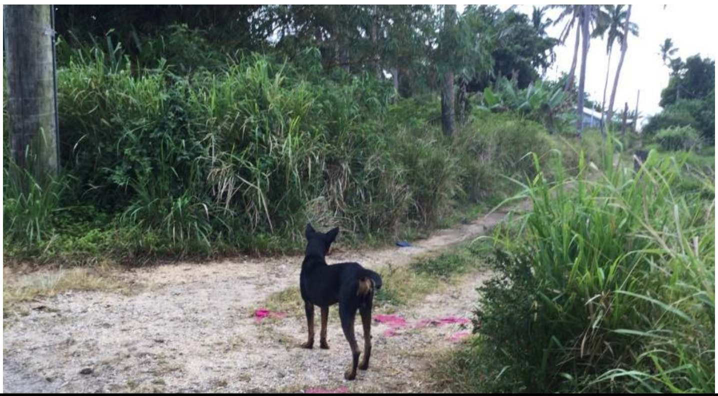
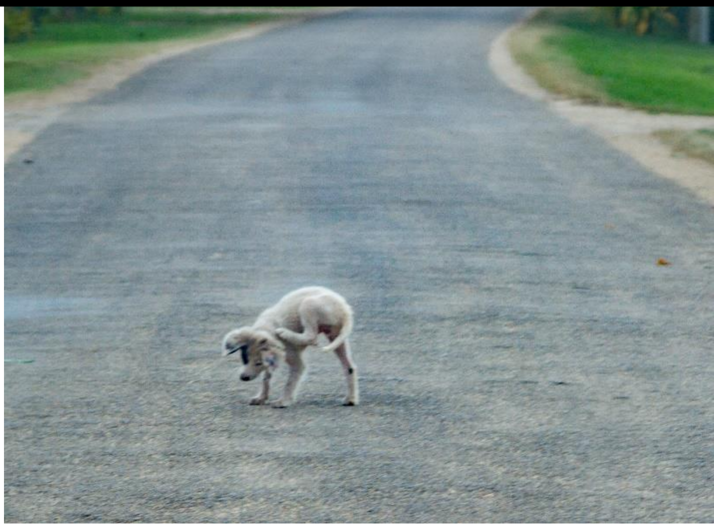
2019

Dogs of Kolovai and Nukunuku, Kingdom of Tonga





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Results of dog counts in Kolovai district, Tongotapu, Kingdom of Tonga

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Executive Summary

A count of all dogs sighted at the residential areas of the western end of the island of Tongatapu of the Kingdom of Tonga was conducted to provide information for a planned de-sexing project in 2020. Dogs observed from a vehicle moving along all the residential roads from 10 towns in Kolovai district and two towns of Nukunuku district were marked on an iPad to record their coordinates. A total of 1179 dogs were counted during the 4-day survey. Maps were generated showing the locations of all dogs counted and the results of spatial analysis including density characteristics based on the number of households, human population, road length and size of residential areas. Results show that based on the overall count within the surveyed residential areas, there is an average of 0.97 households/dog, 5.8 humans/dog, 24.05 dogs/km of road length and 4.24 dogs per unit area in hectares. If these values are used to estimate dogs at the adjacent towns of Vaotu'u and Houma, the total dogs including those counted would reach 1,598 (using humans/dog), 1,434 (using dogs/km) and 1,478 (using dogs/hectare). The dog counts and the estimate are considered undercounts due to the presence of obviously lactating females and non-coverage of roads outside the residential areas. The geodatabase created from the results of the survey provide baseline maps for future surveys as well as data and photographs that can be further assessed to derive dog conditions. Online maps supporting not only future surveys but also related interventions with similar data requirements are also available.

1 Introduction

1.1 Background and Rationale

Free roaming dogs, domestic and otherwise, are a common feature of communities and streets of the Kingdom of Tonga as highlighted in anecdotal reports, blogs and online sources (Nomads, 2019; O'Sullivan, 2018; Penny, 2009). The presence of roaming dogs all over the archipelago as well as their territorial characteristics, significant numbers and the need for awareness of dogs in most areas are likewise mentioned in travel and tourist guides (Asleson, Hunsicker, Schneider, & Quast, 2011; TripAdvisor, 2012). In terms the effects on people, a survey of students from Tonga, Fiji, New Zealand and Australia in 2005-2006 showed that approximately 60% of the respondents from Tonga reported being bothered by dogs in their neighbourhoods which is almost double that of Fiji and three times greater than New Zealand and Australia (Utter et al., 2008).

With agriculture as a major economic activity, related reports include attacks of dogs on birthing sheep in some projects introducing sheep into the country (MAFFF, 2014). Roaming dogs together with pigs and goats contributed to the destruction of crops and replanting efforts (Department of Environment, 2002).

In terms of animal welfare, the lack of veterinary services aside from clinics conducted twice yearly by the South Pacific Animal Welfare (SPAW) (Moger, 2019), the unchecked growth of the dog population has to be addressed as a prerequisite for significantly improving the conditions of a favourite companion animal. Originally, an island wide de-sexing project was proposed by SPAW accompanied by a dog census intended to provide accurate data needed for determining the resources required and evaluating the success of the activity. An initial survey of dogs at selected towns and roads was conducted in December 2017 (Aguilar, 2017) to determine the methodology for the planned island-wide dog count and provide initial estimates of dog population. When finally approved, the de-sexing project was adjusted to cover a smaller extent at the western side of the island including the district of Kolovai with its villages. The accompanying dog counting survey was therefore limited to this area and conducted prior to the project which is scheduled for 2020.

Surveys of dog populations are normally used to inform projects such as vaccinations, de-sexing, area-based animal control or similar activities with the main goal of improving animal welfare while equally addressing human health and socio-economic concerns (Belo, Werneck, Da Silva, Barbosa, & Struchiner, 2015). Monitoring and evaluation of project outcomes depend on initial baseline data and repeat counts or estimates to assess the effectiveness of the interventions.

Related work include estimating existing animal population from surveys of households to extrapolate a total count from the sampling size (Downes et al., 2013). Methods include the use of mail (AVMA, 2012), door to door interviews (Butler & Bingham, 2000), direct observation approaches (Hudson, Brookes, & Ward, 2018), telephone survey for urban areas together with door to door surveys for rural areas (Ortega-Pacheco et al., 2007) and combinations of surveys with aerial photography (Aiyedun & Olugasa, 2012). Most methods require sampling an area and determining a measure of dog count associated with a parameter with known values such as human density (Slater et al., 2008) or households (Atuman, Ogunkoya, Adawa, Nok, & Biallah, 2014; Butler & Bingham, 2000; Ortega-Pacheco et al., 2007).

1.2 Objectives

For the Kolovai area project, a count of dogs in the area is required for planning the implementation of the de-sexing and subsequent monitoring and evaluation. Follow-up surveys are required in order to determine the effectivity of the intervention. In consideration was the necessity to conduct the follow-up surveys without significant resources required involving local personnel from the Ministry of Agriculture Food and Forests (MAFF) of the Kingdom of Tonga. Hence the objectives of this effort are 1) to estimate the number of dogs in the western section of the country including Kolovai and surrounding villages 2) determine the extent of the coverage area to cover at least 80% of the target 1,500 dogs and 3) provide a geospatial database and methods for in conducting the follow-up survey.

