International Cartographic Association Working Group on Cartography and Sustainable Development

Dr. Britta Ricker & Tim Trainor

Copernicus Institute for Sustainable Development

Utrecht University

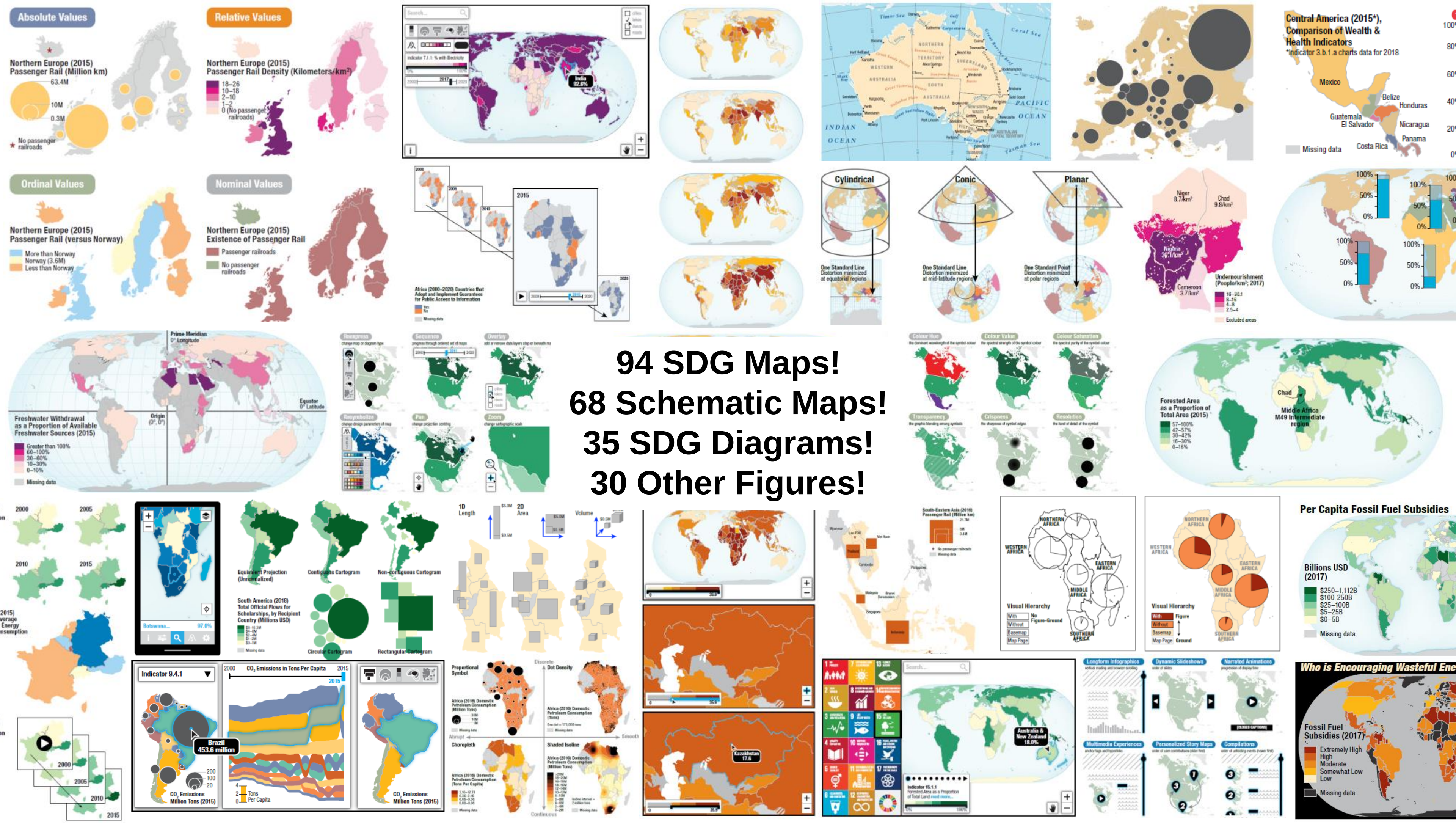
Objectives of the Presentation

- The power of cartography
- Many options and choices to make for effective communication
- Maps as a catalyst for acting on the SDGs
- Maps show data for areas of interest
    - Absence of data can highlight where data are needed

Map Design Considerations

Cartography = Art + Science of map making

Mapping for a Sustainable World



94 SDG Maps!
68 Schematic Maps!
35 SDG Diagrams!
30 Other Figures!

UNITED NATIONS Geospatial
Working Group on GeoVisualization

MAPPING
FOR A SUSTAINABLE WORLD

Outline:

