

Release Statement

Gridded population estimates for Ukraine using UN COD-PS estimates 2022, version 3.0

8 November 2022

These data were produced by [WorldPop](#) at the University of Southampton and the Leverhulme Centre for Demographic Science at the University of Oxford. These data include gridded estimates of population at approximately 100m for 2022, along with estimates of the number of people belonging to individual age-sex groups. These results were produced using subnational population estimates for Ukraine in 2022 provided in the Common Operational Dataset on Population Statistics ([COD-PS](#) [1]) and built-up surfaces/volumes/height covariates extracted from GHSL datasets; GHS-BUILT-Surface epoch 2020 layer was used to delineate settled areas [2]. The [constrained](#) top-down disaggregation method was used to produce the datasets, i.e. population was only estimated within areas classified as containing built settlements. The modelling work and geospatial data processing was led by Bondarenko M., Priyatikanto R., Sorichetta A., Leasure D.R.. Oversight was provided by Tatem A.J.

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The authors followed rigorous procedures designed to ensure that the used data, the applied method and thus the results are appropriate and of reasonable quality. If users encounter apparent errors or misstatements, they should contact WorldPop at release@worldpop.org.

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CITATION

Bondarenko M., Priyatikanto R., McKeen T., Sorichetta A., Leasure D.R., and Tatem A.J. 2022 *Gridded population estimates for Ukraine using UN COD-PS estimates 2022, version 3.0*. WorldPop, University of Southampton. doi:10.5258/SOTON/WP00742.

POPULATION REFERENCE DATE: 1 January, 2022*

MAIN DATA SOURCES

- **Population: Subnational (Oblast-level)** population estimates for Ukraine in 2022 provided in the Common Operational Dataset on Population Statistics (COD-PS). It is an update to an earlier COD-PS released by UNFPA on March 4, 2022. This COD-PS update projected the population forward, by age and sex for each ADM-1 geographic area. [1] Reference date: 1 January 2022.
- Settlement area: GHS-BUILT-S R2022A - GHS built-up surface grid, derived from Sentinel-2 composite and Landsat, multitemporal (1975-2030) [2]. Reference dates: GHS-BUILT-Surface, epoch: 2020; GHS-BUILT-Volume, epoch: 2020; GHS-BUILT-Height, epoch: 2018
- Subnational Administrative Boundaries for Ukraine provided by OCHA [3].
- Geospatial covariate layers available at WorldPop [4].

* Reference date refers to Oblast-level population totals and corresponds to the COD-PS reference date [1]. Sub-Oblast population estimates may have additional uncertainty associated with the reference dates of other data sources.

RELEASE CONTENT

1. ukr_pop_2022_100m_constrained_v3.zip
2. ukr_agesex_2022_100m_constrained_v3.zip

FILE DESCRIPTIONS

The projection for all GIS files is the geographic coordinate system WGS84 (World Geodetic System 1984).

ukr_pop_2022_100m_constrained_v3.zip

This geotiff raster, at a spatial resolution of 3 arc-seconds (approximately 100m at the equator), contains estimates of total population size per grid cell across Ukraine. NA values represent areas that were mapped as unsettled based on the GHS settlement layer [2]. These data are stored as floating-point numbers rather than integers to avoid rounding errors in aggregated populations for larger areas.

ukr_agesex_2022_100m_constrained_v3.zip

This zip file contains 34 raster files in geotiff format at a spatial resolution of 3 arc-seconds (approximately 100m at the equator). Each raster provides gridded population estimates for an age-sex group of settled areas (NA represent unsettled areas). Files are labelled with either an “M” (male) or an “F” (female) followed by the age-range of the group (five year bins). For instance, “F_00_04” and “M_05_09” are population counts of under 5 year olds for females and between 5 and 9 years old for males, respectively. Eighty year olds and over are represented in the groups “F_80Plus” and “M_80Plus”. These data were produced using age-sex national proportions from COD-PS [1]. The age-sex proportions were applied to the gridded population estimates (*ukr_pop_2022_100m_constrained_v3*) to allocate the population to the different age-sex classes. While this data represents population counts, values contain decimals, i.e. fractions of people. This is because we do not estimate which grid cell each individual in a given age group occupies. For this reason, it is advised to aggregate the rasters at a coarser scale. For example, if four grid cells next to each other have values of 0.25 this indicates that there is 1 person of that age group somewhere in those four grid cells.