2 Methods

A direct counting method based on counting from roads (Childs et al., 1998; Hiby & Hiby, 2017) was used. Commonly employed in wildlife sample techniques in ecological studies that use transects, this method was found to be comparable to the sight-resight methods recommended by WPSA (AVMA, 2012; Meunier et al., 2019) and preferred mainly due to its simplicity that facilitates subsequent repeat surveys (Hiby & Hiby, 2017). Also, because all the roads are covered in the areas were surveyed, a random sampling of transect lines was not necessary. This random sampling requirement was pointed out as one of the weaknesses of this method (Belo et al., 2015). Given the requirement to monitor the progress of de-sexing interventions through subsequent dog counts, the availability of local staff to conduct the survey and planned follow-up ones as well as the accessibility of most roads, this simple approach was deemed more suitable for this effort.

2.1 Preparation of maps and Collector app

Prior to the survey, maps were prepared in ArcGIS online to facilitate data gathering. The Collector for ArcGIS app (ESRI, 2018) was installed on an iPad and maps covering the area downloaded for offline use. Included in the maps were administrative areas, roads, residential areas and residential buildings available from ArcGIS Online sources (https://data.humdata.org/dataset/tonga-administrative-level-0-1-2-3-boundary-polygons; https://data.humdata.org/dataset/hotosm_ton_roads). Aside from location data, the gender of dogs, age classification (categorised into juvenile, adult and old) and a simple condition scoring attribute using the standard 9-point dog condition scale (German et al., 2006; Laflamme, 1997) was added to the survey form to enable the development of a database that will characterise the dog population. The database created also allowed the storage of pictures associated with each point location, allowing further analysis of the data when the images are reviewed. Twelve villages were identified for coverage, 10 in Kolovai district and 2 in Nukunuku district. In the Tonga Census of 2016 (Department of Statistics, 2017), the villages of Fahefa and Ha'autu were separate but are treated as one area in this study as they are adjacent and covered by one residential area (Figure 1).

Figure 1. Areas covered by the survey 2-5 October 2019.

2.2 Survey using Collector for ArcGIS

As determined in the December 2017 pilot study (Aguilar, 2017), the best times for survey were early in the morning (7:00-9:00) and late in the afternoon (4:00-6:00) with enough light to see and when the dogs were out in the roads or not in the shade sheltering from the sun. A car was used for the survey for safety reasons based on previous experience with some aggressive dogs. In some instances during this survey, car windows had to be closed when dogs rushed the car.

All roads in the survey areas were driven at a speed between 10-15 km/hr. As most dogs had access to the road with the absence of fences in most cases or if there are fences, most of the gates are open, all sighted dogs were marked on the app. Photographs of dogs were taken whenever possible and other data such as gender and body condition entered. In some cases there was insufficient time to input data in the fields of the app and the photographs serve as a reference to complete the information. As a backup to the app-based data collection, printed maps and tally sheets were used by a second recorder to mark locations and record the count manually

2.3 Processing of Data using ArcGIS Pro

Location data collected was processed in ArcGIS Pro after the collected data in the iPad was synced. Related data including roads, land cover classification and census data were downloaded and combined with the location data gathered. Each town covered in the survey was individually clipped from the residential site class of the Tonga land cover map. Roads from the downloaded databases were then clipped to each town area and merged with the dog locations.

Since each location recorded by the iPad GPS was taken on board the car, each set of coordinates was near or on the road itself. A snap function set at a buffer of 30m on both sides from the road was used to align each location to the roads. This alignment facilitated calculating the number of dogs per road length and removes the requirement to measure distance and implement more complicated distance functions (Childs et al., 1998). Also calculated was the number of dogs per area of each town and the number of persons per dog, both used as a comparison with other similar studies. The results of the survey for number per road length (in km), humans per dog and numbers per area (in hectares) were used characterise and compare the towns surveyed and to provide an acceptable estimate for the numbers required for the de-sexing project. A comparison of the current survey with the earlier one on December 2017 was also done.

3 Results

3.1 Data Collected

Seven survey sessions starting at 6:30 until 9:00 in the morning and from 4-5:30 in the afternoon were undertaken. This total count includes dogs outside of town areas sighted along the roads in between towns (Table 1). Cool weather and absence of rain made counting conditions favourable although when the sun is out at later times, most dogs are in the shade such as under cars making spotting difficult. The use of Collector on iPad facilitated the input of location data, taking of pictures and adding additional information (Figure 2).

Table 1. Counts per day, time of survey and towns covered.

Date	Morning	Afternoon	Towns Covered
Day 1: 2 October 2019	159	161	Hatafu, Ahau, Kanokopolu, Kolovai
Day 2: 3 October 2019	159	138	Havakatolo, Foui, Fahefa and Kala’au
Day 3: 4 October 2019	155	319	Masilamea, Tee’ikiu, Matahau, Nukunuku
Day 4: 5 October 2019	85		Nukunuku

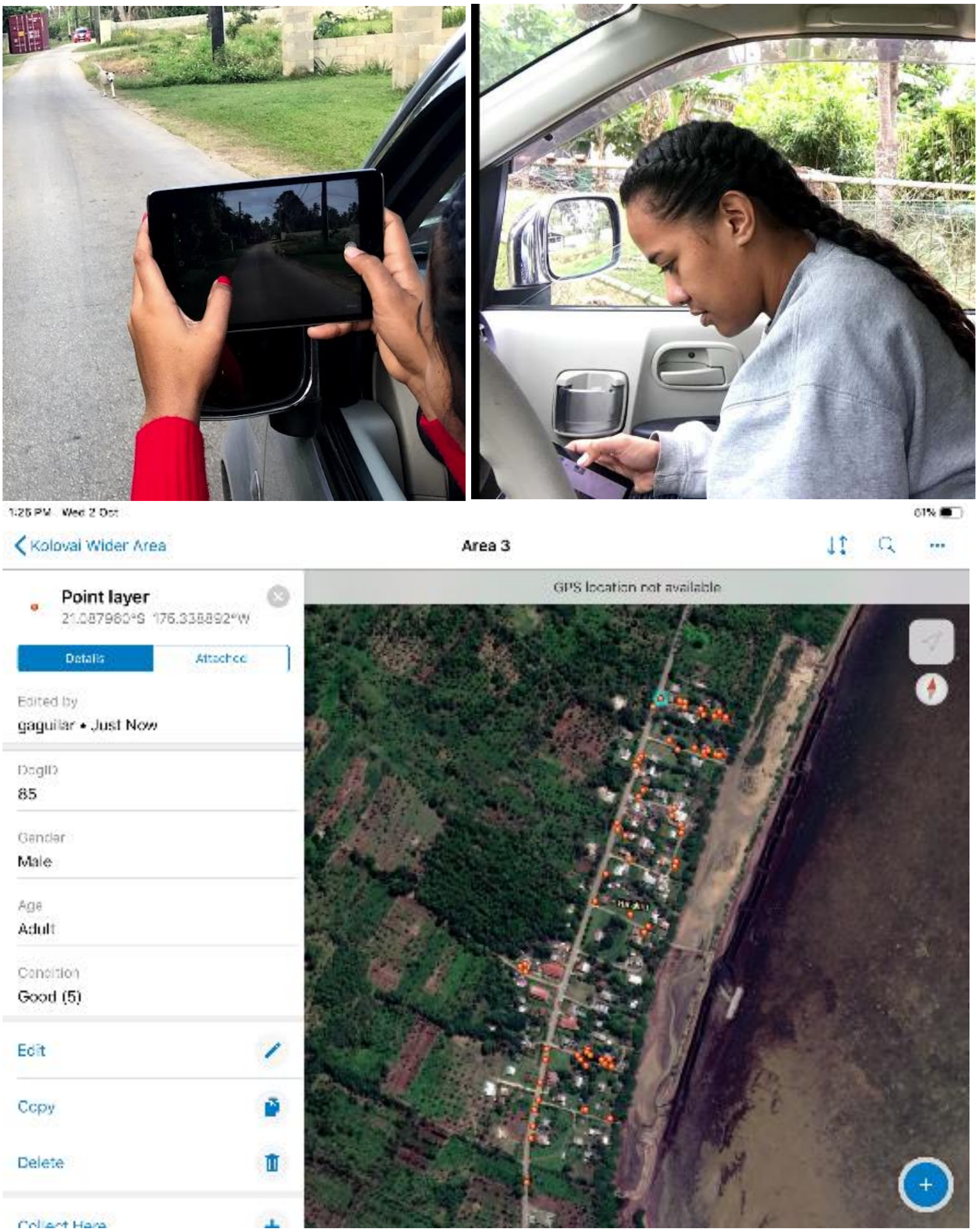

Figure 2. Surveying using the Collector app in a mini-iPad with Ministry staff (top) and the interface of the survey in Collector.

