figure 6. Ward-wise total dog count comparison between years 2014 and 2024 in Mumbai, India. Blue bars indicate the initial 2014 count. Orange bars indicate a decrease in total dog count, and red bars indicate an increase in total dog count in each ward during the 2024 survey.
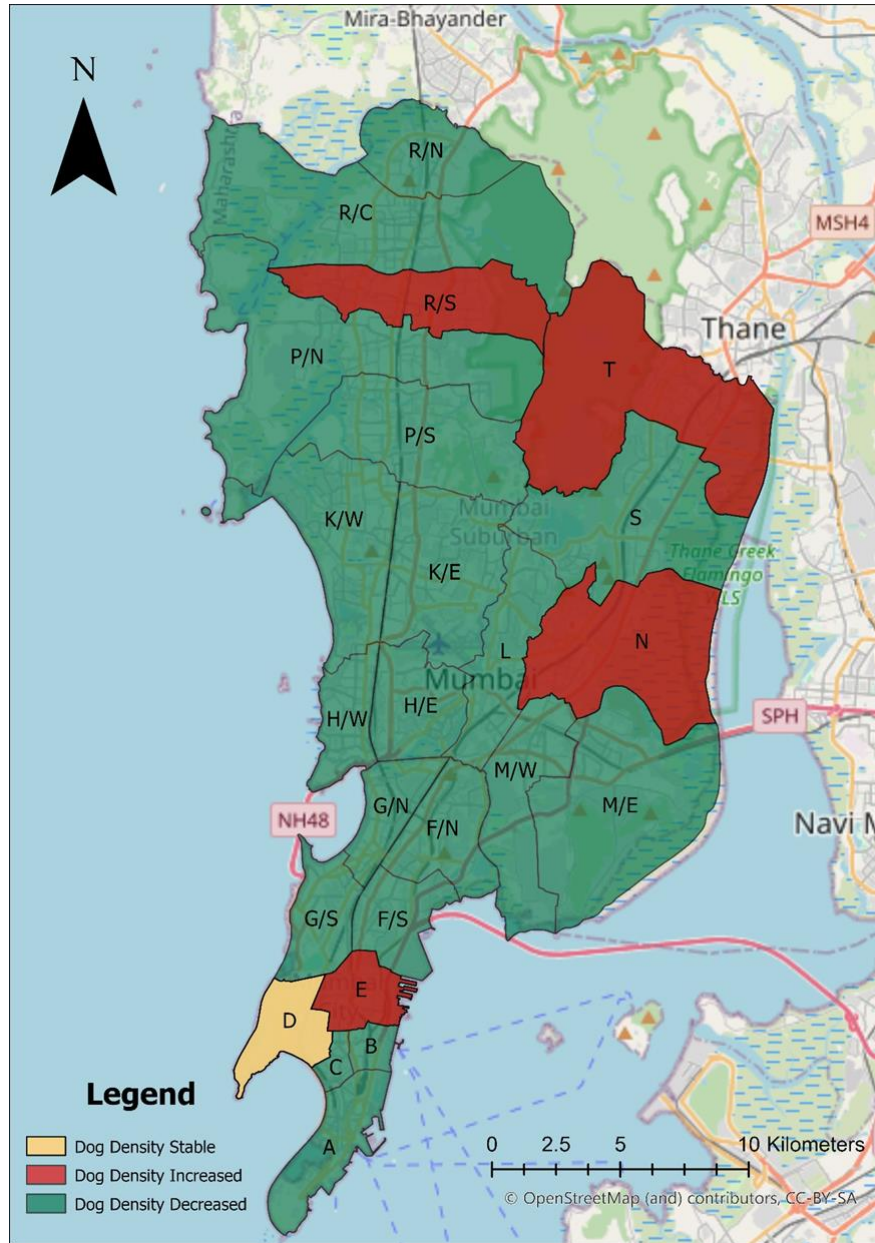
Figure 7. ArcGIS map of Mumbai, India, during the 2024 dog count survey. The map shows which wards have decreased in dog populations (green), remained stable (yellow), and increased in dog populations (red).

Our survey results indicate that while there is an overall decrease in the dog population ward-wise in Mumbai, there are component issues. Table 3 displays the count results, extrapolation of total dogs roaming the streets, and total population adjusted for detectability. During our 2024 street dog survey, our population estimate indicated an overall decrease of dog density, but we did see an increase in intact males and females. Our 2014 survey found that 8.5% of males were intact and 5.8% of females were intact, with a total sterilization rate of 74.8% (77.1% males and 72.0% females; Figures 8 and 9). However, our 2024 survey found that 18.3% of males were intact and 10.3% of females were intact, with a total sterilization rate of 62.9% (63.7% males and 61.7% females; Figures 8 and 9). This is an increase of 9.8% of intact males and 4.5% of intact females, and a decrease

of 11.9% total sterilization (13.4% males and 10.3% females). The ward-wise comparison for the 2024 survey demonstrates that many wards decreased in sterilization rates compared to the 2014 survey (Table 4). The survey recorded an average of 8.01 dogs per km of the approximately 930 km of street lengths (Figure 10). This is a decrease from the 2014 survey, which had an average of 10.54 dogs per km (Figure 10). We estimate that there is a 21.8% decrease in street dog populations ward-wise in Mumbai in 2024 compared to 2014 (Table 5).
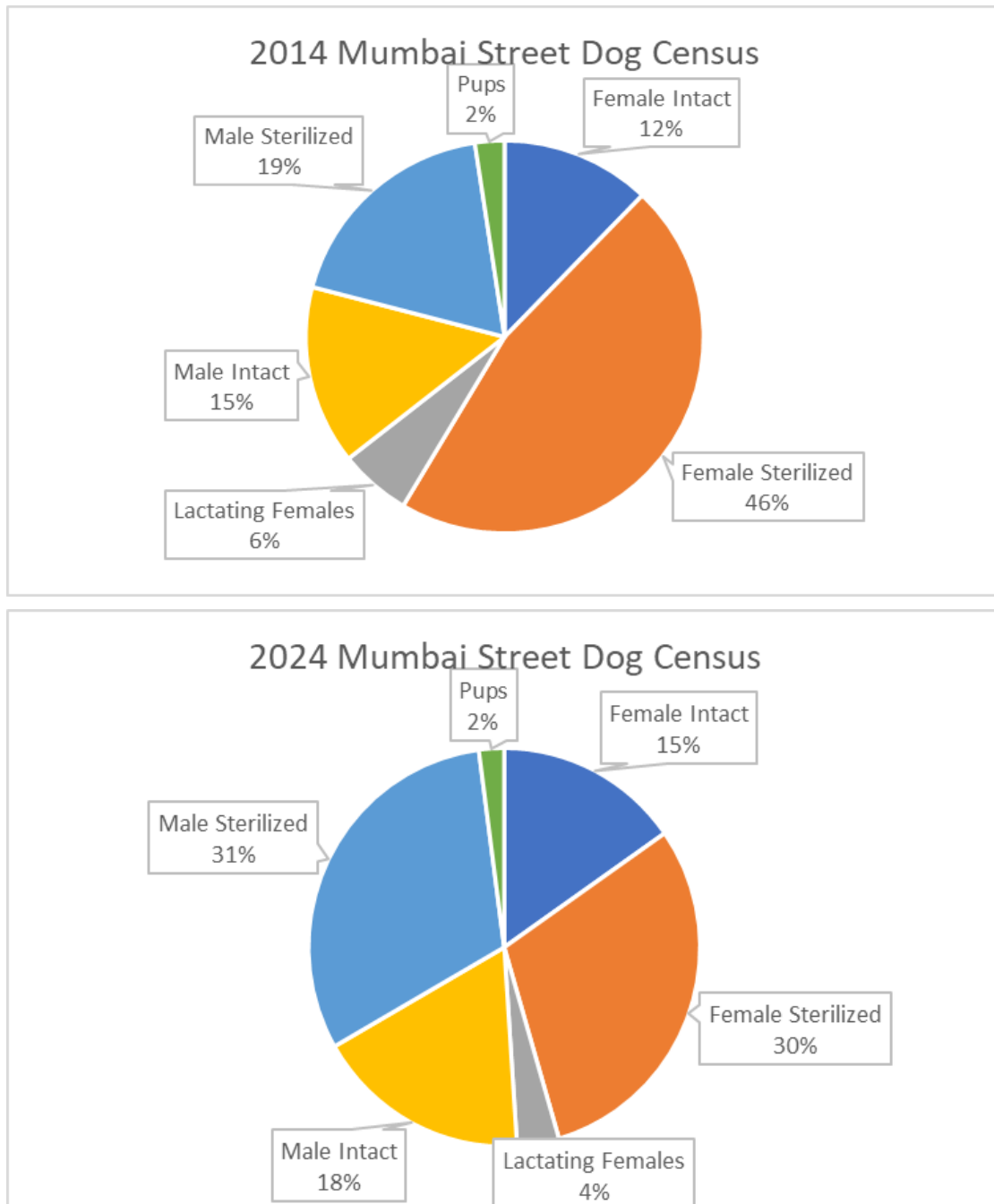
Figure 8. Street dog population census from 2014 and 2024 in Mumbai, India. Total dog count of 9,825 (2014) and 9,064 (2024) individuals categorized based on male and female sterilization, male and female intact, unknown adults, lactating females, and pup percentages.
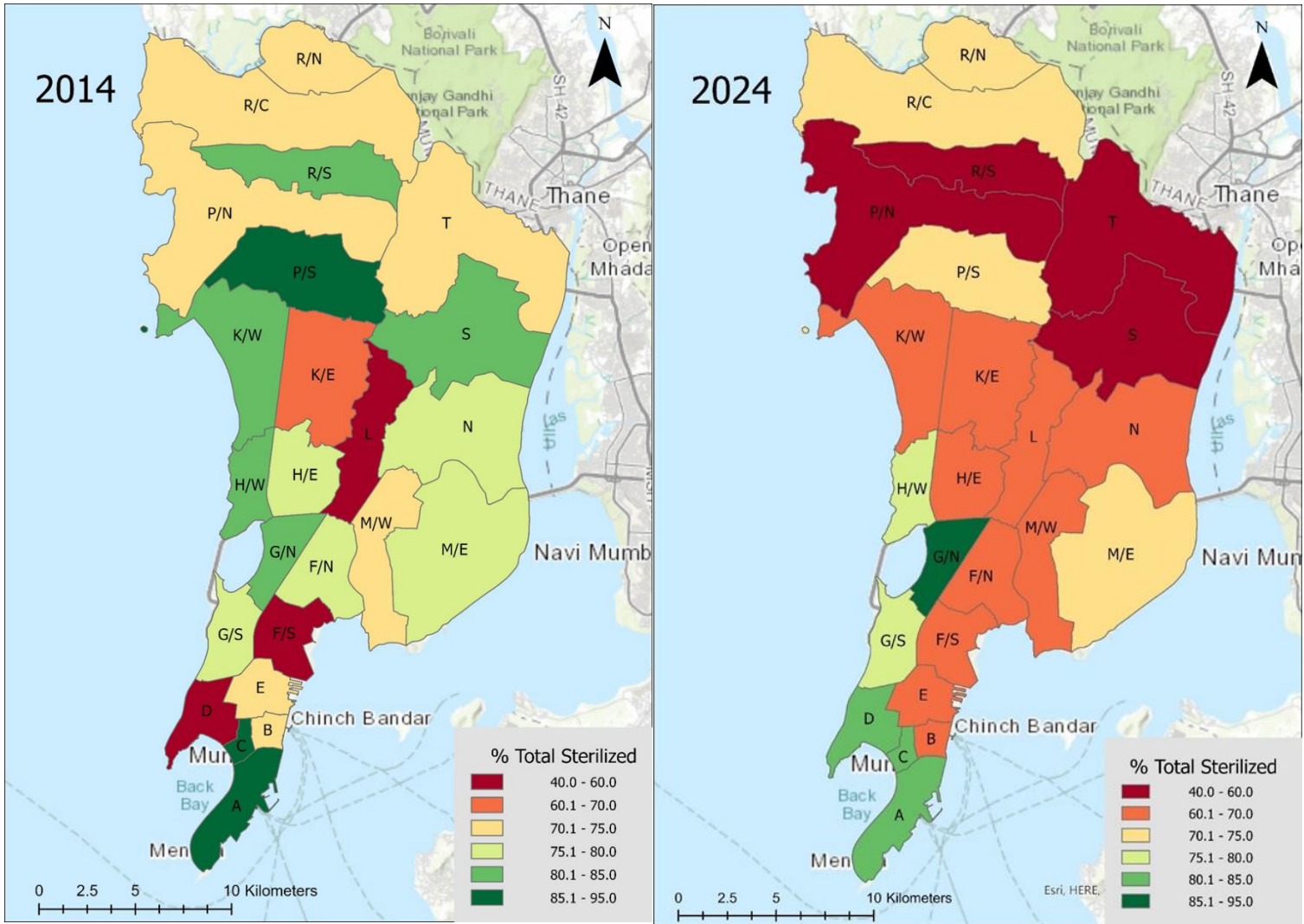
Figure 9. An ArcGIS map of the 2014 and 2024 dog survey counts. The map shows ward-wise comparisons of the percentage of total sterilization. Red wards are wards with 40–60% sterilization, orange wards are 60.1–70% sterilization, yellow wards are 70.1–75.0% sterilization, light green wards are 75.1–80.0% sterilization, green wards are 80.1–85.0% sterilization, and dark green wards are 85.1–95% sterilization.