RELEASE HISTORY

- Version 3.0 (8 November 2022) [<https://dx.doi.org/10.5258/SOTON/WP00742>]
 - Using updated COD-PS population projections. This COD-PS is based on post-censal population projections . It is an update to an earlier COD-PS that had a reference date of 1 January 2020. . The updated COD-PS projects the population forward, by age and sex for each ADM-1 geographic area, to 1 January 2022. For basic attributes of the COD-PS, please refer to the COD-PS Metadata [1].
 - Using GHS-BUILT-S R2022A - GHS built-up surface grid, derived from Sentinel-2 composite and Landsat, multitemporal. This replaced the World Settlement Footprint 3D data from version 2.0.
- Version 2.0 (28 March 2022) [<https://dx.doi.org/10.5258/SOTON/WP00735>]
 - Refinement of gridded population estimates using more recent settlement data based on the German Aerospace Centre’s (DLR) World Settlement Footprint 3D product (WSF-3D) [1].
- Version 1.0 (14 March 2022) [<https://dx.doi.org/10.5258/SOTON/WP00734>] Original release of Ukraine 2020 population dataset

METHODS

Pre-processing: Subnational Administrative Boundaries provided by OCHA were nibbled (i.e. cells with no data are replaced with the values of the nearest neighbors) to match the WorldPop mastergrid and avoid mismatch with the WorldPop covariates.

Modelling: Building height/area/volume per pixel were extracted from GHS in addition to classifying pixels as residential or non-residential. The population modelling described below used the Random Forest (RF)-based dasymetric mapping approach (Stevens et al., 2015 [6]) implemented in the popRF 'R' package [5] based on the Breiman (2001) [7] algorithm.

The UN COD-PS [1] population projections do not have a sufficient number of admin units (27 regular admin 1 units and 30 cities with over 100K population) to apply the RF methodology well. Therefore admin 3 (636 admin units) projected 2020 population data from WorldPop [8] was used to train the RF model and produce an unconstrained prediction weighting layer, where all non-residential pixels were given a value of zero in the built-up covariate inputs (APPENDIX 2). An assessment of which of the ancillary data covariates were important for accurately estimating population density at the census unit level can be seen in the APPENDIX 3. The model could explain 92.1% of the population input variance (i.e. the admin 3 projected population data from WorldPop [8]). The unsettled areas of this unconstrained weighting layer were then removed by using the GHS-BUILT-Surface epoch 2020 layer containing all built-up surfaces (residential and non-residential) as a mask, thus creating a constrained weighting layer. Finally, this constrained prediction weighting layer was used for dasymetric redistribution of the UN COD-PS [1] population estimates 2022 (APPENDIX 1). The gridded population estimates were then combined with the COD-PS [1] age/sex pyramid table for Ukraine to produce gridded population estimates for females and males at regular age intervals.

WORK CITED

1. United Nations Population Fund (UNFPA). Common Operational Dataset on Population Statistics for Ukraine. Updated: 14 November, 2022. Available at: <https://data.humdata.org/dataset/cod-ps-ukr>
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7. Breiman L. Random Forests. Mach Learn. 2001 [cited 2013 Jan 24].45(1):5–32. Available: <http://link.springer.com/article/10.1023/A:1010933404324>
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APPENDIX 1

Table of *ADM1_PCODE* Subnational Administrative Boundaries for Ukraine provided by OCHA.
Source <https://data.humdata.org/dataset/cod-ps-ukr>

