

Paper title

Urban Heat, Mortality, and Economic Costs: Evidence from Bangkok, Thailand

Overview

- The R script is written to access and extract gridded monthly maximum (Tmax) and minimum (Tmin) temperature data from TerraClimate, and calculate the average of Tmax and Tmin across pixels in each of Bangkok's amphurs (districts).
- The Stata code constructs the analysis file and generates the underlying data for all the figures in the manuscript, except for figure 1 that was directly generated in Excel.

Data Availability

Publicly available:

- Monthly mortality for Thailand, January 2016–December 2018
 - Source: Ministry of Public Health
 - URL: <https://spd.moph.go.th/wp-content/uploads/2022/11/Hstatistics2563.pdf>
 - Note: Page 41 (PDF page 52)
 - File name: Data/Raw/01eap_tha_month_deaths.xlsx
- Annual mortality for Bangkok by Amphur, 2016–2018
 - Source: National Statistics Office
 - URL: <https://stathub.nso.go.th/>
 - Note: Data points for years from 2016 to 2018 (2559 to 2561 based on the Thai calendar) were extracted from the raw data containing years from 1998 to 2023 (2541 to 2566). See Stata do-file line 199.
 - Variable: Demographic indicators = Number of deaths; Sex = Total; Region = Bangkok; Province = Krung Thep Maha Nakhon (Bangkok); Frequency = Annual; Amphor = 50 items
 - File name: Data/Raw/ 02eap_tha_bkk_amp_annual_deaths.xlsx
- Annual population for Bangkok by Amphur, 2016–2018
 - Source: National Statistics Office
 - URL: <https://stathub.nso.go.th/>
 - Note: Data points for years from 2016 to 2018 (2559 to 2561 based on the Thai calendar) were extracted from the raw data containing years from 2010 to 2022 (2553 to 2565). See Stata do-file line 323.
 - Variable: Demographic indicators = Population from registration; Region = Bangkok; Province = Krung Thep Maha Nakhon (Bangkok); Frequency = Annual
 - File name: Data/Raw/ 03eap_tha_bkk_amp_annual_pop.xlsx
- Value of Statistical Life, 2011
 - Source: Witvorapong & Komonpaisarn (2019)

- URL: <https://link.springer.com/article/10.1007/s10603-019-09431-2>
- Note: A Thai's Value of Statistical Life directly taken from the article; Properly cited in the manuscript.
- Citation: Witvorapong, N., & Komonpaisarn, T. (2020). "The Value of a Statistical Life in Thailand: Evidence from the Labour Market." Journal of Consumer Policy 43: 491–518. <https://link.springer.com/article/10.1007/s10603-019-09431-2>.
- File name: Data/Raw/04eap_tha_bkk_vsl.xlsx
- Consumer Price Index, US City Average, 2011 & 2016–2018
 - Source: U.S. Bureau of Labor Statistics
 - URL: https://www.bls.gov/regions/northeast/data/consumerpriceindex_us_table.htm
 - Variable: Avg for 2011, 2016, 2017, and 2018.
 - Note: Manually recorded based on the source data.
 - File name: Data/Raw/04eap_tha_bkk_vsl.xlsx
- Exchange rates (Thai Baht to one U.S. Dollar), 2016–2018
 - Source: Federal Reserve Bank of St. Louis
 - URL: <https://fred.stlouisfed.org/series/AEXTHUS>
 - Note: Manually recorded based on the source data.
 - File name: Data/Raw/04eap_tha_bkk_vsl.xlsx
- Monthly maximum and minimum temperatures for Bangkok by amphur, 2011–2020
 - Source: TerraClimate
 - URL: <https://www.climatologylab.org/terraclimate.html>
 - Note: Processed in R.
 - Access date: August 20, 2024.
 - File name: Data/Raw/ 06eap_tha_bkk_month_tmax_terraclimate.csv
 - File name: Data/Raw/ 06eap_tha_bkk_month_tmin_terraclimate.csv
- Administrative boundaries shapefile for Bangkok's amphurs
 - Source: Humanitarian Data Exchange
 - URL: <https://data.humdata.org/dataset/cod-ab-tha>
 - Note: Boundaries for Bangkok's 50 amphurs were extracted from Thailand's level-2 administrative boundaries.
 - File name: Data/Shape/ tha_admbnda_adm2_rtsd_20220121_bkk.shp

Permission from the third parties required:

- Relative risk of mortality
 - Source: Denpetkul & Phosri (2021)
 - URL: <https://doi.org/10.1016/j.scitotenv.2021.148373>
 - Note: Acquired through authors' request for data sharing. Dr. Arthit Phosri can be contacted at arthit.pho@mahidol.ac.th.
 - Citation: Denpetkul, T. & Phosri, A. (2021). " Daily ambient temperature and mortality in Thailand: Estimated effects, attributable risks, and effect

modifications by greenness". *Science of The Total Environment* 791: 148373.