Table 3. Count results for all wards in Mumbai, India, during the 2024 street dog survey count. Dogs counted per km of street surveyed, total street length, and estimate of total dogs on the street per ward during the survey. The final column uses a 0.4 probability of detecting a dog to extrapolate the total roaming dog population per ward, a process known as corrected detectability.

Ward/Track ID	Dogs counted per km	Total street length	Dogs on the streets	Total roaming dogs
A	3.3	74.76	249	622
B	9.47	44.32	420	1049
C	5.01	33.28	167	417
D	2.91	80.08	233	583
E	7.52	60.08	452	1130
FN	7.35	91.16	670	1675
FS	6.42	70.8	455	1136
GN	7.33	75.6	554	1385
GS	4.24	61.08	259	647
HE	4.23	82.8	350	876
HW	1.73	85.84	149	371
KE	6.73	158.76	592	1480
KW	3.28	175.6	576	1440
L	13.52	114.04	1542	3855
ME	9.34	115.84	1082	2705
MW	10.12	112.48	1138	2846
N	12.81	119.76	1534	3835
PN	17.61	132.8	2339	5847
PS	9.60	133.76	1284	3210
RN	12.94	59.81	774	1935
RS	9.06	105.17	953	2382
S	7.62	160	1219	3048
T	12.05	68.72	828	2070
RC*	11.8	137.42	1617	4041
Street Total		2353.96	19436	48585
Slum Total	5.2	1622.6	8437.6	21094
Total		3976.56	27873.6	69679

*Ward RC is included in the Ward RN track.

Table 4. Ward-wise comparison of sterilization rates for total sterilized, female sterilization rates, and male sterilization rates in Mumbai, India, during the January 2024 Street dog survey. Red boxes represent a decrease, green boxes represent an increase, and gray boxes represent no change in sterilization rates compared to the 2014 survey.

Ward Number	Total Count	% Total Sterilized	% Sterilized Females	% Sterilized Males
A	72	82.2	93.0	76.0
B	82.5	68.6	57.8	73.1
C	74.5	83.8	80.9	85.4
D	34s	82.7	85.0	81.3
E	113.5	68.8	62.3	73.2
FN	186	66.6	68.6	65.2
FS	111	67.9	59.7	73.9
GN	119.5	89.6	94.3	86.7
GS	61.5	76.6	82.9	72.9
HE	93.5	63.8	70.9	59.3
HW	34.5	78.8	88.9	71.8
KE	181.5	61.5	60.5	62.3
KW	83.5	63.5	67.1	59.1
L	358	67.6	66.8	68.3
ME	247.5	70.8	66.9	72.9
MW	215.5	61.4	54.4	64.8
N	275.5	64.4	69.3	60.8
PN	396	50.1	55.0	45.5
PS	240.5	72.6	75.1	70.8
RN and RC	317	73.1	69.5	75.7
RS	282	49.5	45.0	51.4
S	191	44.2	42.9	45.0
T	243	46.7	46.5	46.9
Slum	315	57.1	60.2	54.9

Table 5. Ward comparison of street dog populations between the 2014 survey and the 2024 survey in Mumbai, India. Wards are broken into whether dogs per km increased, decreased, or remained stable and at what percentage they increased or decreased.

Stable Ward	Dogs counted on survey track (Dog per km) in 2014	Dogs counted on survey track (Dog per km) in 2024	% change
D	34 dogs (2.9 dogs/km)	34 dogs (2.9 dogs/km)	0.0%

Increased Wards	Dogs counted on survey track (Dog per km) in 2014	Dogs counted on survey track (Dog per km) in 2024	% change
E	93 dogs (6.2 dogs/km)	113.5 dogs (7.5 dogs/km)	+22.0%
N	237.5 dogs (11 dogs/km)	275.5 dogs (12.8 dogs/km)	+16.0%
RS	254.5 dogs (11.7 dogs/km)	282 dogs (12.9 dogs/km)	+10.8%
T	177.5 dogs (8.8 dogs/km)	243.5 dogs (12.1 dogs/km)	+37.2%
		Total Increase in 4 wards	+19.9%

| Decreased Wards	Dogs counted on survey track (Dog per km) in 2014	Dogs counted on survey track (Dog per km) in 2024	% change
A	93.5 dogs (4.3 dogs/km)	72 dogs (3.3 dogs/km)	-23.0%
B	121 dogs (13.9 dogs/km)	82.5 dogs (9.5 dogs/km)	-31.8%
C	120 dogs (8.1 dogs/km)	74.5 dogs (5.0 dogs/km)	-37.9%
FN	255 dogs (10.1 dogs/km)	186 dogs (7.4 dogs/km)	-27.1%
FS	148 dogs (8.6 dogs/km)	111 dogs (6.4 dogs/km)	-25.0%
GN	120.5 dogs (7.4 dogs/km)	119.5 dogs (7.3 dogs/km)	-0.8%
GS	95.5 dogs (6.6 dogs/km)	61.5 dogs (4.2 dogs/km)	-35.6%
HE	230 dogs (10.4 dogs/km)	93.5 dogs (4.2 dogs/km)	-59.3%
HW	108.5 dogs (5.4 dogs/km)	34.5 dogs (1.7 dogs/km)	-68.2%
KE	377 dogs (14 dogs/km)	181.5 dogs (6.7 dogs/km)	-51.9%
KW	284.5 dogs (11.2 dogs/km)	83.5 dogs (3.4 dogs/km)	-70.7%
L	410 dogs (15.5 dogs/km)	358 dogs (13.5 dogs/km)	-12.7%
ME	281 dogs (10.6 dogs/km)	247.5 dogs (8.6 dogs/km)	-11.9%
MW	327 dogs (15.4 dogs/km)	215.5 dogs (7.6 dogs/km)	-34.1%
PN	505 dogs (22.4 dogs/km)	396 dogs (17.6 dogs/km)	-21.6%
PS	306.5 dogs (12.2 dogs/km)	240.5 dogs (9.6 dogs/km)	-21.5%
RN and RC	424 dogs (11.9 dogs/km)	317 dogs (9.1 dogs/km)	-25.5%
S	275 dogs (11 dogs/km)	191 dogs (7.6 dogs/km)	-30.5%
		Total Decrease in 19 wards	-31.6%
	Total Dog Density Declined in Mumbai		-21.8%
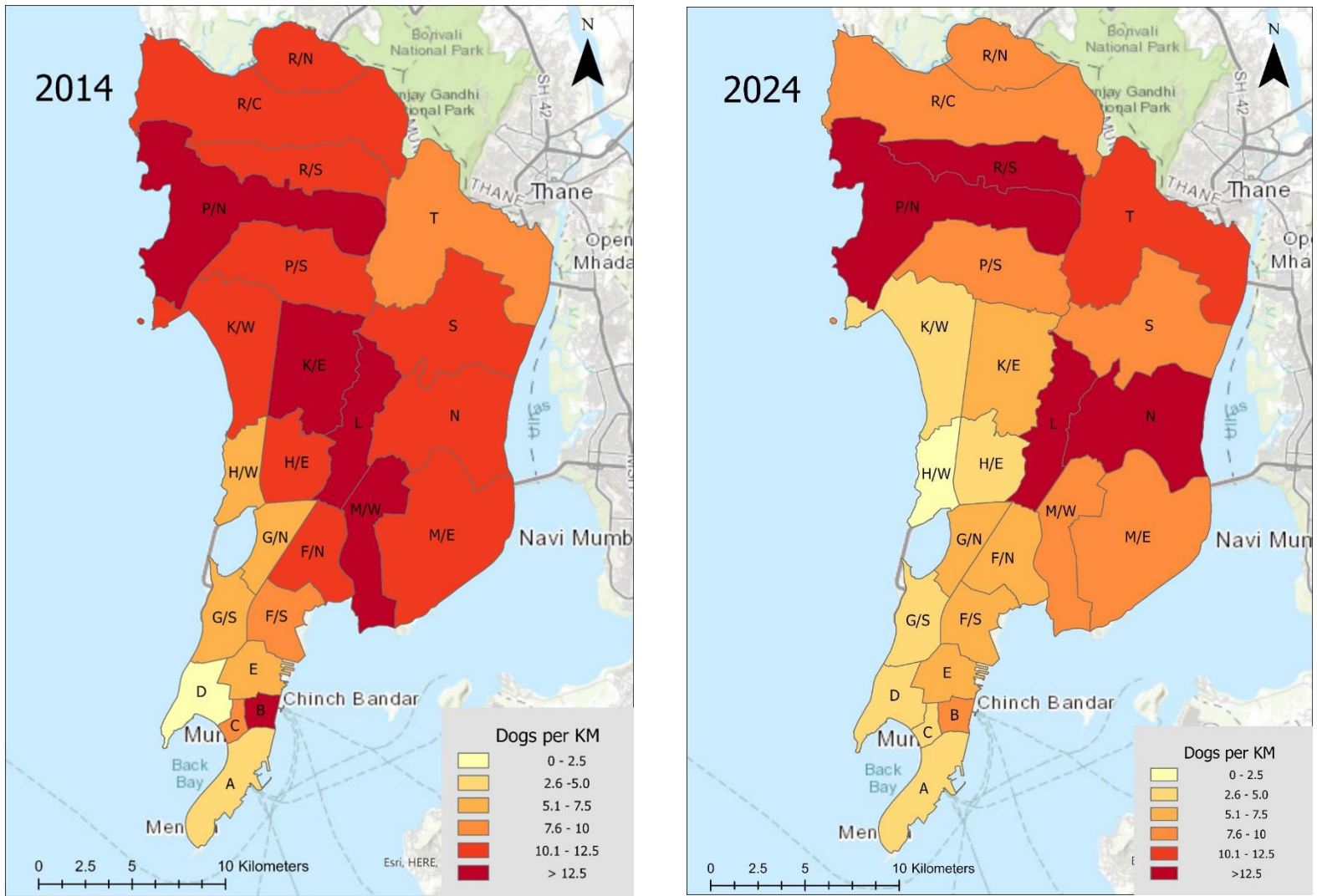
Figure 10. Ward-wise comparison of dogs per km for the 2014 and 2024 dog survey count in Mumbai, India. An average of 10.54 dogs per km (2014) and 8.01 dogs per km (2024) were recorded ward-wise.

In our 2024 survey, we implemented a protocol to count collared dogs in each ward, an approach not included in the 2014 survey, likely due to fewer of collared dogs at that time. As a result, direct comparisons between the two surveys regarding collared dogs are not possible. In 2024, we counted a total of 210 collared dogs. In Ward D we recorded the highest percentage at 44.2%, followed by wards HW (16.7%) and KW (16.2%), as detailed in Table 6. The presence of these collared dogs could result from pet abandonment, roaming owned dogs, or community owned street dogs that were collared by local residents. In India, most owned dogs are pedigree dogs, and during both the 2014 and 2024 surveys, we rarely spotted pedigree dogs on the streets. This suggests that collars on street dogs primarily signify informal care or different forms of acknowledged ownership, pointing to most being community-owned rather than personal pets.

Table 6. Collared dogs counted during our 2024 street dog survey count in Mumbai, India.

