



STARC Mapping: Tool for campaign planning & resource prioritisation

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Worldwide Veterinary Service

**WOAH Regional Training Workshop on Rabies Control
in the Southern African Development Community**



World Organisation
for Animal Health



Blantyre, Malawi
21–24 April 2026



Rabies Control Challenges

- Rabies resources are limited!
- Campaigns planned by political boundaries
- Dog vaccination data often incomplete
 - No GPS location
- Surveillance data not consistently reported

Populations
defined at...

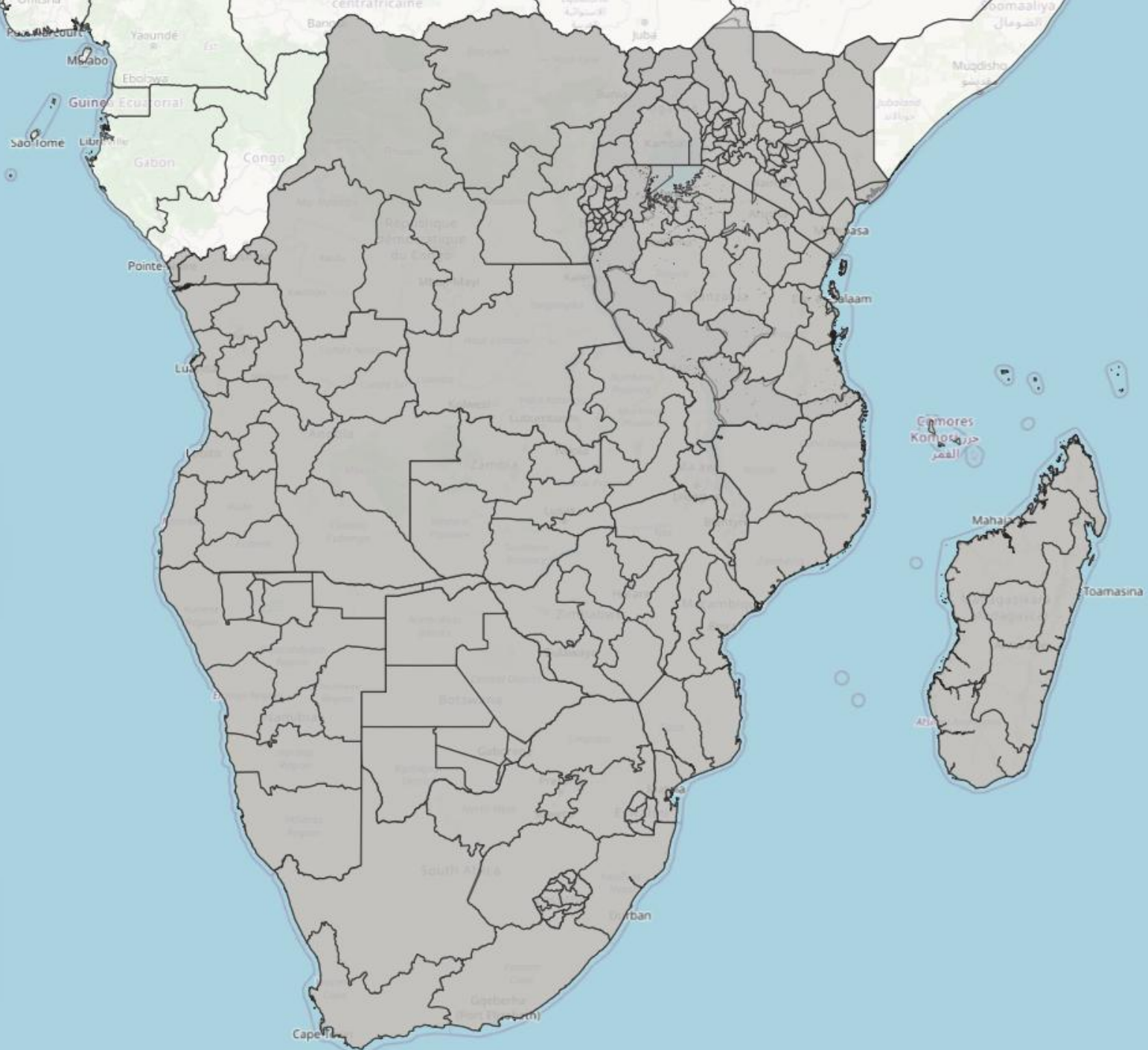
Country-level



Populations
defined at...

Region

Province



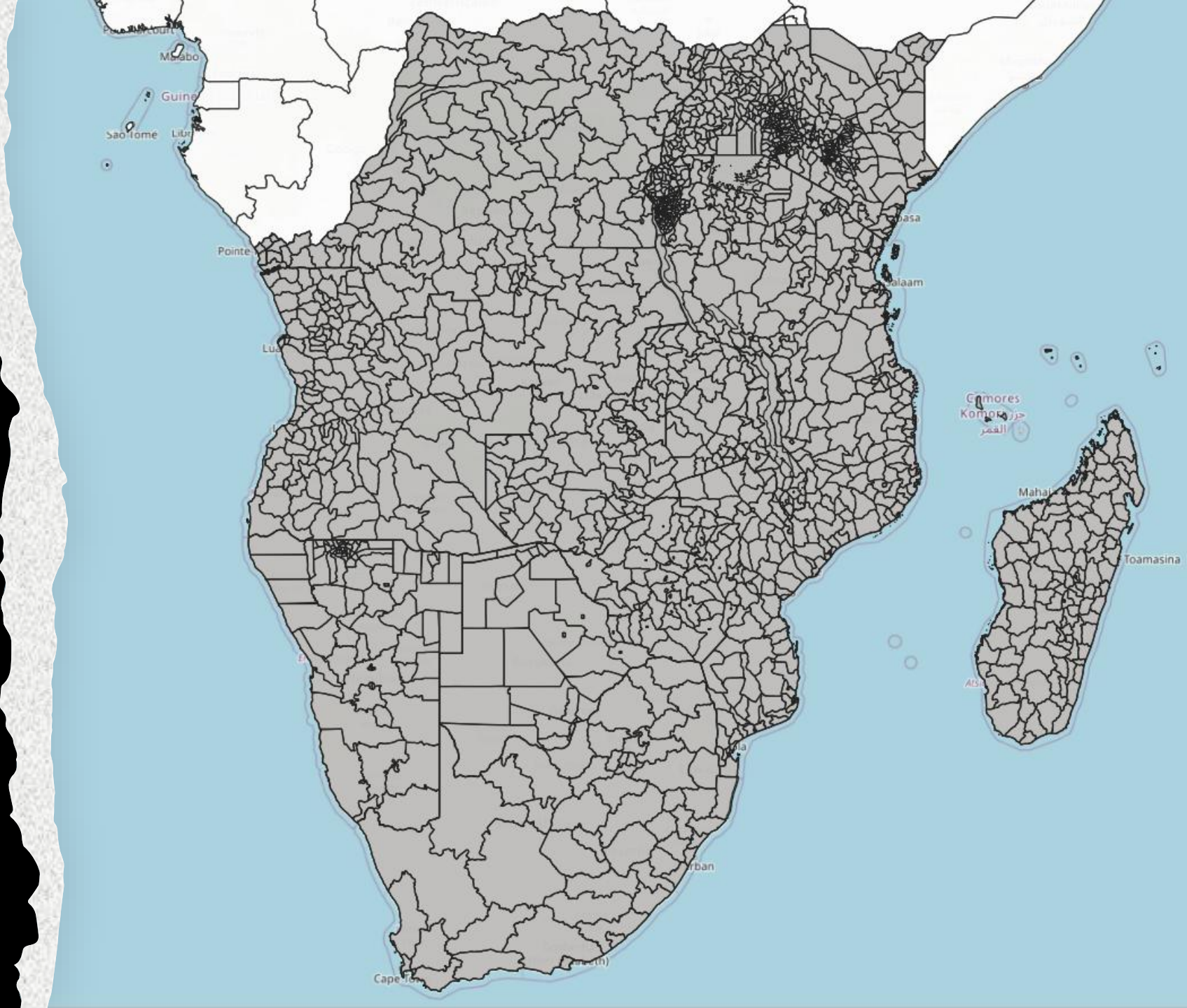
Populations defined at...

District

Municipality

Constituency

Ward

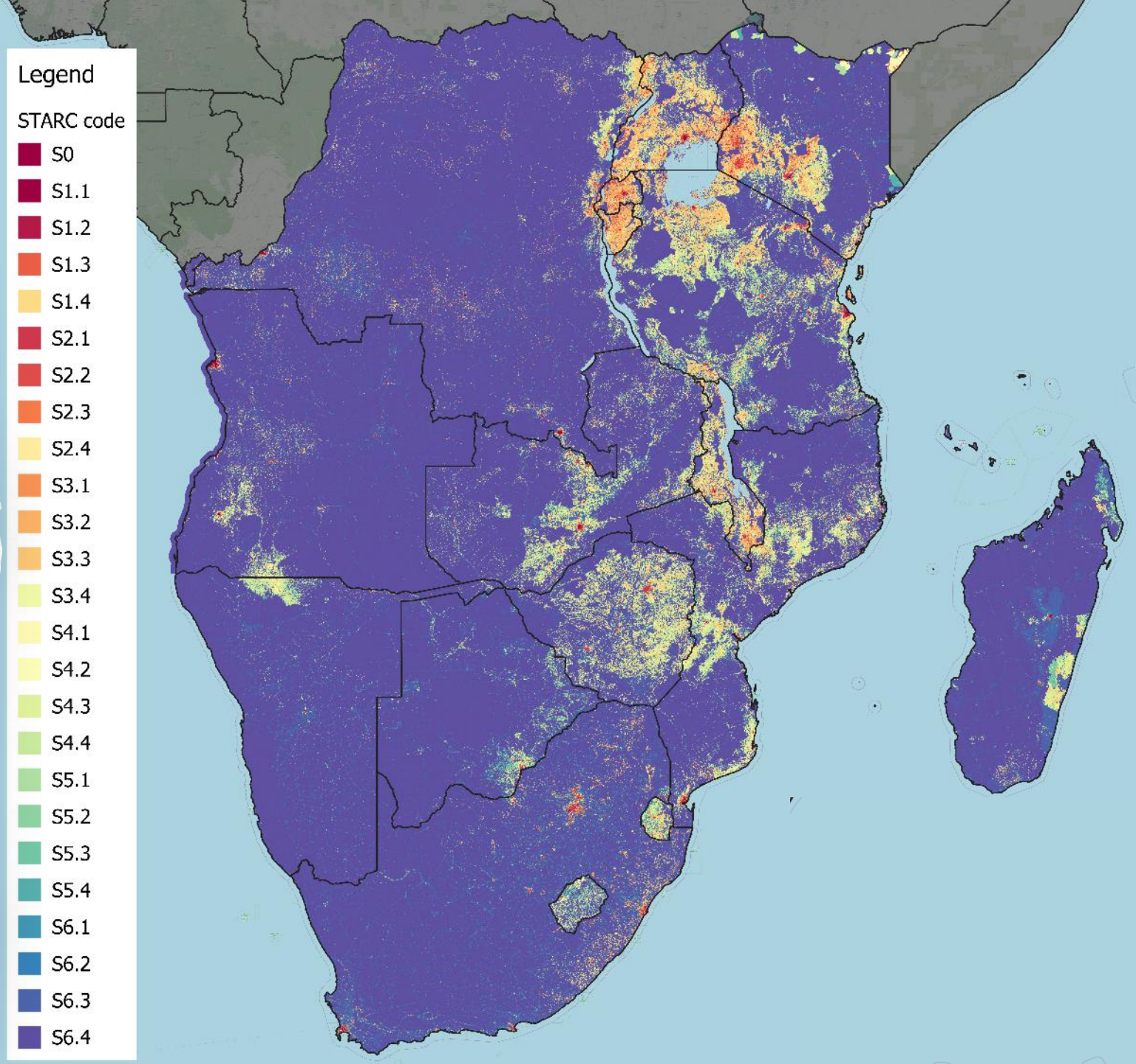


Challenge:

Rabies does **not** respect political boundaries

Solution:

Settlement Type
and Road
Connectivity -
STARC Model



STARC: Basic Concept

Settlement Type

Built Up Areas (BUA)



- Urban areas
- Densely packed buildings

Small Settlement Areas (SSA)



- Small towns
- Generally 50-500 structures

Hamlet Areas



- Rural Villages
- 1-50 structures

Road Connectivity

Primary Highway



- Transportation routes between major cities
- Often paved

Secondary Highway



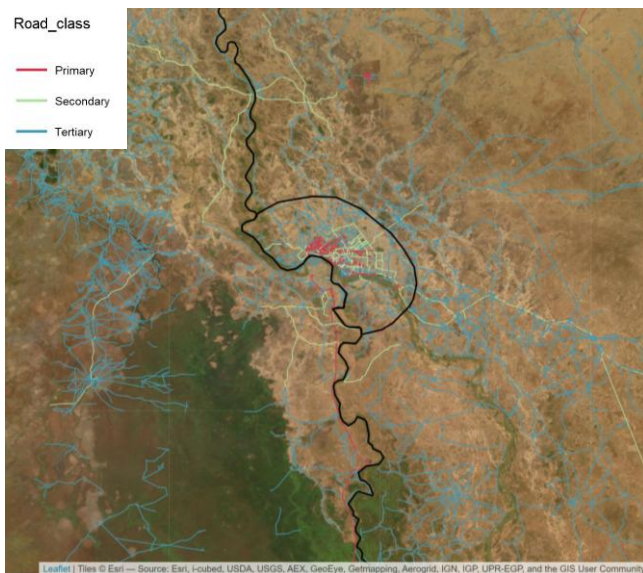
- Transportation routes between towns
- Collector roads in urban areas

Tertiary Highway

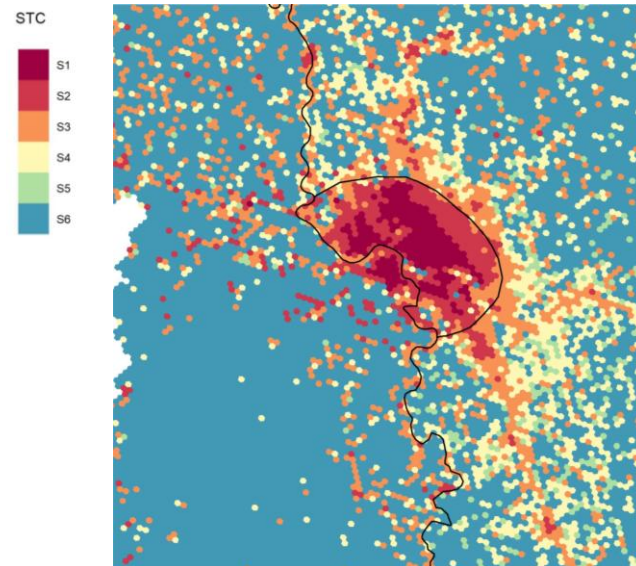


- Transportation routes between towns and villages
- Residential streets

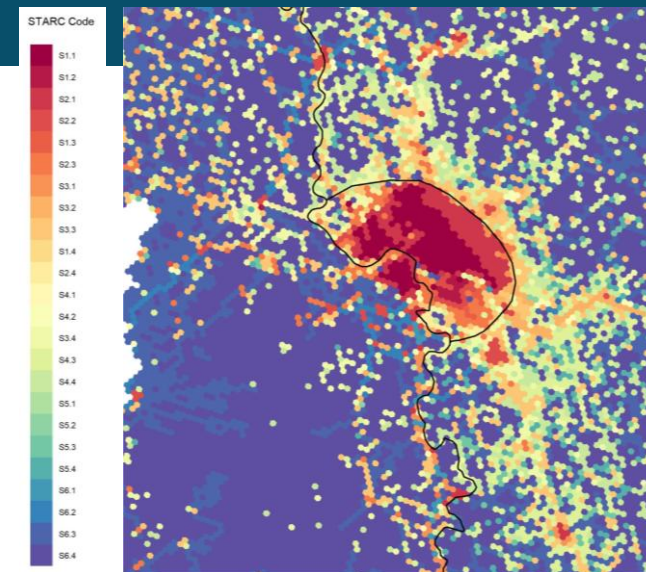
STARC: Urbanicity



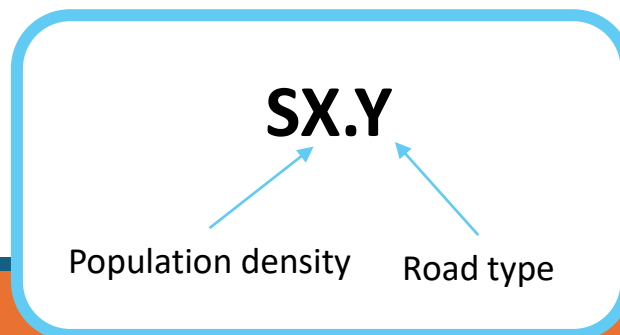
Determine Road Type
(OpenStreetMap data)



Determine Population
(Meta HRSL)



Combine
Defined on ~1km² scale



		Human Population Density per km ² (STC)					
		>5000	500 - 4999	50 - 499	5 - 49	1 - 5	0
Road Type (RCC)	Primary	S1.1	S2.1	S3.1	S4.1	S5.1	S6.1
	Secondary	S1.2	S2.2	S3.2	S4.2	S5.2	S6.2
	Tertiary	S1.3	S2.3	S3.3	S4.3	S5.3	S6.3
	Unconnected	S1.4	S2.4	S3.4	S4.4	S5.4	S6.4

STARC: Campaign planning

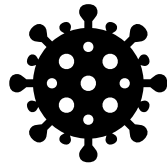
1

Dog
population
estimates



2

Identify
transmission
zones



3

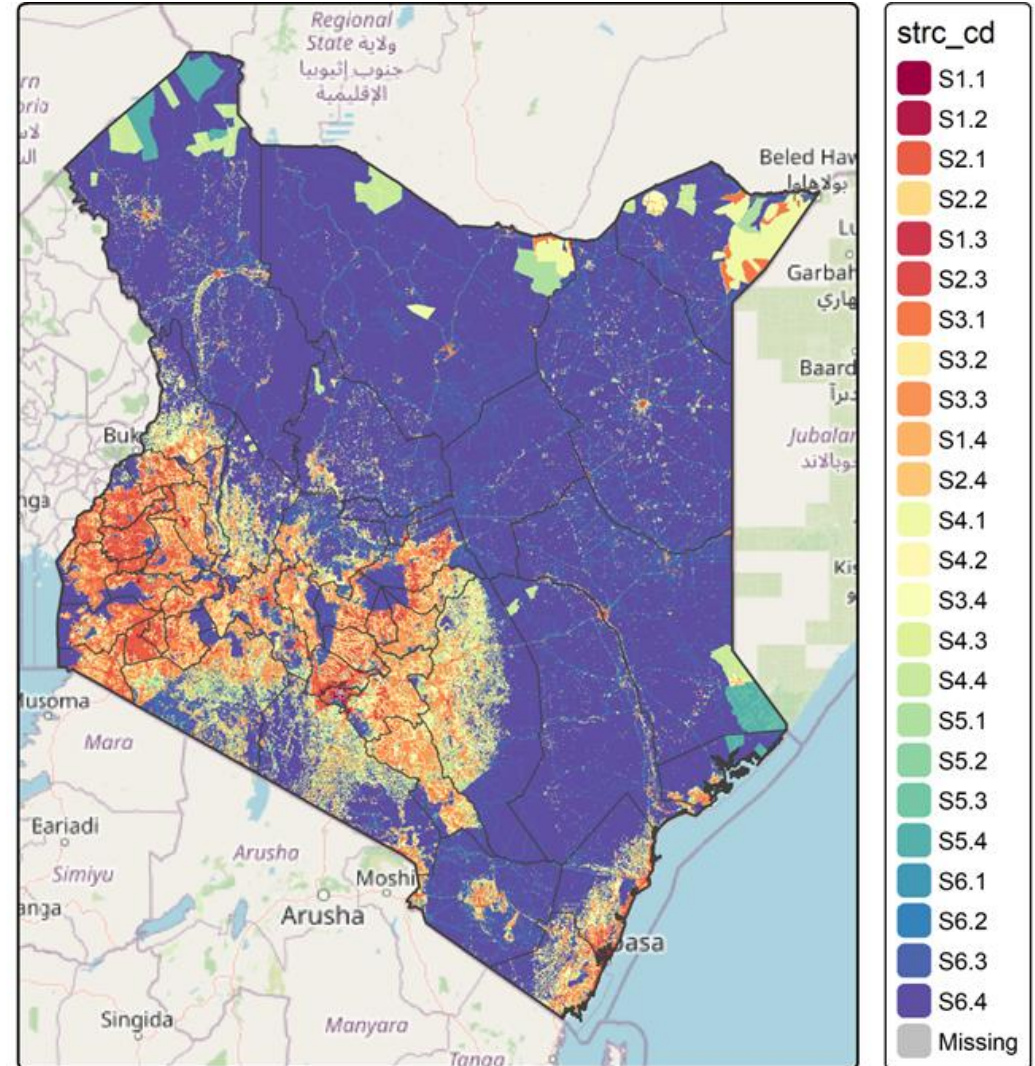
Resource
allocation



STARC: Kenya example

1. Categorise urbanicity

		Human Population Density per km ² (STC)					
		>5000	500 - 4999	50 - 499	5 - 49	1 - 5	0
Road Type (RCC)	Primary	S1.1	S2.1	S3.1	S4.1	S5.1	S6.1
	Secondary	S1.2	S2.2	S3.2	S4.2	S5.2	S6.2
	Tertiary	S1.3	S2.3	S3.3	S4.3	S5.3	S6.3
	Unconnected	S1.4	S2.4	S3.4	S4.4	S5.4	S6.4



STARC: Kenya example

2. Assign Human:Dog ratios (HDRs)

		>20,000					
		S0					
		Human Population Density per km ² (STC)					
		>5000	500 - 4999	50 - 499	5 - 49	1 - 5	0
Road Type (RCC)	Primary	S1.1	S2.1	S3.1	S4.1	S5.1	S6.1
	Secondary	S1.2	S2.2	S3.2	S4.2	S5.2	S6.2
	Tertiary	S1.3	S2.3	S3.3	S4.3	S5.3	S6.3
	Unconnected	S1.4	S2.4	S3.4	S4.4	S5.4	S6.4
		Urban	Peri-urban	Rural - Connected	Rural - Disconnected		