1. SDGs & Geospatial Data
("How to think about the SDGs like a cartographer")

2. Map Design Considerations
("10 ways to make more effective maps today")

3. Maps & Effect
("What are the maps communicating?")

4. Tutorial…find data…

A JOINT PUBLICATION OF

The UN Committee of Experts on Global Geospatial Information Management (GGIM)

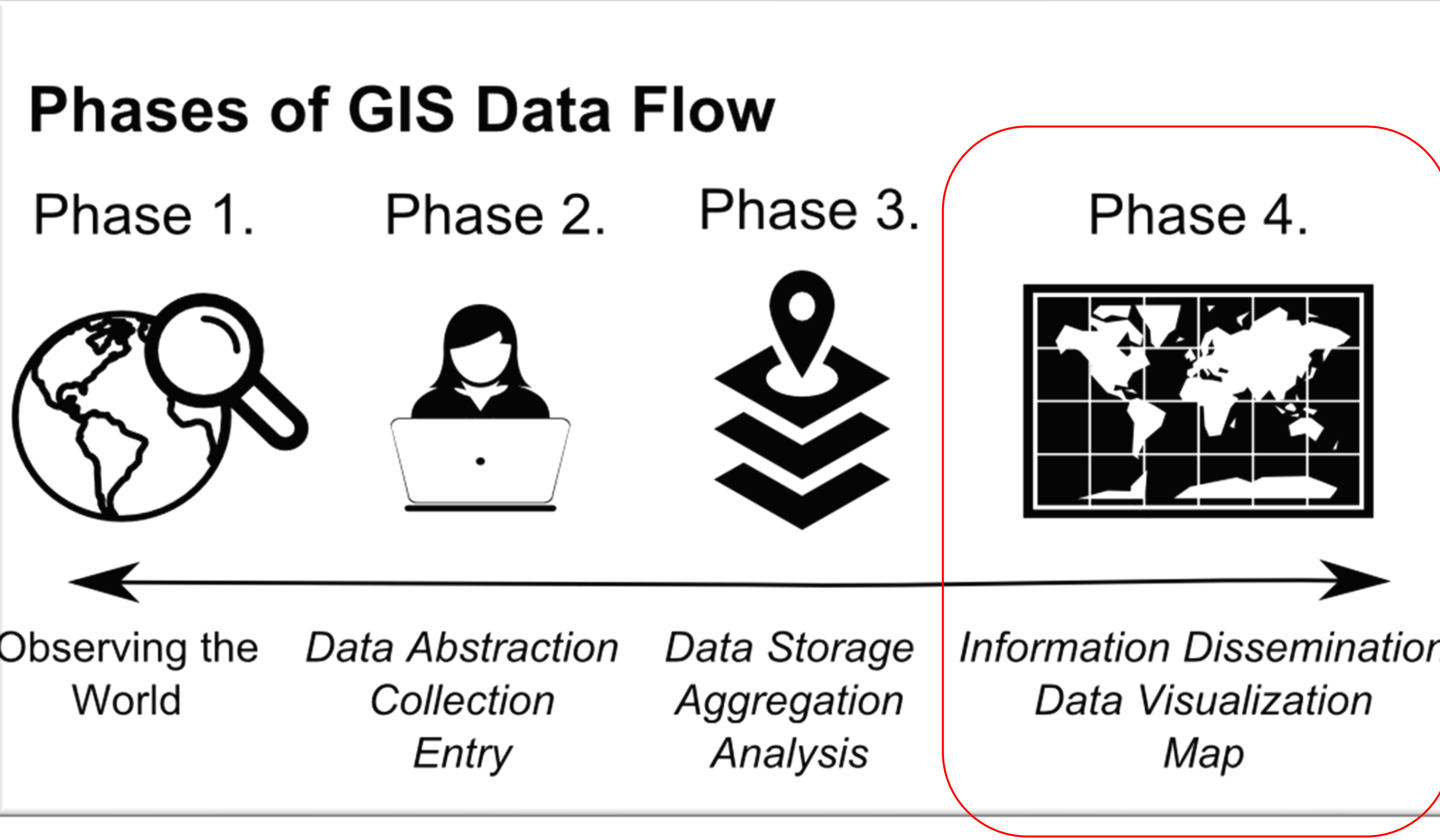
International Cartographic Association | Association Cartographique Internationale

MAPPING
FOR A SUSTAINABLE WORLD

ICA ACI

The book consists of **four sections**. Section 1 introduces the SDGs and their relation to geospatial data. Section 2 describes foundational design decisions in the cartographic workflow. Section 3 introduces the most relevant map types and diagrams for visualizing the SDG indicators. Finally, Section 5 discusses considerations for map use environments.