Track ID	Total Collared Dogs	% Collared Dogs
A	8.5	14.4
B	1.5	2.0
C	1.5	2.2
D	11.5	44.2
E	1	1.1
FN	19.5	13.2
FS	6	7.5
GN	14	12.6
GS	5.5	9.9
HE	4.5	6.4
HW	5.5	16.7
KE	14	9.6
KW	12	16.2
L	9	3.1
ME	5.5	2.4
MW	7	4.0
N	14	8.7
PN	13	4.0
PS	20.5	9.7
RN and RC	10.5	3.6
RS	7	2.8
S	3	1.7
T	17	8.3
Total	**210**	**6.1**

The comparison between the wards aids in identifying potential areas for increased sterilization efforts (Figure 11). Given the decrease in female sterilization in 2024, efforts to reduce the number of lactating females and pups in Mumbai would be difficult. Sterilization rates across Mumbai decreased from our 2014 survey by 11.9% (Figure 12). The percentage of lactating females decreased from 9.1% to 7.1% (Figure 13), and the percentage of pups increased from 3.7% to 4.3% (Figure 14). Both surveys were conducted in January, when pups are being born and growing. Furthermore, this suggests that more pups were present despite having a decreased percentage of lactating females within the wards in 2024 compared to 2014.

Figure 11. Ward-wise comparison of percent total sterilization throughout Mumbai, India, from the 2014 and 2024 street dog surveys. Red bars represent the 2014 survey count, and green bars represent the 2024 survey count.
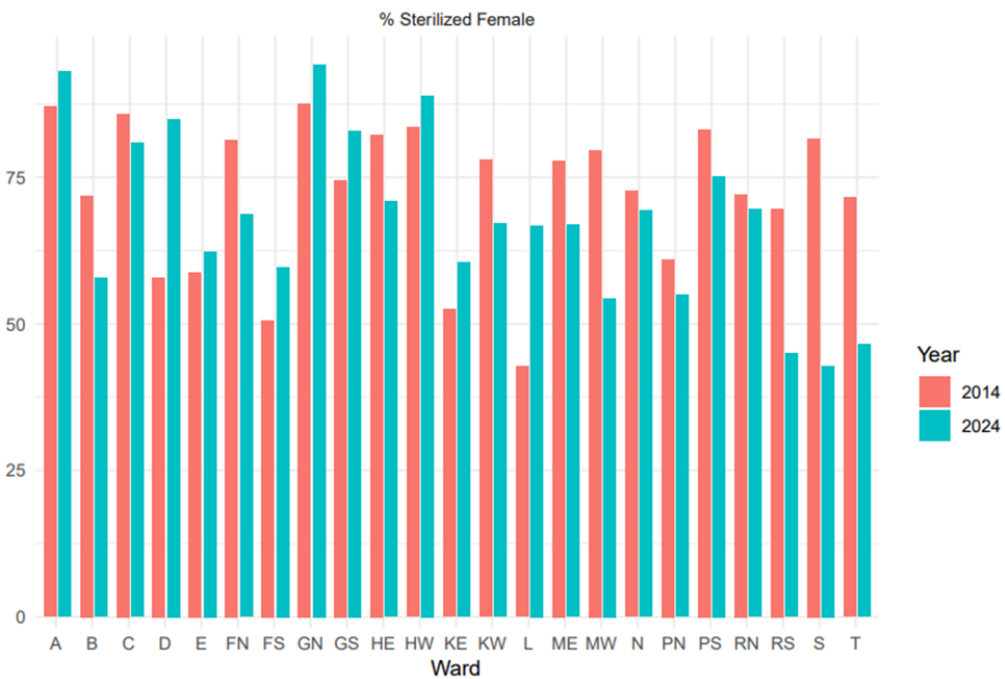

Figure 12. Ward-wise comparison of percent female sterilization rates throughout Mumbai, India, from the 2014 and 2024 street dog surveys. Red bars represent the 2014 survey count, and green bars represent the 2024 survey count.
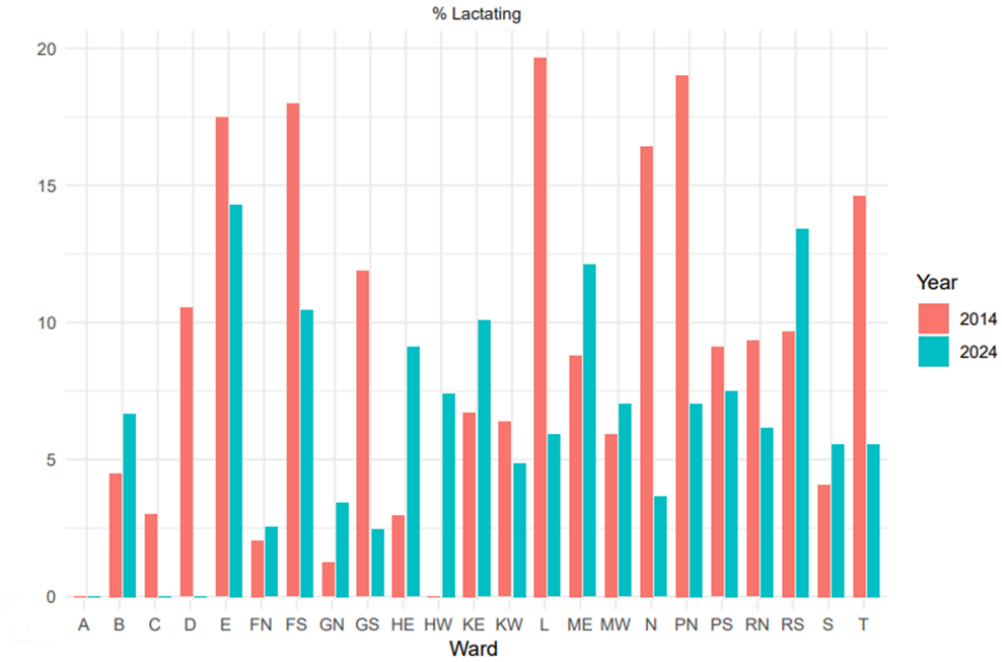
Figure 13. Ward-wise comparison of percent lactating females throughout Mumbai, India, from the 2014 and 2024 street dog surveys. Red bars represent the 2014 survey count, and green bars represent the 2024 survey count.
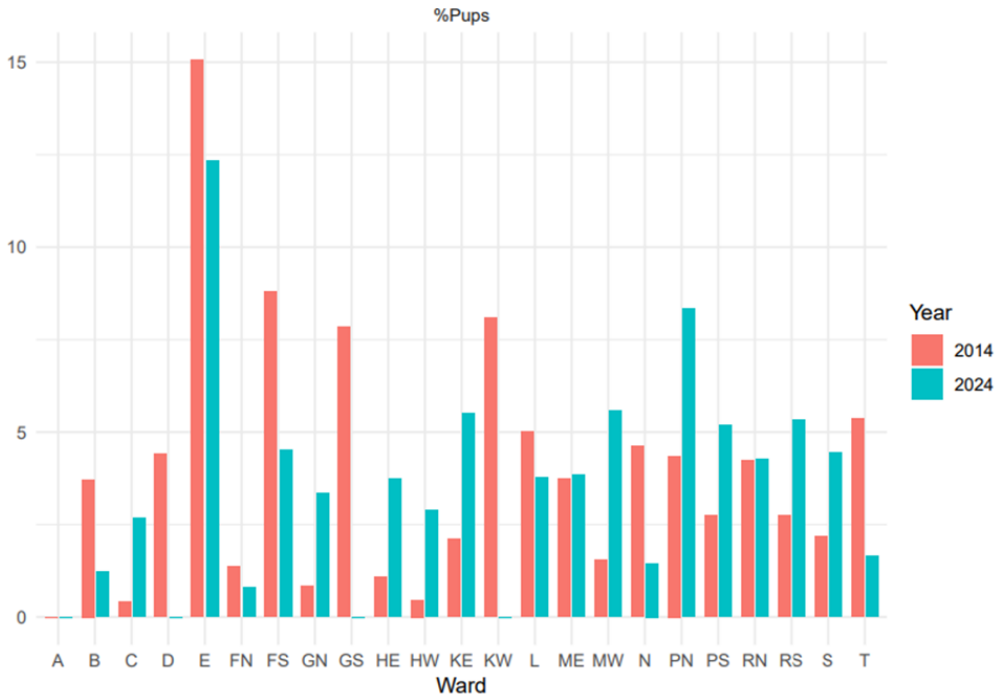

Figure 14. Ward-wise comparison of percent pups throughout Mumbai, India, from the 2014 and 2024 street dog surveys. Red bars represent the 2014 survey count, and green bars represent the 2024 survey count.

Welfare indicators were also recorded during both the 2014 and 2024 dog count surveys. We focused our welfare indicators on dogs with skin conditions and body scores. During the 2014 survey, 20 dogs (o.6%) were accounted for having skin conditions (Figure 15), and ~10 dogs (0.3%) were accounted for having low body conditions (Figure 16). We saw an increase in dogs with skin conditions but a decrease in low body conditions during our 2024 survey. Our 2024 survey found a total of 44 dogs with skin conditions (1.3%; Figure 15) and 8 dogs with low body conditions (0.2%; Figure 16). Ward-wise comparisons between the 2014 and 2024 surveys can be shown in Figures 12–15. In the 2014 survey, wards FN, MW, and S had the highest percentages of skin problems, and wards D, C, MW, HE, and S had the highest percentage of low body conditions. In 2024, wards L and N had the highest percentage of dogs with skin problems, followed by wards PS, ME, FN, and GS. We did not have any wards with an extremely high percentage of low body conditions, but wards KW, KE, FN, and GS still had a high percentage of low body conditions.
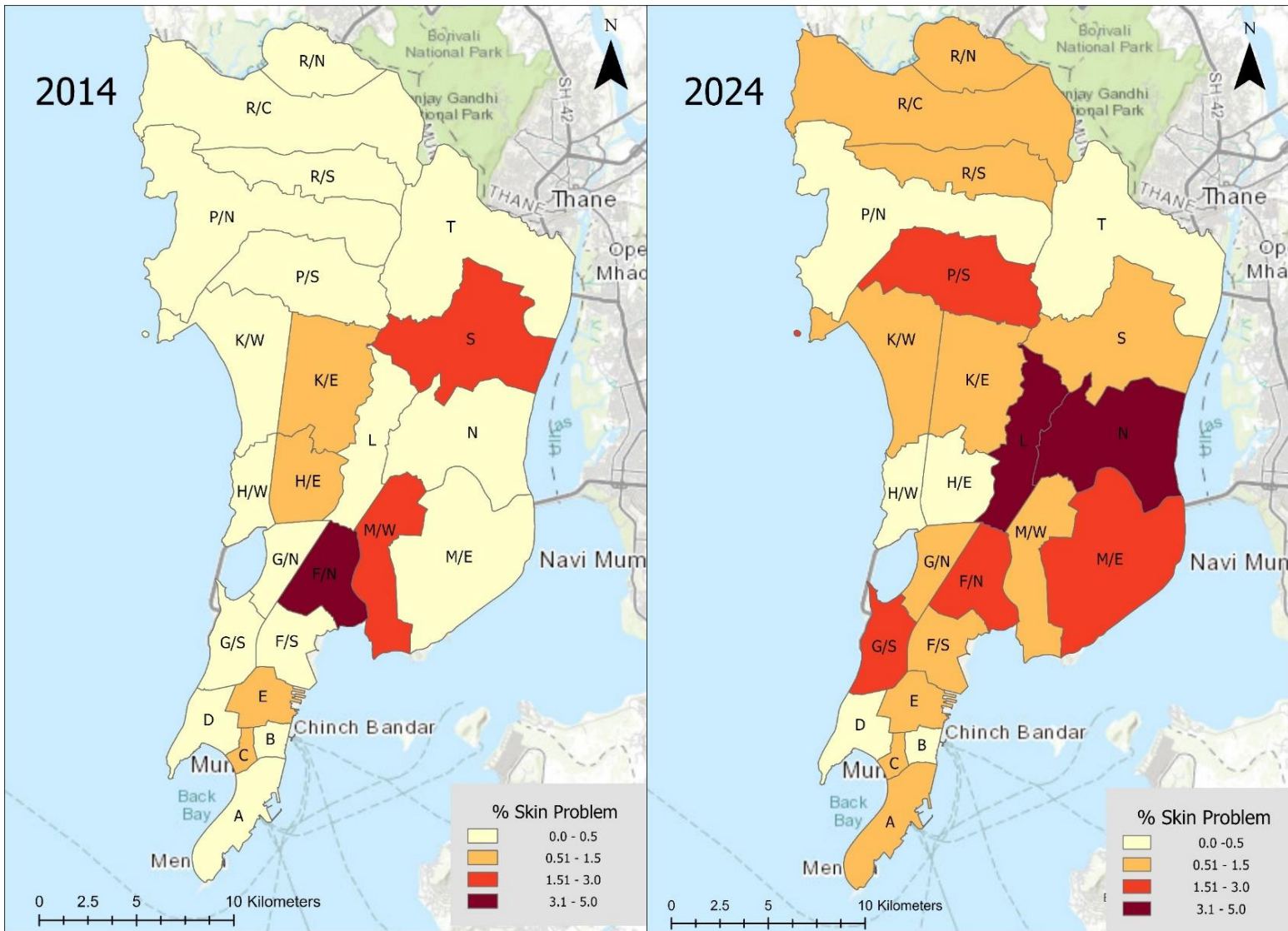