After each survey day, data collected was synced with the ArcGIS online account to save to the geodatabase. This also ensures that a cloud based backup of the data exists. Aside from viewing the point locations, it is also possible to view hotspots based on the point distribution as well as pictures associated with each point. (Figure 3).

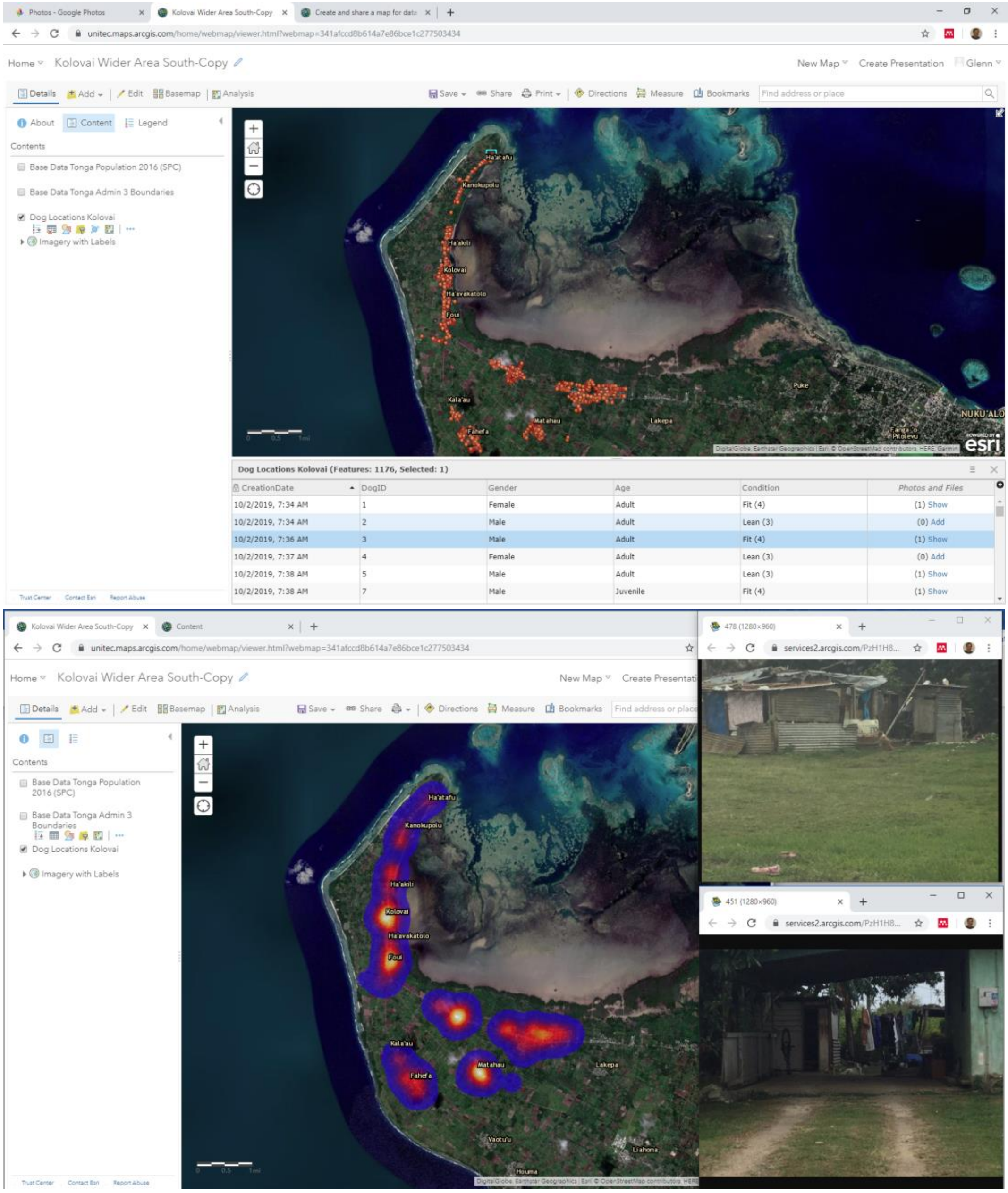

Figure 3. Data collected with locations and attribute table in ArcGIS Online with density maps and pictures associated with each point.

3.2 Maps of counts with example pictures of dogs

The survey covered all 338 roads within the residential areas with all dogs counted when sighted at both sides of the road. Dogs sighted on roads between towns were also recorded but are not included in the calculations.

Results of the count overall is shown in Figure 4. Except for the main road Hihifo that traverses towns from Ha'atafu all the way to Nuku'alofa, the rest of the mainly residential roads are unpaved with varying degrees of maintenance. Most are passable except during rains when some may be flooded or too muddy to be passable by non-4-wheel drive vehicles. In several cases, new settlements are under development and the roads present are not yet reflected or present in the existing database. Aside from dog locations shown in the town maps, roads are shown with dog counts represented in graduated colours indicating which roads have the most number counted.