STARC code	Total HDR	Free-Roaming HDR
S0	80	100
S1	15	20
S2	5	10
S3	4	5
S4	3	3
S5	2	2

STARC code	Human Population	Area (km2)	Total Dog Population	Total HDR	Free-Roaming Dogs	FRD HDR
S.0	3,854,609	102	48,183	80	38,546	100
S.1	5,780,961	665	385,397	15	289,048	20
S.2	27,572,977	27,762	5,514,595	5	2,757,298	10
S.3	15,484,060	78,364	3,871,015	4	3,096,812	5
S.4	1,181,183	51,688	393,728	3	393,728	3
S.5	41,816	14,130	20,908	2	20,908	2
S.6	0	421,185	0	0	0	0
TOTAL	53,915,607	593,897	10,233,826	5.3	6,596,340	8.2

3. Estimate dog population

Adjustable
STARC inputs

Kenya: Dog Population

STARC code	Human Population	Area (km2)	Total Dog Population	Total HDR	Free-Roaming Dogs	FRD HDR
S.0	3,854,609	102	48,183	80	38,546	100
S.1	5,780,961	665	385,397	15	289,048	20
S.2	27,572,977	27,762	5,514,595	5	2,757,298	10
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STARC inputs

Kenya: Dog Population

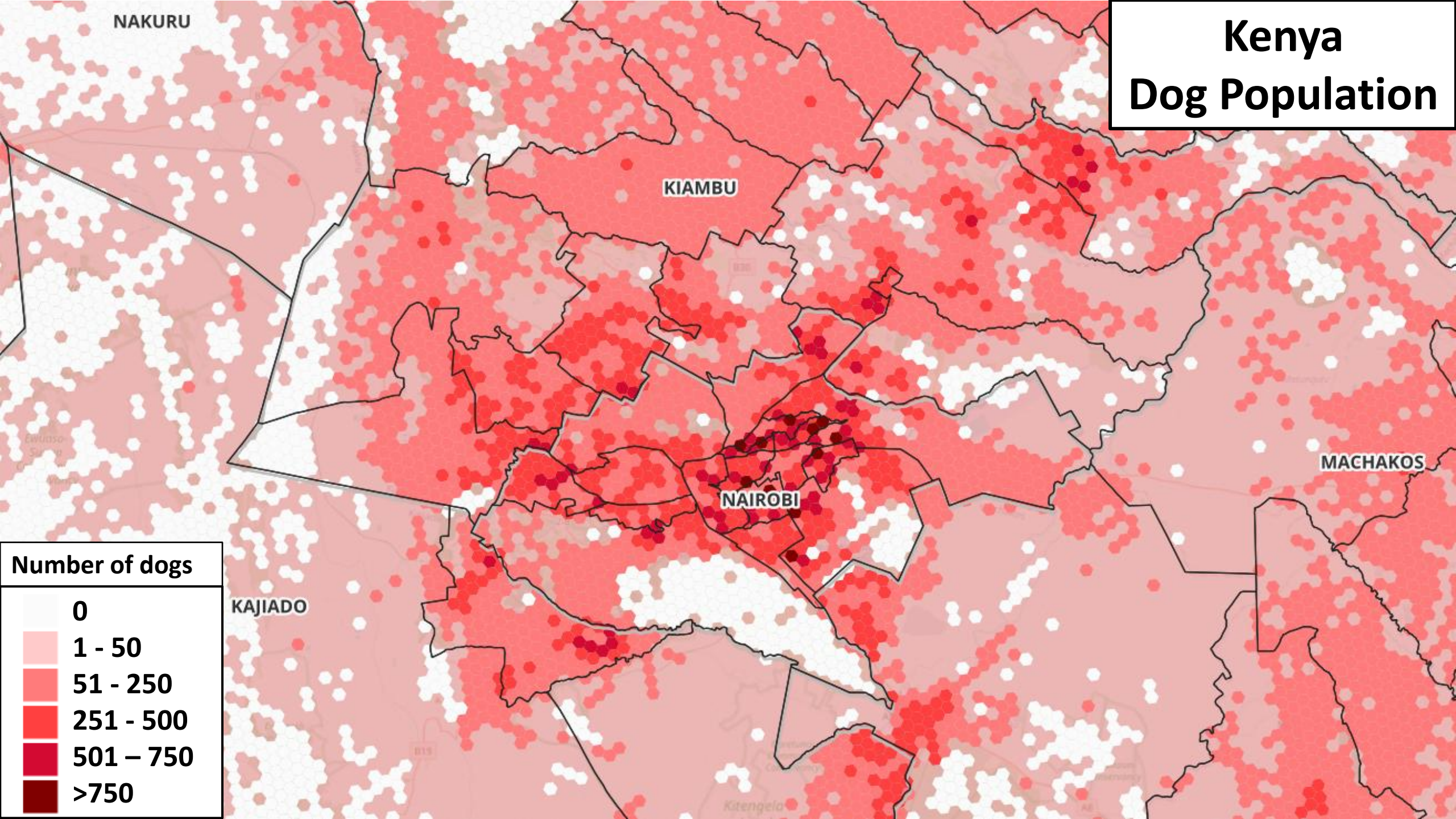
Urbanicity	Human Population	Area (km2)	Total Dog Population	Total HDR	Free-Roaming Dogs	FRD HDR
Highly urban	3,854,609	102	48,183	80	38,546	100
Urban	22,523,303	15,268	3,733,866	6	1,963,282	11.5
Peri-urban	22,224,746	71,820	5,083,173	4.4	3,498,921	6.4
Rural	5,312,948	506,706	1,368,605	3.9	1,095,590	4.8
TOTAL	53,915,607	593,897	10,233,826	5.3	6,596,340	8.2

3. Estimate dog population

>83% of dog population in peri-urban and urban areas

Kenya: Dog Population

Kenya Dog Population



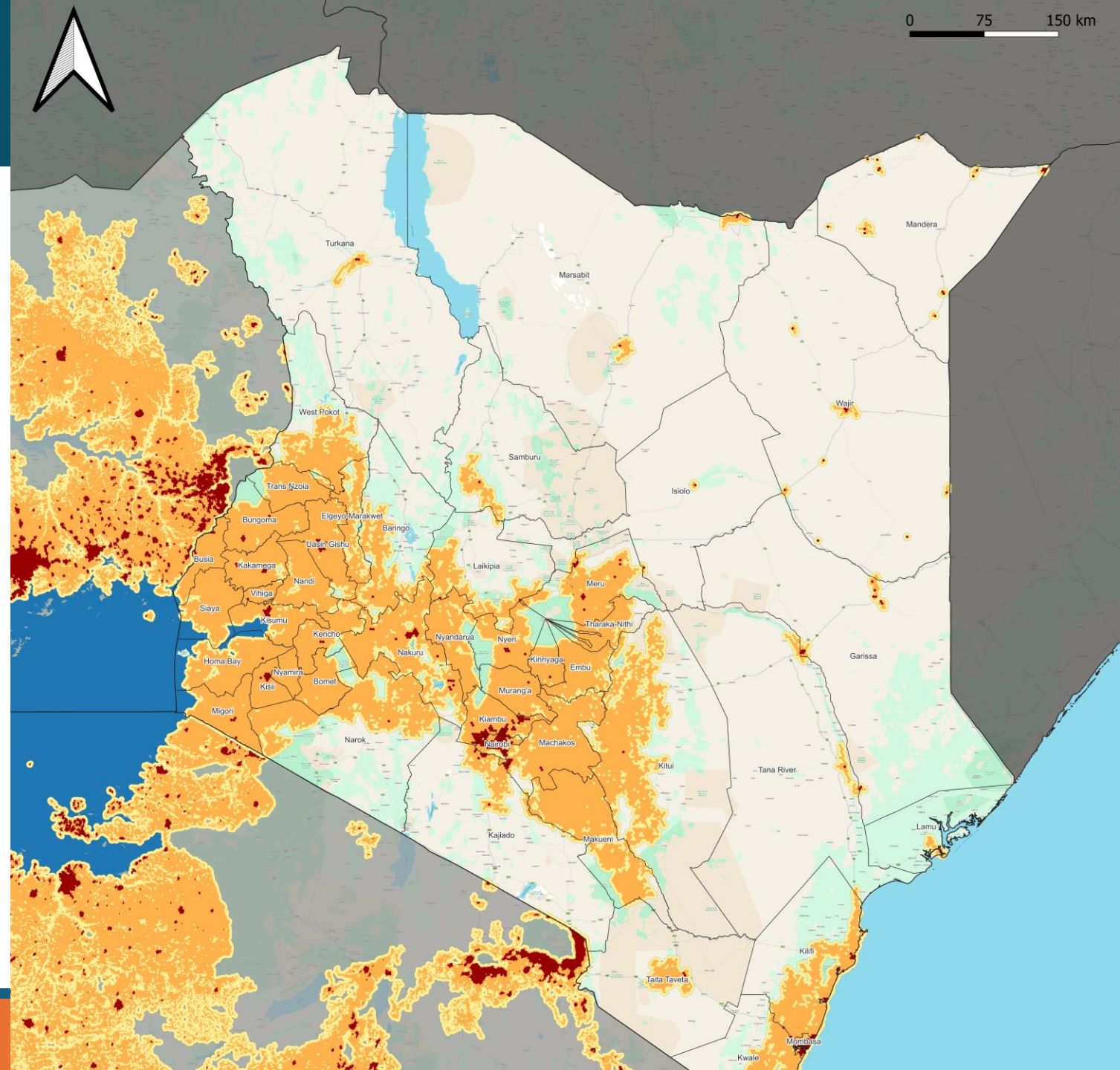
Number of dogs	
0	White
1 - 50	Light Pink
51 - 250	Red
251 - 500	Dark Red
501 - 750	Dark Red
>750	Brown

STARC: Kenya

4. Identify transmission zones

Legend

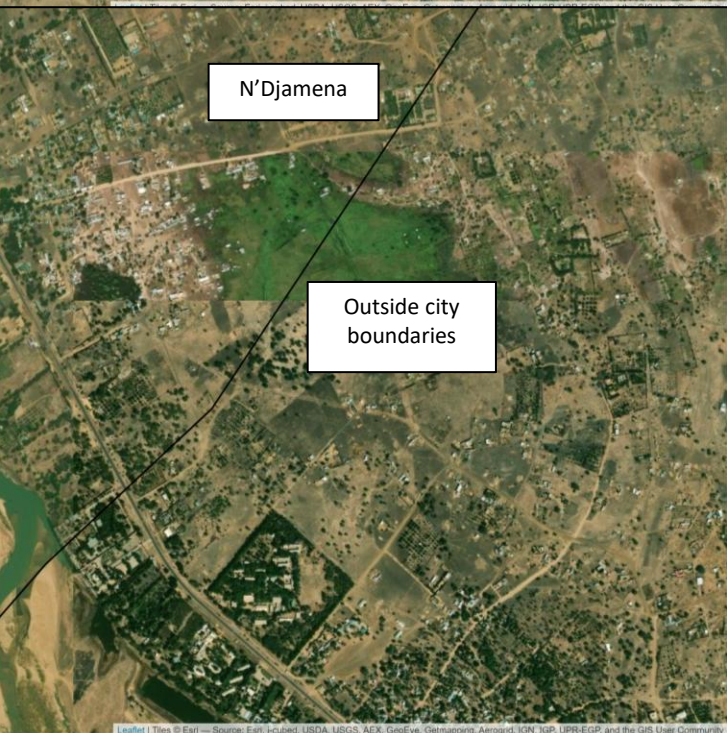
- Hot spots: Areas with significantly high concentration of dogs that are likely to maintain rabies transmission if rabies is present.
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Chad