How spatial indicators are collected and then mapped



3.1 Thematic Maps

Thematic Map
A map that depicts variation in one or several attributes

A *thematic map* depicts the variation of one or sometimes several (see Section 3.7) geographic phenomena, mapping spatial and attribute information together. Meeting the United Nations Sustainable Development Goals requires themat- … attribute information that is enumerated within polygonal geographic units (see Section 1.4). Enumerated attributes typically are mapped at an ordinal or numerical level of measurement, as enumeration results in quantitative counts or frequencies. However, nominal differences also can be represented in thematic … the mode or binary value …ence, yes/no), resulting …*map* (see Section 3.2). …atic map type symbolises … using a different visual …Section 2.9). For instance, a …*ap* (see Section 3.3) shades enumeration units by their attribute values, primarily relying on colour value.

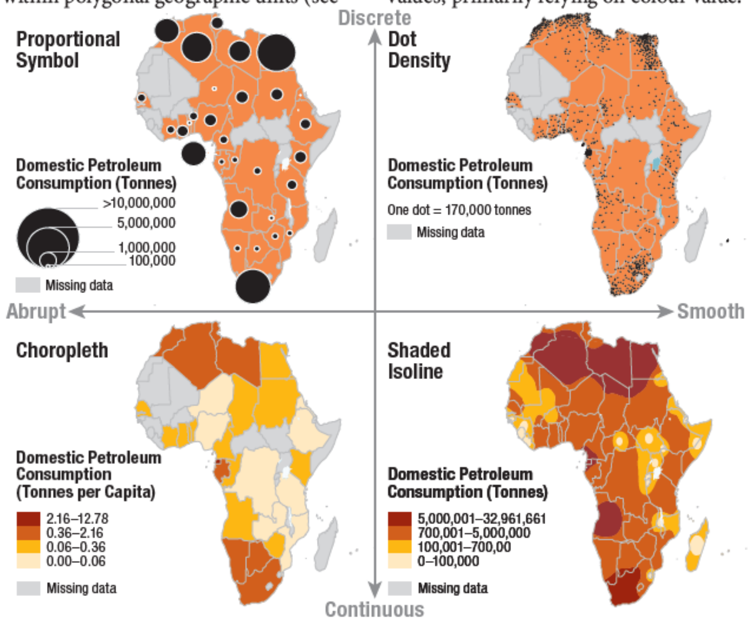


Figure 3.1-1: Thematic map types. The four maps depict Indicator 12.2.2 (2016) on domestic petroleum consumption. **Top-left:** Proportional Symbol. **Top-right:** Dot density. **Bottom-left:** Choropleth. **Bottom-right:** Shaded isoline.

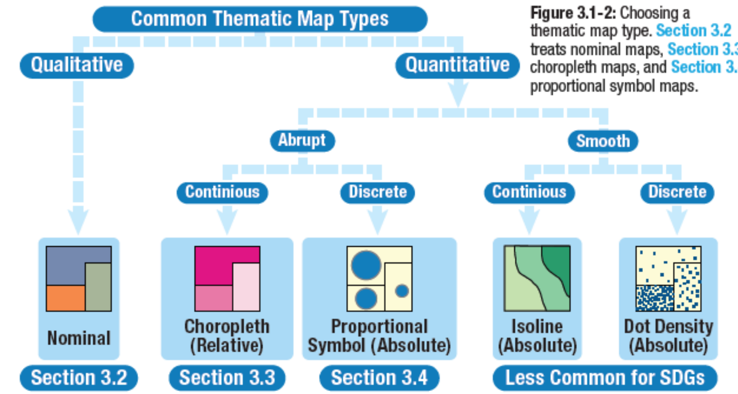


Figure 3.1-2: Choosing a thematic map type. Section 3.2 treats nominal maps, Section 3.3 choropleth maps, and Section 3.4 proportional symbol maps.

A *proportional symbol map* (see Section 3.4) uses the visual variable size to scale point symbols placed at the centroids of enumeration units by their attribute values. A *dot density map* (different from dot maps; see Section 3.2) uses the composite visual variable *numerousness* (arrangement combined with size) to adjust the density of dots placed within enumeration units by their attribute values. Finally, an *isoline map* interpolates attribute values from the centroids of enumeration units, using the visual variable location to represent the interpolated attribute gradient atop spatial locations.

Each thematic map type also evokes a different *visual metaphor* about the mapped geographic phenomenon, leading to different framings of and conclusions about the same attribute data. Visual metaphors are particularly pertinent when mapping enumerated data like the SDG indicators because information about how the phenomenon exists within space (discrete versus vs. continuous) and varies across space (abruptly vs. smoothly) is lost during enumeration (Figure 3.1-1). Choropleth maps evoke a metaphor of continuous and abrupt phenomena, such as governmental activities, policies, and regulations fixed to political jurisdictions (i.e., enumeration units). Proportional symbol maps evoke a discrete and abrupt metaphor, suggesting economic sites of production and distribution like mines, factories, offices, and stores. Dot density maps evoke a discrete and smooth metaphor, suggesting the individual bodies of human and social phenomena. Isoline maps evoke a continuous and smooth metaphor, suggesting environmental or geophysical phenomena.