ISO3	NAME	ADM1_PCODE
UKR	Autonomous Republic Crimea	UA01
UKR	Cherkasy oblast	UA71
UKR	Chernihiv oblast	UA74
UKR	Chernivtsi oblast	UA73
UKR	Dnipropetrovsk oblast	UA12
UKR	Donetsk oblast	UA14
UKR	Ivano-Frankivsk oblast	UA26
UKR	Kharkiv oblast	UA63
UKR	Kherson oblast	UA65
UKR	Khmelnyskiy oblast	UA68
UKR	Kirovohrad oblast	UA35
UKR	Kyiv (Capital)	UA80
UKR	Kyiv oblast	UA32
UKR	Luhansk oblast	UA44
UKR	Lviv oblast	UA46
UKR	Mykolayiv oblast	UA48
UKR	Odesa oblast	UA51
UKR	Poltava oblast	UA53
UKR	Rivne oblast	UA56
UKR	Sevastopol	UA85
UKR	Sumy oblast	UA59
UKR	Ternopil oblast	UA61

UKR	Vinnytsya oblast	UA05
UKR	Volyn oblast	UA07
UKR	Zakarpattia oblast	UA21
UKR	Zaporizhzhya oblast	UA23
UKR	Zhytomyr oblast	UA18

Table of *adm4_PCODE* Subnational Administrative Boundaries for Ukraine provided by OCHA.

Source <https://data.humdata.org/dataset/cod-ps-ukr>

ISO3	NAME	ADM4_PCODE
UKR	Cherkasy oblast Cherkasy city	UA7108049001
UKR	Chernihiv oblast Chernihiv city	UA7410039001
UKR	Chernivtsi oblast Chernivtsi city	UA7306061001
UKR	Dnipropetrovsk oblast Kamianske city	UA1204015001
UKR	Dnipropetrovsk oblast Kryvyi Rih city	UA1206017001
UKR	Dnipropetrovsk oblast Nikopol city	UA1208005001
UKR	Dnipropetrovsk oblast Pavlohrad city	UA1212007001
UKR	Dnipropetrovsk oblast Dnipro city	UA1202001001
UKR	Ivano-Frankivsk oblast Ivano-Frankivsk city	UA2604019001
UKR	Kharkiv oblast Kharkiv city	UA6312027001
UKR	Kherson oblast Kherson city	UA6510015001
UKR	Khmelnyskiy oblast Khmelnytskyi city	UA6804047001
UKR	Kirovohrad oblast Kropyvnytskyi city	UA3504021001
UKR	Kyiv oblast Bila Tserkva city	UA3202001001
UKR	Kyiv oblast Brovary city	UA3206005001
UKR	Lviv oblast Lviv city	UA4606025001
UKR	Mykolayiv oblast Mykolayiv city	UA4806015001
UKR	Odesa oblast Odesa city	UA5110027001
UKR	Poltava oblast Kremenchuk city	UA5302011001
UKR	Poltava oblast Poltava city	UA5308037001
UKR	Rivne oblast Rivne city	UA5606047001
UKR	Sumy oblast Sumy city	UA5908027001
UKR	Ternopil oblast Ternopil city	UA6104049001
UKR	Vinnytsya oblast Vinnytsya city	UA0502003001
UKR	Volyn oblasts Lutsk city	UA0708017001
UKR	Zakarpattia oblast Uzhhorod city	UA2110023001
UKR	Zaporizhzhya oblast Melitopol city	UA2308007001
UKR	Zaporizhzhya oblast Zaporizhzhya city	UA2306007001
UKR	Zaporizhzhya oblasts Berdiansk city	UA2302005001
UKR	Zhytomyr oblast Zhytomyr city	UA1804019001

APPENDIX 2

List of covariates.

