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Global Health

Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

Supplement to: Local Burden of Disease Household Air Pollution Collaborators. Mapping development and health effects of cooking with solid fuels in low-income and middle-income countries, 2000–18: a geospatial modelling study. *Lancet Glob Health* 2022; **10:** e1395–411.

Supplementary Information: HAP Stage II (2000–2018)

Contents

0.0 Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) Compliance

Supplementary Table 1 provides the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) compliance checklist.

1.0 Data

1.1 Known issues

1.1.1 Countries with no data

This analysis does not produce estimates in countries where data did not meet our inclusion criteria due to data availability or quality of cooking fuel use data. We have masked all estimates in countries for which we had no data that we could geolocate below the national level. For cooking fuel use, this included Cabo Verde, Cuba, French Guyana, Equatorial Guinea, Malaysia, Venezuela, and Western Sahara. If data become available from any of these countries, we will include them in the models and share the results.

1.2 Model geographies

This analysis selected 98 countries based on their Socio-demographic Index (SDI).[1] The SDI is a measure of education, fertility, and income. Countries included were in the middle, lower-middle, or low SDI quintiles, with certain exceptions. China and Libya were included despite higher-middle SDI status to create better geographical continuity. Despite the requisite SDI quintiles for inclusion, we excluded the countries of Cabo Verde, Cuba, French Guyana, Equatorial Guinea, Malaysia, Venezuela, and Western Sahara as they had no relevant data available. We also excluded island nations with fewer than 1 million inhabitants, which were the nations of Fiji, Solomon Islands, Maldives, Vanuatu, Samoa, Saint Lucia, Kiribati, St. Vincent and the Grenadines, Grenada, Micronesia, Tonga, Seychelles, Dominica, Marshall Islands, and American Samoa. These countries were typically data-scarce and did not have sufficient geographical continuity for a geospatial analytical approach to be advantageous over a national one.

We subdivided the spatial modelling domain into 18 regions, consisting of groupings of countries. The regions were created in consideration of geographical contiguity and epidemiological similarity between the constituent countries. In the case of China, Mongolia, Nigeria, South Africa, and the combined area of Eritrea, Djibouti, and Yemen, the data exhibited distinct spatial and temporal trends in comparison of their neighbouring countries. Therefore, the aforementioned countries were modelled individually. By creating modelling regions, we were able to account for potential non-stationarity in the relationships between covariates and the outcome across the modelling domain as each region would be modelled independently. Furthermore, subdividing the 98 countries into 18 modelling regions allowed for computational feasibility.

Computational limitations meant that we were unable to account for potential non-stationarity within countries/regions, as we assumed an isotropic and stationary Matérn function (see Section 3.1 for more detail) to model spatial covariance at that level. Assuming stationarity likely introduces bias to the results but would be computationally infeasible to model at the spatial scale required for the scope of this analysis. Community-level drivers have been observed to account for within-country heterogeneity in solid fuel use, and the spatial correlation introduced by these socioeconomic effects is unlikely to be fully captured by an isotropic process.[1] Comparison of stationary and non-stationary models for other health risk data has previously demonstrated that non-stationary models can increase prediction accuracy, while estimating roughly similar spatial trends.[2] An inherent irony is that modelling non-stationarity becomes more important as the size of the modelling area increases, while being increasingly computationally intensive on the same axis. The environmental indicators we used as geospatial covariates, such as land use and travel time to the nearest settlement, should explain some of this variation,[3,4] but additional anisotropic effects may exist as cooking behaviours are understood to correlate with nuanced social patterns.[5,6] We expect that relaxing the assumption of isotropy for modelling cooking fuel use would reveal additional within-country heterogeneity and demonstrate even higher subnational inequalities, and we think this is an important area for future research as additional data become accessible and as the computational power available to researchers continues to increase. Given that most of our results are derived from the aggregation of the geospatial model to administrative units for comparison, an additional area of further investigation could be the use of areal modelling approaches such as locally adaptive conditional auto-regressive (CAR) models, which could relax the assumption of stationarity and potentially reveal discontinuities in the spatial surface that may be smoothed over by our geostatistical model.

1.3 Data inclusion criteria

Sources were only included for modelling if they were representative of the entire population during the time period and across the geographical area of measurement. Furthermore, certain sources were excluded if the associated estimates seemed implausible based on expert review of estimates and comparison with other sources in the same country and time period.

1.4 Summary of included data sources

The household surveys used in modelling solid fuel use are listed in Table 4. Each source is listed with the number of households represented, country, and year. Additionally, the tables provide the number of georeferenced points or spatial areas represented by each source as well as a unique identifier (GHDx ID) which can be used to reference the source via the Global Health Data Exchange (GHDx).[2] 663 household surveys from 98 countries were included in the solid fuel use model.

1.5 Processing data for modelling

Data corresponding to each georeferenced point were summarised as survey weighted means. For data without corresponding GPS coordinates, data were summarised across the smallest spatial area the data were representative over to produce areal estimates. Household sizes and survey weights were used to produce weighted means of access representative at the individual level. The household sizes and survey weights were further used in a Kish approximation[4] of an effective sample size for each mean to account for the complex survey design of most of the data used.

1.6 Processing areal data for geostatistical modelling

For areal data, 10,000 locations were randomly sampled from the area using population values from WorldPop[5] raster to weight the sampled points. K-means clustering was performed over these points to generate integration points (1 point per 1000 WorldPop grid cells encompassing the area) to be used in the modelling. Weights were assigned to integration points as the proportion of the original 10,000 points that entered the k-means cluster. Each of these integration points was assigned the areal mean. The integration points were included in the input dataset for further modelling. In this manner, the spatial variation of covariates could be leveraged and areal data could be incorporated into the geostatistical model. The above resampling method used is consistent with the resampling conducted in the previously published geospatial modelling of child growth failure.

1.7 Data validity

Following the vetting of indicator string matching, all surveys were systematically reviewed for data quality. Country-specific diagnostic plots were produced for cooking fuel. The estimate for each indicator from each data source was compared to the other available data sources for that country for similar years. If the data source's estimate was considered implausibly different from other sources, then the source was excluded. Each country-specific diagnostic plot was independently reviewed, considering country and time trends, as well as whether a survey was nationally and/or subnationally representative.

2.0 Covariates

2.1 Covariate selection

The first stage of modelling used 27 covariates, composed of various environmental and social indicators. Each covariate was formatted at a 5 x 5 km resolution from 2000 to 2018. They included travel time to nearest settlement, aridity, diurnal temperature range, frost day frequency, potential evapotranspiration, average daily mean temperature, dependency ratio of dependents to working age adults, distance from rivers or lakes ≥ 50 km^2, nighttime lights, elevation, agricultural land, enhanced vegetation index, fertility, urban or rural, nutrient yield, irrigation, urban proportion of location, average land surface temperature, precipitation, normalised difference vegetation index, tassled cap brightness, tassled cap wetness, and population. For covariates which were continuous variables, we calculated rolling means using a 5-year window and used the results for modelling. This was conducted to stabilise any shocks in the time-trends of the covariates, aiding in stabilising the time-series predicted from modelling.

In the first stage, for each region, three types of models were fit to the data: generalised additive models, boosted regression trees, and lasso regression. In doing so, we attempted to account for the varying and potentially non-linear relationship between each of the covariates and the outcome indicator. Each of the 23 covariates was used in the boosted regression tree and lasso regression model. To prevent issues with collinearity and optimise performance, covariate selection was performed for the generalised additive model as follows:

Each covariate was regressed against all other covariates in order to identify if a covariate's variance can be accounted for via a linear combination of the other covariates. A variance inflation factor (VIF) was calculated for each such regression. The covariate corresponding with the independent variable in the regression with highest VIF was eliminated. This procedure was iteratively repeated until all associated VIFs were under 5.

2.2 Modelling covariates via stacked generalisation

As noted above, for each region, three models were fit to the data: generalised additive models, boosted regression trees, and lasso regression. Each model was fit using five-fold cross validation (out-of-sample) as well as on the entire dataset at once (in-sample). Out of sample predictions were generated from each model and logit transformed for subsequent use as covariates in the geostatistical model. The logit transformation was conducted to ensure the covariate and the outcome solid fuel use sanitation indicator data would be in the same functional space. The in-sample predictions from these "sub-models" were used as covariates when generating predictions using the fitted relationships from the geostatistical model.

3.0 Geostatistical model

3.1 Model parameters

$$C_d | p_{i(d),} N_d \sim Binomial(p_{i(d)}, N_d) \; \forall \; obs. clusters \; d$$

$$logit(p_{i,t}) = \beta_0 + X_{i,\beta} + \varepsilon_{c(i)} + \varepsilon_{n(i)} + \varepsilon_i + Z_i$$

$$\sum_{h=1}^{3} \beta_h = 1$$

$$\varepsilon_c \overset{iid}{\sim} N(0, {\gamma_c}^2)$$

$$\varepsilon_n \overset{iid}{\sim} N(0, {\gamma_n}^2)$$

$$\varepsilon_i \overset{iid}{\sim} N(0, \sigma^2)$$

$$Z \sim GP\left(0, \sum^{space}\right)$$

$$\sum^{space} = \frac{\omega^2}{\Gamma(v) 2^{v-1}} * (kD)^v * K_v(kD)$$

The coefficients $X_{i,\beta}$ for the three stacked sub-models represent their respective predictive weighting in the mean logit link, while the joint error term, Z_i, accounts for any residual spatiotemporal autocorrelation. These residuals, Z_i, are modelled as a three-dimensional space-time Gaussian process (GP) which was centred at zero. The covariance matrix for this GP was constructed from a Kronecker product of spatial and temporal covariance. The spatial covariance, Σspace, is modelled based on a stationary and isotropic Matérn function. For the Matérn function, Γ is the gamma function, Kv is the modified Bessel function of order v > 0, κ > 0 is a scaling parameter, D represents the distance (Euclidean), and ω2 is the marginal variance. We defined the scaling parameter, κ, as $k = \sqrt{8v}/_{\delta}$ where δ is a range parameter (reflective of the distance where the covariance function is approaching 0.1) and v is a scaling constant, which is set to 2. This scaling constant, v, has been documented in other analyses to be difficult to fit reliably from data and is generally recommended to be fixed at the aforementioned value of 2.[7,8]

Our implementation of INLA using the R-INLA software relies on a Gaussian approximation of the full conditional distribution of latent variables, and uses the empirical Bayes approximation for the hyperparameters. We have tried the full hyperparameter grid integration and CCD integration in various settings and have found our models to be nearly indistinguishable. For the sake of computing resource efficiency (with which we always operate at the margins), we have proceeded with using the empirical Bayes procedure. In a very similar setting with malaria household survey data, other authors compared the INLA results directly with results from Hamiltonian Markov Chain Monte Carlo and found nearly identical results between the two fits.[9,10]

3.2 Metrics of predictive validity

We assessed model performance based on a five-fold out-of-sample cross-validation framework with spatial stratification. Each fold was derived using a modified bi-tree algorithm[11] in order to aggregate datapoints spatially. The algorithm generates recursive partitions in two-dimensional space, alternating horizontal and vertical divisions on the median values of weighted sample sizes of the data until each spatial partition contains data of similar sample size. Constraints on the depth of the recursive partition are derived from the target sample size in each partition, as well as the minimum number of clusters or pseudo-clusters allowed for a given partition. For this analysis, a minimum sample size of 500 was used. We allocated these spatial partitions to five different folds for the cross-validation analysis. Each of these five folds was then excluded in turn while fitting the entire model five times. The withheld data were then compared with model predictions in order to generate the OOS metrics, including the mean error (bias), root-mean-squared-error (RMSE), correlation, and the 95% coverage rate of the predicted intervals (proportion of observed data that fall within the predicted 95% credible intervals). Each metric was produced by aggregating the data and predictions up to different administrative levels (levels 0, 1, 2 as defined by the Database of Global Administrative Areas [GADM]), in order to assess performance at different levels of spatial granularity. These metrics are calculated across all modelling regions and summarised in Supplementary Tables 8-10 and Figures 21a-22.

3.3 Propagating uncertainty

All estimates were generated by taking 1,000 draws of all model parameters from the approximated joint posterior distribution using the inla.posterior.sample() function in R-INLA[12,13], yielding 1000 candidate maps from which to summarise the grid-cell- and aggregated-level statistics. For estimates at the grid-cell level, these draws were used directly to generate estimates and uncertainty. Aggregated estimates, in which grid-cell-level estimates were summarised to administrative boundaries, were generated by creating population-weighted averages for each administrative boundary, for each draw. 95% uncertainty intervals around the mean of our estimates were generated.

3.4 $PM_{2.5}$ exposure and proportional PAFs

To estimate the increased health risk from cooking with solid fuels using a dose-specific risk function, we estimated the level of exposure to $PM_{2.5}$ expected for households using solid fuels to cook. WHO's Global Household Air Pollution (HAP) Measurements database contains 196 studies with measurements from 43 countries of various pollution metrics in households using solid fuel for cooking.[14] From this database, a model was constructed based on all measurements of $PM_{2.5}$ using indoor or personal monitors. The final dataset included 336 estimates from 75 studies in 43 unique locations. 274 estimates were in households using solid fuels, 47 in households only using clean (gas or electricity) fuels, and 15 in households using a mixture of solid and clean fuels. Before modelling, each datapoint was converted from total particulates to the excess particulate matter in households using solid fuel by subtracting off the predicted ambient $PM_{2.5}$ value in the study location and year based on the GBD 2017 $PM_{2.5}$ exposure model.[15] A model constructed from this database was used as part of the GBD 2019 study to predict the expected incremental $PM_{2.5}$ for every modelled location.[16]

The excess $PM_{2.5}$ exposure that was generated by households primarily using solid fuels for cooking was combined for each location with an updated model from GBD 2019 of geospatially resolved ambient $PM_{2.5,}$ calculating the total $PM_{2.5}$ exposure for every modelled location. The ratio of excess household particulates to ambient particulates was estimated as part of this process. To account for overlap in ambient and household particulate exposures in countries with a high dual burden and prevent double-counting, we utilised a proportional PAF approach that was developed for GBD 2017.[15] This method relies on using published $PM_{2.5}$ dose–response curves (see appendix, section 3.5) applied to estimates of the total $PM_{2.5}$ exposure in a given location to estimate the PAF for total $PM_{2.5,}$ and then splitting it proportionally based on the previously estimated ambient:household $PM_{2.5}$ ratio (see appendix, figure 2b). This method assumes that it is unknown which area of the dose–response curve each source is contributing to, and therefore they must be considered equivalently as opposed to being subtracted from a particular slope of risk increase. Our approach is also dependent on an assumption of particle equitoxicity, and there is evidence that bias may be introduced by this method if there are fundamental differences in the chemical composition of particles generated by household and ambient sources of pollution.[17] Upon the availability of adequate data from which to develop more granular risk–response curves that provide source-specific distinctions, this assumption should be revisited.

3.5 $PM_{2.5}$ dose–response

To estimate the relative risk of exposure to ambient and household particulate matter ($PM_{2.5}$) air pollution we leveraged a cause-specific risk curve for acute lower respiratory infection, which had been produced as part of the GBD 2019 study.[16] To generate dose–response curves as a function of $PM_{2.5}$, splines were fit to relative risk and $PM_{2.5}$ exposure estimates from studies of ambient $PM_{2.5}$, household solid fuel use, and secondhand smoking using an open-source Bayesian, regularised, trimmed, meta-regression software (MR-BRT). With the flexibility of splines in MR-BRT and the addition of recent studies from high exposure settings,[18–22] the approach utilised for GBD 2019 no longer included studies of active smoking data in the risk curves. Specifically, for each of the risk–outcome pairs, various model settings and priors were tested in order to fit splines specified for the relationship as:

log((MRBRT(X))/MRBRT(X_CF))~log(Published Effect Size) where X and XCF represent the range of exposure characterised by the effect size. The final models included third-order splines with two interior knots and a constraint on the right-most segment forcing a linear fit. GBD 2019 used an ensemble approach to knot placement, where 100 different models were run with randomly placed knots and then combined by weighting based on a measure of fit that penalises excessive changes in the third derivative of the curve. Knots were free to be placed anywhere within the 5th and 95th percentile of the data, as long as a minimum width of 10% of that domain exists between them. The functions were shaped constrained, such that the curves were monotonically increasing and concave downwards, the most biologically plausible shape for $PM_{2.5}$ risks. On the nonlinear segments, a Gaussian prior was specified on the third derivative of mean 0 and variance 0.01 to prevent over-fitting; on the linear segment, a stronger prior of mean 0 and variance 1e-6 was used to ensure that the risk curves did not continue to increase beyond the range of the data. Additional information about how this approach was specified is available in the GBD 2019 risk factors summary manuscript.[16]

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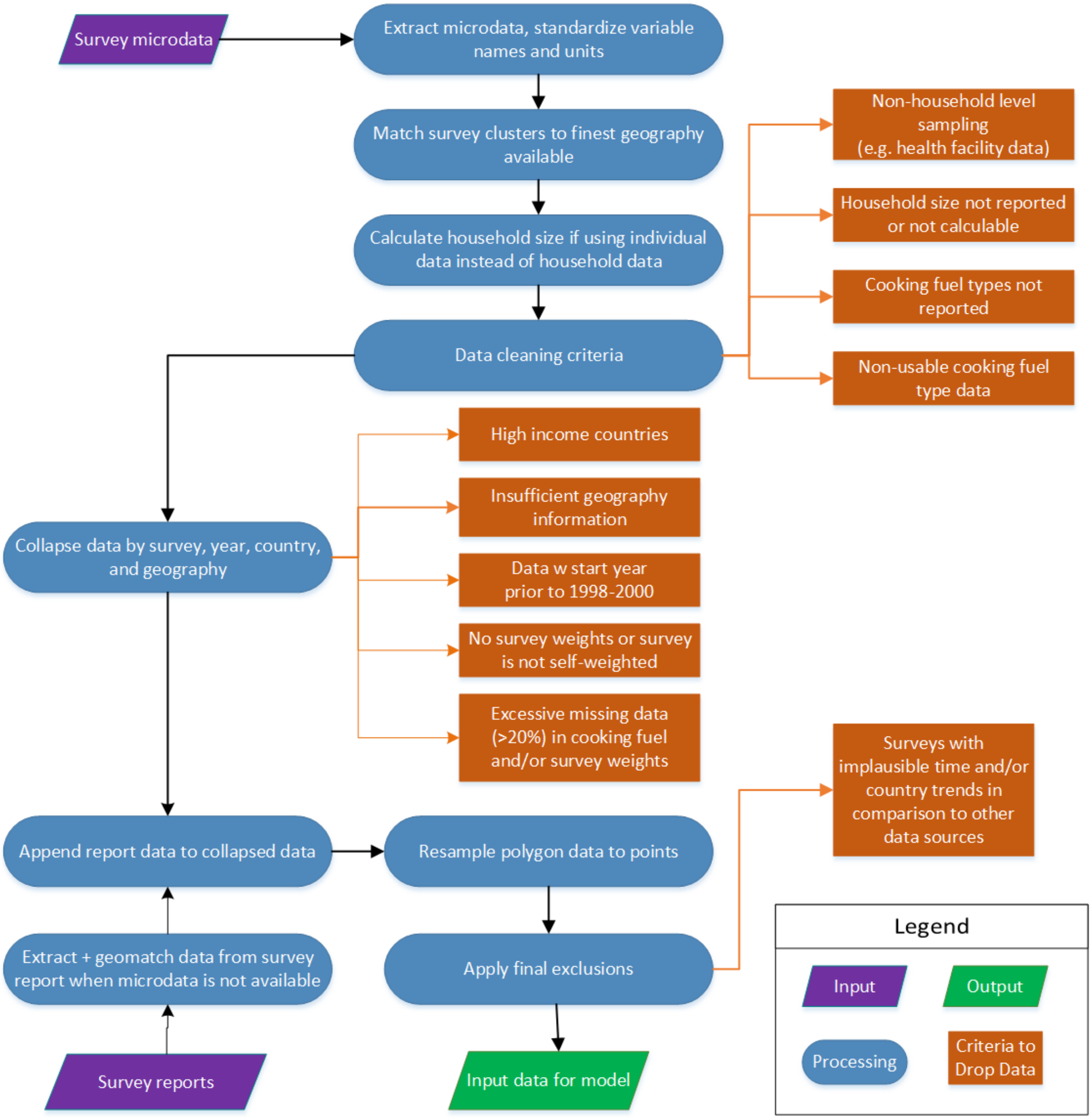
4.0 Supplementary figures

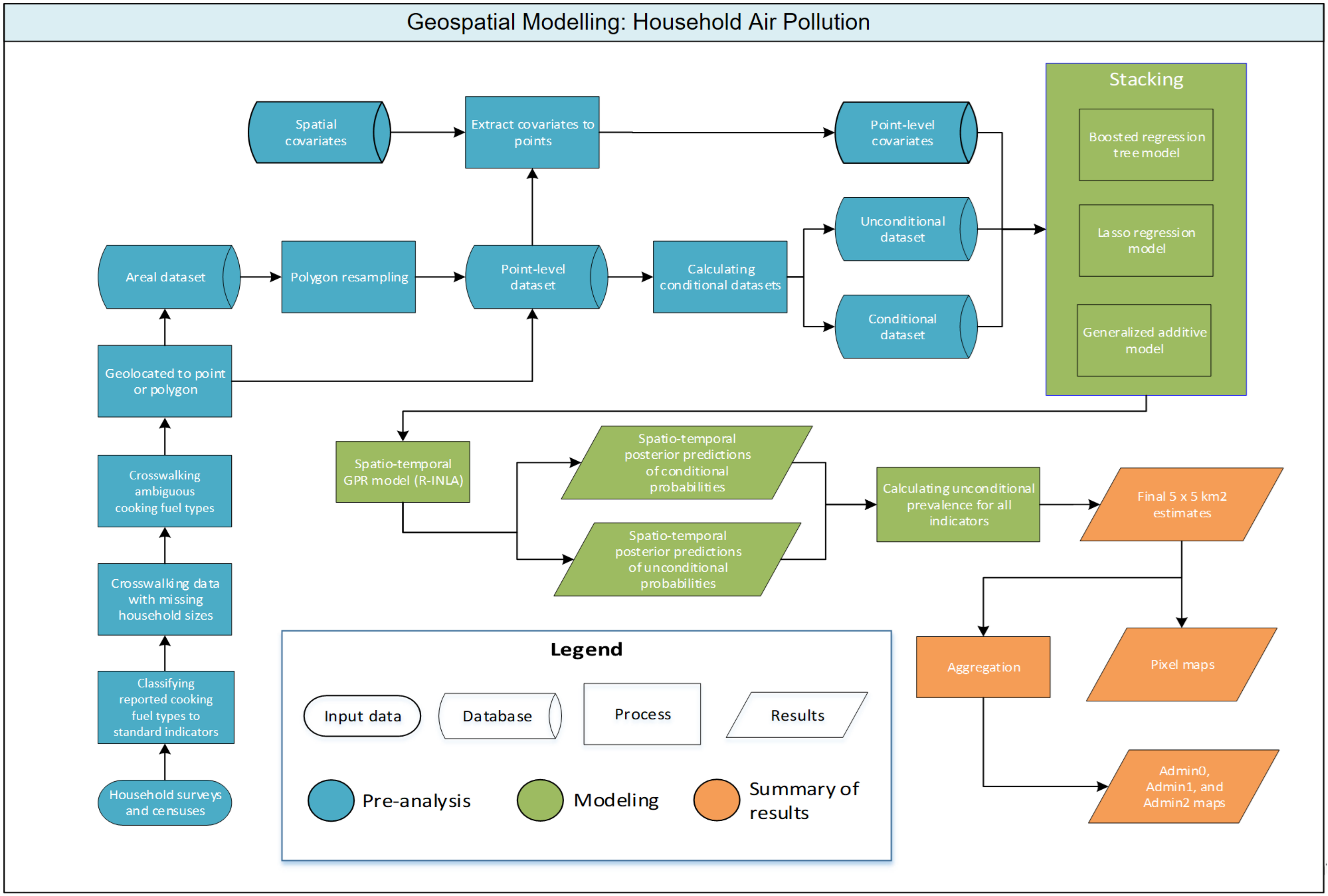
Supplementary Figure 1: Data processing flowchart

Source identification and inclusion and exclusion criteria are outlined above. This illustrates the data pipeline starting with data intake to finalised data for modelling. Sources that met initial cooking fuel, household sampling, country, and time frame criteria were extracted and standardised. Each survey's set of clusters were matched to the finest geography possible. Surveys were dropped due to implausible or insufficient cooking fuel and household sampling data. All remaining data were then collapsed by survey, year, country, and geography. The collapse process filters out high-income countries, data before 1998–2000, and the absence of survey weights. Observations and survey clusters were also dropped if there was excessive (>20%) missing data in cooking fuel or survey weights as well as if geography information was not able to be matched. Usable survey reports were manually extracted at the finest aggregated level available and appended onto collapsed data, where all polygon data were then resampled to points. All surveys underwent final vetting reviews with diagnostic plots, where final exclusions took place due to implausible trends. The resulting cleaned data were used as input data ready for modelling.


Survey microdata
Extract microdata, standardize variable names and units
Match survey clusters to finest geography available
Calculate household size if using individual data instead of household data
Data cleaning criteria
Non-household level sampling (e.g. health facility data)
Household size not reported or not calculable
Cooking fuel types not reported
Non-usable cooking fuel type data
High income countries
Insufficient geography information
Data w start year prior to 1998-2000
No survey weights or survey is not self-weighted
Excessive missing data (>20%) in cooking fuel and/or survey weights
Collapse data by survey, year, country, and geography
Surveys with implausible time and/or country trends in comparison to other data sources
Append report data to collapsed data
Resample polygon data to points
Extract + geomatch data from survey report when microdata is not available
Apply final exclusions
Survey reports
Input data for model
Legend
Input
Output
Processing
Criteria to Drop Data

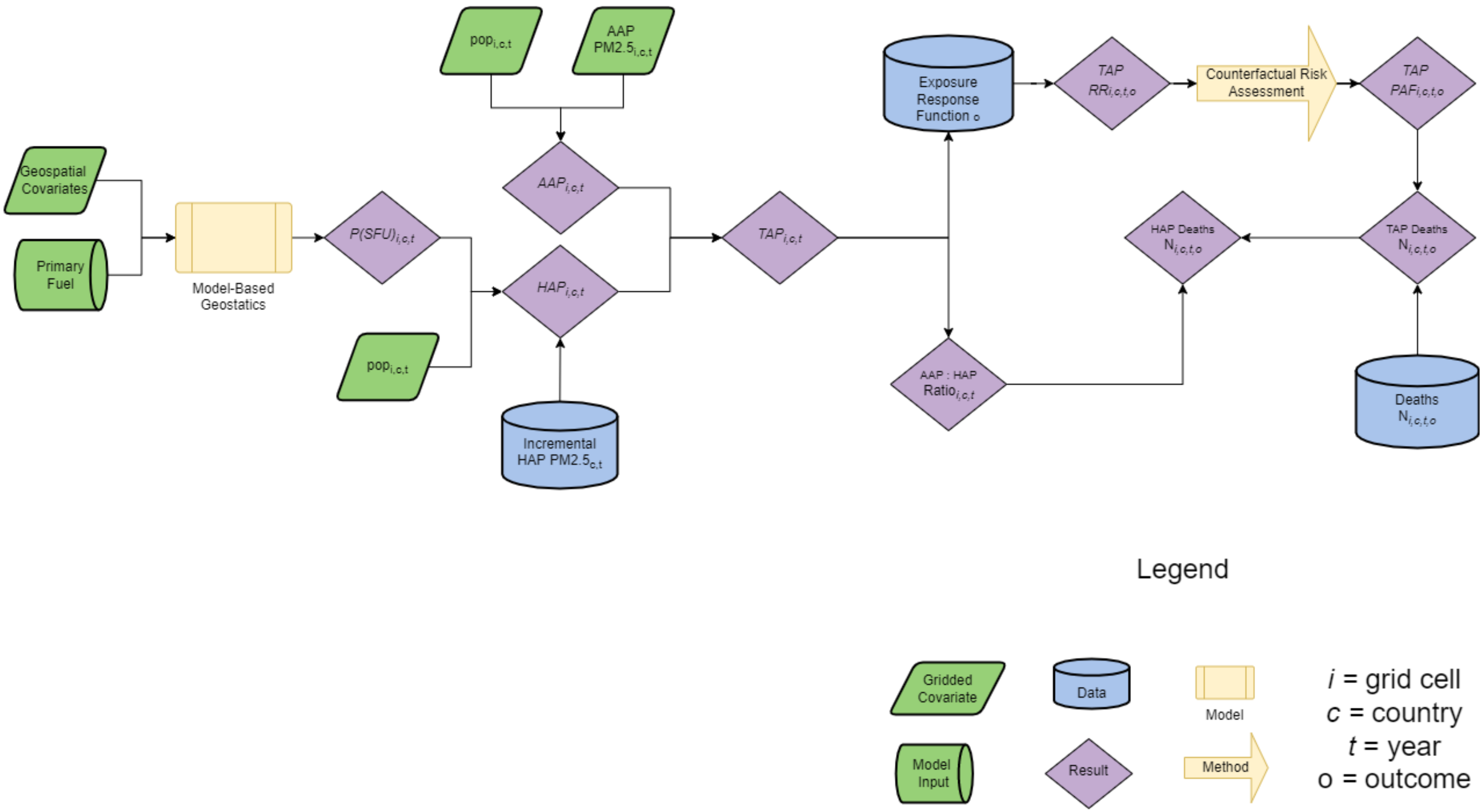
Supplementary Figure 2a: Geospatial modelling flowchart

The geospatial modelling process consists of three sections. First (in blue), all available survey data are compiled if they could be referenced to coordinates/points or polygon units from survey clusters as well as calculate the use of cooking fuel types at their respective levels. Data matched to polygons are resampled into pseudo points using a k-means clustering algorithm. Covariates are subsequently merged to the points and pseudo points via a spatial join. Second (in green), point data and their associated covariates along with a stacked generalisation ensemble model is used. The children models, boosted regression trees, generalised additive models, and elastic net regression were fit using a 5-fold cross-validation process. The cross-validated predictions from each model then serve as the covariate values for the main/parent model (spatiotemporal GPR) model. The predictions from when the child models were fit on all the data (rather than 4/5ths implied by the cross-validation) are then used to create posterior predictions of solid fuel use prevalence in a 5x5 km grid for the years 2000–2018. Finally (in orange), our estimates are aggregated to the first administrative-level units.


Geospatial Modelling: Household Air Pollution
Spatial covariates
Extract covariates to points
Point-level covariates
Stacking
Boosted regression tree model
Lasso regression model
Generalized additive model
Areal dataset
Polygon resampling
Point-level dataset
Calculating conditional datasets
Unconditional dataset
Conditional dataset
Geolocated to point or polygon
Crosswalking ambiguous cooking fuel types
Crosswalking data with missing household sizes
Classifying reported cooking fuel types to standard indicators
Household surveys and censuses
Spatio-temporal GPR model (R-INLA)
Spatio-temporal posterior predictions of conditional probabilities
Spatio-temporal posterior predictions of unconditional probabilities
Calculating unconditional prevalence for all indicators
Final 5 x 5 km2 estimates
Aggregation
Pixel maps
Admin0, Admin1, and Admin2 maps
Legend
Input data
Database
Process
Results
Pre-analysis
Modeling
Summary of results

Supplementary Figure 2b: Post-estimation flowchart

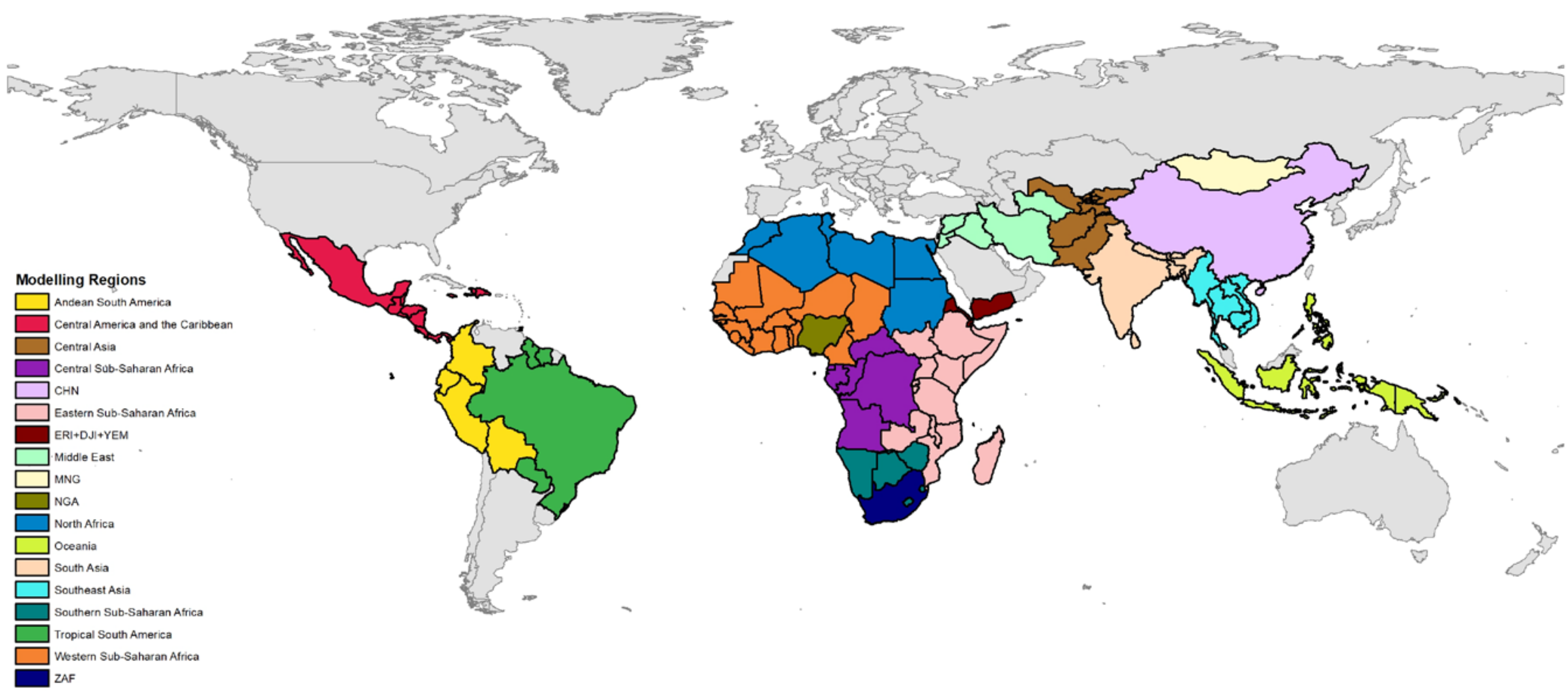
We combined the model output with geospatial estimates of ambient $PM_{2.5}$ exposure from GBD 2019[23] in order to calculate personal exposure to total $PM_{2.5}$ pollution (TAP) concentration of $PM_{2.5}$ as the sum of the AAP and HAP concentration in each 5 x 5-km grid cell i (pixel). Estimates of the expected incremental $PM_{2.5}$ concentration (see *Definitions)* generated in a household using solid fuels ($HPM_{2.5}$) for a given country (c) and year (t) from GBD 2019 were used to calculate the HAP concentration for the exposed population.[24] The per capita annual average ambient $PM_{2.5}$ estimate from GBD 2019 ($APM_{2.5}$) was summed with the HAP concentration to provide the TAP concentration. The fraction of TAP contributed by HAP in each pixel was estimated to provide the HAP share ($AAP{:}\, HAP\ ratio$). Finally, the per capita TAP concentration in each pixel was used as an input to the GBD 2019 risk (IER)[23] curve for LRI in order to estimate a relative risk (RR) and PAF for every $PM_{2.5}$-associated outcome (o) in each pixel. The PAF for LRI was combined with pixel-level estimates[25] of under-5 LRI mortality counts $\left(N_{i,c,t,o}\right)$ in order to estimate the count ($TAP\ N$) and rate of LRI deaths that were attributable to TAP and – using the estimated HAP share – HAP $\left(HAP\ Deaths\ N_{i,c,t,o}\right)$ versus AAP in each district.



Geospatial Covariates
Primary Fuel
Model-Based Geostatics
$P(SFU)_{i,c,t}$
$pop_{i,c,t}$
AAP $PM2.5_{i,c,t}$
$AAP_{i,c,t}$
$HAP_{i,c,t}$
$pop_{i,c,t}$
Incremental HAP $PM2.5_{c,t}$
$TAP_{i,c,t}$
Exposure Response Function $_o$
$TAP\ RR_{i,c,t,o}$
Counterfactual Risk Assessment
$TAP\ PAF_{i,c,t,o}$
TAP Deaths $N_{i,c,t,o}$
HAP Deaths $N_{i,c,t,o}$
AAP : HAP $Ratio_{i,c,t}$
Deaths $N_{i,c,t,o}$
Legend
Gridded Covariate
Data
Model
Model Input
Result
Method
i = grid cell
c = country
t = year
o = outcome

Supplementary Figure 3: Map of modelling regions

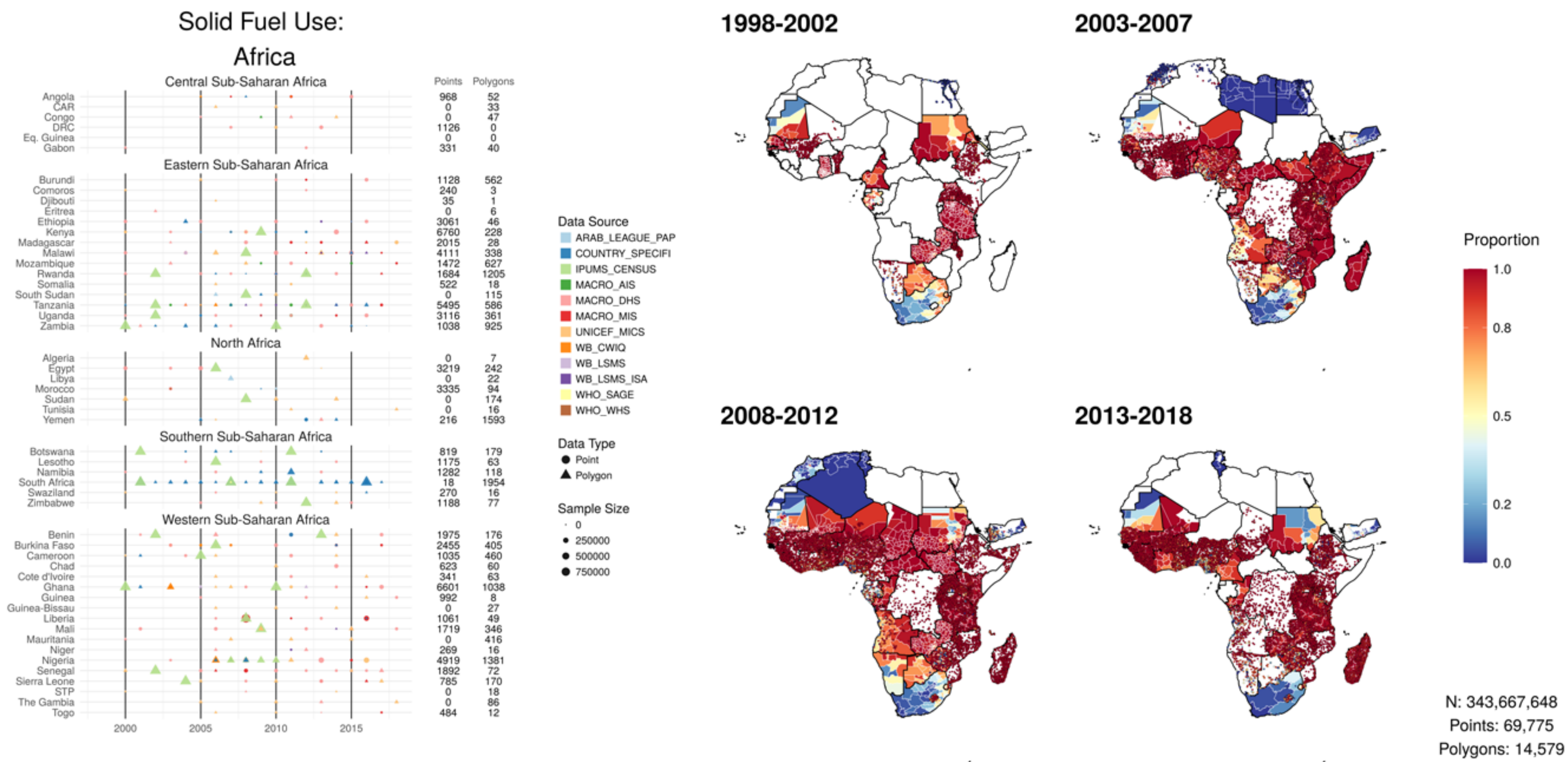
We stratified our data and analyses into 21 contiguous regions selected. Each color represents a different modelling region, where grey represents countries that we did not include in our analysis. In order of appearance in the legend, the regions are: Andean South America (yellow), Central America and the Caribbean (red), China (lavender), central sub-Saharan Africa (purple), Eritrea, Djibouti and Yemen (burgundy), eastern sub-Saharan Africa (light pink), Middle East (mint green), Mongolia (pastel yellow), north Africa (blue), Oceania (lime green), southeast Asia (turquoise), south Asia (peach), southern sub-Saharan Africa (dark teal), central Asia (brown), Tropical South America (green), western sub-Saharan Africa (orange), and South Africa (navy).



