District overview of travel time to ART facilities: Machinga

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Objectives

- Map the estimated prevalence and number of people living with HIV (PLHIV) by approximately 1 km grid cells.
- Estimate the travel time to the nearest ART facility for PLHIV in Malawi.
- Identify optimal locations for additional facilities with ART service to reach PLHIV with long travel times to existing ART facilities (>60, 90, or 120 minutes).

Interactive results are available at: https://mrc-ide.github.io/mwi-hiv/ART_facilities/index.html.

HIV prevalence and PLHIV estimates

Figure 2 illustrates estimates for spatial HIV prevalence for adults aged 15-49 years. Figure 3 shows the estimated number of PLHIV (all ages), and the locations of health facilities with ART services (labelled with **A**) and without current ART services (labelled with **F**).

Table 1: Summary estimates for Machinga, September 2020.

Total PLHIV (all ages)	31,683 (27,891–36,303)
HIV prevalence, age 15-49 years	6.6% (5.8%–7.6%)
Total patients receiving ART	54,179
Average walking time to nearest ART (minutes)	51 (49–54)
Number PLHIV > 60 minutes walking time	10,452 (8,765–12,323)
Percentage PLHIV > 60 minutes walking time	32.0% (29.3%–34.9%)

Table 2: Traditional authorities with the lowest and highest estimated number of PLHIV, 15-49 Prevalence, and average walking time, respectively.

	Lowest TA	Largest TA
PLHIV	Liwonde National Park: 11 (8–14)	TA Liwonde: 3,358 (2,615–4,265)
15-49 Prevalence	TA Ngokwe: 3.8% (2.4%–5.8%)	Liwonde Town: 10.8% (7.9%–14.4%)
Average Walking Time	Machinga Boma: 6 min (6–6 min)	STA Chesale: 128 min (125–131 min)

Travel time to existing ART facilities

In Machinga, there are 21 ART facilities that had at least 1 patient in September 2020. The median number of ART patients per facility was 976. The list of *active ART facilities* is in Table 4. Private not-for-profit facilities have been excluded from the analysis. Figure 4 shows the modelled travel times to the nearest active ART facility. The average walking time to the nearest facility for residents in each traditional authority are in (Figure 5).

- The estimated average walking time for PLHIV to the closest ART facility across Machinga is 51 minutes (49-54 min).
- The shortest estimated average walking time to the closest ART facility is in Machinga Boma (6 minutes (6-6 min)).
- The longest estimated average walking time to the closest ART facility is in STA Chesale (128 minutes (125-131 min)).

An estimated 32.0% (29.3%–34.9%) of PLHIV reside more than 60 minutes walking time to their nearest ART facility, compared to 36.3% of the total population. This decreases to 13.6% (11.5%–15.9%) of PLHIV and 15.9% of the total population residing more than 90 minutes walking time to their nearest ART facility. More details are provided in Table 3.

Table 3: Estimated PLHIV and population not reached at different thresholds

Threshold (minutes)	Population not reached	As % of total population	PLHIV not reached	As % of total estimated PLHIV
45	409,992	52.0%	15,431 (13,262–17,835)	47.3% (44.8%–50.0%)
60	286,526	36.3%	10,452 (8,765–12,323)	32.0% (29.3%–34.9%)
90	125,668	15.9%	4,431 (3,507–5,530)	13.6% (11.5%–15.9%)
120	53,727	6.8%	1,840 (1,330–2,499)	5.6% (4.4%–7.3%)

Proposed facilities for new ART services

A list of 10 *non-ART facilities* were considered to identify existing health facility locations for expanding ART services, listed in Table 5. Figure 6 shows the number of PLHIV in grid cells where the estimated travel time is longer than 60 minutes and candidate new ART facilities.

