

1. TITLE
2. INVESTIGATOR(S)
3. INTRODUCTION
4. THEORY OF ALGORITHM/MEASUREMENTS
5. EQUIPMENT
6. PROCEDURE
7. OBSERVATIONS
8. DATA DESCRIPTION
9. DATA MANIPULATIONS
10. ERRORS
11. NOTES
12. REFERENCES
13. DATA ACCESS
14. GLOSSARY OF ACRONYMS

1. TITLE

1.1 Data Set Identification

ISLSCP II Global Population of the World

1.2 Database Table Name(s)

Not applicable to this data set.

1.3 File Name(s)

The data files in this directory are provided at three spatial resolutions of 0.25, 0.5 and 1.0 degrees in both latitude and longitude. This data set includes the following files :

1) Population Counts ([gpw_population_counts_xdeg.zip](#))

- a) [gpw_pop_counts_XX_YYYYa.asc](#): ASCII maps of the global gridded population counts (persons per cell). XX can be qd, hd, and 1d, denoting a spatial resolution of 1/4, 1/2 and 1 degree, respectively. YYYY is the year (1990 or 1995), and if there is an "a" after the year, the population counts have been adjusted to match United Nations (U.N.) population totals at the national level. Both adjusted and unadjusted data are provided.
- b) [gpw_pop_counts_XX_YYYYa.dif](#): ASCII tables of "differences" or points in the original file that didn't match the ISLSCP II Land/Water mask, and were removed from the ASCII map files (see sections 8.4 and 9.2.3 for more details).
- c) [gpw_land_area_XX_changemap.asc](#): See 3a) below.

2) Population Density ([gpw_population_density_xdeg.zip](#))

- a) [gpw_pop_density_XX_YYYYa.asc](#): Same as 1a) above but for global gridded population density (persons per square km per cell).
- b) [gpw_pop_density_XX_YYYYa.dif](#): Same as 1b) above but for population density.
- c) [gpw_land_area_XX_changemap.asc](#): See 3a) below.

3) Land Area ([gpw_land_area_xdeg.zip](#))

- a) [gpw_land_area_XX.asc](#): ASCII maps of the global gridded land area (square km of land per cell) used to calculate the population density (2a above) from the population counts

(1a above). XX can be qd, hd, and 1d, denoting a spatial resolution of 1/4, 1/2 and 1 degree, respectively. There is only one file per spatial resolution.

- b) [gpw land area XX.dif](#): Same as 1b) and 2b) above but for global land area.
- c) [gpw land area XX changemap.asc](#): Gridded ASCII map showing the differences between the ISLSCP II land/water mask and the original data set: All points with negative values (“-1”) are those where the ISLSCP II mask showed water but where the original data set showed land (i.e. Land Area>0). All points with a value of zero are those points where the two land/water masks agreed and all points with positive values were land or water points with no data over land or water in the original data set which were filled in with a “missing data” value (see sections 8.4 and 9.2.3 for more details). There is one file per spatial resolution. Duplicates of these files are included in the archives for both population counts and density.

1.4 Revision Date of this Document

April 16, 2010

2. INVESTIGATOR(S)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

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2.4 Data Set Citation

Balk, D., U. Deichmann, and G. Yetman. 2010. ISLSCP II Global Population of the World. In Hall, Forrest G., G. Collatz, B. Meeson, S. Los, E. Brown de Colstoun, and D. Landis (eds.). ISLSCP Initiative II Collection. Data set. Available on-line [<http://daac.ornl.gov/>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. [doi:10.3334/ORNLDAAC/975](https://doi.org/10.3334/ORNLDAAC/975)

2.5 Requested Form of Acknowledgment

Users of the International Satellite Land Surface Climatology (ISLSCP) Initiative II data collection are requested to cite the collection as a whole (Hall et al. 2006) as well as the individual data sets. Please cite the following publications when these data are used:

Hall, F.G., E. Brown de Colstoun, G. J. Collatz, D. Landis, P. Dirmeyer, A. Betts, G. Huffman, L. Bounoua, and B. Meeson, The ISLSCP Initiative II Global Data sets: Surface Boundary Conditions and Atmospheric Forcings for Land-Atmosphere Studies, *J. Geophys. Res.*, 111, doi:10.1029/2006JD007366, 2006.