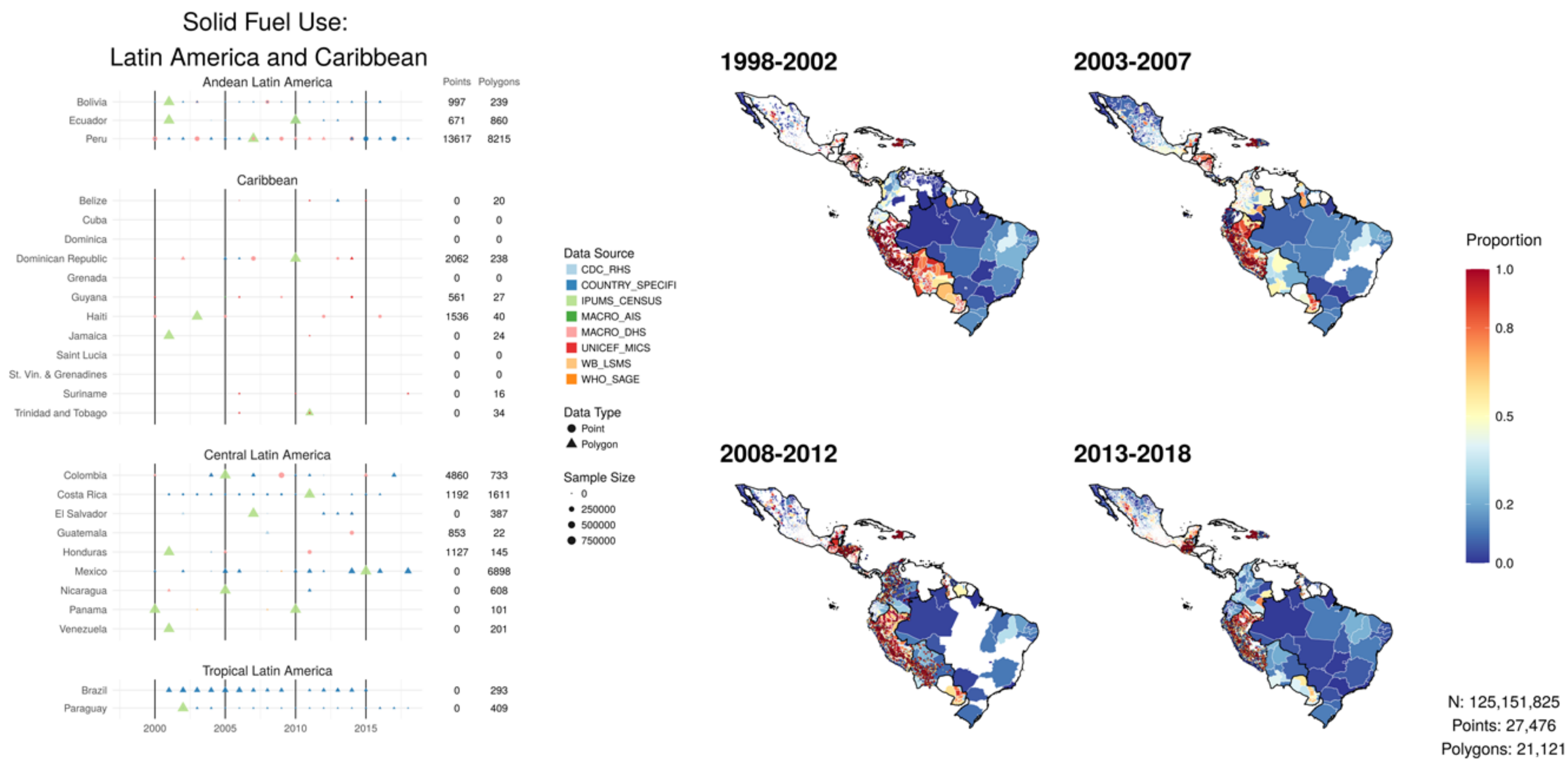
Supplementary Figure 3a-e: Solid fuel use data availability by type and country, 2000–2018

All data shown are by country and year of survey and mapped at its corresponding geopositioned coordinate or cluster area. In the left panel, the total number of points and polygons (areal) for each country are plotted by data source, data type (point coordinate or polygon area) and sample size. The sample size represents the total number of individual microdata records for each survey. In the right panel, the mean solid fuel use for the input coordinate or area is mapped. Figure **a)** displays solid fuel use data availability in Africa by type and country from 2000 to 2018. Figure **b)** displays solid fuel use data availability in Latin America and the Caribbean by type and country from 2000 to 2018. Figure **c)** displays solid fuel use data availability in Middle East and central Asia by type and country from 2000 to 2018. Figure **d)** displays solid fuel use data availability in southeast Asia by type and country from 2000 to 2018. Figure **e)** displays solid fuel use data availability in south Asia by type and country from 2000 to 2018.

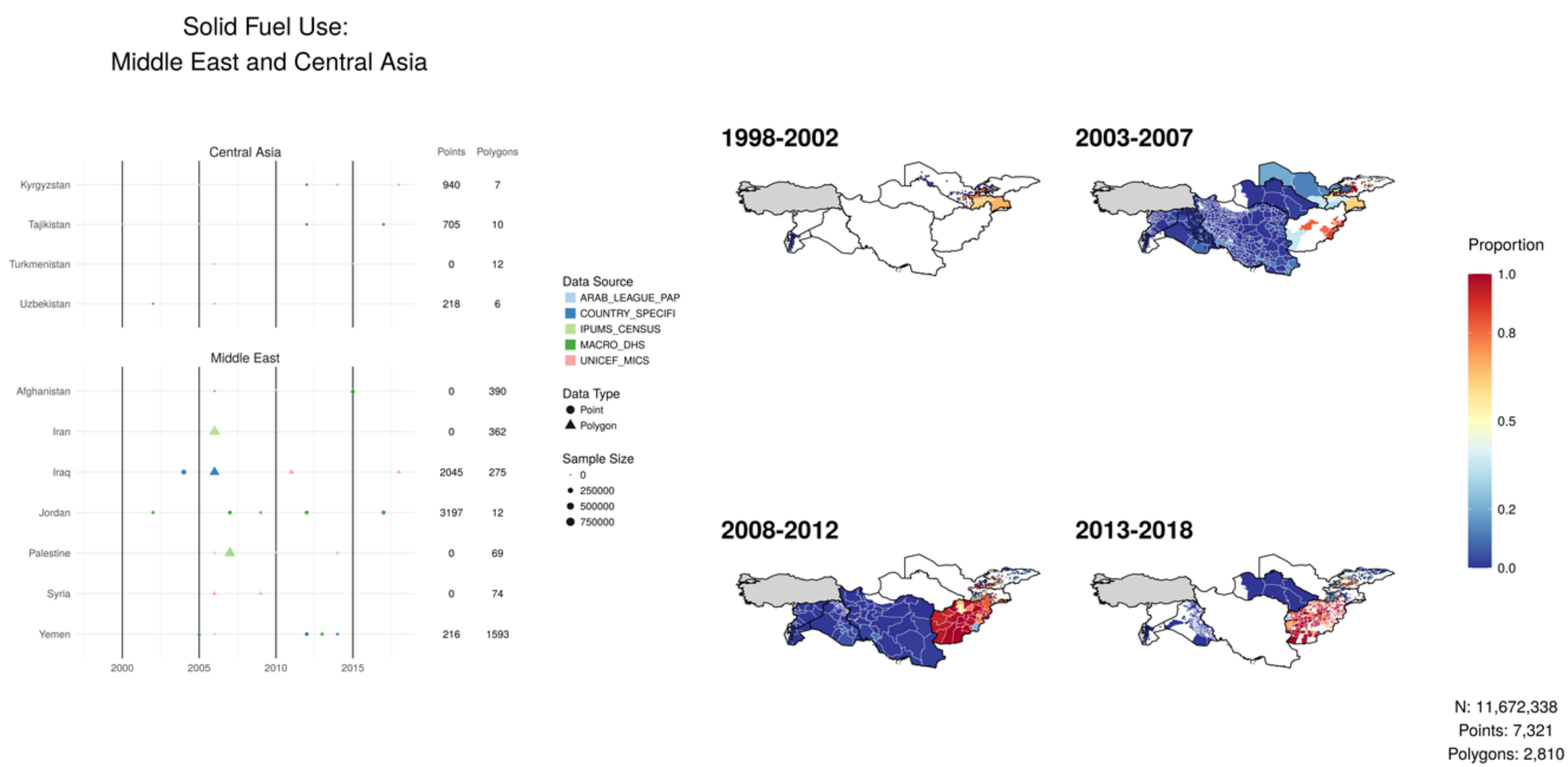
a)



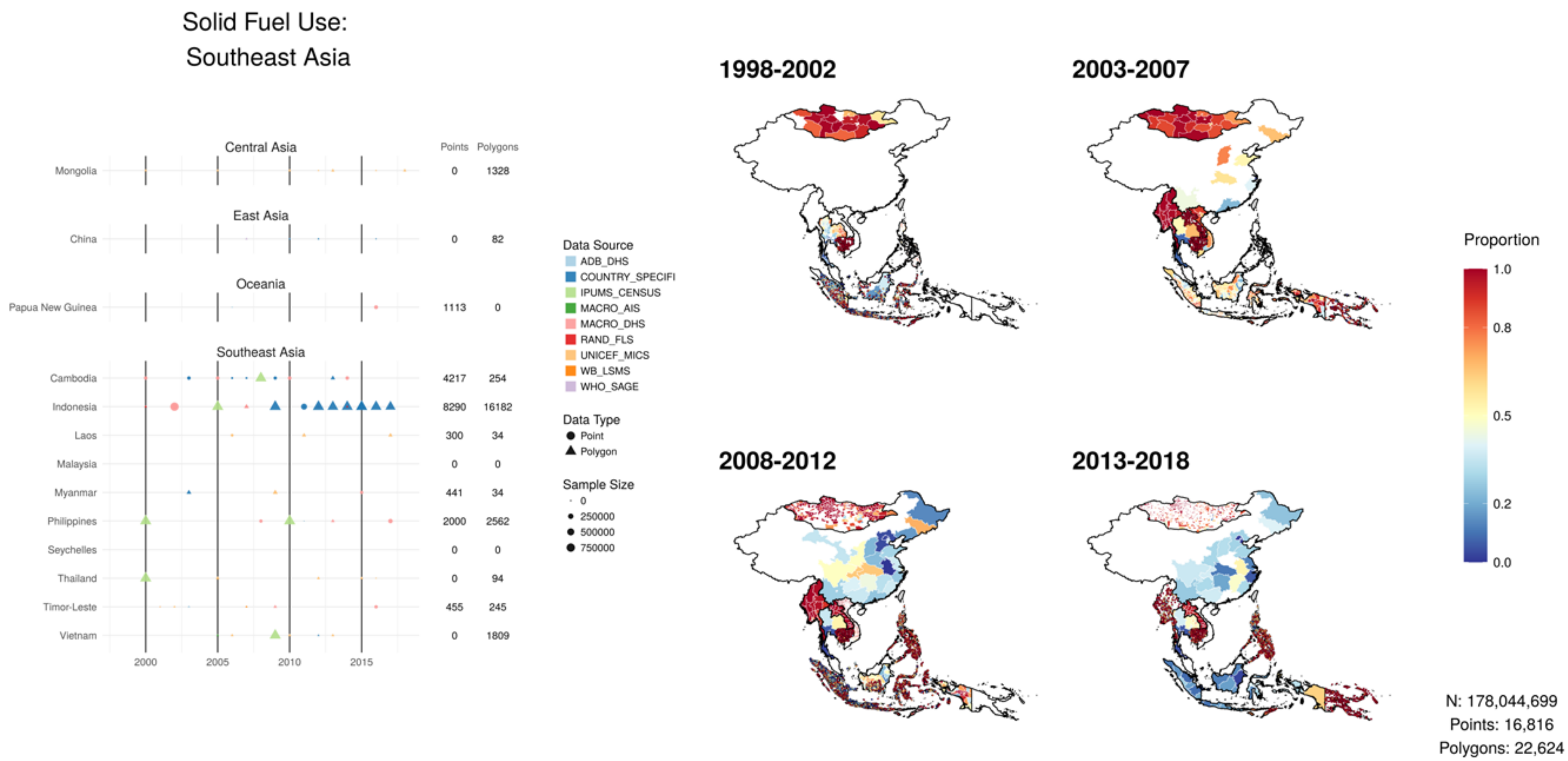
b)


Solid Fuel Use:
Latin America and Caribbean
Andean Latin America
Points
Polygons
Bolivia 997 239
Ecuador 671 860
Peru 13617 8215
Caribbean
Belize 0 20
Cuba 0 0
Dominica 0 0
Dominican Republic 2062 238
Grenada 0 0
Guyana 561 27
Haiti 1536 40
Jamaica 0 24
Saint Lucia 0 0
St. Vin. & Grenadines 0 0
Suriname 0 16
Trinidad and Tobago 0 34
Central Latin America
Colombia 4860 733
Costa Rica 1192 1611
El Salvador 0 387
Guatemala 853 22
Honduras 1127 145
Mexico 0 6898
Nicaragua 0 608
Panama 0 101
Venezuela 0 201
Tropical Latin America
Brazil 0 293
Paraguay 0 409
2000
2005
2010
2015
Data Source
CDC_RHS
COUNTRY_SPECIFI
IPUMS_CENSUS
MACRO_AIS
MACRO_DHS
UNICEF_MICS
WB_LSMS
WHO_SAGE
Data Type
Point
Polygon
Sample Size
0
250000
500000
750000
1998-2002
2003-2007
2008-2012
2013-2018
Proportion
1.0
0.8
0.5
0.2
0.0
N: 125,151,825
Points: 27,476
Polygons: 21,121

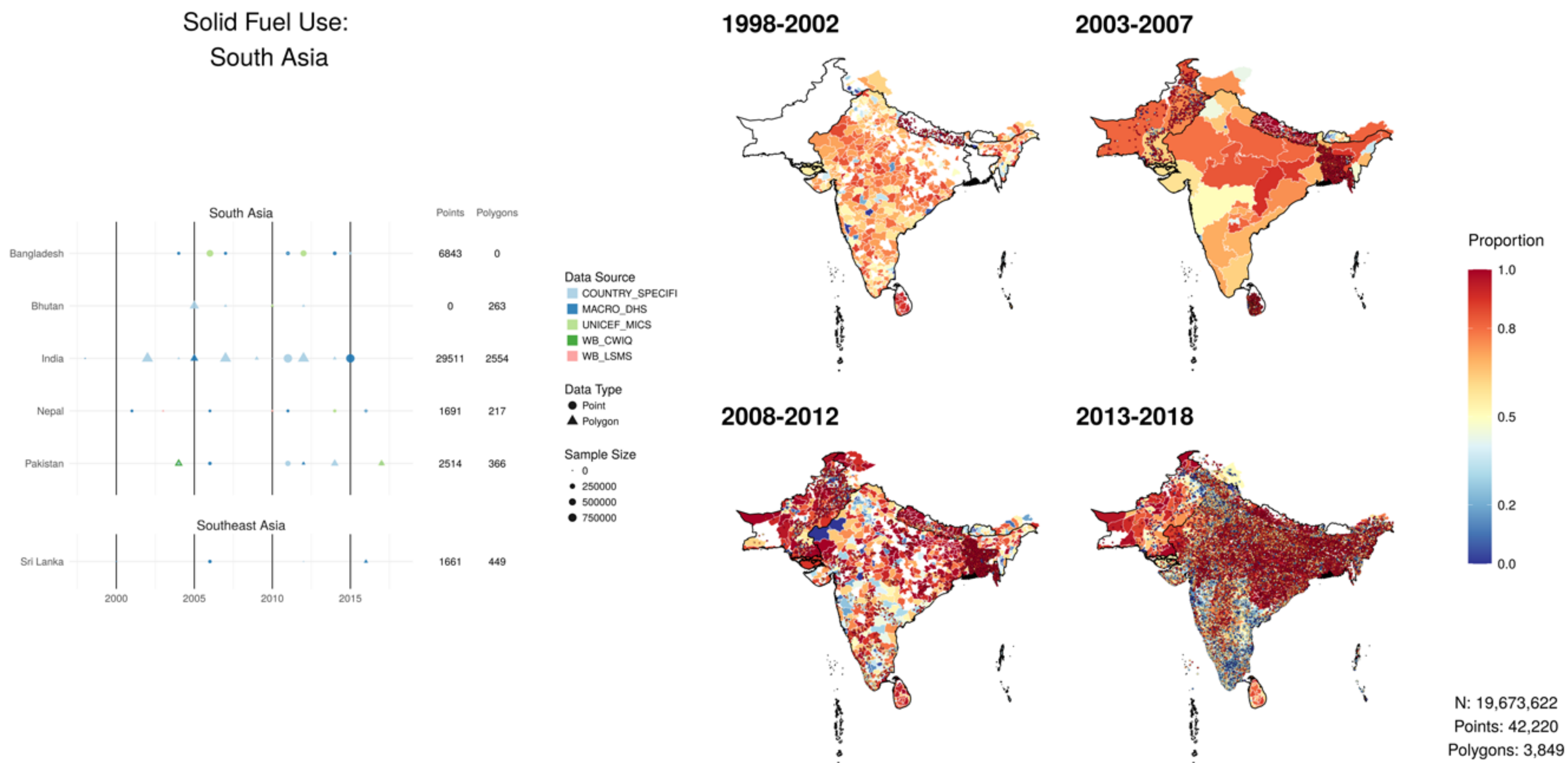
c)


Solid Fuel Use:
Middle East and Central Asia
Central Asia
Points
Polygons
Kyrgyzstan 940 7
Tajikistan 705 10
Turkmenistan 0 12
Uzbekistan 218 6
Middle East
Afghanistan 0 390
Iran 0 362
Iraq 2045 275
Jordan 3197 12
Palestine 0 69
Syria 0 74
Yemen 216 1593
2000
2005
2010
2015
Data Source
ARAB_LEAGUE_PAP
COUNTRY_SPECIFI
IPUMS_CENSUS
MACRO_DHS
UNICEF_MICS
Data Type
Point
Polygon
Sample Size
0
250000
500000
750000
1998-2002
2003-2007
2008-2012
2013-2018
Proportion
1.0
0.8
0.5
0.2
0.0
N: 11,672,338
Points: 7,321
Polygons: 2,810

d)


Solid Fuel Use:
Southeast Asia
Central Asia
East Asia
Oceania
Southeast Asia
Points
Polygons
Mongolia 0 1328
China 0 82
Papua New Guinea 1113 0
Cambodia 4217 254
Indonesia 8290 16182
Laos 300 34
Malaysia 0 0
Myanmar 441 34
Philippines 2000 2562
Seychelles 0 0
Thailand 0 94
Timor-Leste 455 245
Vietnam 0 1809
2000
2005
2010
2015
Data Source
ADB_DHS
COUNTRY_SPECIFI
IPUMS_CENSUS
MACRO_AIS
MACRO_DHS
RAND_FLS
UNICEF_MICS
WB_LSMS
WHO_SAGE
Data Type
Point
Polygon
Sample Size
0
250000
500000
750000
1998-2002
2003-2007
2008-2012
2013-2018
Proportion
1.0
0.8
0.5
0.2
0.0
N: 178,044,699
Points: 16,816
Polygons: 22,624

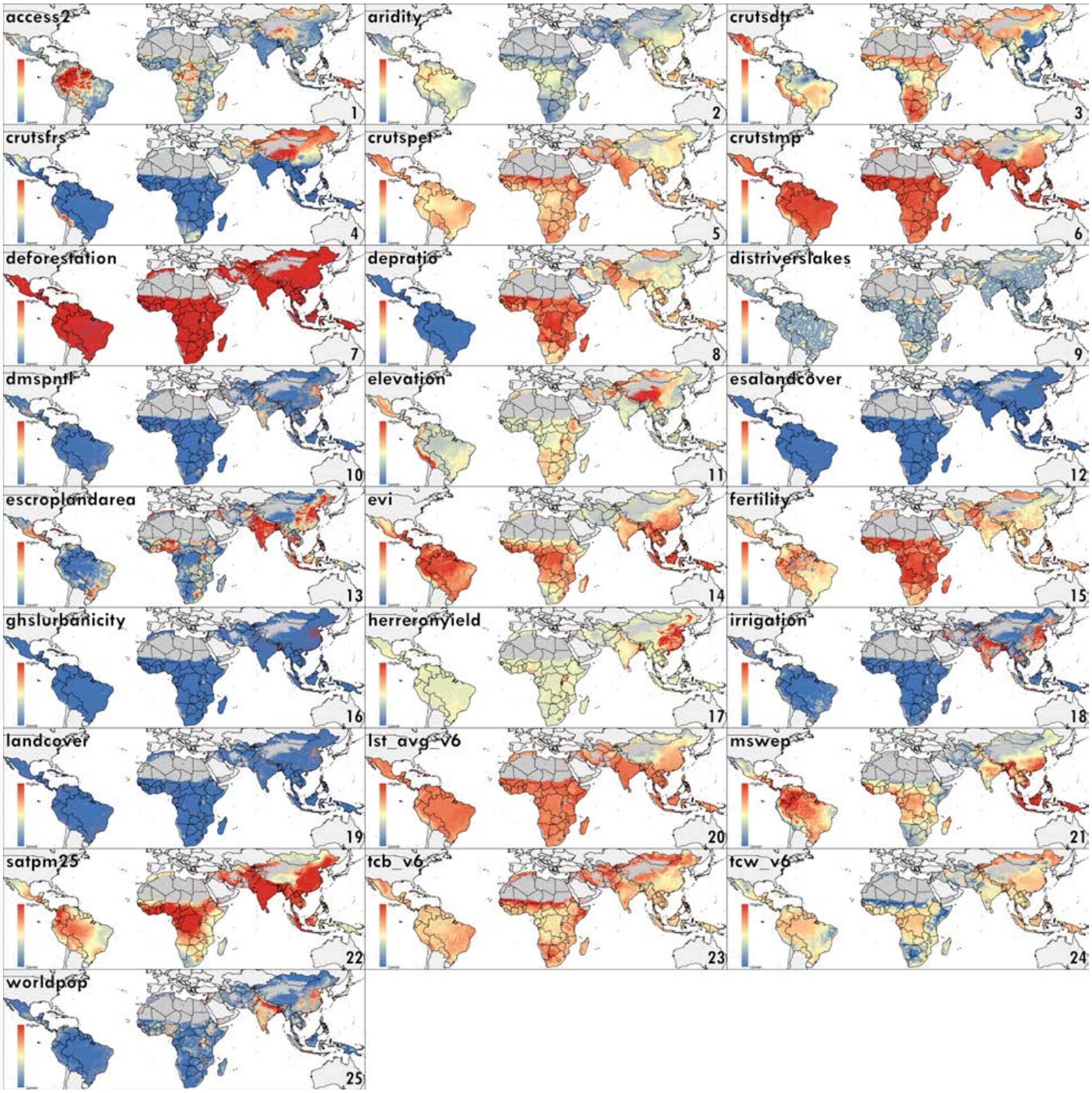
e)



Solid Fuel Use:
South Asia
South Asia
Points
Polygons
Bangladesh
6843
0
Bhutan
0
263
India
29511
2554
Nepal
1691
217
Pakistan
2514
366
Southeast Asia
Sri Lanka
1661
449
2000
2005
2010
2015
Data Source
COUNTRY_SPECIFI
MACRO_DHS
UNICEF_MICS
WB_CWIQ
WB_LSMS
Data Type
Point
Polygon
Sample Size
0
250000
500000
750000
1998-2002
2003-2007
2008-2012
2013-2018
Proportion
1.0
0.8
0.5
0.2
0.0
N: 19,673,622
Points: 42,220
Polygons: 3,849

Supplementary Figure 5: Geospatial covariates

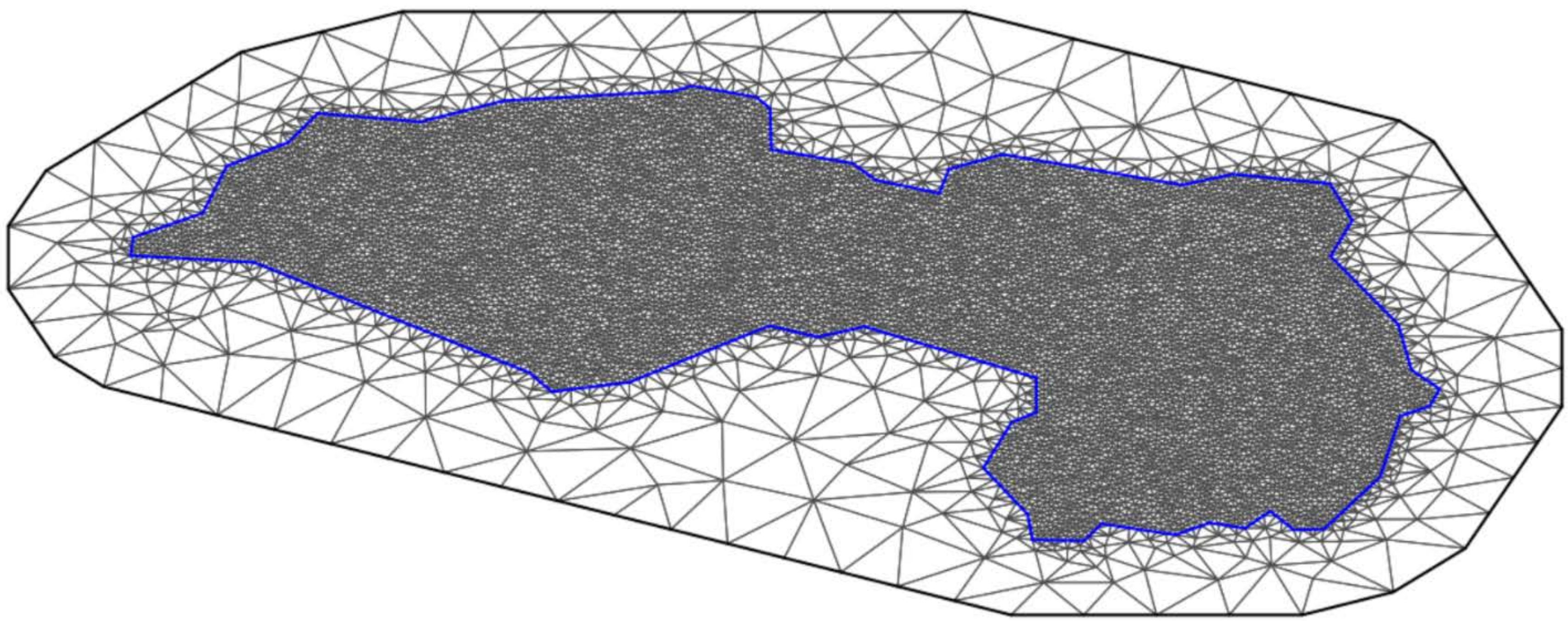
23 covariate raster layers of possible socioeconomic and environmental correlates of solid fuel use were used as inputs for the stacking modelling process. Time-varying covariates are presented for the year 2018. For the year of production of non-time-varying covariates and additional details, please refer to the individual covariate citation in Supplementary Table 4 for additional details. These maps reflect administrative boundaries, land cover, lakes, and population. Pixels with fewer than ten people per 1x1 km grid cell and classified as "barren" or "sparsely vegetated" are colored in grey. Covariates are labeled as follows: travel time to nearest settlement [*access2*], aridity [*aridity*], diurnal temperature range [*crutsdtr*], frost day frequency [*crutsfrs*], potential evapotranspiration [*crutspet*], average daily mean temperature [*crutstmp*], dependency ratio of dependents to working-age adults [*depratio*], distance from rivers or lakes ≥ 50 km^2 [*distriverslakes*], nighttime lights [*dmspntl*], elevation [*elevation*], agricultural land [*escroplandarea*], enhanced vegetation index [*evi*], fertility [*fertility*], urban or rural [*ghslurbanicity*], nutrient yield [*herreronyield*], irrigation [*irrigation*], urban proportion of location [*landcover*], average land surface temperature [*lst_avg_v6*], precipitation [*mswep*], normalised difference vegetation index [*nexndvi*], tassled cap brightness [*tcb_v6*], tassled cap wetness [*tcw_v6*], and population [*worldpop*].


access2
1
aridity
2
crutsdtr
3
crutsfrs
4
crutspet
5
crutstmp
6
deforestation
7
depratio
8
distriverslakes
9
dmspntl
10
elevation
11
esalandcover
12
escroplandarea
13
evi
14
fertility
15
ghslurbanicity
16
herreronyield
17
irrigation
18
landcover
19
lst_avg_v6
20
mswep
21
satpm25
22
tcb_v6
23
tcw_v6
24
worldpop
25

Supplementary Figure 5: Finite elements mesh

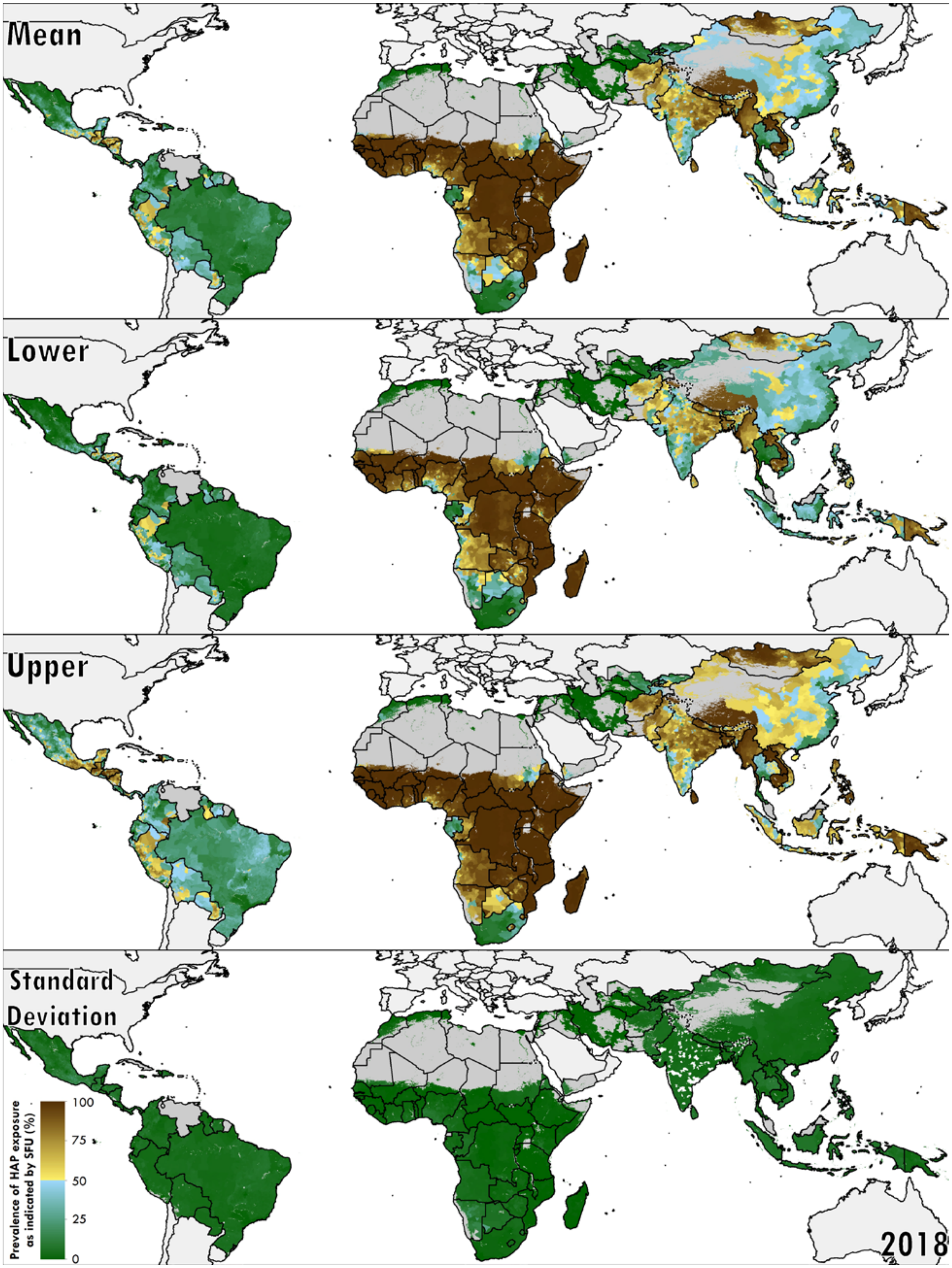
The finite elements mesh used to fit the space-time correlated error for the north Africa (NOAF) region overlaid on the countries in NOAF. Both the fine-scale mesh over land in the modelling region as well as the coarser buffer region mesh are shown. The simplified region polygon used to determine the boundary for the modelling region is shown in blue.

Finite elements mesh over north Africa



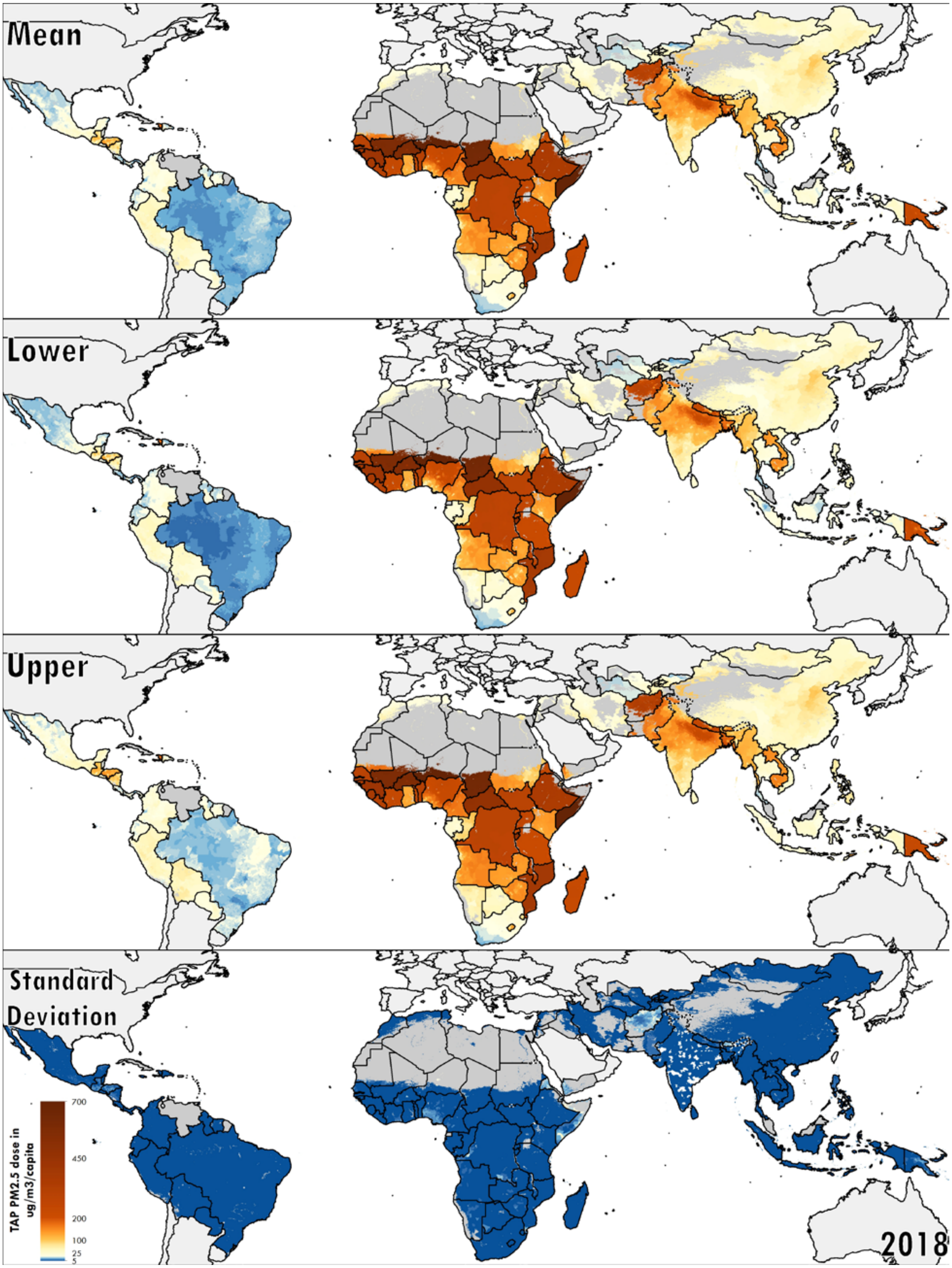
Supplementary Figure 6: Posterior means and 95% uncertainty intervals for solid fuel use prevalence at the second administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the second administrative level for solid fuel use prevalence. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.


Mean
Lower
Upper
Standard Deviation
Prevalence of HAP exposure as indicated by SFU (%)
100
75
50
25
0
2018

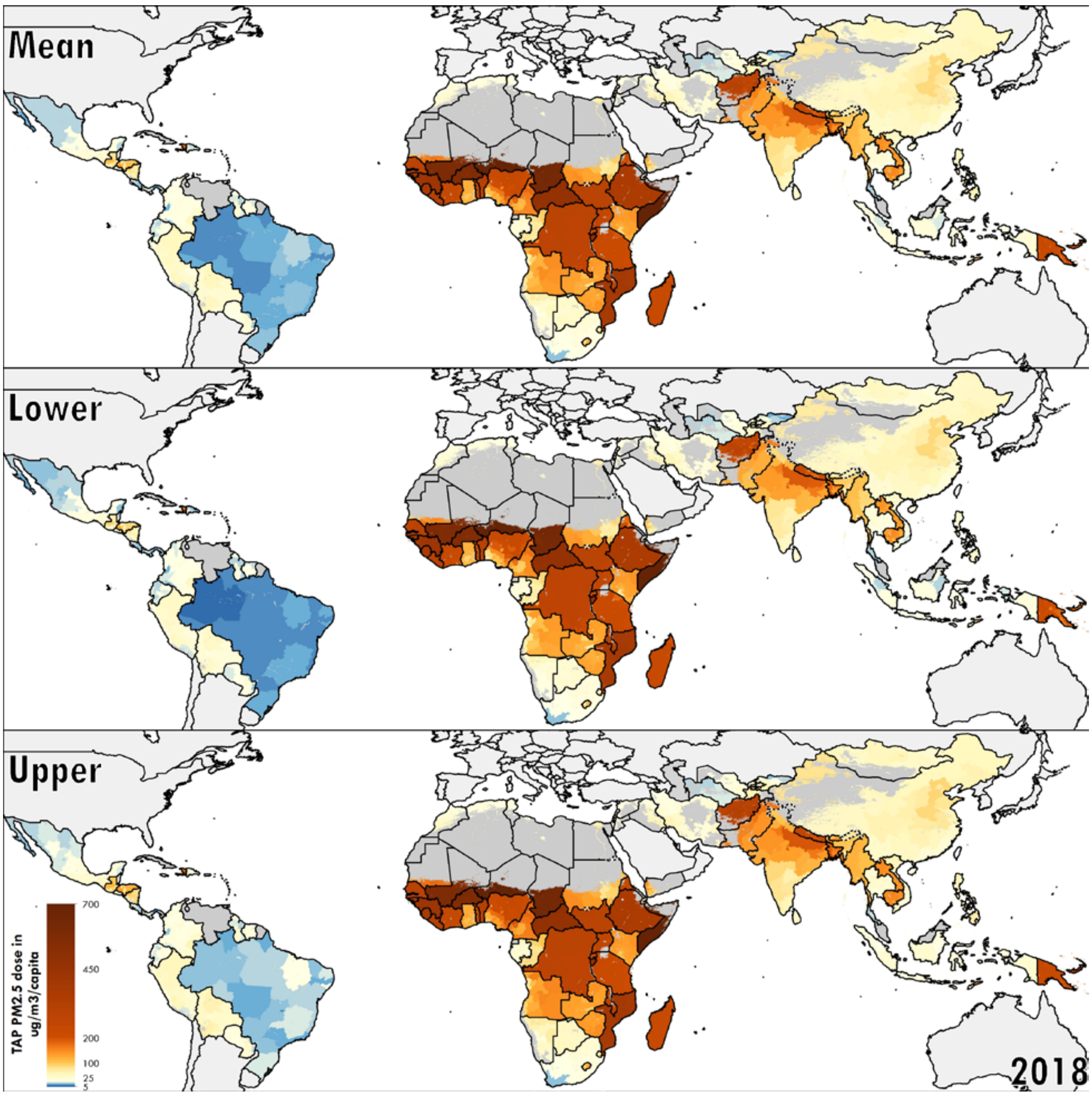
Supplementary Figure 7: Posterior means and 95% uncertainty intervals for TAP dose at the second administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the second administrative level for TAP dose. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.