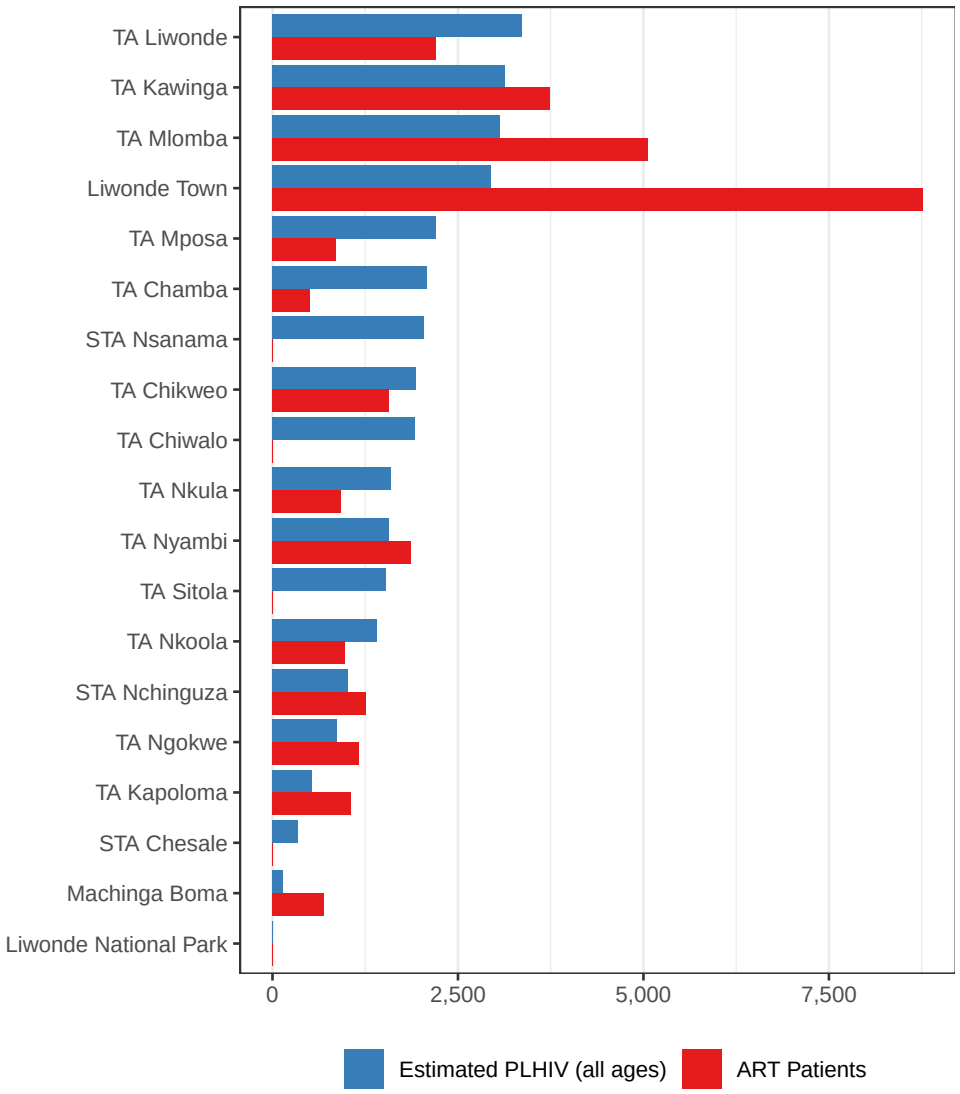
- The TA with the largest number of PLHIV residing more than 60 minutes from their closest ART facility is TA Chikweo (1407 PLHIV (926-2005) with walking time > 60 minutes).
- The facility that can reach the most PLHIV residing outside 60 minutes travel time is **MOLIPA**, with 851 PLHIV (585-1182) reached.

Limitations

There are several important limitations to this analysis:

- Travel time surfaces and catchments may not optimally reflect typical routine travel or movement patterns, for example for work or other activities.
- Results do not represent uncertainty in the 1km gridded maps of PLHIV arising from uncertainty about the gridded populations.
- There are discrepancies in the gridded HIV prevalence estimates from the Bayesian geostatistical model and the Naomi estimates for some districts which should be further reviewed, especially neighbouring urban and rural districts.
- Geographic locations of some health facilities are discrepant between multiple data sources and need to be confirmed.
- The physical infrastructure and suitability of candidate health facilities for supporting an ART service is unknown.
- Optimisation analysis for locations for new facilities has not considered overcrowding, wait times, or other barriers to access at existing facilities. It could be more optimal to expand services in some geographically dense locations to address barriers to access.

Summary figures and maps



Est. PLHIV (all ages)	Prevalence 15–49
3,358	6.4%
3,128	5.6%
3,068	8.3%
2,940	10.8%
2,200	9.7%
2,087	10.4%
2,046	8.9%
1,929	4.0%
1,917	5.5%
1,599	9.7%
1,570	4.9%
1,526	10.2%
1,403	4.4%
1,020	5.2%
865	3.8%
531	5.4%
347	4.0%
141	10.3%
11	8.1%

Figure 1: Number registered ART clients within each TA and estimated number of PLHIV within the TA. The right table indicates the estimated 15-49 HIV prevalence.

