



An overview of dog population estimation methods with focus on free-roaming dogs in South Asian context

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Why to estimate dog population size?

- To plan an intervention (Eg: DPM, MDV)
 - How much resources is required?
 - Manpower, vehicles, vaccines, medicines, consumables
 - Where to focus?
 - Places with higher dog density; and areas with higher proportion of un-neutered dogs
 - Prioritize areas: Cities, Districts, sub-Districts, towns, zones etc
 - When to implement/ how much time required?
 - Months, duration?
- To monitor and evaluate an intervention
 - An initial estimate of the population serves as the base line for future comparisons as the programme progresses
 - Coverage (%) - vaccination and sterilization coverage
 - Quantify population in terms of dog human ratio; dogs per square km; ratio of un-owned to owned dogs etc



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Common method used for estimating dog population size

Owned dogs

- Household survey -
Extrapolating number of dogs per dog owning household to total number of HH with dogs
 - Survey – door to door survey, random phone survey
 - Mean number of dogs multiplied by total dog owning household
- Mark-resight method using Lincoln Petersen formula

$$N = \frac{n_1 n_2}{m}$$

Free-roaming dogs

- Population estimate by total or direct counts
 - Count in blocks
 - Count in street length
- Mark-resight surveys
 - Photographic recapture (Beck's method)
 - By application of temporary marks (collars, vegetable paints)
 - By application of permanent marks (ear notch, tatoos)



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Principles behind estimating free-roaming dog population size

Population estimate by direct counts

- All dogs may not be sighted during the counts
- Some proportions of dogs will be missed during the field counts
- Corrective factors should be incorporated into the resultant estimates
- Detection probability should be estimated through mark-resight survey
- Impractical to count all the dogs in a large city
- Estimate by counting all the dogs in a random sample of blocks/ street length and extrapolating this count to the whole city

Population estimate by mark-resight method

- There is no mortality, emigration and recruitment into the population between the mark and recapture times
- Marks should not wash off or wear off
- All individuals within the population have an equal chance of being counted

Mark-Resight Survey Methods

$$N = \frac{n_1 n_2}{m}$$

**Lincoln-Petersen
Formula**

n_1 = Number of dogs marked, and
released back into the population (Day 1)

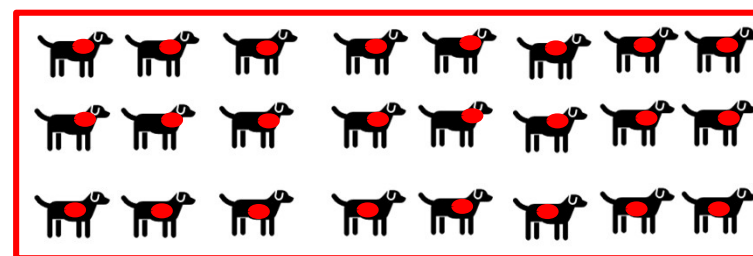
n_2 = Number of dogs that are sighted
on the following day (Day 2)

m = Number of dogs that are marked
on Day 1 are resighted on Day 2

N = Total population size

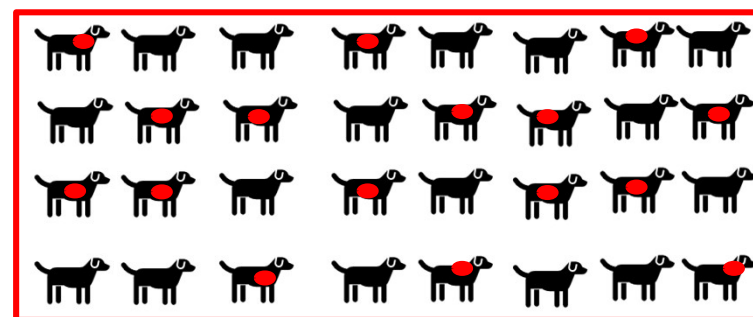
Day 1

$n_1 = 24$



Day 2

$n_2 = 32$



$m = 16$



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Mark-Resight Survey – Estimating Detection Probability

$$N = \frac{n_1 n_2}{m}$$

$$N = \frac{24 \times 32}{16} = 48$$

Total population size (N) = 48

Detection Probability

Detection probability (p) is the likelihood the dog would roam and sighted on any given day

p = likelihood the dog will be sighted on Day 1 out of the total dog population

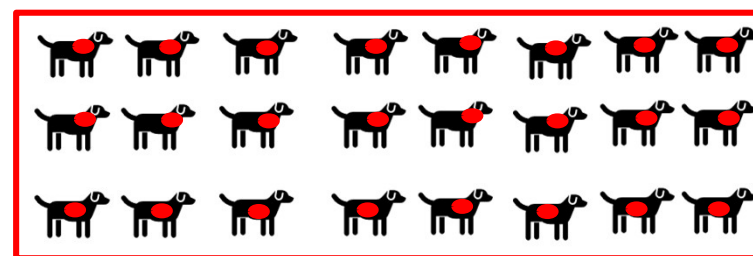
$$p = n_1 / N = 24 / 48 = 0.5$$

p = likelihood the dogs marked on day 1 will be sighted on Day 2

$$p = m / n_2 = 16 / 32 = 0.50$$

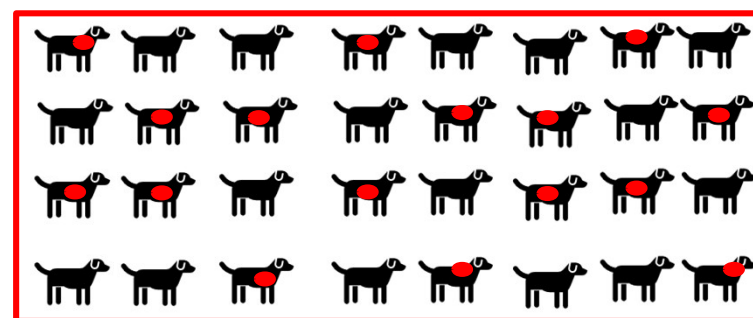
Day 1

$n_1 = 24$



Day 2

$n_2 = 32$



$m = 16$

Applying Detection Probability to correct missing proportion

$$N = C/p$$

where C is dogs counted or sighted on any given time

Estimated detection probability is 0.5

This indicates that the 50% of the dogs will be missed during the count, C

Therefore the population estimate should be corrected for the detection probability of 0.5