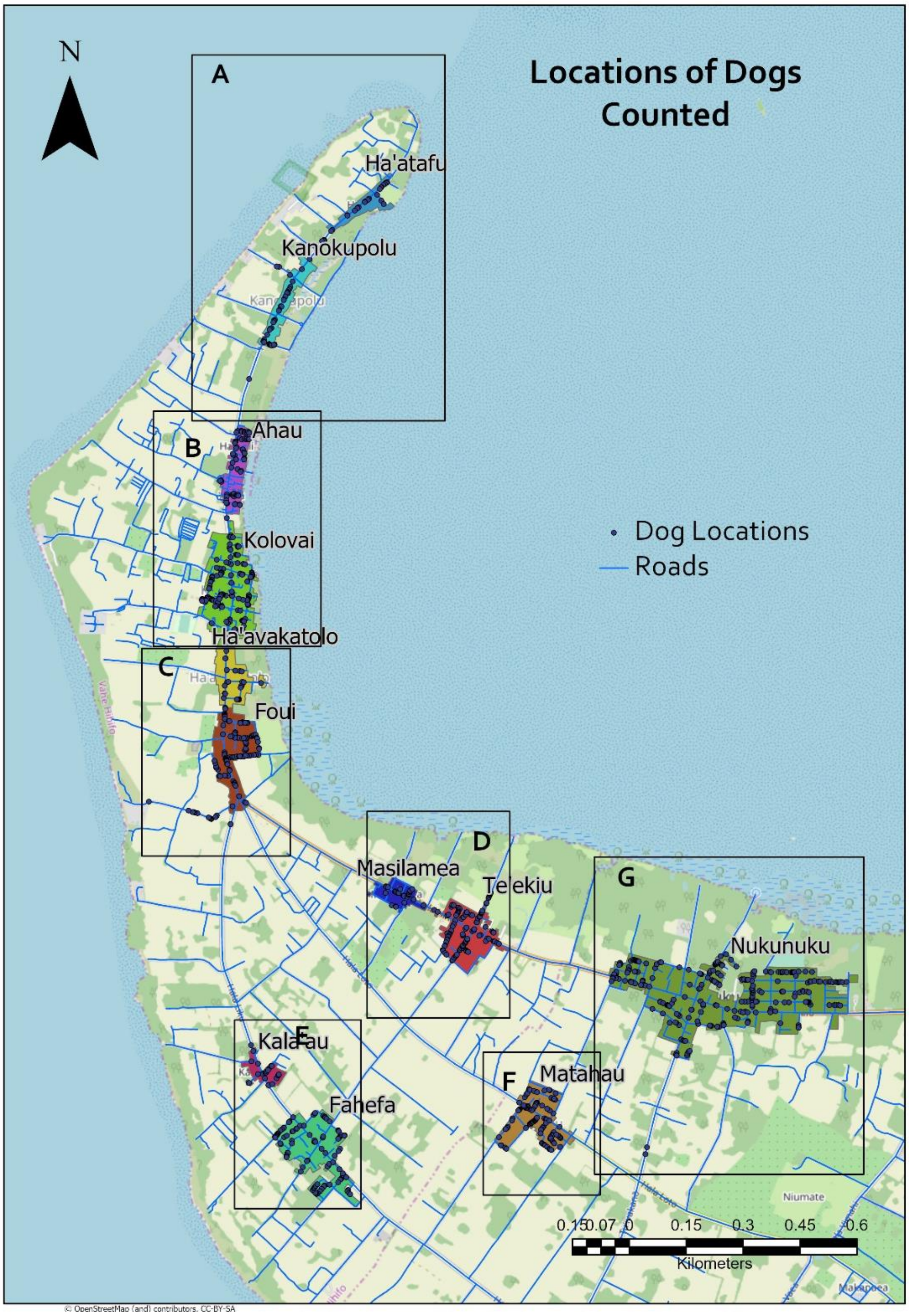

Figure 4. Overview of total dogs sighted and extent of area maps.

The towns of Ha’atafu and Kanokupolu are relatively small and traversed by the main Hihifo road with residential buildings concentrated by the roadsides. Majority of the area is agricultural with coconut and taro plantations dominating the landscape. Resorts are located on the Western beach area while mangroves dominate on the Eastern side (Figure 5).

Figure 5. Results from Ha'tafu and Kanokopulo towns (A).

Most dogs sighted were roaming or within the vicinity of their residences with open access to roads. Unpaved driveways or service roads to residences were also present but were not further explored in this area due to privacy concerns. In one instance a group of 9 dogs were gathered around a person feeding them (Figure 6).

Figure 6. Dogs sighted in Ha'atafu and Kanokopolu.

Kolovai is the largest town in the Kolovai district just separated from Ahau by a couple of hundred meters. On both towns, the eastern side borders on mangrove areas with newly developed roads at the margins of the mangroves (Figure 7).

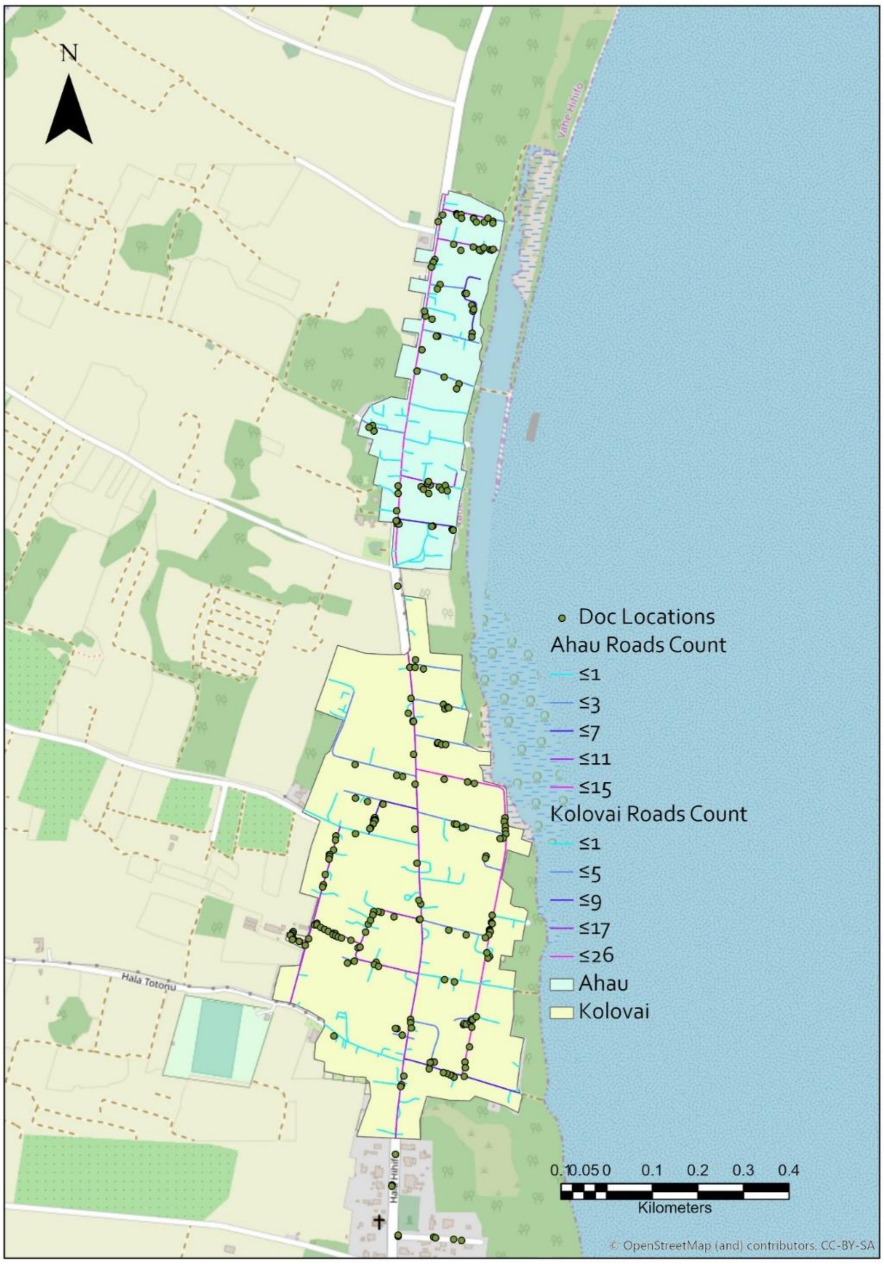

Figure 7. Results of Ahau and Kolovai towns (B).

A few new roads at the periphery of Kolovai show an abundance of dogs that are obviously nursing and may have puppies hidden somewhere. In a construction site, 15 puppies with 4 adult dogs were found congregating and being fed (Figure 8).

Figure 8. Dogs of Ahau and Kolovai towns.

South of Kolovai, Ha’avakatolo and Foui are two small towns with one main road Hihifo and a few side roads leading to agricultural areas west and mangrove areas east. There is a concentration of dogs at the Southeastern most street of Foui (Figures 9 and 10).