Cameroon



N'Djamena

Outside city boundaries

How is STARC helpful? Example: Chad, Africa

Multi-year, high-coverage dog vaccination program from 2012-2014

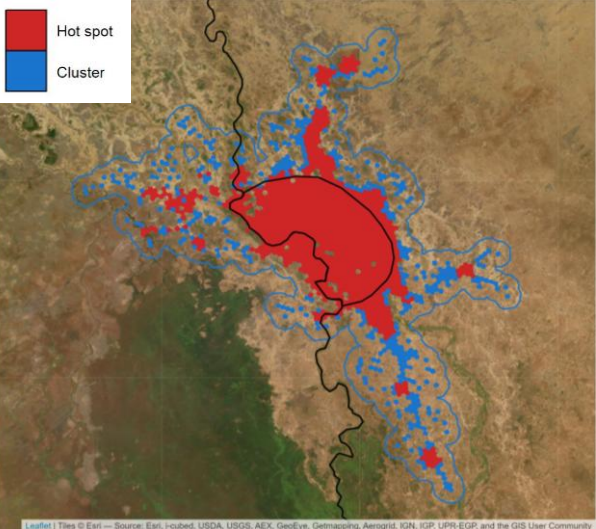
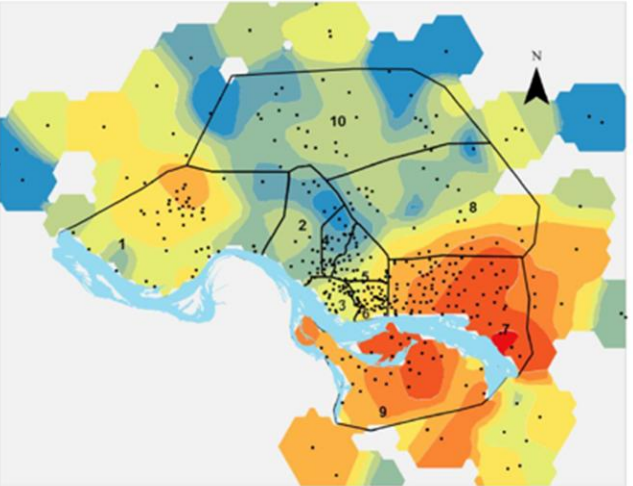
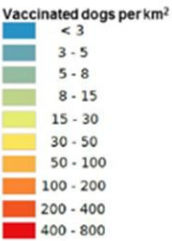
- Rabies cases were successfully halted
- BUT once vaccination stopped, and cases returned in less than one year!

STARC Assessment

- Dog populations extend beyond the city boundaries
- While 70% vaccination coverage may have been achieved within the city, coverage is just 55% when considering the entire transmission cluster

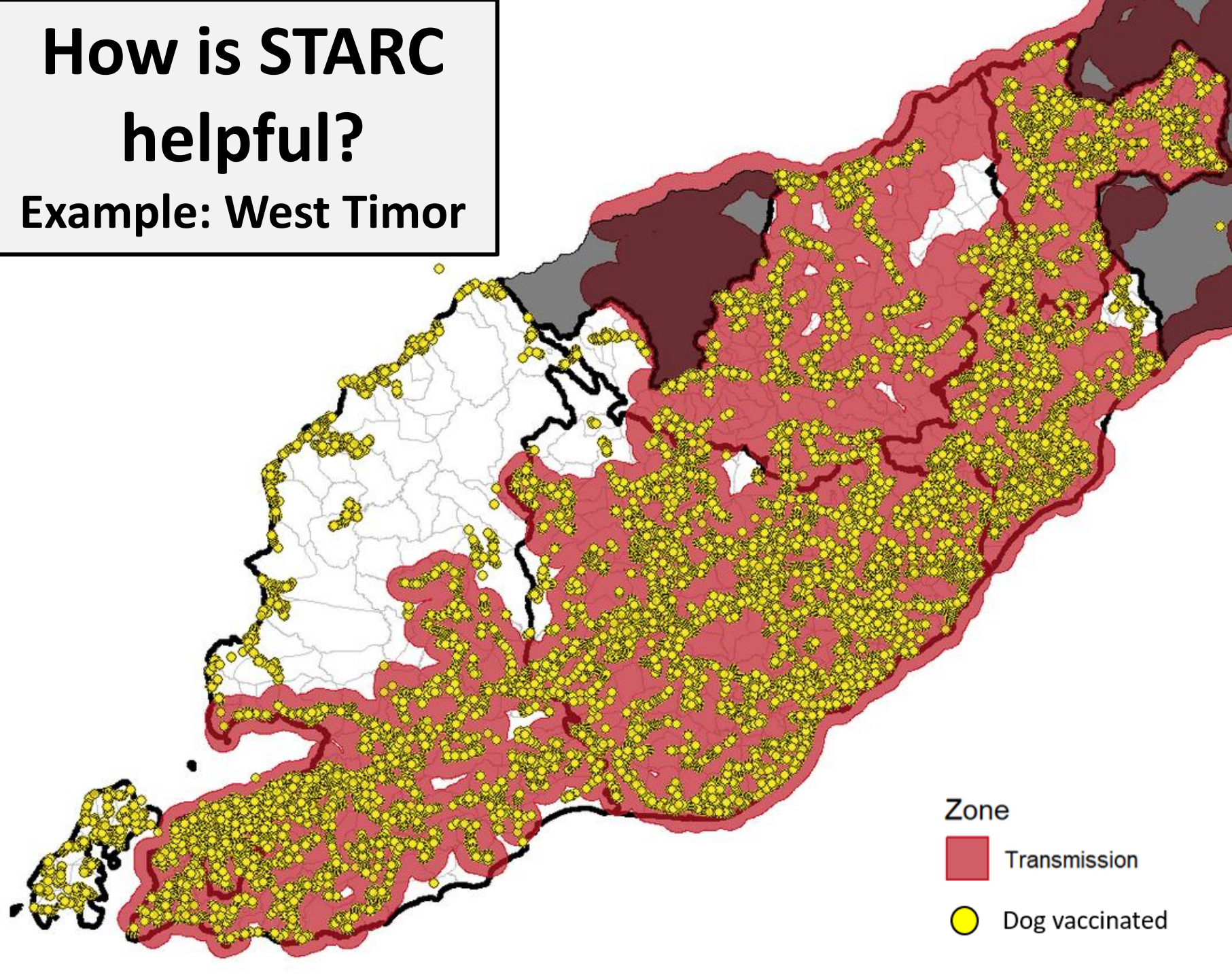
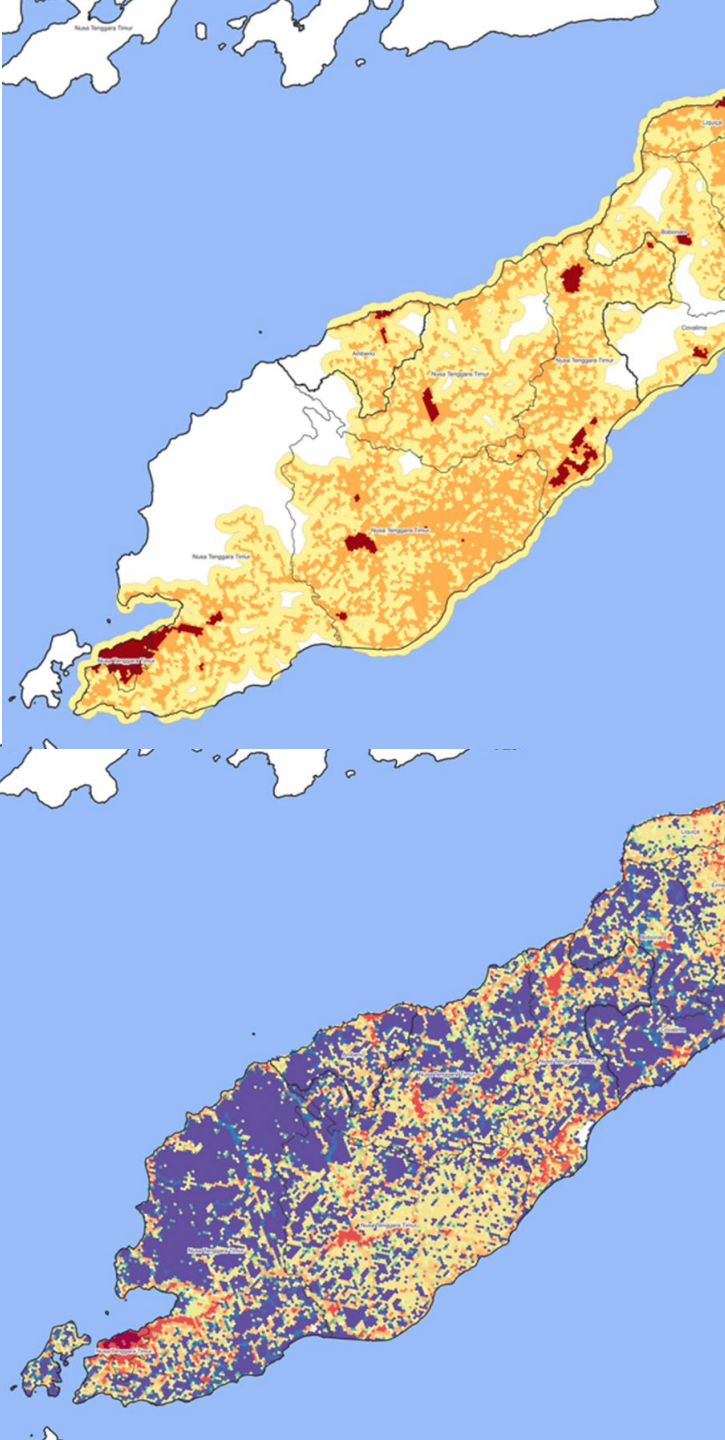
Density of vaccinated dogs in 2013