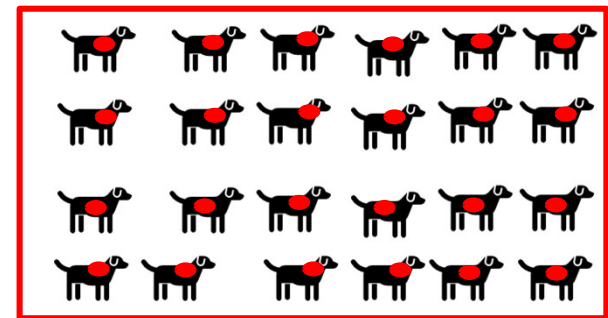
For example on Day 1 we sighted 24 dogs, we know that the detection probability is 0.5

Therefore dog population size is

$$N = C/p = 24/0.5 = 48$$

$$N = C/p = 24/0.4 = 60$$

$$N = C/p = 24/0.8 = 30$$



$$C = 24 \quad p = 0.5$$

$$C = 24 \quad p = 0.4$$

$$C = 24 \quad p = 0.8$$

Different methods for estimating free-roaming dog population

Mark-resight survey
Lincoln Petersen
Index

$$N = \frac{n_1 n_2}{m}$$

n_1 = Marked dogs
 n_2 = number sighted
during second count
 m = number resighted

Mark-resight survey
Proportion of
permanently marked
dogs

$$N = \frac{n_s}{p}$$

n_s = No. of surviving
ear notched dogs
 p = proportion of ear
notched dogs

Rapid survey
and detection
probability

$$N = \frac{C}{p}$$

C = No. of dogs
sighted - rapid survey
 p = detection
probability from MR
survey

Population estimate of free-roaming dogs

We used vegetable colour paints to mark dogs
Most dogs that are marked are inactive or lazy and
more dogs are resighted (m); reducing the population estimate

Thromdey (Block)	Marked (n1)	Count (n2)	Resighted (m)	Population (95% CI)
Bapisa	267	323	202	426 (408 - 445)
Changbangdu	521	778	376	1078 (1037 - 1119)
Norzin	298	357	150	709 (649 - 769)
Changangkha	190	179	112	303 (281 - 325)
Motithang	155	190	134	219 (212 - 226)
Kawang Jungshina	353	537	283	669 (645 - 693)
Taba-Dechenchoeling	244	257	153	409 (384 - 434)
Total	2028	2621	1410	3817 (3743 - 3891)

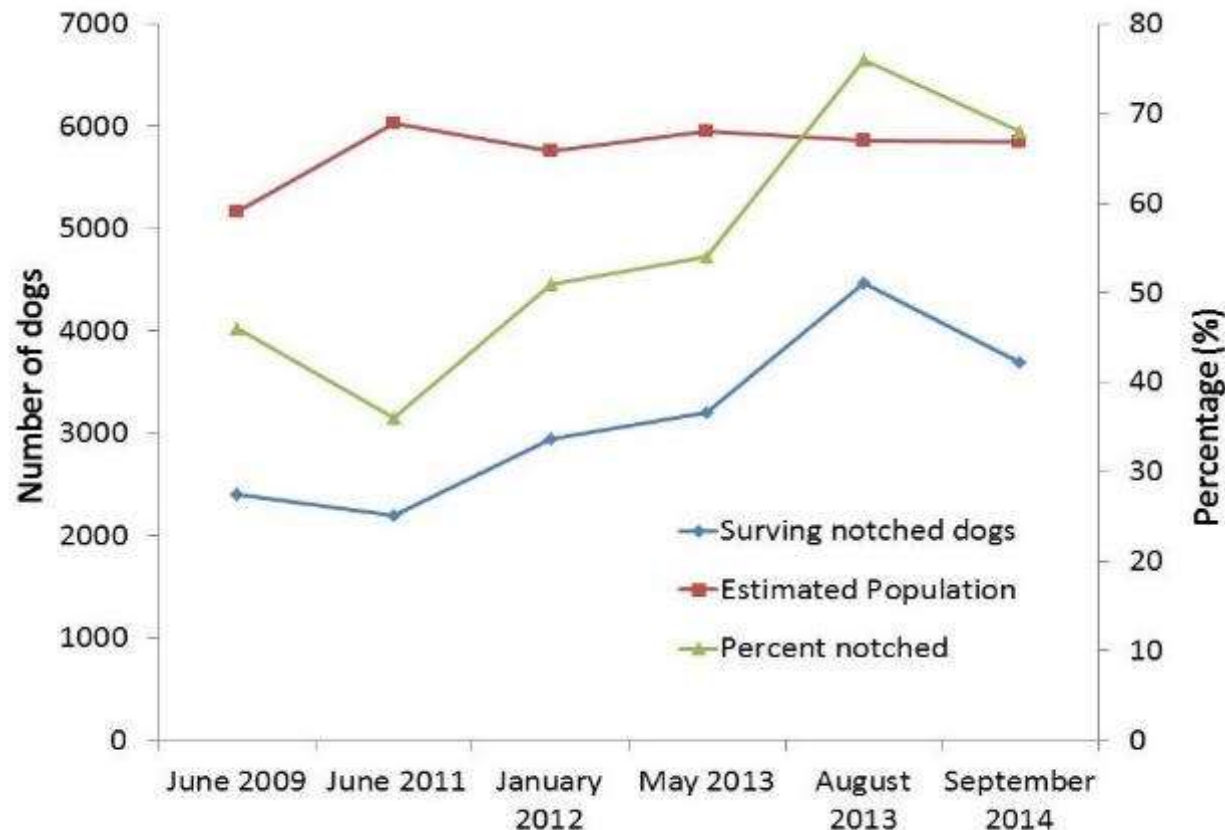
$$N = \frac{n_1 n_2}{m}$$

Monitoring of population trend in Thimphu city based on the population survey of the free-roaming dogs at frequent interval using permanent marks (ear notch).