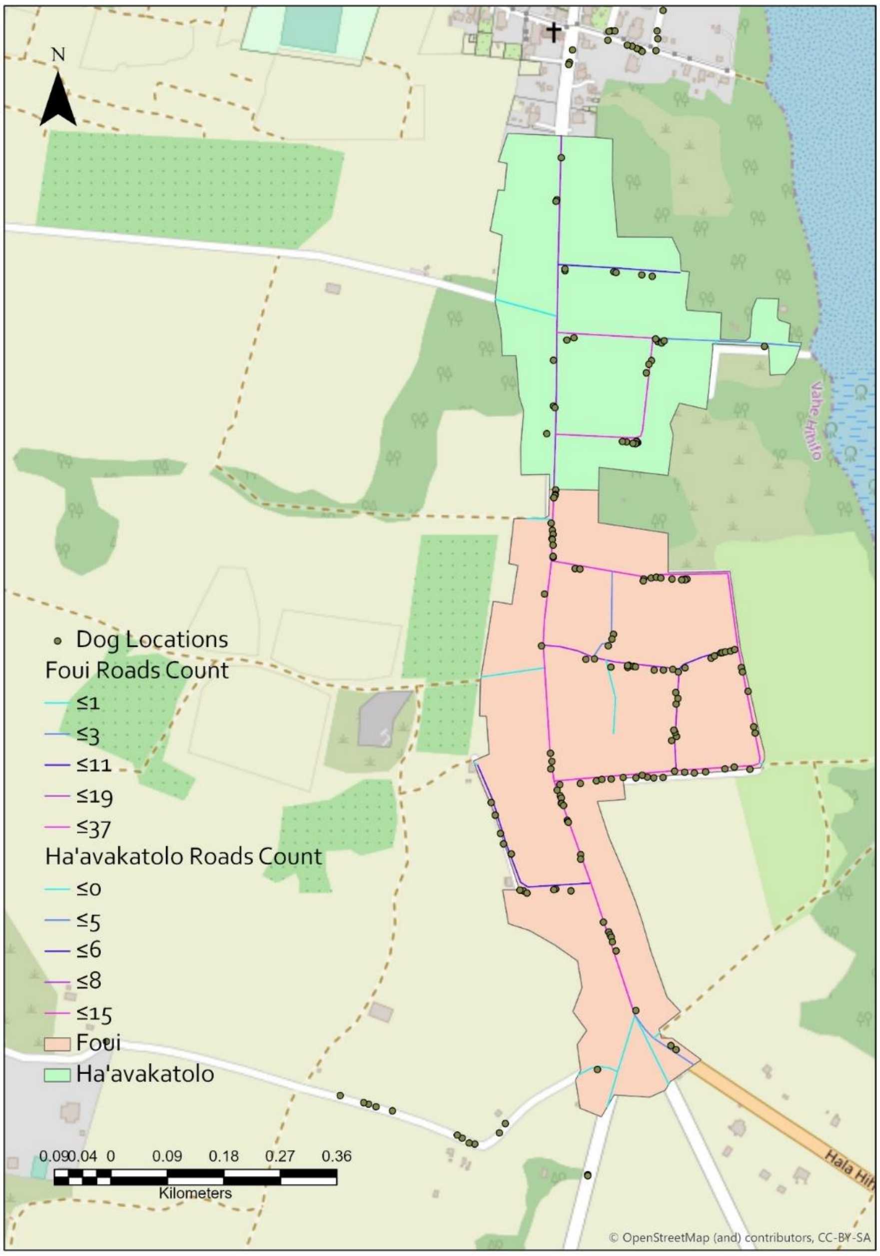

Figure 9. Ha’avakatolo and Foui results.

Figure 10. Dogs found at Ha’avakatolo and Foui.

Down the main paved Hihifo Road to Nuku'alofa are the neighbouring towns of Masilamea and Tee'kiu. Most roads in both towns have roaming dogs of varying conditions (Figure 11 and 12).

Figure 11. Masilamea and Tee'kiu results.

Figure 12. Dogs of Masilamea and Tee'kiu.

The southern road that forks from Foui is unpaved and passes through the towns of Kala'au and Fahefa. Both towns are surrounded by agricultural land planted to coconuts, taro, squash and other root crops. Adults and puppies were sighted and in some cases, children showed their puppy to be counted (Figure 13 and 14).

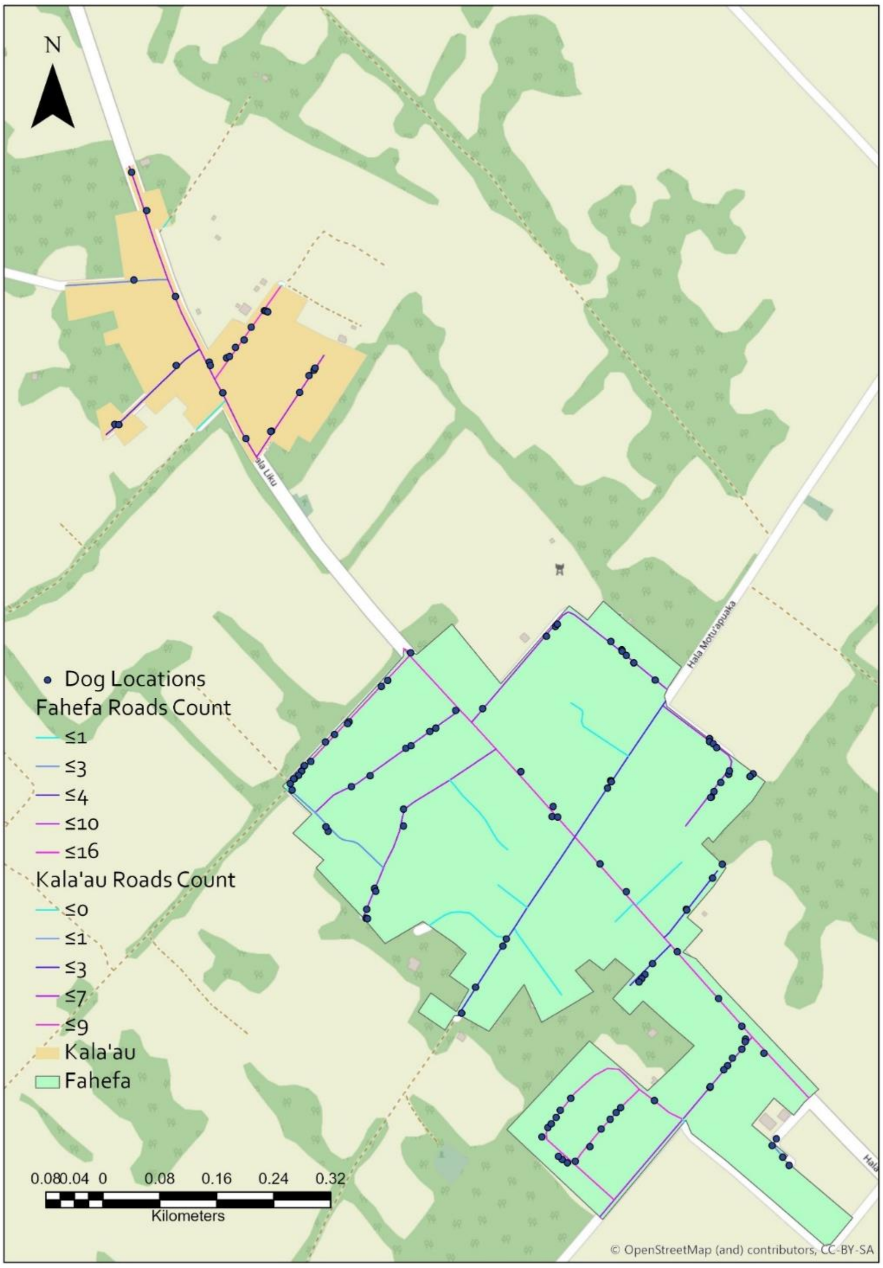

Figure 13. Kala’au and Fahefa (includes Ha’utu) results.