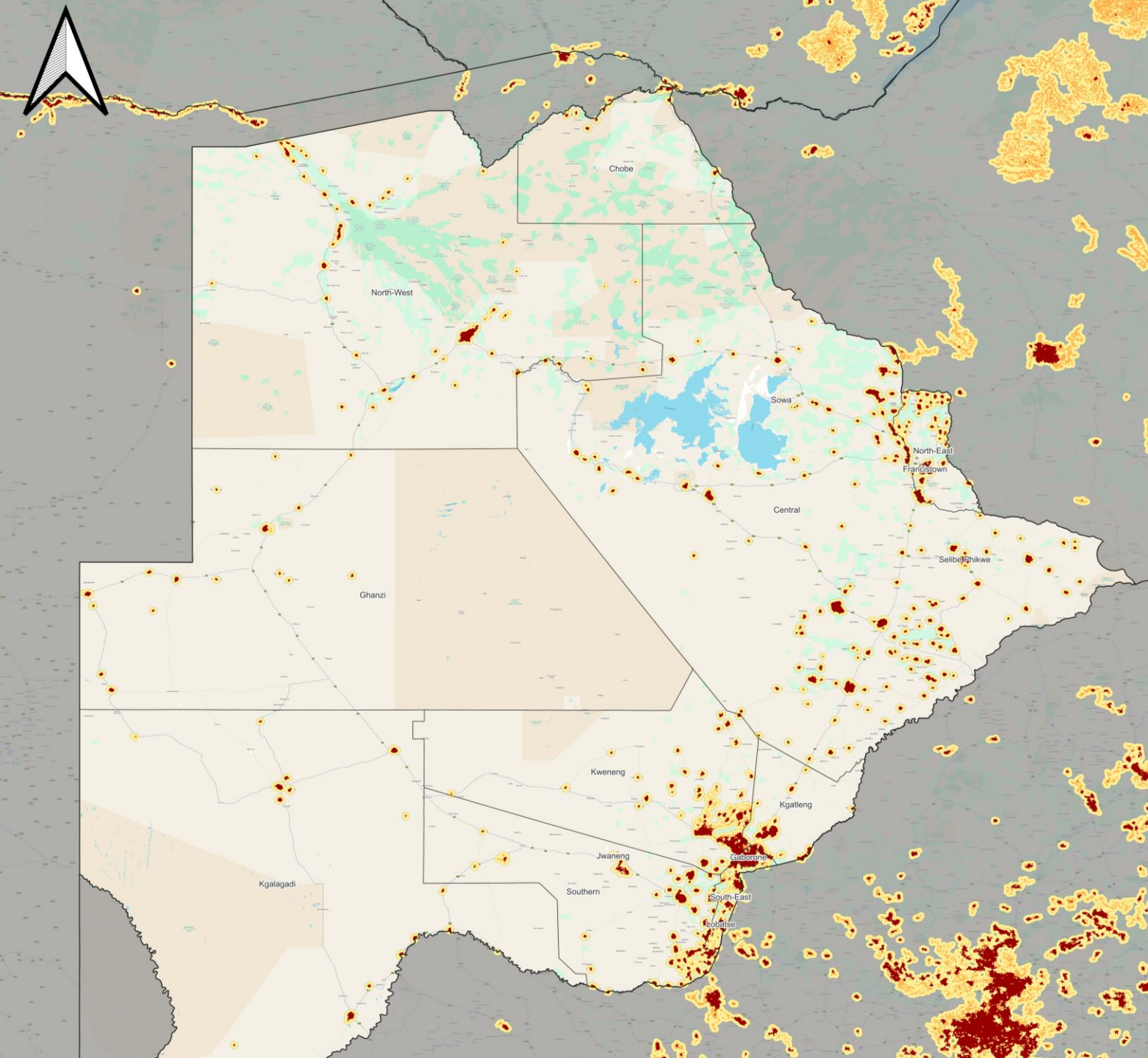
- Vaccination posts
- Water surface
- District boundaries



How is STARC helpful?

Example: West Timor





Botswana

Total Dogs: **235,570**

Dogs in TZs: **190,958**

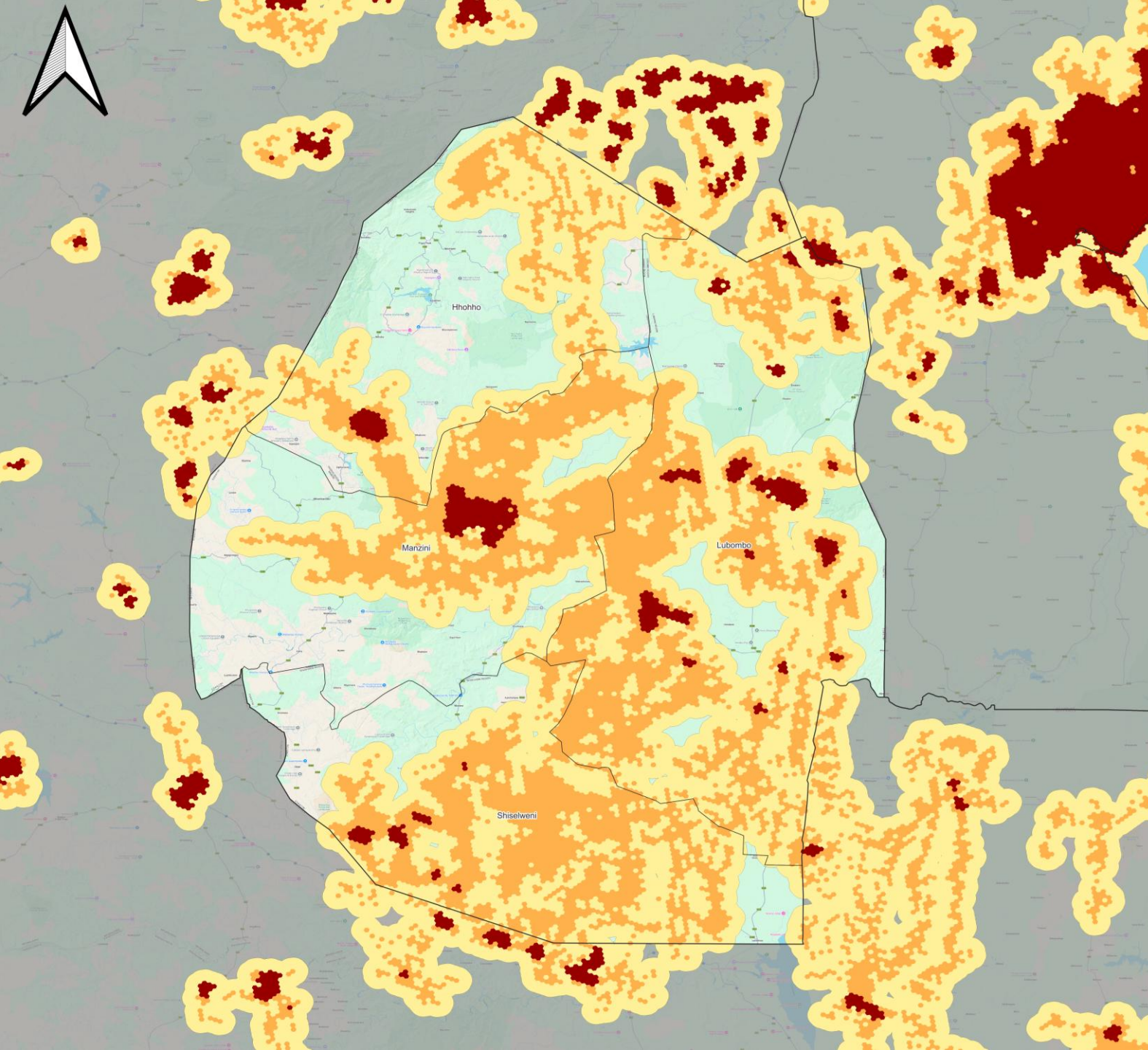
81.1% of dogs in TZs

Free-Roaming HDR

urban	15
Peri-urban	10
Rural	5

Legend

- Hot spots: Areas with significantly high concentration of dogs that are likely to maintain rabies transmission if rabies is present.
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eSwatini