Mean
Lower
Upper
Standard Deviation
TAP PM2.5 dose in ug/m3/capita
700
450
200
100
25
5
2018

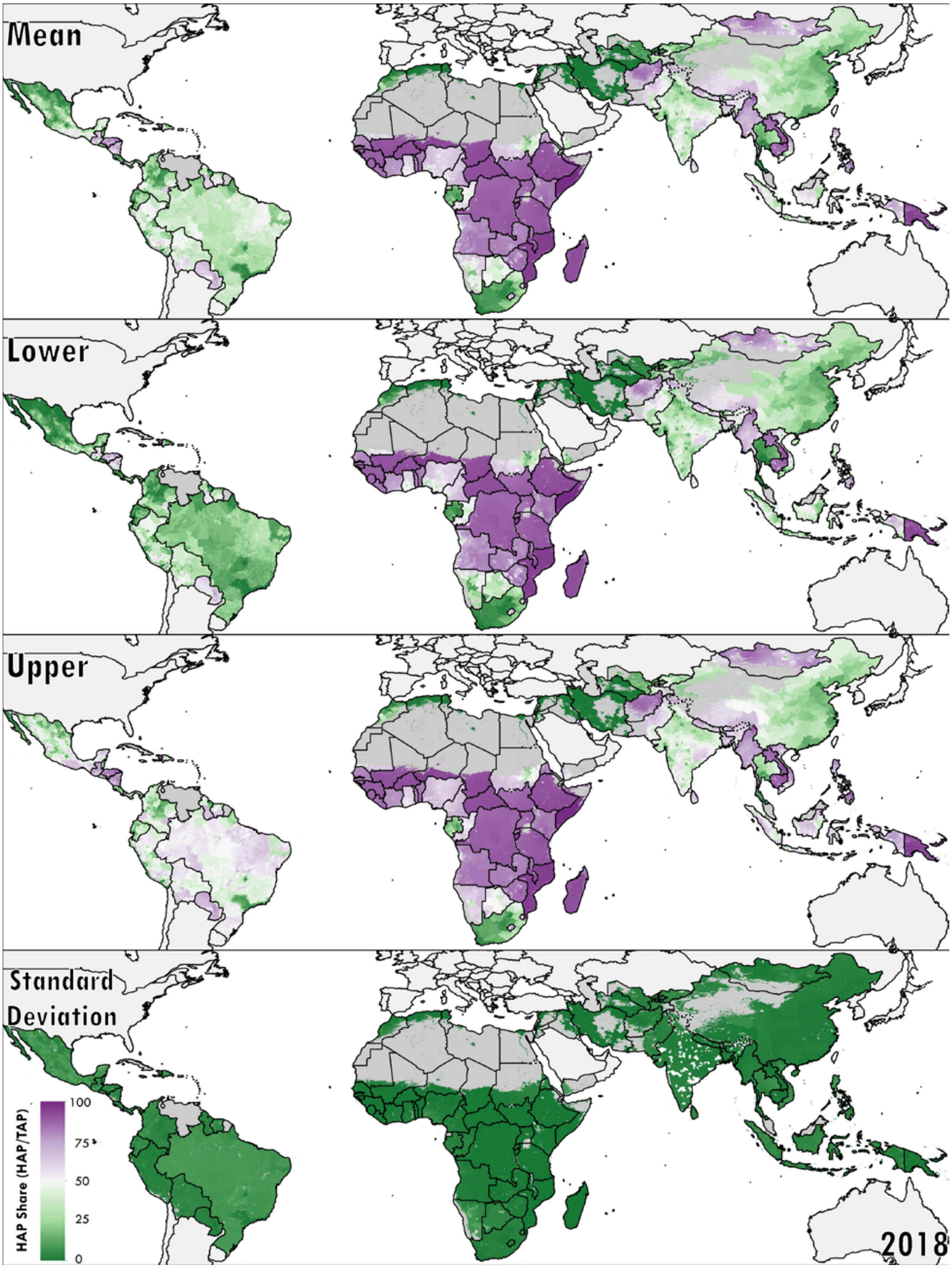
Supplementary Figure 8: Posterior means and 95% uncertainty intervals for TAP dose at the first administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the first administrative level for TAP dose. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Supplementary Figure 9: Posterior means and 95% uncertainty intervals for HAP share at the second administrative level, 2018

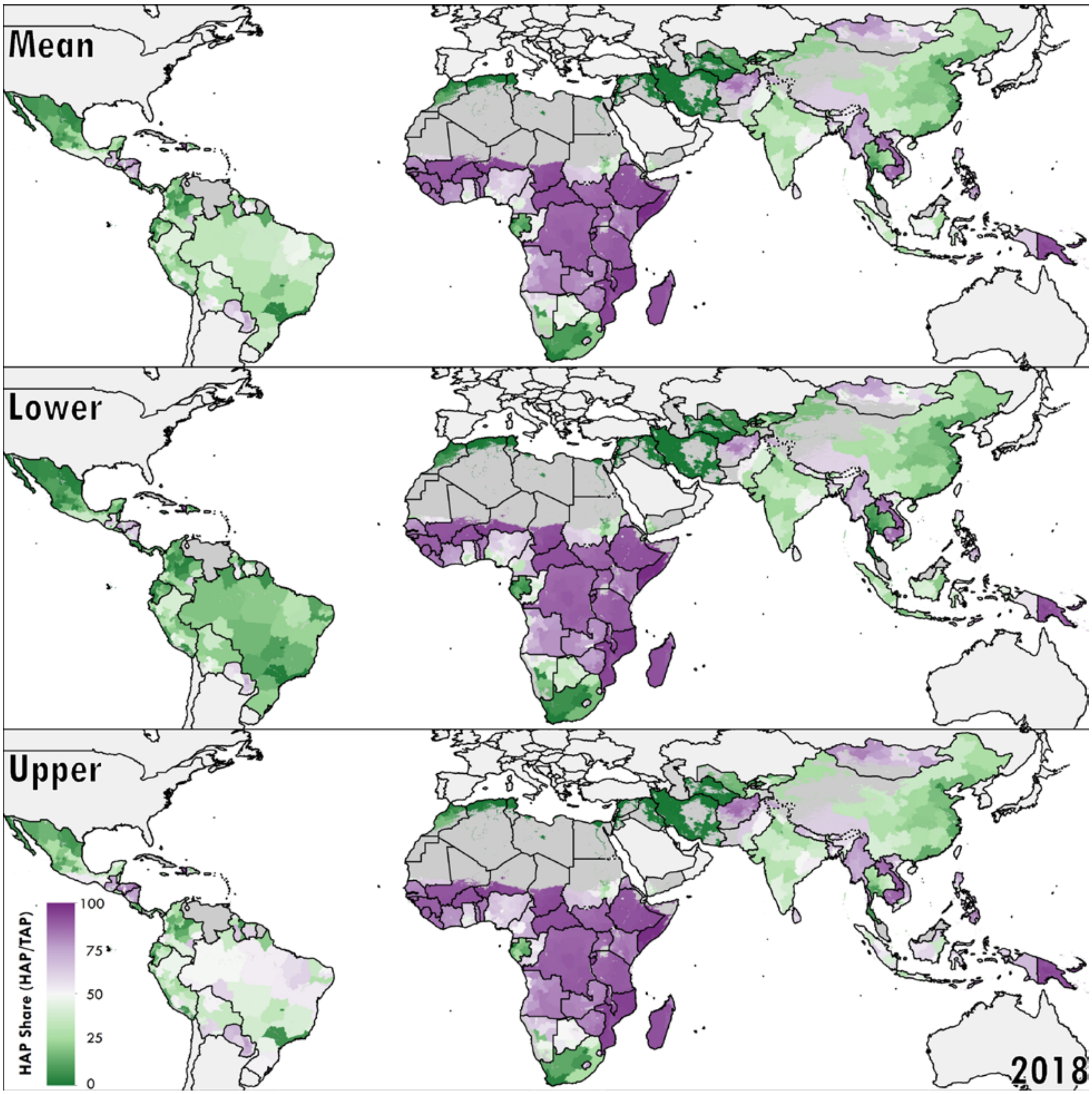
95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the second administrative level for HAP ratio. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Mean
Lower
Upper
Standard Deviation
HAP Share (HAP/TAP)
100
75
50
25
0
2018

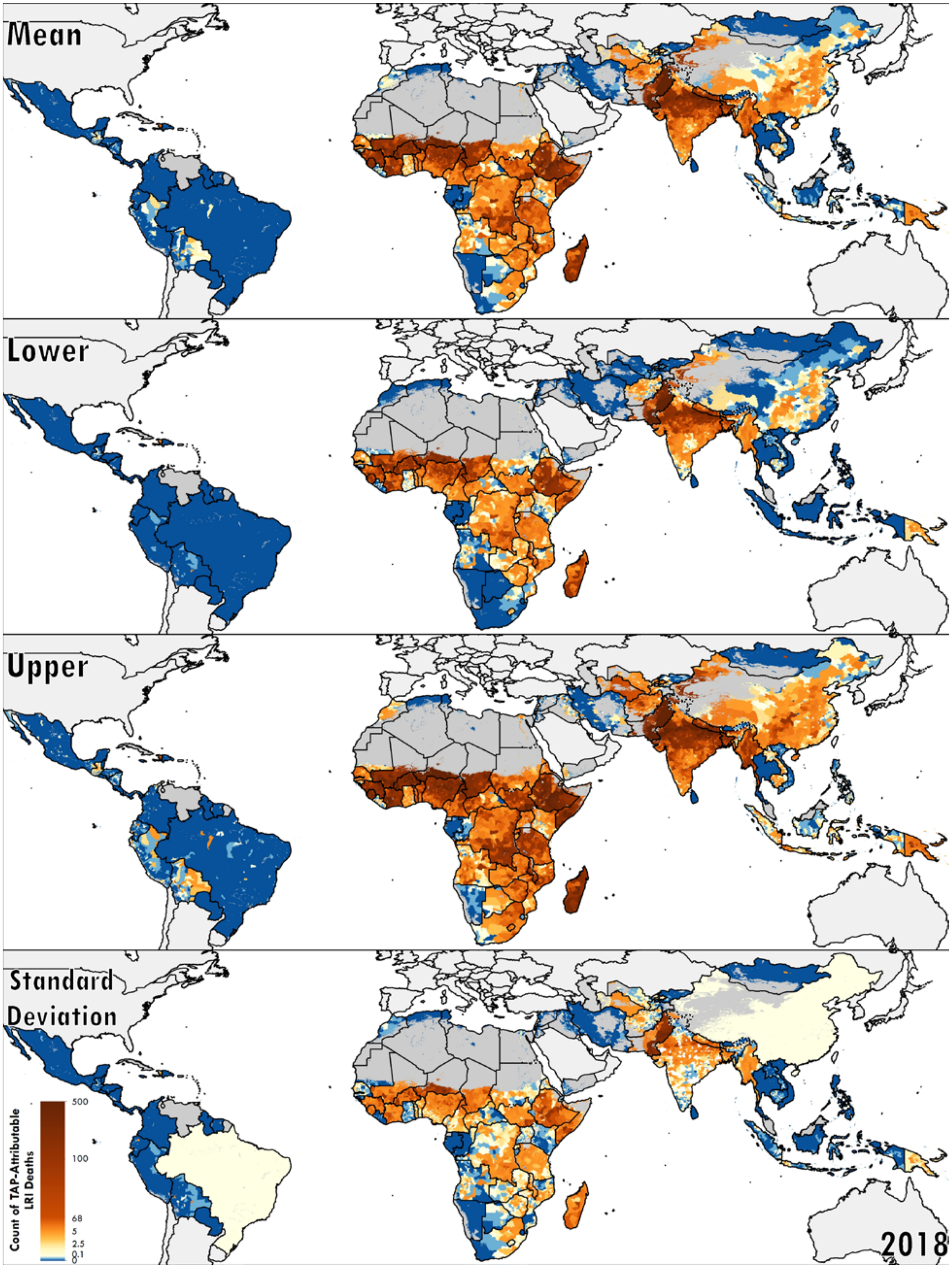
Supplementary Figure 10: Posterior means and 95% uncertainty intervals for HAP share at the first administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the first administrative level for HAP ratio. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as "barren or sparsely vegetated" and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Supplementary Figure 11: Posterior means and 95% uncertainty intervals for LRI mortality counts due to TAP at the second administrative level, 2018

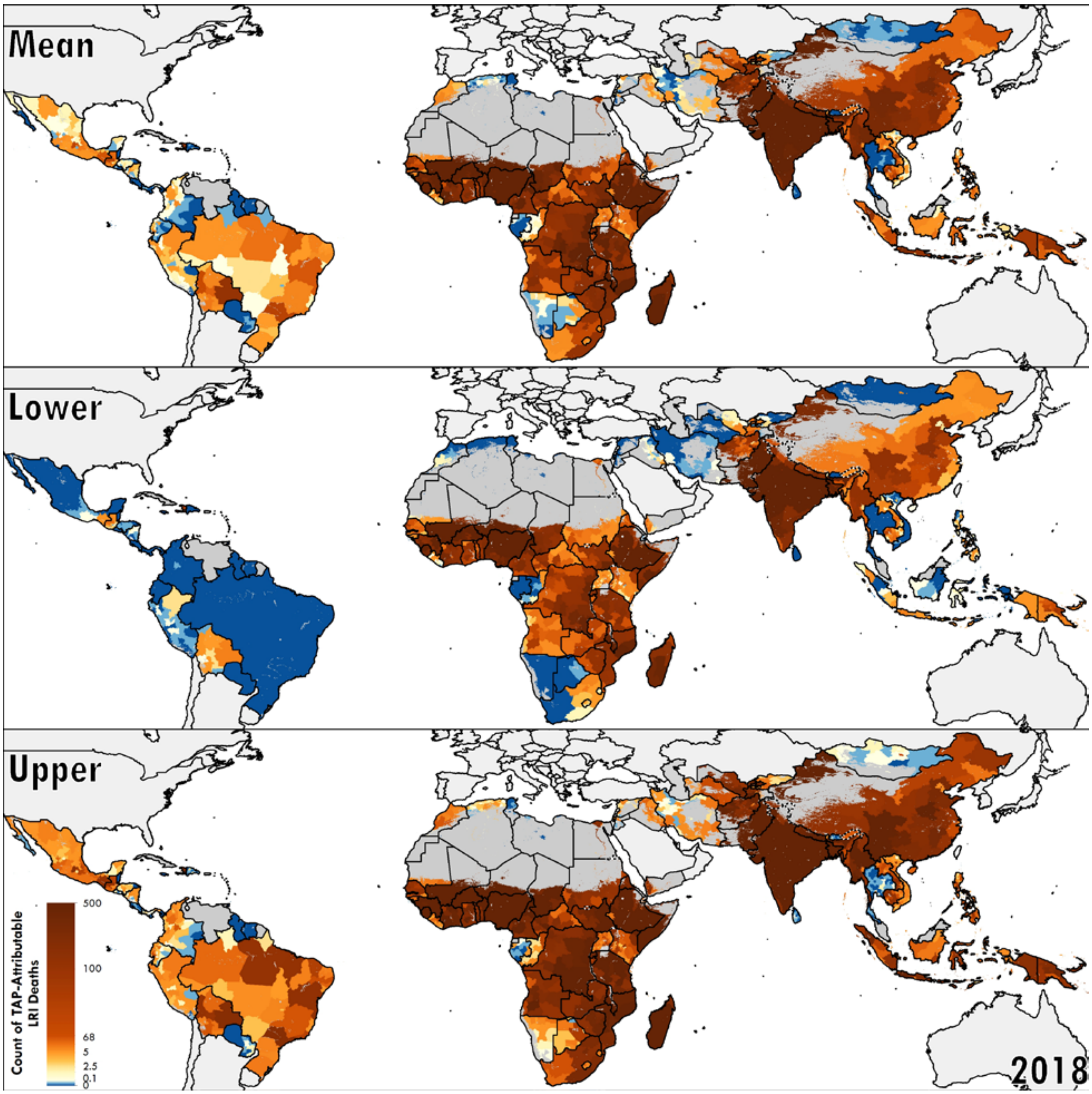
95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the second administrative level for LRI mortality counts due to TAP. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Mean
Lower
Upper
Standard Deviation
Count of TAP-Attributable LRI Deaths
500
100
68
5
2.5
0.1
0
2018

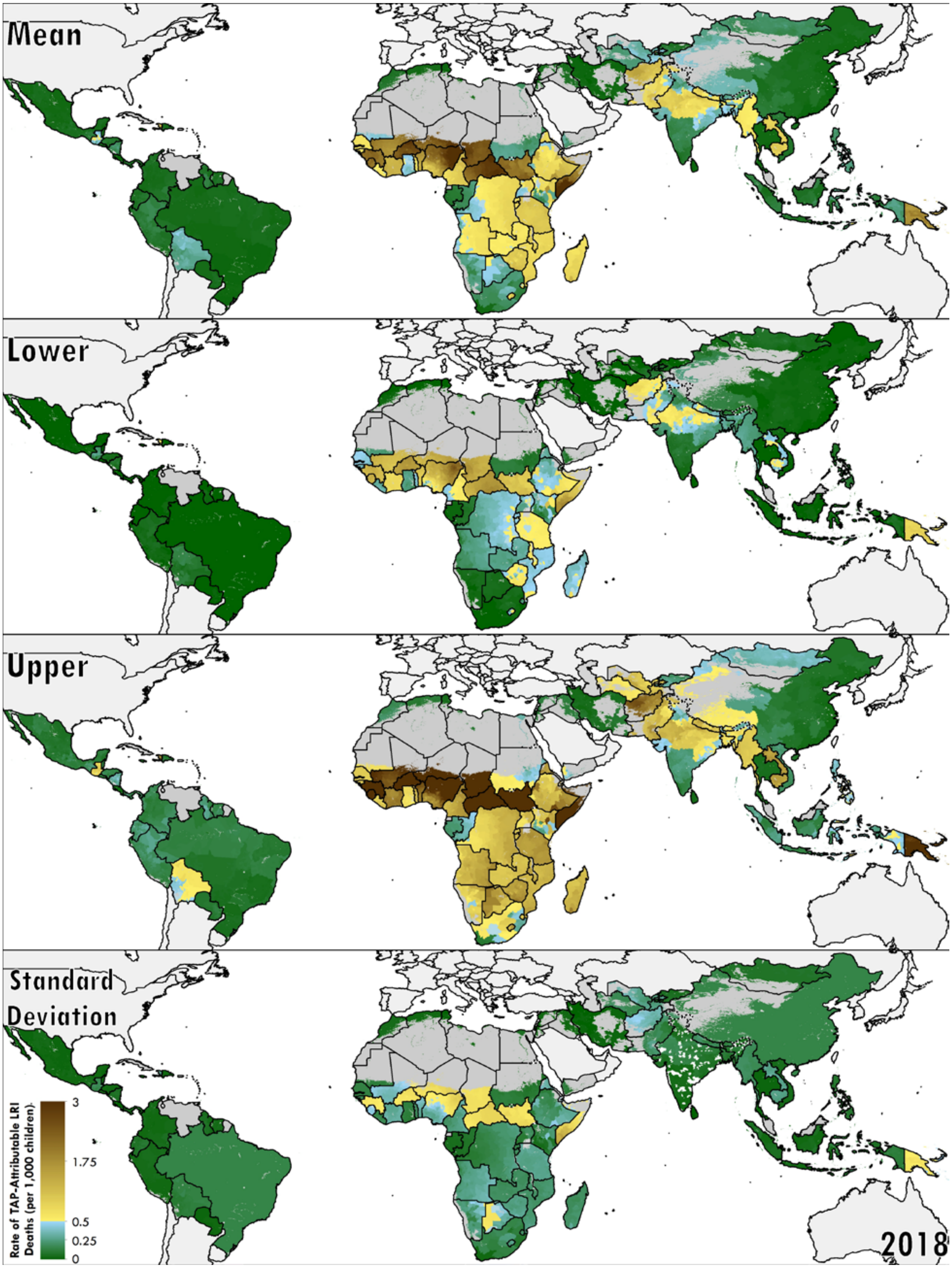
Supplementary Figure 12: Posterior means and 95% uncertainty intervals for LRI mortality counts due to TAP at the first administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the first administrative level for LRI mortality counts due to TAP. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Supplementary Figure 13: Posterior means and 95% uncertainty intervals for LRI mortality rates due to TAP at the second administrative level, 2018

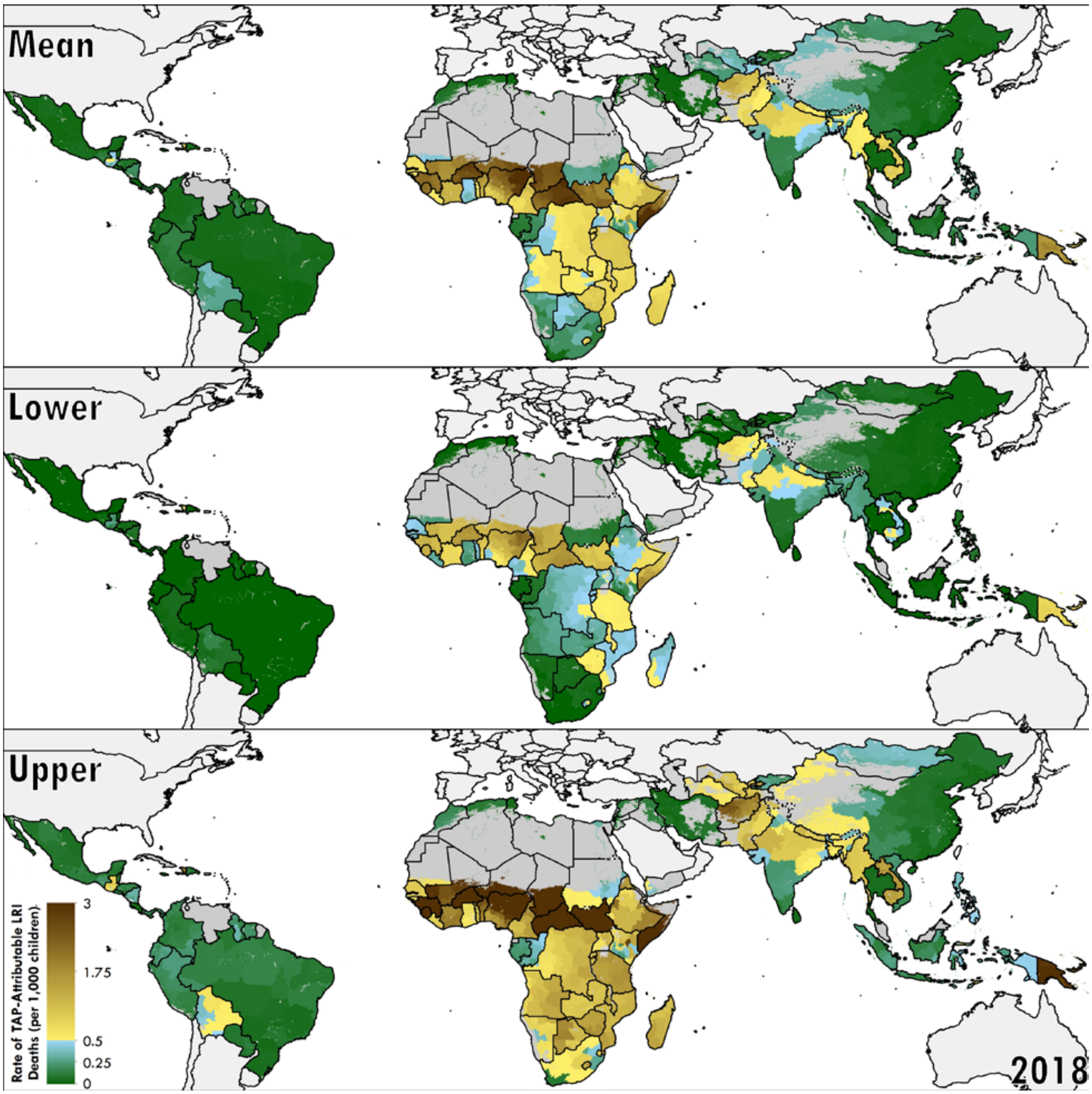
95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the second administrative level for LRI mortality rates due to TAP. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Mean
Lower
Upper
Standard Deviation
Rate of TAP-Attributable LRI Deaths (per 1,000 children)
3
1.75
0.5
0.25
0
2018

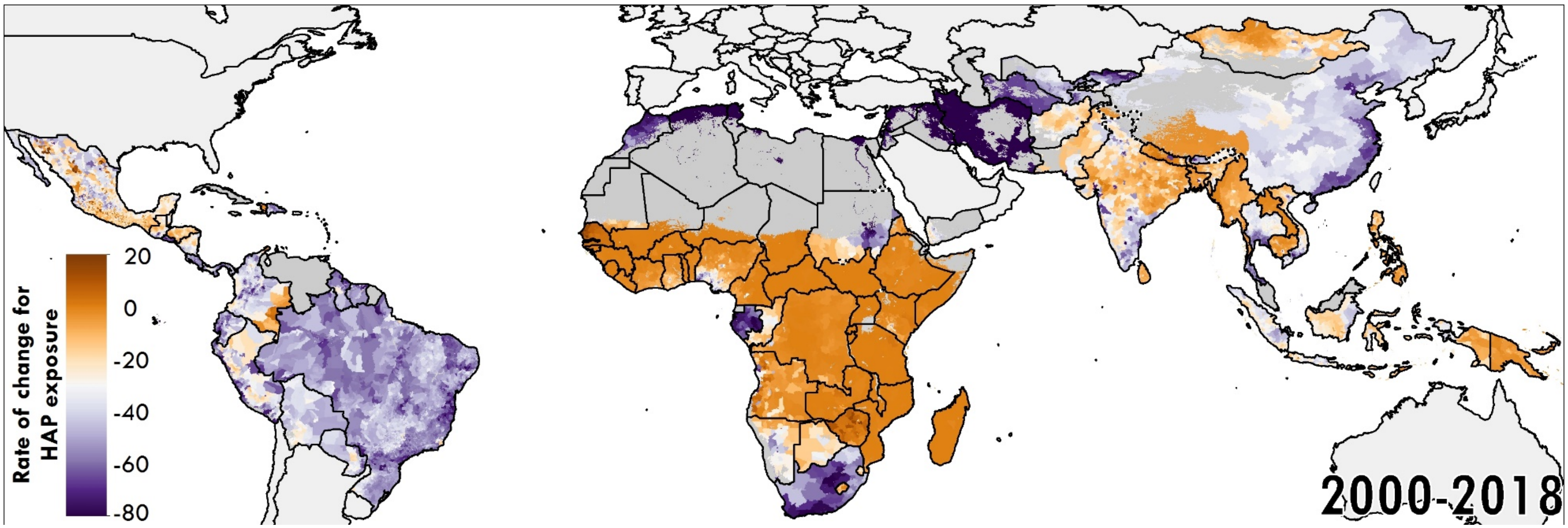
Supplementary Figure 14: Posterior means and 95% uncertainty intervals for LRI mortality rates due to TAP at the first administrative level, 2018

95% uncertainty intervals were calculated as the difference between the 97.5th percentile and the 2.5th percentile of 1000 draws from the posterior distribution. This map presents uncertainty at the first administrative level for LRI mortality rates due to TAP. Maps reflect administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as “barren or sparsely vegetated” and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



Supplementary Figure 15: HAP percentage change, 2000–2018, at the second administrative level

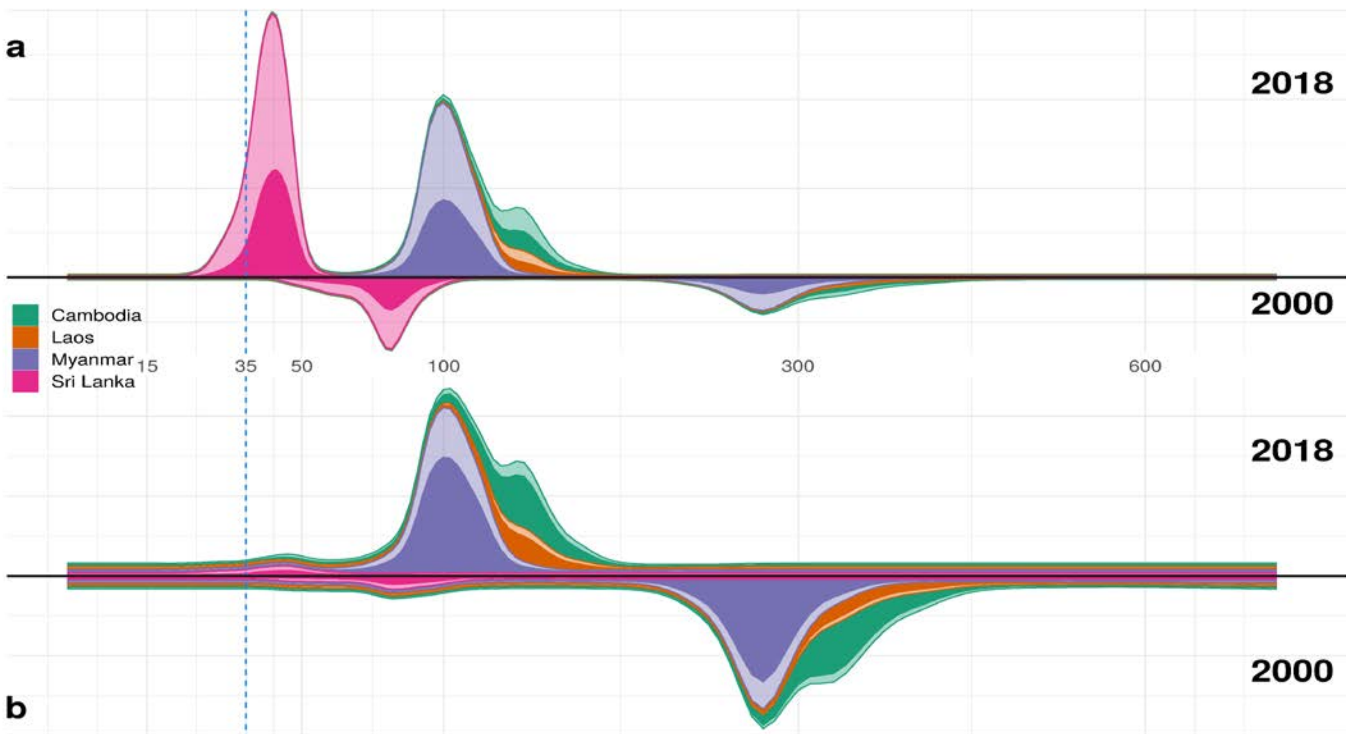
Estimated percentage decrease in household air pollution from 2000 to 2018. Maps display the rates aggregated up to the second administrative level using population weighting and reflects administrative boundaries, land cover, lakes, and population; grey-coloured grid cells were classified as "barren or sparsely vegetated" and had fewer than ten people per 1x1km grid cell, or were not included in these analyses.



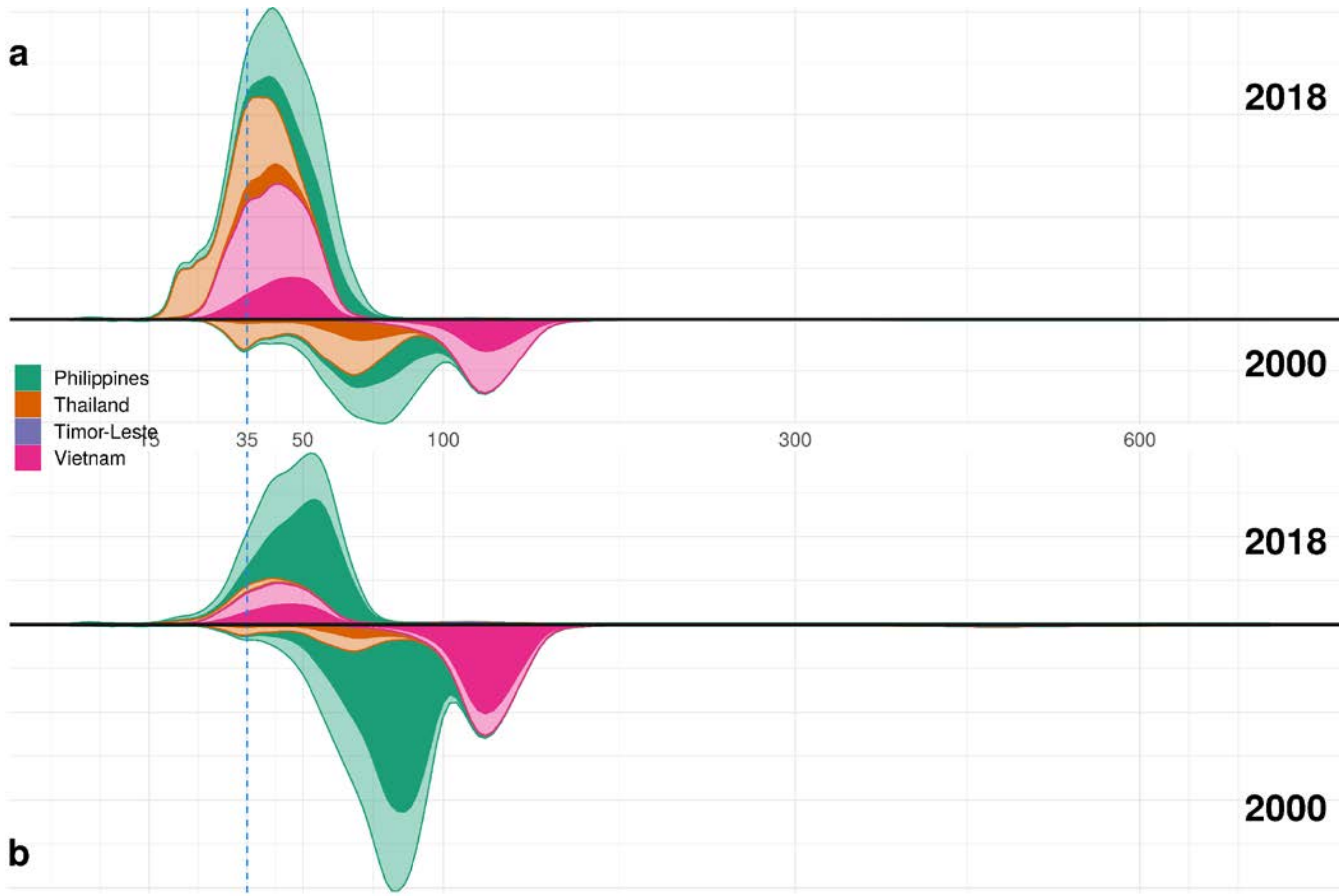
Supplementary Figure 17a-u: Population and attributable under-5 LRI mortalities, distributed as a function of PM2.5 by region.

Population (a) and under-5 LRI mortality attributable to total PM2.5 (b) for the year 2018, plotted a function of total PM2.5 concentrations. The mirror image reflects the distribution for the year 2000. The distributions are colored bycountry. Within each distribution, the dark shading represents the portion contributed by household sources, while the lighter shading indicates the portion contributed by ambient sources. The plotted data represent local smoothing of normalized distributions that were computed over 400 logarithmically spaced bins. The dashed vertical line indicates WHO's interim threshold of 35 ug/m3.

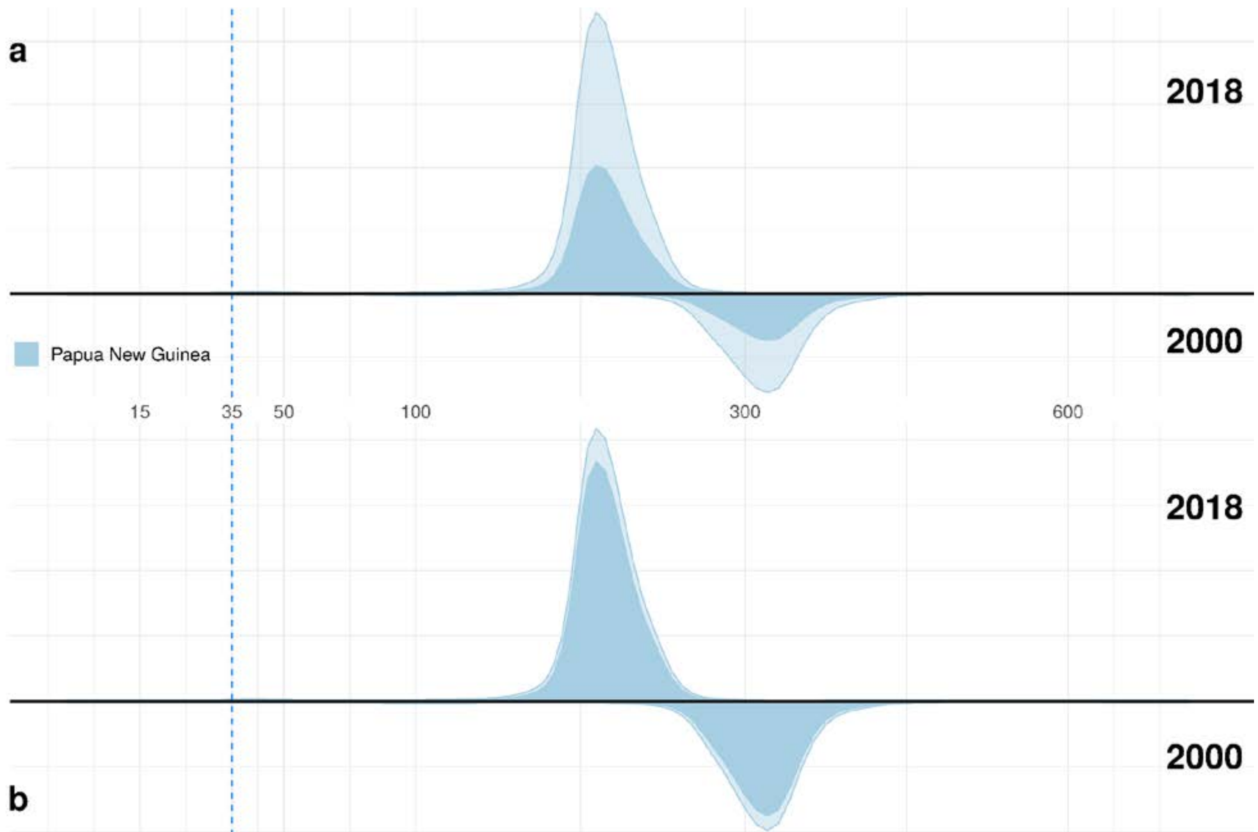
a) Southeast Asia



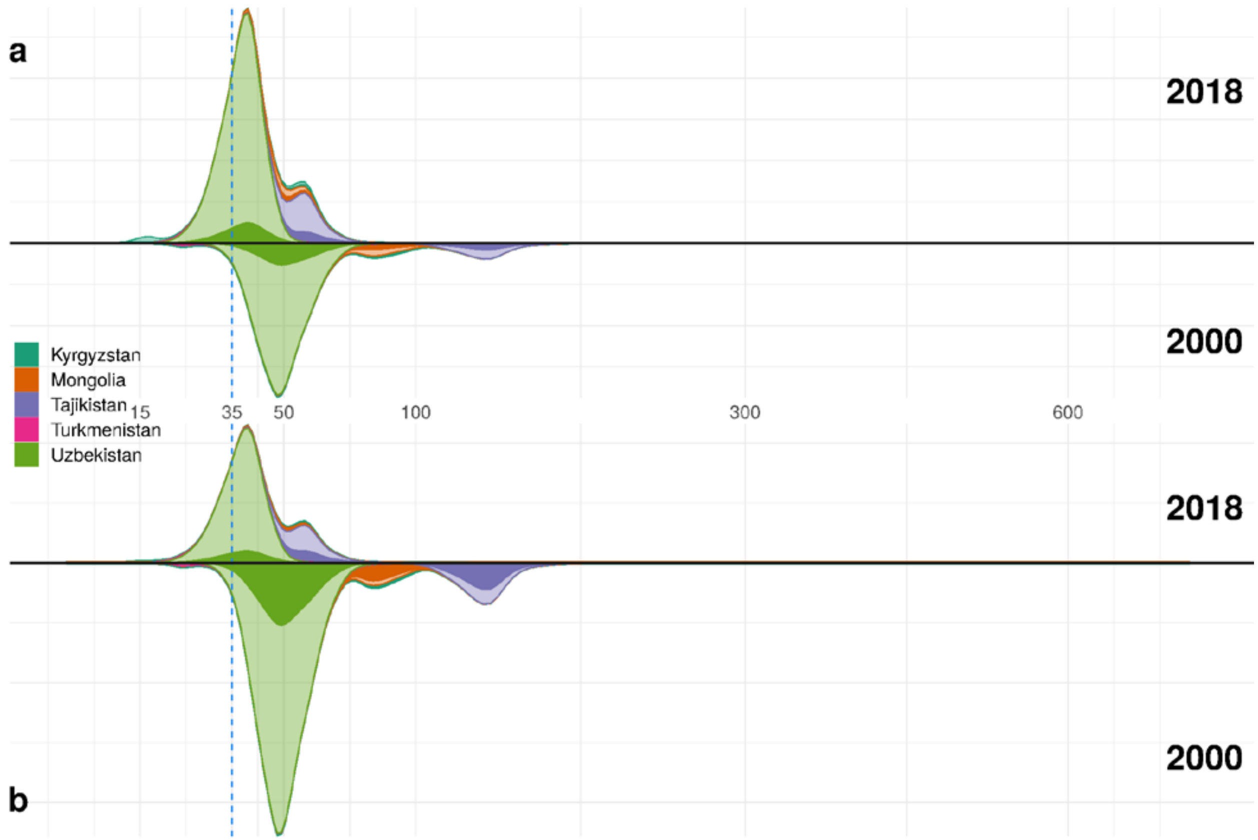
b) Southeast Asia, continued



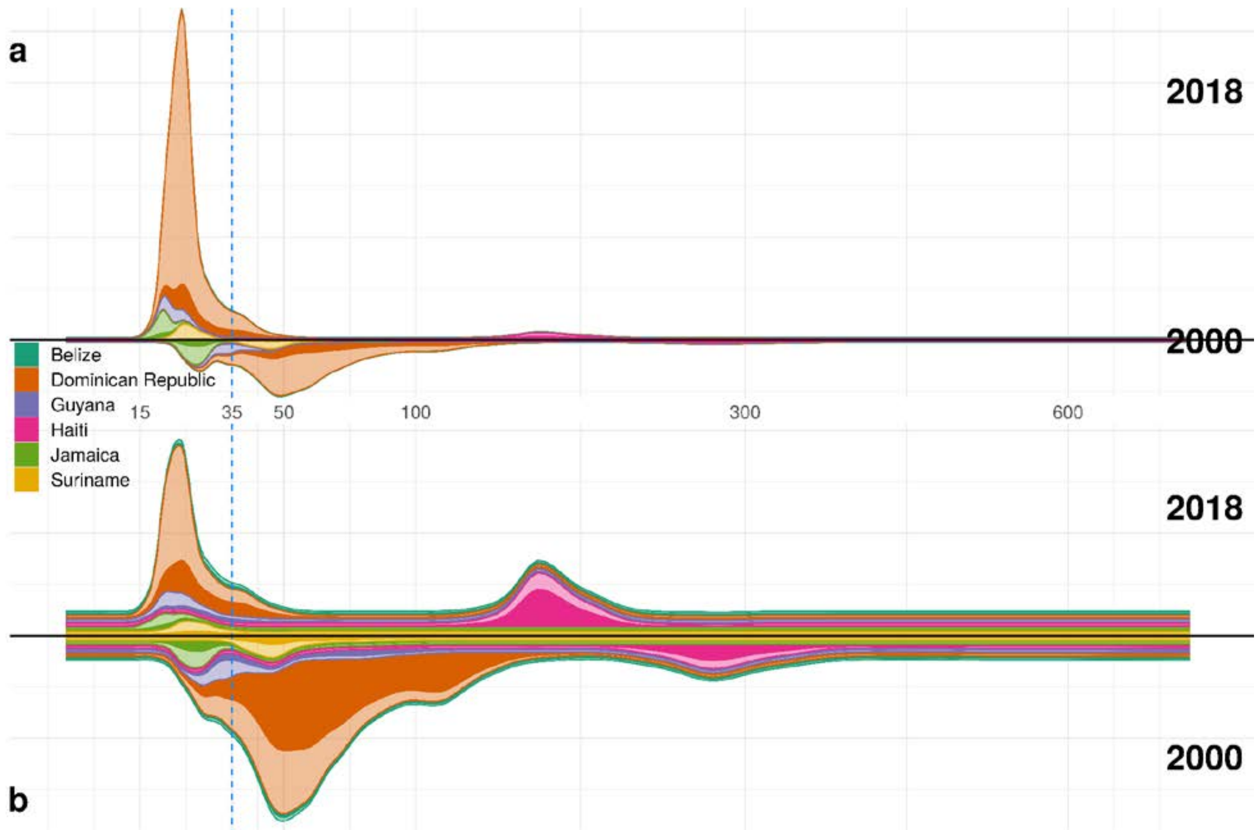
c) Oceania



d) Central Asia

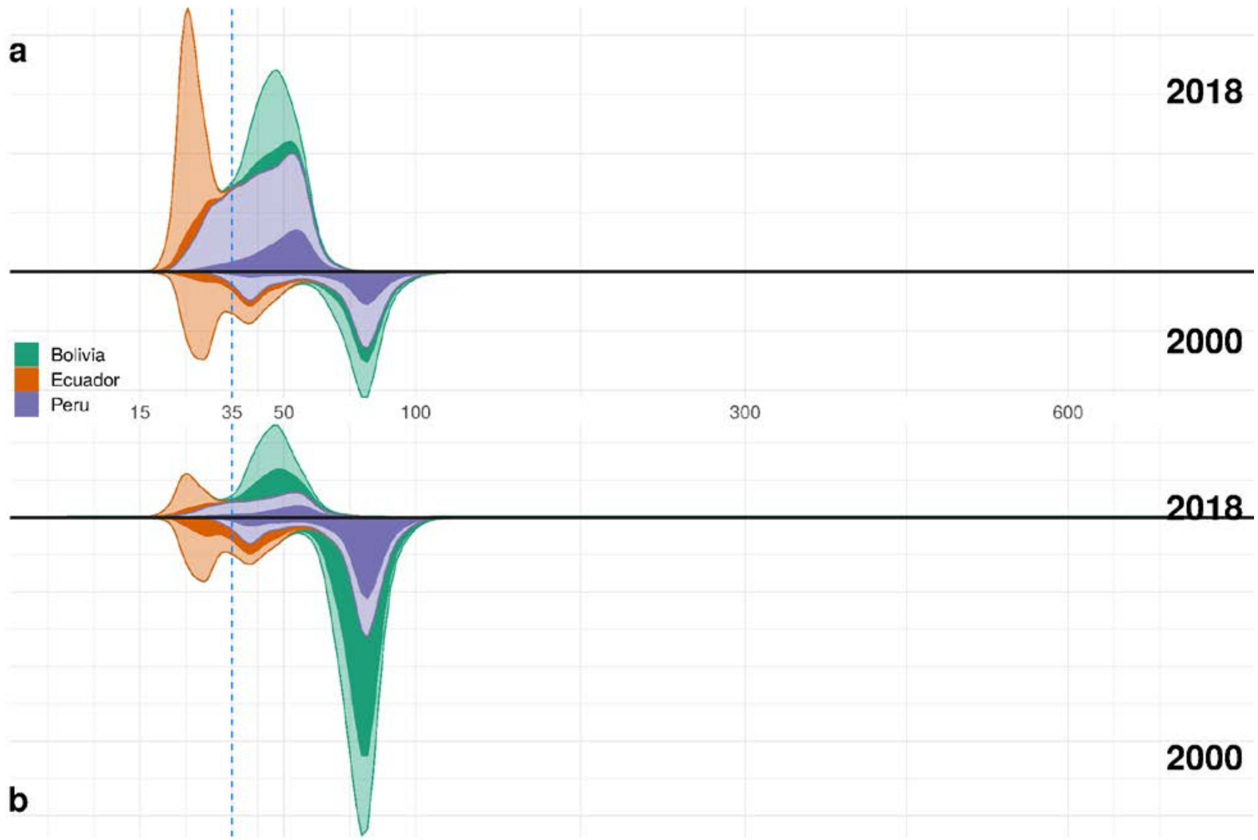


e) Caribbean

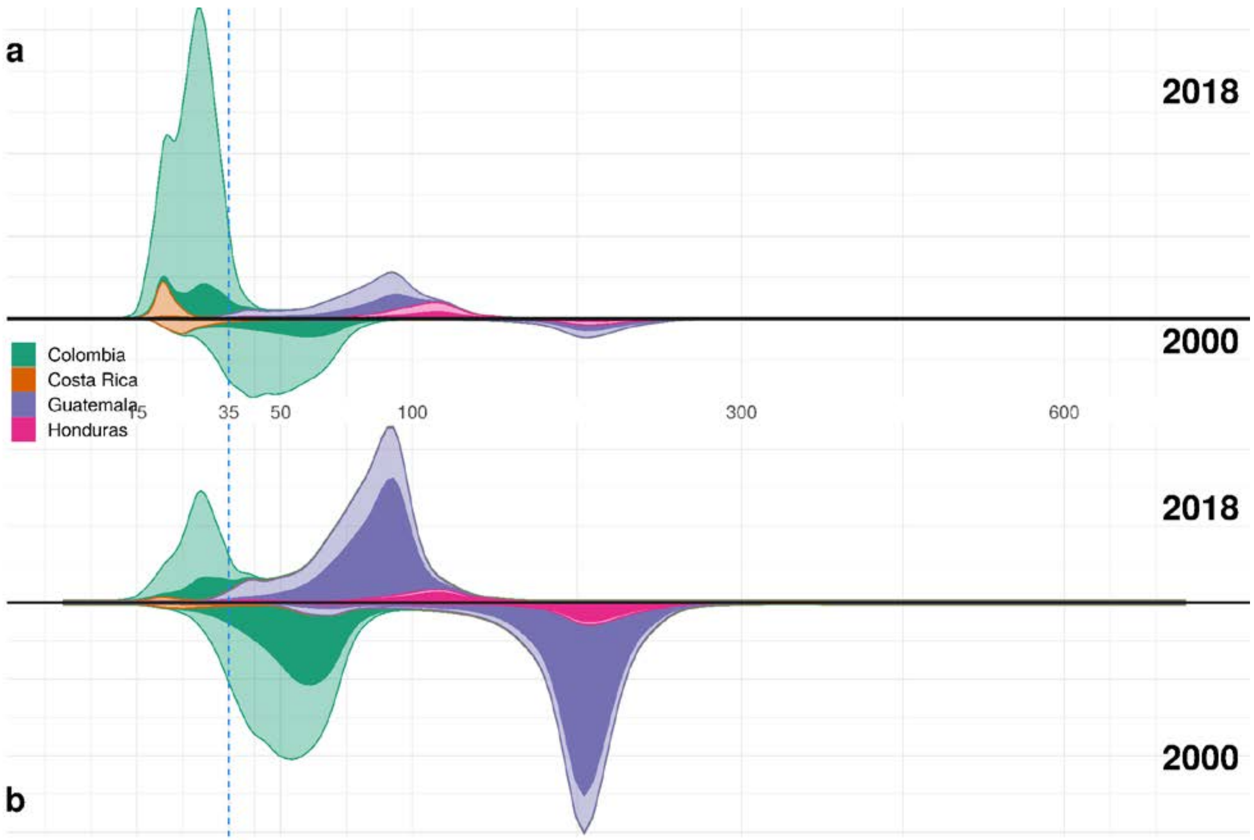


a
2018
2000
Belize
Dominican Republic
Guyana
Haiti
Jamaica
Suriname
15
35
50
100
300
600
2018
2000
b