<https://doi.org/10.1016/j.scitotenv.2021.148373>.

- Filename: Data/Raw/ 05eap_tha_bkk_rr_raw.dta

Statement about Rights

I certify that the author(s) of the manuscript have legitimate access to and permission to use the data used in this manuscript.

Instructions for Replicators

To create monthly maximum and monthly minimum temperatures for each of Bangkok's 50 amphurs, a new user should:

1. Open `eap_tha_bkk_heat_temperature.R` in the Code folder.
2. Update the working directory (line 8) from `setwd("C:/Users/...")` to her/his local directory.
3. Install R packages (`sf`, `climate`, `AOI`, and `exactextractr`).
4. Execute the script to access and download monthly temperature data from TerraClimate, calculate statistics at the amphur level, and save CSV files in the `Data/Raw` folder.
 - a. The `getTerraClim` function allows users to access the variables of interest (tmax and tmin) for the area of interest (Bangkok amphurs) and the period of interest in the TerraClimate's cloud (lines 15 and 29).
 - b. The `exact_extract` function calculates the mean tmax and tmin across pixels intersecting with each of the amphur polygons (lines 21 and 35).
 - c. The `write.csv` function exports these district-level datasets as CSV files (lines 26 and 40).
5. Note that TerraClimate updates data periodically. Hence, replicators may obtain slightly different temperature values depending on the timing of code running.

To produce the underlying data for the figures in the manuscript, a new user should:

1. Open the script `eap_tha_bkk_heat_analysis.do` in the Code folder.
2. Update the global directory (line 8) from `"C:\Users\...\EAP_THA_BKK_Heat_Package"` to her/his local directory.
3. Execute the script to generate all the output data to be saved in the `Outputs` folder.

The data saved in the Outputs folder will underpin Figure 2, Figure 3 (panels a–d), Figure 4 (panels a, c, and d), and Figure 5 (panels a and b) in the manuscript.

Software Requirement

- Data processing and analysis
 - RStidop 2024.12.1 used to process gridded temperature data.

- StataNow MP 19.5 used for all other data preparation and analysis.
- Visualization of the results
 - Microsoft Excel for Figure 1; Figure 2; Figure 3, panels a–d; Figure 5, panels a and b
 - ArcMap 10.2.2 for Figure 4, panels a and d
 - QGIS Desktop 3.34.0 for Figure 4, panel c

List of Exhibits

The provided Stata code reproduces the underlying data for the figures in the paper, as explained below:

Exhibit	Output filename	Script
Figure 2	eap_tha_bkk_heat_figure2.dta	eap_tha_bkk_heat_analysis.do (line 222–247)
Figure 3	eap_tha_bkk_heat_figure3abc.dta eap_tha_bkk_heat_figure3d.dta	eap_tha_bkk_heat_analysis.do (line 249–290)
Figure 4	eap_tha_bkk_heat_figure4a.dta eap_tha_bkk_heat_figure4c.dta eap_tha_bkk_heat_figure4d.dta	eap_tha_bkk_heat_analysis.do (line 292–337)
Figure 5	eap_tha_bkk_heat_figure5.dta	eap_tha_bkk_heat_analysis.do (line 339–396)

Note: Output data are copied to **EAP_THA_BKK_Heat_Figures.xlsx** for the generation of figures 2, 3, and 5, and exported to ArcMap and QGIS for figures 4a, 4c, and 4d.

Folder Structure

Data

- Raw: 2 CSV files, 4 MS Excel files, and 7 DTA files.
- Clean: 6 DTA files generated by executing EAP_THA_BKK_Heat_Code.do.
- Shape: Bangkok’s level-2 administrative boundaries in vector format.

Code

- eap_tha_bkk_heat_temperature.R
- eap_tha_bkk_heat_analysis.do

Outputs

- 7 DTA files generated by executing EAP_THA_BKK_Heat_Code.do.
- EAP_THA_BKK_Heat_Figures.xlsx