Total Dogs: **119,529**

Dogs in TZs: **105,610**

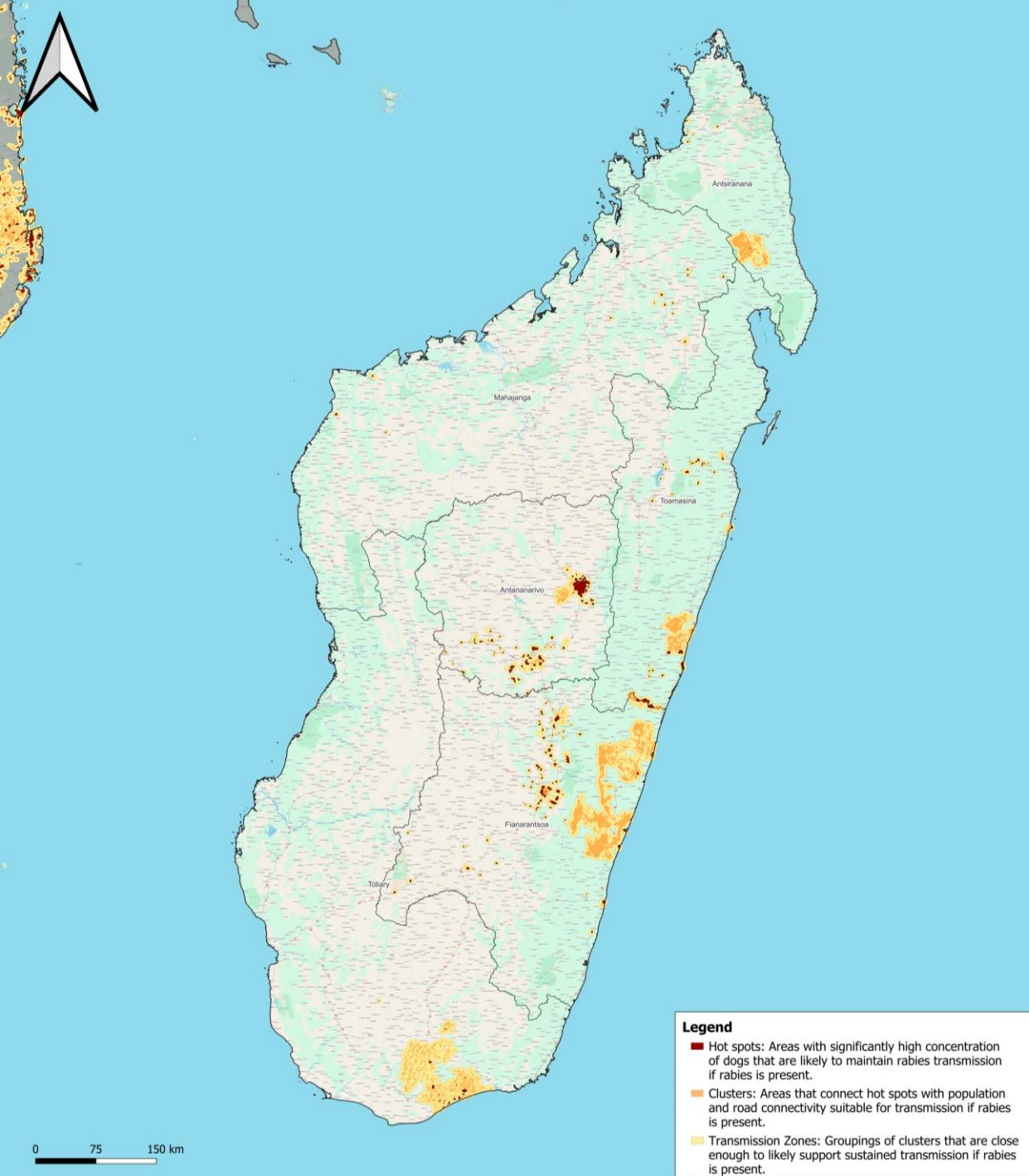
88.4% of dogs in TZs

Free-Roaming HDR

urban	12
Peri-urban	10
Rural	5

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Madagascar

Total Dogs: **1,504,203**

Dogs in TZs: **1,315,667**

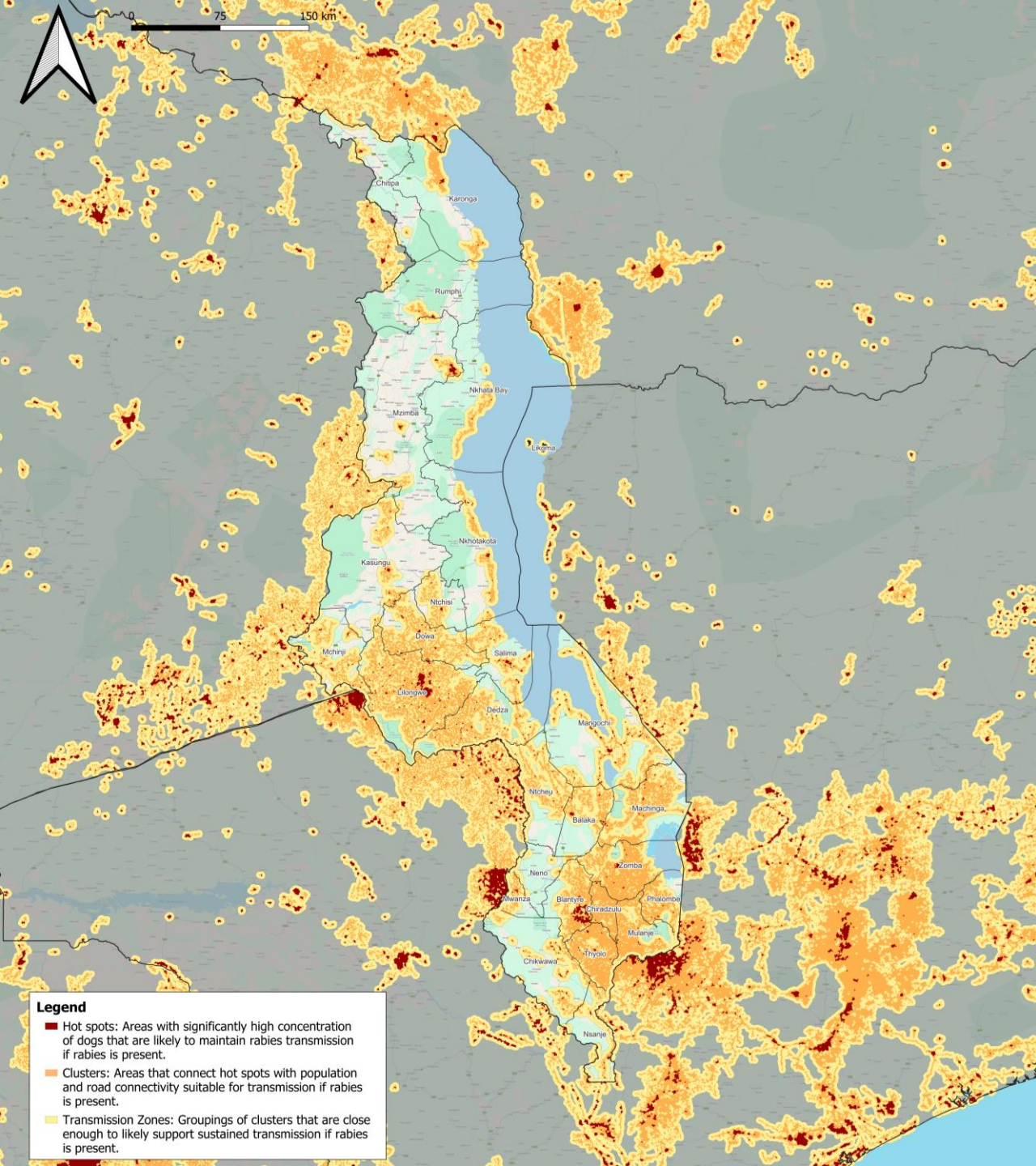
87.5% of dogs in TZs

Free-Roaming HDR

urban	15
Peri-urban	9
Rural	6

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Malawi

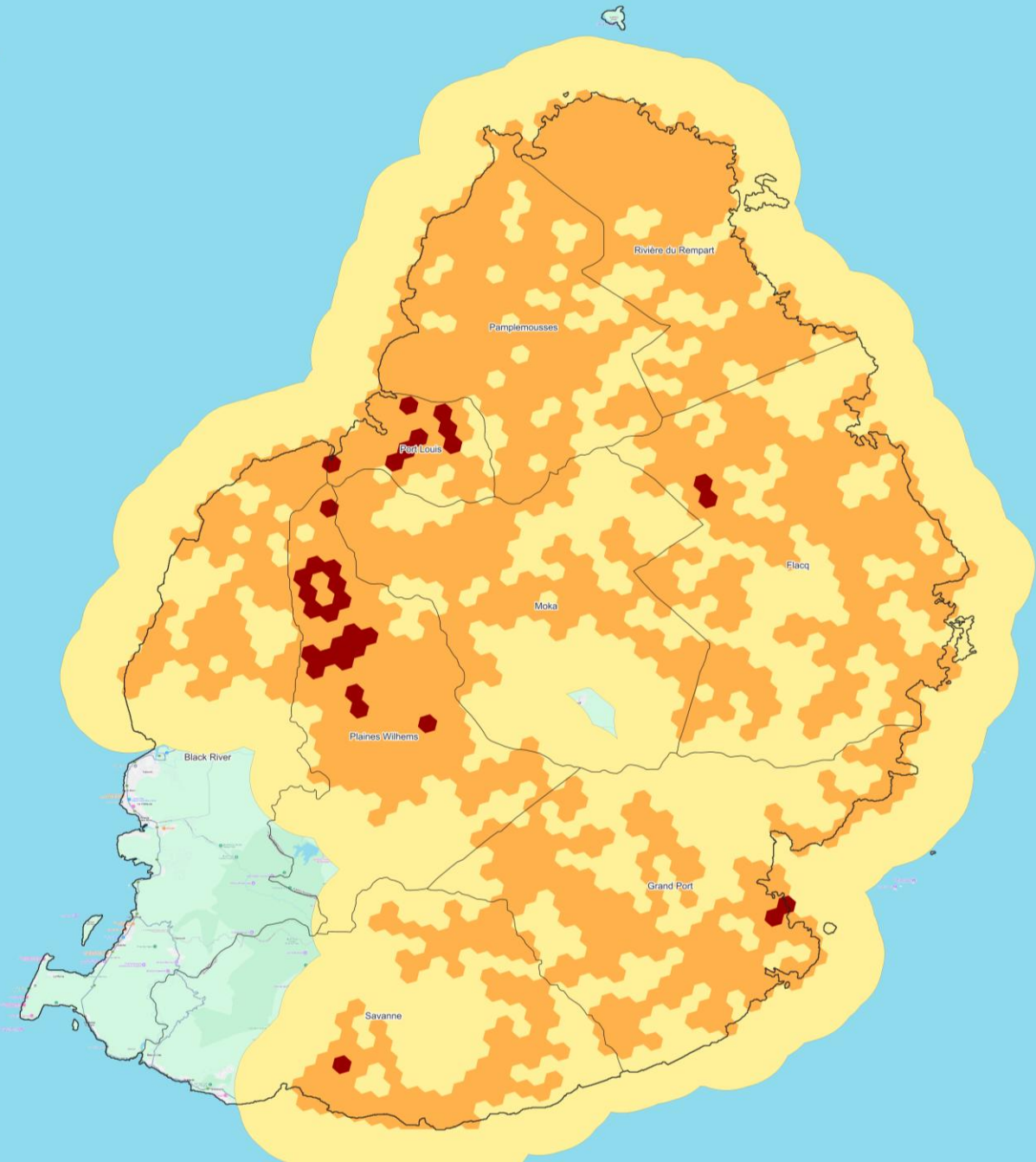
Total Dogs: **1,061,191**
 Dogs in TZs: **827,459**