Figure 14. Dogs in Fahefa and Kala’au.

Matahau is a relatively isolated town south of Foui accessed by the central road Lota with a limited length of paved road sections. Dogs nap on or by the roadside and are generally of the lean condition (Figures 15 and 16).

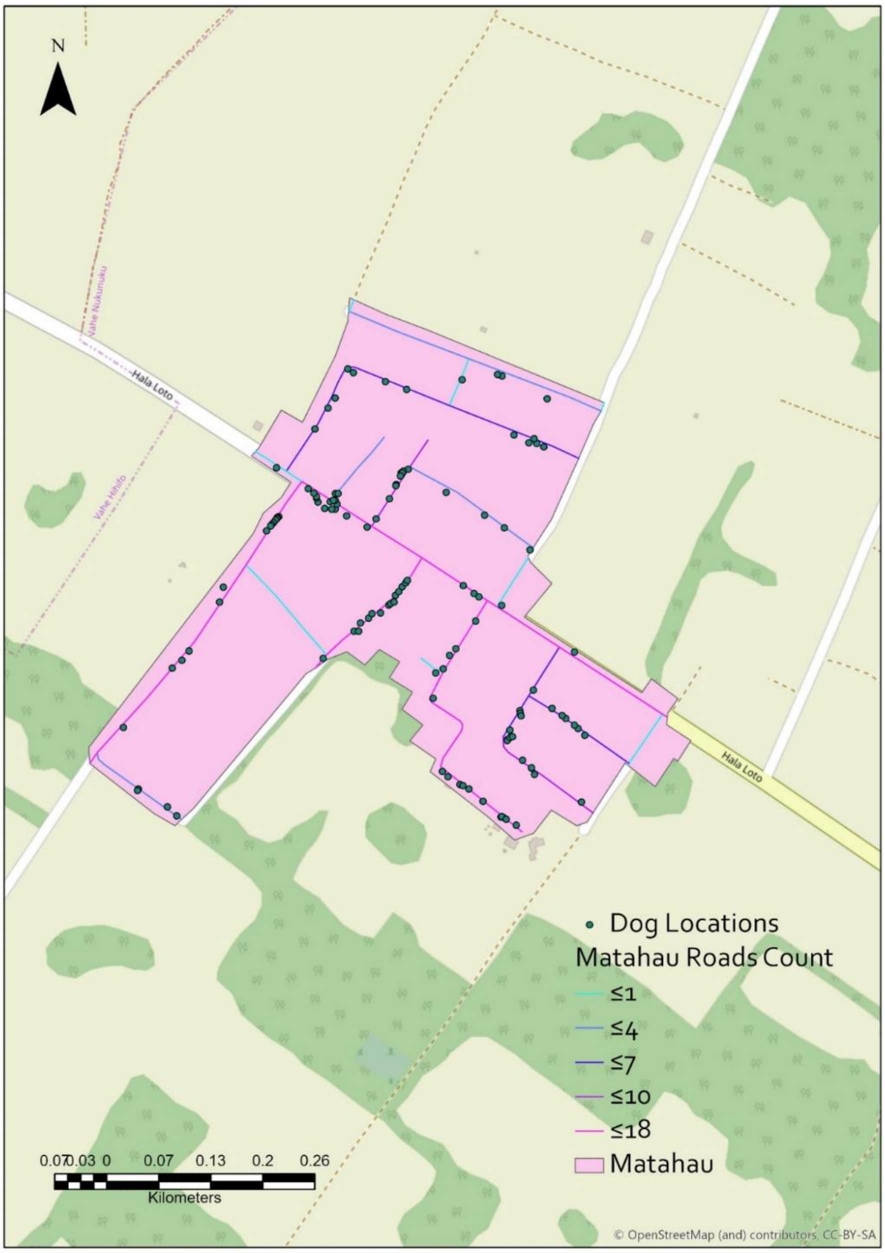

Figure 15. Matahau results.

Figure 16. Dogs of Matahau

The town of Nukunuku is the largest surveyed with the highest human population. New roads with newly constructed houses particularly towards the mangrove side of the town are present and a high number of groups of roaming dogs are present (Figures 17 and 18).

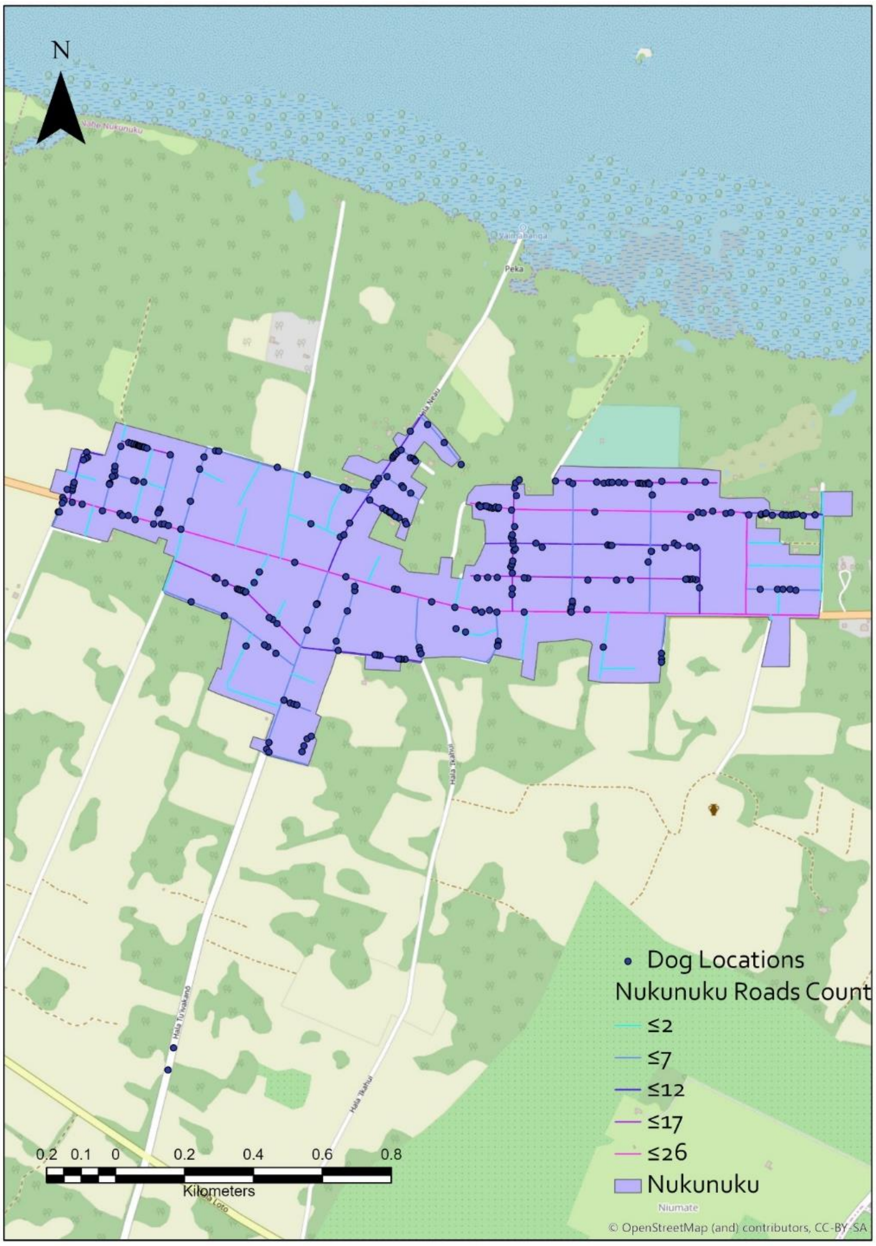

Figure 17. Nukunuku results.