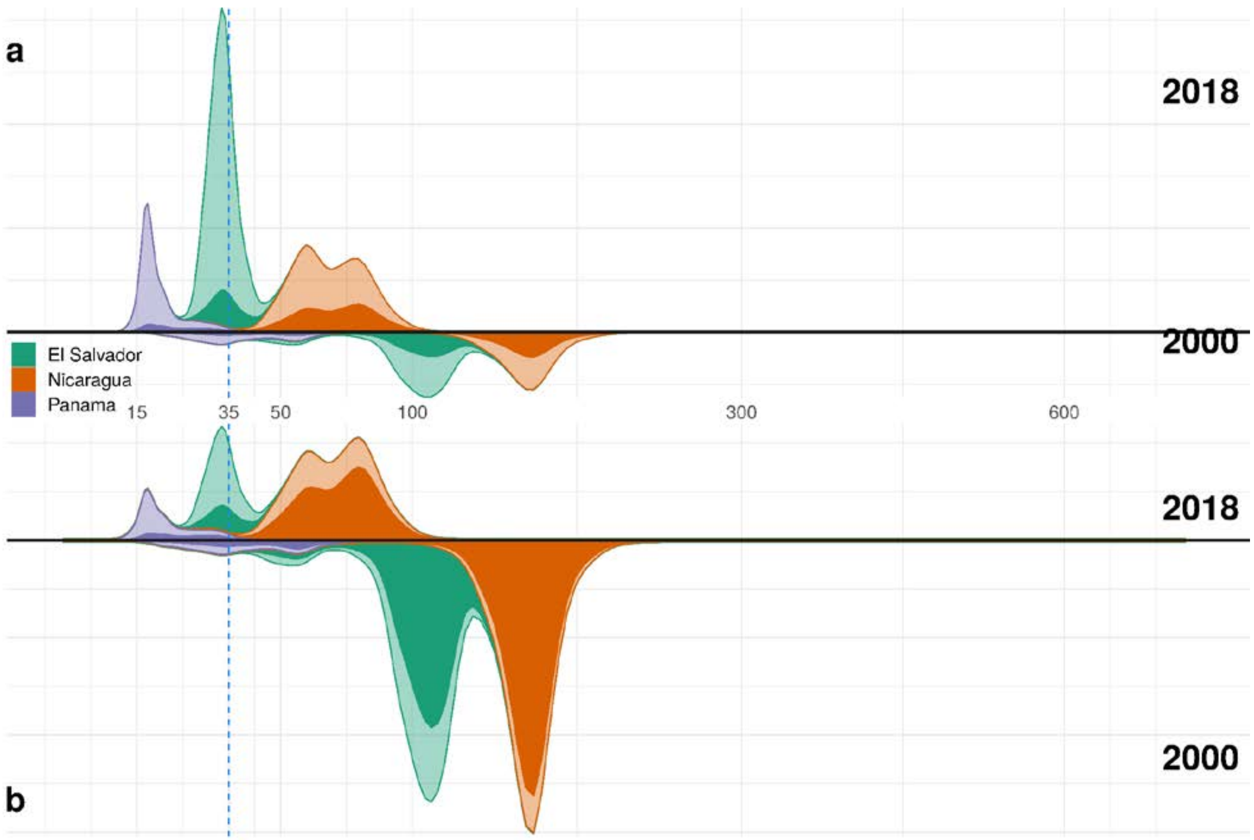
f) Andean Latin America



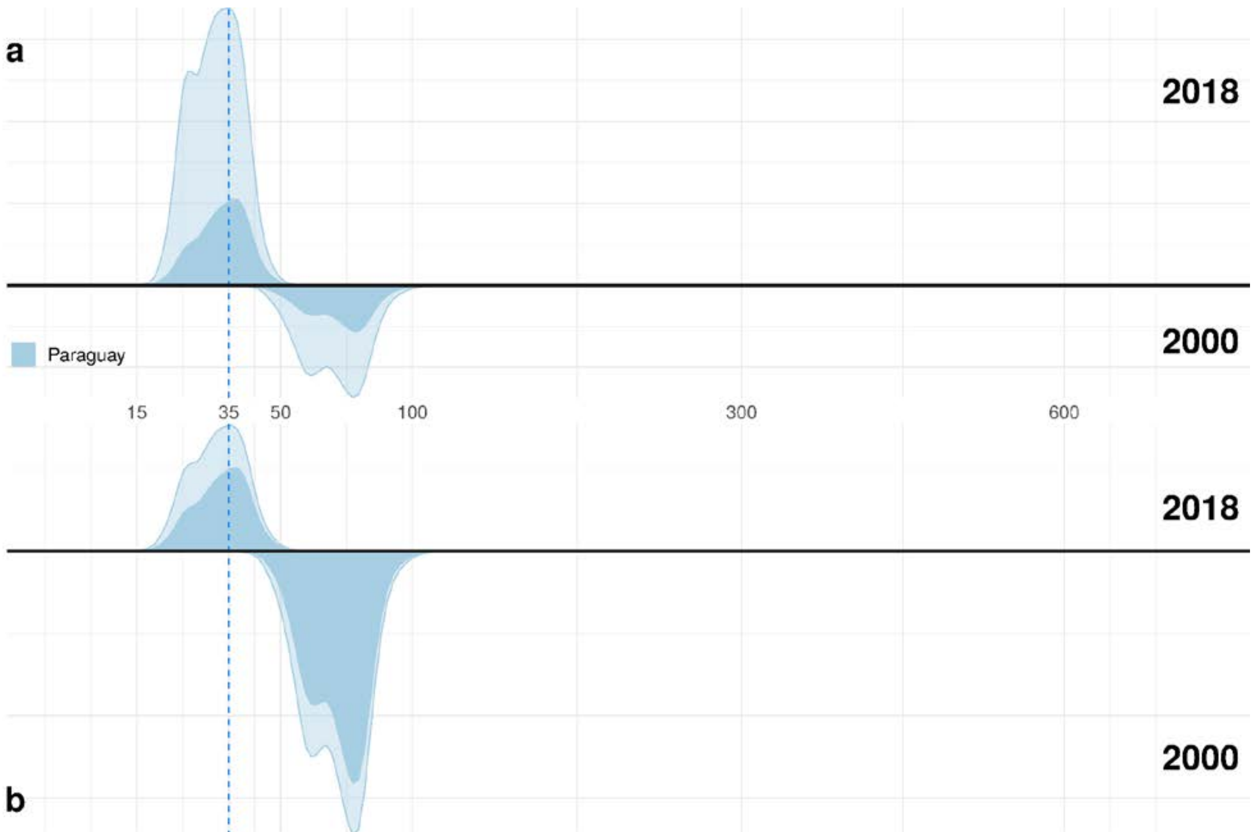
g) Central Latin America



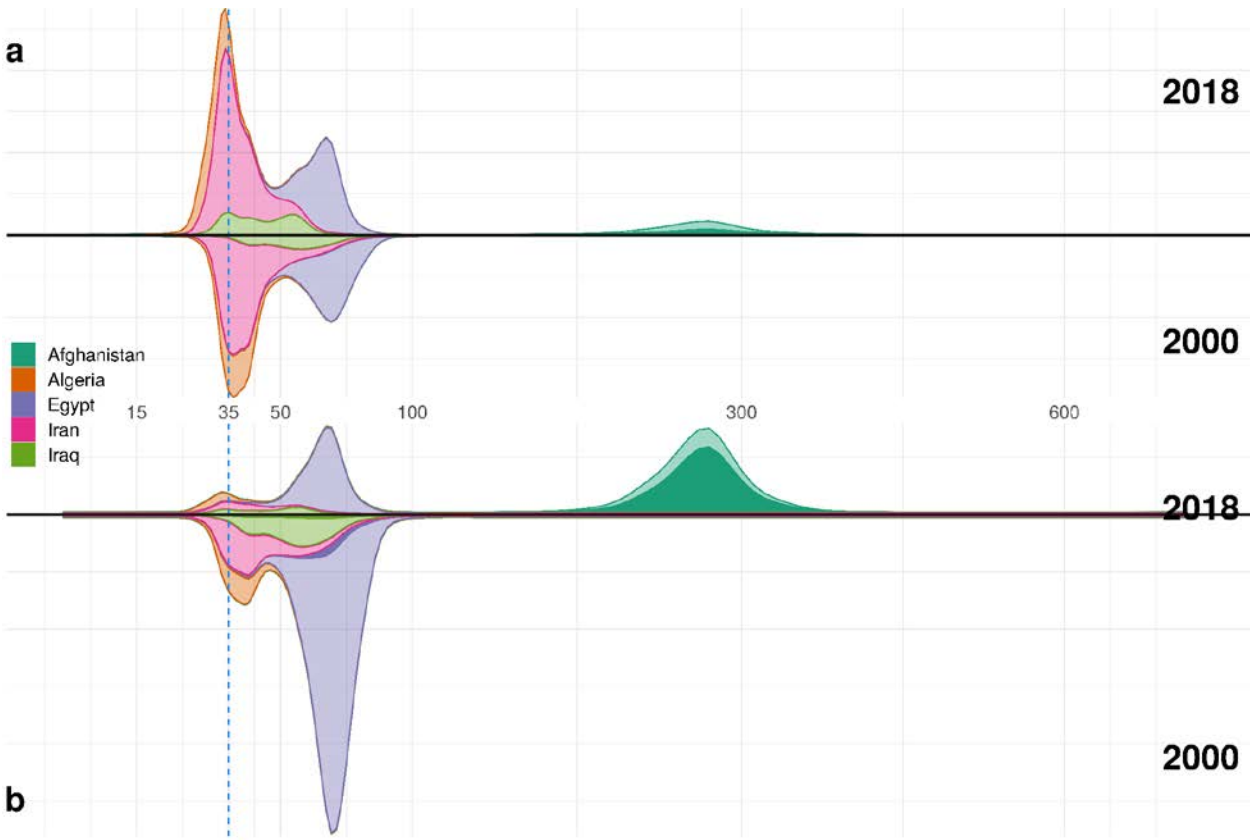
h) Central Latin America, continued



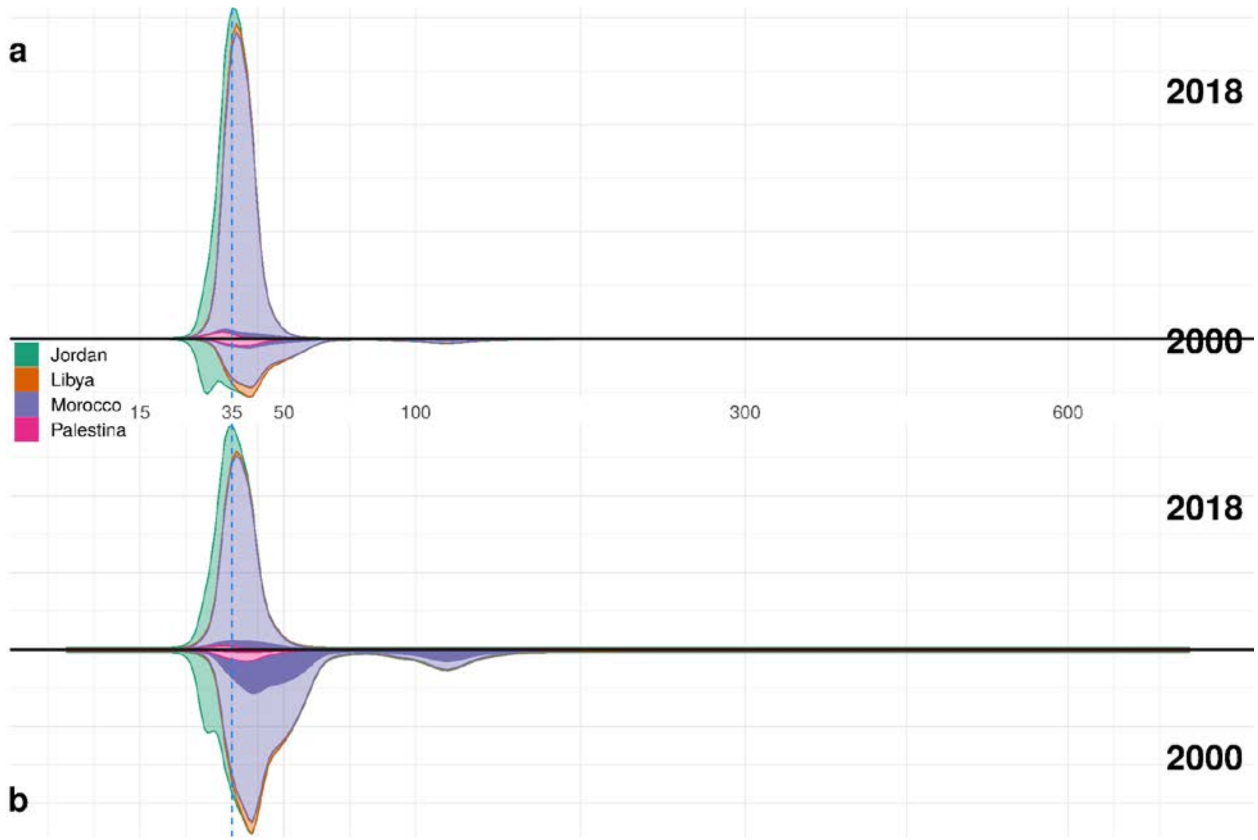
i) Tropical Latin America



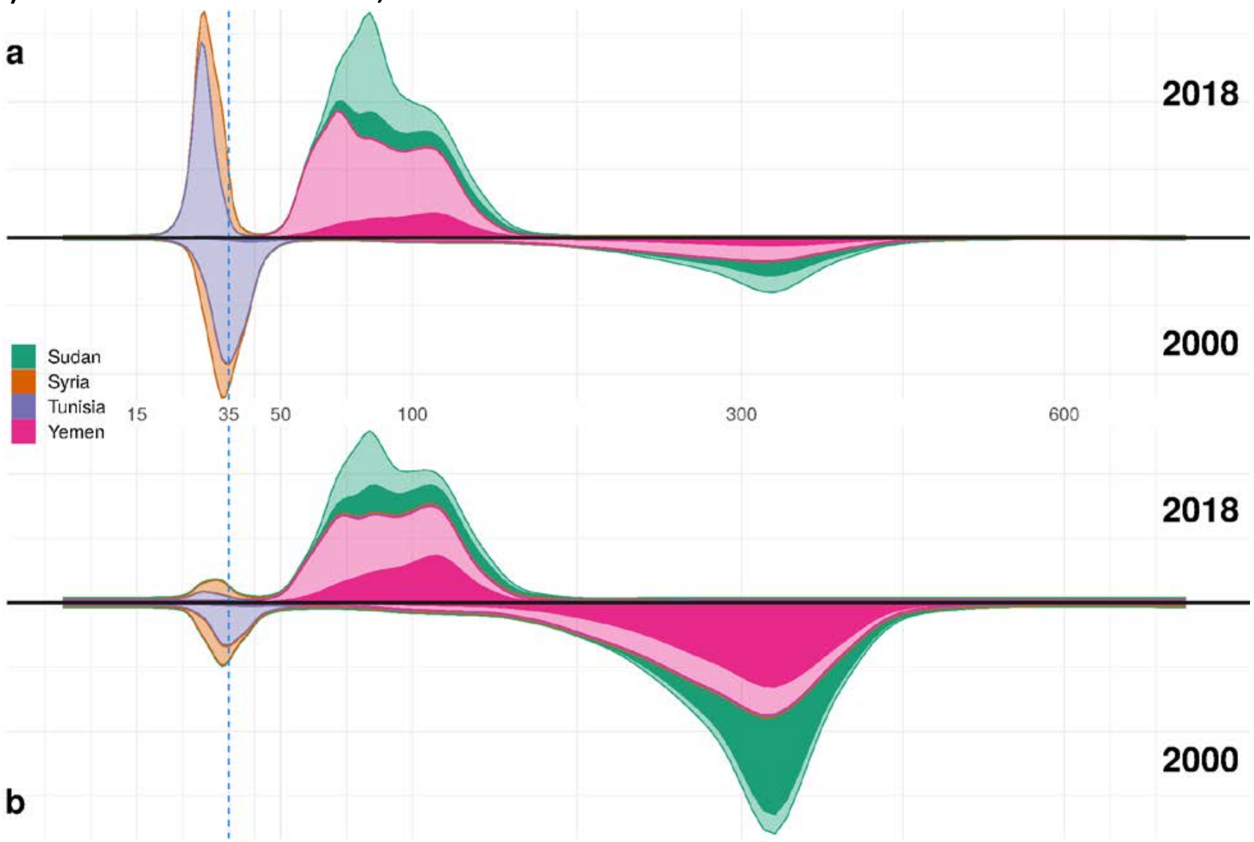
j) North Africa and Middle East



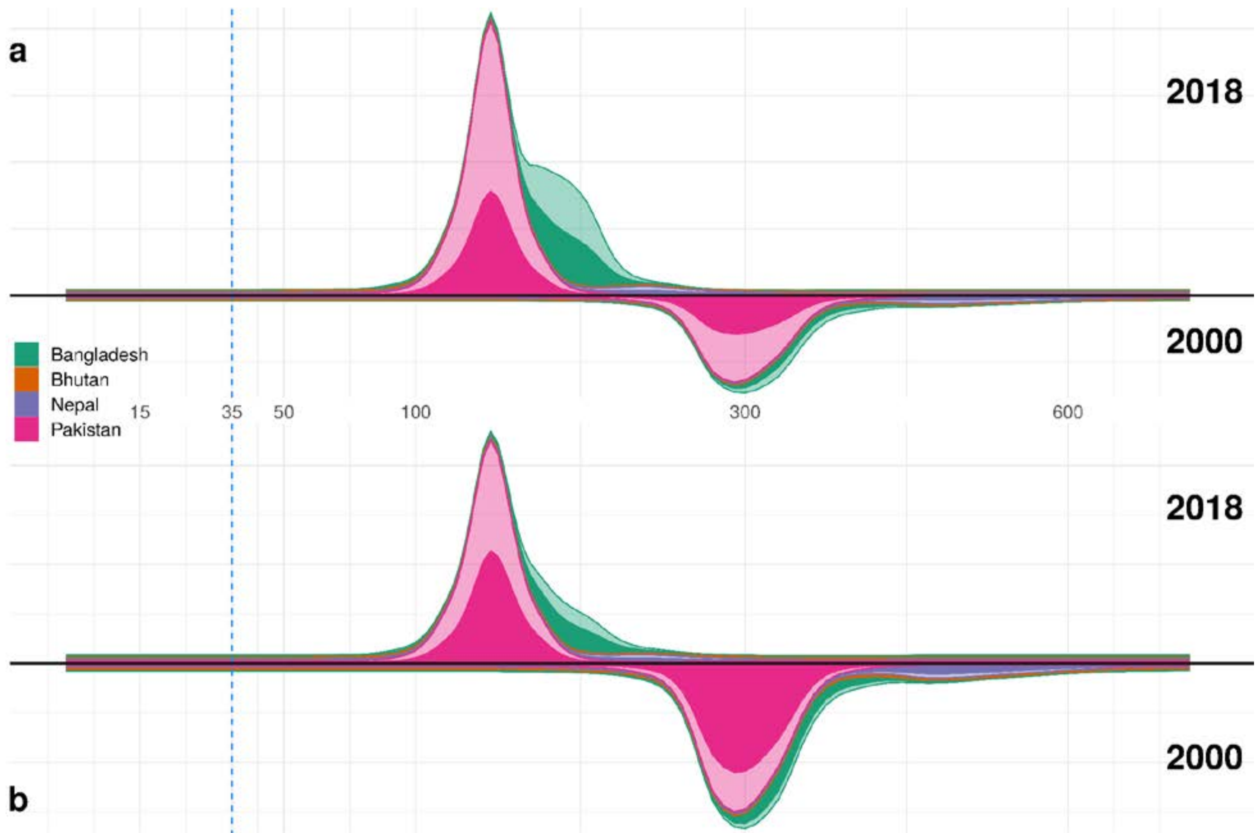
k) North Africa and Middle East



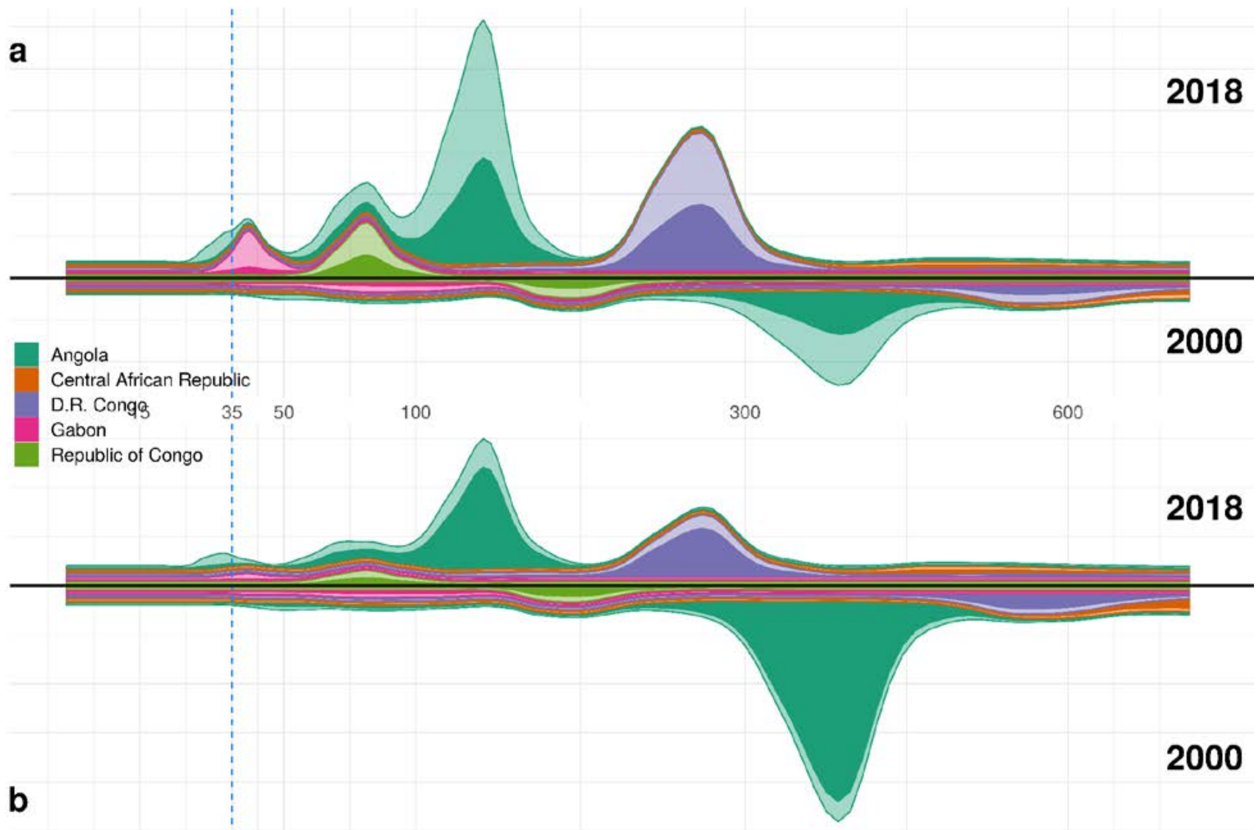
l) North Africa and Middle East, continued



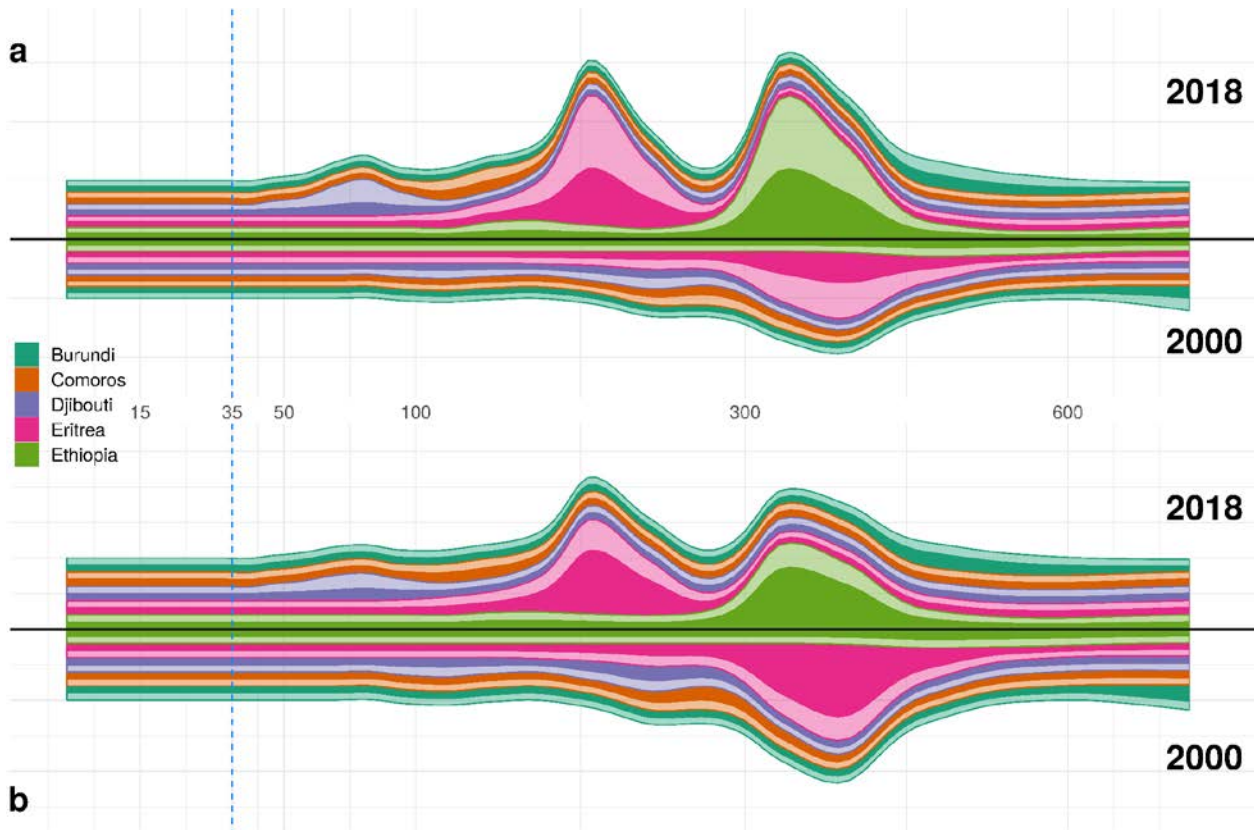
m) South Asia


a
2018
2000
Bangladesh
Bhutan
Nepal
Pakistan
15
35
50
100
300
600
2018
2000
b

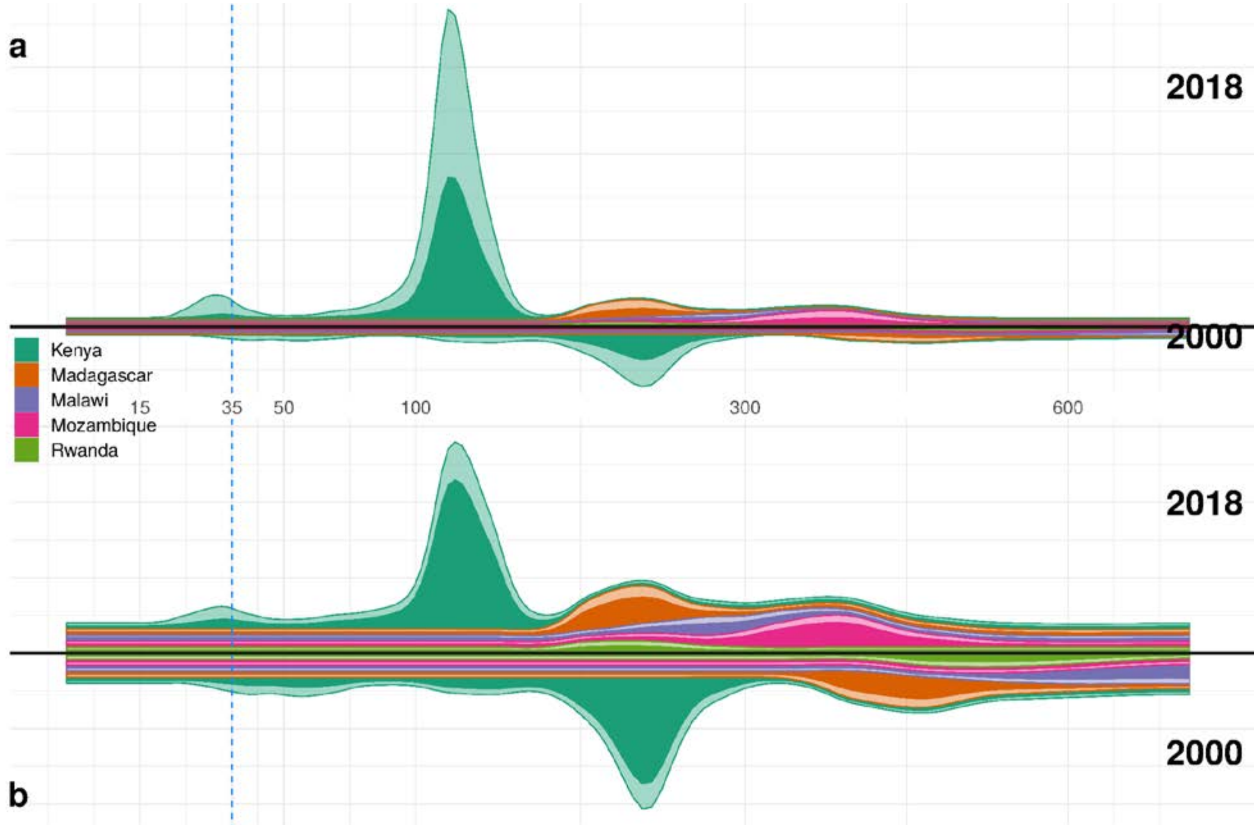
n) Central Sub-Saharan Africa



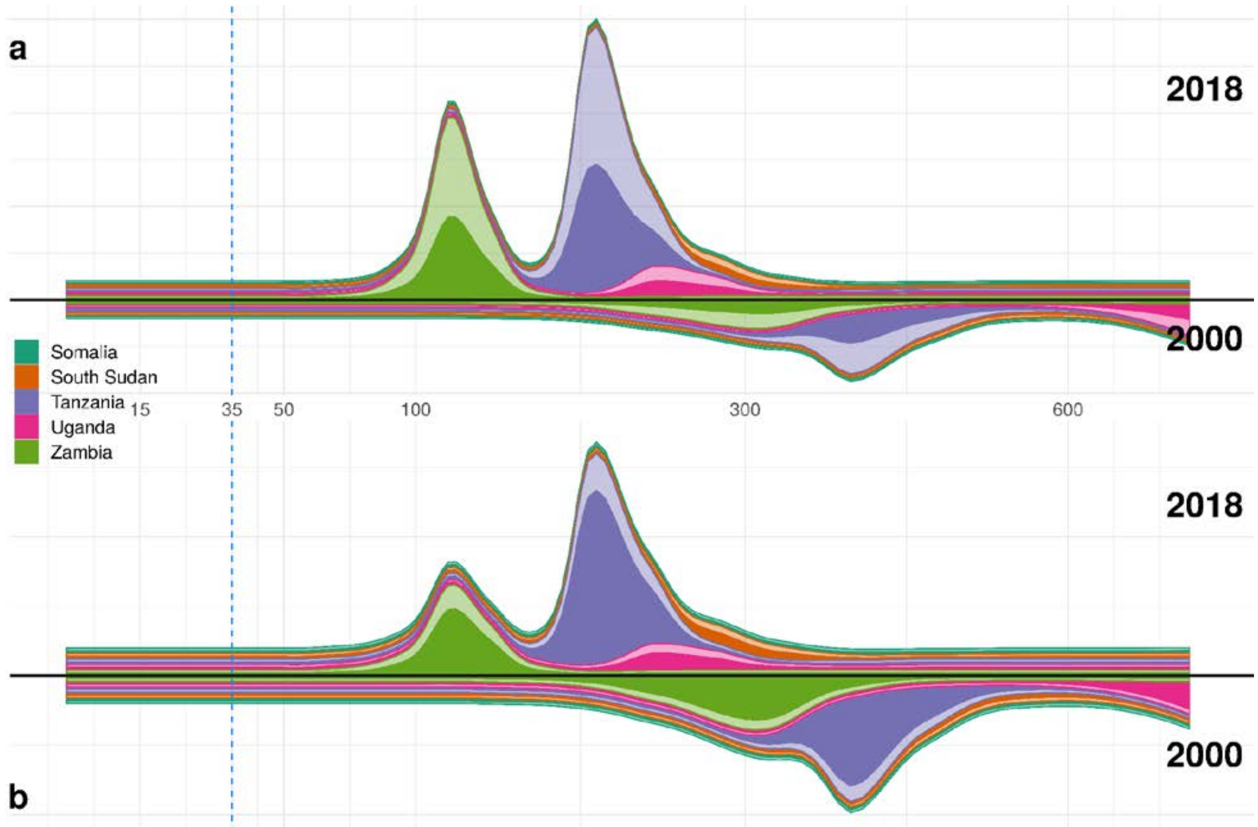
o) Eastern Sub-Saharan Africa



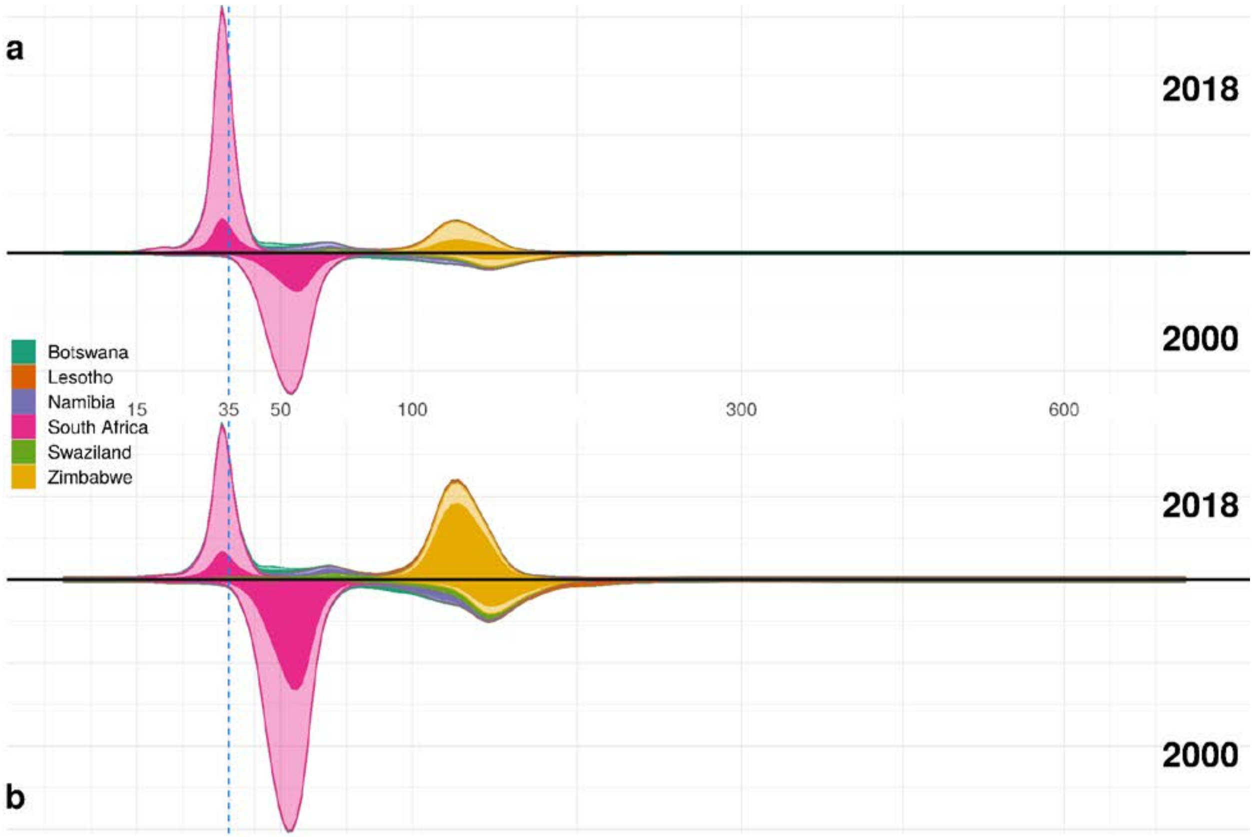
p) Eastern Sub-Saharan Africa, continued



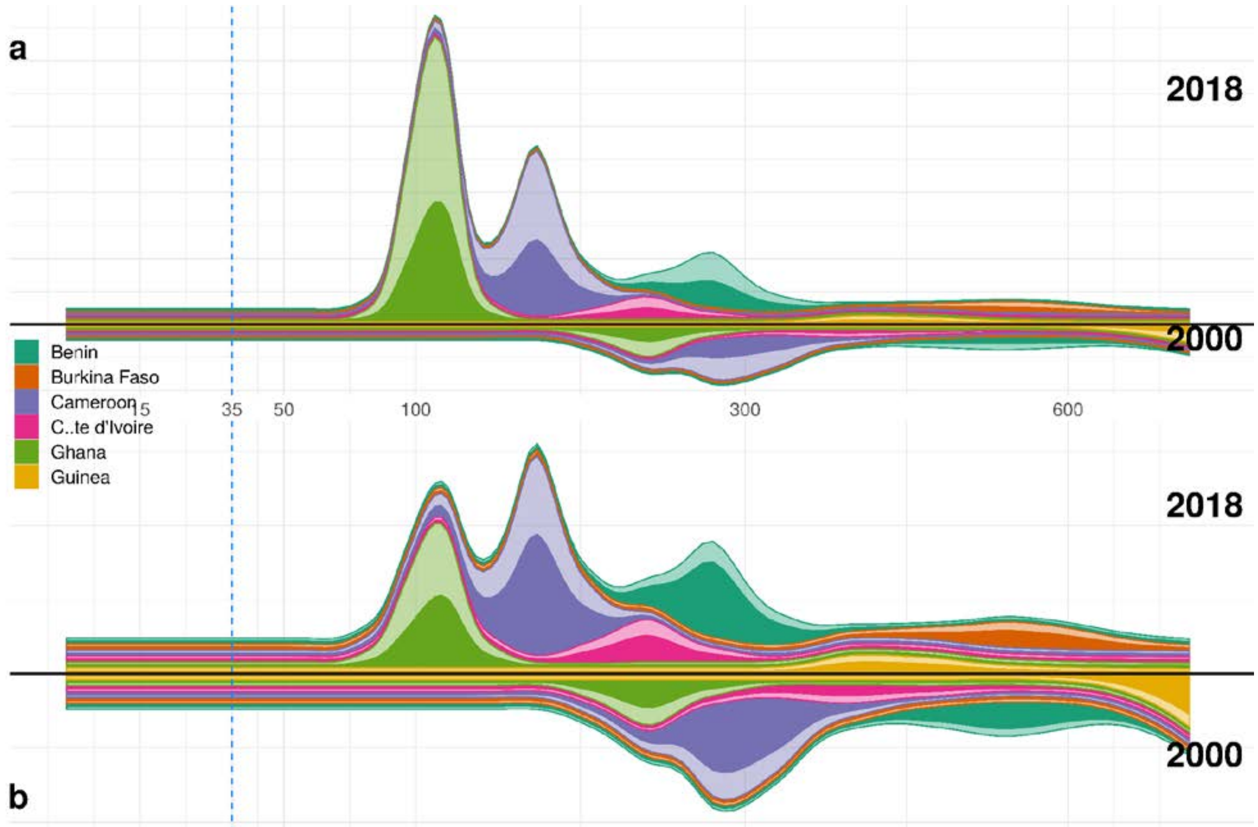
q) Eastern Sub-Saharan Africa, Continued