Center for International Earth Science Information Network (CIESIN), Columbia University; International Food Policy Research Institute (IFPRI); and World Resources Institute (WRI). 2000. *Gridded Population of the World (GPW), Version 2*. Palisades, NY: CIESIN, Columbia University.

3. INTRODUCTION

3.1 Objective/Purpose

Demographic information is often provided on a national basis, but global environmental and other cross-disciplinary studies usually require data that are referenced by geographic coordinates, such as latitude and longitude, rather than by political or administrative units. In the GPW data set, the distribution of human population is converted from national or subnational

units to a series of georeferenced quadrilateral grids. GPW provides estimates of the population of the world in 1990 and 1995, both population counts (raw counts) and population densities (per square km). National figures have been reconciled to be consistent with United Nations population estimates for those years; unadjusted data are also available.

3.2 Summary of Parameters

This data set for the International Satellite Land Surface Climatology Project (ISLSCP) Initiative II contains population counts (U.N. adjusted and unadjusted), population densities (U.N. adjusted and unadjusted), and the land area used to calculate the population density, at spatial resolutions of 1/4, 1/2 and 1 degree in both latitude and longitude. Land area in this data set refers to the land area of each grid cell not including water bodies and ice. Files showing the differences between the original data set and the Land/water mask used in the ISLSCP Initiative II data collection are also provided.

3.3 Discussion

GPW translates census population data to a latitude-longitude grid so that population data may be used in cross-disciplinary studies. Over 127,000 administrative units and population counts were collected and integrated from various sources to create the gridded data. In brief, GPW was created using the following steps:

- Population data were estimated for the product reference years, 1990 and 1995, either by the data source or by interpolating or extrapolating the given estimates for other years.
- Additional population estimates were created by adjusting the source population data to match UN national population estimates for the reference years.
- Borders and coastlines of the spatial data were matched to the Digital Chart of the World (DCW) where appropriate and lakes from the Digital Chart of the World were added. Where DCW was out of date (for example, for recently formed countries), DCW was not used. Borders, in these cases, were derived from the national-level administrative boundaries acquired for the project.
- The resulting data were then transformed into grids of UN-adjusted and unadjusted population counts for the reference years.
- Grids containing the area of administrative boundary data in each cell (net of lakes) were created and used with the population count grids to produce population densities.

As with any global data set based on multiple data sources, the spatial and attribute precision of GPW is variable. The level of detail and accuracy, both in time and space, vary among the countries for which data were obtained. The factors that contribute to the varying precision and accuracy of GPW include:

- Data timeliness and population adjustment, 1990 and 1995.
- Algorithm introduced error.
- Spatial accuracy.

For data set consistency throughout the ISLSCP II collection, we have imposed the ISLSCP II land/water mask on the original GPW data set. Because significant amounts of people live near coastlines and on islands with relatively small land areas, we recognize that mismatches

between the ISLSCP II land/water mask and the original data set may cause significant differences, particularly for global population counts. However, we do provide all of the data needed to reconstruct the original data as separate files. We urge users to consult these files when needed.

4. THEORY OF ALGORITHM/MEASUREMENTS

The population associated with each administrative unit was distributed across grid cells that fall wholly or partly within the administrative unit based on areal weighting. Population distribution within administrative units was not modeled; population counts were assigned to grid cells based on the assumption that the distribution is equal within an administrative unit. Additional details are provided in Deichmann, Balk and Yetman, "Transforming Population Data for Interdisciplinary Usages: From census to grid," 1 October 2001, available at <http://sedac.ciesin.columbia.edu/gpw-v2/GPWdocumentation.pdf>.

5. EQUIPMENT

This data set is derived entirely from country population data. No instrumentation was used.

5.1 Instrument Description

5.1.1 Platform (Satellite, Aircraft, Ground, Person)

Not applicable to this data set.

5.1.2 Mission Objectives

Not applicable to this data set.

5.1.3 Key Variables

Not applicable to this data set.

5.1.4 Principles of Operation

Not applicable to this data set.

5.1.5 Instrument Measurement Geometry

Not applicable to this data set.