Figure 15. Ward-wise comparison of street dogs with skin conditions during the 2014 and 2024 dog count survey in Mumbai, India.
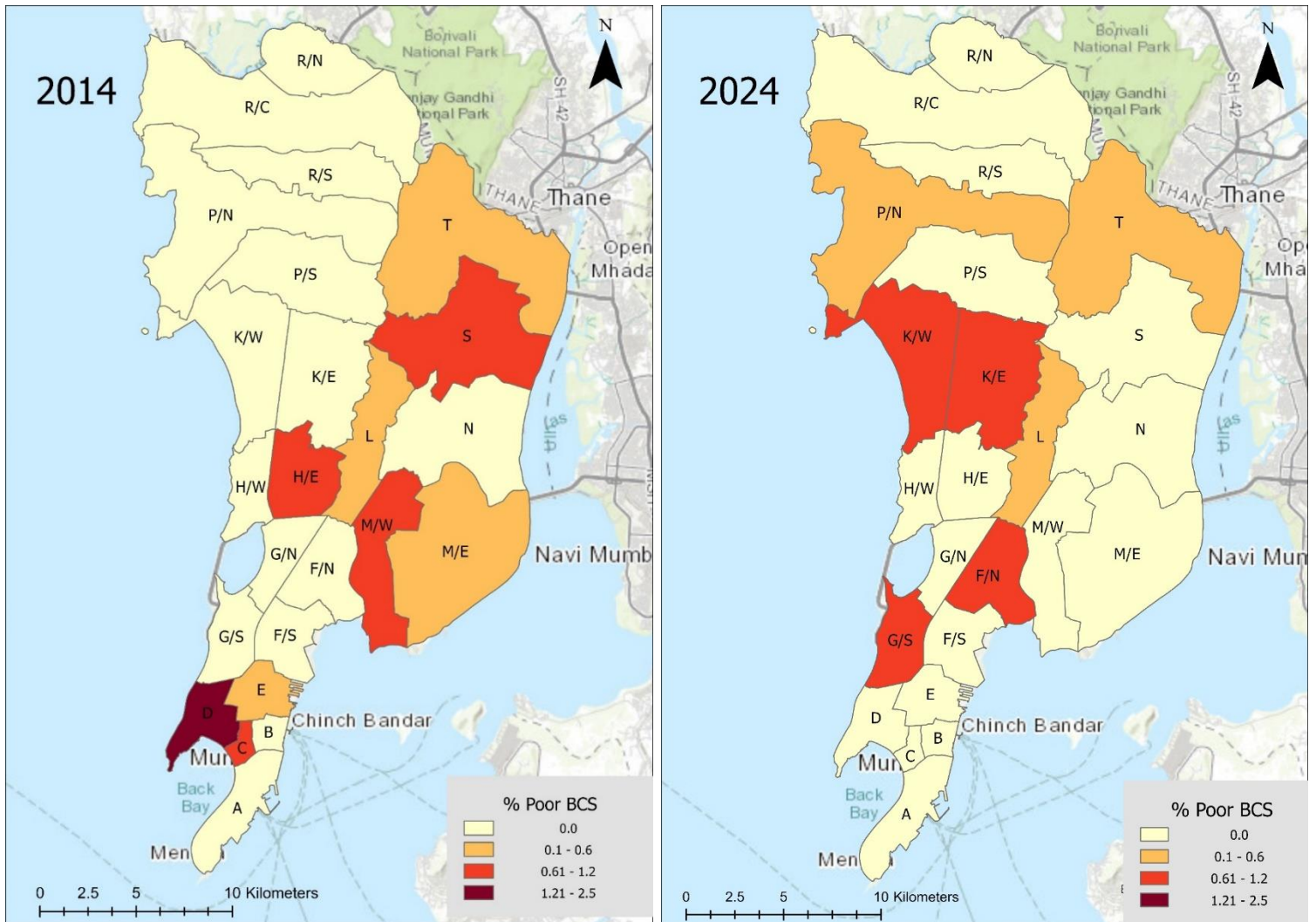
Figure 16. Ward-wise comparison of street dog body conditions during the 2014 and 2024 dog count surveys in Mumbai, India.

IN SLUMS

During the 2024 survey, street dog counts were conducted in Mumbai's slum areas using the same methodology as in 2014. The surveyed slum areas included Dharavi, Bhatia Nagar, Raval Pada (Wadala East), and Jogeshwari East (Southeast of Mahakali Caves Rd). All passageways within these regions were covered, and the areas were measured using Google Earth and an area calculator (Earth Point, 2024). The survey covered a total distance of 53.9 km on foot within the selected slum area of the Brihanmumbai Municipal Corporation (Table 8).

Table 7. Survey Route Coverage and the dogs counted in Four Slum Locations

Slum	Street covered under walking survey (KM)	Dog Count	Dogs/km
Jogeswari East	8.1	58	7.2
Dharavi	26.7	120	4.5
Bhatiya Nagar Slum	8.4	67	8.0
Raval Pada	10.8	37	3.4
Total	**53.9**	**282**	**5.2**

Based on the survey conducted in the slum area, the average of 5.2 dogs per kilometer are found within Mumbai's slum areas (Table 8). To calculate the average street length, we analyzed the distance covered in a 1.4 km² area, which was 53.9 km. This translates to an average street length of 38.4 km per square kilometer.

According to the data shared by BMC, we have the total slum area in Mumbai is 42.3 km² based on which, we estimate a total street length of 1622.6 km within the slums.

By extrapolating our estimated street length, we estimated that approximately 21,093.9 dogs roam the slum areas, covering the entire 42.3 km² (Table 9).

Table 8: Estimated Street Length and Dog Population in Slum areas of Mumbai

Average Street Length per km²	Mumbai Slum Area (km²) (Official Data)	Dog Density per km in Slum	Estimated Road Network in Slums Areas (km)	Dogs in the Slum	Total Free-Roaming dogs in the Slum (Estimated)	Detectability
38.4	42.3	5.2	1622.6	8437.6	21093.9	0.4

A 10-year comparative analysis of Mumbai's slum dog population reveals a decline in total density. In 2014, the estimated population was 29,085 dogs, which decreased by 27.4% by 2024. However, the sterilization rates among female and male dogs have also decreased over the decade. In 2024, the overall sterilization rate in slums was 57% (60% for females and 55% for males), down from 63% in 2014 (66% for females and 61% for males). Furthermore, our 2024 survey observed a decline in the percentage of lactating females (4% vs. 11% in 2014) and pups (10% vs. 12% in 2014).

ABUNDANCE ESTIMATE FROM ABC RELEASE DATA

To estimate abundance, we use records of total released and sterilized dogs from the BMC. These records have data dating back to 1994; however, to get a more accurate estimated population, we used data from 1998 and forward. Ear tipping (cutting left or right ear tip for identification) began in 1998; therefore, we used that as a starting point for population estimation. These records are used to estimate the number of surviving dogs with a survival percentage of 76.4% (Table 10). We used this survival percentage based on the 2014 report, in which the number of survivors prior to 1998 was not recorded.

Table 9. Number of dogs sterilized and released by ABC programs since 1998, the interval since release, and the number of surviving dogs to today, assuming 76.4% survival in Mumbai, India.

Year	Dogs sterilized and released	Interval since years	Survivors
1994	2975	29.5	1.1
1995	4899	28.5	2.3
1996	4379	27.5	2.7
1997	5585	26.5	4.5
1998	4936	25.5	5.2
1999	5594	24.5	7.6
2000	5728	23.5	10
2001	8204	22.5	19
2002	7761	21.5	24
2003	7682	20.5	31
2004	7852	19.5	41
2005	9204	18.5	63
2006	11242	17.5	101
2007	13152	16.5	155
2008	33245	15.5	512
2009	36990	14.5	746
2010	34045	13.5	899
2011	26961	12.5	932
2012	15134	11.5	685
2013	9722	10.5	576
2014	7236	9.5	561
2015	6414	8.5	651
2016	11967	7.5	1589
2017	24290	6.5	4222
2018	21886	5.5	4979
2019	18912	4.5	5632
2020	14407	3.5	5616
2021	17534	2.5	8946
2022	10484	1.5	7001
2023	14954	0.5	13071

TOTAL	403,374		57086
Estimated Dog Population for Mumbai			90,757
Estimated Unsterilized Dog in Mumbai			33,671

Of the dogs counted on the street and in the slums, we had a sterilization rate of 62.9%. With the estimates from the BMC, there is an estimated 57,086 survivors and a total population estimation of 90,757 roaming dogs (0.43 dogs per 100 people) and an unsterilized dog estimation of 33,671. HSI's street count estimates a population of **69679** (0.31 dogs per 100 people). Factors such as true survival rates year-to-year, migration, and immigration effect the accuracy of the two estimates. During our survey, we noticed intensive dog feeders that could be assisting in pup survival and allowing a small portion of dogs to successfully breed. Open sports grounds, schools/university, and gardens can also serve for additional feeding spots and safe areas for breeding. However, our street count estimate is not a gross underestimate from the BMC estimate.

CAT POPULATION DEMOGRAPHY

Free-roaming cat populations were surveyed during our 2024 street dog survey counts. We did not count free roaming cats during the 2014 survey count, which prevents us from making comparisons in this report. During the dog count, we manually recorded cats using verbal cues from bike riders and surveyors. To count roaming cats, we replicated the street dog count methodology, which might underestimate the total roaming cat population. Furthermore, we need to establish a sampling method for cats to provide a more accurate population estimate across all wards in Mumbai. A total of 325 cats were recorded in the 10 wards that accounted for free-roaming cats (Table 11).

Table 10. Free roaming cats that were counted during our 2024 dog survey count in Mumbai, India. Ten of the 24 wards were able to count for free roaming cats, accounting for 325 cats within those 10 wards.

Ward Number	Survey street length	Total street length	Number of roaming Cats	Cats counted per km
B	8.7	44.32	41	0.93
D	11.7	80.08	16	0.20
GS	14.5	61.08	38	0.62
HW	20.1	85.84	12	0.14
KW	24.7	175.6	25	0.14
L	26.5	114.04	53	0.46
N	21.5	119.76	18	0.15
PN	22.5	132.8	65	0.49
RN	11.2	105.17	23	0.22
S	25.1	160.0	34	0.21
Total	186.5	1,078.69	325	

ANALYSIS OF DOG-RELATED COMPLAINTS AND BITE INCIDENTS

Data on dog-related complaints and bites recorded by the Brihanmumbai Municipal Corporation (BMC) from 1994 to 2023 provides valuable insights into public concerns and behaviors of stray dogs. This extensive dataset enables us to identify patterns that could help in addressing the underlying causes of these complaints and potential dog bite incidents. Understanding these patterns is crucial for developing strategic measures aimed at enhancing public safety and promoting animal welfare.