Population Survey	Surviving notched dogs	Notched dogs sighted	Total dogs sighted	Proportion notched	Population Estimate
Jun-09	2343	903	1945	0.46	5047
Jun-11	1867	1022	2901	0.35	5300
Jan-12	2552	828	1618	0.51	4987
May-13	2620	1410	2621	0.54	4870
Aug-13	3860	1642	2151	0.76	5057

$$N = \frac{n_s}{p}$$

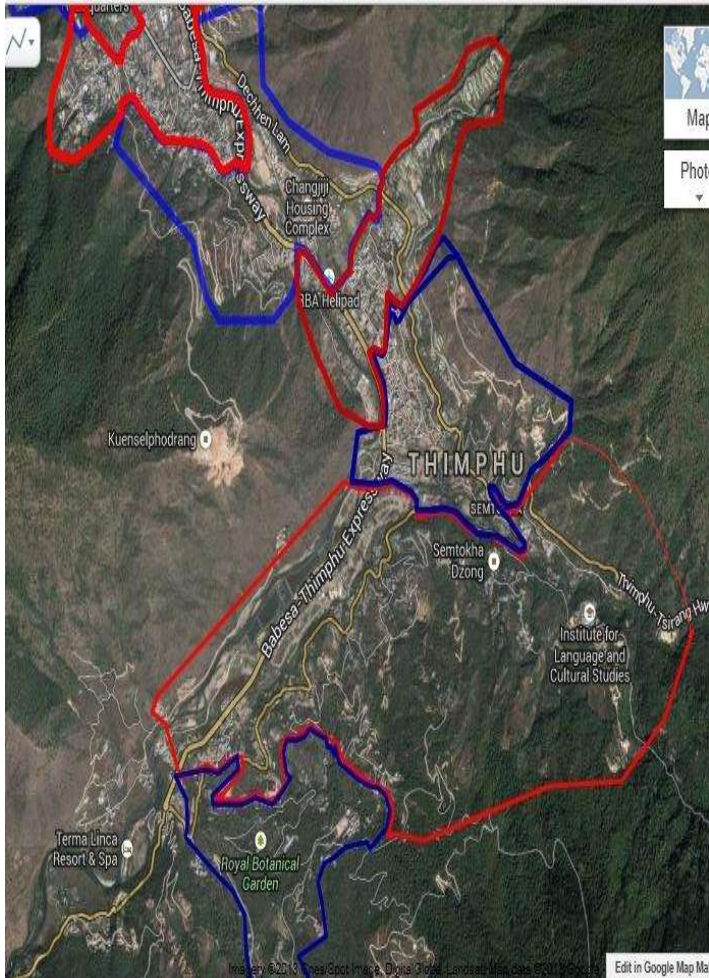
Estimated number of surviving ear-notched dogs, the total free-roaming dog population and the percentage of ear-notched dogs out of all total sighted dogs in Thimphu (June 2009 – September 2014)



Population estimate is determined by surviving ear notch dogs. Any outbreak of infectious diseases (CD) may affect the number of surviving ear notched dogs. Any biased intervention on the dog population will influence estimate of “p”, in this case proportion of ear notch dogs

$$N = \frac{n_s}{p}$$

Population estimate using detection probability and rapid survey



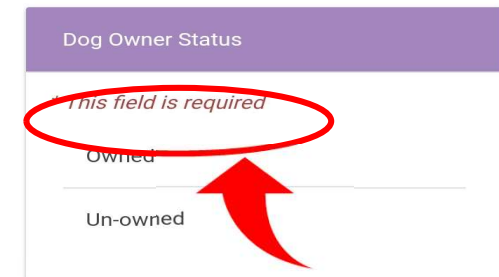
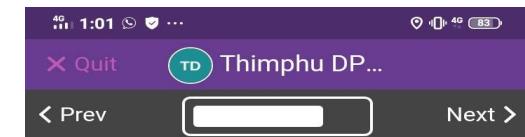
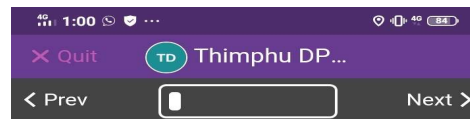
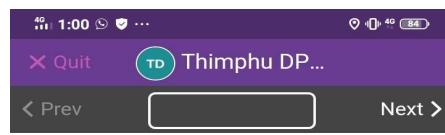
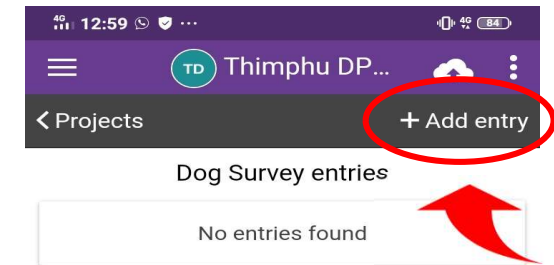
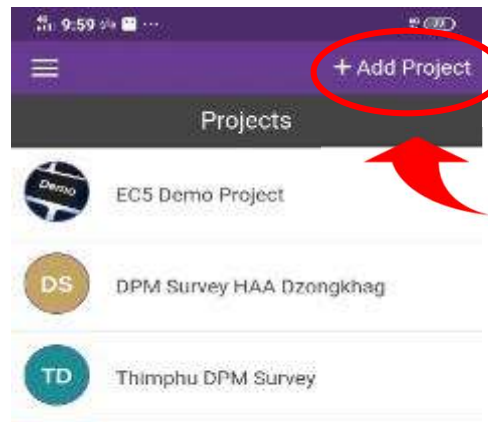
- Thimphu city divided into 15 wards (7 blue & 8 red wards)
- MR survey undertaken in blue wards
- Estimated pop size in BLUE ward (MR)
 $= n_1 \times n_2 / m = (658 \times 558) / 323 = \mathbf{1137}$
- Detection probability (p) in blue ward
 $= n_1 / N = 658 / 1137 = \mathbf{0.58}$
- Dogs counted (C) in RED ward = 1635
- Estimated pop size in red wards
 $= C / p = 1635 / 0.58 = \mathbf{2819}$
- Total population size in Thimphu is
 $1137 + 2819 = \mathbf{3956}$