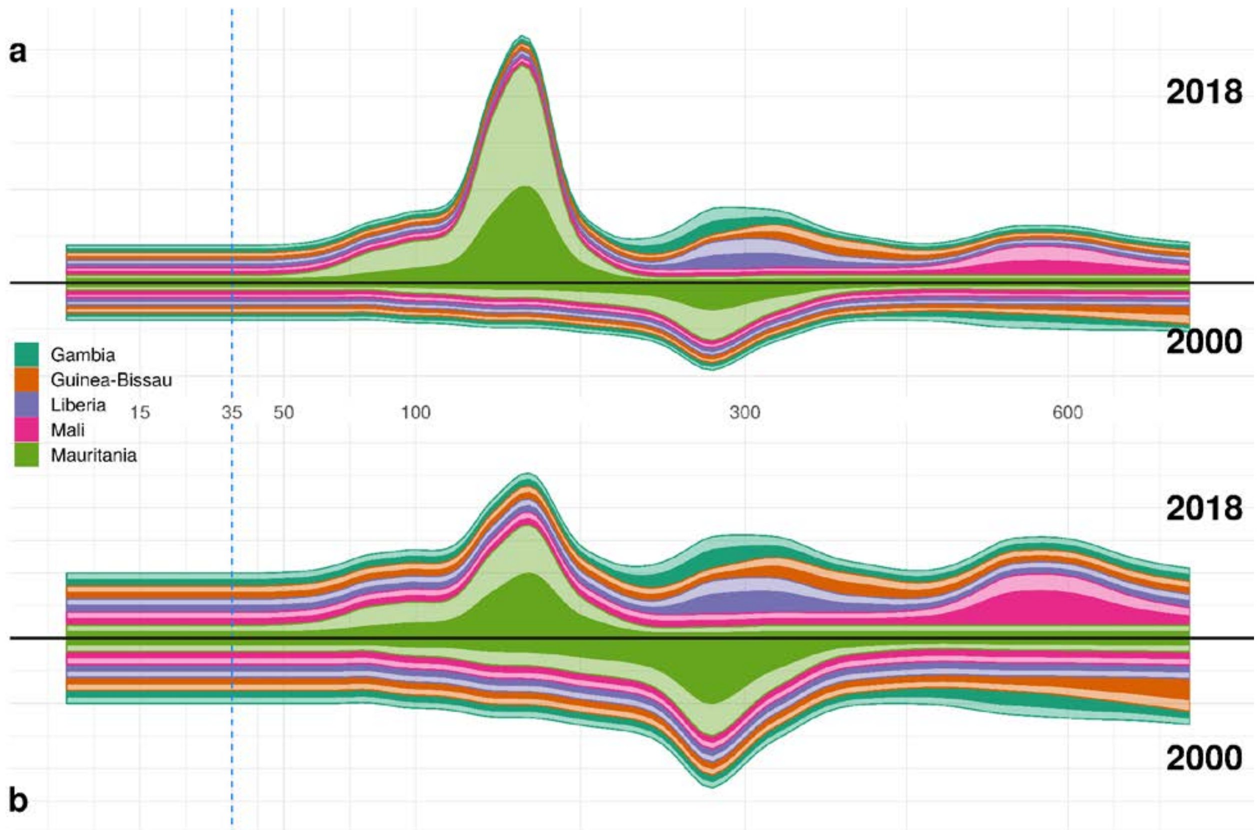
r) Southern Sub-Saharan Africa



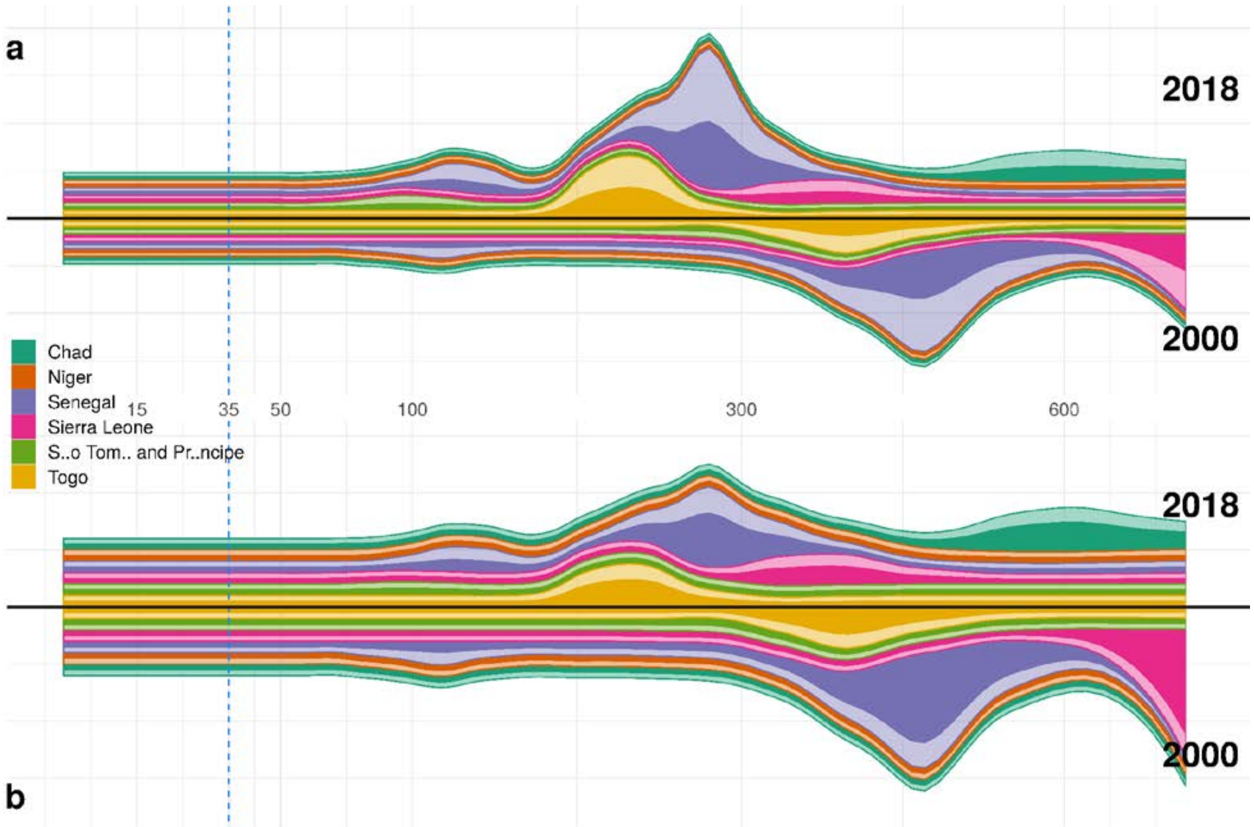
s) Western Sub-Saharan Africa



t) Western Sub-Saharan Africa, Continued



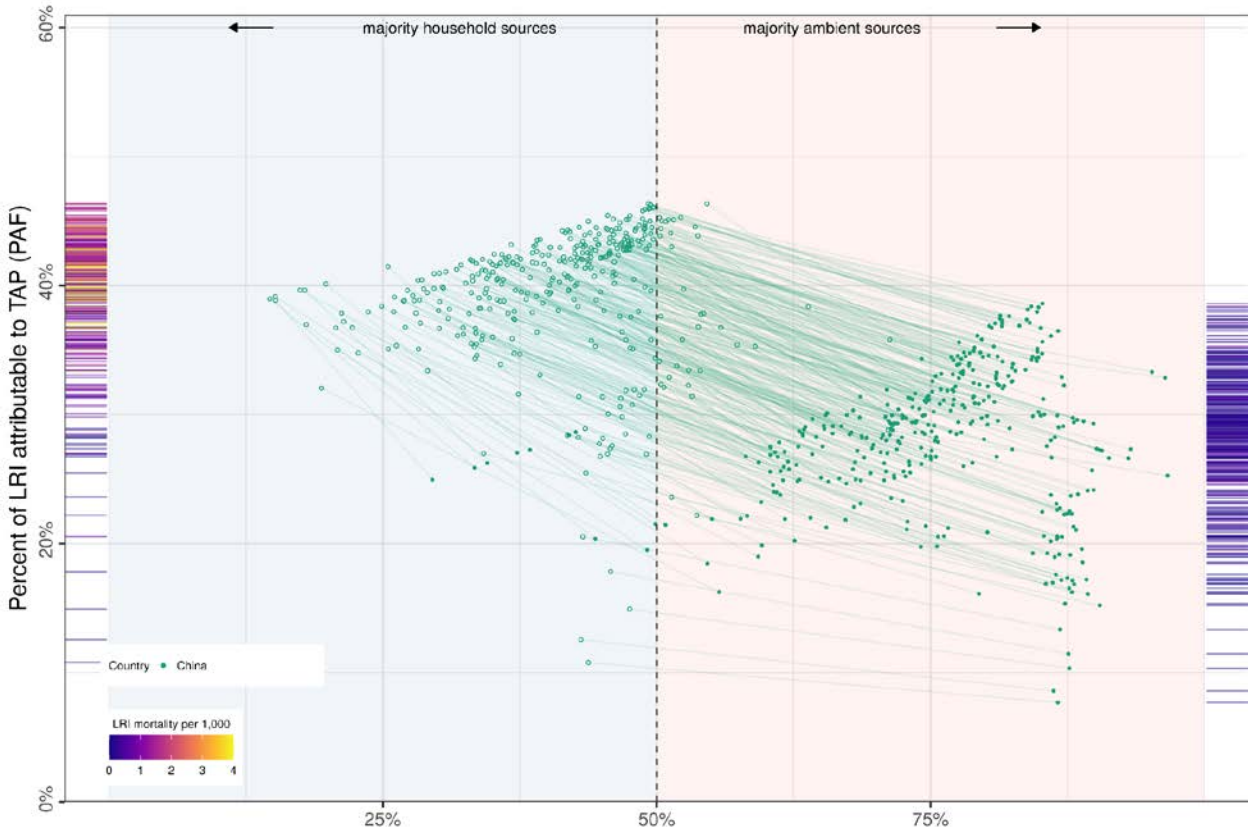
u) Western Sub-Saharan Africa, Continued



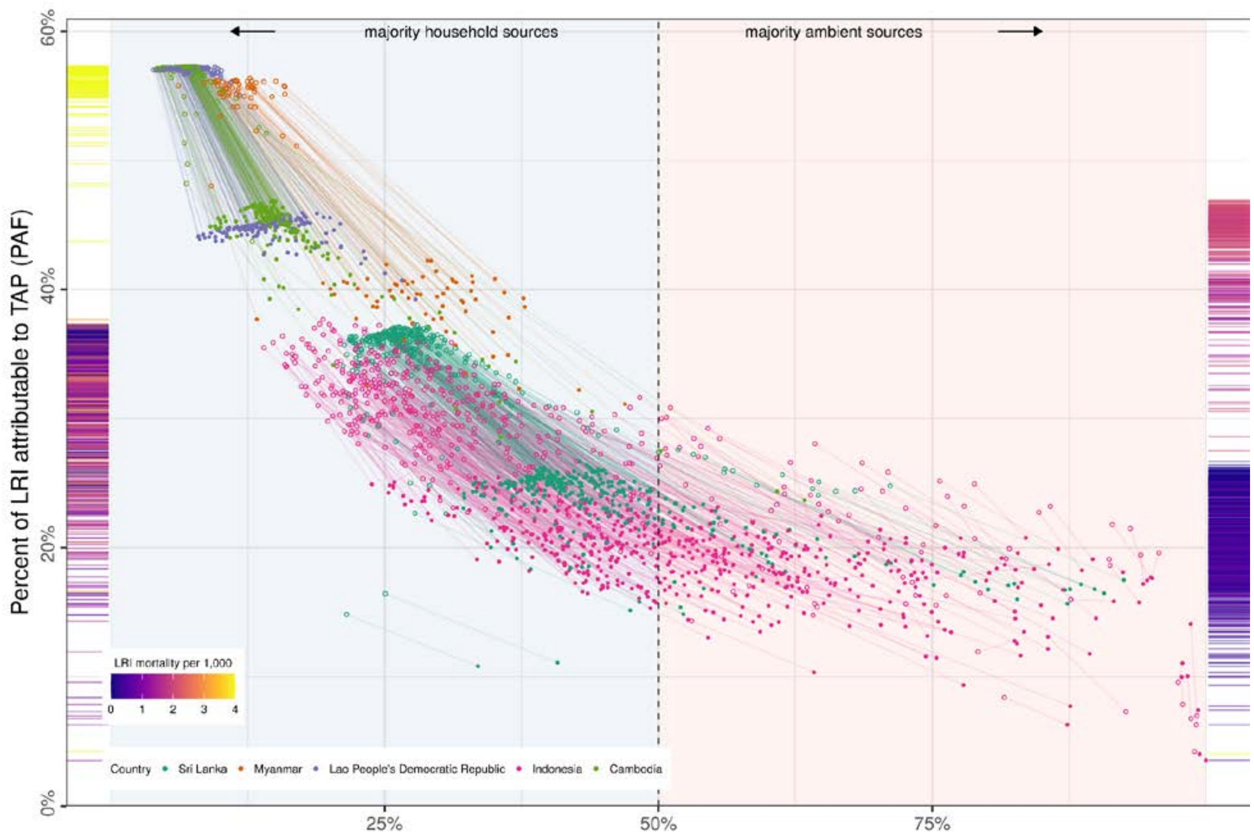
Supplementary Figure 18a-v: Air pollution risk transition (2000–2018) by region.

a. Trends in the percent of LRIs attributed to TAP at the second administrative unit (districts). The x-axis displays the percent of total air pollution exposure that is contributed by ambient air pollution. The blue and red background shading indicate the dominant source of air pollution is household or ambient sources. The y-axis displays the fraction of under-5 LRIs that are attributable to TAP, as estimated by the population attributable fraction (PAF). The y-axis rugs indicate the gradient of background LRI mortality rates for 2000 (left) and 2018 (right), illustrating the correlation between LRI rates and the fraction attributable to TAP. The lines connect a district to its preceding time point across the series.

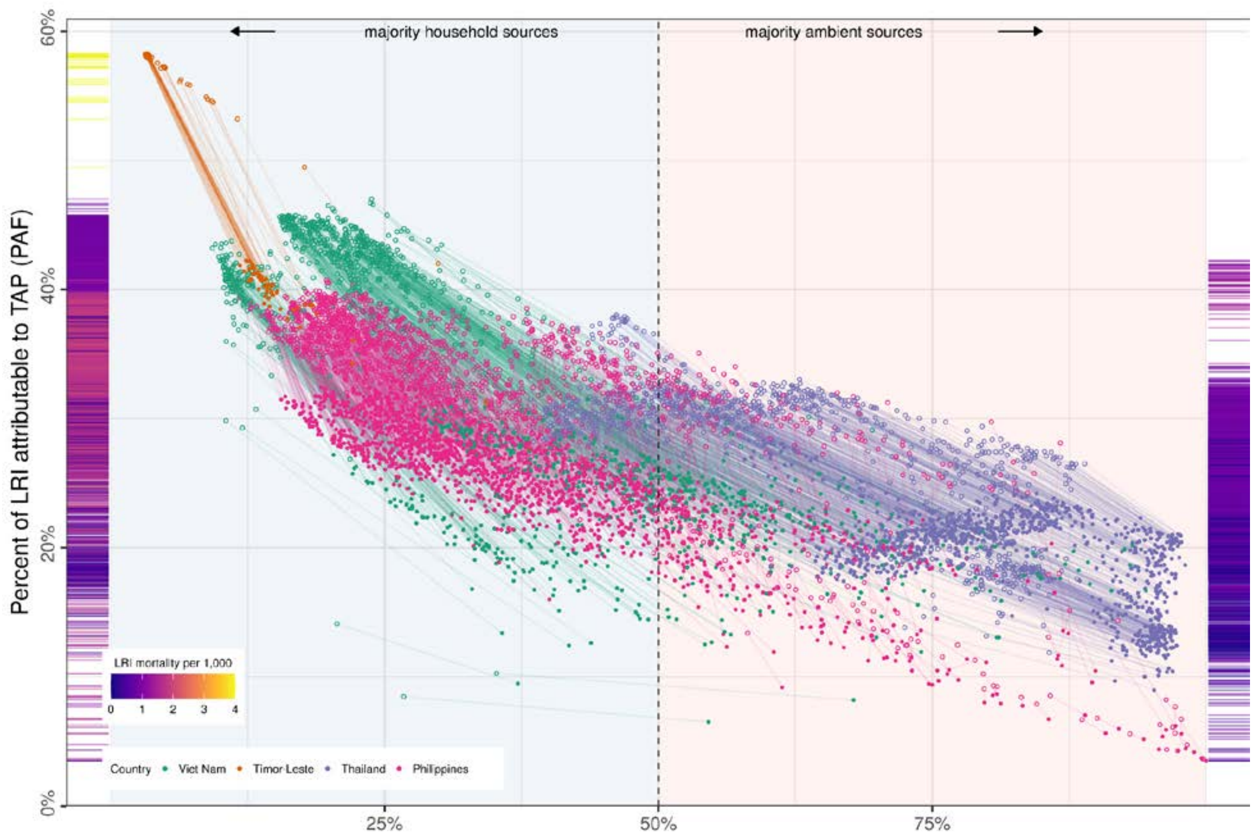
a) East Asia



b) Southeast Asia



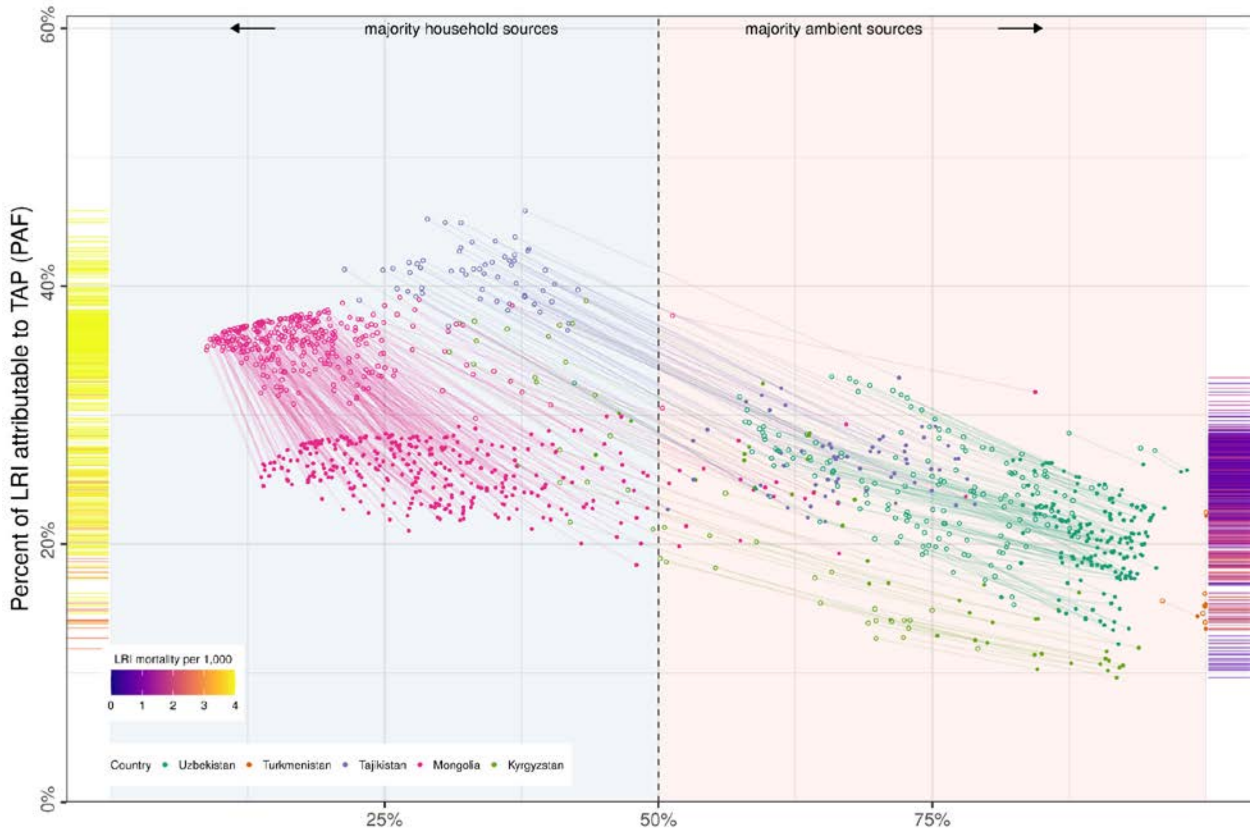
c) Southeast Asia, continued



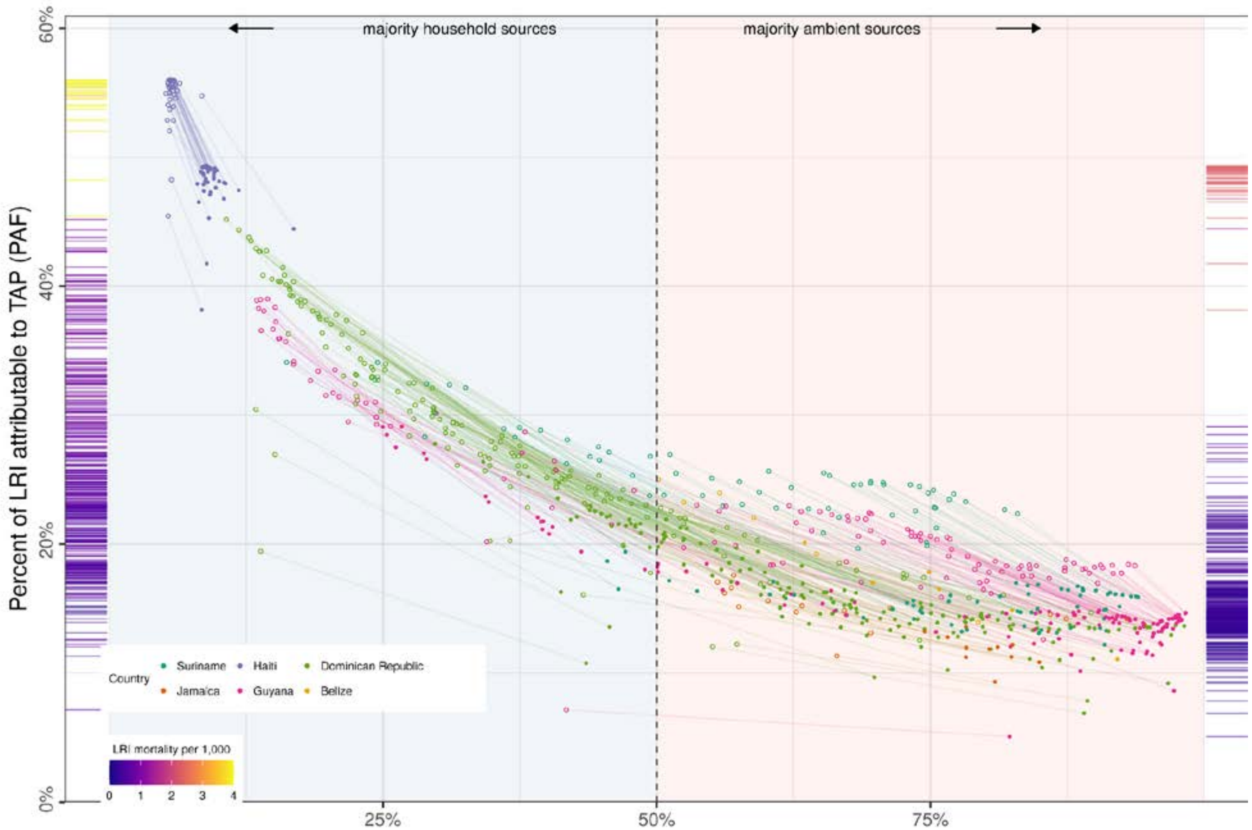
d) Oceania


majority household sources
majority ambient sources
Percent of LRI attributable to TAP (PAF)
60%
40%
20%
0%
25%
50%
75%
Country • Papua New Guinea
LRI mortality per 1,000
0 1 2 3 4

e) Central Asia

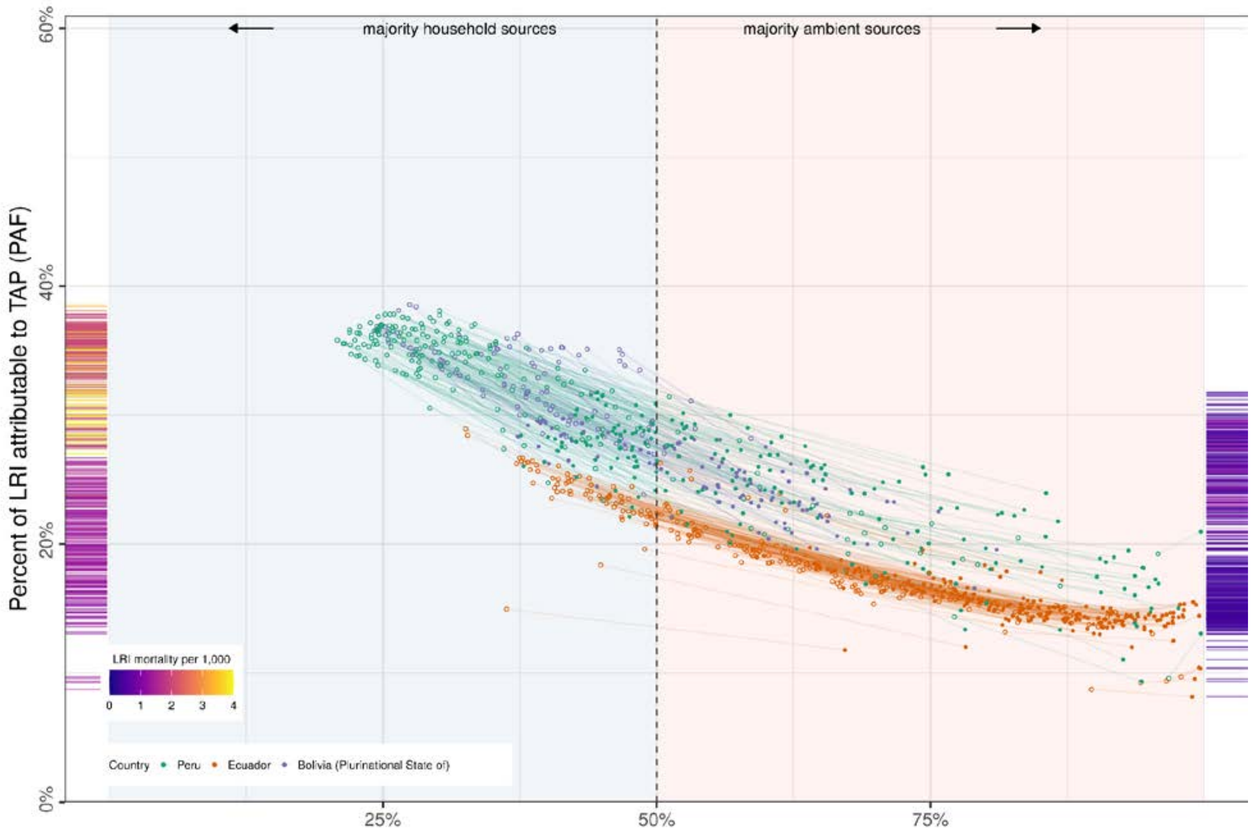


f) Caribbean

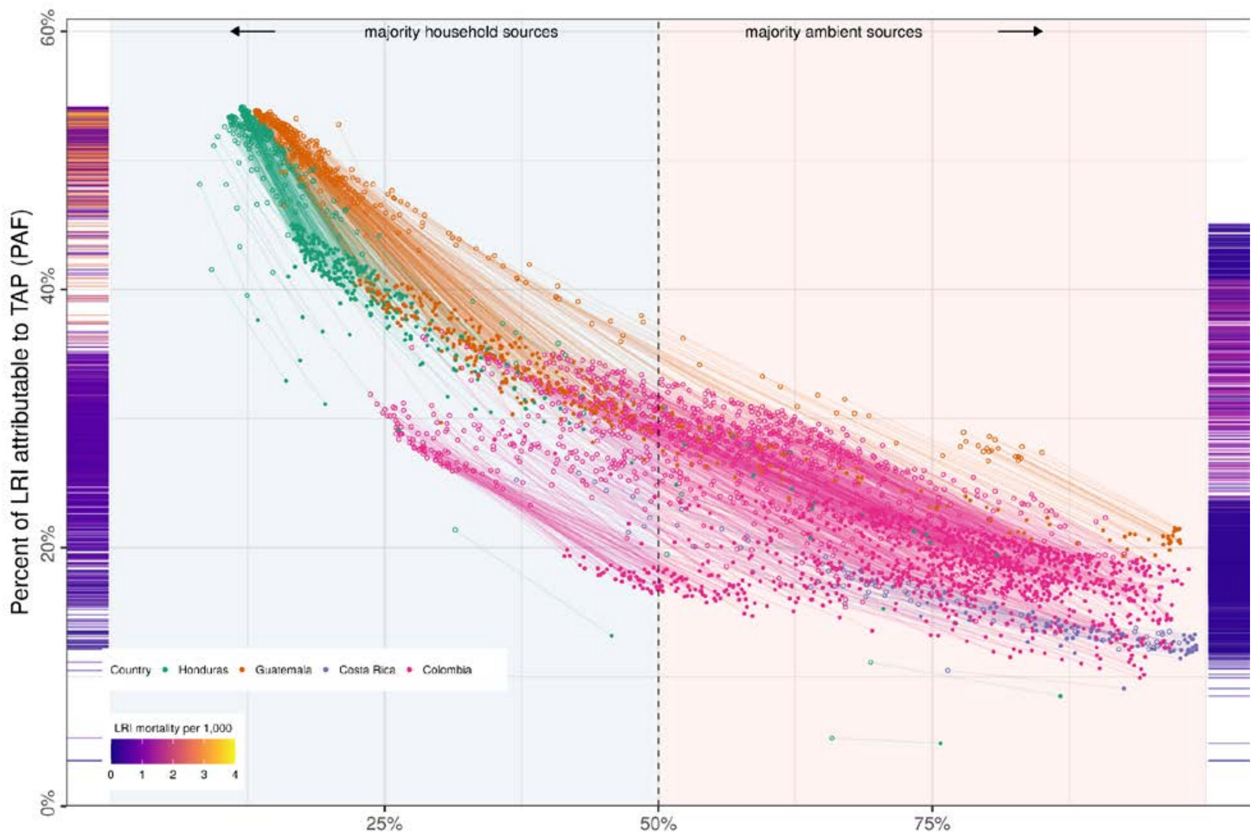


majority household sources
majority ambient sources
Percent of LRI attributable to TAP (PAF)
60%
40%
20%
0%
25%
50%
75%
Country
Suriname
Haiti
Dominican Republic
Jamaica
Guyana
Belize
LRI mortality per 1,000
0
1
2
3
4

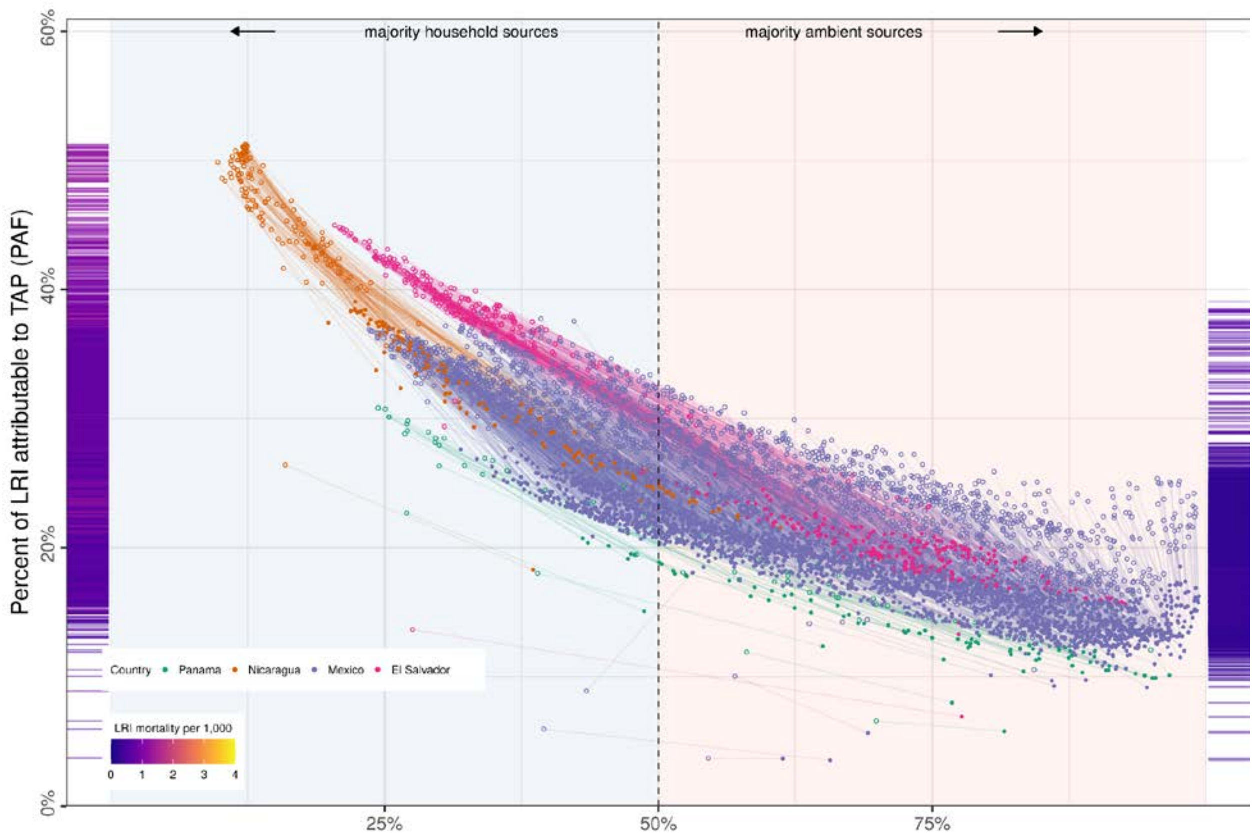
g) Andean Latin America



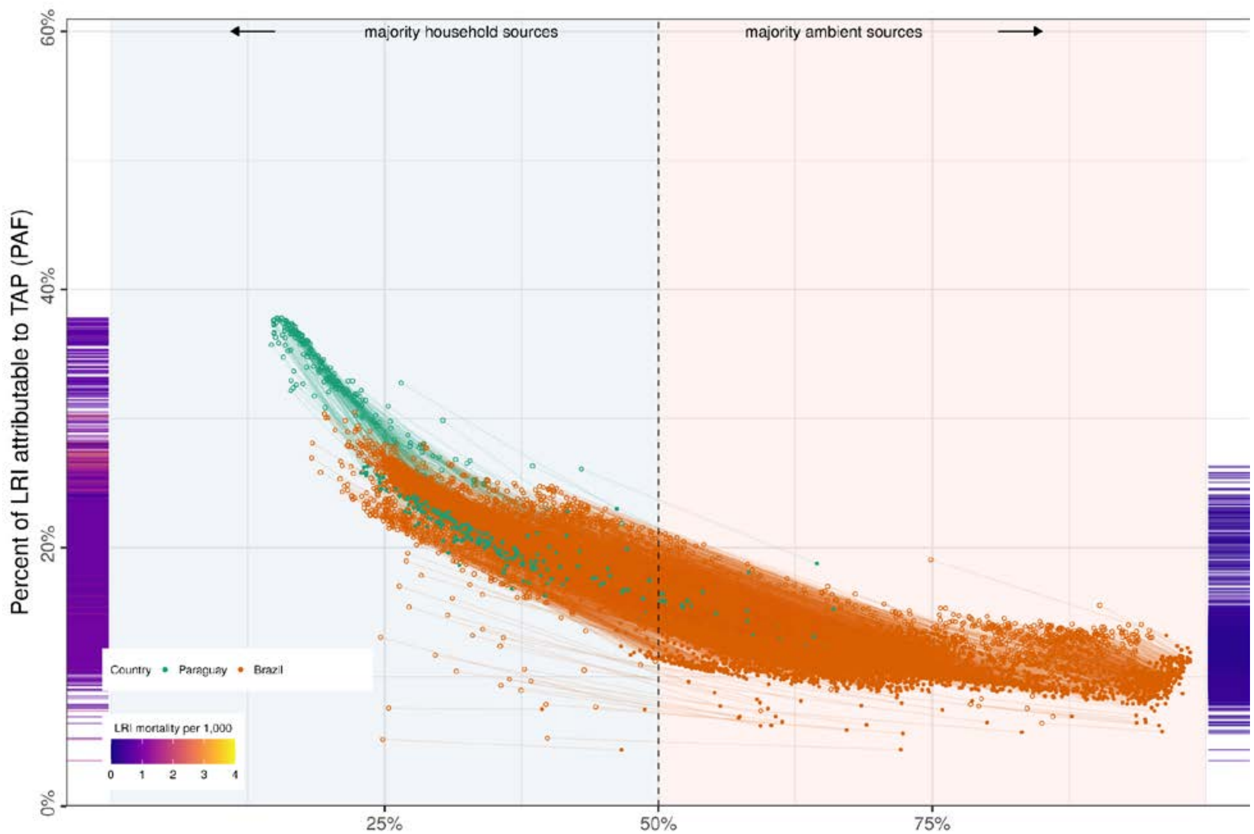
h) Central Latin America



i) Central Latin America, continued

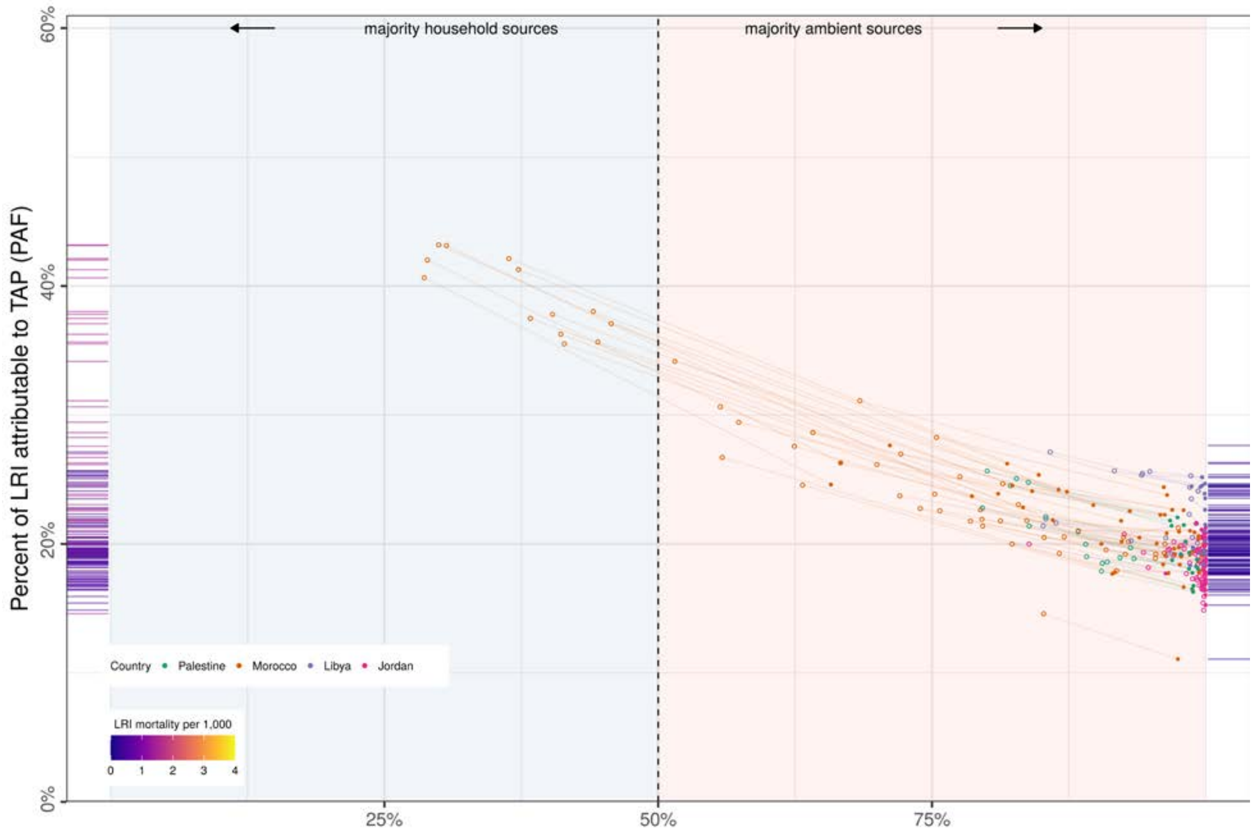


j) Tropical Latin America

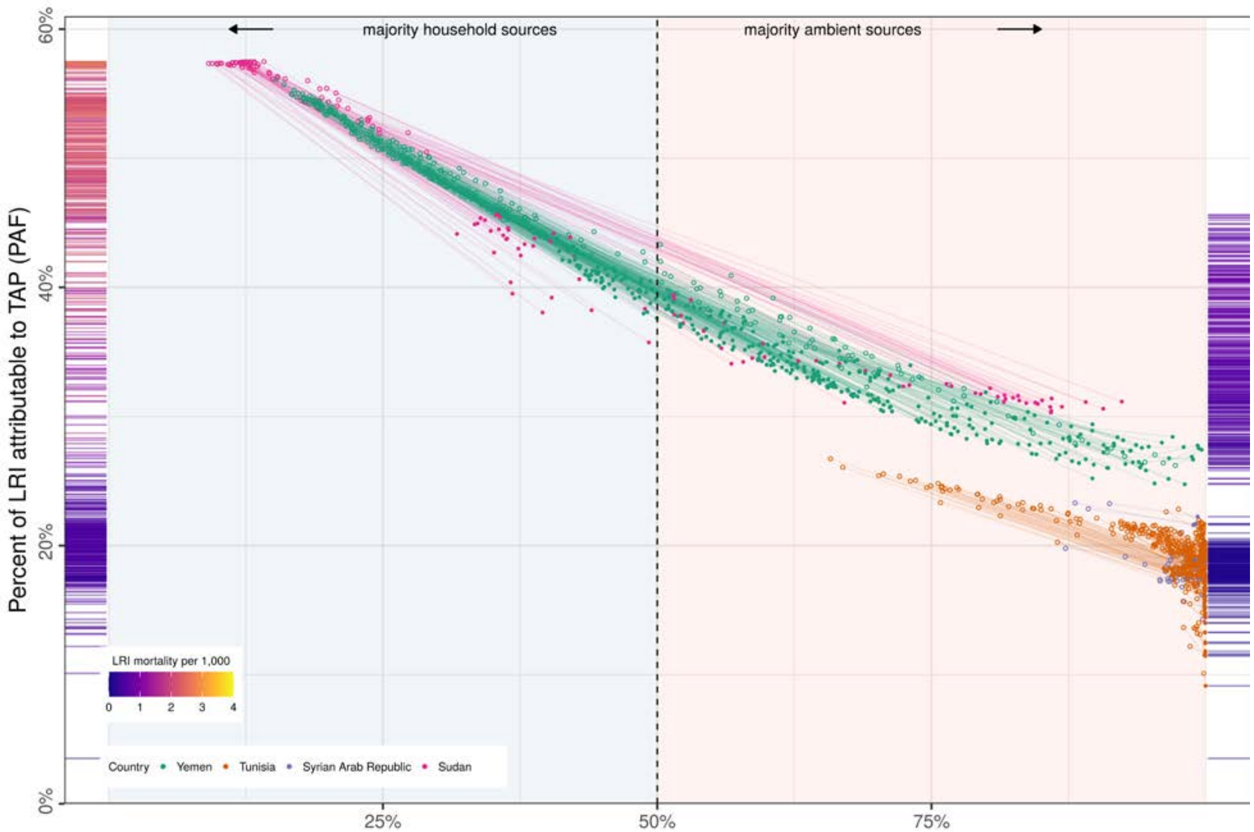


k) North Africa and Middle East

l) North Africa and Middle East



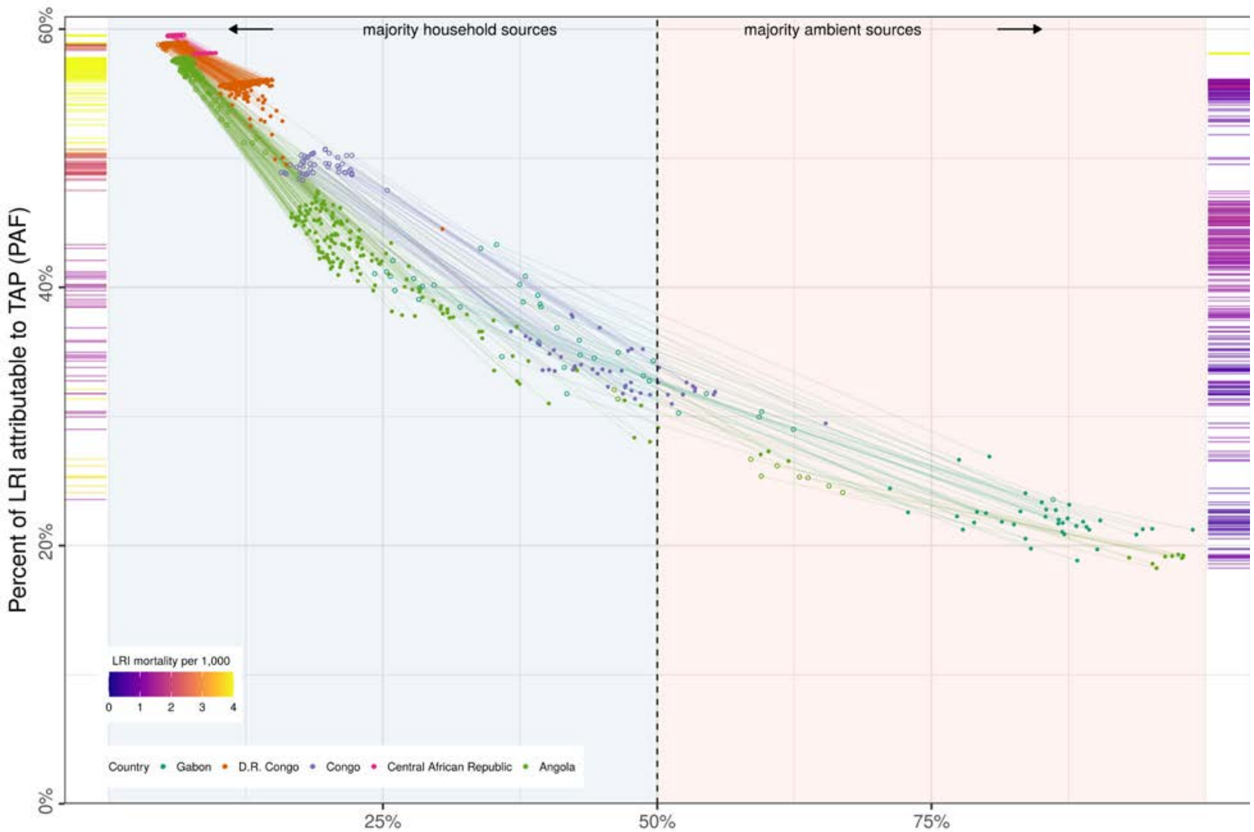
m) North Africa and Middle East, continued