DOG-RELATED COMPLAINTS

BMC has provided dog-related complaint data since 1994. Since 1994, we have evaluated trends in dog-related complaints (Figure 17). Our results demonstrated an overall decrease in dog-related complaints since 1994; however, an increase in complaints has occurred since the start of the Covid-19 pandemic. The pandemic is suspected to have decreased overall interaction with street dog populations due to shelter-in-place requirements. With pandemic requirements subsiding, it is not surprising to see an increase in complaints.
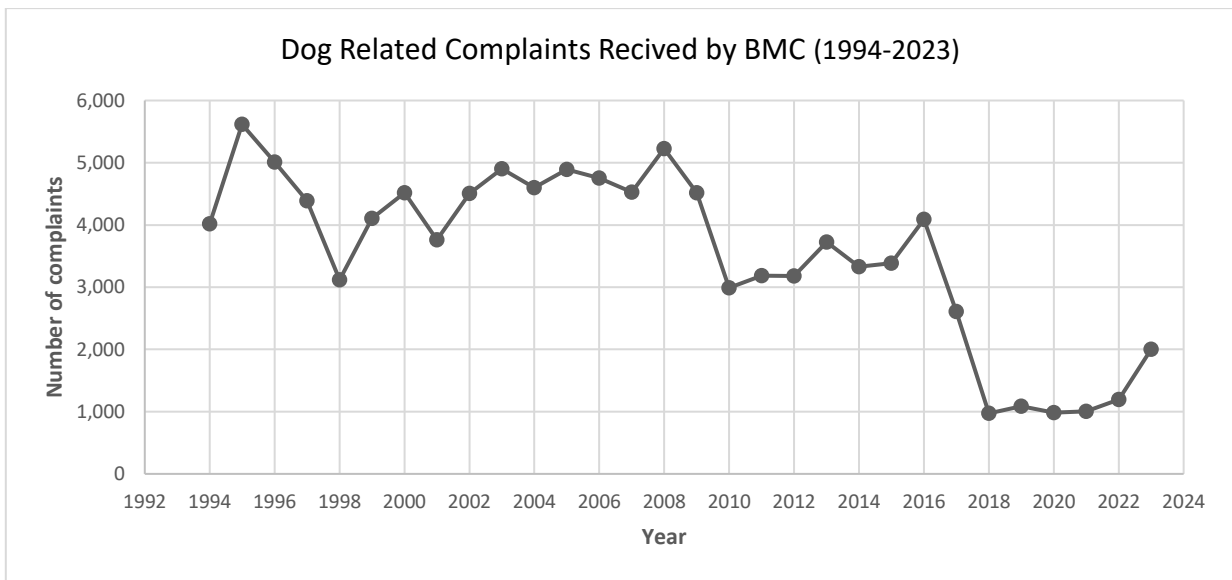

Figure 17. Dog-related complaints from the BMC in Mumbai, India, from 1994–2023.

Dog-related complaints from the years 2007–2016 offered insight into street dog behaviours in urban communities and public concerns. An analysis of month-wise complaint distribution each year resulted in three key findings (Figure 18). Peak complaints occur during the months of July and August. This corresponds with street dog mating season, where dogs could display more aggression, territorialism, and fights among other street dogs. The second key finding is that there is a noticeable decrease in complaints after monsoon months. This may reflect that street dogs return to less aggressive behaviours. However, the persistence of complaints, albeit at lower levels, throughout the year underscores the ongoing nature of human-dog interactions and conflicts. The final key finding is the variability of complaints year after year, emphasizing a dynamic interplay between humans and animal populations (Figure 19). These dynamics can be influenced by changing environmental conditions, municipal interventions, and public awareness, perception, and behaviour.

To provide further context, we observe a significant decline in dog-related complaints after the year 2016. However, in post-COVID time after 2022, there has been a slight increase in such complaints.
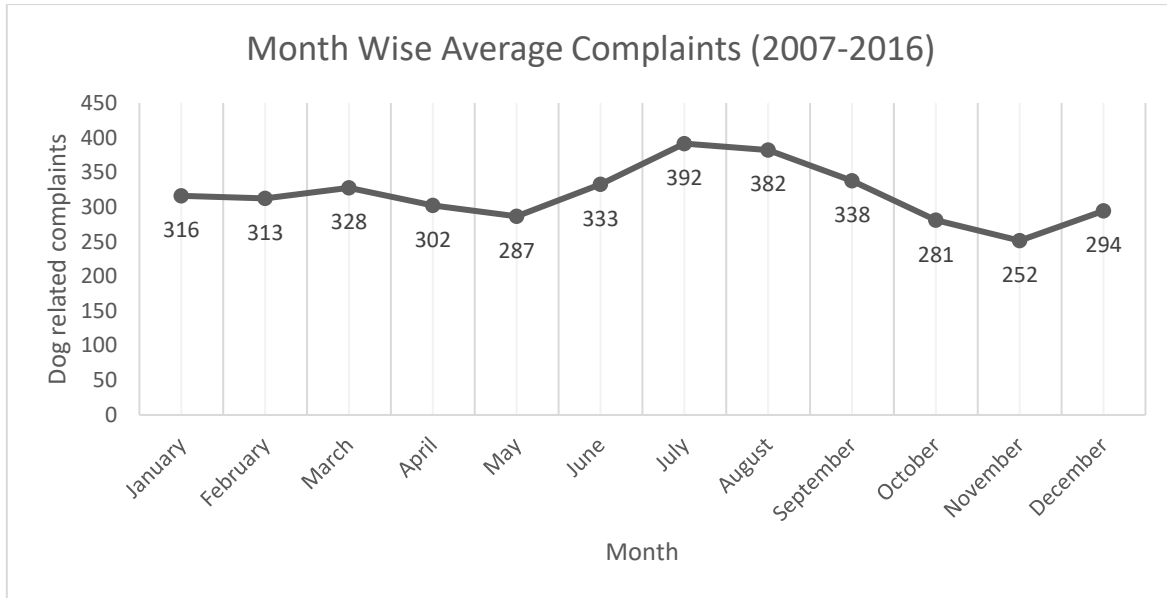
Figure 18. Month-wise comparison of average dog-related complaints in Mumbai, India. Data collected from BMC from 2007-2016.
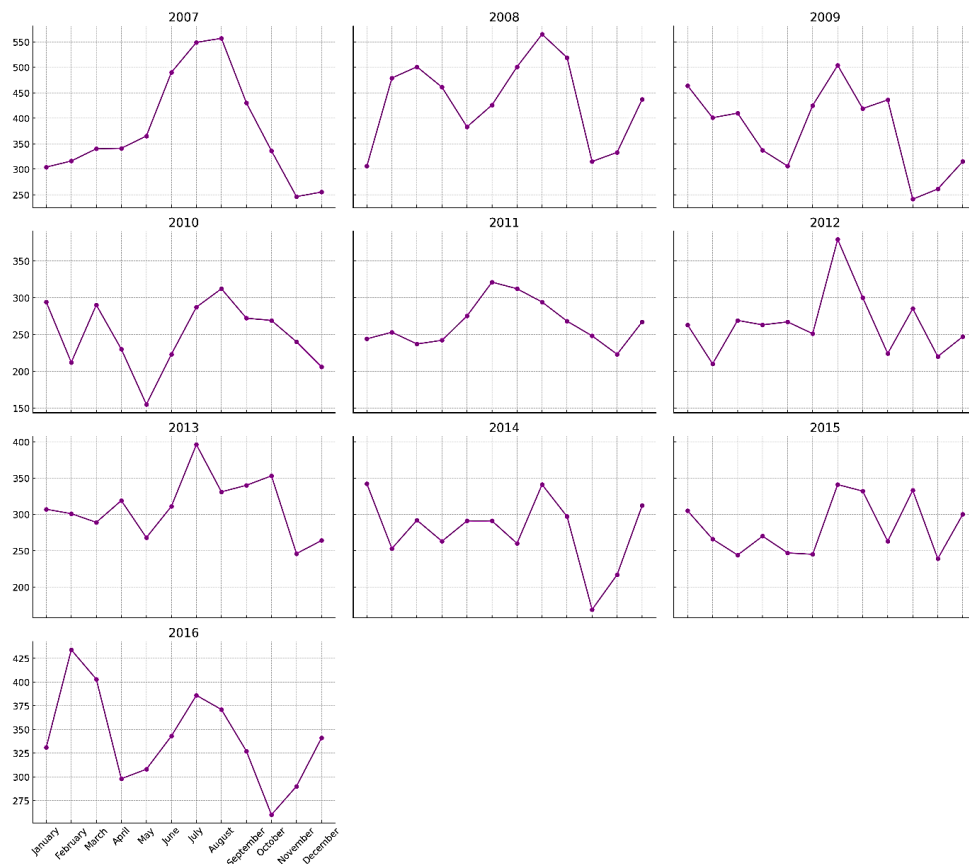

Figure 19. Dog-related complaint charts with month-wise comparison from the years 2007-2016 in Mumbai, India. Data collected from the BMC.

Brihanmumbai Municipal Corporation

DOG-RELATED BITE CASES

Analysis of dog-bite data from 1994 to 2023 reveals significant trends, particularly when adjusted for population size (per 100,000 people), facilitating comparisons with other metrics (Figure 20). There was a decline in dog bite cases during the COVID-19 pandemic, which persisted until 2023, followed by a recent increase. These trends parallel those observed in dog-related complaints (Figure 21), suggesting similar underlying factors affecting both metrics. Additionally, the data shows a clear seasonal pattern in dog bite incidents, with peaks from late winter to early summer (January–April), and the highest averages in March, around 8,124 cases (Figure 19). The lowest numbers are reported during the monsoon and post-monsoon months (July–September). An ANOVA analysis confirmed a significant correlation between the number of intact females and higher incident counts ($P < 0.001$), highlighting the need for targeted control measures during specific periods to effectively mitigate these incidents.
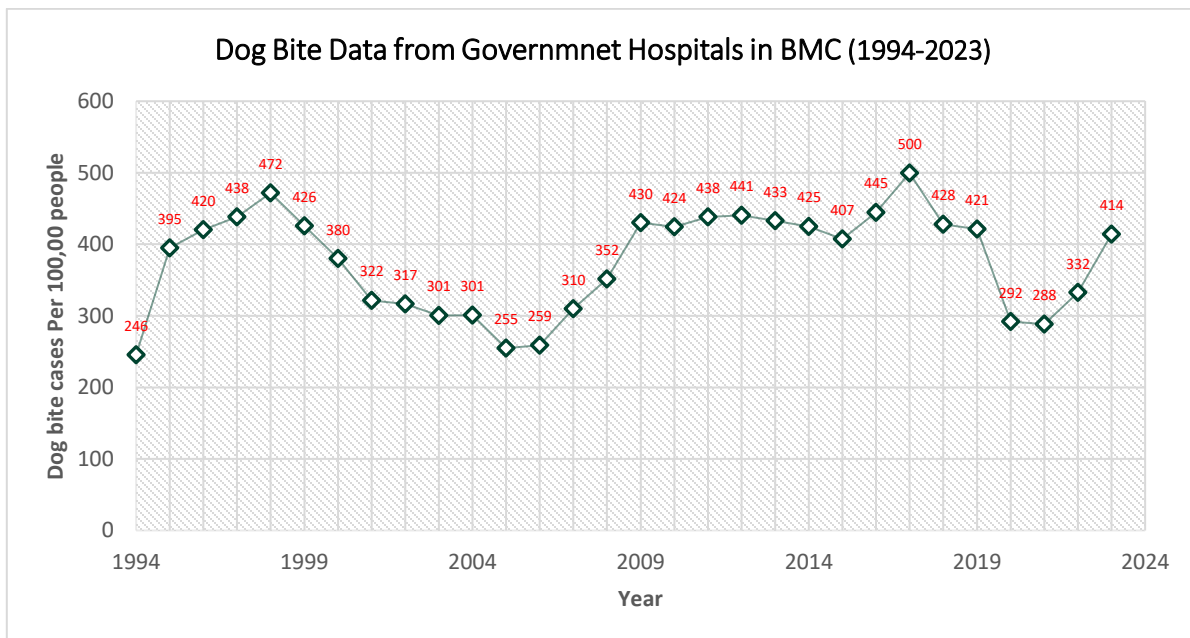

Figure 20: Dog Bite Incidence Rate - Cases per 100,000 People Reported at Government Hospitals in BMC Area (1994-2023)

For precise assessment and comparison, dog bite cases within the Brihanmumbai Municipal Corporation (BMC) area are standardized to per 100,000 people rather than absolute numbers. This standardization facilitates meaningful comparisons with other metropolitan cities across India. For example, from 2014 to 2018, Ahmedabad (Gujarat), reported approximately 800 dog bite cases per 100,000 people, while Vadodara (Gujarat), had about 400 cases per 100,000 people from 2015 to 2019. Given Mumbai's high population density, its situation is more akin to that of Ahmedabad. In contrast, Vadodara, with its relatively smaller municipal population, faces different challenges and conditions, making direct comparisons with Mumbai less suitable. This approach allows for a more accurate evaluation of the public health impact of dog bites by accounting for population density and urban dynamics.
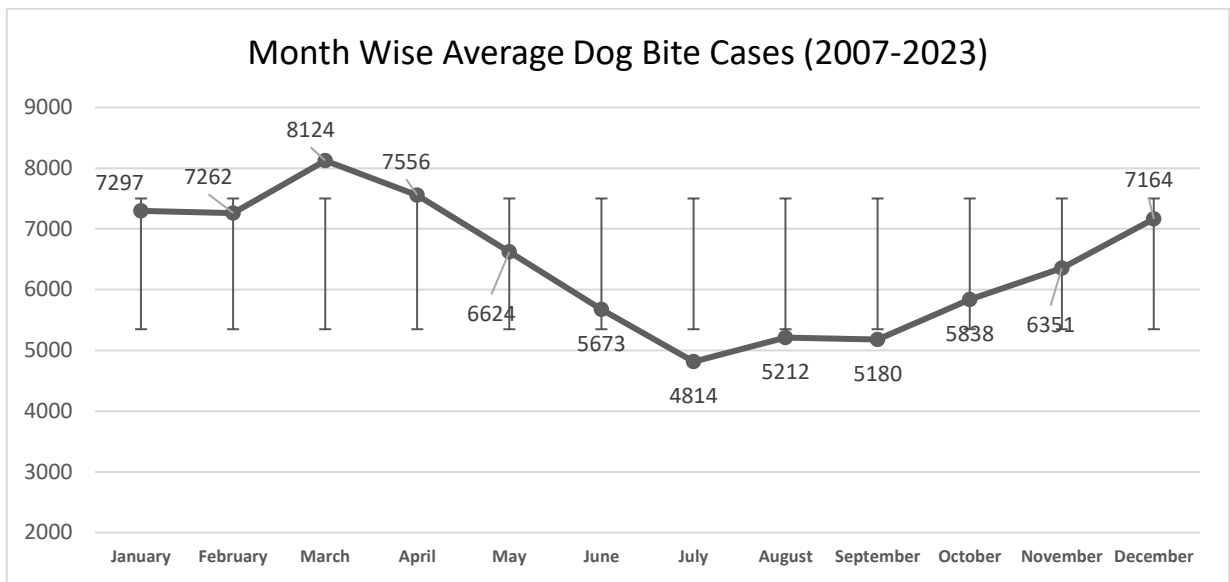
Figure 21. Month-wise comparison of reported dog bite cases to the BMC in Mumbai, India. Data was collected by the BMC from 2007 to 2023.