Figure 18. Dogs of Nukunuku

A total of 1,179 dogs were counted with 1,152 within the residential boundaries of the selected towns. These dogs were counted over a total length of 47.905km with a total residential area of 271.86 hectares (Table 1). There were 27 dogs counted outside of residential areas mainly between the town areas surveyed. These were not included in the calculations as are many other roads are not accessible with the vehicle used. Nukunuku had the most number of dogs and the highest length of roads with the largest area while at the Kala'au has the least dogs and was the smallest town covered. When the overall count and the totals of households, total human population and total road length per area (including roads without any dogs) and total residential areas are used, the results show values of Households/dog at **0.97**, Humans/dog at **5.80**, Dogs/km at **24.05** and Dogs per unit area (hectares) at **4.24**.

Table 1. Results of the dog count and characteristics of the towns surveyed.

Town	Dog Count	Road Length (km)	Area (Ha)	Human Population Statistics			
				Households	Male	Female	Total 2016
Ahau	72	3.214	11.621	61	183	210	393
Fahefa	111	4.769	27.856	111	317	366	683
Foui	116	3.240	21.025	106	344	313	657
Ha'atafu	31	1.042	6.684	47	140	129	269
Ha'avakatolo	32	1.440	12.719	40	91	104	195
Kala'au	26	1.097	5.594	26	76	76	152
Kanokupolu	52	1.272	10.320	68	157	175	332
Kolovai	158	7.247	36.026	118	306	312	618
Masilamea	30	1.505	7.398	34	128	93	221
Matahau	122	3.579	20.672	105	295	286	581
Nukunuku	278	16.166	91.405	371	1015	995	2,010
Te'ekiu	124	3.333	20.537	104	293	277	570
Total	1,152	47.905	271.857	1,191	3,345	3,336	6,681

3.3 Density distribution

When the ratios are calculated for each individual town, variation in the various measures are apparent (Table 2). When three parameters (Human/Dog, Dogs/km and Dogs/ha are compared using one-factor ANOVA with Kruskal-Wallis they were found to be independent (p-value = 0.000002). This independence allows a range of options on the use of these as parameters as estimates of dog population depending on data availability, temporal relevance (such as updated census data) and modes of survey dictated by resources and personnel availability.

Table 2. Dog count ratios calculated for each town.

Town	Household/Dog	Human/Dog	Dogs/km	Dogs/ha
Ahau	0.84	5.46	22.41	6.20
Fahefa	1.01	6.21	23.07	3.99
Foui	0.93	5.76	35.18	5.45
Ha'atafu	1.52	8.68	29.75	4.64
Ha'avakatolo	1.25	6.09	22.22	2.52
Kala'au	1.00	6.71	23.69	4.82
Kanokupolu	1.31	6.38	40.87	5.04
Kolovai	0.75	3.91	21.80	4.39
Masilamea	1.13	7.37	19.93	4.06
Matahau	0.85	4.72	34.37	5.95
Nukunuku	1.33	7.23	17.20	3.04
Te'ekiu	0.83	4.52	37.81	6.14

When plotted on a density map for the areas surveyed, the highest density in terms of dogs/hectares are in the towns of Ahau, Foui, Te’ekiu and Matahau while Nukunuku and Ha’avakatolo showing the lease density values. In terms of humans/dog, Kolovai, Matahau and Te’ekiu have the lowest figures while Masilamea has the highest followed by Nukunuku. For the dogs/km values, Kanokupolu and Te’ekiu has the highest values while Kolovai and Nukunuku has the lowest values (Figure 19).

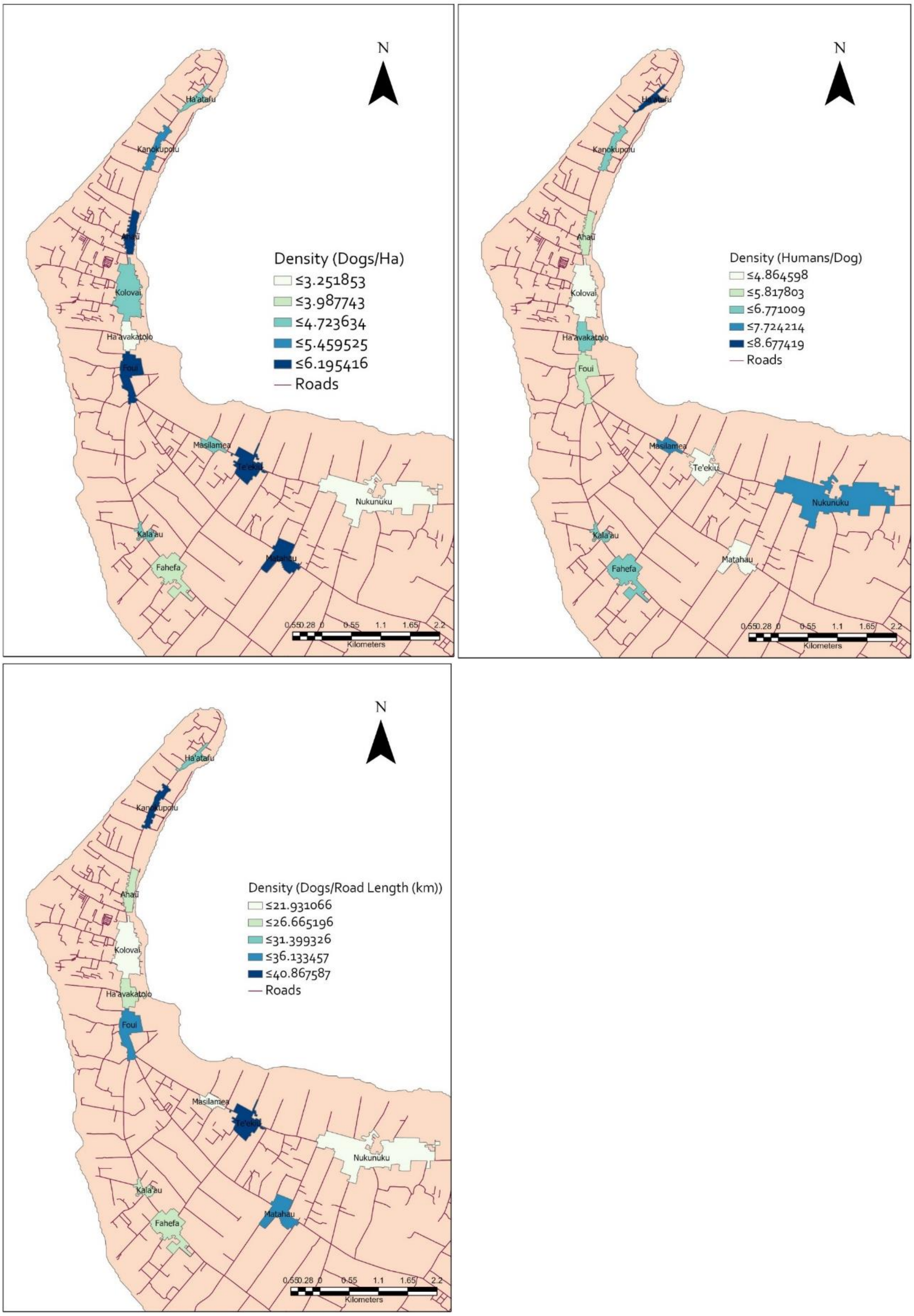

Figure 19. Density per unit area, humans per dog, dogs per road length.