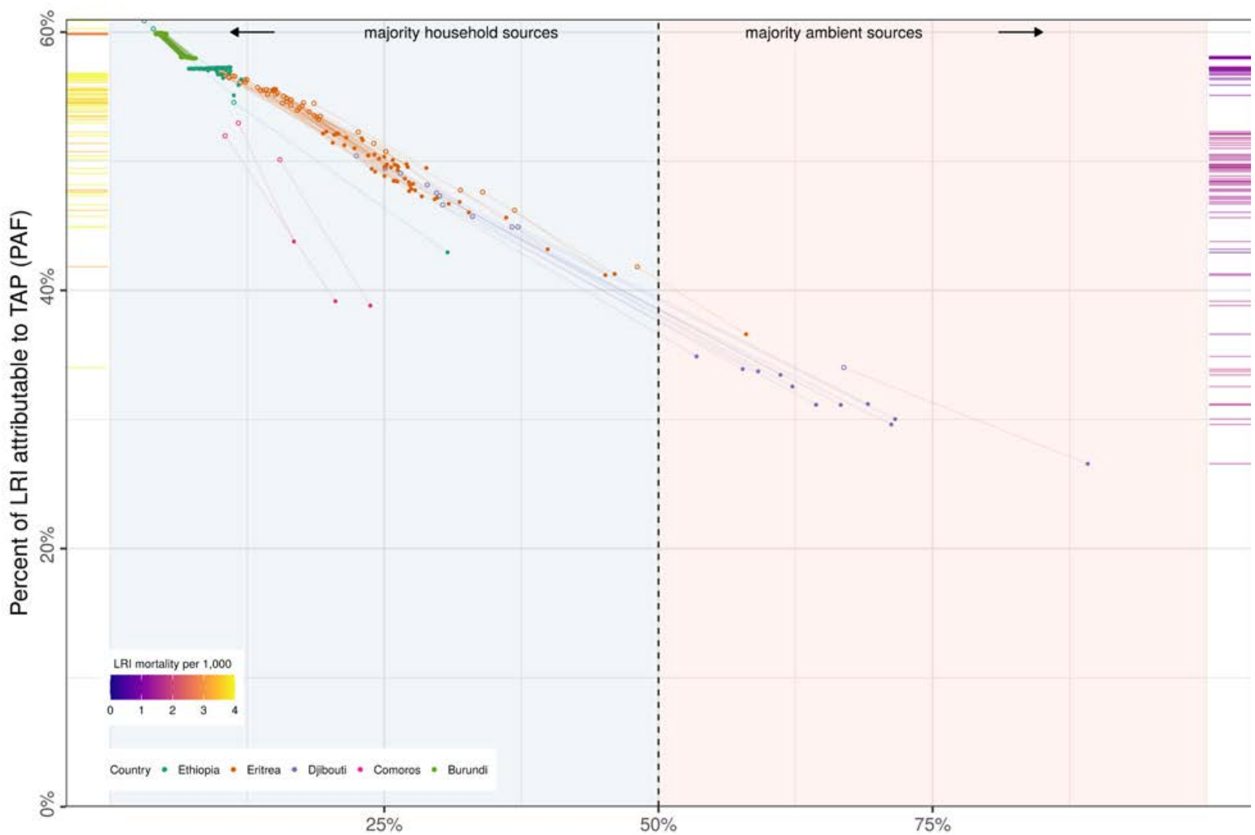
n) South Asia


majority household sources
majority ambient sources
Percent of LRI attributable to TAP (PAF)
60%
40%
20%
0%
25%
50%
75%
LRI mortality per 1,000
0
1
2
3
4
Country
Pakistan
Nepal
India
Bhutan
Bangladesh

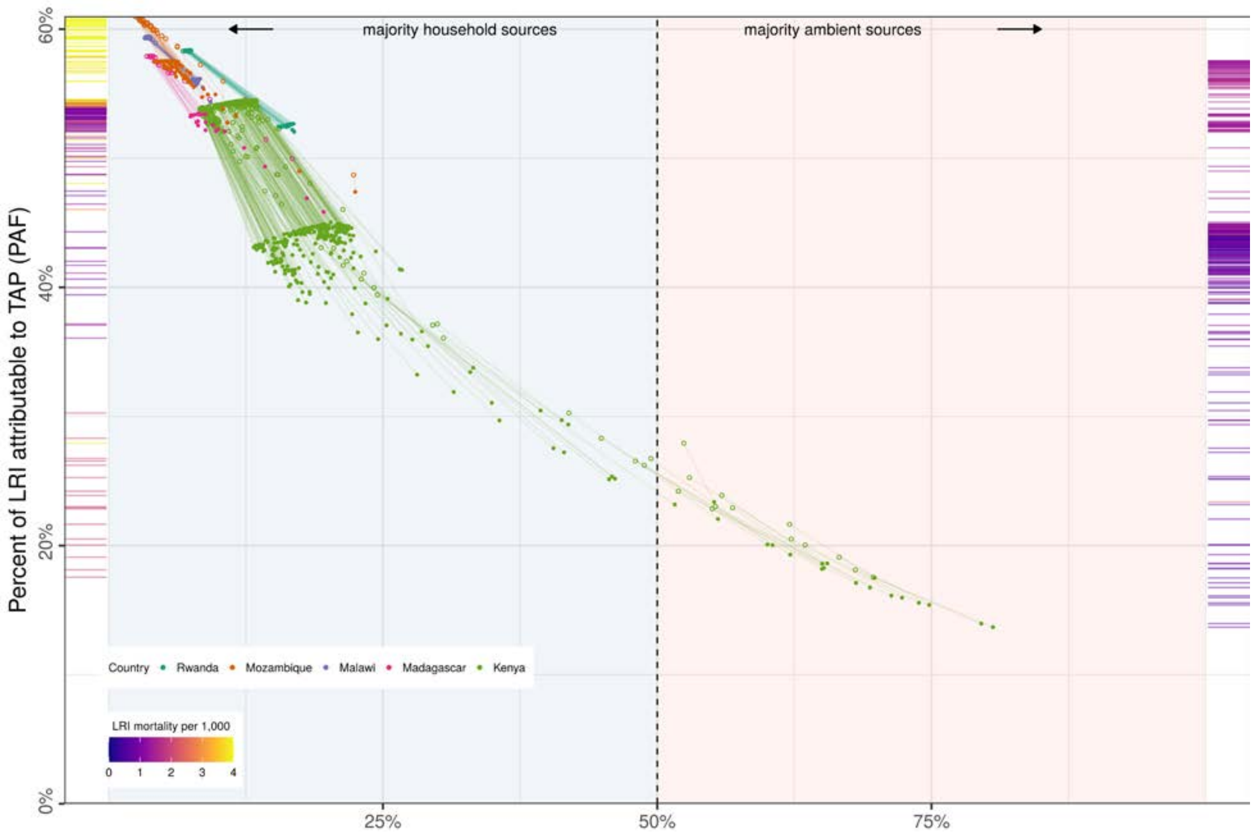
o) Central Sub-Saharan Africa



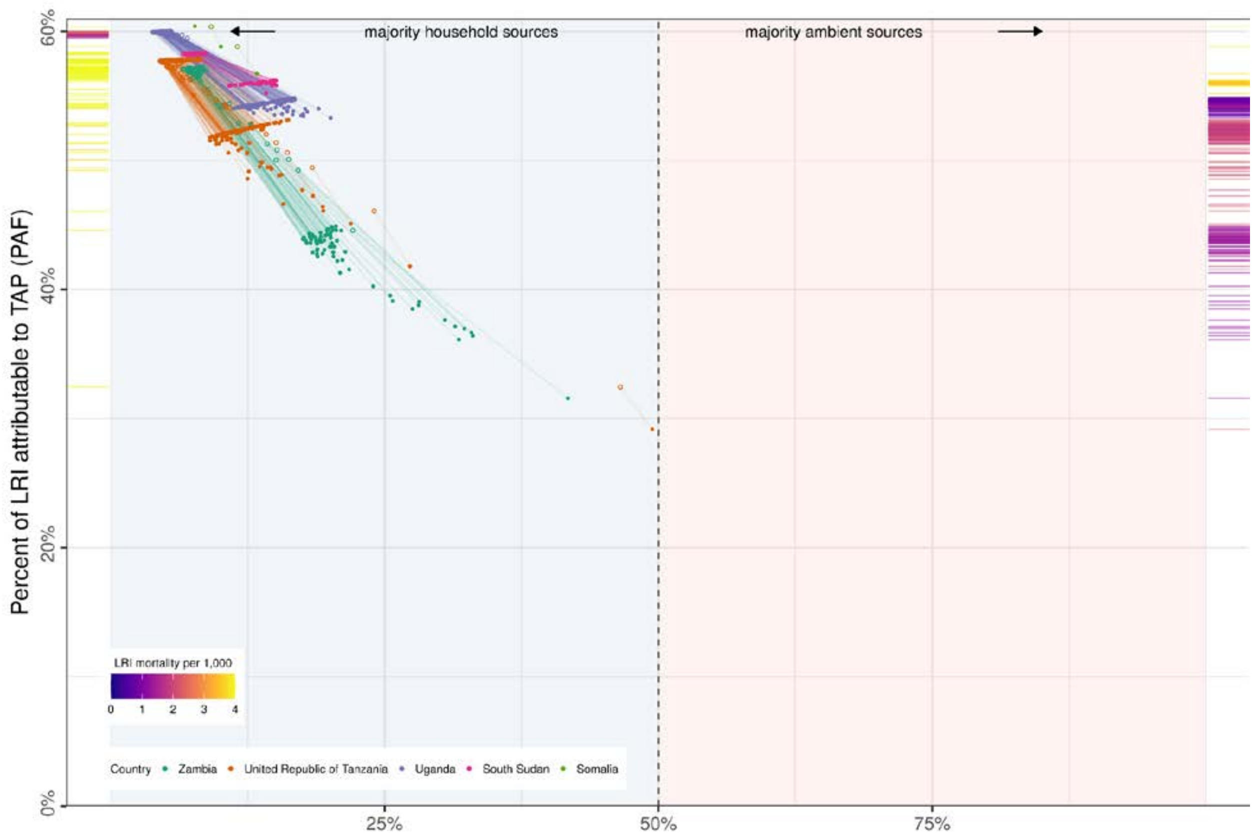
p) Eastern Sub-Saharan Africa



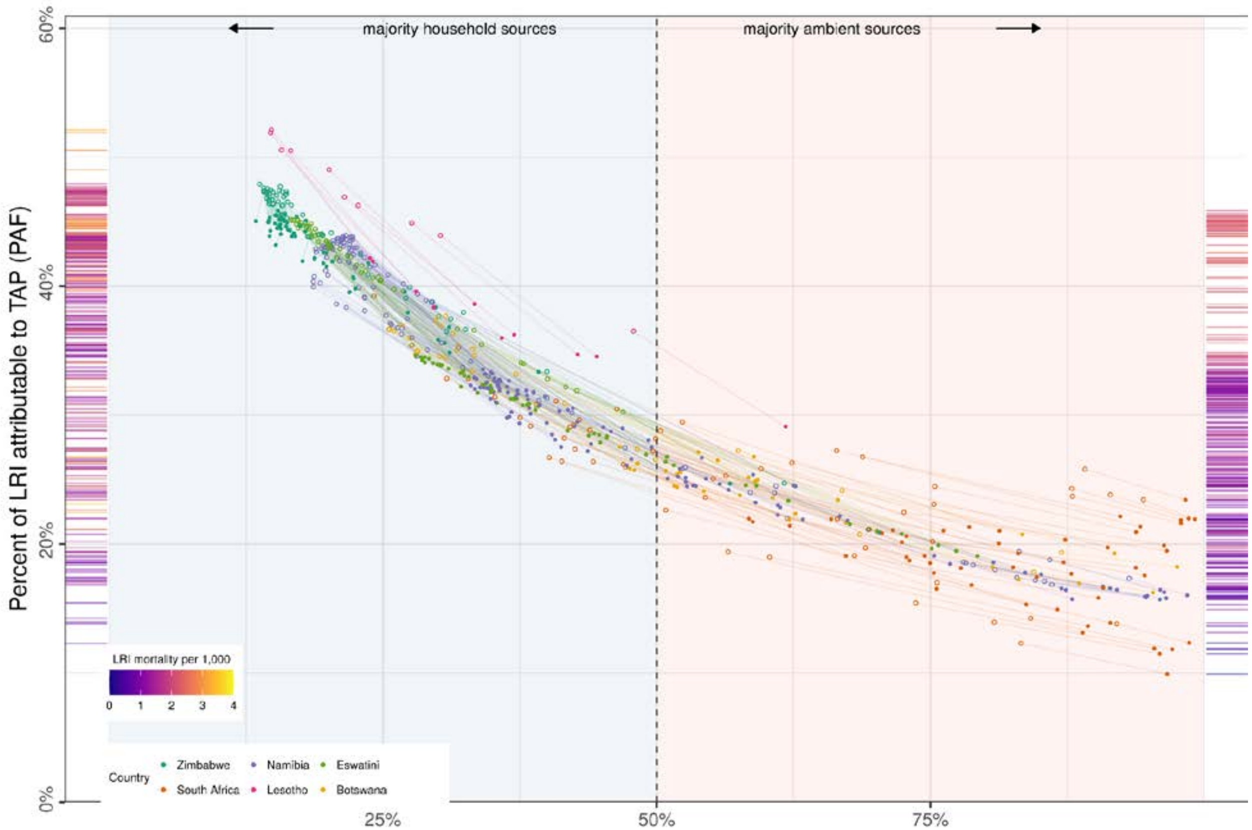
q) Eastern Sub-Saharan Africa, continued



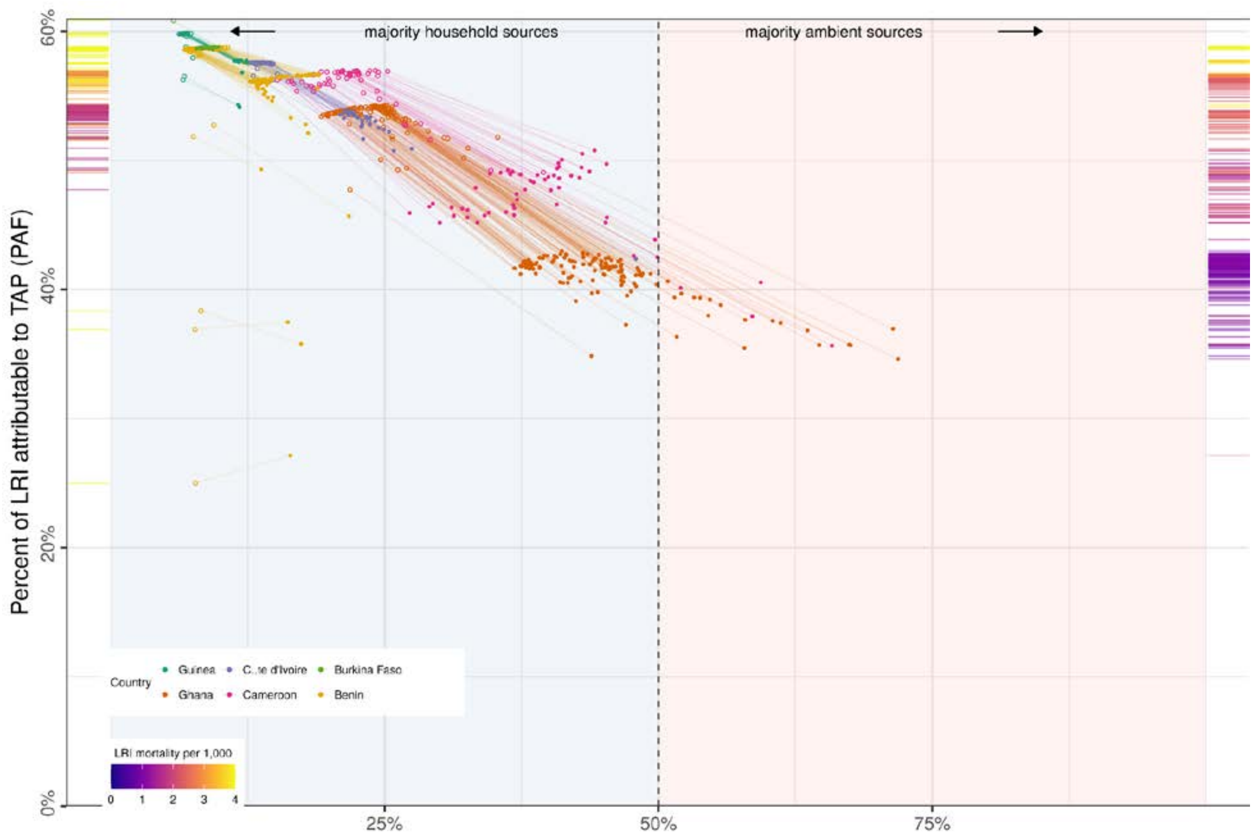
r) Eastern Sub-Saharan Africa, Continued



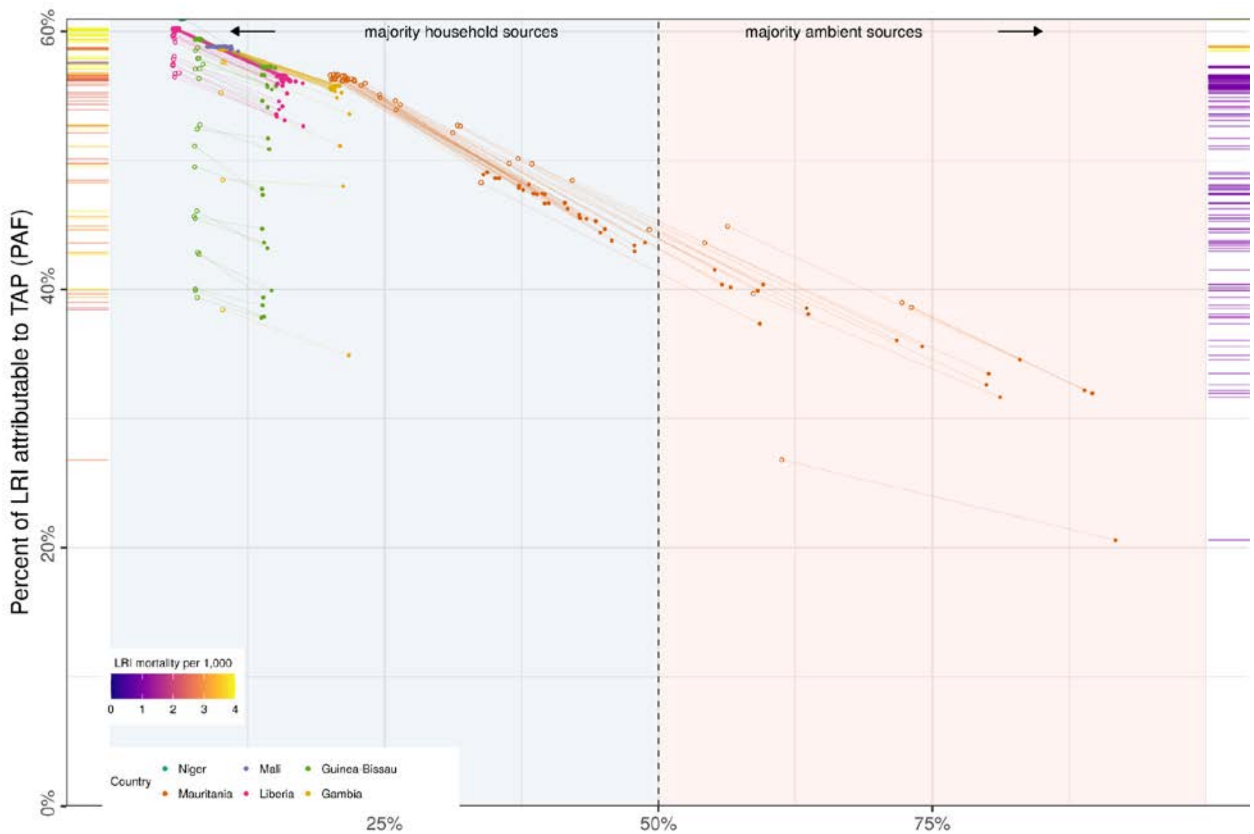
s) Southern Sub-Saharan Africa



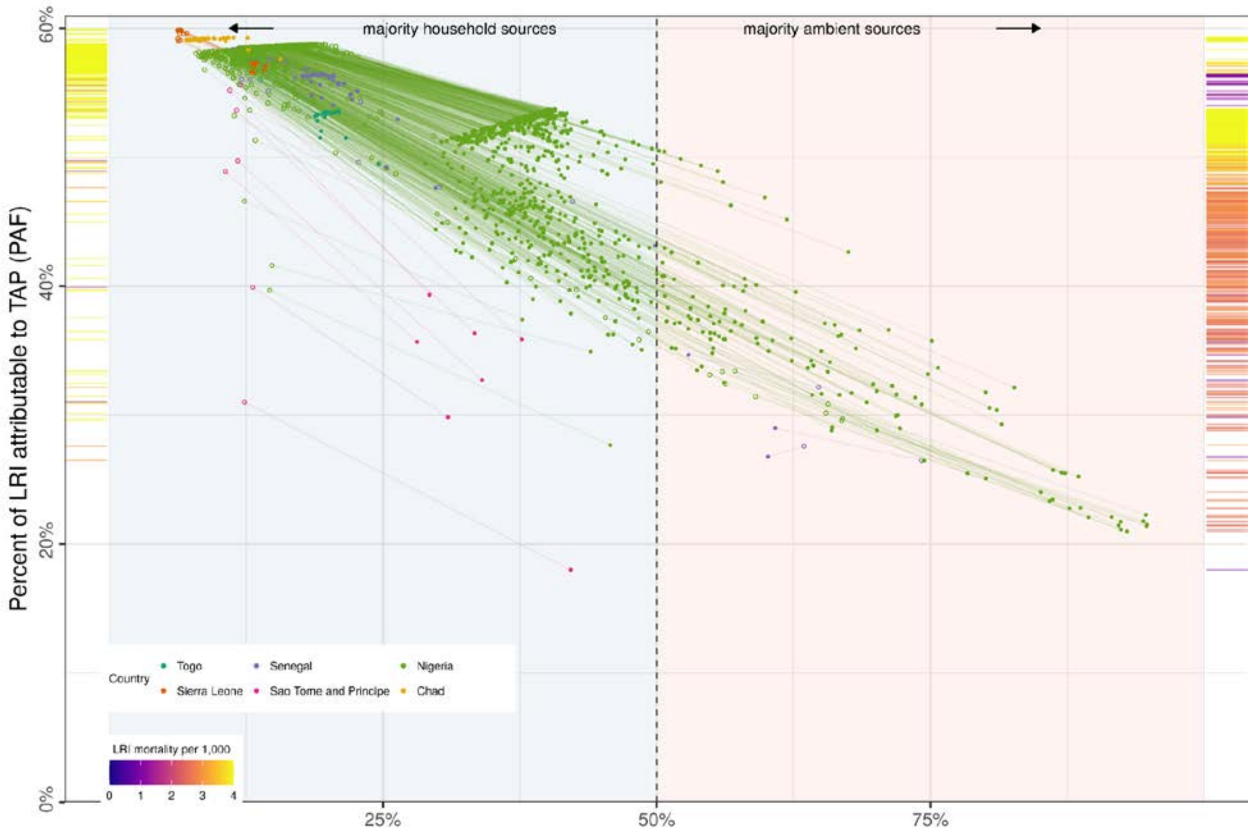
t) Western Sub-Saharan Africa



u) Western Sub-Saharan Africa, Continued

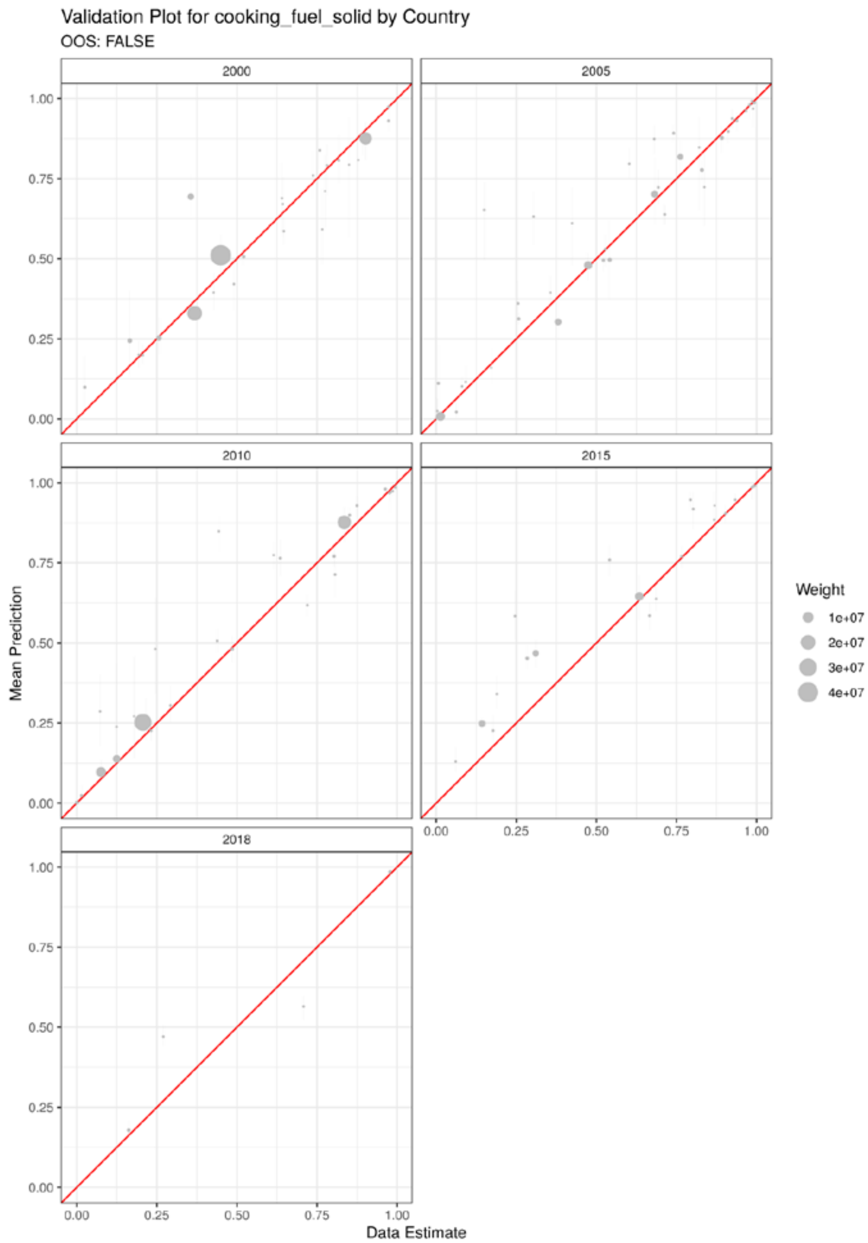


v) Western Sub-Saharan Africa, Continued

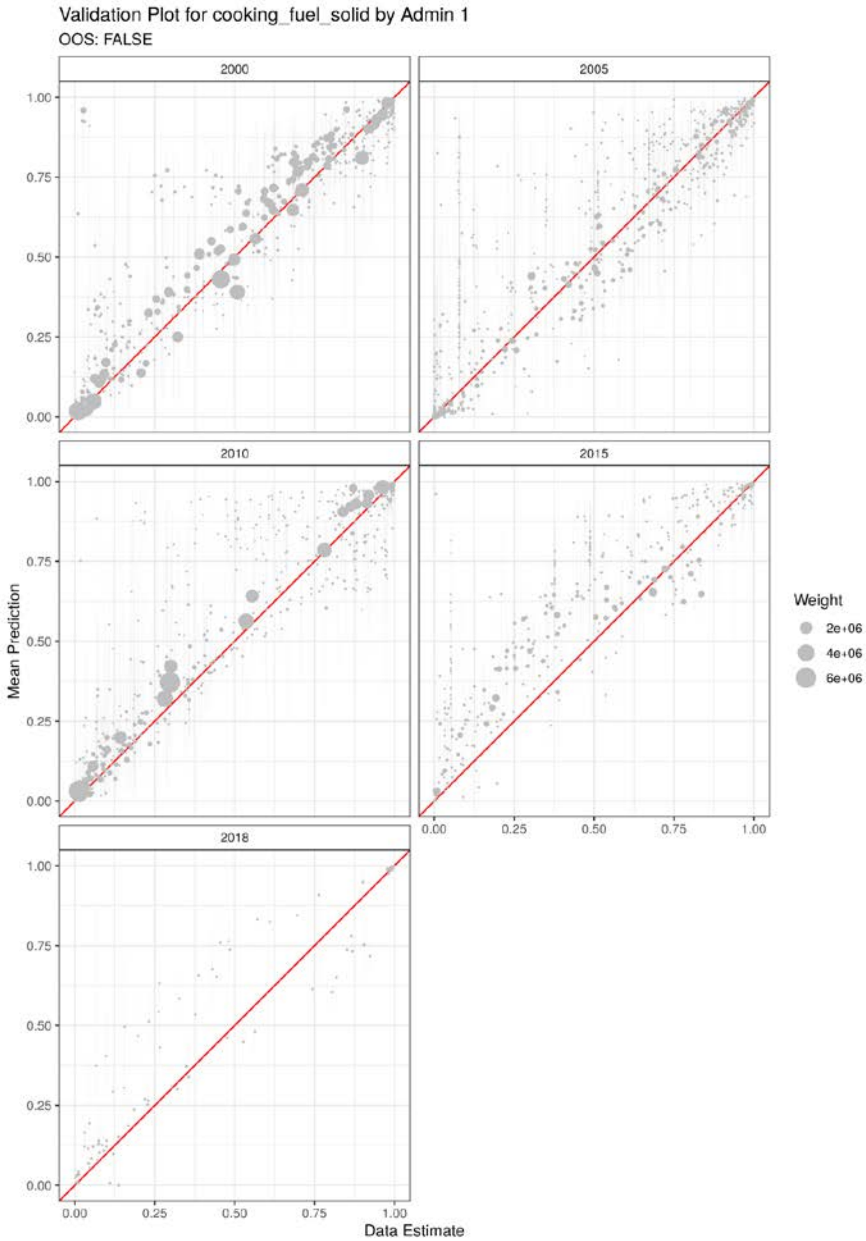


Supplementary Figure 19a-c: SFU in-sample by aggregation level

a) **Admin 0**

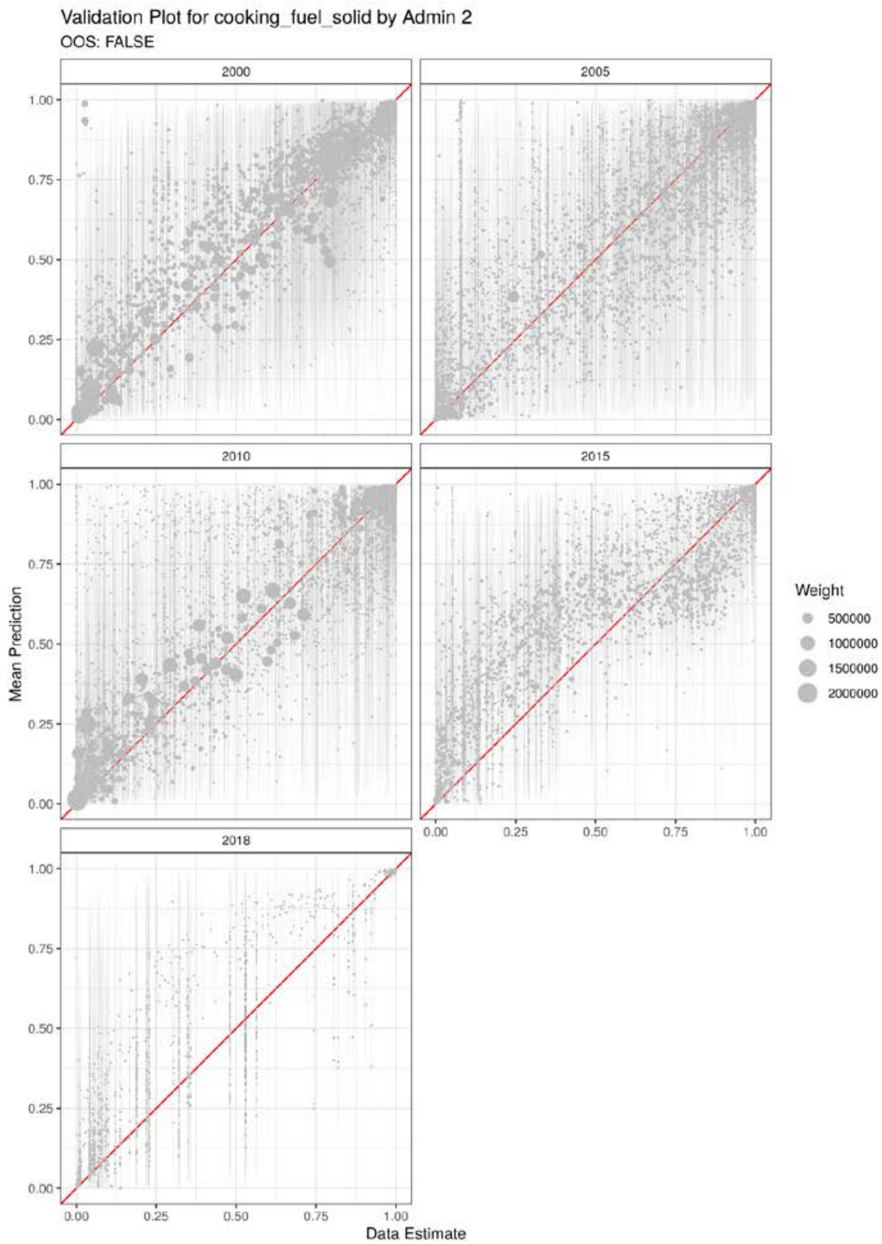


b) Admin 1



Validation Plot for cooking_fuel_solid by Admin 1
OOS: FALSE
2000
2005
2010
2015
2018
Mean Prediction
Data Estimate
0.00
0.25
0.50
0.75
1.00
Weight
2e+06
4e+06
6e+06

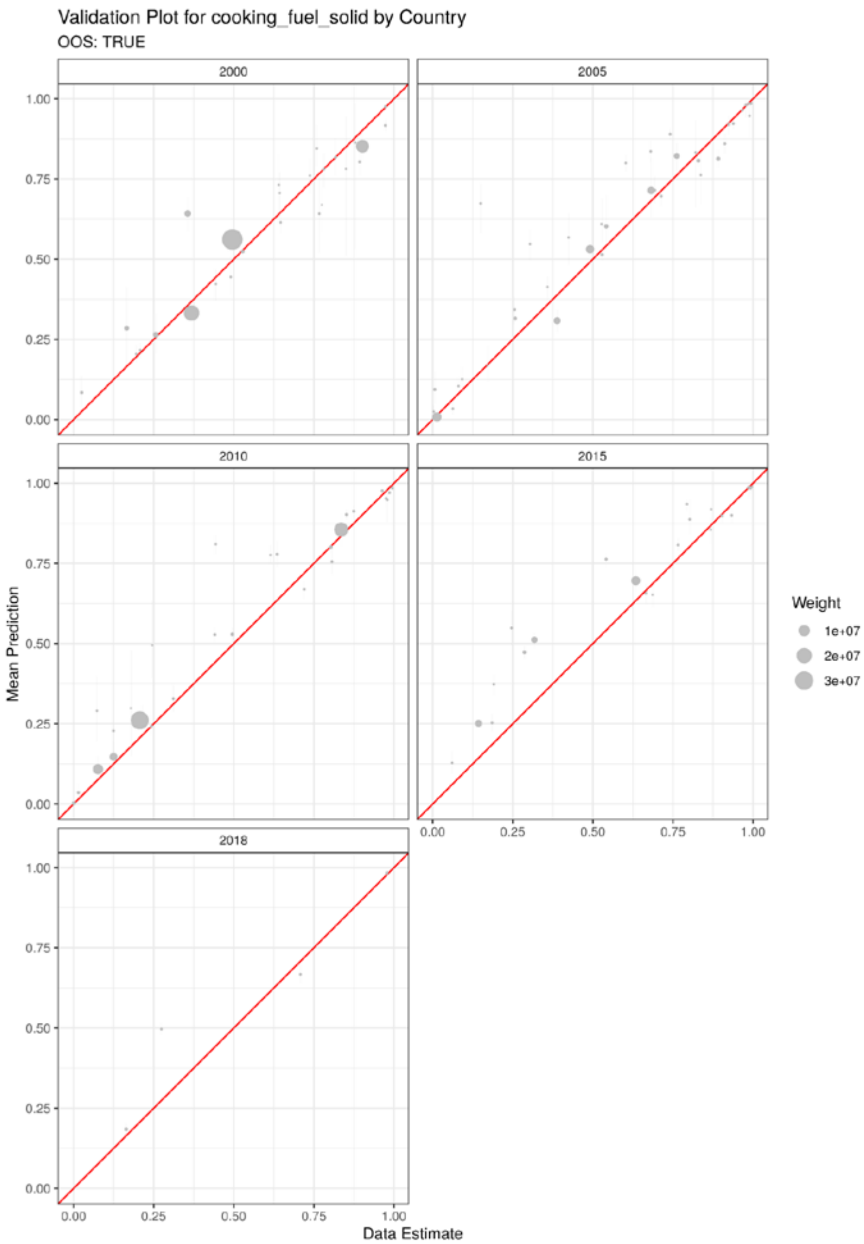
c) Admin 2



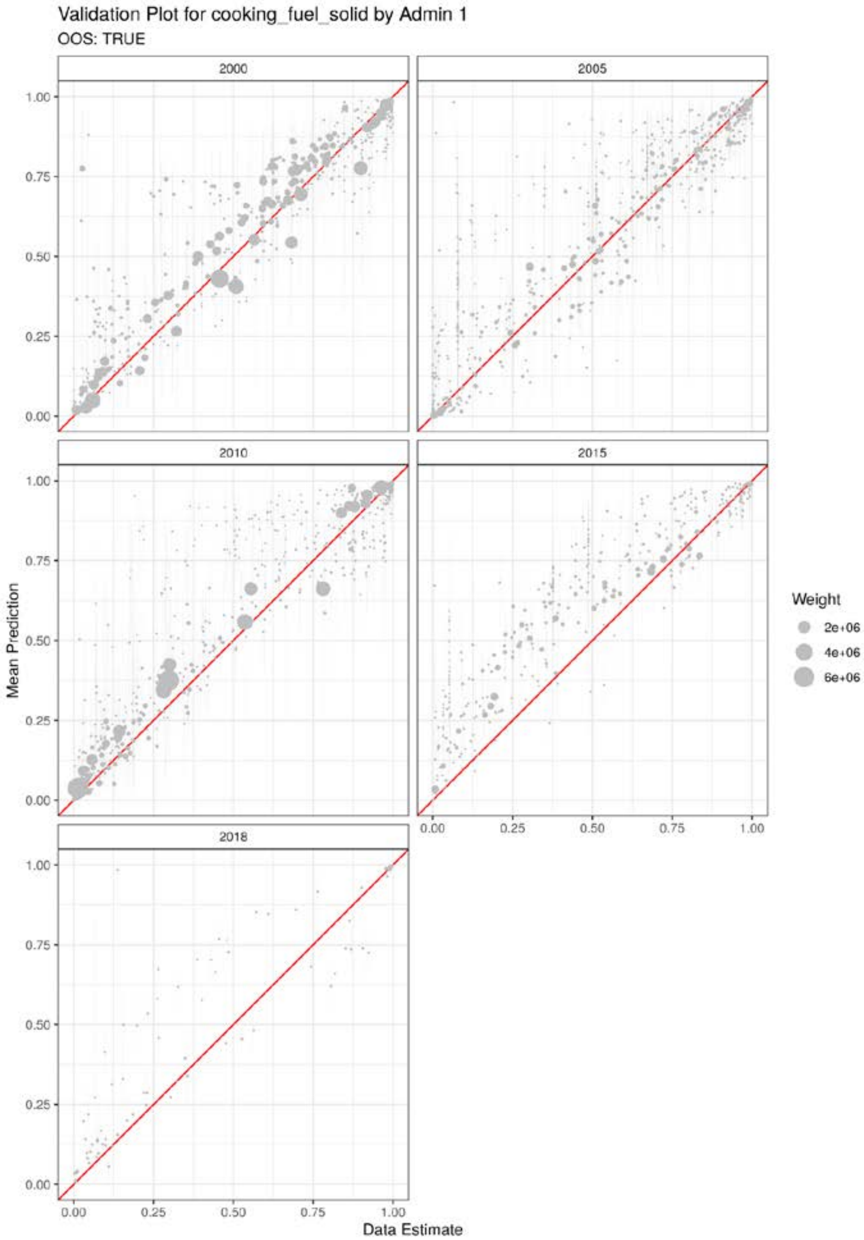
Validation Plot for cooking_fuel_solid by Admin 2
OOS: FALSE
2000
2005
2010
2015
2018
Mean Prediction
Data Estimate
0.00
0.25
0.50
0.75
1.00
Weight
500000
1000000
1500000
2000000