5.1.6 Manufacturer of Instrument

Not applicable to this data set.

5.2 Calibration

5.2.1 Specifications

5.2.1.1 Tolerance

Not applicable to this data set.

5.2.2 Frequency of Calibration

Not applicable to this data set.

5.2.3 Other Calibration Information

Not applicable to this data set.

6. PROCEDURE

6.1 Data Acquisition Methods

Source administrative boundary and population data were obtained from various sources, including national statistical agencies, international agencies such as the UN, and commercial data providers. A summary of all the data sources can be seen on-line for particular countries from <http://sedac.ciesin.columbia.edu/gpw-v2/index.html?main.html&2>.

6.2 Spatial Characteristics

Administrative units are variable in size depending on how each country defines the units. The level of administrative unit data obtained varies by country. A breakdown of the units obtained by administrative level is shown in Table 1 below.

<i>Administrative Level</i>	<i>Frequency</i>	<i>Cumulative %</i>	<i>US Equivalent</i>
0	47	21.17%	Nation
1	68	51.80%	State
2	88	91.44%	County
3	18	99.55%	Tract
4	1	100.00%	Block
Total	222		

The original GPW was created at a resolution of 2.5 arc-minutes. The data products described here have been aggregated to lower spatial resolutions of 1/4 degree (15 arc-minutes), 1/2 degree (30 arc-minutes) and 1 degree (60 arc-minutes).

6.2.1 Spatial Coverage

Administrative units were obtained for the entire world, excluding Antarctica. The original GPW data products provide a spatial coverage from 85 degrees N to 58 degrees S in latitude. The ISLSCP II staff have added 'no data' regions to provide complete global layers.

6.2.2 Spatial Resolution

The GPW data products described here are provided in equal-angle Earth grids that have spatial resolutions of 1/4 degree (15 arc-minutes), 1/2 degree (30 arc-minutes) and 1 degree (60 arc-minutes) in both latitude and longitude. In all cases the resolution is identical in the horizontal and vertical dimensions.

6.3 Temporal Characteristics

6.3.1 Temporal Coverage

The population data were adjusted from many different years to the two reference years of 1990 and 1995 before gridding. The GPW data products are for these two time intervals.

6.3.2 Temporal Resolution

Annual.

7. OBSERVATIONS

7.1 Field Notes

Not applicable to this data set.

8. DATA DESCRIPTION

8.1 Table Definition with Comments

Not applicable to this data set.

8.2 Type of Data

8.2.1 Parameter/ Variable Name	8.2.2 Parameter/ Variable Description	8.2.3 Data Range*	8.2.4 Units of Measurement	8.2.5 Data Source
Population Count Maps (*.asc)				
gpw_pop_counts_1990	Population counts in 1990.	9358913, 11782169, 23426706 No data over water = -99, No data over land = -88	People/cell	Original GPW
gpw_pop_counts_1995	Population counts in 1995.	10337416, 14070349, 23812028	People/cell	
gpw_pop_counts_1990a	Population counts in 1990, adjusted to match UN country totals.	9580258, 12277715, 23412648	People/cell	
gpw_pop_counts_1995a	Population counts in 1995, adjusted to match UN country totals.	10409294, 14204700, 23793262	People/cell	
Population Density Maps (*.asc)				
gpw_pop_density_1990	Population density in 1990.	20464, 9272, 4664	People/km ² /cell	Population counts, land area

gpw_pop_density_1995	Population density in 1995.	21469, 10381, 5393	People/km ² /cell	
gpw_pop_density_1990a	Population density in 1990, UN adjusted values.	20461, 9492, 4860	People/km ² /cell	
gpw_pop_density_1995a	Population density in 1995, UN adjusted values.	21618, 10453, 5444	People/km ² /cell	
Land Area Maps (*.asc)				
gpw_land_area	Land area per cell used to calculate the pop. density	773, 3091, 12363	Km ² /cell	Earth Grid
Differences Tables (*.dif)				
Lat	Latitude for the center of a cell. South latitudes are negative.	Min=-55.875 Max=83.625	Decimal Degrees	Earth Grid
Lon	Longitude for the center of a cell. West longitudes are negative.	Min=-179.875 Max=179.875	Decimal Degrees	Earth Grid
Data_Removed	Value in each cell of the original file that did not match the ISLSCP II land/water mask, and was removed.	Varies with data layer	People/cell, People/km ² /cell or Km ² /cell	Original data
Change Maps (*_changemap.asc)				
Points_changed	Differences between the ISLSCP II land/water mask and the original land area maps data: -1 = ISLSCP II mask is water and original data is land (cell set to 0) 0 = Data sets agree over land or water (data unchanged) 1 = ISLSCP II mask is land or water and original data is missing (fill value used).	Min=-1 Max=1	See 8.2.2	Original land area data and ISLSCP II land/water mask