Figure 3.1-2 provides guidance for choosing a thematic map type. Dot density and isoline maps are used infrequently for the national-level indicator datasets given difficulty in reliably depicting smoothly changing patterns at coarser levels of enumeration.

Level of Measurement	Absolute/ Relative	Attributes	Mappable Values		Example
ratio	absolute (one value)	one attribute	absolute value		count X
	relative (calculated using two or more attributes)	one attribute	proportion	proportion of total population	% of total population
				other proportion	% of X, other than population
		two attributes	rate	rate per capita	count X per capita/ population
				change rate (per time unit)	% change or count X per time
				other rate	X per Y, other than population or time
		many attributes	index (calculated)		formula
interval			interval value		*not used for SDGs*
ordinal			ordinal value		level or rank
nominal			nominal value		presence/ absense

Ratio-level SDG indicators include both absolute and relative attributes. Absolute attributes often are described as "raw" data, and need to be converted to relative attributes through ***normalisation*** (see Section 1.7).

Many enumerated SDG indicators already are reported as proportions or rates related to population. However, population and other enumerated attributes rarely are evenly distributed within the enumeration units. Normalising ratio-level data is useful both to mask

Level of Measurement
The scale on which the attribute data is collected

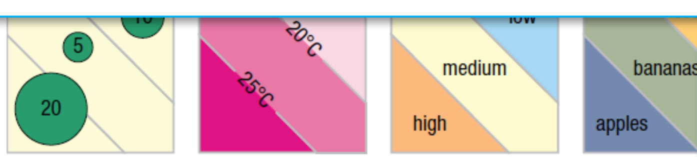
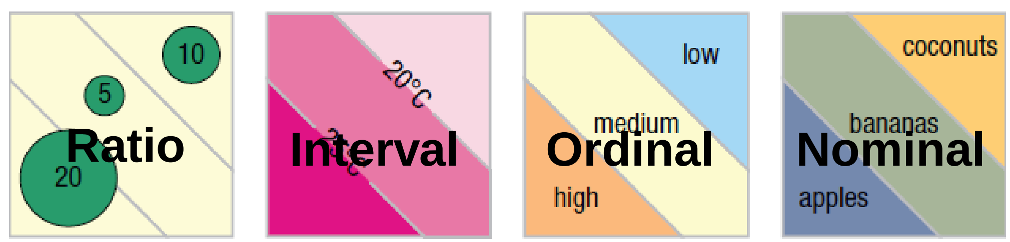


Figure 1.4–1: Attribute levels of measurement and associated example symbolisation **(Left to Right)**: Ratio d… mapped with a proportional symbol map (see Section 3.4), interval data mapped with an isoline map (see Se… 3.1), ordinal data mapped with a choropleth map (see Section 3.3), and nominal data mapped with a nomina… (see Section 3.2).