Name of the covariate	Description
ukr_grid_100m_ccilc_dst011_2015.tif	Distance to ESA-CCI-LC cultivated area edges 2015
ukr_grid_100m_ccilc_dst040_2015.tif	Distance to ESA-CCI-LC woody-tree area edges 2015
ukr_grid_100m_ccilc_dst130_2015.tif	Distance to ESA-CCI-LC shrub area edges 2015
ukr_grid_100m_ccilc_dst140_2015.tif	Distance to ESA-CCI-LC herbaceous area edges 2015
ukr_grid_100m_ccilc_dst150_2015.tif	Distance to ESA-CCI-LC sparse vegetation area edges 2015
ukr_grid_100m_ccilc_dst160_2015.tif	Distance to ESA-CCI-LC aquatic vegetation area edges 2015
ukr_grid_100m_ccilc_dst190_2015.tif	Distance to ESA-CCI-LC artificial surface edges 2015
ukr_grid_100m_ccilc_dst200_2015.tif	Distance to ESA-CCI-LC bare area edges 2015
ukr_grid_100m_cciwat_dst.tif	ESA-CCI-LC inland waterbodies 2000-2012
ukr_grid_100m_gpw4coast_dst.tif	Distance to coastline 2000-2020
ukr_grid_100m_osmint_dst.tif	Distance to OSM major road intersections
ukr_grid_100m_osmriv_dst.tif	Distance to OSM major waterways
ukr_grid_100m_osmroa_dst.tif	Distance to OSM major roads
ukr_grid_100m_px_area.tif	Grid-cell surface areas
ukr_grid_100m_slope.tif	SRTM-based slope 2000 (SRTM is Shuttle Radar Topography Mission)
ukr_grid_100m_topo.tif	SRTM elevation 2000
ukr_grid_100m_viirs_2020.tif	VIIRS night-time lights 2020 (VIIRS is Visible Infrared Imaging Radiometer Suite)
ukr_grid_100m_wclim_prec.tif	Current average annual total precipitation
ukr_grid_100m_wclim_temp.tif	Current average annual temperature
ukr_grid_100m_wdpa_cat1_dst_2017.tif	Distance to IUCN strict nature reserve and wilderness area edges 2017
LandScanHDUkraine_dst.tif	Distance to settlement ORNL LandScan High Definition (HD) Data for Ukraine
Builtup_Height.tif	GHS built height 2018
Builtup_Surfaces.tif	GHS built surfaces 2020
Builtup_Volume.tif	GHS built volume 2020

APPENDIX 3

Variable importance.

Importance Ranking	Covariate	%IncMSE	IncNodePurity
1	Builtup_Dist	17.73569393	406.6391162
2	Builtup_Height	14.78727236	418.45701
3	Builtup_Surfaces	14.13053126	325.5509791
4	osmint_dst	12.85328833	59.06691551
5	Builtup_Volume	11.34162496	191.209494
6	topo	10.34319522	9.512470515
7	cls_dst130_100m_2015	9.863453514	9.085078684
8	Building_Fraction	9.861821229	195.5426615
9	cls_dst190_100m_2015	9.525020287	117.9571408
10	wclim_prec	9.38529413	8.41910873
11	slope	7.585688603	5.979715905
12	cls_dst140_100m_2015	7.47294621	8.664973102
13	gpw4coast_dst	7.327546433	7.829843607
14	viirs_2020	7.161335824	44.61292669
15	cls_dst040_100m_2015	6.514824418	4.651848005
16	cls_dst011_100m_2015	5.7266194	11.7863684
17	osmroa_dst	5.65278888	15.95696757
18	wclim_temp	5.016748212	4.259180521
19	wdpa_cat1_dst_2017	3.986868645	4.709106056
20	cls_dst200_100m_2015	3.960830519	5.53607652
21	cls_dst150_100m_2015	3.946405516	5.938638683
22	cciwat_dst	3.320784422	7.962653964
23	cls_dst160_100m_2015	2.605957581	5.507088298
24	osmriv_dst	1.723692353	4.478338825