While seasonality patterns exist, multiple factors appear to influence the reported number of dog bite cases (Figure 21). Most years follow the general pattern of higher cases reported during warmer months; however, there is considerable variability and no consistent shift in peak months across years. Instead, peaks fluctuate, suggesting other factors influence peak trends on a year-to-year basis. In recent years, there has been no clear pattern indicating a shift toward earlier or later months for peak reported cases.

RABIES

Data collected from 1994–2023 has shown an overall decrease in rabies-related mortalities. However, again, since the pandemic, we have seen a slight increase in rabies mortalities (Figure 22). Monthly comparisons show that deaths are highest in January and May, with April, June, and July being the next highest. The number of rabies-related deaths decreases during the August–December months (Figure 23). Rabies-related mortalities do appear to be correlated with peaks of bites within Mumbai. However, almost 4x of patient mortalities related to rabies come from patients outside of Mumbai (Figure 24).

Rabies related Human Deaths reported in BMC Hospitals (1994-2023)
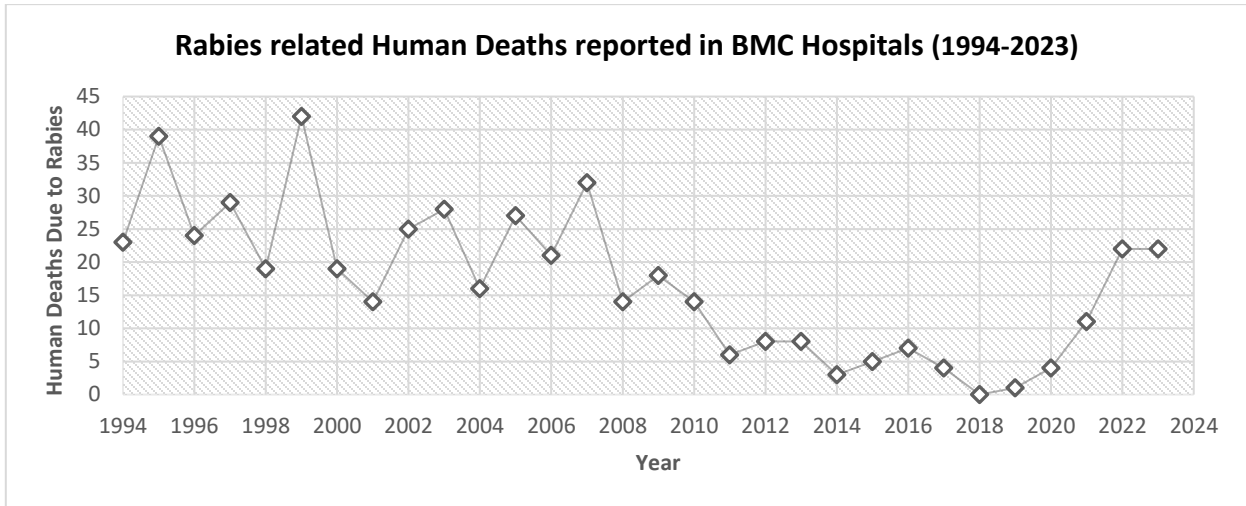
Figure 22. Rabies-related human mortalities from the years 1994–2023 in BMC Hospitals within Mumbai, India.

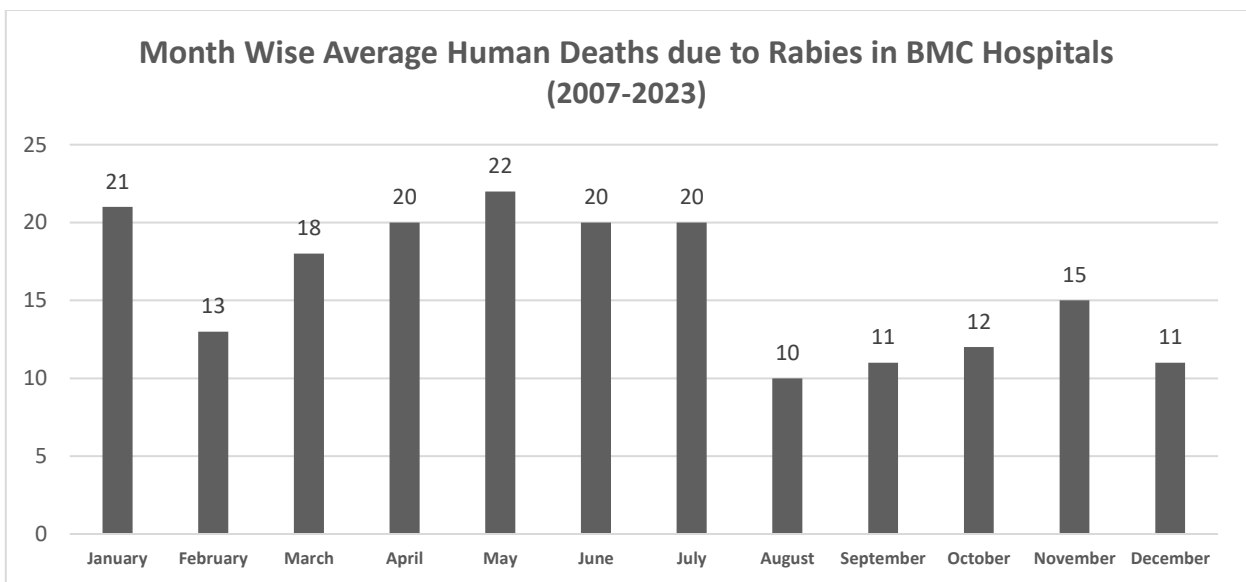**Month Wise Average Human Deaths due to Rabies in BMC Hospitals (2007-2023)**

Figure 23. Month-wise comparison of average rabies-related human mortalities from BMC hospitals within Mumbai, India, for the period of 2007–2023.
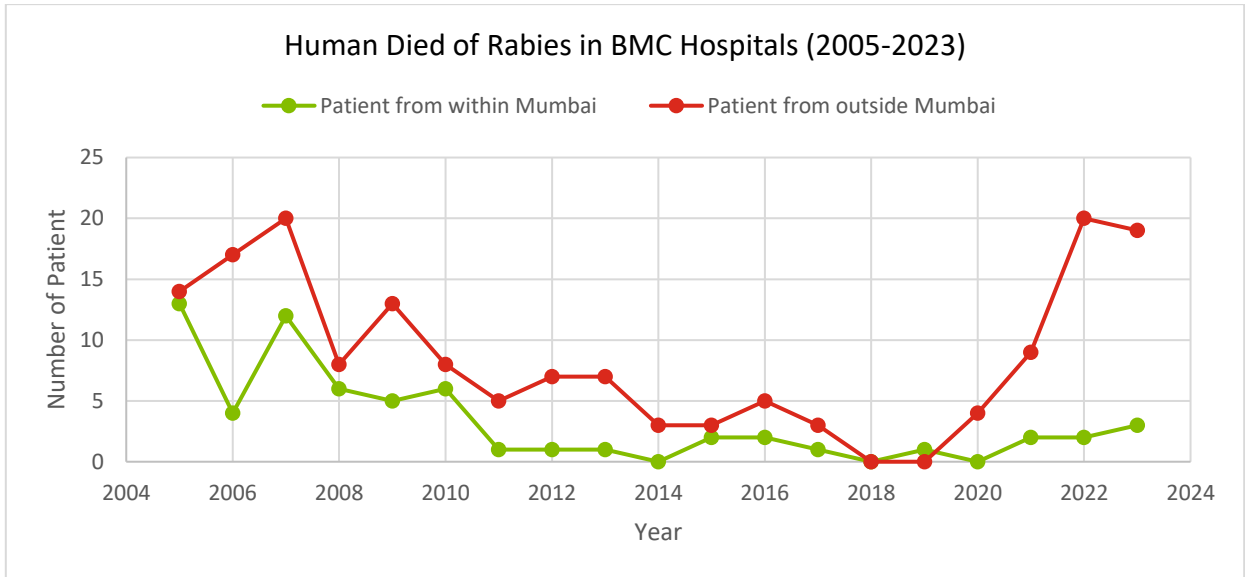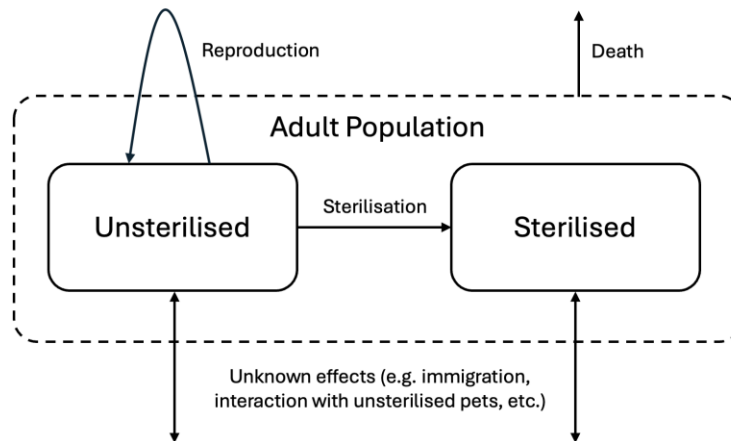
Figure 24. Rabies-related human mortalities from patients residing in and outside of Mumbai. Data was collected at BMC Hospitals from 2005 to 2023.

Mumbai Sterilization Outlook

MODEL PARAMETERS

The model is constructed based on the following logic:

POPULATION VARIABLES

Calculated from estimated total street dog counts in Mumbai in 2014 and 2024, including both street and slum regions.

Sterilised Dogs (S) = (1-D) x 0.956 x (S$_{(n-1)}$ + N$_{(n-1)}$)
Unsterilised Dogs (U) = (1-D) x 0.867 x ((U$_{(n-1)}$ x R) + U$_{(n-1)}$) - N$_{(n-1)}$)

where n-1 represents the value from the previous year. See below for coefficients.

MODEL COEFFICIENTS

Sterilization (N): Actual counts used for each year from 2014-2023. Inputted thereafter as scenarios to be investigated.

Death (D): 0.236 based on survivorship analysis of sterilized dogs in Mumbai between 1998-2007 and 2007-2014

Reproduction (R): 0.260 based on average adult recruitment values for unsterilized dog population models (Belsare & Vanak 2020)

Unknown effects: Modelled using additional coefficients for each sterilized and unsterilized population variables, calculated to achieve agreement between model estimates and actual survey values in 2024. Coefficients as 1.0750 and 0.7676 for sterilised and unsterilised dogs respectively.

ASSUMPTIONS

- Comparable dog population dynamics in slum and street locations in both 2014 and 2024, and intervening years.
- Constant rates of death, reproduction and unknown effects.
- Equal rates of survivorship across all populations cohorts.
- Equal sterilization and reproduction rates for male and female dogs.