* **NOTE:** The minimum value for population counts and density in all cases is 0, while the maximum values vary for each data set and are given for data sets of spatial resolution 1d, hd, and qd respectively. In all layers areas with no data over oceans are assigned the value of -99. Areas with no data over land (i.e. Antarctica) are assigned the value of -88.

8.3 Sample Data Record

The "differences" file is an ASCII table with some header lines, then the Lat and Lon coordinates of each removed point, plus the value of that point. See the sample below.

```
ISLSCP II Differences for file 'gpw_land_area_1d.asc'.
```


Contains Lat-Lon coordinates and data for each point in the original file that differed from the ISLSCP II Land/Water mask, and thus was removed.

```
Lat, Lon, Data_Removed
83.5, -77.5, 23
83.5, -76.5, 60
83.5, -75.5, 21
83.5, -74.5, 49
83.5, -73.5, 3
83.5, -72.5, 79
83.5, -71.5, 50
83.5, -70.5, 100
83.5, -69.5, 37
83.5, -46.5, 65
83.5, -45.5, 105
83.5, -44.5, 134
83.5, -43.5, 194
83.5, -42.5, 312
```

8.4 Data Format

All of the files in the ISLSCP Initiative II data collection are in the Arc GIS ASCII Grid format. The file format consists of numerical fields of varying length, which are delimited by a single space and arranged in columns and rows. All values in these files are written as integer numbers. However, note the very large maximum values given in Section 8.2.3. In all layers areas with no data over oceans are assigned the value of -99. Areas with no data over land (i.e. Antarctica) are assigned the value of -88.

The files at different spatial resolutions each contain the following numbers of columns and rows:

- 1 degree: 360 columns by 180 rows
- 1/2 degree: 720 columns by 360 rows
- 1/4 degree: 1440 columns by 720 rows

The ASCII map files (with the extension of ".asc") have all had the ISLSCP II land/water mask applied to them. All points removed from the ASCII map files were replaced with the value of zero. The removed points are stored in "differences" files (with the extension ".dif"). These ASCII files contain the Latitude and Longitude location of the cell-center of each removed point, and the data value at that point. There is one ".dif" file for each ASCII map file.

The "change map" files show the results of applying the land/water mask, as a viewable ASCII map: all points added ("1"), all points unchanged ("0"), and all points removed ("-1"). There is one file per spatial resolution.

All files are gridded to a common equal-angle lat/long grid, where the coordinates of the upper left corner of the files are located at 180 degrees W, 90 degrees N and the lower right corner coordinates are located at 180 degrees E, 90 degrees S. Data in the map files are ordered from North to South and from West to East beginning at 180 degrees West and 90 degrees North.

8.5 Related Data Sets

The GPW data description and data access are available at: <http://sedac.ciesin.columbia.edu/gpw/>. A global gridded Gross Domestic Product (GDP) data set is also included in the ISLSCP II data collection available from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC)

http://daac.ornl.gov/ISLSCP_II/islscpii.html . The Digital Chart of the World is available from Penn State University at: <http://www.maproom.psu.edu/dcw/> . Additional ISLSCP II project information and data sets can also be obtained from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC) http://daac.ornl.gov/ISLSCP_II/islscpii.html .