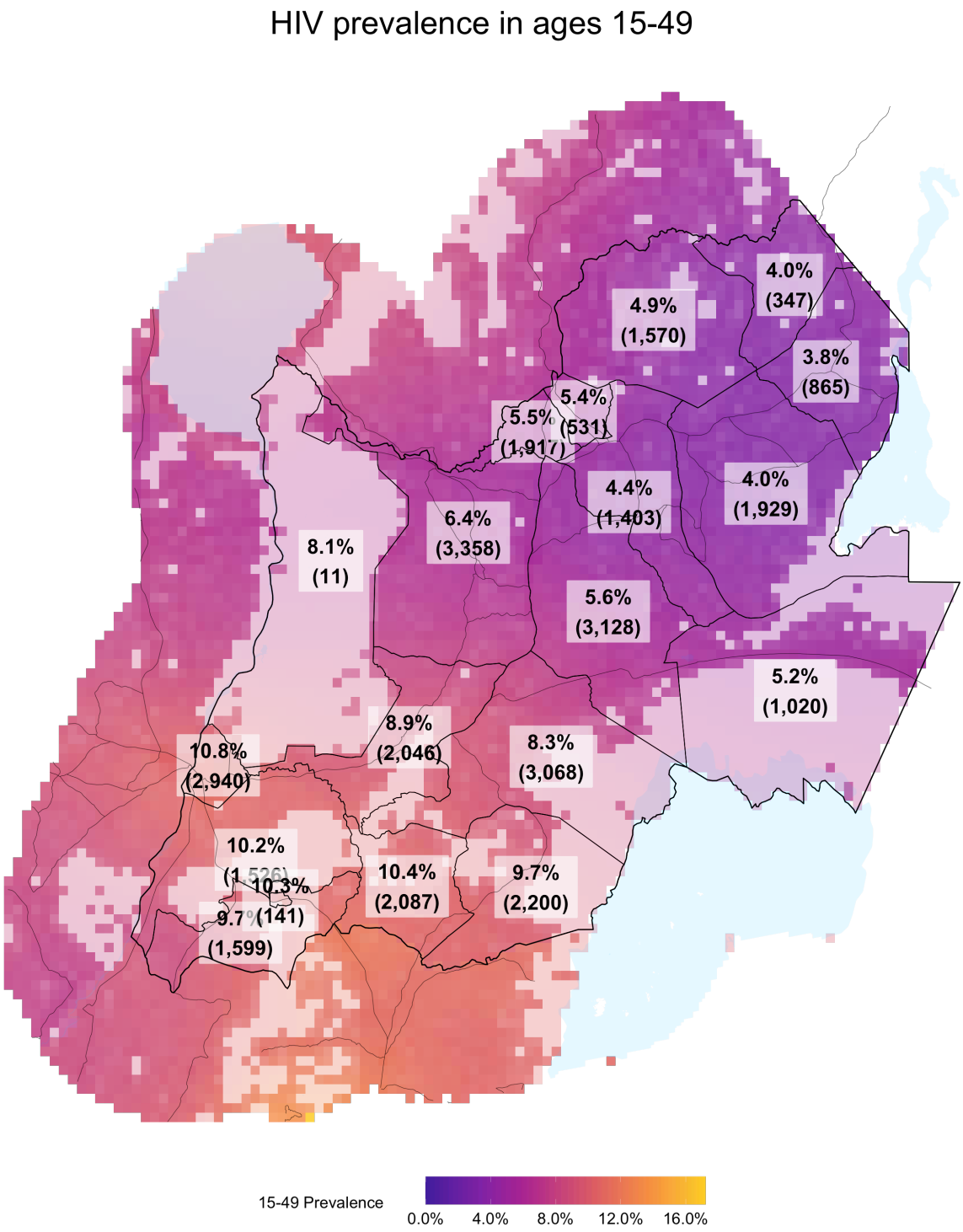


Figure 2: Estimated spatial HIV prevalence. Percentages correspond to TA level 15-49 HIV prevalence and numbers in brackets indicate the estimated number of PLHIV overall.