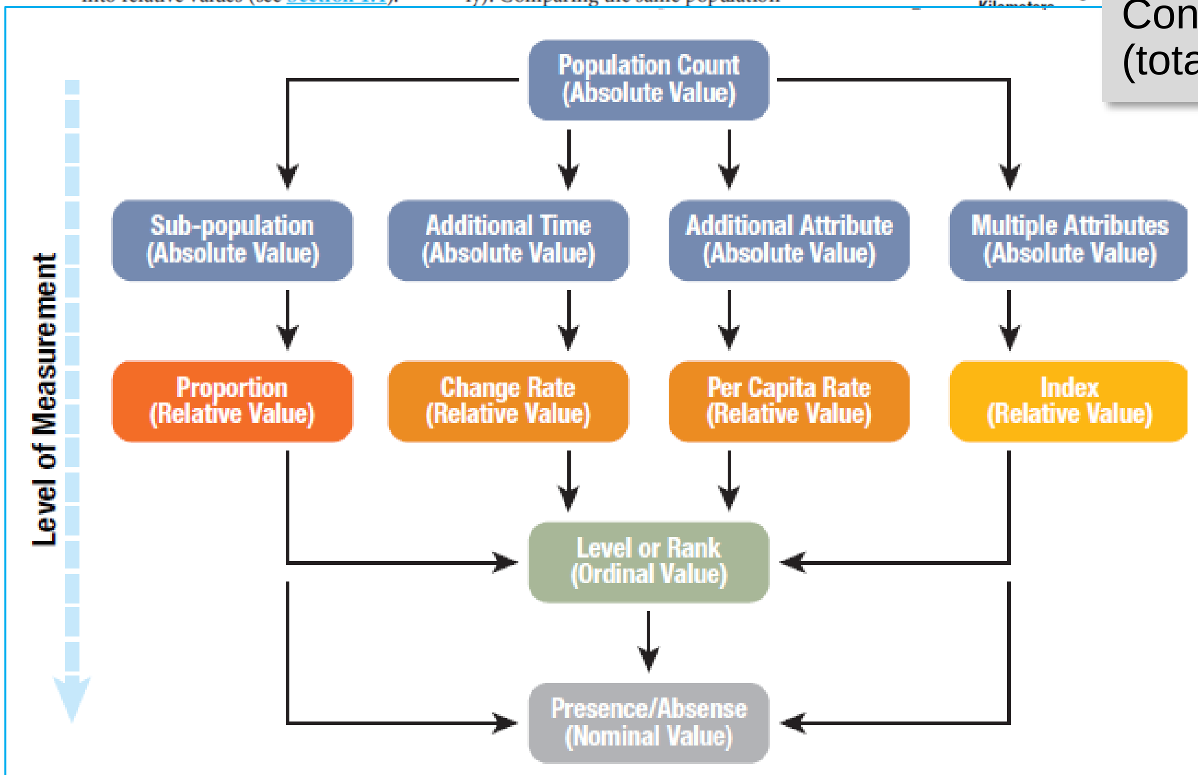
1.7 Data Transformation & Normalisation

Data transformation describes the statistical conversion of an attribute, including a downgrade in level of measurement or normalisation of absolute values into relative values (see Section 1.4).

and ordinal values into nominal values.

Comparing a subset of the population to a count of the population results in a proportion (e.g., percentage of elderly). Comparing the same population

Normalisation
Conversion of absolute values (totals/counts) to relative values



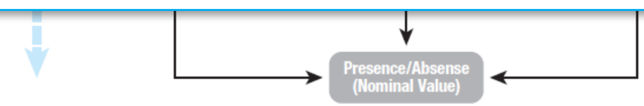
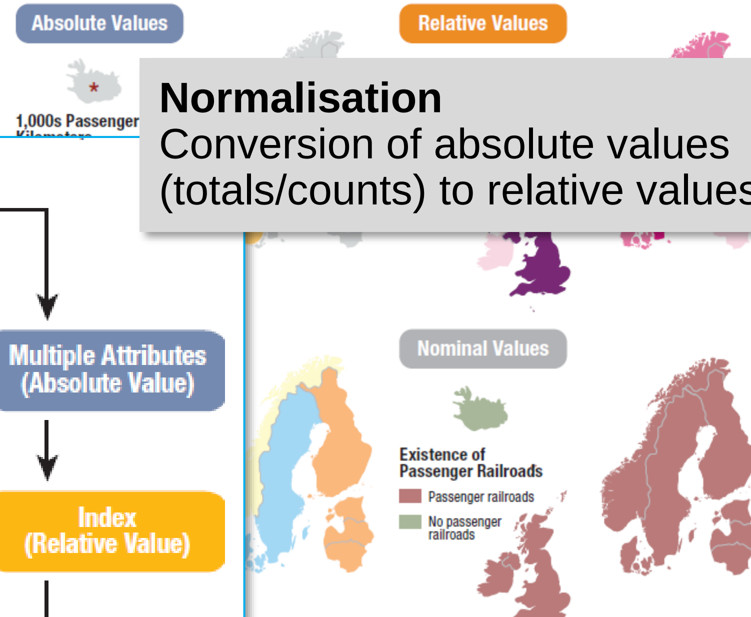


Figure 1.7-1: Data conversion options for enumerated, population-based attributes.

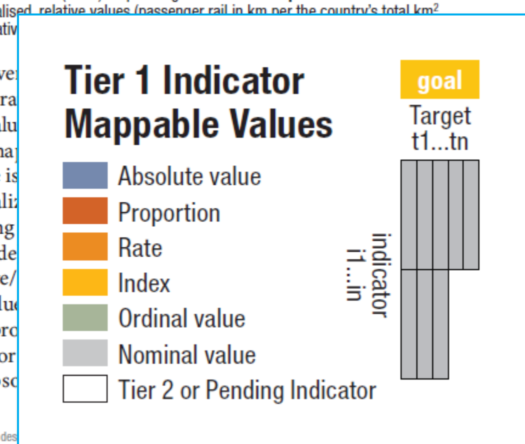


for Indicator 9.1.2. (2015) on passenger rail volume. **Top-left:** Absolute values
t: Normalised, relative values (passenger rail in km per the country's total km²
(rank relativ

However
solute ra
inal valu
a for ma
e value is
normaliz
culating
n, mode
or external (e.g., percentage above/
low overall average) summary valu

Figure 1.7-2 shows the maps pro
duced from transforming Indicator
on passenger rail volume from abso

The boundaries and names shown and the des



1.9 Data Classification

Classification describes the process of organizing map features into groups to improve legibility in the representation. Classification is one of the ways in which cartographers generalise thematic maps, reducing visual complexity in the attribute data to clarify map patterns (see Section 2.7). However, classification also

Classification
The process of organizing map features into groups to improve legibility in the map

ordinal and nominal values (e.g., the Figure 1.7-2 ordinal map reclassifies all unique rankings to show only the ranking above and below Norway's value). Classification grows in difficulty when applied to numerical data. As with all aspects of cartographic design, a perfect classification does not exist, and all classifications have trade-offs. Instead, cartographers weigh several considerations to arrive at an appropriate ***classification scheme***, such as the portion of the distribution the cartographer wishes to emphasise, the total number of classes (with most schemes using four to seven classes), and critical values that produce rounded or meaningful class breaks.