$$N = \frac{C}{p}$$

Dog Population Survey using EpiCollect5 APP

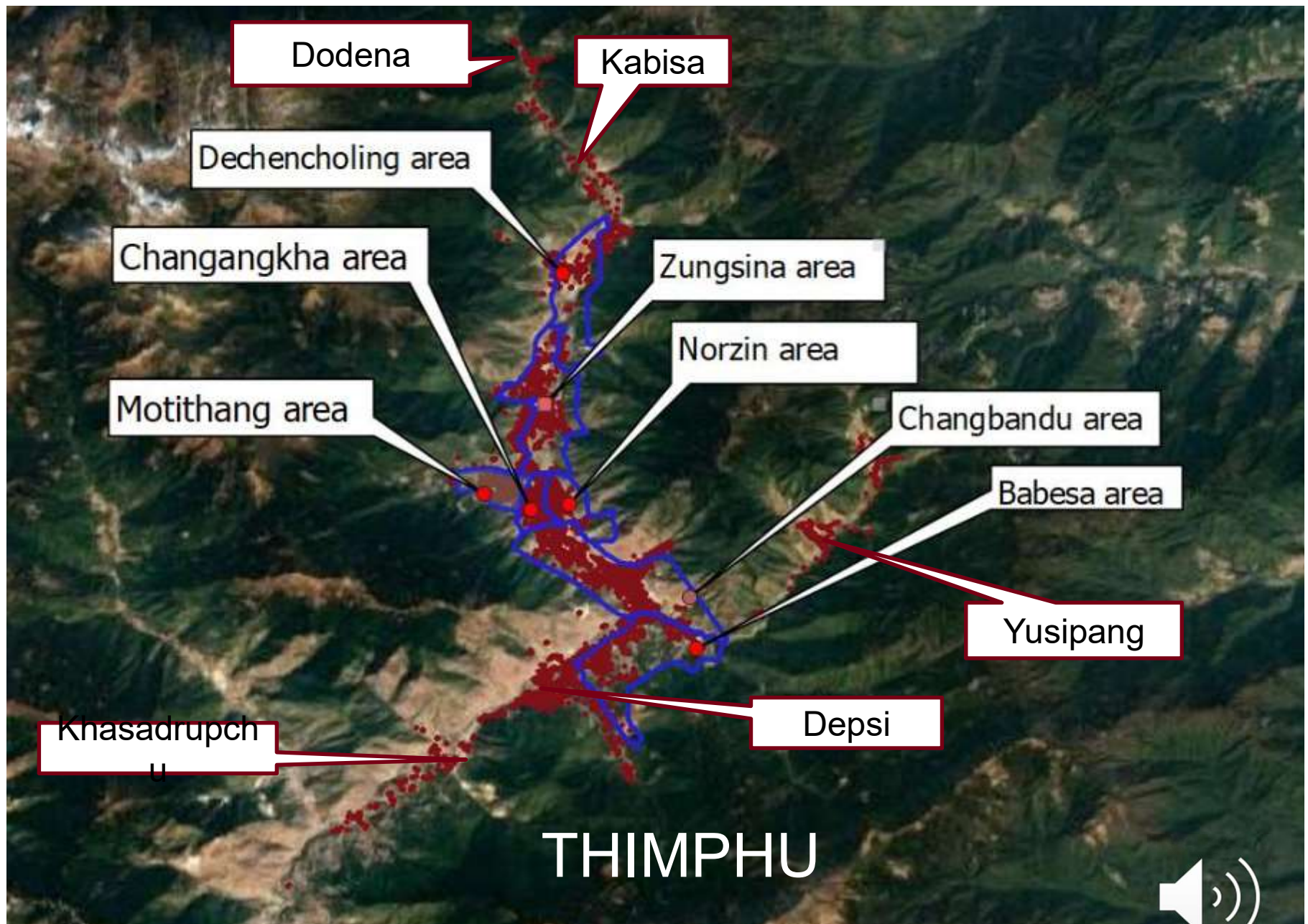


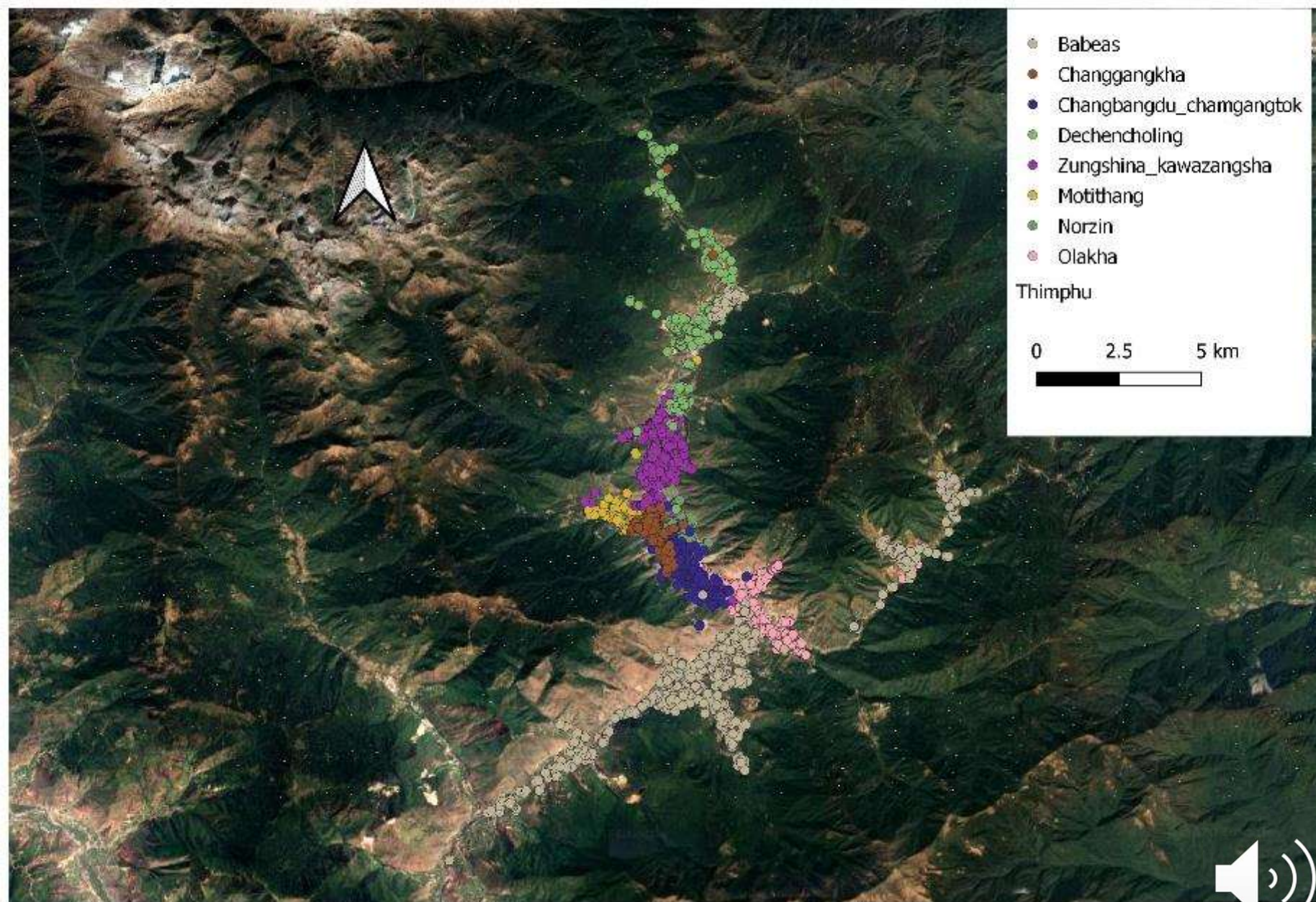
“Harnessing Technology for Dog Population Management and Mass Dog Vaccination Campaign ”