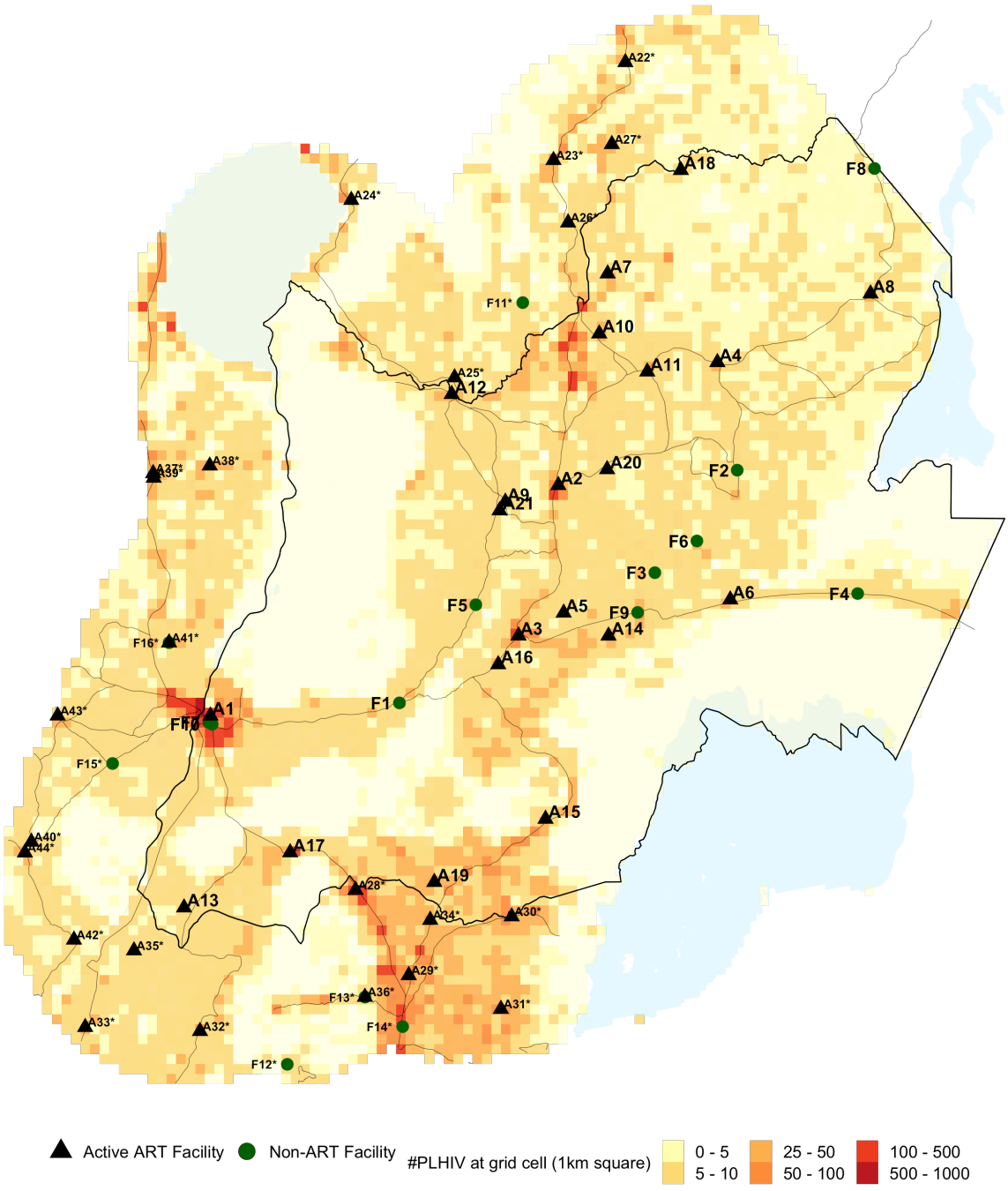


Figure 3: Estimated number of PLHIV on a 1km square.

Table 4: List of active ART facilities that had at least 1 registered ART patient in September 2020. The column ”ART” indicates how many ART patients are registered at the ART facility. Facilities outside the district boundaries that may be accessible to residents within the district are marked with ”*”.