For SDG indicators reported as

distributions, including ***arithmetic*** or ***geometric*** for skewed attribute distributions, ***equal interval*** for uniform attribute distributions (Figure 1.9-2), ***optimal breaks*** for multimodal attribute distributions (Figure 1.9-3), and ***mean & standard deviation*** for normal attribute distributions (Figures 1.9-4).

A ***quantile scheme*** is useful for comparing multiple indicators that are on different scales or for ordinal level attributes (Figure 1.9-5). Figures 1.9-2, 1.9-3, 1.9-4, and 1.9-5 incorrectly reclassify the Figure 1.9-1 data, showing how the classification impacts the resulting map.

Because many of the SDG indicators exhibit a left- or right-skew in their attribute distribution—with many countries clustering together on one end of the scale with several extreme outliers—the arithmetic scheme currently is common for SDG indicator data. However, if extreme global inequities are mitigated in the future, the SDG indicator data will exhibit a more uniform or normal data distribution, leading to increased use of the equal interval and mean & standard classification schemes.

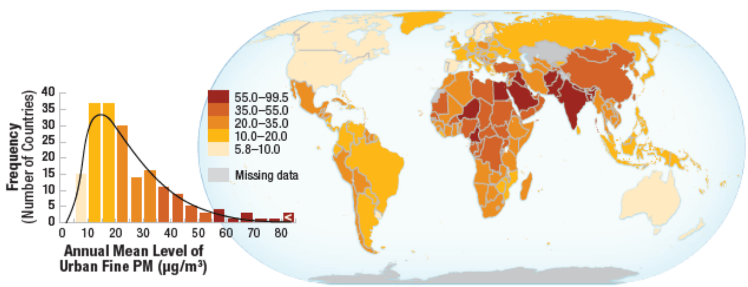


Figure 1.9-1: Data distributions and classification. **Left:** The histogram depicts the left-skewed attribute distribution for Indicator 11.6.2 (2016) on the annual mean levels of urban fine particulate matter. **Right:** The resulting arithmetic scheme increases distances between class breaks in a regular progress, here expanding each class width by 5 µg/m3, to provide more detail for features in the clustered side of the distribution, rather than emphasizing outliers.

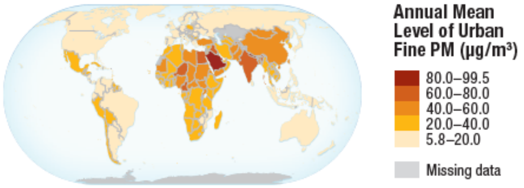


Figure 1.9-2: Equal interval. Equal interval places class breaks equidistant from each other. Use equal interval for indicators with a uniform distribution. Equal interval has the added advantage of resulting in simple, easy to understand map legends good for general audiences.

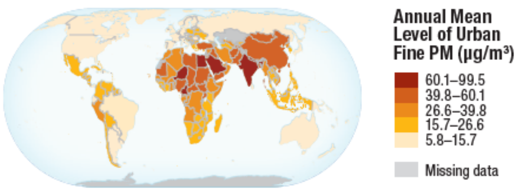


Figure 1.9-3: Optimal breaks. Optimal breaks treats classes like clusters, minimising differences within the class while maximising differences among classes. Use optimal breaks for indicators with multiple clusters in the distribution or to emphasise outliers (e.g., Figure 1.8-2).

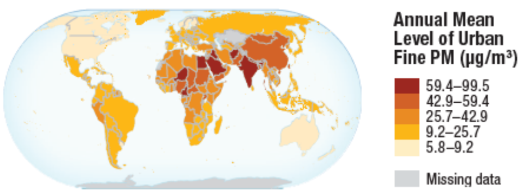


Figure 1.9-4: Mean & standard deviation. Mean & standard deviation is a variation of equal interval in which the equal interval is in standard deviations from the mean. Use mean & standard deviation for indicators with a normal distribution or when the mean value is meaningful.