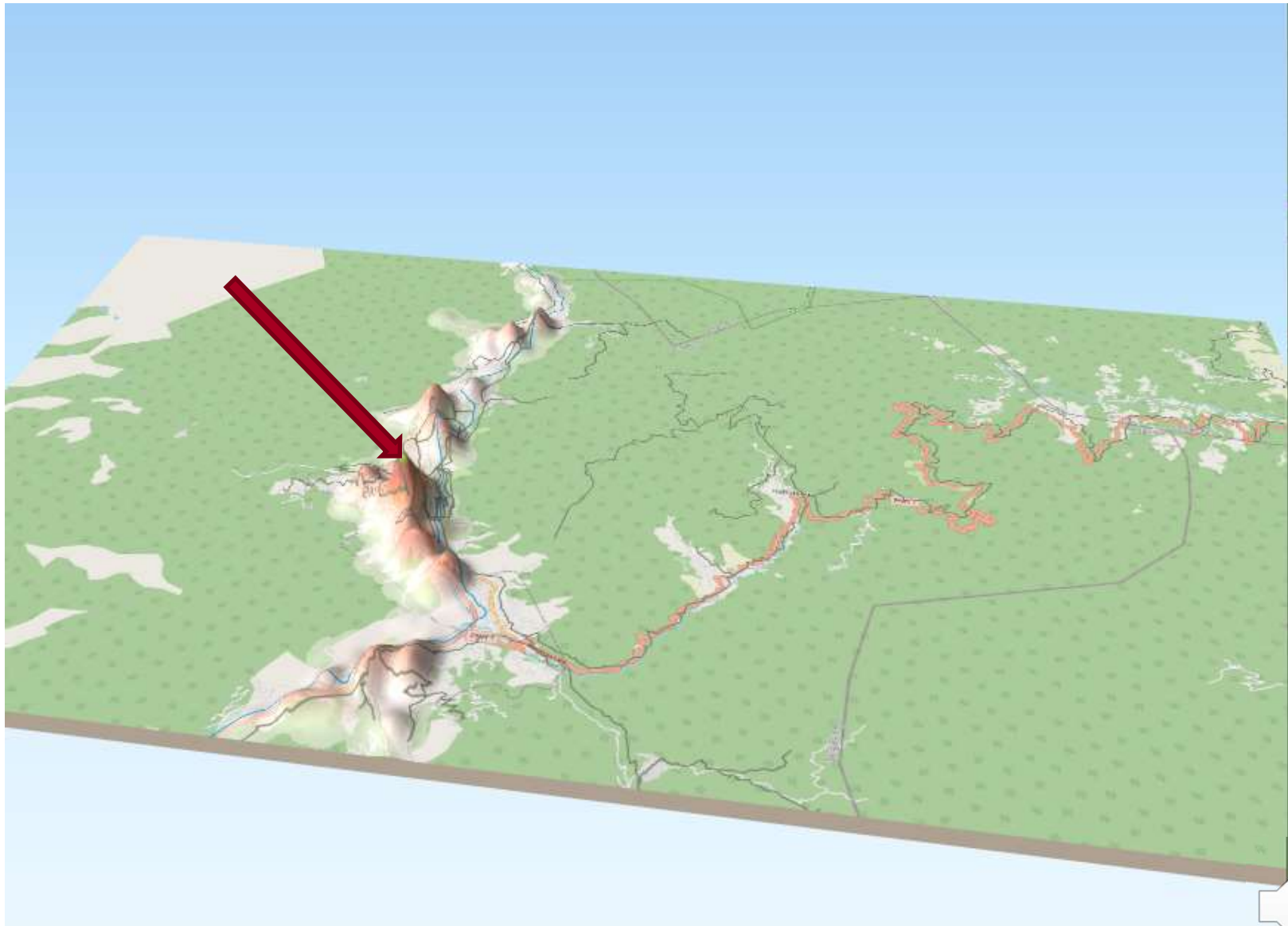


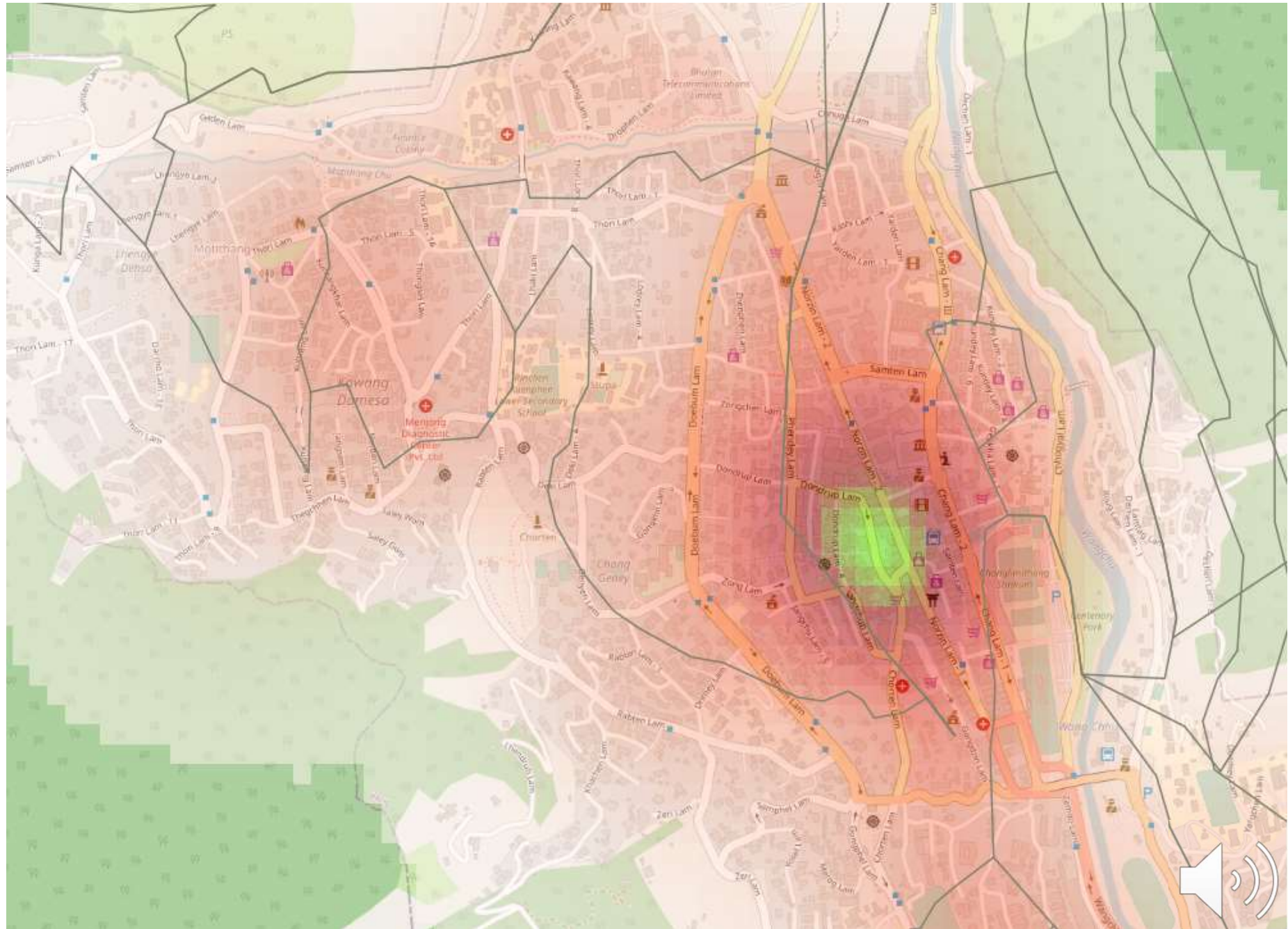
Sex status
Neuter status
Age
Lactating
Puppies
Health status
Skin condition