ID	District	TA	Name	Type	Authority	Long.	Lat.	ART
A1	Machinga	Liwonde Town	Machinga District Hosp.	District hospital	Government	35.23	-15.06	8773
A2	Machinga	TA Kawinga	Ntaja HC	Health centre	Government	35.53	-14.87	3450
A3	Machinga	TA Mlomba	Nsanama HC	Health centre	Government	35.49	-14.99	1994
A4	Machinga	TA Chikweo	Chikweo HC	Health centre	Government	35.67	-14.76	1568
A5	Machinga	TA Mlomba	Nayuchi HC	Health centre	Government	35.53	-14.98	1491
A6	Machinga	STA Nchinguza	Namanja HC	Health centre	Government	35.68	-14.96	1264
A7	Machinga	TA Nyambi	Nyambi HC	Health centre	Government	35.57	-14.69	1222
A8	Machinga	TA Ngokwe	Ngokwe HC	Health centre	Government	35.80	-14.71	1161
A9	Machinga	TA Liwonde	Namandanje HC	Health centre	CHAM	35.48	-14.88	1070
A10	Machinga	TA Kapoloma	Nayinunje HC	Health centre	Government	35.57	-14.74	1062
A11	Machinga	TA Nkoola	Mpiri HC	Health centre	Government	35.61	-14.77	976
A12	Machinga	TA Liwonde	Mangamba HC	Health centre	Government	35.44	-14.79	928
A13	Machinga	TA Nkula	Gawanani HC	Health centre	CHAM	35.20	-15.22	927
A14	Machinga	TA Mlomba	Ntholowa HC	Health centre	CHAM	35.57	-14.99	870
A15	Machinga	TA Mposa	Mposa HC	Health centre	CHAM	35.52	-15.15	857
A16	Machinga	TA Mlomba	Mlomba HC	Health centre	Government	35.48	-15.02	710
A17	Machinga	Machinga Boma	Machinga HC	Health centre	Government	35.30	-15.18	689
A18	Machinga	TA Nyambi	Mkwepere HC	Dispensary	Government	35.64	-14.60	645
A19	Machinga	TA Chamba	Chamba Disp.	Dispensary	Government	35.42	-15.20	501
A20	Machinga	TA Kawinga	Kayembe HC	Health centre	Government	35.57	-14.85	289
A21	Machinga	TA Liwonde	Mbonechera HC	Health centre	Government	35.48	-14.89	202
A22*	Mangochi	TA Mbwana Nyambi	Mulibwanji Hosp.	Rural/Community	CHAM	35.59	-14.51	1306
A23*	Mangochi	TA Mbwana Nyambi	Mkumba HC	Health centre	Government	35.53	-14.59	883
A24*	Mangochi	TA Chowe	Malombe HC	Health centre	Government	35.35	-14.63	870
A25*	Mangochi	STA Chiunda	Chiunda HC	Dispensary	Government	35.44	-14.78	778
A26*	Mangochi	TA Mbwana Nyambi	Somba HC	Health centre	Government	35.54	-14.65	366
A27*	Mangochi	TA Mbwana Nyambi	Sinyala HC	Health centre	Government	35.58	-14.58	123
A28*	Zomba	TA Malemia	St Lukes Mission Hosp.	District hospital	CHAM	35.35	-15.21	3715
A29*	Zomba	TA Malemia	Domasi Rural Hosp.	Rural/Community	Government	35.40	-15.28	2381
A30*	Zomba	TA Kuntumanji	Namasalima HC Zomba	Health centre	Government	35.49	-15.23	1438
A31*	Zomba	TA Kuntumanji	Bimbi HC	Health centre	Government	35.48	-15.31	1319
A32*	Zomba	STA Nkapita	Nkasala HC	Health centre	Government	35.22	-15.33	825
A33*	Zomba	TA Mlumbe	Chilipa HC Zomba	Health centre	CHAM	35.12	-15.32	665
A34*	Zomba	TA Malemia	Machinjiri HC	Health centre	Government	35.42	-15.23	560
A35*	Zomba	STA Nkapita	Mmambo HC	Health centre	Government	35.16	-15.26	551
A36*	Zomba	TA Malemia	H. Parker Sharp HC (Domasi CCAP)	Health centre	CHAM	35.36	-15.30	237
A37*	Balaka	TA Kalembo	Kalembo HC	Health centre	Government	35.18	-14.86	1880
A38*	Balaka	TA Kalembo	Namdumbo HC	Health centre	Government	35.23	-14.85	1050
A39*	Balaka	TA Kalembo	Ulongwe HC	Health centre	CHAM	35.18	-14.86	992
A40*	Balaka	TA Nkaya	Utale 2 HC	Health centre	Government	35.07	-15.17	879
A41*	Balaka	TA Amidu	Namanolo HC	Health centre	Government	35.19	-15.00	809
A42*	Balaka	TA Nkaya	Phimbi HC	Health centre	Government	35.11	-15.25	807
A43*	Balaka	TA Msamala	Kwitanda HC	Health centre	Government	35.09	-15.06	683
A44*	Balaka	TA Nkaya	Utale 1 HC	Health centre	CHAM	35.06	-15.18	413

Table 5: List of non-ART facilities considered in the analysis. The column ”PLHIV” indicates the number of PLHIV that currently need more than 60 minutes to walk to the closest ART facility but less than 60 minutes to the listed health facility in the table. Facilities outside the district boundaries that may be accessible to residents within the district are marked with ”*”.

ID	District	TA	Name	Type	Authority	Long.	Lat.	PLHIV	95% CI
F1	Machinga	STA Nsanama	MOLIPA	Health Post	Government	35.39	-15.05	851	(585-1182)
F2	Machinga	TA Chikweo	Chipolonga HP	Health Post	Government	35.69	-14.86	804	(524-1151)
F3	Machinga	TA Kawinga	CHAPUSA	Health Post	Government	35.61	-14.94	448	(314-613)
F4	Machinga	STA Nchinguza	LIKHONYOWA	Health Post	Government	35.79	-14.96	447	(220-815)
F5	Machinga	STA Nsanama	CHISUWI	Health Post	Government	35.46	-14.97	425	(293-598)
F6	Machinga	TA Kawinga	CHITUNDU	Health Post	Government	35.65	-14.92	534	(347-777)
F7	Machinga	Liwonde Town	Liwonde Health Information	Special	NGO	35.22	-15.07	104	(79-137)
F8	Machinga	STA Chesale	CHIMBIRA	Health Post	Government	35.81	-14.60	97	(51-165)
F9	Machinga	TA Kawinga	MBANIRA	Health Post	Government	35.60	-14.98	254	(181-344)
F10	Machinga	Liwonde Town	BLM Liwonde	Special	NGO	35.23	-15.07	104	(79-137)
F11*	Mangochi	STA Chiunda	Mbalama Disp.	Dispensary	Government	35.50	-14.71	527	(361-748)
F12*	Zomba	TA Malemia	Zomba Forestry Disp.	Dispensary	Other	35.29	-15.36	35	(27-45)
F13*	Zomba	TA Malemia	H Parker Sharp Disp.	Health Centre	CHAM	35.36	-15.30	0	(0-0)
F14*	Zomba	TA Malemia	Compassionate Mission Clinic	Clinic	NGO	35.39	-15.32	0	(0-0)
F15*	Balaka	TA Msamala	DZIWE	Health Post	Government	35.14	-15.10	486	(348-638)
F16*	Balaka	TA Amidu	Mwima HP	Health Centre	Government	35.19	-15.00	0	(0-0)