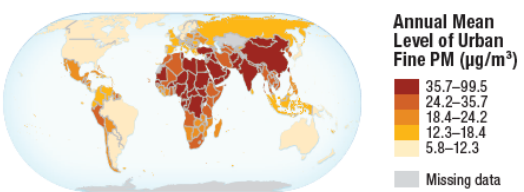


Figure 1.9-5: Quantile. Quantile places the same number of features into each class. Use quantile for side-by-side or bivariate comparison of multiple indicators, as the scheme effectively reduces numerical attributes a similar ordinal scale, or when the median value is meaningful.

Symbolisation describes the graphic encoding of geospatial data in the map. As cartography is a visual language, symbols are the words that cartographers

to encode the locational component of geospatial data in maps), size, shape, orientation, arrangement, texture, colour hue, colour value, colour saturation,

Visual Variables
The ways that a symbol can be modified to convey information; "the visual grammar"

tions are limited. The ***visual variables*** describe the ways that a symbol can be modified to convey information. Visual variables include location (logically used

seen by the eye such as small versus large (size) or light versus dark (colour value). This causes some symbol variations to rise to figure in the visual hierarchy (see

Section 2.13). Other visual variables do not imply an order such as circle versus square (shape) or blue versus green (colour hue). Cartographers use this

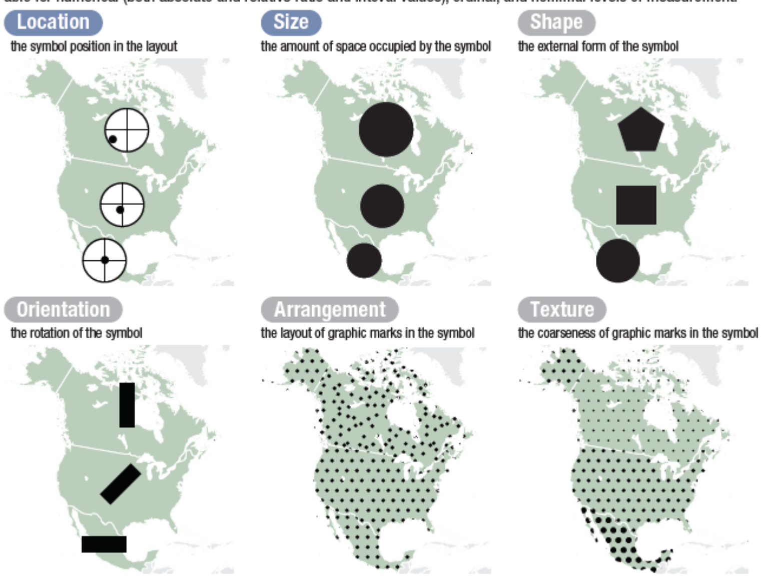
mended for encoding indicators that are collected at an ordinal level of measurement. Finally, besides location, the only ***quantitative visual variable***

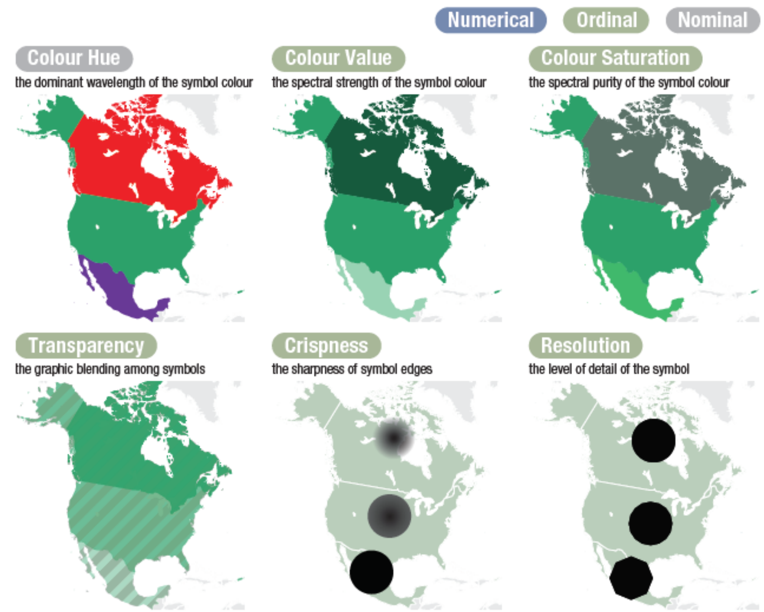
Symbolisation
The graphic encoding of geospatial data in the map; the "visual language"

a nominal level of measurement. ***Ordered visual variables*** such as colour value, colour saturation, transparency, crispness, and resolution are recommended for encoding indicators that

used for numerical data if transformed into an ordinal set of classes (see Section 1.9), a common solution for many thematic map types (see Section 3.1).

Figure 2.9-1: Visual variables and level of measurement. Colouring depicts the recommended use of each visual variable for numerical (both absolute and relative ratio and inteval values), ordinal, and nominal levels of measurement.