78% of dogs in TZs

Free-Roaming HDR	
urban	23
Peri-urban	16
Rural	6

Legend

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Mauritius

Total Dogs: 255,625

Dogs in TZs: **239,800**

93.8% of dogs in TZs

Free-Roaming HDR

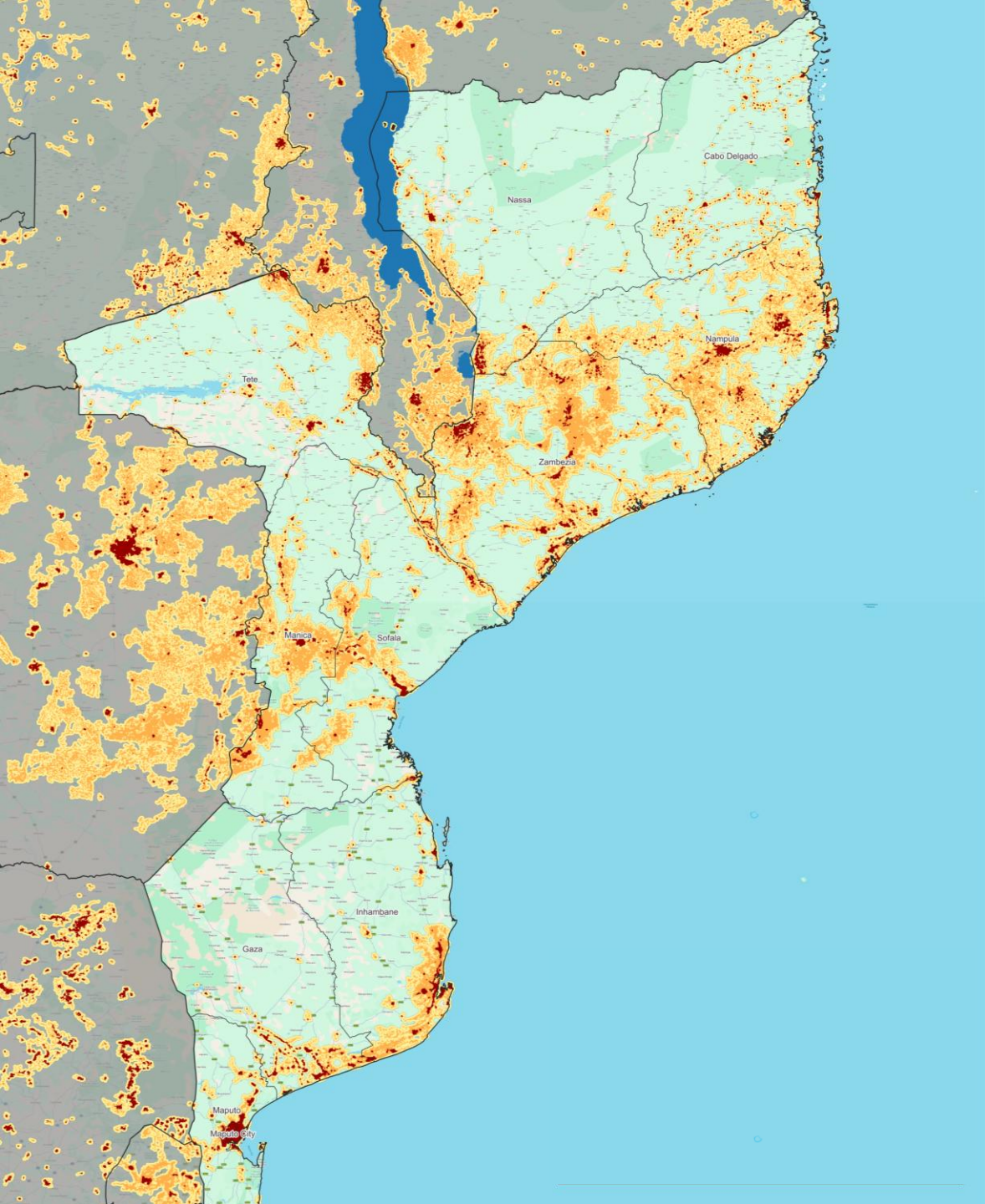
urban 7

Peri-urban 3

Rural 2

Legend

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Mozambique

Total Dogs: **3,987,135**

Dogs in TZs: **3,386,072**

85% of dogs in TZs




Free-Roaming HDR

urban	15
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Peri-urban	6
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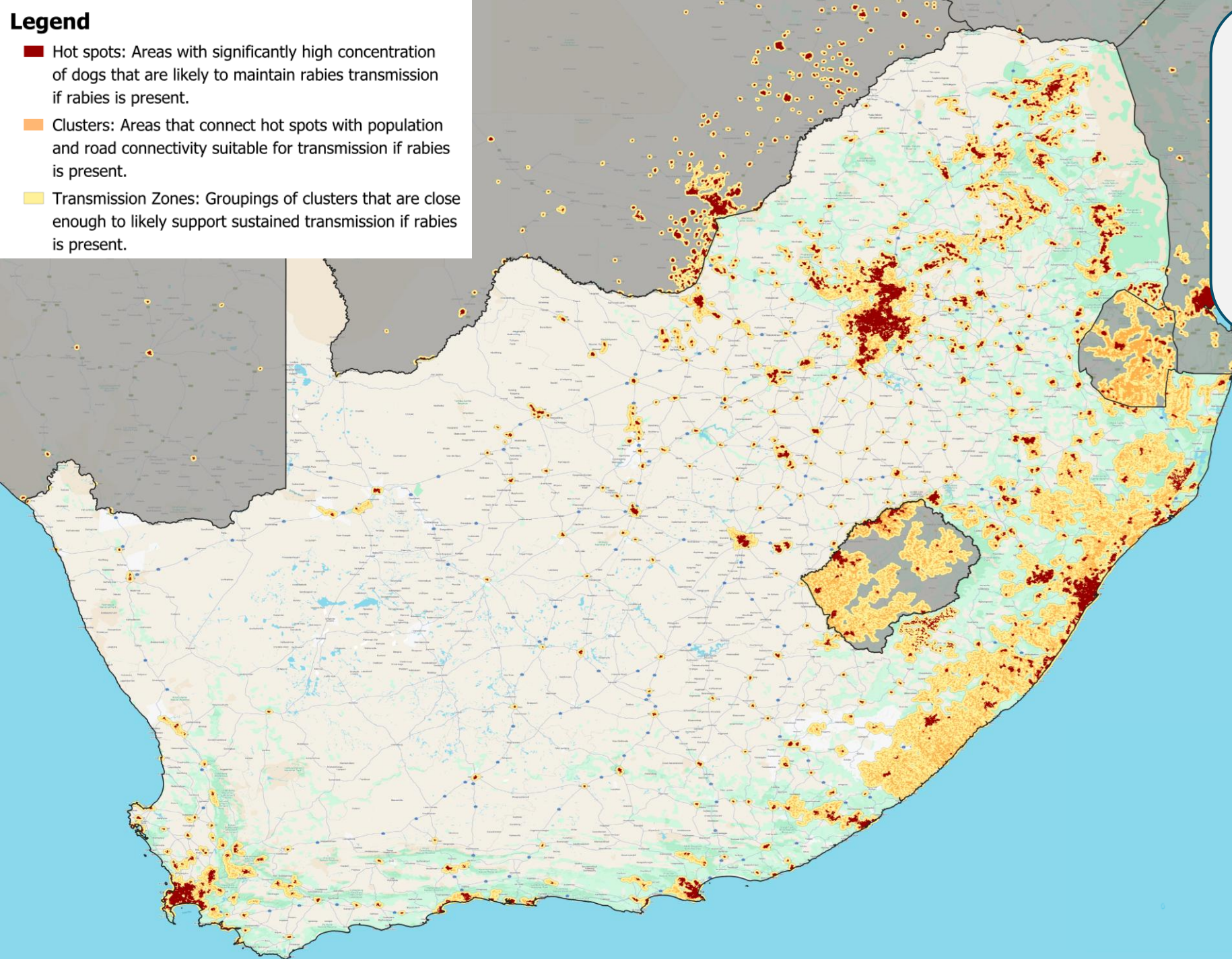
Rural	4
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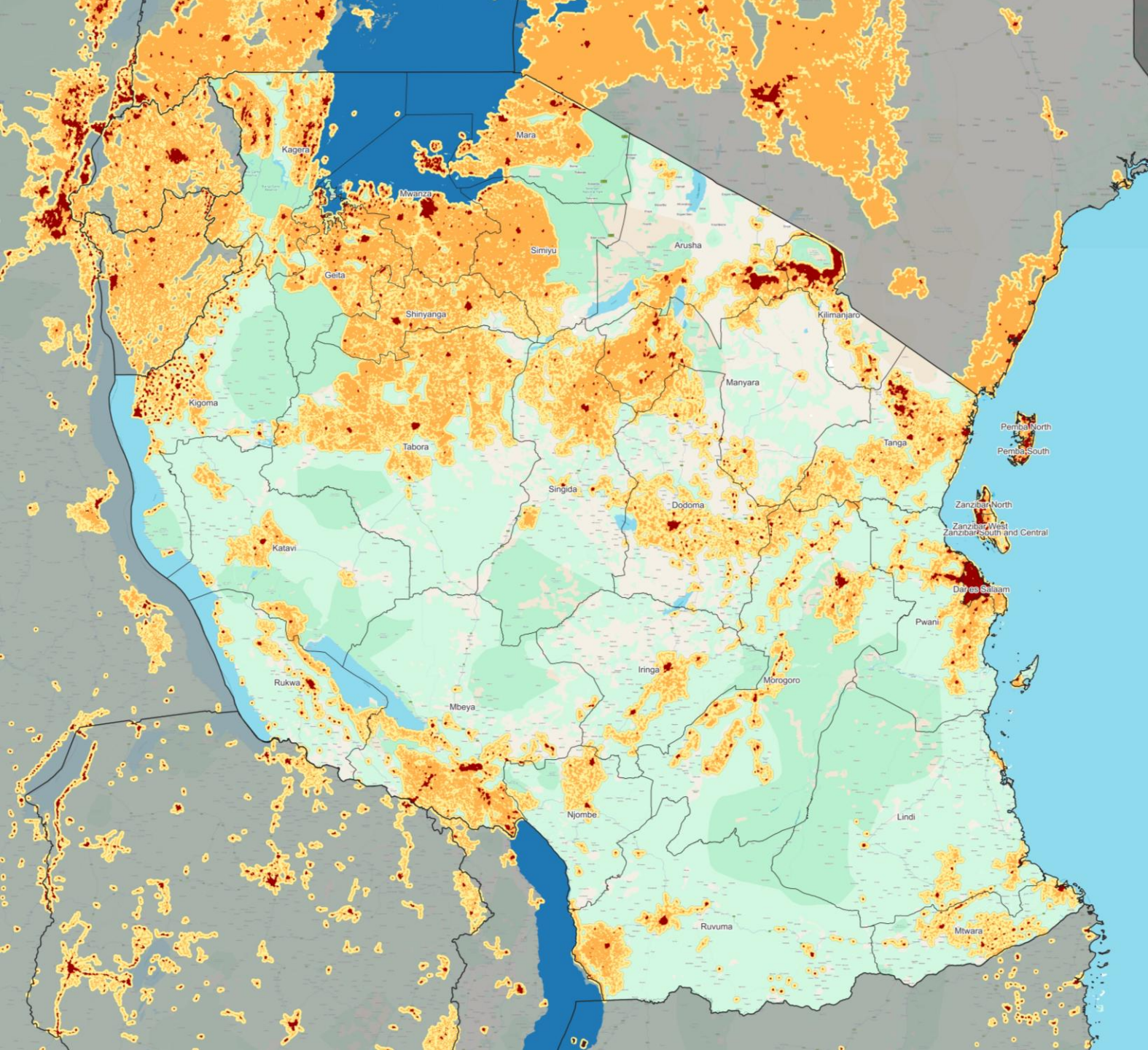
South Africa