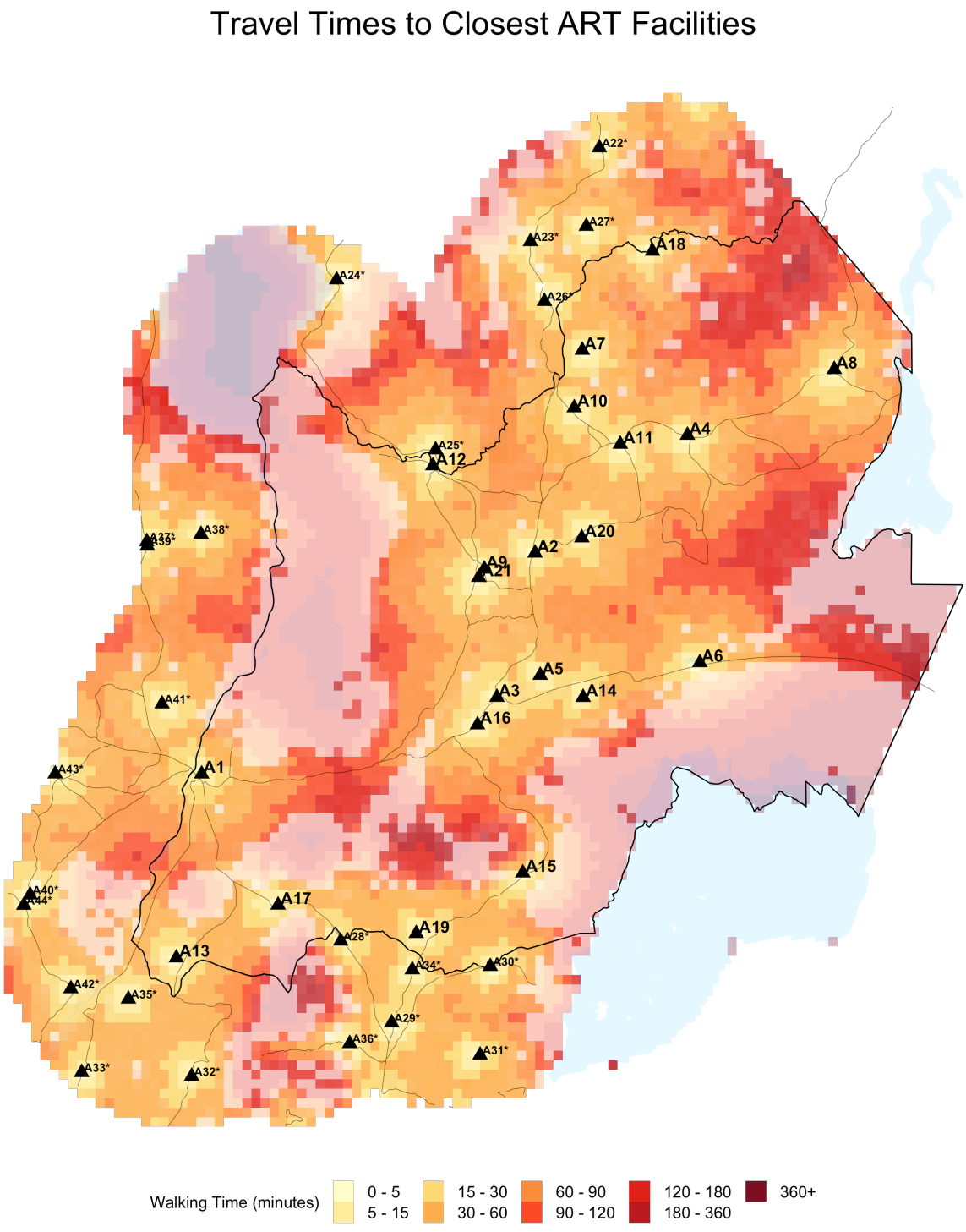
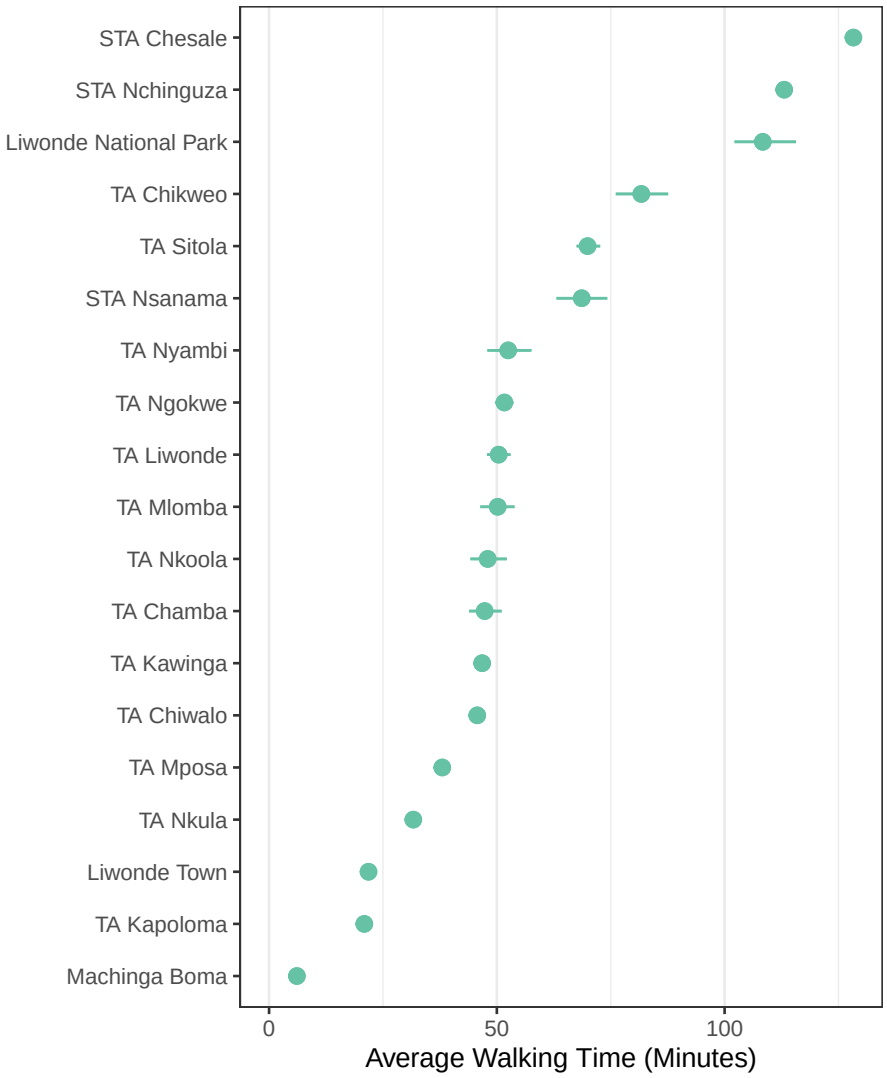