Results of the survey conducted in December 2017 at different areas of Tongatapu are shown in Table 3. While not a complete coverage of all the roads per town, the dogs/km measured provide a comparison with the current count results. A comparison using single-factor ANOVA with the current results returned an f-value of 1.030662936 (p-value 0.322757) and Kruskall-Wallis (p-value = 0.434369), showing no significant difference between the two periods. This also provides an indication that consistent repeat surveys of randomly chosen representative roads may provide acceptable estimates in lieu of covering all the roads in target areas.

Table 3. Dogs per road length on selected roads in December 2017.

Areas	Dog Count	Road Length (Km)	Dogs/Km
A1 (Hofoa)	57	1.91	29.77
A2 (Nuku'alofa)	127	4.07	31.20
A3 (Nuku'alofa)	101	3.86	26.17
A4 (Nuku'alofa)	26	0.96	26.99
B1 (Sia'atoutai)	11	0.27	40.19
B2 (Houma)	75	3.37	22.25
B3 (Holonga)	130	3.02	43.02
B4 (Nukunuku)	66	3.10	21.31
B5 (Masilamea)	15	0.59	25.54
Grand Total	608	21.16	

4 Discussion

The survey resulted in four different measures of dog density compared to related studies that used one or two types. In terms of humans per dog, the closest value is reported in Shimotsu, Japan (Kato, Yamamoto, Inukai, & Kira, 2003) while for dogs per area, the closest value is from the Philippines (Childs et al., 1998) (Table 4). The range of values from the different towns surveyed in terms of dogs/km ranges from 17.20 at Nukunuku to 40.87 at Kanoupolu. This is significantly higher than those found in other areas of the world (0.78-27.14) with only one zone in Kathmandu reporting a greater dogs/km value. The greater concentration of dogs along or adjacent to the roads of residential areas surveyed in Tongatapu confirms anecdotal reports from a wide variety of sources about the ubiquitous presence of dogs in its streets and roads.

Table 4. A comparison of dog density values in several measures from different sources.

Location	Household/ Dog	Human/ Dog	Dog/ Hectare (Area)	Dog/km (Road Length)	Reference
Kolovai, Tonga (and surrounding towns)	0.97	5.80	4.24	24.05	This Study
Dhaka, Bangladesh	828		0.52		(Tenzin, Ahmed, Debnath, Ahmed, & Yamage, 2015)
Kathmandu, Nepal		4.7	29.30		(Kato et al., 2003)
Shimotsui, Japan		5.2	2.25		
Bhutan (Urban)		16.30			(Rinzin, Tenzin, &
Bhutan (Rural)		8.43			Robertson, 2016)
Goa, India			2.77	8	(Meunier et al., 2019)
Valencia, Spain			1.27 to 13.04		(Font, 1987)

Sorsogon, Philippines	4.68		(Childs et al., 1998)
Bosnia		0.78-9.07	(Hiby & Hiby, 2017)
Panama City		1.07-5.62	
Puerto Rico		1.13-1.73	
San Jose, Costa Rica		1.50-4.09	
Kathmandu, Nepal		8.40-27.14	
Machakos, Kenya			(Kitala et al., 2001)
(Urban)	1.1		
(Rural)	0.06-0.21		

This study covered all the roads and counted every sighted dogs but the overall count should be considered as an undercount of the total dog population in the area. This observation is due to sighting several female dogs in obvious lactating stages that indicate the presence of puppies of indeterminate number that were not observable during the survey (Figure 18). When the sun is higher up and temperatures warmer, many dogs hide in the shade, under cars, vegetation and other structures making sighting difficult. Also, the count covered only the residential areas and a number of dogs along all types of roads between towns were observed indicating dog presence on other roads and areas outside of the towns. Hence the total number of 1,179 dogs counted during the survey is qualified as dogs sighted and represents the *minimum* number of dogs in the 12 towns surveyed.

Figure 20. Female dogs at different stages of lactating observed during the count.

The results are used to estimate numbers the nearest two towns after Fahefa that have very similar conditions. The towns Houma and Vaotu'u should have ideally been included in the survey but time constraints prevented their coverage. Instead, estimates using humans/dog, dogs/km road and dogs/ha (area) resulted in totals of **1,598**, **1,434** and **1,478** dogs respectively. These again do not include the roads outside of the residential areas and is considered an under-estimate. Hence attaining at least 1,200 dogs for the de-sexing project is comfortably reached by including Houma and Vaotu'u to the towns surveyed in this study.

Table 5. Estimating dogs in the two next towns using the dog counts

Town	Total Population	Estimate using Humans/Dog	Road Length (km)	Estimate using Dogs/km	Area (ha)	Estimate using Dogs/ha
Houma	2,097	362	8.989	216	57.920	245
Vaotu'u	488	84	2.720	65	19.084	81
Total		446		282		326
Survey Count		1,152		1,152		1,152
Grand Total		1,598		1,434		1,478

In terms of determining the dog population of the entire island, the most reliable results would be from conducting a similar survey island-wide. To use the results of this work to estimate total numbers is expected be affected by factors used with the dog density measure that need to be verified for recency and coverage. For instance, during the survey, we found and followed roads that did not exist in the map, having been newly developed together with houses recently built as part of the reconstruction effort from the effects the very destructive Cyclone Gita in 2018. The existing road layers in the database had to be modified to provide data on these new roads. When using areas to measure dogs/hectare, the streets in the urban area of Nuku'alofa are excluded in the polygons of residential areas which is inconsistent with the other towns that include the roads in the residential areas, affecting the calculation of the total residential area used in the dogs/hectare estimate. In terms of using the humans/dog measure, some changes in population data from the available 2016 census is expected and the estimate may change. This emphasises the need to acquire updated and accurate data when available.

This report does not cover the results of data on sex, age and body condition recorded for some dogs. While a few dogs had the information gathered during the survey period, the number of dogs sighted while moving through the roads did not provide enough time to individually enter all the data in the fields on the Collector for ArcGIS app. Instead, the photographs taken can serve as the basis for determining the information captured, develop a more in-depth description of the dogs counted and provide data for interested students or researchers to derive knowledge from. The data is available in a geodatabase and when processed should provide insights such as the distribution of dogs in terms of gender, body condition and age. When related to socio-economic and environmental features of the landscape, relevant information in map format will be available for stakeholders with an interest in the management of dog population in the island as well as evaluating interventions or relevant projects planned and implemented.

5 Conclusions and Recommendations

The resulting dog count covering 12 towns of Kolovai and neighbouring Nukunuku districts provide data for a planned intervention to manage the dog population. Maps were generated depicting the dog locations and characteristics of the dogs measured by humans/dog, dogs/area and dogs/km of residential roads. A repeat survey of the covered areas using the same counting method should be conducted to determine the effectiveness of the intervention. Available data collected on relevant measures such as gender, age and body condition are available for processing to provide additional knowledge about the dog population of Tonga.

6 Acknowledgements

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