Total Dogs: 4,300,016

Dogs in TZs: **3,842,183**

89.4% of dogs in TZs

Free-Roaming HDR	
Urban	15
Peri-urban	10
Rural	5



Tanzania

Total Dogs: **7,263,814**

Dogs in TZs: **6,274,754**

86.4% of dogs in TZs

Free-Roaming HDR

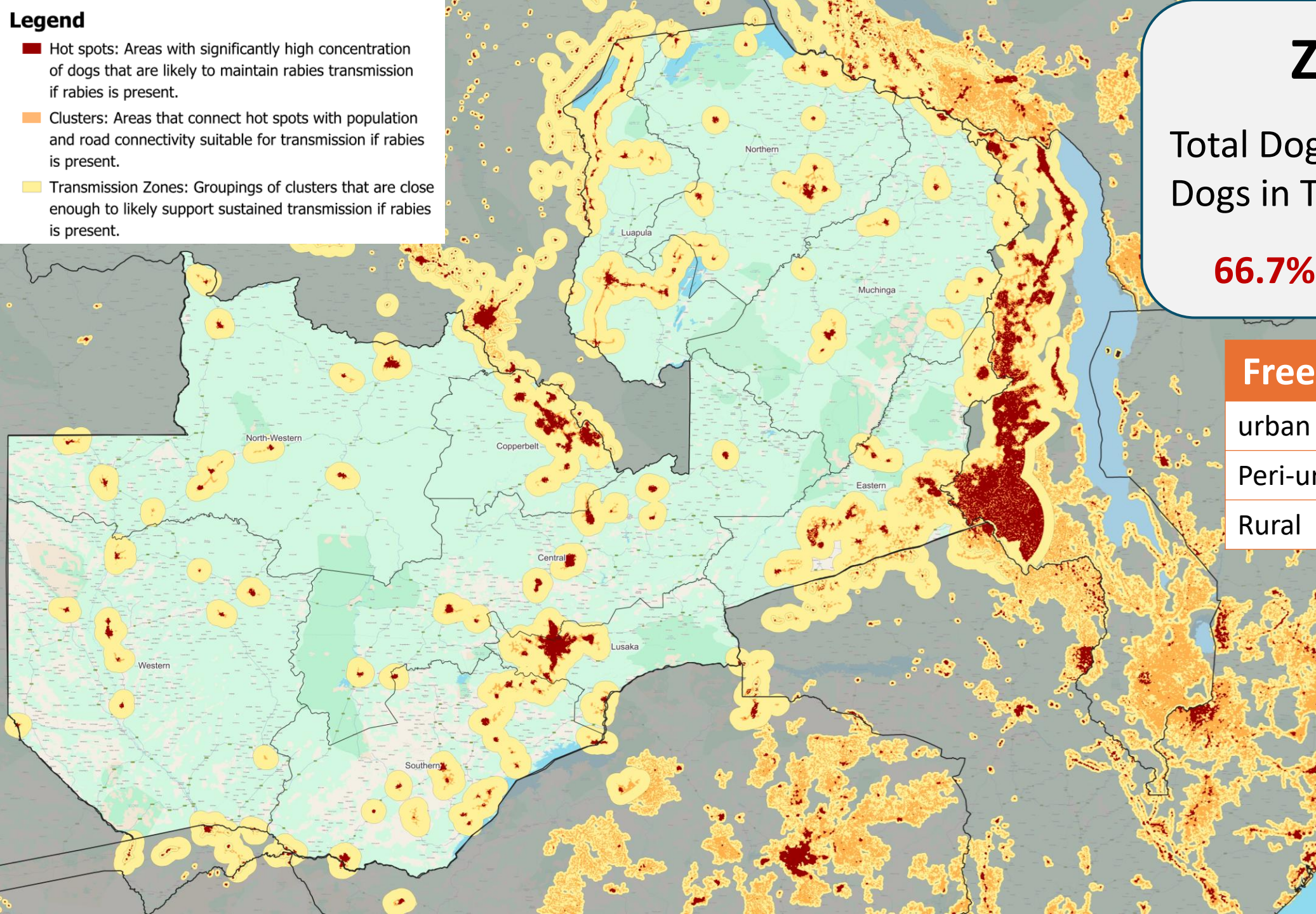
urban	15
Peri-urban	6
Rural	4

Legend

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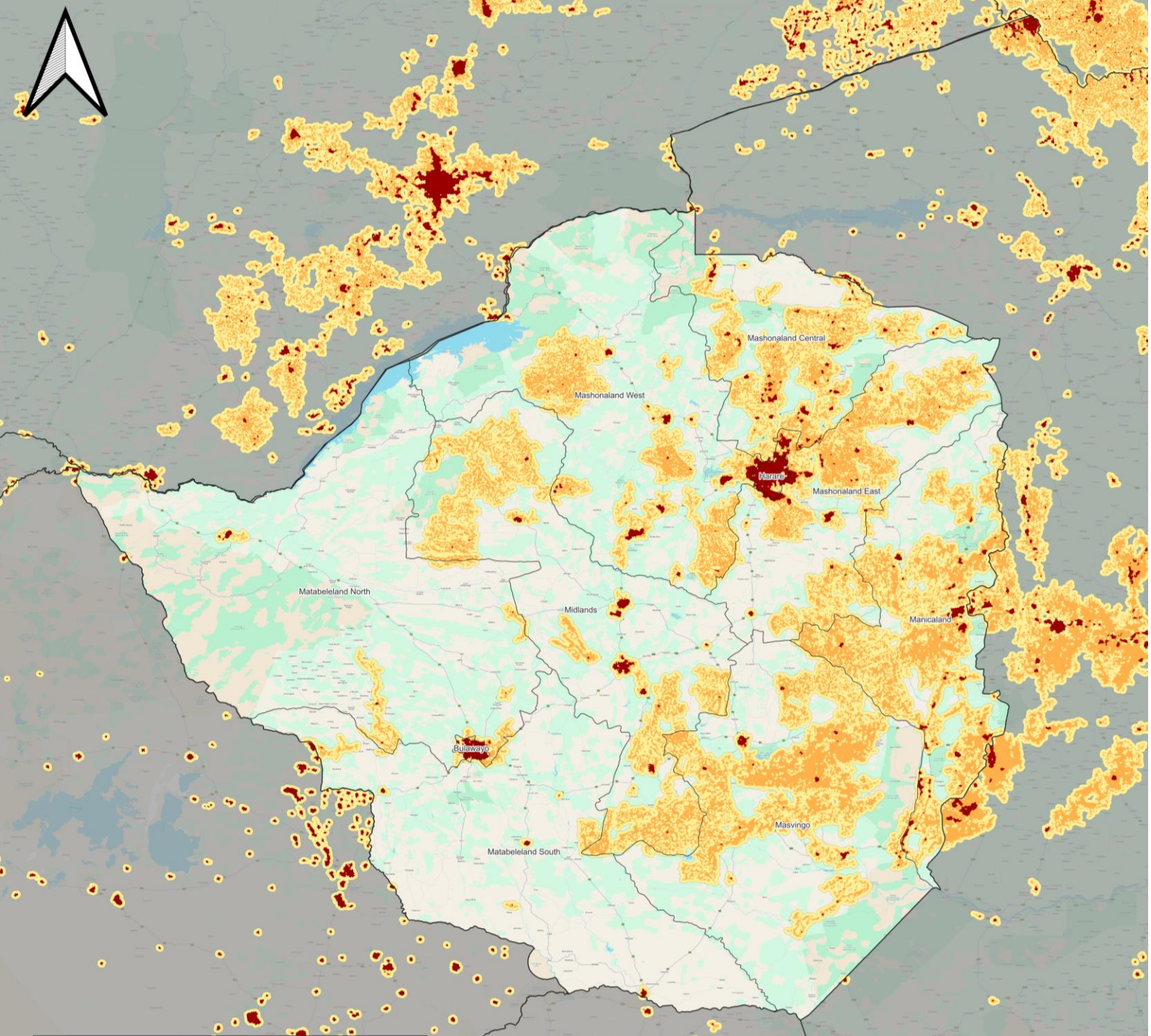
Zambia

Total Dogs: **1,845,843**

Dogs in TZs: **1,230,773**

66.7% of dogs in TZs

Free-Roaming HDR	
urban	33
Peri-urban	16.5
Rural	5



Zimbabwe

Total Dogs: **2,361,811**

Dogs in TZs: **1,709,676**

72.4% of dogs in TZs

Free-Roaming HDR

urban	12
Peri-urban	6
Rural	2

Legend

- Hot spots: Areas with significantly high concentration of dogs that are likely to maintain rabies transmission if rabies is present.
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Summary: Uses of STARC



QUICK ESTIMATION OF DOG POPULATIONS



ENSURE CONNECTED DOG POPULATIONS ARE VACCINATED



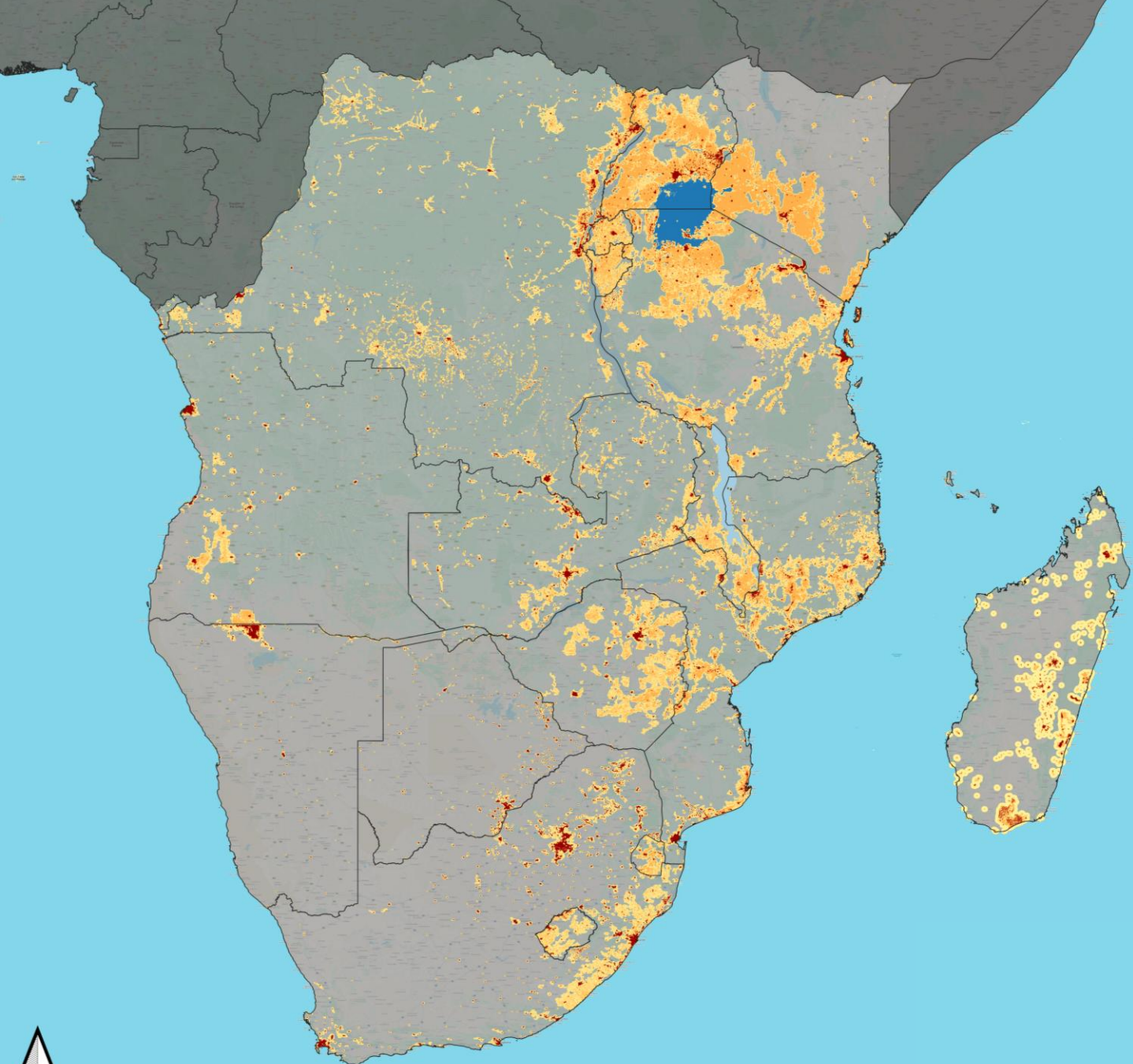
SUPPORT PRIORITIZATION OF RESOURCES



EVALUATE VACCINATION COVERAGES



VISUALISE RABIES SURVEILLANCE DATA



Questions
about
STARC?

Thank you!

For more information on STARC, please email:

rabies@cdc.gov

irt@wvs.org.uk

STARC publication:

› [Int J Health Geogr.](#) 2026 Mar 14. doi: 10.1186/s12942-026-00456-8. Online ahead of print.

What is rural? Examining the relationship between human populations and their inter-connectedness in the context of communicable disease transmission

[Cassandra Boutelle](#) ^{# 1}, [Patrick Corbett](#) ^{# 2}, [Andrew Gibson](#) ³, [Frederic Lohr](#) ³,
[Catherine Swedberg](#) ², [Jesse Blanton](#) ², [Ryan Wallace](#) ²

Affiliations + expand

PMID: 41832528 DOI: [10.1186/s12942-026-00456-8](https://doi.org/10.1186/s12942-026-00456-8)

UAR Forum webinar:

11 Dec 2024

Speaker: Ms. Cassandra Boutelle – *US Centers for Disease Control & Prevention*

Title: Defining urbanicity, mapping rabies risk, and estimating dog populations with STARC

[Link to STARC webinar](#)