Figure 4: Estimated travel times to the closest ART facility. Travel times were calculated using data on road infrastructure, types of terrain and land elevation.



	#PLHIV >60 mins	%PLHIV >60 mins
STA Chesale	342	99.0%
STA Nchinguza	760	71.7%
Liwonde National Park	9	86.9%
TA Chikweo	1,407	72.3%
TA Sitola	1,000	64.1%
STA Nsanama	1,361	64.4%
TA Nyambi	563	35.1%
TA Ngokwe	320	37.0%
TA Liwonde	1,082	31.3%
TA Mlomba	1,197	37.1%
TA Nkoola	435	30.3%
TA Chamba	283	13.1%
TA Kawinga	983	30.1%
TA Chiwalo	397	20.0%
TA Mposa	188	8.2%
TA Nkula	104	6.3%
Liwonde Town	21	0.7%
TA Kapoloma	0	0.0%
Machinga Boma	0	0.0%

Figure 5: Estimated average walking time to the closest ART facility, weighted by the estimated number of PLHIV within the traditional authority. The right table indicates estimated number and proportion of PLHIV that need more than 60 minutes to travel to the closest ART facility, respectively.

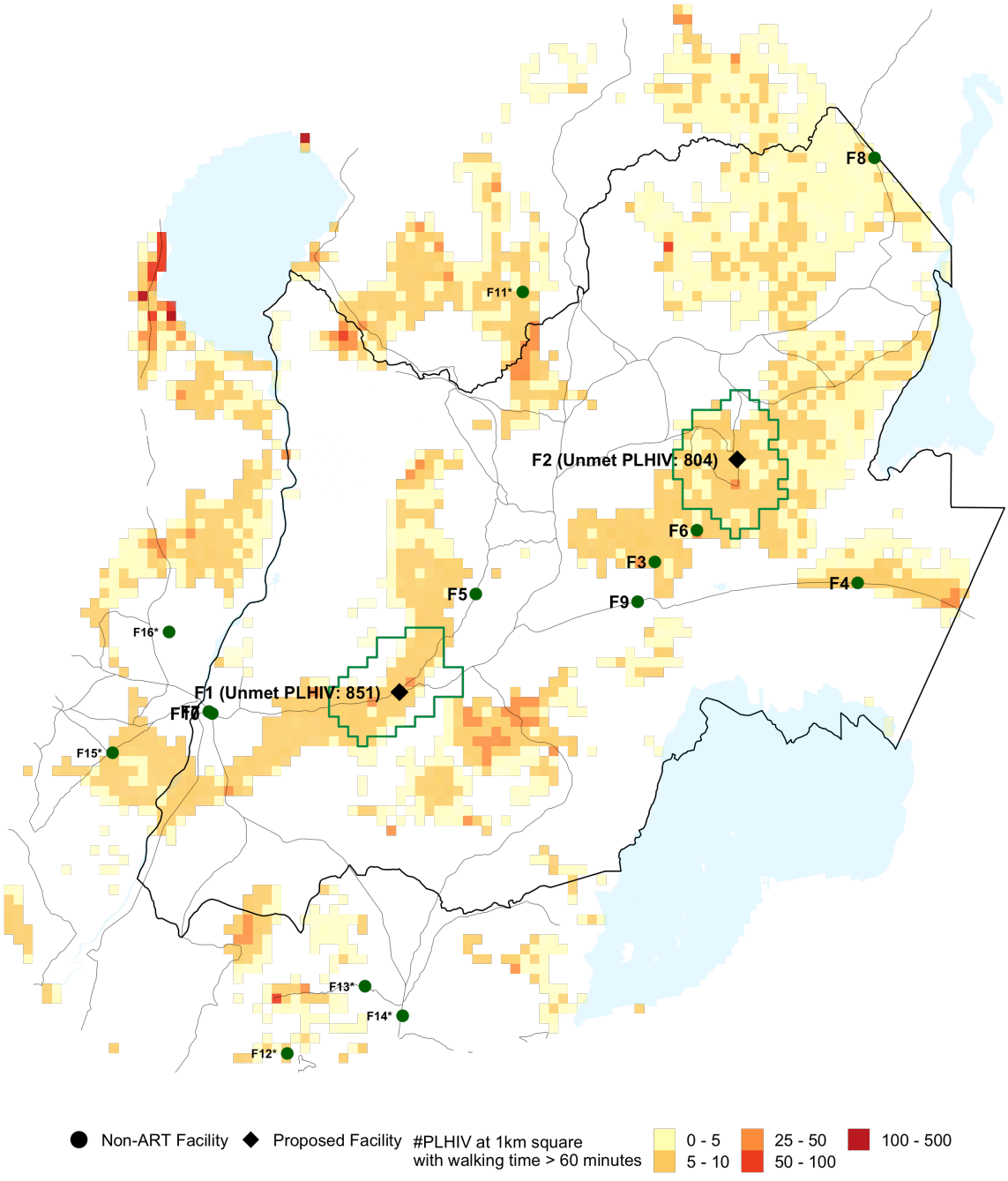


Figure 6: Proposed facility locations. Areas where the walking time to the closest ART facility is <60 minutes have been removed. Green lines indicate the 60-minutes catchment area of the proposed facility.

Appendix (Methods Summary)

The analysis involved several steps:

1. **Creating a map of spatial prevalence by approximately 1km grid cells.** We used cluster-level survey data from the 2015/16 MDHS and MPHIA household surveys and HIV prevalence amongst ANC clients from routine health facility data to obtain a gridded PLHIV prevalence map (1km grid cells).
2. **Calculate the estimated number of PLHIV in each 1km grid cell.**
   - Modelled estimates of total population by 1km grid cell were sourced from the WorldPop project (https://www.worldpop.org/geodata/summary?id=49698). Gridded populations are constrained to only grid cells containing built settlements based on satellite imagery.
   - Gridded populations were adjusted to match traditional authority (TA) population data from the 2018 household census, projected forward to 2020 based on district population projections.