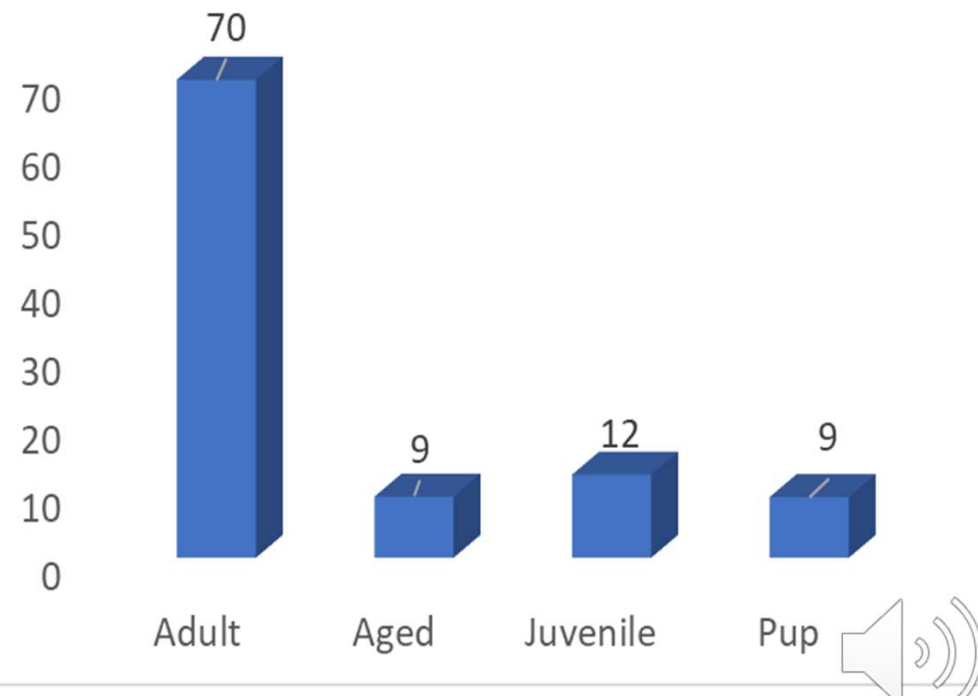
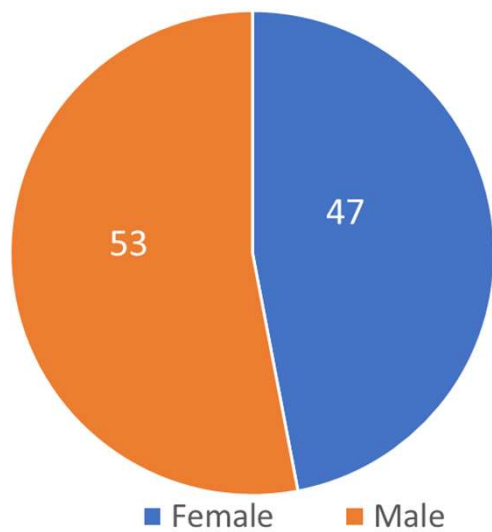
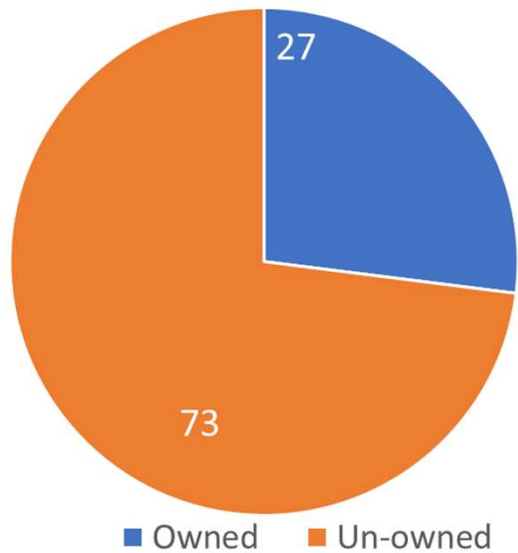