Supplementary Figure 20a-c: SFU out-of-sample by aggregation level

a) **Admin 0**

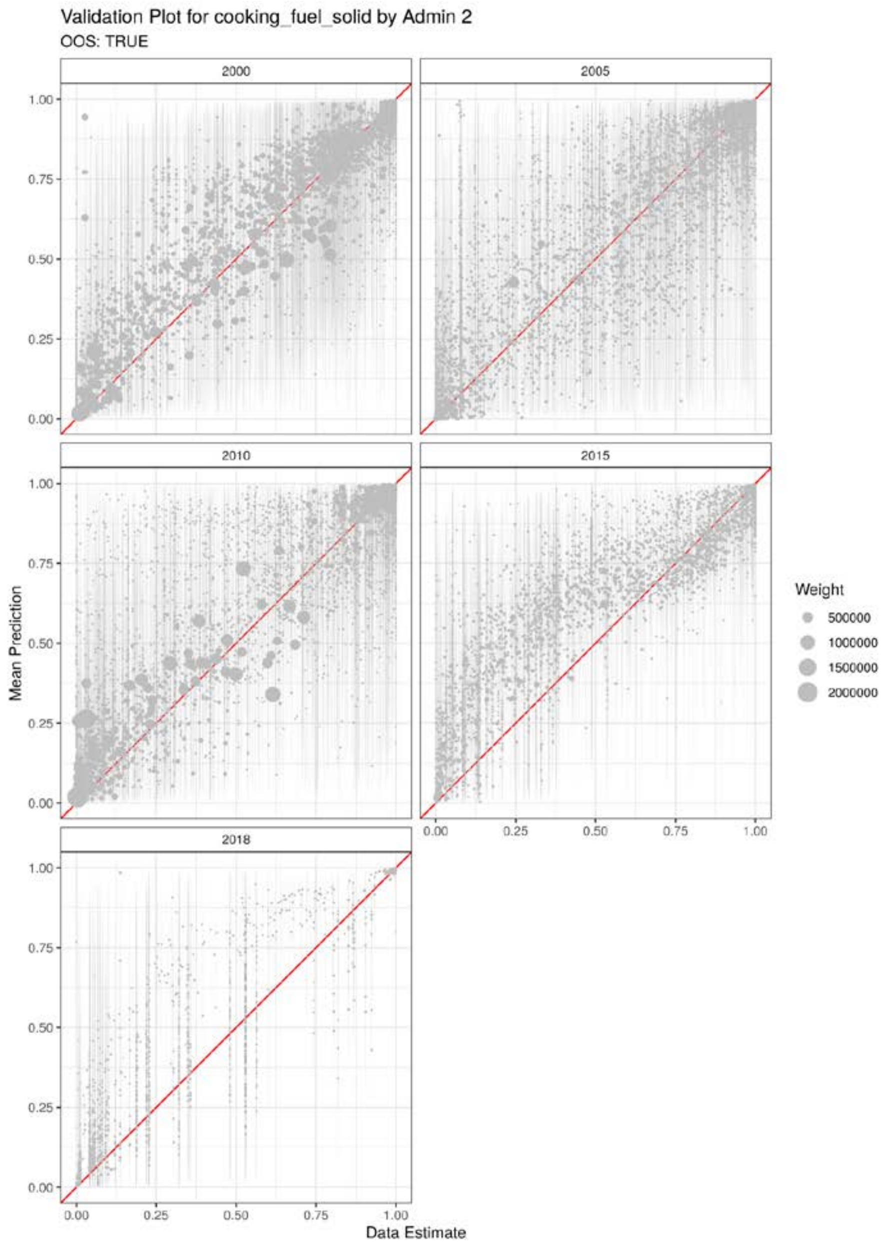


b) Admin 1



Validation Plot for cooking_fuel_solid by Admin 1
OOS: TRUE
2000
2005
2010
2015
2018
Mean Prediction
Data Estimate
0.00
0.25
0.50
0.75
1.00
Weight
2e+06
4e+06
6e+06

c) Admin 2



Validation Plot for cooking_fuel_solid by Admin 2
OOS: TRUE
2000
2005
2010
2015
2018
Mean Prediction
Data Estimate
0.00
0.25
0.50
0.75
1.00
Weight
500000
1000000
1500000
2000000

5.0 Supplementary Tables

Supplementary Table 1: Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER)

This table's 'Reported on' column is currently only tentative will be updated when all manuscript and Supplementary Information text are finalized.

Item #	Checklist item	Reported on
Objectives and funding		
1	Define the indicator(s), populations (including age, sex, and geographic entities), and time period(s) for which estimates were made.	Manuscript: Methods Supplementary Information: Data Section
2	List the funding sources for the work.	Manuscript: Acknowledgements
Data Inputs		
For all data inputs from multiple sources that are synthesized as part of the study:		
3	Describe how the data were identified and how the data were accessed.	Manuscript: Methods Supplementary Information: Data Section
4	Specify the inclusion and exclusion criteria. Identify all ad-hoc exclusions.	Manuscript: Methods Supplementary Information: Data Section; Figure 1
5	Provide information on all included data sources and their main characteristics. For each data source used,	Supplementary Information: Data Section

	report reference information or contact name/institution, population represented, data collection method, year(s) of data collection, sex and age range, diagnostic criteria or measurement method, and sample size, as relevant.	
6	Identify and describe any categories of input data that have potentially important biases (e.g., based on characteristics listed in item 5).	Manuscript: Methods, Limitations
For data inputs that contribute to the analysis but were not synthesized as part of the study:		
7	Describe and give sources for any other data inputs.	Manuscript: Methods Supplementary Information: Covariates Section
For all data inputs:		
8	Provide all data inputs in a file format from which data can be efficiently extracted (e.g., a spreadsheet rather than a PDF), including all relevant meta-data listed in item 5. For any data inputs that cannot be shared because of ethical or legal reasons, such as third-party ownership, provide a contact name or the name of the institution that retains the right to the data.	**GHDx link available upon publication** Supplementary Information: Data Section
Data analysis		
9	Provide a conceptual overview of the data analysis method. A diagram may be helpful.	Manuscript: Methods Supplementary Information: Figure 1-2
10	Provide a detailed description of all steps of the analysis, including mathematical formulae. This description should cover, as relevant, data cleaning, data pre-processing, data adjustments and weighting of data sources, and mathematical or statistical model(s).	Manuscript: Methods Supplementary Information: Data section, Figure 1-2
11	Describe how candidate models were evaluated and how the final model(s) were selected.	Manuscript: Methods
12	Provide the results of an evaluation of model performance, if done, as well as the results of any relevant sensitivity analysis.	Manuscript: Methods
13	Describe methods for calculating uncertainty of the estimates. State which sources of uncertainty were, and were not, accounted for in the uncertainty analysis.	Manuscript: Methods
14	State how analytic or statistical source code used to generate estimates can be accessed.	https://github.com
Results and Discussion		
15	Provide published estimates in a file format from which data can be efficiently extracted.	**GHDx link available upon publication**

16	Report a quantitative measure of the uncertainty of the estimates (e.g., uncertainty intervals).	Manuscript: Methods
17	Interpret results in light of existing evidence. If updating a previous set of estimates, describe the reasons for changes in estimates.	Manuscript: Discussion, Limitations, Future Work
18	Discuss limitations of the estimates. Include a discussion of any modelling assumptions or data limitations that affect interpretation of the estimates.	Manuscript: Discussion, Limitations, Future Work

Supplementary Table 2: Socio-demographic Index (SDI) of countries included in analysis

Location Name	ISO3	Region	SDI Level (2019)	SDI (2019)
Afghanistan	AFG	North Africa and Middle East	Low SDI	0.343232181
Benin	BEN	Western Sub-Saharan Africa	Low SDI	0.352031382
Burkina Faso	BFA	Western Sub-Saharan Africa	Low SDI	0.25738523
Burundi	BDI	Eastern Sub-Saharan Africa	Low SDI	0.2839369
Central African Republic	CAF	Central Sub-Saharan Africa	Low SDI	0.273669311
Chad	TCD	Western Sub-Saharan Africa	Low SDI	0.238012087
Comoros	COM	Eastern Sub-Saharan Africa	Low SDI	0.45466725
Cote d'Ivoire	CIV	Western Sub-Saharan Africa	Low SDI	0.408196034
Democratic Republic of the Congo	COD	Central Sub-Saharan Africa	Low SDI	0.382172191
Eritrea	ERI	Eastern Sub-Saharan Africa	Low SDI	0.39598799

Ethiopia	ETH	Eastern Sub-Saharan Africa	Low SDI	0.342967449
Guinea	GIN	Western Sub-Saharan Africa	Low SDI	0.324580469
Guinea-Bissau	GNB	Western Sub-Saharan Africa	Low SDI	0.355423473
Haiti	HTI	Caribbean	Low SDI	0.431969896
Liberia	LBR	Western Sub-Saharan Africa	Low SDI	0.369615587
Madagascar	MDG	Eastern Sub-Saharan Africa	Low SDI	0.396293769
Malawi	MWI	Eastern Sub-Saharan Africa	Low SDI	0.383936706
Mali	MLI	Western Sub-Saharan Africa	Low SDI	0.263484935
Mozambique	MOZ	Eastern Sub-Saharan Africa	Low SDI	0.3073155
Nepal	NPL	South Asia	Low SDI	0.421996036
Niger	NER	Western Sub-Saharan Africa	Low SDI	0.161629227
Papua New Guinea	PNG	Oceania	Low SDI	0.394095992
Rwanda	RWA	Eastern Sub-Saharan Africa	Low SDI	0.429139732
Senegal	SEN	Western Sub-Saharan Africa	Low SDI	0.388935561
Sierra Leone	SLE	Western Sub-Saharan Africa	Low SDI	0.347333599
Somalia	SOM	Eastern Sub-Saharan Africa	Low SDI	0.080983671
South Sudan	SSD	Eastern Sub-Saharan Africa	Low SDI	0.363419895
Tanzania	TZA	Eastern Sub-Saharan Africa	Low SDI	0.423252126
The Gambia	GMB	Western Sub-Saharan Africa	Low SDI	0.398656595
Togo	TGO	Western Sub-Saharan Africa	Low SDI	0.417121069
Uganda	UGA	Eastern Sub-Saharan Africa	Low SDI	0.404470575
Yemen	YEM	North Africa and Middle East	Low SDI	0.412238638
Algeria	DZA	North Africa and Middle East	Middle SDI	0.651946134
Botswana	BWA	Southern Sub-Saharan Africa	Middle SDI	0.634369974
Brazil	BRA	Tropical Latin America	Middle SDI	0.639528523
Colombia	COL	Central Latin America	Middle SDI	0.632568305
Costa Rica	CRI	Central Latin America	Middle SDI	0.680111655
Ecuador	ECU	Andean Latin America	Middle SDI	0.639975089

Egypt	EGY	North Africa and Middle East	Middle SDI	0.657680121
Equatorial Guinea	GNQ	Central Sub-Saharan Africa	Middle SDI	0.685124105
Gabon	GAB	Central Sub-Saharan Africa	Middle SDI	0.655830167
Guyana	GUY	Caribbean	Middle SDI	0.618266528
Indonesia	IDN	Southeast Asia	Middle SDI	0.659878161
Iraq	IRQ	North Africa and Middle East	Middle SDI	0.670654
Jamaica	JAM	Caribbean	Middle SDI	0.684352436
Mexico	MEX	Central Latin America	Middle SDI	0.64908918
Namibia	NAM	Southern Sub-Saharan Africa	Middle SDI	0.612335601
Panama	PAN	Central Latin America	Middle SDI	0.685526052
Paraguay	PRY	Tropical Latin America	Middle SDI	0.638276934
Peru	PER	Andean Latin America	Middle SDI	0.648408781
Philippines	PHL	Southeast Asia	Middle SDI	0.622858401
South Africa	ZAF	Southern Sub-Saharan Africa	Middle SDI	0.67825053
Suriname	SUR	Caribbean	Middle SDI	0.635912299
Syria	SYR	North Africa and Middle East	Middle SDI	0.619444771
Thailand	THA	Southeast Asia	Middle SDI	0.686576643
Tunisia	TUN	North Africa and Middle East	Middle SDI	0.67176511
Turkmenistan	TKM	Central Asia	Middle SDI	0.670472955
Uzbekistan	UZB	Central Asia	Middle SDI	0.631435113
Vietnam	VNM	Southeast Asia	Middle SDI	0.61743942
Angola	AGO	Central Sub-Saharan Africa	Low-middle SDI	0.469857606
Bangladesh	BGD	South Asia	Low-middle SDI	0.482676885
Belize	BLZ	Caribbean	Low-middle SDI	0.602517206
Bhutan	BTN	South Asia	Low-middle SDI	0.455077121
Bolivia	BOL	Andean Latin America	Low-middle SDI	0.56641717
Cambodia	KHM	Southeast Asia	Low-middle SDI	0.468990684
Cameroon	CMR	Western Sub-Saharan Africa	Low-middle SDI	0.489610885
Djibouti	DJI	Eastern Sub-Saharan Africa	Low-middle SDI	0.458670351
Dominican Republic	DOM	Caribbean	Low-middle SDI	0.591906159
El Salvador	SLV	Central Latin America	Low-middle SDI	0.572623622
Ghana	GHA	Western Sub-Saharan Africa	Low-middle SDI	0.556887637
Guatemala	GTM	Central Latin America	Low-middle SDI	0.526345014
Honduras	HND	Central Latin America	Low-middle SDI	0.495975306

India	IND	South Asia	Low-middle SDI	0.565900043
Kenya	KEN	Eastern Sub-Saharan Africa	Low-middle SDI	0.50844187
Kyrgyzstan	KGZ	Central Asia	Low-middle SDI	0.595661124
Laos	LAO	Southeast Asia	Low-middle SDI	0.48997377
Lesotho	LSO	Southern Sub-Saharan Africa	Low-middle SDI	0.507011919
Mauritania	MRT	Western Sub-Saharan Africa	Low-middle SDI	0.49569688
Mongolia	MNG	Central Asia	Low-middle SDI	0.605566533
Morocco	MAR	North Africa and Middle East	Low-middle SDI	0.548494837
Myanmar	MMR	Southeast Asia	Low-middle SDI	0.520765117
Nicaragua	NIC	Central Latin America	Low-middle SDI	0.516771682
Nigeria	NGA	Western Sub-Saharan Africa	Low-middle SDI	0.51525579
Pakistan	PAK	South Asia	Low-middle SDI	0.448851517
Palestine	PSE	North Africa and Middle East	Low-middle SDI	0.587868157
Republic of the Congo	COG	Central Sub-Saharan Africa	Low-middle SDI	0.568429044
Sao Tome and Principe	STP	Western Sub-Saharan Africa	Low-middle SDI	0.502156323
Sudan	SDN	North Africa and Middle East	Low-middle SDI	0.515086174
Swaziland	SWZ	Southern Sub-Saharan Africa	Low-middle SDI	0.577452676
Tajikistan	TJK	Central Asia	Low-middle SDI	0.538654316
Timor-Leste	TLS	Southeast Asia	Low-middle SDI	0.51372636
Zambia	ZMB	Eastern Sub-Saharan Africa	Low-middle SDI	0.505086432
Zimbabwe	ZWE	Southern Sub-Saharan Africa	Low-middle SDI	0.475632182
China	CHN	East Asia	High-middle SDI	0.685967969
Iran	IRN	North Africa and Middle East	High-middle SDI	0.670415892
Jordan	JOR	North Africa and Middle East	High-middle SDI	0.731025449
Libya	LBY	North Africa and Middle East	High-middle SDI	0.709294185
Sri Lanka	LKA	Southeast Asia	High-middle SDI	0.689520933
Trinidad and Tobago	TTO	Caribbean	High-middle SDI	0.756858482

Supplementary Table 3: Socio-demographic Index (SDI) of countries excluded from analysis

Location Name	ISO3	Region	SDI Level (2019)	SDI (2019)
Solomon Islands	SLB	Oceania	Low SDI	0.406846203
Cuba	CUB	Caribbean	Middle SDI	0.667855786
Fiji	FJI	Oceania	Middle SDI	0.664044301
Grenada	GRD	Caribbean	Middle SDI	0.66915426
Saint Lucia	LCA	Caribbean	Middle SDI	0.670409821
Saint Vincent and the Grenadines	VCT	Caribbean	Middle SDI	0.626784725
Samoa	WSM	Oceania	Middle SDI	0.640812792
Tonga	TON	Oceania	Middle SDI	0.635899444
Cape Verde	CPV	Western Sub-Saharan Africa	Low-middle SDI	0.524957239
Federated States of Micronesia	FSM	Oceania	Low-middle SDI	0.579853271
Kiribati	KIR	Oceania	Low-middle SDI	0.526513752
Maldives	MDV	Southeast Asia	Low-middle SDI	0.561816599
Marshall Islands	MHL	Oceania	Low-middle SDI	0.544149104
Vanuatu	VUT	Oceania	Low-middle SDI	0.484678789
Venezuela	VEN	Central Latin America	Low-middle SDI	0.606514719
American Samoa	ASM	Oceania	High-middle SDI	0.712008609
Dominica	DMA	Caribbean	High-middle SDI	0.72914183
Malaysia	MYS	Southeast Asia	High-middle SDI	0.737370877
Seychelles	SYC	Southeast Asia	High-middle SDI	0.723944512

Supplementary Table 4: Cooking Fuel input dataset

NID	ISO3	Start Year	End Year	Survey Series	Survey Module
20888	TLS	2003	2003	ADB_DHS	HH
18468	AFG	2006	2006	AFG/HEALTH_SURVEY_2006	HH
30394	AGO	2008	2009	AGO/INTEGRATED_SURVEY_ON_POPULATION_WELFARE	HHM
107340	LBY	2007	2007	ARAB_LEAGUE_PAPFAM	HHM
126909	MAR	2010	2011	ARAB_LEAGUE_PAPFAM	WN
9999	PSE	2006	2007	ARAB_LEAGUE_PAPFAM	HH
126911	SYR	2009	2009	ARAB_LEAGUE_PAPFAM	HH
151805	BEN	2011	2012	BEN/HOUSEHOLD_LIVING_CONDITIONS_SURVEY	HH

236156	BFA	2014	2014	BFA/CONTINUOUS_MULTISECTORAL_SURVEY_EMC	HHM
283269	BGD	2015	2015	BGD/INTEGRATED_HOUSEHOLD_SURVEY	HHM
153062	BGD	2011	2012	BGD/INTEGRATED_HOUSEHOLD_SURVEY_MALE	HH
336686	BOL	2016	2016	BOL_HHS	HHM
317285	BOL	2015	2015	BOL_HHS	HHM
1245	BOL	2000	2000	BOL/HH_SURVEY	HH
1259	BOL	2001	2001	BOL/HH_SURVEY	HHM
1278	BOL	2002	2002	BOL/HH_SURVEY	HH
32374	BOL	2003	2004	BOL/HH_SURVEY	HHM
32388	BOL	2005	2005	BOL/HH_SURVEY	HHM
148343	BOL	2006	2006	BOL/HH_SURVEY	WN
148344	BOL	2007	2007	BOL/HH_SURVEY	HHM
164634	BOL	2011	2011	BOL/HH_SURVEY	HHM
164635	BOL	2013	2013	BOL/HH_SURVEY	HH
283486	BOL	2014	2014	BOL/HH_SURVEY	HHM
93522	BRA	2009	2009	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
93487	BRA	2008	2008	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
1489	BRA	2003	2003	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
238441	BRA	2014	2014	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
106724	BRA	2011	2011	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
156581	BRA	2012	2012	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
156583	BRA	2013	2013	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
281548	BRA	2015	2015	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
1488	BRA	2002	2002	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
93490	BRA	2007	2007	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
1490	BRA	2004	2004	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
1477	BRA	2001	2001	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HHM
80311	BRA	2005	2005	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
93528	BRA	2006	2006	BRA/HOUSEHOLD_SAMPLE_SURVEY_PNAD	HH
195010	BRA	2013	2013	BRA/NATIONAL_HEALTH_SURVEY_PNS	HHM
32244	BRA	2002	2005	BRA/RISK_FACTOR_MORBIDITY_NCD_SURVEY	HH
1175	BTN	2005	2005	BTN/CENSUS	HHM
151536	BWA	2009	2010	BWA_CWIS	HHM
22114	BWA	2004	2004	BWA/AIDS_IMPACT_SURVEY	HHM
134753	BWA	2013	2013	BWA/AIDS_IMPACT_SURVEY	HHM

21970	BWA	2006	2006	BWA/DEMOGRAPHIC_SURVEY	HH
22125	BWA	2007	2008	BWA/FAMILY_HEALTH_SURVEY	HH
4779	GTM	2008	2009	CDC_RHS	WN
10370	PRY	2004	2004	CDC_RHS	WN
27525	PRY	2008	2008	CDC_RHS	WN
27599	SLV	2002	2003	CDC_RHS	WN
314646	BLZ	2013	2013	CHILD_ACTIVITY_SURVEY	HH
283812	CHN	2010	2010	CHINA_FAMILY_PANEL_STUDIES	HH
283815	CHN	2012	2012	CHINA_FAMILY_PANEL_STUDIES	HH
2039	CMR	2001	2001	CMR/HH_SURVEY	HH
3100	COL	2007	2008	COL/NATIONAL_HEALTH_SURVEY_ENS	HH
68396	COL	2011	2011	COL/NATIONAL_QUALITY_OF_LIFE_SURVEY_ENCV	HH
68334	COL	2010	2010	COL/NATIONAL_QUALITY_OF_LIFE_SURVEY_ENCV	HH
3209	CRI	2001	2001	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3212	CRI	2002	2002	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3218	CRI	2003	2003	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3215	CRI	2004	2004	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3177	CRI	2005	2005	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3180	CRI	2006	2006	CRI/MULTIPURPOSE_HH_SURVEY	HHM
3183	CRI	2007	2007	CRI/MULTIPURPOSE_HH_SURVEY	HHM
30434	CRI	2008	2008	CRI/MULTIPURPOSE_HH_SURVEY	HHM
30437	CRI	2009	2009	CRI/MULTIPURPOSE_HH_SURVEY	HHM
149360	CRI	2010	2010	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
149366	CRI	2011	2011	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
149372	CRI	2012	2012	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
169717	CRI	2014	2014	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
238431	CRI	2015	2015	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
282883	CRI	2016	2016	CRI/NATIONAL_HOUSEHOLD_SURVEY_ENAHO	HHM
3455	DOM	2006	2006	DOM/HOUSEHOLD_SURVEY_ENHOGAR	HH
3441	DOM	2007	2007	DOM/HOUSEHOLD_SURVEY_ENHOGAR	HH
35583	DOM	2005	2005	DOM/HOUSEHOLD_SURVEY_ENHOGAR	HHM
95320	ECU	2010	2010	ECU/CENSUS	HH
46924	ECU	2005	2006	ECU/LIVING_CONDITIONS_SURVEY_ECV	HHM
153674	ECU	2012	2012	ECU/NATIONAL_HEALTH_AND_NUTRITION_SURVEY_ENSA NUT	HHM

323944	BOL	2016	2016	EDSA	HHM
34085	ETH	2004	2004	ETH/WELFARE_MONITORING_SURVEY	HH
365281	ETH	2015	2016	ETH/WELFARE_MONITORING_SURVEY	HH
4010	GHA	2001	2001	GHA/CHILD_LABOR_SURVEY	HHM
5009	HND	2004	2004	HND/SURVEY_OF_LIVING_CONDITIONS	HH
219201	IDN	2012	2012	IDN/FAMILY_LIFE_SURVEY_EAST	HH
43552	IDN	2009	2009	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
150884	IDN	2012	2012	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
151184	IDN	2013	2013	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
85265	IDN	2011	2011	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
65181	IND	2009	2010	IND/COVERAGE_EVALUATION_SURVEY	CH
23219	IND	2002	2004	IND/DISTRICT_LEVEL_HOUSEHOLD_SURVEY	HH
23258	IND	2007	2008	IND/DISTRICT_LEVEL_HOUSEHOLD_SURVEY	HH
165390	IND	2012	2014	IND/DISTRICT_LEVEL_HOUSEHOLD_SURVEY	HH
174154	IND	2010	2010	IND/LONGITUDINAL_AGING_STUDY_IN_INDIA	HH_HHM
225626	IND	2014	2014	IND/NATIONAL_SAMPLE_SURVEY	HHM
5285	IND	2004	2004	IND/NATIONAL_SAMPLE_SURVEY	HH_HHM
129770	IND	2011	2012	IND/NNMB_RURAL_SURVEY	HH
367347	BEN	2002	2002	IPUMS_CENSUS	HHM
367419	BEN	2013	2013	IPUMS_CENSUS	HHM
105403	BFA	2006	2006	IPUMS_CENSUS	HHM
1362	BOL	2001	2001	IPUMS_CENSUS	HHM
294205	BWA	2001	2001	IPUMS_CENSUS	HHM
105800	CMR	2005	2005	IPUMS_CENSUS	HHM
3029	COL	2005	2006	IPUMS_CENSUS	HHM
227111	CRI	2011	2011	IPUMS_CENSUS	HHM
151304	DOM	2010	2010	IPUMS_CENSUS	HHM
3549	ECU	2001	2001	IPUMS_CENSUS	HHM
105801	ECU	2010	2010	IPUMS_CENSUS	HHM
35578	EGY	2006	2006	IPUMS_CENSUS	HHM
38508	GHA	2000	2000	IPUMS_CENSUS	HHM
151306	GHA	2010	2010	IPUMS_CENSUS	HHM
367563	HND	2001	2001	IPUMS_CENSUS	HHM
106473	HTI	2003	2003	IPUMS_CENSUS	HHM

56573	IDN	2005	2005	IPUMS_CENSUS	HHM
39396	IRN	2006	2006	IPUMS_CENSUS	HHM
39450	JAM	2001	2001	IPUMS_CENSUS	HHM
35329	KHM	2008	2008	IPUMS_CENSUS	HHM
151310	LBR	2008	2008	IPUMS_CENSUS	HHM
367585	LSO	2006	2006	IPUMS_CENSUS	HHM
151311	MLI	2009	2009	IPUMS_CENSUS	HHM
40186	MWI	2008	2008	IPUMS_CENSUS	HHM
151312	NGA	2007	2007	IPUMS_CENSUS	HHM
151314	NGA	2009	2009	IPUMS_CENSUS	HHM
151315	NGA	2010	2010	IPUMS_CENSUS	HHM
56520	NIC	2005	2005	IPUMS_CENSUS	HHM
40907	PAN	2000	2000	IPUMS_CENSUS	HHM
106529	PAN	2010	2010	IPUMS_CENSUS	HHM
41267	PER	2007	2007	IPUMS_CENSUS	HHM
41296	PHL	2000	2000	IPUMS_CENSUS	HHM
367607	PHL	2010	2010	IPUMS_CENSUS	HHM
227167	PRY	2002	2002	IPUMS_CENSUS	HHM
41088	PSE	2007	2007	IPUMS_CENSUS	HHM
42432	RWA	2002	2002	IPUMS_CENSUS	HHM
367645	RWA	2012	2012	IPUMS_CENSUS	HHM
43167	SDN	2008	2008	IPUMS_CENSUS	HHM
11661	SLE	2004	2004	IPUMS_CENSUS	HHM
56476	SLV	2007	2007	IPUMS_CENSUS	HHM
106548	SSD	2008	2008	IPUMS_CENSUS	HHM
43231	THA	2000	2000	IPUMS_CENSUS	HHM
294807	TTO	2011	2011	IPUMS_CENSUS	HHM
43212	TZA	2002	2002	IPUMS_CENSUS	HHM
294725	TZA	2012	2012	IPUMS_CENSUS	HHM
43328	UGA	2002	2002	IPUMS_CENSUS	HHM
43412	VEN	2001	2001	IPUMS_CENSUS	HHM
43726	VNM	2009	2009	IPUMS_CENSUS	HHM
43152	ZAF	2001	2001	IPUMS_CENSUS	HHM
43158	ZAF	2007	2007	IPUMS_CENSUS	HHM
227194	ZAF	2011	2011	IPUMS_CENSUS	HHM

151325	ZMB	2000	2000	IPUMS_CENSUS	HHM
151326	ZMB	2010	2010	IPUMS_CENSUS	HHM
367747	ZWE	2012	2012	IPUMS_CENSUS	HHM
34524	IRQ	2006	2007	IRQ/HH_SOCIOECONOMIC_SURVEY	HHM
133219	KEN	2007	2007	KEN/AIDS_INDICATOR_SURVEY	HHM
133304	KEN	2012	2013	KEN/AIDS_INDICATOR_SURVEY	HH
157397	KEN	2010	2010	KEN/CHILD_LABOR_SURVEY	HHM
157635	KEN	2007	2007	KEN/HH_HEALTH_EXPENDITURE_UTILIZATION_SURVEY	HH
7375	KEN	2005	2006	KEN/KIHBS	HH
57990	KEN	2007	2007	KEN/MALRIA_INDICATORY_SURVEY	HH
164729	KHM	2013	2013	KHM/INTERCENSAL_POPULATION_SURVEY	HH
30963	KHM	2003	2005	KHM/SOCIO_ECONOMIC_SURVEY	HH
165631	KHM	2007	2008	KHM/SOCIO_ECONOMIC_SURVEY	HH
31143	KHM	2009	2009	KHM/SOCIO_ECONOMIC_SURVEY	HH
327852	MWI	2016	2017	LSMS_ISA	HHM
3133	COG	2009	2009	DHS_AIS	HH
4837	GUY	2005	2005	DHS_AIS	HH
8906	MOZ	2009	2009	DHS_AIS	HH
157060	MOZ	2015	2015	DHS_AIS	HHM
12630	TZA	2003	2004	DHS_AIS	HH
12644	TZA	2007	2008	DHS_AIS	HH
77395	TZA	2011	2012	DHS_AIS	HH
55973	UGA	2011	2011	DHS_AIS	HH
13544	VNM	2005	2005	DHS_AIS	HH
157018	AFG	2015	2016	DHS	HHM
218555	AGO	2015	2016	DHS	HH
30431	BDI	2010	2011	DHS	HH
286766	BDI	2016	2017	DHS	HHM
18950	BEN	2001	2001	DHS	HH
18959	BEN	2006	2006	DHS	HH
79839	BEN	2011	2012	DHS	HH
19088	BFA	2003	2003	DHS	HH
19133	BFA	2010	2011	DHS	HH
18902	BGD	2004	2004	DHS	HH
18913	BGD	2007	2007	DHS	HH

55956	BGD	2011	2012	DHS	HH
157021	BGD	2014	2014	DHS	HH
19001	BOL	2003	2004	DHS	HH
19016	BOL	2008	2008	DHS	HH
18533	CIV	2011	2012	DHS	HH
19211	CMR	2004	2004	DHS	HH
19274	CMR	2011	2011	DHS	HH
19381	COD	2007	2007	DHS	HH
76878	COD	2013	2014	DHS	HH
19391	COG	2005	2005	DHS	HH
56151	COG	2011	2012	DHS	HH
19359	COL	2000	2000	DHS	HH
19324	COL	2004	2005	DHS	HH
21281	COL	2009	2010	DHS	HH
218566	COL	2015	2016	DHS	HHM
76850	COM	2012	2013	DHS	HH
19444	DOM	2002	2002	DHS	HH
19456	DOM	2007	2007	DHS	HH
77819	DOM	2013	2013	DHS	HH
19511	EGY	2000	2000	DHS	HH
19529	EGY	2003	2003	DHS_INTERIM	HH
19521	EGY	2005	2005	DHS	HH
19539	ERI	2002	2002	DHS	HH
19571	ETH	2000	2000	DHS	HH
19557	ETH	2005	2005	DHS	HH
21301	ETH	2010	2011	DHS	HH
218568	ETH	2016	2016	DHS	HH
19579	GAB	2000	2001	DHS	HH
76706	GAB	2012	2012	DHS	HH
19627	GHA	2003	2003	DHS	HH
21188	GHA	2008	2008	DHS	HH
157027	GHA	2014	2014	DHS	HH
218572	GHA	2017	2017	DHS_SPECIAL	HH
19683	GIN	2005	2005	DHS	HH
69761	GIN	2012	2012	DHS	HH

77384	GMB	2013	2013	DHS	HH
157031	GTM	2014	2015	DHS	HH
21348	GUY	2009	2009	DHS	HH
19728	HND	2005	2006	DHS	HH
95440	HND	2011	2012	DHS	HH
19708	HTI	2000	2000	DHS	HH
19720	HTI	2005	2006	DHS	HH
65118	HTI	2012	2012	DHS	HH
218574	HTI	2016	2017	DHS	HH
20011	IDN	2002	2003	DHS	HH
20021	IDN	2007	2007	DHS	HH
76705	IDN	2012	2012	DHS	HH
19950	IND	1998	2000	DHS	HH
19963	IND	2005	2006	DHS	HH
157050	IND	2015	2016	DHS	HH
20073	JOR	2002	2002	DHS	HH
20083	JOR	2007	2007	DHS	HH
21206	JOR	2009	2009	DHS_INTERIM	HH
77517	JOR	2012	2012	DHS	HH
20145	KEN	2003	2003	DHS	HH
21365	KEN	2008	2009	DHS	HH
157057	KEN	2014	2014	DHS	HH
77518	KGZ	2012	2012	DHS	HH
19156	KHM	2000	2000	DHS	HH
19167	KHM	2005	2006	DHS	HH
30379	KHM	2010	2011	DHS	HH
157024	KHM	2014	2014	DHS	HH
20191	LBR	2006	2007	DHS	HH
77385	LBR	2013	2013	DHS	HH
20167	LSO	2004	2005	DHS	HH
21382	LSO	2009	2010	DHS	HH
157058	LSO	2014	2014	DHS	HH
20361	MAR	2003	2004	DHS	HH
20223	MDG	2003	2004	DHS	HH
21409	MDG	2008	2009	DHS	HH

20315	MLI	2001	2001	DHS	HH
20274	MLI	2006	2006	DHS	HH
77388	MLI	2012	2013	DHS	HH
157061	MMR	2015	2016	DHS	HH
20394	MOZ	2003	2004	DHS	HH
55975	MOZ	2011	2011	DHS	HH
20322	MRT	2000	2001	DHS	HH
20252	MWI	2000	2000	DHS	HH
20263	MWI	2004	2005	DHS	HH
21393	MWI	2010	2010	DHS	HH
218581	MWI	2015	2016	DHS	HH
20417	NAM	2000	2000	DHS	HH
20428	NAM	2006	2007	DHS	HH
150382	NAM	2013	2013	DHS	HH
20499	NER	2006	2006	DHS	HH
74393	NER	2012	2012	DHS	HH
20567	NGA	2003	2003	DHS	HH
21433	NGA	2008	2008	DHS	HH
77390	NGA	2013	2013	DHS	HH
20487	NIC	2001	2001	DHS	HH
20450	NPL	2001	2001	DHS	HH
20462	NPL	2006	2006	DHS	HH
21240	NPL	2011	2011	DHS	HH
286782	NPL	2016	2017	DHS	HHM
20595	PAK	2006	2007	DHS	HH
77521	PAK	2012	2013	DHS	HH
20649	PER	2000	2000	DHS	HH
275090	PER	2003	2008	DHS	HH
270404	PER	2009	2009	DHS	HH
270469	PER	2010	2010	DHS	HH
270470	PER	2011	2011	DHS	HH
270471	PER	2012	2012	DHS	HH
210182	PER	2014	2014	DHS	HHM
21421	PHL	2008	2008	DHS	HH
142943	PHL	2013	2013	DHS	HH

337877	PHL	2017	2017	DHS	HH
44870	PNG	2006	2007	MACRO_DHS	HH
20722	RWA	2000	2000	DHS	HH
20740	RWA	2005	2005	DHS	HH
21222	RWA	2007	2008	DHS_INTERIM	HH
56040	RWA	2010	2011	DHS	HH
157063	RWA	2014	2015	DHS	HH
26855	SEN	2005	2005	DHS	HH
56063	SEN	2010	2011	DHS	HH
111432	SEN	2012	2013	DHS	HH
191270	SEN	2014	2014	DHS	HH
218592	SEN	2015	2015	DHS	HH
286772	SEN	2016	2016	DHS	HH
353526	SEN	2017	2017	DHS	HH
21258	SLE	2008	2008	DHS	HH
131467	SLE	2013	2013	DHS	HH
26866	STP	2008	2009	DHS	HH
20829	SWZ	2006	2007	DHS	HH
157025	TCD	2014	2015	DHS	HH
77515	TGO	2013	2014	DHS	WN
74460	TJK	2012	2012	DHS	HH
341838	TJK	2017	2017	DHS	HH
21274	TLS	2009	2010	DHS	HH
20875	TZA	2004	2005	DHS	HH
21331	TZA	2009	2010	DHS	HH
218593	TZA	2015	2016	DHS	HH
20993	UGA	2000	2001	DHS	HH
21014	UGA	2006	2006	DHS	HH
56021	UGA	2011	2011	DHS	HH
286780	UGA	2016	2016	DHS	HH
112500	YEM	2013	2013	DHS	HH
21102	ZMB	2001	2002	DHS	HH
21117	ZMB	2007	2007	DHS	HH
77516	ZMB	2013	2014	DHS	HH
21163	ZWE	2005	2006	DHS	HH

55992	ZWE	2010	2011	DHS	HH
157066	ZWE	2015	2015	DHS	HH
56099	AFG	2010	2010	DHS_SPECIAL	HH
21173	GHA	2007	2008	DHS_SPECIAL	HH
21173	GHA	2007	2008	DHS_SPECIAL	WN
137351	IDN	2012	2012	DHS_SPECIAL	HH
20040	IDN	2002	2003	MACRO_DHS_SP	HHM
21039	UZB	2002	2002	DHS_SPECIAL	HH
672	AGO	2007	2007	DHS_MIS	HH
56169	AGO	2011	2011	DHS_MIS	HH
108080	BDI	2012	2013	DHS_MIS	HHM
188785	BFA	2014	2014	DHS_MIS	HH
286788	GHA	2016	2016	DHS_MIS	HH
58006	KEN	2010	2010	DHS_MIS	HH
34279	LBR	2008	2009	DHS_MIS	HH
56828	LBR	2011	2011	DHS_MIS	HH
286768	LBR	2016	2016	DHS_MIS	HHM
69806	MDG	2011	2011	DHS_MIS	HH
111438	MDG	2013	2013	DHS_MIS	HH
218580	MDG	2016	2016	DHS_MIS	HH
218587	MLI	2015	2015	DHS_MIS	HH
77387	MWI	2012	2012	DHS_MIS	HH
157059	MWI	2014	2014	DHS_MIS	HH
30991	NGA	2010	2010	DHS_MIS	HH
218590	NGA	2015	2015	DHS_MIS	HH
77391	RWA	2012	2013	DHS_MIS	HH
350836	RWA	2017	2017	DHS_MIS	HHM
11540	SEN	2008	2009	DHS_MIS	HH
286773	SLE	2016	2016	DHS_MIS	HH
359318	TGO	2017	2017	DHS_MIS	HHM
350798	TZA	2017	2017	DHS_MIS	HH
13109	UGA	2009	2010	DHS_MIS	HH
157065	UGA	2014	2015	DHS_MIS	HH
150485	MAR	2009	2010	MAR/HOUSEHOLD_AND_YOUTH_SURVEY	HHM