   - Gridded HIV prevalence (step 1) was multiplied by population for estimates of the distribution of PLHIV by 1km grid cell.
   - The gridded PLHIV in each district were scaled to align to total PLHIV in each district from the from 2020 Naomi model estimates.
3. **Calculate walking travel time for PLHIV to existing ART services.** We used data on land cover terrain type (Global Land Cover 2000), roads (OpenStreetMap), elevation (GMTED2010), and water bodies (NASA Shuttle Radar Topography Mission) to model walking time from each grid cell to 757 public or not-for-profit health facilities providing ART services using the AccessMod software. Walking speed was assumed to be 6-7km/h on roads and 2-3 km/h on non-road surfaces.
4. **Analyse the number and locations of PLHIV residing greater than 60, 90, or 120 minutes walking time from existing ART facilities.** Grid cells were classified by the travel time to the nearest public or not-for-profit ART facility using the travel time model. Maps were filtered for PLHIV residing greater than 60, 90, or 120 minutes, thresholds of interest defined based on discussions with the Department of HIV and AIDS (DHA).
5. **Identify optimal locations to reach the most PLHIV who currently reside greater than 60 or 90 minutes from ART services.** An optimisation algorithm was implemented to systematically select the best facilities and locations where ART service delivery can be introduced to reach the most PLHIV residing outside travel time thresholds.

The list of 757 active facilities currently providing ART services was sourced from DHA-MIS database. Facilities that were private-for-profit were excluded from the analysis of travel time catchments. Health facilities which do not currently provide an ART service, which are candidate locations for expanding ART services, were sourced from facilities visited during the 2018/19 Service Availability and Readiness Assessment (SARA). Candidate facilities included existing health posts which are not staffed full time.