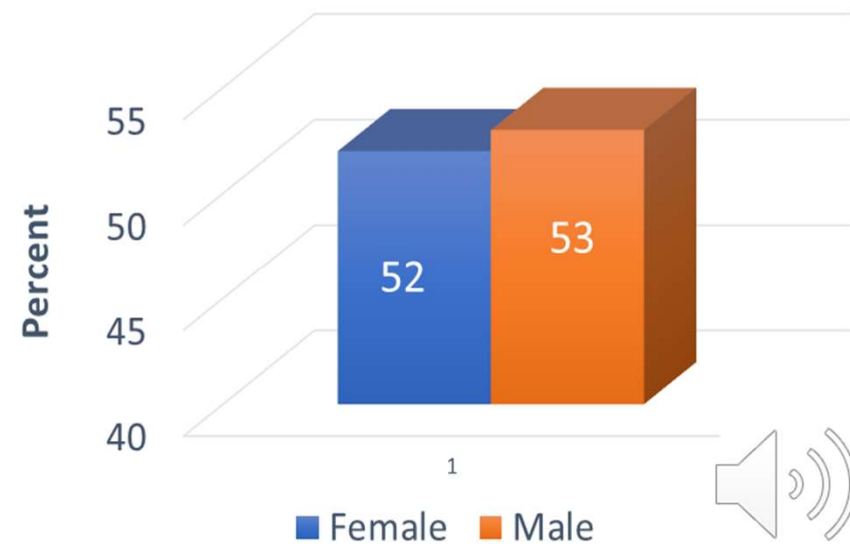
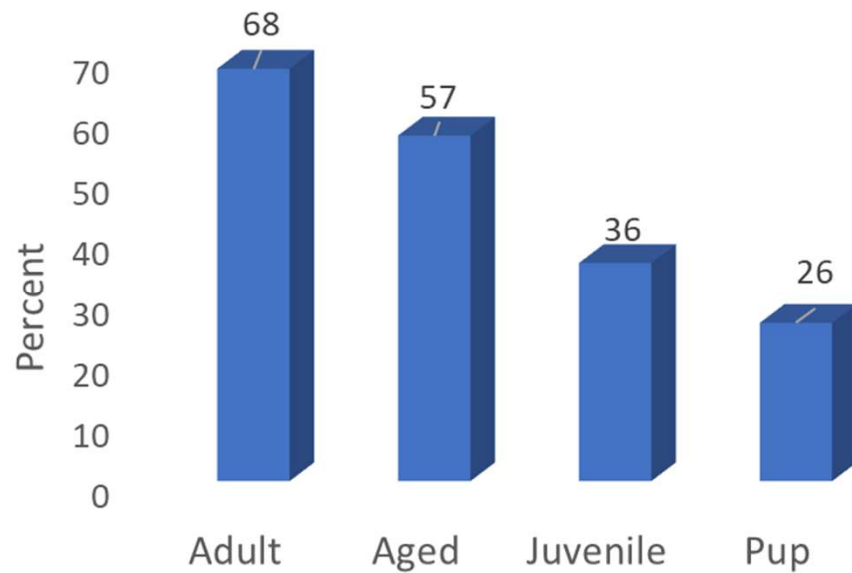
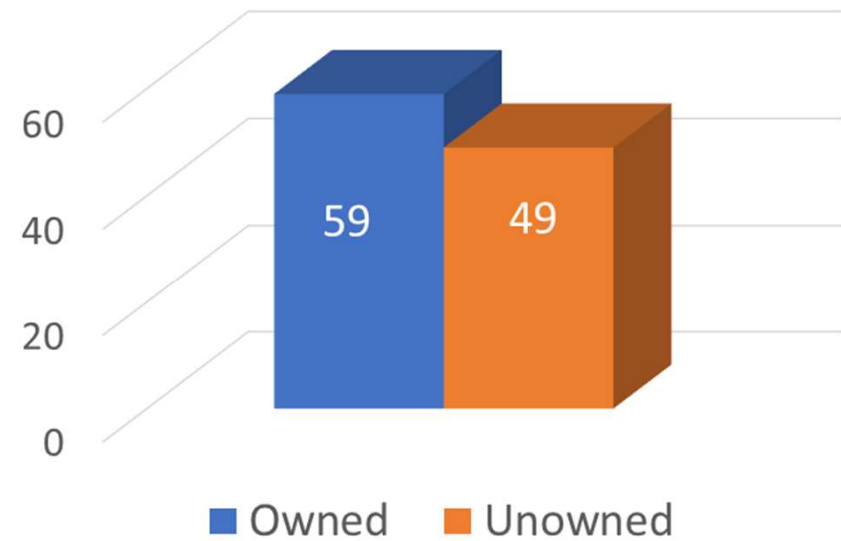
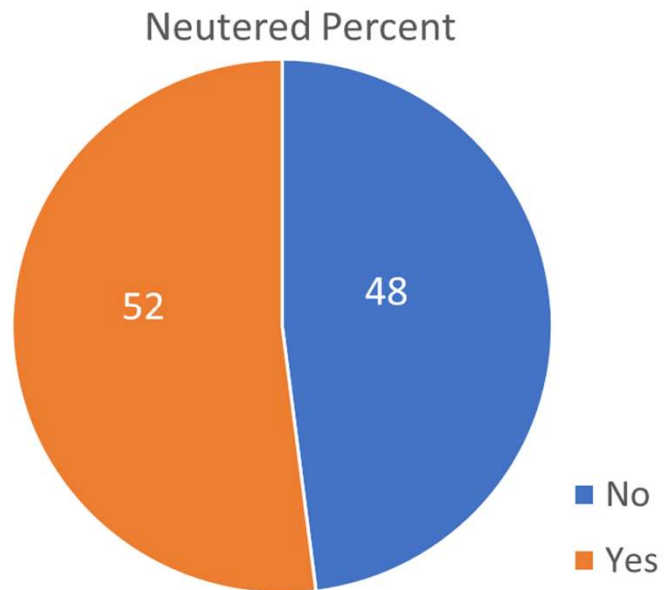




Owner status, sex and age structure of sighted dogs



Sterilization Coverage



Estimate of owned dog population in Thimphu City

- Total household in Thimphu Municipality = 25408
- Household with dogs = 15.1% (2018 survey)
- Total dogs owning household ($25403 \times 15.1\%$) = 3837
- Average number of dogs per dog owning HH = 1.37

Total owned dogs (3837×1.37) = **5257 dogs**

Owned dogs free-roaming – 24.3%

Roaming owned dogs = $5257 \times 24.3\%$ = **1277 dogs**

Estimate of free-roaming dog population in Thimphu City

- Total free-roaming dogs sighted = 4507
- Detectability rate = 0.727
- Estimated un-owned dog population
= $4507/0.727 = \mathbf{6199 \text{ dogs}}$
- Total dogs = $6199 + 5257 = \mathbf{11,456 \text{ dogs}}$
- Dog per house hold = 0.451 (11456/25408)
- Dog per person = 0.1 (11456/114551)

$$N = \frac{C}{p}$$

Detection Probability

$$N = \frac{m}{n_2}$$

Dogs photographed on Day 1 (n_1) and Day 2 (n_2); and; those dogs sighted and photographed on Day 1 is resighted on day 2 (m)

What was achieved from this survey?

- To monitor and evaluate an intervention
 - The population trend
 - Coverage (%) - vaccination and sterilization coverage
 - Assess other impact – welfare
- To plan an intervention (Eg: DPM, MDV)
 - How much resources is required?
 - Know the number of dogs that are not sterilized
 - Can work on the resources required - manpower, vehicles, vaccines, medicines, consumables
 - Where to focus?
 - Places with higher dog density; and areas with higher proportion of un-neutered dogs (hot spots mapped)
 - How much time required?
 - Months, duration?

Conclusion

■ Direct count methods

- Use **mobile phone Apps** for counting, capturing **GPS locations** and other parameters
- **Epicollect5** is an option if Apps are not readily available
- Apply **correction factor** to substitute **Missing proportion** by estimating **detection probability**
- Conduct count in smaller areas/ street lengths and **extrapolate** to the total area/ length of street

■ Mark-resight method

- Use **MR survey** for estimating detection probability/ **detectability** rate only
- **Photographic** capture/ recapture without disturbing the dogs may be applied

DIRECT COUNTS

Mobile Phone APPS

Geo Locations

Missing Proportion

Correction factor

MARK-RESIGHT

Detectability

Photography

Extrapolation



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