9. DATA MANIPULATIONS

9.1 Formulas

Where necessary, the input population data were adjusted to the reference years of 1990 and 1995. Two recent census totals or official estimates were used to compute an average annual population growth rate (Palmore and Gardner, 1983) as follows:

$$r = \frac{\log e \left(\frac{P_2}{P_1} \right)}{t}, \quad (1)$$

where r is the average rate of growth, P_1 and P_2 are the population totals for the first and second reference years, and t is the number of years between the two census enumerations. This rate was then applied to the census figures to interpolate or extrapolate population totals to 1990 and 1995. For example, the 1995 estimate is calculated:

$$P_{1995} = P_1 e^{rt} \quad (2)$$

9.1.1 Derivation Techniques/Algorithms

The reduced-resolution population and land area grids described here were aggregated from the original GPW data using the aggregate function in ArcInfo GRID™ software. For example, to create the 15 arc-minute resolution grids, this function sums the population or land area in a 6 by 6 cell (or pixel) neighborhood from the 2.5 arc-minute data and assigns that value to one output cell with a resolution of 15 arc-minutes. 12 by 12 and 24 by 24 cell neighborhoods were used to produce the 30 and 60 arc-minute versions of GPW, respectively.

The density grids were created by dividing the population count grids by the land area grids at each of the three resolutions. All of the grids were rounded to whole numbers and exported to BIL format.

9.2 Data Processing Sequence

9.2.1 Processing Steps and Data Sets

The original GPW data were processed as described in Section 9.1.1 to produce the data described here. For each country or area, the following steps were carried out:

- d) Obtain digital administrative boundaries and population data.
- e) Estimate 1990 and 1995 population by administrative district (P90 and P95) and link to the digital administrative map.

- f) Create alternative population estimates for 1990 and 1995 (P90A and P95A) by adjusting each figure uniformly so that the national total matches the UN World Population Prospects estimate.
- g) Overlay a digital map of lakes and ice fields and set the population estimate for the lakes areas to zero.
- h) Compute population densities in km², now net of lake areas, for each administrative unit.
- i) Create a regular grid in vector GIS format (“fishnet”) with a resolution of 2.5 arc minutes and overlay with the administrative units boundaries.
- j) Calculate the area in km² for each polygon of overlap. Multiply this area with the corresponding administrative unit’s population density to get a population estimate for each polygon of overlap.
- k) For each of the four population estimates and the land area in km², aggregate all polygons of overlap that belong to a given grid cell. Then, link these grid cell totals back to the original regular grid (“fishnet”).
- l) Convert this result to five raster GIS data sets: one each for population in 1990 and 1995, adjusted and unadjusted, and one for land area.
- m) Create continental and global grids by adding the individual country or area grids together.

9.2.2 Processing Changes

None.

9.2.3 Additional Processing by the ISLSCP II Staff

The data files submitted by CIESIN were transformed from the ARCINFO binary format into the ISLSCP II ASCII format. Additionally, the original data files were missing the top 5 degrees and bottom 31 degrees of each map file (in each of the three resolutions). This missing data was added from the appropriate scale of the ISLSCP II land-water mask, with areas with no data over water assigned the value of -99 and areas with no data over land (i.e. Antarctica) assigned the value of -88. The data files were then renamed to the current naming scheme (see Section 1.3).

The ISLSCP II staff also processed the data files by comparing them for consistency against the ISLSCP II land/water mask. This comparison was done between the ISLSCP II mask and the original “land area” maps to separate all land/water mismatches from actual zero population areas. Any point where the ISLSCP II land/water mask showed water but where the land area data were greater than zero was removed and replaced with the value zero. New ASCII table files containing the removed points, also called “differences” files with the extension “.dif”, were created for all layers. These files contain the Latitude and Longitude of the cell-center of each removed point, and the original data value for that point. Users should note that the number of records in each “.dif” file is different (e.g. from 1990 to 1995, or UN adjusted vs. non-adjusted) simply because some of the mismatches in land/water boundaries occurred where zero population counts or densities also occurred.

Finally, a “change map” was created for the land area layers at each spatial resolution, showing the results of applying the land/water mask, as a viewable ASCII map: all points added (“1”), all points unchanged (“0”), and all points removed (“-1”). Note that no actual population was added, all added points were “-88”. Identical copies of the

[gpw_land_area_XX_changemap.asc](#) files are included in the archives for both population counts and densities.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

The UN estimates often reflect adjustments of nationally reported figures to compensate for over- or under-reporting. We used the ratio of the UN estimate of national total population to the country total of our estimates to produce a second set of 1990 and 1995 figures for each administrative unit. These adjusted administrative unit figures are thus based on a uniform inflation or deflation of each estimate.