8684	MEX	2002	2003	MEX/NATIONAL_PERFORMANCE_EVALUATION_SURVEY_ENED	HH
23982	MEX	2006	2006	MEX/SURVEY_DEMOGRAPHIC_DYNAMICS_ENADID	HH
8618	MEX	2005	2006	MEX/SURVEY_HEALTH_AND_NUTRITION_ENSANUT	HH
8618	MEX	2005	2006	MEX/SURVEY_HEALTH_AND_NUTRITION_ENSANUT	HH
8618	MEX	2005	2006	MEX/SURVEY_HEALTH_AND_NUTRITION_ENSANUT	HH
81748	MEX	2011	2012	MEX/SURVEY_HEALTH_AND_NUTRITION_ENSANUT	HH
165610	MEX	2012	2012	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
165610	MEX	2012	2012	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
93321	MEX	2010	2010	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25358	MEX	2008	2008	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25335	MEX	2006	2006	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25317	MEX	2005	2005	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25293	MEX	2004	2004	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25273	MEX	2002	2002	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
25254	MEX	2000	2000	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
141910	MMR	2003	2003	MMR/MULTIPLE_INDICATOR_CLUSTER_SURVEY	HH
134132	NAM	2011	2011	NAM/CENSUS	HHM
134371	NAM	2009	2010	NAM/HH_INCOME_AND_EXPENDITURE_SURVEY	HHM
24890	NGA	2006	2007	NGA/GENERAL_HOUSEHOLD_SURVEY	HHM
24915	NGA	2007	2008	NGA/GENERAL_HOUSEHOLD_SURVEY	HHM
151719	NGA	2008	2010	NGA/LIVING_STANDARDS_SURVEY	HHM
126952	NIC	2011	2012	NIC/DHS_ENDESA	HH
9951	PAK	2004	2005	PAK/SOCIAL_AND_LIVING_MEASUREMENT_SURVEY	HHM
265082	PAK	2014	2015	PAK/SOCIAL_AND_LIVING_MEASUREMENT_SURVEY	HHM
303663	PER	2015	2015	PER/DEMOGRAPHIC_AND_FAMILY_HEALTH_SURVEY_ENDES	HH
358824	PER	2017	2017	PER/DEMOGRAPHIC_AND_FAMILY_HEALTH_SURVEY_ENDES	HH
44275	PER	2000	2000	PER/NATIONAL_HH_SURVEY_ENAHO	HH
44315	PER	2000	2000	PER/NATIONAL_HH_SURVEY_ENAHO	HH

44470	PER	2001	2001	PER/NATIONAL_HH_SURVEY_ENAHO	HH
44696	PER	2002	2002	PER/NATIONAL_HH_SURVEY_ENAHO	HH
44748	PER	2003	2004	PER/NATIONAL_HH_SURVEY_ENAHO	HH
49279	PER	2004	2004	PER/NATIONAL_HH_SURVEY_ENAHO	HH
49429	PER	2006	2006	PER/NATIONAL_HH_SURVEY_ENAHO	HH
33702	PER	2009	2009	PER/NATIONAL_HH_SURVEY_ENAHO	HH
33829	PER	2010	2010	PER/NATIONAL_HH_SURVEY_ENAHO	HH
265406	PER	2014	2014	PER/NATIONAL_HH_SURVEY_ENAHO	HH
265409	PER	2015	2015	PER/NATIONAL_HH_SURVEY_ENAHO	HH
283383	PER	2016	2016	PER/NATIONAL_HH_SURVEY_ENAHO	HH
126396	PHL	2011	2011	PHL/FNRI	HH
243566	PRY	2014	2014	PRY/PERMANENT_HH_SURVEY_EPH	HH
243564	PRY	2013	2013	PRY/PERMANENT_HH_SURVEY_EPH	HH
243562	PRY	2012	2012	PRY/PERMANENT_HH_SURVEY_EPH	HH
336799	PRY	2016	2016	PRY/PERMANENT_HH_SURVEY_EPH	HH
286233	PRY	2015	2015	PRY/PERMANENT_HH_SURVEY_EPH	HH
367995	PRY	2017	2017	PRY/PERMANENT_HH_SURVEY_EPH	HH
243548	PRY	2011	2011	PRY/PERMANENT_HH_SURVEY_EPH	HH
243537	PRY	2010	2010	PRY/PERMANENT_HH_SURVEY_EPH	HH
41856	PRY	2009	2009	PRY/PERMANENT_HH_SURVEY_EPH	HH
41851	PRY	2008	2008	PRY/PERMANENT_HH_SURVEY_EPH	HH
41844	PRY	2007	2007	PRY/PERMANENT_HH_SURVEY_EPH	HH
41837	PRY	2006	2006	PRY/PERMANENT_HH_SURVEY_EPH	HH
41830	PRY	2005	2005	PRY/PERMANENT_HH_SURVEY_EPH	HH
41823	PRY	2004	2004	PRY/PERMANENT_HH_SURVEY_EPH	HH
10377	PRY	2003	2003	PRY/PERMANENT_HH_SURVEY_EPH	HH
10373	PRY	2002	2002	PRY/PERMANENT_HH_SURVEY_EPH	HH
10040	PSE	2007	2008	PSE/CENSUS	HHM
264956	IDN	2014	2015	RAND_FLS/IDN	HHM
6464	IDN	2007	2007	RAND_FLS/IDN	HHM
6111	IDN	2000	2000	RAND_FLS/IDN	HH
58185	RWA	2006	2006	RWA/COMPREHENSIVE_FOOD_SECURITY_AND_VULNERABILITY_ASSESSMENT	HH
151436	RWA	2012	2012	RWA/COMPREHENSIVE_FOOD_SECURITY_AND_VULNERABILITY_ASSESSMENT	CH
151437	RWA	2010	2011	RWA/INTEGRATED_LIVING_CONDITIONS_SURVEY_EICV	HHM

58218	RWA	2008	2008	RWA/VISION_2020_UMURENGE_PROGRAM_BASELINE_SURVEY	HHM
30368	SSD	2009	2009	SDN/NATIONAL_BASELINE_HOUSEHOLD_SURVEY	HH
30349	SSD	2009	2009	SDN/NORTH_NATIONAL_BASELINE_HH_SURVEY	HH
165017	SLV	2013	2013	SLV/MULTIPURPOSE_HH_SURVEY_EHPM	HH
238389	SLV	2014	2014	SLV/MULTIPURPOSE_HH_SURVEY_EHPM	HHM
137328	SLV	2012	2012	SLV/MULTIPURPOSE_HH_SURVEY_EHPM	HH
240604	MEX	2014	2014	SURVEY_DEMOGRAPHIC_DYNAMICS_ENADID	HHM
31740	TZA	2000	2001	TZA/HH_BUDGET_SURVEY	HH
31887	TZA	2007	2007	TZA/HH_BUDGET_SURVEY	HH
280228	TZA	2014	2014	TZA/INTEGRATED_LABOR_FORCE_SURVEY_ILFS	HH
23687	UGA	2005	2006	UGA/HOUSEHOLD_SURVEY	HH
56830	AFG	2010	2011	UNICEF_MICS	HH
1981	BDI	2005	2005	UNICEF_MICS	HH
206075	BEN	2014	2014	UNICEF_MICS	HH
1927	BFA	2006	2006	UNICEF_MICS	HH
951	BGD	2006	2006	UNICEF_MICS	HH
151086	BGD	2012	2013	UNICEF_MICS	HH
1089	BLZ	2006	2006	UNICEF_MICS	HH
76699	BLZ	2011	2011	UNICEF_MICS	HH
40028	BTN	2010	2010	UNICEF_MICS	HH
2223	CAF	2006	2006	UNICEF_MICS	HH
82832	CAF	2010	2011	UNICEF_MICS	HH
26433	CIV	2006	2006	UNICEF_MICS	HH
218611	CIV	2016	2016	UNICEF_MICS	HH
2053	CMR	2000	2000	UNICEF_MICS	HH
2063	CMR	2006	2006	UNICEF_MICS	HH
244455	CMR	2014	2014	UNICEF_MICS	HH
26998	COD	2010	2010	UNICEF_MICS	HH
234733	COG	2014	2015	UNICEF_MICS	HH
3114	COM	2000	2000	UNICEF_MICS	HH
125596	CRI	2011	2011	UNICEF_MICS	HH
3404	DJI	2006	2006	UNICEF_MICS	HH
200697	DOM	2014	2014	UNICEF_MICS	HH
210614	DZA	2012	2013	UNICEF_MICS	HH

159617	EGY	2013	2014	UNICEF_MICS	HH
4694	GHA	2006	2006	UNICEF_MICS	HH
160576	GHA	2007	2008	UNICEF_MICS	HH
56241	GHA	2010	2011	UNICEF_MICS	HH
63993	GHA	2011	2011	UNICEF_MICS	HH
303458	GIN	2016	2016	UNICEF_MICS	HH
3935	GMB	2005	2006	UNICEF_MICS	HH
91506	GMB	2010	2010	UNICEF_MICS	HH
4818	GNB	2006	2006	UNICEF_MICS	HH
174049	GNB	2014	2014	UNICEF_MICS	HH
27215	GNB	2010	2010	UNICEF_MICS	WN
4916	GUY	2000	2000	UNICEF_MICS	HH
4926	GUY	2006	2007	UNICEF_MICS	HH
200598	GUY	2014	2014	UNICEF_MICS	HH
7028	IRQ	2006	2006	UNICEF_MICS	HH
76707	IRQ	2011	2011	UNICEF_MICS	HH
141336	JAM	2011	2011	UNICEF_MICS	HH
7387	KEN	2000	2000	UNICEF_MICS	HH
155335	KEN	2007	2007	UNICEF_MICS	HH
7401	KEN	2008	2008	UNICEF_MICS	HH
56420	KEN	2009	2009	UNICEF_MICS	HH
7540	KGZ	2005	2006	UNICEF_MICS	HH
162283	KGZ	2014	2014	UNICEF_MICS	HH
7629	LAO	2006	2006	UNICEF_MICS	HH
103973	LAO	2011	2012	UNICEF_MICS	HH
375362	LAO	2017	2017	UNICEF_MICS	HHM
125594	MDG	2012	2012	UNICEF_MICS	HH
264590	MEX	2015	2015	UNICEF_MICS	HH
270627	MLI	2009	2010	UNICEF_MICS	HH
248224	MLI	2015	2015	UNICEF_MICS	HH
90696	MMR	2009	2010	UNICEF_MICS	HHM
8788	MNG	2000	2000	UNICEF_MICS	HH
8777	MNG	2005	2005	UNICEF_MICS	HH
76704	MNG	2010	2010	UNICEF_MICS	HH
150866	MNG	2013	2013	UNICEF_MICS	HH

189048	MNG	2012	2012	UNICEF_MICS	HH
27031	MOZ	2008	2009	UNICEF_MICS	HH
8115	MRT	2007	2007	UNICEF_MICS	HH
152783	MRT	2011	2011	UNICEF_MICS	HH
7919	MWI	2006	2006	UNICEF_MICS	HH
161662	MWI	2013	2014	UNICEF_MICS	HH
9516	NGA	2007	2007	UNICEF_MICS	HH
76703	NGA	2011	2011	UNICEF_MICS	HH
218613	NGA	2016	2017	UNICEF_MICS	HH
39999	NPL	2010	2010	UNICEF_MICS	HH
162317	NPL	2014	2014	UNICEF_MICS	HH
324470	PRY	2016	2016	UNICEF_MICS	HH
125591	PSE	2010	2010	UNICEF_MICS	HH
161590	PSE	2014	2014	UNICEF_MICS	HH
12243	SDN	2000	2000	UNICEF_MICS	HH
153643	SDN	2010	2010	UNICEF_MICS	HH
200617	SDN	2014	2014	UNICEF_MICS	HH
27044	SEN	2000	2000	UNICEF_MICS	HH
287639	SEN	2015	2016	UNICEF_MICS	HH
11649	SLE	2005	2005	UNICEF_MICS	HH
76700	SLE	2010	2010	UNICEF_MICS	HH
218619	SLE	2017	2017	UNICEF_MICS	HH
200636	SLV	2014	2014	UNICEF_MICS	HH
11774	SOM	2006	2006	UNICEF_MICS	HH
91508	SOM	2011	2011	UNICEF_MICS	HH
91507	SOM	2011	2011	UNICEF_MICS	HH
12232	SSD	2000	2000	UNICEF_MICS	HH
32189	SSD	2010	2010	UNICEF_MICS	HH
27055	STP	2000	2000	UNICEF_MICS	HH
214640	STP	2014	2014	UNICEF_MICS	HH
12289	SUR	2006	2006	UNICEF_MICS	HH
81203	SUR	2010	2010	UNICEF_MICS	HH
12320	SWZ	2000	2000	UNICEF_MICS	HH
30325	SWZ	2010	2010	UNICEF_MICS	HH
200707	SWZ	2014	2014	UNICEF_MICS	HH

12399	SYR	2006	2006	UNICEF_MICS	HH
76701	TCD	2010	2010	UNICEF_MICS	HH
12896	TGO	2006	2006	UNICEF_MICS	HH
40021	TGO	2010	2010	UNICEF_MICS	HH
12732	THA	2005	2006	UNICEF_MICS	HH
148649	THA	2012	2012	UNICEF_MICS	HH
296646	THA	2015	2016	UNICEF_MICS	HH
331377	THA	2016	2016	UNICEF_MICS	HH
12595	TJK	2000	2000	UNICEF_MICS	HH
12608	TJK	2005	2005	UNICEF_MICS	HH
13064	TKM	2006	2006	UNICEF_MICS	HH
264583	TKM	2015	2016	UNICEF_MICS	HH
12950	TTO	2006	2006	UNICEF_MICS	HH
76709	TUN	2011	2012	UNICEF_MICS	HH
13445	UZB	2006	2006	UNICEF_MICS	HH
13719	VNM	2006	2006	UNICEF_MICS	HH
57999	VNM	2010	2011	UNICEF_MICS	HH
152735	VNM	2013	2014	UNICEF_MICS	HH
13816	YEM	2006	2006	UNICEF_MICS	HH
35493	ZWE	2009	2009	UNICEF_MICS	HH
152720	ZWE	2014	2014	UNICEF_MICS	HH
151568	AGO	2011	2011	WB_CWIQ	HHM
1855	BFA	2003	2003	WB_CWIQ	HH
22950	BFA	2005	2005	WB_CWIQ	HH
18499	BFA	2007	2007	WB_CWIQ	HH
23017	GHA	2003	2003	WB_CWIQ	HH
9522	NGA	2006	2006	WB_CWIQ	HH
31797	TZA	2005	2005	WB_CWIQ	HH
31831	TZA	2006	2007	WB_CWIQ	HH
31786	TZA	2004	2004	WB_CWIQ	HHM
4679	GHA	2005	2006	WB_LSMS	HHM
165101	GHA	2012	2013	WB_LSMS	HH
46317	MWI	2004	2005	WB_LSMS	HH
9422	NIC	2001	2001	WB_LSMS	HH
44645	NIC	2005	2005	WB_LSMS	HH

46480	NPL	2003	2004	WB_LSMS	HH
94168	NPL	2010	2011	WB_LSMS	HHM
10224	PAN	2003	2003	WB_LSMS	HH
46517	PAN	2008	2008	WB_LSMS	HH
12863	TLS	2001	2001	WB_LSMS	HHM
46682	TLS	2007	2008	WB_LSMS	HH
235215	ETH	2013	2014	WB_LSMS_ISA	HH
286657	ETH	2015	2016	WB_LSMS_ISA	HH
260407	MLI	2014	2015	WB_LSMS_ISA	HHM
224223	MWI	2013	2013	WB_LSMS_ISA	HH
94140	NER	2011	2012	WB_LSMS_ISA	HH
27297	TZA	2008	2009	WB_LSMS_ISA	HH
81005	TZA	2010	2011	WB_LSMS_ISA	HH
224096	TZA	2012	2013	WB_LSMS_ISA	HHM
311265	TZA	2014	2016	WB_LSMS_ISA	HHM
299064	LKA	2012	2012	WB_STEP_HH_SURVEY	HH
299045	VNM	2012	2012	WB_STEP_HH_SURVEY	HH
111485	GHA	2007	2008	WHO_SAGE	HH
111488	ZAF	2007	2008	WHO_SAGE	HH
244480	YEM	2014	2014	YEM/COMPREHENSIVE_FOOD_SECURITY_SURVEY_CFSS	HH
22882	YEM	2005	2006	YEM/HH_BUDGET_SURVEY	HH
249499	YEM	2012	2013	YEM/NATIONAL_SOCIAL_PROTECTION_MONITORING_SURVEY_NSPMS	HHM
12146	ZAF	2011	2011	ZAF/CENSUS	HH
280803	ZAF	2016	2016	ZAF/COMMUNITY_SURVEY	HHM
25100	ZAF	2007	2007	ZAF/COMMUNITY_SURVEY	HHM
115481	ZAF	2002	2002	ZAF/HH_SURVEY	HHM
11787	ZAF	2003	2003	ZAF/HH_SURVEY	HHM
11788	ZAF	2004	2004	ZAF/HH_SURVEY	HHM
11789	ZAF	2005	2005	ZAF/HH_SURVEY	HHM
115486	ZAF	2006	2006	ZAF/HH_SURVEY	HHM
11790	ZAF	2007	2007	ZAF/HH_SURVEY	HHM
115488	ZAF	2008	2008	ZAF/HH_SURVEY	HHM
115489	ZAF	2009	2009	ZAF/HH_SURVEY	HH
115490	ZAF	2010	2010	ZAF/HH_SURVEY	HH

115491	ZAF	2011	2011	ZAF/HH_SURVEY	HH
238485	ZAF	2014	2014	ZAF/HH_SURVEY	HH
265084	ZAF	2015	2015	ZAF/HH_SURVEY	HH
238483	ZAF	2013	2013	ZAF/HH_SURVEY	HH
317089	ZAF	2016	2016	ZAF/HH_SURVEY	HH
11848	ZAF	2005	2006	ZAF/INCOME_AND_EXPENDITURE_SURVEY	HH
265153	ZAF	2014	2015	ZAF/NATIONAL_INCOME_DYNAMICS_STUDY	HH
369644	ZAF	2017	2017	ZAF/NATIONAL_INCOME_DYNAMICS_STUDY	HH
14027	ZMB	2002	2003	ZMB/LCMS	HHM
14063	ZMB	2004	2005	ZMB/LCMS	HH
14105	ZMB	2006	2006	ZMB/LCMS	HH
58660	ZMB	2010	2010	ZMB/LCMS	HH
286783	PAK	2017	2018	DHS	HH
237943	IDN	2015	2015	IDN/INTERCENSAL_POPULATION_SURVEY_SUPAS	HH
165186	IDN	2014	2014	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
238332	IDN	2015	2015	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
282087	IDN	2016	2016	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
395694	IDN	2017	2017	IDN/SOCIOECONOMIC_SURVEY_SUSENAS	HH
356955	JOR	2017	2018	DHS	HH
218565	BEN	2017	2018	DHS	HHM
369294	CHN	2016	2016	CHINESE_FAMILY_PANEL_STUDIES_CFPS/2016	HH
286781	IDN	2017	2017	DHS	HH
393799	ZAF	2016	2016	ZAF/HH_SURVEY	HH
364181	ECU	2013	2014	ECU_LIVING_CONDITIONS_SURVEY_ECV	HH
141521	PAK	2011	2011	PAK_NATIONAL_NUTRITION	HHM
400338	LBR	2016	2017	LBR_HH_INCOME_EXPENDITURE	HHM
385708	IRQ	2018	2018	UNICEF_MICS	HH
165290	BTN	2012	2013	BTN/NATIONAL_HEALTH_SURVEY	HH
31050	KHM	2006	2007	KHM/SOCIO_ECONOMIC_SURVEY	HHM
24143	SDN	2006	2006	ARAB_LEAGUE_PAPFAM	HH
24143	SSD	2006	2006	ARAB_LEAGUE_PAPFAM	HH
327591	TZA	2016	2017	ICAP_PHIA	HH
151566	AGO	2005	2006	WB_CWIQ	HHM
287629	MWI	2015	2016	MWI_ICAP_PHIA	HH
409558	TUN	2018	2018	UNICEF_MICS	HH

413556	BFA	2017	2018	DHS_MIS	HH
408226	KGZ	2018	2018	UNICEF_MICS	HH
415531	SWZ	2016	2017	ICAP_PHIA	HH
400526	PAK	2017	2018	UNICEF_MICS	HH
413934	MOZ	2018	2018	DHS_MIS	HH
12865	TLS	2002	2002	UNICEF_MICS	HH
21622	GHA	2003	2003	WHO_WHS	HHM
77393	SLE	2013	2013	DHS_MIS	HH
27885	ZAF	2008	2008	ZAF/NATIONAL_INCOME_DYNAMICS_STUDY	HHM
60405	CHN	2007	2010	WHO_SAGE	HHM
339653	MEX	2016	2016	MEX/SURVEY_INCOME_AND_HOUSEHOLD_EXPENDITURE_ENIGH	HH
326837	LKA	2016	2016	DHS	HHM
18815	LKA	2006	2007	DHS	HHM
90707	LKA	2000	2000	MACRO_DHS	HH
396957	GIN	2018	2018	DHS	HH
398033	MLI	2018	2018	DHS	HH
81416	IRN	2010	2010	IRN/MULTIPLE_INDICATOR_DEMOGRAPHIC_HEALTH_SURVEY	HH
264910	BLZ	2015	2016	UNICEF_MICS	HH
267343	MRT	2015	2015	UNICEF_MICS	HH
286769	MWI	2017	2017	DHS_MIS	HH
286785	TLS	2016	2016	DHS	HH
336042	MNG	2016	2016	UNICEF_MICS	HH
335994	MNG	2016	2016	UNICEF_MICS	HH
332558	TTO	2011	2011	UNICEF_MICS	HH
22108	BTN	2007	2007	BTN/LIVING_STANDARDS	HH
404407	MEX	2018	2018	MEX/ENADID	HH
400219	NPL	2016	2016	NPL_RISK_VULNERABILITY_ASSESSMENT	HHM
403435	BOL	2012	2012	BOL/HOUSEHOLD_SURVEY	HH
124467	COL	2004	2005	COL/NATIONAL_SURVEY_ON_NUTRITION_SITUATION_ENSIN	HHM
407869	PER	2018	2018	PER/DEMOGRAPHIC_AND_FAMILY_HEALTH_SURVEY_ENDES	HH
403655	PRY	2018	2018	PRY/PERMANENT_HOUSHEOLD_SURVEY_EPH	HH
148346	BOL	2009	2009	BOL/HH_SURVEY	HHM

413667	PER	2007	2008	DHS	HH
413666	PER	2003	2006	DHS	HH
400535	TZA	2014	2015	TZA/MEASURING_LIVING_STANDARDS_WITHIN_CITIES	HHM
148345	BOL	2008	2008	BOL/HH_SURVEY	HHM
424884	GMB	2018	2018	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
317305	THA	2015	2016	UNICEF_MICS	HH
426238	PNG	2016	2018	DHS	HH
399853	MDG	2018	2018	UNICEF_MICS	HH
427952	MNG	2018	2018	UNICEF_MICS	HH
427983	SUR	2018	2018	UNICEF_MICS	HH
431951	ZWE	2019	2019	UNICEF_MICS	HH
284177	ZMB	2015	2015	ZMB/LCMS	HHM

Supplementary Table 5: Covariates used in mapping

A variety of socioeconomic and environmental variables were used to estimate cooking fuel type use. Where available, the finest spatiotemporal resolution of gridded datasets was used. In addition to the geospatial covariates detailed below, the last three covariates listed are country level covariates: *healthcare access and quality index, lag distributed income per capita,* and *proportion of the population with access to adequate sanitation.*

Covariate	Temporal Resolution	Justification	Source	Reference
Distance from rivers or lakes >= 50 sq. km	Static	Related to availability of biofuels	Natural Earth Data (derived)	Available at: http://www.naturalearthdata.com/downloads/10m-physical-vectors/10m-rivers-lake-centerlines/ AND http://www.worldwildlife.org/pages/global-lakes-and-wetlands-database
Night-time lights	Annual	Related to development	NOAA DMSP satellite program (derived)	Available at: https://www.ngdc.noaa.gov/eog/dmsp/downloadV4composites.html
Elevation	Static	Related to availability of biofuels	NOAA GlOBE	Available at: https://www.ngdc.noaa.gov/mgg/topo/gltiles.html
Agricultural land	Static	Related to availability of biofuels	Earth Stat Project	Ramankutty, N., Evan, A.T., Monfreda, C., & Foley, J.A. Farming the planet. Part 1: Geographic distribution of global agricultural lands in the year 2000. Global Biogeochemical Cycle 22, GB1003 (2008), doi: 10.1029/2007GB002952. Available at: http://www.earthstat.org/data-download/
Enhanced vegetation index	Annual	Related to availability of biofuels	MODIS, pre-processed by Oxford	Weiss, D. J. et al. An effective approach for gapfilling continental scale remotely sensed timeseries. Isprs J. Photogramm. Remote Sens. 98, 106–118 (2014). USGS & NASA. Vegetation indices 16-Day L3 global 500m MOD13A1 dataset. Available at: https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mcd43b4. (Accessed: 25th July 2017) Huete, A., Justice, C. & van Leeuwen, W. MODIS vegetation index (MOD 13) algorithm theoretical basis document. (1999).
Fertility	Annual	Related to development	WorldPop (derived)	Lloyd, C. T., Sorichetta, A. & Tatem, A. J. High resolution global gridded data for use in population studies. Sci. Data 4, sdata20171 (2017). Available at: http://www.worldpop.org.uk/data/get_data/. (Accessed: 25th July 2017)
Urban or rural	Annual	Related to availability of clean fuels and technologies	European Commission/GHS	Pesaresi, M. et al. Operating procedure for the production of the Global Human Settlement Layer from Landsat data of the epochs 1975, 1990, 2000, and 2014. JRC Technical Report EUR 27741 EN; doi:10.2788/253582 (online) Available at: http://ghsl.jrc.ec.europa.eu/data.php
Nutrient yield	Static	Related to availability of biofuels	Herrero et al.	Herrero, M. et al. Farming and the geography of nutrient production for human use: a transdisciplinary analysis. Lancet Planet. Health 1, e33–e42 (2017).

Irrigation	Static	Related to availability of biofuels	University of Frankfurt and FAO	Siebert, S., Doll, P., Hoogeveen, J., Faures, J.-M., Frenken, K., & Feick, S. Development and validation of the global map of irrigation areas. Hydrology and Earth System Sciences 9, 535-547 (2005). Goethe-Universität. Generation of a digital global map of irrigation areas. Available at: https://www.unifrankfurt.de/45218039/Global_Irrigation_Map. (Accessed: 25th July 2017) Also from: http://www.fao.org/nr/water/aquastat/irrigationmap/index10.stm
Land cover	Annual	Related to availability of clean fuels and technologies	MODIS	Available at: https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mcd12q1
Average land surface temperature	Annual	Related to availability of biofuels	MODIS	Weiss, D. J. et al. An effective approach for gapfilling continental scale remotely sensed timeseries. Isprs J. Photogramm. Remote Sens. 98, 106–118 (2014). Available at: https://modis.gsfc.nasa.gov/data/dataprod/mod11.php

Covariate	Temporal Resolution	Justification	Source	Reference
Precipitation	Annual	Related to availability of biofuels	Beck et al.	Beck, H.E., A.I.J.M. van Dijk, V. Levizzani, J. Schellekens, D.G. Miralles, B. Martens, & A. de Roo. MSWEP: 3-hourly 0.25 global gridded precipitation (1979-2015) by merging gauge, satellite, and reanalysis data. Hydrology and Earth System Sciences 21(1), 589-615 (2017). Available at: https://data.princetonclimate.com/opendap
Tassled cap brightness	Annual	Related to availability of biofuels	MODIS	Lobser, S.E. & Cohen, W.B. MODIS tasselled cap: land cover characteristics expressed through transformed MODIS data. International Journal of Remote Sensing 28(22), 5079-5101 (2007). C. Schaaf, Z. Wang. (2015). MCD43A1 MODIS/Terra+Aqua BRDF/Albedo Model Parameters Daily L3 Global - 500m V006. NASA EOSDIS Land Processes DAAC. http://doi.org/10.5067/MODIS/MCD43A1.006 Available at: https://modis.gsfc.nasa.gov/data/dataprod/mod43.php
Tassled cap wetness	Annual	Related to availability of biofuels	MODIS	Lobser, S.E. & Cohen, W.B. MODIS tasselled cap: land cover characteristics expressed through transformed MODIS data. International Journal of Remote Sensing 28(22), 5079-5101 (2007). C. Schaaf, Z. Wang. (2015). MCD43A1 MODIS/Terra+Aqua BRDF/Albedo Model Parameters Daily L3 Global - 500m V006. NASA EOSDIS Land Processes DAAC. http://doi.org/10.5067/MODIS/MCD43A1.006 Available at: https://modis.gsfc.nasa.gov/data/dataprod/mod43.php

Population	Annual	Related to development	WorldPop	Lloyd, C. T., Sorichetta, A. & Tatem, A. J. High resolution global gridded data for use in population studies. Sci. Data 4, sdata20171 (2017). World Pop. Get data. Available at: http://www.worldpop.org.uk/data/get_data/. (Accessed: 25th July 2017)
Healthcare access and quality index	Annual	Related to development	Barber et al.	Barber, R. M. et al. Healthcare Access and Quality Index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990-2015: a novel analysis from the Global Burden of Disease Study 2015. Lancet 390, 231-266 (2017).
Lag distributed income per capita	Annual	Related to development	Global Burden of Disease Study	Institute for Health Metrics and Evaluation (IHME). Findings from the Global Burden of Disease Study 2017. Seattle, WA: IHME, 2018.
Concentration of Particulate Matter 2.5	Annual	Related to target indicator	van Donkelaar et al (derived)	van Donkelaar, A., Martin, R.V., Brauer, M., & Boys, B.L. Use of Satellite Observations for Long-Term Exposure Assessment of Global Concentrations of Fine Particulate Matter. *Environmental Health Perspectives***123**(2), 135-143 (2015). Available at: https://ehp.niehs.nih.gov/1408646/#tab1
Deforestation	Annual	Related to availability of biofuels	University of Maryland's Global Forest Change project, based on Landsat data archive	Hansen, M. C. *et al.* High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science.* **342**, 850-853 (2013).
Landcover classes	Annual	Related to development	ESA-CCI project	Available at: https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-land-cover?tab=overview

Supplementary Table 6a-b: Covariates used in ensemble modelling via stacked generalisation, stratified by modelling region

Each 'TRUE' indicates that a specific covariate was used in the model for a specific modelling region. Table **a)** presents the first 10 modelling regions. Table **b)** presents the remaining 11 modelling regions.

a)

Covariate	Andean South America	Central America and the Caribbean	China	Central Sub-Saharan Africa	Eritrea, Djibouti, Yemen	Eastern Sub-Saharan Africa	Middle East	Mongolia	Nigeria
Travel time to nearest settlement	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
aridity	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE
Diurnal temperature range	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
Frost day frequency	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE
Potential Evapotranspiration	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE
Average daily mean temperature	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE
deforestation	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	TRUE
Dependency ratio of dependents to working age adults	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Distance from rivers or lakes >= 50 sq km	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE
Nighttime lights	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE
elevation	FALSE	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Landcover classes	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
escroplandarea	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
evi_v6	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
fertility	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
Urbanicity	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
haqi	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
nutrient yield	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
irrigation	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

landcover	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE
ldi_pc	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE
Average Land Surface Temperature	TRUE	TRUE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	TRUE
Precipitation	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Concentration of Particulate Matter 2.5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE
tcb_v6	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
tcw_v6	TRUE	FALSE	TRUE	FALSE	FALSE	TRUE	FALSE	TRUE	FALSE
Population	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

b)

Covariate	North Africa	Oceania	Southeast Asia	South Asia	Southern Sub-Saharan Africa	Central Asia	Tropical South America	Western Sub-Saharan Africa	South Africa
Travel time to nearest settlement	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
aridity	FALSE	TRUE	TRUE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Diurnal temperature range	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE
Frost day frequency	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
Potential Evapotranspiration	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE
Average daily mean temperature	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE
deforestation	FALSE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
Dependency ratio of dependents to working age adults	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	TRUE
Distance from rivers or lakes >= 50 sq km	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Nighttime lights	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE

elevation	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Landcover classes	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
escroplandarea	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
evi_v6	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
fertility	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Urbanicity	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
haqi	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE	FALSE
nutrient yield	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
irrigation	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
landcover	FALSE	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	TRUE	TRUE
ldi_pc	FALSE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	TRUE
Average Land Surface Temperature	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Precipitation	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Concentration of Particulate Matter 2.5	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
tcb_v6	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
tcw_v6	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	FALSE	FALSE	FALSE
Population	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

Supplementary Table 7: Fitted parameters by region for model of Solid Fuel Use

Lower, median, and upper quantiles (0.025%, 0.50%, 0.975%) are displayed for the main parameters by region. The first four columns provide information on the fixed effects: the intercept (int) and the covariates (gam, gbm, and enet) corresponding to the predicted ensemble rasters. Fitted values for the spatio-temporal field hyperparameters and the precisions (inverse variance) for our random effects are shown in the next four columns.

	Quantiles	int	gam	gbm	xgboost	Nominal Range	Nominal Variance	Ar1 ρ	precis	Country Random Effect Precision
Andean South America	0.025	-1.58485	-0.00068	0.08620	0.83292	0.84010	0.87280	0.59480	2.20950	0.35370
	0.5	-0.86580	0.02452	0.11619	0.85927	0.99670	0.93520	0.60280	3.19800	1.39030
	0.975	-0.14735	0.04972	0.14615	0.88561	1.13830	0.97870	0.60830	5.19730	4.70690
Central America and the Caribbean	0.025	-0.63052	0.04751	0.10272	0.69755	1.12050	0.93050	0.43840	2.75290	0.63980
	0.5	-0.11545	0.09848	0.16087	0.74063	1.31580	0.98090	0.44920	4.14210	1.76390
	0.975	0.39920	0.14940	0.21901	0.78367	1.47420	1.04530	0.46810	6.89890	4.82600
China	0.025	-0.33666	-0.09953	-0.37279	1.18108	5.45100	0.29750	4153.28410	12.54080	NA
	0.5	-0.12063	-0.01129	-0.25980	1.27109	7.90640	0.40100	20603.90910	57.67960	NA
	0.975	0.09519	0.07690	-0.14714	1.36121	12.50670	0.57670	91703.73690	220.36210	NA
Central Sub-Saharan Africa	0.025	1.38080	-0.03779	-0.31687	1.08055	2.85840	1.17350	0.71050	1.37830	0.32300
	0.5	2.12847	0.02503	-0.20675	1.18151	3.72010	1.44100	0.76220	3.03750	1.75460
	0.975	2.87562	0.08836	-0.09688	1.28240	4.97860	1.81470	0.79540	6.77940	8.64240
Eritrea, Djibouti, and Yemen	0.025	-1.92666	-0.03216	-0.51720	0.78475	2.56670	1.23210	0.14830	1.18240	1163.70890
	0.5	-1.05112	0.17834	-0.25479	1.07615	4.09890	1.62410	0.15490	10.72630	16039.60500
	0.975	-0.17760	0.38971	0.00724	1.36722	6.72600	2.21540	0.16470	46.47140	76312.09290
Eastern Sub-Saharan Africa	0.025	1.65691	0.03735	0.17986	0.67583	1.12480	0.76090	0.44880	0.89430	1.33090
	0.5	1.97228	0.06752	0.21961	0.71273	1.19110	0.78280	0.45640	1.14240	5.66250
	0.975	2.28739	0.09800	0.25933	0.74953	1.28730	0.81840	0.46060	1.37570	26.12950
Middle East	0.025	-3.74763	-0.07895	0.53827	0.24256	1.84990	2.17190	0.77020	0.03510	1139.92650
	0.5	-2.51122	-0.03559	0.66598	0.36715	2.25990	2.53560	0.84960	0.09680	14124.22670
	0.975	-1.27655	0.01337	0.79359	0.49137	2.59610	2.82120	0.90710	0.19890	70417.66600
Mongolia	0.025	0.43626	0.01661	-0.93653	1.53200	1.97440	0.71600	0.67810	3.03670	NA
	0.5	0.80808	0.11109	-0.78340	1.67242	3.11170	0.91340	0.80250	9.94220	NA
	0.975	1.17972	0.20572	-0.63059	1.81264	4.65920	1.17310	0.87440	21.42290	NA
Nigeria	0.025	0.94962	0.12214	-0.87223	1.36671	1.02520	0.73130	0.47810	1.58970	NA
	0.5	1.31404	0.21557	-0.71940	1.50385	1.23430	0.81860	0.49150	3.17030	NA

	Quantiles	int	gam	gbm	xgboost	Nominal Range	Nominal Variance	Ar1 ρ	precis	Country Random Effect Precision
	0.975	1.67817	0.30897	-0.56671	1.64086	1.51260	0.93390	0.50170	7.06070	NA
North Africa	0.025	-2.60989	0.02938	0.32645	0.55286	3.44670	1.44620	1.07860	0.00860	1279.38900
	0.5	-1.39878	0.04992	0.36344	0.58641	4.22000	1.70570	1.13920	0.06330	12656.89930
	0.975	-0.18897	0.07114	0.40023	0.61993	5.50710	2.09670	1.17960	0.18020	65596.20270
Oceania	0.025	0.20310	-0.01904	-0.00413	0.94406	1.07990	0.89370	0.50410	0.50370	1295.97220
	0.5	0.62047	0.00064	0.02642	0.97293	1.17200	0.92120	0.50890	0.95770	12718.42720
	0.975	1.03753	0.02035	0.05693	1.00178	1.24950	0.95900	0.51610	3.03050	69850.65680
Southeast Asia	0.025	0.26101	0.17272	-0.04960	0.68451	1.32550	0.82130	0.50130	0.08010	1269.42210
	0.5	0.78153	0.24449	0.01628	0.74068	1.57150	0.89440	0.51790	0.36290	13665.42090
	0.975	1.30165	0.31134	0.08317	0.79732	1.78310	0.96770	0.54250	0.76430	69249.11850
South Asia	0.025	0.93389	-0.01766	-1.44295	2.26529	0.83740	0.97750	0.30960	0.41740	2039.97530
	0.5	1.38598	0.04739	-1.37639	2.32899	0.95310	0.99930	0.31370	0.57560	14399.55650
	0.975	1.83772	0.11239	-1.30989	2.39264	1.02760	1.03390	0.31700	0.82640	62740.85950
Southern Sub-Saharan Africa	0.025	0.07039	0.44656	-0.73129	0.91923	0.45910	0.93520	0.32540	0.75520	1212.84440
	0.5	0.41526	0.55710	-0.60577	1.04872	0.62710	0.99640	0.33630	1.47970	12216.45070
	0.975	0.75985	0.66760	-0.48039	1.17807	0.77600	1.04740	0.34450	2.52000	66768.69320
Central Asia	0.025	-0.93006	-0.08087	-0.38585	1.22377	10.86020	1.16420	0.17930	0.75020	652.34450
	0.5	-0.27388	0.00292	-0.30124	1.29824	12.00080	1.28420	0.19010	0.87470	7236.75560
	0.975	0.38177	0.08674	-0.21671	1.37265	14.93530	141870.26620	195.34510	1.19530	91991.31560
Tropical South America	0.025	-0.31025	0.14782	0.17325	0.62631	2.49180	0.75620	17.62900	5.89530	0.23750
	0.5	0.51561	0.16671	0.19252	0.64076	2.70010	0.80770	18.21250	8.87290	1.01690
	0.975	1.34085	0.18559	0.21178	0.65520	2.97310	0.87270	19.09090	14.03920	3.05940
Western-Sub Saharan Africa	0.025	1.08673	-0.00911	0.26714	0.58305	1.93070	0.77510	0.52940	0.81450	1329.71270
	0.5	1.34195	0.03971	0.32913	0.63044	2.36570	0.83890	0.53940	1.08000	13907.71210
	0.975	1.59697	0.09127	0.39009	0.67779	2.70350	0.90480	0.54600	1.42260	72484.39230
South Africa	0.025	-0.55307	-0.04261	0.42272	0.54545	0.84230	0.46760	3.30410	14.98960	NA
	0.5	-0.42193	-0.01947	0.45087	0.56860	1.03310	0.51830	3.36150	19.83510	NA

	Quantiles	int	gam	gbm	xgboost	Nominal Range	Nominal Variance	Ar1 ρ	precis	Country Random Effect Precision
	0.975	-0.29090	0.00366	0.47899	0.59173	1.24440	0.58990	3.42720	30.36190	NA

Supplementary Table 8: Predictive metrics for SFU, aggregated to the national level (Admin 0)

YEAR	OOS	Median SS	Mean err.	RMSE	Corr.	95% Cov.
2000	FALSE	74,345.660	-0.029	0.077	0.928	0.944
2005	FALSE	84,999.073	0.000	0.052	0.986	0.957
2010	FALSE	110,729.798	-0.038	0.043	0.998	0.853
2015	FALSE	84,022.000	-0.071	0.099	0.971	0.736
2018	FALSE	96,822.000	-0.014	0.080	0.976	0.936
2000	TRUE	74,345.660	-0.025	0.076	0.928	0.944
2005	TRUE	84,926.073	-0.011	0.056	0.985	0.932
2010	TRUE	110,729.798	-0.039	0.044	0.998	0.803
2015	TRUE	84,022.000	-0.101	0.118	0.975	0.745
2018	TRUE	96,822.000	-0.029	0.073	0.983	0.946

Supplementary Table 9: Predictive metrics for SFU, aggregated to the first administrative level (Admin 1)

YEAR	OOS	Median SS	Mean err.	RMSE	Corr.	95% Cov.
2000	FALSE	10,066.000	-0.029	0.100	0.950	0.944
2005	FALSE	5,592.593	0.000	0.075	0.975	0.957
2010	FALSE	5,180.552	-0.038	0.055	0.993	0.853
2015	FALSE	5,192.436	-0.071	0.134	0.921	0.736
2018	FALSE	9,477.775	-0.014	0.092	0.974	0.936
2000	TRUE	9,937.514	-0.026	0.097	0.949	0.944
2005	TRUE	5,592.593	-0.011	0.082	0.971	0.932
2010	TRUE	5,180.552	-0.039	0.067	0.987	0.803
2015	TRUE	5,094.664	-0.101	0.140	0.944	0.745
2018	TRUE	9,477.775	-0.029	0.126	0.951	0.946

Supplementary Table 10: Predictive metrics for SFU, aggregated to the second administrative level (Admin 2)

YEAR	OOS	Median SS	Mean err.	RMSE	Corr.	95% Cov.
2000	FALSE	1,423.868	-0.029	0.124	0.933	0.944
2005	FALSE	764.000	0.000	0.117	0.947	0.957
2010	FALSE	333.046	-0.038	0.092	0.972	0.853
2015	FALSE	710.463	-0.071	0.175	0.870	0.736
2018	FALSE	159.633	-0.014	0.131	0.946	0.936
2000	TRUE	1,405.583	-0.026	0.127	0.924	0.944

2005	TRUE	763.358	-0.011	0.129	0.937	0.932
2010	TRUE	331.275	-0.039	0.111	0.957	0.803
2015	TRUE	708.381	-0.101	0.170	0.906	0.745
2018	TRUE	159.170	-0.029	0.154	0.926	0.946

6.0 Author Contributions

Managing the estimation or publications process

Brigette F Blacker, Simon I Hay, and Robert C Reiner Jr.

Writing the first draft of the manuscript

Joseph Jon Frostad, Simon I Hay, and Robert C Reiner Jr.

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