Model Results

Table 11. Seven sterilization scenarios demonstrating how efforts impact the outcome of free-roaming dog populations and achieving an 85% sterilization target rate in Mumbai, India.

Scenario	Dogs sterilised per year	Outcome	85% Sterilization achieved	Total sterilizations required since 2023 for population control (~85% sterilization)
1	10,000	Ineffective	-	Continued
2	13,000	Ineffective	-	Continued
3	14,000 (average 2014-2024)	Population control	2035	159,939
4	15,000	Population control	2031	117,003
5	20,000	Population control	2027	74,641
6	20,000 (1yr) then 10,000	Ineffective	-	Continued
7	20,000 (2yrs) then 10,000	Population control	2032	105,814

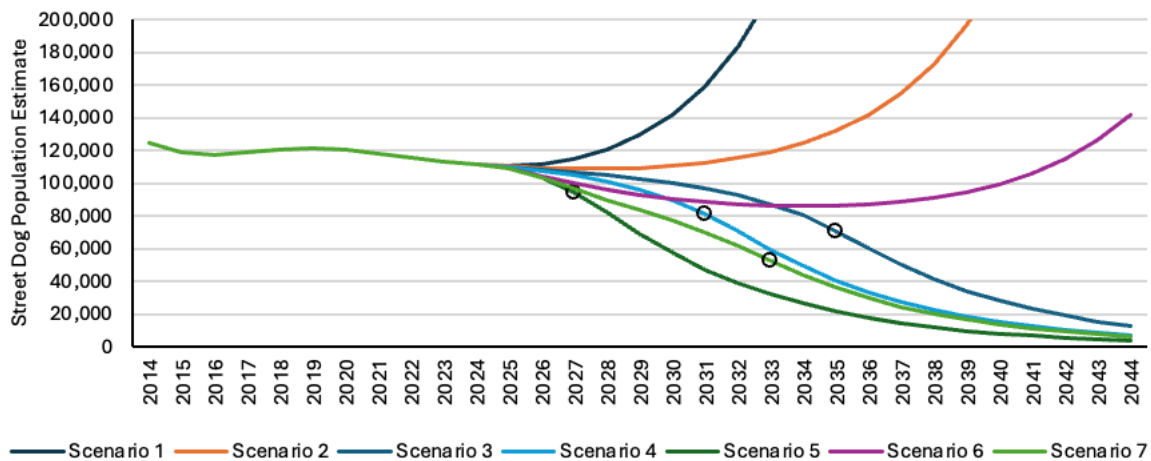**Figure 25.** Model outcomes for various scenarios of sterilization following the 2023 survey count. Black circles indicate point at which scenarios reach 85% sterilization, which coincides in each case with the year in which no further sterilizations are theoretically required (population control). In reality, this represents the point at which control may easily be maintained with lower levels of sterilization.

Caveats

- The model assumes no carrying capacity. In reality, exponential population growth would not be possible, however increasing population indicates that dog population will continue to increase or remain stable at rates higher than are desired.
- Should population be reduced, it is likely that an increase in population migration into the void created will occur from outside populations/slums, etc. As a result, the theoretical result of no further sterilization required is unrealistic, however, should such population control be achieved lower levels of sterilization will be required to maintain the resultant population of greater than 85% sterilized.
- The model assumes equal rates of male and female sterilization. A female-centric approach may increase the efficacy and speed of population reduction in comparison to the outcomes shown here.

Key Findings and Strategic Recommendations: BMC Report 2024

We used sterilization data provided by BMC for the period of 1994 to 2023, and in all 24 wards, we estimated 90,757 free roaming dogs using the annual survival method and identified sterilized dogs by ear notch. For the 2024 report, we only used the survival estimate method to estimate the total free roaming population, unlike the 2014 survey, in which we used two methods: street length extrapolation and survival estimates. In 2024, the focus was on monitoring and evaluation rather than abundance estimation. It's important to note that initially, our street count survey excluded dogs from slum areas, primarily due to the survey's focus on monitoring and evaluation. The slum dog count was added later as recommended by Animal Birth Control Monitoring Committee, Brihanmumbai Municipal Corporation.

Several factors contribute to the free-roaming dog population's growth. One significant factor is the growth of Mumbai's human population, which fosters an environment where compassionate individuals actively care for street dogs. During our survey, we frequently observed that people were providing nutritious food at specific spots along roadsides and within residential communities. Such regular provision of food and care significantly influences the survival rates of pups, transforming their chances from very low to notably high. This observation highlights the pivotal role of compassionate individuals in the urban ecosystem who actively support the welfare of street dogs. To further enhance the effectiveness of the street dog sterilization program in Mumbai, it is essential to integrate these dog feeders into the ongoing efforts. Encouraging dog feeders to participate actively in the sterilization initiatives could be highly beneficial. Providing them with a helpline number would enable easy communication with NGOs involved in the sterilization program within the Brihanmumbai Municipal Corporation (BMC) area, ensuring that feeders can quickly reach out for support or to coordinate sterilization activities. This integration not only aids in managing the dog population but also leverages community involvement to improve animal welfare comprehensively. Another contributor could be associated with unintentional feeding grounds, such as sports grounds, gardens, schools, and universities. These areas provide safe places for roaming street animals to gather and allow for successful breeding.

Another factor contributing to the population is the possible migration of dogs between wards and/or from outside of Mumbai. Despite the continuous efforts of sterilization programs, we saw more unsterilized dogs in our 2024 survey. We saw an increase in both intact males and females. Fourteen of the 24 wards demonstrated a decrease in female sterilization rates compared to our 2014 survey. We hypothesize that dogs migrating to Mumbai from outside of BMC areas are the cause. Unsterilized dogs could be coming into Mumbai because of the increase in feeders and safe grounds, contributing to successful breeding. Pet abandonment could also be causing once-pampered pets to migrate into larger city areas to look for resources. Given these factors, it is important to mitigate and educate the public about improving sterilization efforts. Educating the public about

sterilization efforts throughout the BMC area can help reduce the number of unnotched dogs roaming the streets. Sterilization programs should aim for a sterilization rate of 85% for maximum benefit. Improving sterilization efforts in wards where the female sterilization rate is below 60% could also help reduce incident reports.

Our analysis of dog-related complaints and dog bite cases demonstrates a nuanced understanding of the interaction between street dog populations and incident reports. Dog migration from outside of Mumbai, pet abandonment, and high rates of unsterilized dogs can increase the risk of incident counts. Peaks, typically, align with periods when pups are growing, and mothers exhibit protective behaviours. During peak times, a mother has a higher chance of perceiving humans as threats to their offspring. Mating season (July and August) could contribute to heightened aggression and territorial disputes against other dogs. Indirectly influencing dog bite incidents through increased human-dog interactions and potential aggressive behaviours. Finally, a complex set of factors influence dog bites, as indicated by yearly fluctuation trends and a lack of consistent shifts in peak months. Factors that can contribute to increased dog bites are environmental conditions (lack of resources like food, water, or shelter), human activity, and dog population dynamics.

In the 2024 survey, we counted 325 cats in 10 wards, which has potential for future comparison.

Recommendations:

DOG DEMOGRAPHIC IN MUMBAI

ENHANCING STERILIZATION EFFORTS IN WARDS WITH LOW RATES

During the 2024 survey, we observed an overall sterilization rate of 62.9% across various wards, marking a decline of 11.8% from the rates reported in our 2014 survey. Notably, Ward S recorded the lowest total sterilization rate at 44.2%, with female sterilization at 42.9% and male sterilization at 45.0%. Ward T followed closely with a total sterilization rate of 46.7%, where female and male sterilization rates stood at 46.5% and 46.9%, respectively. According to the data presented in Table 1, 14 out of the 24 wards experienced a decrease in female sterilization rates since the 2014 survey. Slum areas also demonstrated a decrease in female sterilization rates from 66% to 60% in our 2024 survey.

In light of these findings, we strongly recommend prioritizing these 14 wards and slum areas to boost female sterilization efforts. Historical data has shown a negative correlation between the number of sterilized females and the occurrence of lactating females or pups. The current increase in numbers of lactating females and pups in these areas indicates that the existing sterilization rates are insufficient to significantly influence the demography of the roaming dog population. By increasing sterilization efforts, especially targeting female dogs in these wards, we can more effectively manage the street dog population and reduce the number of unwanted litters, ultimately contributing to better public safety and animal welfare.

STERILIZATION PLAN

To achieve population control of free-roaming dogs in Mumbai, a strategic sterilization plan is essential. The model presented in the Mumbai Sterilization Outlook section of the report suggests that maintaining the current annual sterilization average (2014-2024) of 14,000 dogs per year will eventually achieve comprehensive population control. However, only a slight reduction to 13,000 per year will lead to unchecked population growth and loss of control, indicating that a minimum threshold exists for effective population control. It is notable that even a single year of lower sterilization numbers due to unforeseen circumstances may lead to a loss of population control even with annual averages at 14,000 sterilizations or above. Once the population has

been allowed to rise it will require much higher annual sterilization rate to bring it back to the current level of control. Thus, we suggest a higher yearly number are necessary to ensure the program maintains efficacy without losing control, for example, ensuring yearly sterilizations are in the region of 15-20,000 dogs sterilised per year.

Female-centric Approach

During our 2024 survey, we saw a slight increase in intact females compared to our 2014 survey. We recommend targeting intact female dogs prior to peak pregnancy and pup-whelping season (July to December; Brill et al., 2022). Sterilizing dogs at a very young age can lead to serious health complications, as noted in various studies on pediatric spay-neuter practices. In alignment with these findings, the ABC Rules 2023 clearly specify age-related parameters for street dog sterilization in India, prohibiting surgeries on dogs under 6 months old. Given the low survival rate of street dog pups—only about 19% survive up to 12 months—it is prudent to focus sterilization efforts on the adult dog population. By concentrating on sterilizing healthy, adult female dogs over 6 months of age, ABC programs can more effectively control the population while also protecting the health of younger dogs.

For ABC programs to be effective, having at least 85% of female dogs sterilized is essential. However, limited resources and personnel make achieving 85% unattainable. For an effective sterilization program, we recommend sterilizing 85% of all female dogs, as previously mentioned in this report. Our recent study, which used HSI/India's spay-neuter programs data from four Indian cities, concluded that female dogs are less likely to have post-operative complications compared to male dogs (Chaudhari et al. 2022). Spayed females can maintain body condition on limited resources, and if there are fewer females in heat, male dogs will display less aggressive behaviours. Also, intact males can protect territories more effectively. This helps to reduce the number of migrant dogs from outside Mumbai who can carry infectious diseases like rabies.

Frontloading Strategy:

Implementing a frontloading approach focuses on high amounts of sterilizations at the start of a program to maintain or improve population efforts. Frontloading approaches reduce the overall sterilizations needed over time to control a population. Thus, future years will require less sterilizations to maintain or improve populations. For more in-depth understanding of a frontloading approach, the annual target rates below demonstrate the high number of sterilizations needed within the first 2 – 3 years to achieve a specific target rate.

Annual Targets to Achieve 85% Sterilization Rate and Long-term Goals:

1-Year Plan (May 2024 – April 2025): To achieve an 85% sterilization rate across all BMC wards within one year, approximately 35,000 dogs need to be sterilized. This target is based on an annual recruitment rate of 26% by birth and an 8% increase due to immigration and pet abandonment.

2-Year Plan: To maintain an 85% sterilization rate, around 48,500 dogs (24,500 in the first year and 24,000 in the second year) need to be sterilized within two years. After reaching the 85% rate, a minimum of 10,000 dogs per year should be sterilized in the third and fourth years to potentially reach a 90% sterilization rate.

3-Year Plan: Extending the plan to three years, approximately 68,500 dogs (22,500 each year) need to be sterilized to manage the population effectively. Continued sterilization of at least 10,000 dogs per year in the subsequent years is crucial for sustaining population control and aiming for a 90% rate.

5-Year Plan: For a comprehensive five-year strategy, about 100,448 dogs (20,000 each year) need to be sterilized. This sustained effort will help manage the population within the dynamic urban environment of

Mumbai effectively. In such long-term plan additional surveys similar to 2014 and 2024 would help redefine the annual target and strategy.

REPEATED SURVEYS

It is critical to continue collecting data on a regular basis, as outlined in this report. Creating a standardized approach helps to ensure accurate data and, therefore, appropriate monitoring and evaluation of the ABC program's progress and success. Regularly monitoring the same routes will provide real-time data for an effective plan and redirect approaches when necessary. Periodic monitoring and evaluation surveys will help ensure an increase in sterilization rates, animal welfare, and study changes in dog density for BMC.