9.4 Graphs and Plots

See <http://sedac.ciesin.columbia.edu/gpw-v2/index.html?main.html&2>

10. ERRORS

10.1 Sources of Error

The sources of error for the original GPW are applicable for the reduced resolution data set described here, including variability in the data timeliness and population adjustment, error introduced by the algorithm that produced the grids and the variable nature of the spatial accuracy of the input data. In addition, aggregating and rounding the original data to produce the lower resolution grids introduces additional rounding error and lowers the spatial resolution. The population totals and land area remain constant globally. Density values are smoothed during aggregation. No independent validation has been undertaken to determine whether this smoothing results in a reduction or increase of error. Also, although DCW is often considered to have some locational inaccuracies, at a 0.25 degree resolution, it is typically much better than the width of one grid cell in this data set.

The application of the ISLSCP II land/water mask may introduce errors for areas near coastlines and small islands. This is because the ISLSCP II land/water mask is defined as land when $\geq 50\%$ of the cell is land so that small islands or coastal areas where significant populations exist but on a small portion of land may be removed. All data that are removed from the original data are provided in the form of “difference” tables.

10.2 Quality Assessment

10.2.1 Data Validation by Source

The original population grids were summed and the totals compared to the input data population totals to quantify algorithm-introduced error. These calculations have not been completed for the reduced resolution data.

10.2.2 Confidence Level/Accuracy Judgment

The level of spatial and attribute accuracy varies in the data set depending on the precision of the input data. The reduced resolution of the data makes it appropriate for use in global studies but not at finer scales.

10.2.3 Measurement Error for Parameters and Variables

Check-sums that compare gridded population totals, by country, with the national administrative population totals were completed. In all cases, the rounding error introduced was less than 0.1% of the national administrative population total.

10.2.4 Additional Quality Assessment Applied

None.

11. NOTES

11.1 Known Problems with the Data

None reported at this revision.

11.2 Usage Guidance

The low spatial resolution of the data make them only appropriate for use in global studies with data of similar resolutions. The simple areal weighting model of population distribution is not a precise delineation of population distribution; population distributions within administrative units often vary widely. This should be considered carefully when interpreting results. In some cases, the population totals obtained as input data are not timely. Details on the dates and administrative levels obtained for each country are available at:

<http://sedac.ciesin.columbia.edu/gpw-v2/index.html?main.html&2>

Users who may wish to re-create the original data set should combine the data provided here with the data provided in the “differences” files or use the “change maps” to visualize the spatial distribution of points that have been changed from their original value.

11.3 Other Relevant Information

None.

12. REFERENCES

12.1 Satellite/Instrument/Data Processing Documentation

A working paper on the processing of GPW is available at:
<http://sedac.ciesin.columbia.edu/gpw/>.

12.2 Journal Articles and Study Reports

A list of citations for published works and descriptions of projects that have used GPW are available at: <http://sedac.ciesin.columbia.edu/gpw/>.

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13. DATA ACCESS

13.1 Contacts for Archive/Data Access Information

The ISLSCP Initiative II data are available are archived and distributed through the Oak Ridge National Laboratory (ORNL) DAAC for Biogeochemical Dynamics at <http://daac.ornl.gov>.

13.2 Contacts for Archive

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

13.3 Archive/Status/Plans

The ISLSCP Initiative II data are archived at the ORNL DAAC. There are no plans to update these data.

14. GLOSSARY OF ACRONYMS

CIESIN	Center for International Earth Science Information Network
DAAC	Distributed Active Archive Center
DCW	Digital Chart of the World
GDP	Gross Domestic Product
GPW	Gridded Population of the World
GSFC	Goddard Space Flight Center
IFPRI	International Food Policy Research Institute
ISLSCP	International Satellite Land Surface Climatology Project
NASA	National Aeronautics and Space Administration
ORNL	Oak Ridge National Laboratory
SEDAC	Socioeconomic Data and Applications Center
UN	United Nations
WRI	World Resources Institute