DOG-RELATED COMPLAINTS/BITES AND STERILIZATION RATES

The complex interactions between human and dog populations within urban ecosystems are well-documented, with incident counts often increasing during Mumbai's pre-monsoon season, a trend observed across other Indian regions as well (Khan et al. 2014; Bashar and Duggal 2019). Recognizing the peak times for complaints during the pre- and monsoon seasons, and their decline post-monsoon, provides valuable insights for managing these interactions.

To mitigate the number of incidents, targeting sterilization efforts prior to the pre-monsoon season is advised. Intact males and females tend to exhibit increased aggression during the mating season and when caring for pups, contributing to higher rates of complaints and bites.

Advocating for safe handling practices is crucial, as children and men are more frequently the victims of animal bites (Bharathy and Gunaseelan 2017; Román et al. 2023; Julka et al. 2024). Educating the public about recognizing warning signs from aggressive street animals can significantly help in preventing bites. Most dog bites occur when dogs are provoked and during the day and evening hours when human activity is highest (Hipparkar et al. 2023).

HUMANE EDUCATION

To foster a community that is informed and compassionate towards street dogs, we recommend the implementation of comprehensive humane education programs across Mumbai. These programs should aim to educate the public, especially children, on responsible pet ownership, the importance of sterilization, and safe interaction with street animals. Schools, community centres, residential welfare societies and social media can serve as effective platforms for these educational campaigns. By increasing awareness about animal welfare and behaviour, we can encourage more humane treatment of street dogs and reduce conflicts between humans and dogs.

PET REGISTRATION

Introducing a mandatory pet registration system is crucial for better management of the pet population and to curb the issues of abandonment and uncontrolled breeding. Registration would help in keeping track of the number of pets, their health status, and vaccination records, facilitating more effective disease control and ensuring compliance with local animal welfare laws. It would also hold pet owners accountable, thereby reducing the number of pets that end up as strays. The system should be easy to access and affordable, possibly integrating microchipping during sterilization to streamline the process.

VACCINATION EFFORTS FOR RABIES PREVENTION

Rabies is an endemic disease in India, accounting for ~35% of the global burden (Hampson et al. 2015, John et al. 2021). Many studies report that dogs are the carriers for rabies and the interaction that leads to humans being bit is what results in human deaths related to rabies. Furthermore, those studies suggest that vaccination status of both pet and street dogs are relatively low or unknown (Bharathy and Gunaseelan 2016; John et al. 2021). It is suggested that the endemic of rabies in India is consistent with inconsistent supplies, lack of awareness, and insufficient rabies control programs (Krishna ASR et al. 2023).

One round of vaccination is not enough to prevent the spread of rabies. Keeping a yearly vaccination on stray dogs is highly recommended. However, achieving 70% vaccination rates within a geographic location can reduce rabies infections (Krishna ASR et al. 2023). Education on proper wound management is encouraged to elementary school children and workers/contractors working in environments where contact with street dogs is likely.

ENHANCED DATA COLLECTION FOR DOG-RELATED INCIDENTS

In addition to basic dog bite statistics, it is crucial to record supplementary details such as the age, gender, and location of victims, which enriches the context and utility of the data. Furthermore, documenting the ownership status of the involved dogs and the severity of bite wounds can significantly aid in understanding the dynamics of such incidents. This extended data collection will enable more precise investigations into the causes and consequences of dog bites, enhancing preventive measures.

Likewise, categorizing dog-related complaints by the nature of the issue—such as chasing, fighting, biting, property damage, and even barking—adds depth to our insights. When recording barking complaints, it is crucial to recognize that barking is a natural form of communication and social behavior among dogs, and not inherently a nuisance. This understanding is important for ensuring that responses and management strategies are balanced and informed, acknowledging the normal behaviors of dogs while addressing genuine concerns of the community.

IMPLEMENTING GPS-BASED TOOLS TO ENHANCE STERILIZATION EFFORTS

Street dogs are territorial hence they must be returned to the exact location from where they were picked up after being sterilized. Using GPS-based tools or software to record sterilization data can greatly improve how we manage these efforts. These tools allow us to see the exact spatial distribution of our sterilization work, helping us to monitor and evaluate the program's effectiveness regularly. Moreover, having access to sterilization data by ward can provide deeper insights into dog movements, including immigration and migration between wards. This geographic information is key to tailoring our strategies to meet the specific needs of different areas, ensuring our interventions are both effective and efficient.

CAT DEMOGRAPHIC IN MUMBAI

We need more information to estimate the number of free-roaming cats in Mumbai. While we have a starting point for the 10 wards and that too only observing cats on the street while counting dogs, obtaining a count on all 24 wards would help in long-term monitoring changes in each ward. Although having cat population estimates for BMC requires a robust method, which also includes detectability for the cat, owned cat, and shelter cat populations, it also depends on how these separate populations interact and overlap. Obtaining BMC sterilization records for the cat demographic would be helpful in understanding the effectiveness of ABC programs in Mumbai.

Literature Cited

Bashar, M., and M. Duggal. 2019. Seasonal variation in incidence and severity of dog bites in a union territory of northern India. Journal of Clinical and Diagnostic Research 13: LM01–LM04.

Belsare, A., and A. T. Vanak. 2020 Modelling the challenges of managing free-ranging dog populations. Sci Rep. doi: 10.1038/s41598-020-75828-6.

Bharathy, S., and L. Gunaseelan. 2017. A cross sectional study to understanding demographics of dog bite victims attending anti rabies ward in Chennai City, Tamil Nadu India. Advances in Animal and Veterinary Sciences 5:78–82.

Brill, G., T. Kartal, D. Prakas Yadav, M. Bhyan, C. Patel, S. Kumar Sheoran, P. Patel, B. Painuly, and A. Chaudhari. 2022. Seasonal patterns of oestrus and reproduction in street dogs of Indian cities. Front. Vet. Sci. 9:821424.

Chaudhari, A, G. Brill, I. Chakravarti, T. Drees, S. Verma, N. Avinash, A. K. Jha, S. Langain, N. Bhatt, S. Kumar, S. Choudhary, P. Singh, S. Chandra, A. Murali, and K. Polak. 2022. Technology for improving street dog welfare and capturing data in digital format during street dog sterilization programmes. Animals. https://doi.org/10.3390/ani12152000.

Earth Point. 2024. Tools for Google Earth: KML Shapes – polygon area, linestring length, placemark point. http://www.earthpoint.us/shapes.aspx.

Gongal, G., and A. E. Wright. 2011. Human rabies in the WHO Southeast Asia region: forward steps for elimination. Adv Prev Med. doi: 10.4061/2011/383870.

Griego, R.D., T. Rosen, I. F. Orengo, and J.E. Wolf. 1995. Dog, cat, and human bites: a review. J Am Acad Dermatol. 33: 1019–1029.

Hampson, K., L. Coudeville, T. Lembo, M. Sambo, A. Kieffer, et al. 2015. Estimating the global burden of endemic canine rabies. PLOS Neglected Tropical Diseases 9:e0003786.

Hipparkar, R., S. Hunjegaonkar, A. Sawant, A. Joshi, G. Sapkale, R. Umbare, S. Pange, N. Kahn, and R. Galande. 2023. Clinico-epidemiological profile of dog bites from a tertiary care hospital in east Marathwada, India: a retrospective study. IJBPAS 12: 5025–5035.

John, D., A. Royal, and O. Bharti. 2021. Burden of illness of dog-mediated rabies in India: a systematic review. Clinical Epidemiology and Global Health 12:100804.

Julka, D., A.M. Khan, N. Kumari, and U. Soni. 2024. Burden of dog bite injuries and wound management practices to prevent rabies among dog owners. J Family Med Prim Care 13:568–571.

Keuster, T.D., J. Lamoureux, and A. Kahn. 2006. Epidemiology of dog bites: a Belgian experience of canine behaviour and public health concerns. Vet J 3:482–487.

Khan, V., D.B. Zala, K.M. Joshi, and V.K. Das. 2014. A study on dog bite incidence in Union Territory of Dadra and Nagar Haveli, India. Journal of Applied and Natural Science 6:38–40.

Krishna, A.S.R., A.S. Hemapriya, and J. S. Sundar. India's sustaining challenges to combat rabies elimination: a comprehensive review. Int. J Community Med Public Health 10: 3952–3957.

Ogundare, E.O., O.S. Olatunya, I.O. Oluwayemi, A.J. Inubile, A.B. Taiwo, O.T. Agaja, A. Airemionkhale, and A. Fabunmi. 2017. Pan African Medical Journal 27:81. doi:10.11604/pamj.2017.27.81.7360.

Román, J., G. Willat, J. Piaggo, M.T. Correa, and J.P. Damián. 2023. Epidemiology of dog bites to people in Uruguay (2010–2020). Veterinary Medicine Science 1–6. https://doi.org/10.1002/vms3.1242

WellBeing International. 2022. Available online: https://wellbeingintl.org/global-dog-campaign/about-gdc/.

APPENDIX

Estimated number of roaming dogs by type in each ward, total on all streets, total in all slum areas and total on all streets and in all slum areas.

Ward	Total Females	Total Males	Females Sterilized	Females Not Sterilized	Males Sterilized	Males Not Sterilized	Females Lactating
Ward A	185.2	323.0	172.3	12.9	245.5	77.5	0.0
Ward B	280.2	687.7	165.6	101.9	503.1	184.7	12.7
Ward C	142.4	248.5	106.1	25.1	212.2	36.3	11.2
Ward D	222.4	273.8	145.4	25.7	222.4	51.3	51.3
Ward E	368.0	557.0	238.7	89.5	407.8	149.2	39.8
Ward FN	563.0	801.7	364.8	153.1	522.5	279.2	45.0
Ward FS	368.3	470.6	204.6	102.3	347.9	122.8	61.4
Ward GN	568.2	782.7	475.4	11.6	678.3	104.4	81.2
Ward GS	294.9	368.6	179.0	31.6	268.5	100.0	84.2
Ward HE	317.0	400.9	181.8	51.3	237.8	163.2	83.9
Ward HW	240.2	208.2	128.1	5.3	149.5	58.7	106.8
Ward KE	1014.3	1190.7	573.3	279.3	742.4	448.4	161.7
Ward KW	906.4	586.5	488.8	204.4	346.6	239.9	213.3
Ward L	1511.6	1694.5	973.6	398.1	1156.5	537.9	139.9
Ward ME	823.2	1462.9	520.7	163.6	1066.2	396.7	138.8
Ward MW	675.7	1172.5	308.0	218.6	760.1	412.4	149.0
Ward N	1141.9	1295.1	661.5	257.6	786.8	508.3	222.8
Ward PN	2397.8	2478.9	1269.0	878.0	1128.8	1350.1	250.8
Ward PS	1305.6	1665.3	866.0	199.8	1179.1	486.3	239.8
Ward RN	1775.6	2249.6	1128.1	393.8	1702.2	547.4	253.7
Ward RC	1824.3	2243.7	1125.2	392.8	1697.8	546.0	306.3
Ward RS	1122.1	2310.6	444.8	411.7	1188.5	1122.1	265.6
Ward S	1282.9	1753.0	430.3	517.9	788.8	964.1	334.7
Ward T	982.3	905.8	391.2	404.0	425.2	480.5	187.1

This estimation is based on the total count made in the survey, track length and ward wise the street length.

FIELD IMAGES FROM THE 2024 BMC STREET DOG SURVEY:

Picture 1, 2& 3: interaction of Deonar Abattoir team with HSI/India team in BMC Deonar Abattoir Office; OSM Tracker Layout (Left) and Google Map Survey Track (Right) - Used during the 2024 BMC Street Dog Survey.

Picture 3 & 4: Human-Dog Interaction and Care - Residents engaging with free-roaming dogs on Mumbai streets.

Picture 5 & 6: Human Proximity and Feeding - Close interactions with free-roaming dogs (left) and direct food provision by locals (right) in Mumbai.

Picture 7 & 8: Urban Dog Behaviour - Dogs using an auto-rickshaw as temporary shelter (left) and pack interaction on the streets (right)

Picture 9 & 10: Maternal Care in Urban Settings - Lactating female dog with pups (left) and another lactating female with pup on a street (right)

Picture 11: Field Survey in Action – HSI/India team member counting dogs during the January 2024 survey.

Picture 12: Survey Implementation – HSI/India team member actively counting street dogs during the January 2024 survey.