2.4 Map Projections

Map projection is the process of transferring geospatial data from a

A *planar* projection conceptually places the map surface on the globe,

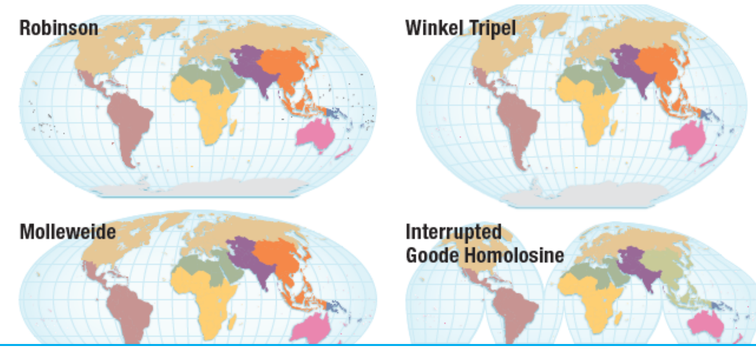
SDG Mapping Best Practice #7
Use an equal-area projection for maps relying on relative amounts of colour or texture (e.g., nominal maps, choropleth maps)

ally wraps the map surface completely around the globe, with the unfurled surface resulting in a rectangular map. Because a normal cylindrical projection intersects the globe at or near the equator, they minimise distortion for regional maps of equatorial regions.

A *conic* projection conceptually wraps the map surface around one hemisphere of the globe, resulting in a semi-circular map. Normal conic projections minimise distortions for regional maps of the mid-latitudes.

angular relationships at infinitely small points, heavily distorting areas as a result. Conformal projections often are used a shape of p two differ result in d

An *equ* jection pr polygon f ing shape that rely c (e.g., chor



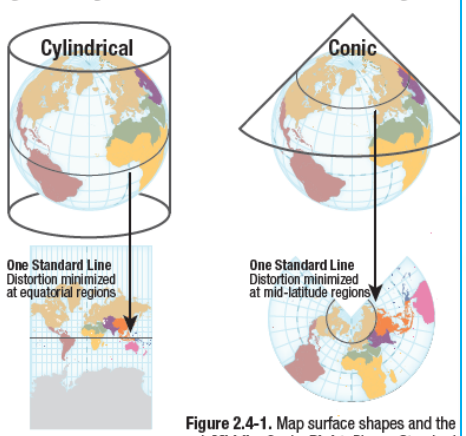


Figure 2.4-1. Map surface shapes and the cal. **Middle:** Conic. **Right:** Planar. Standard

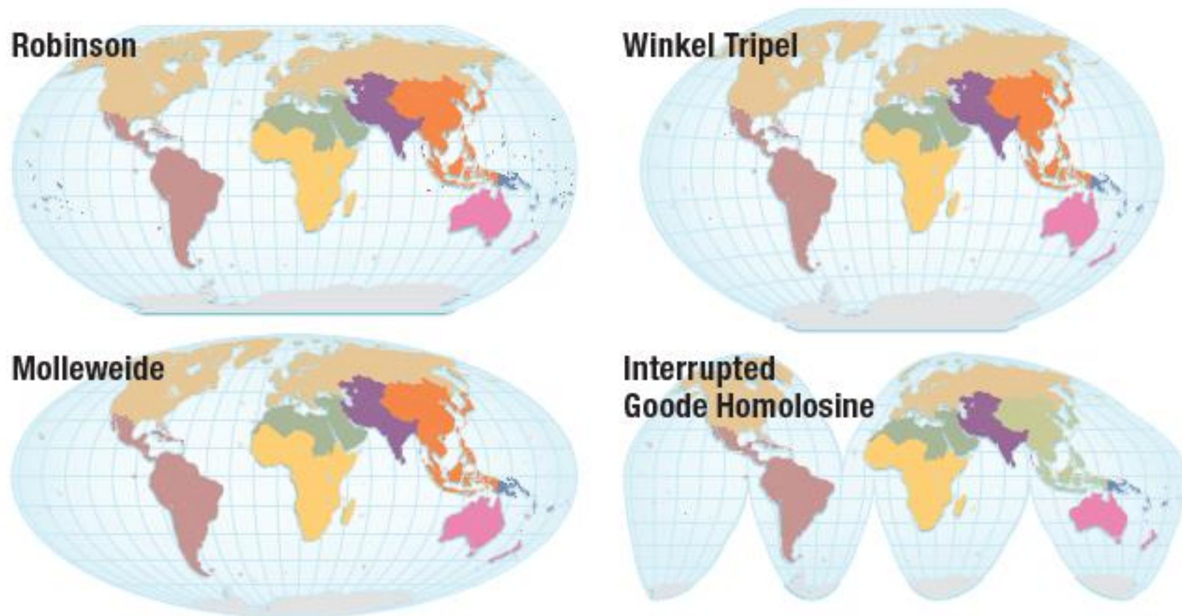
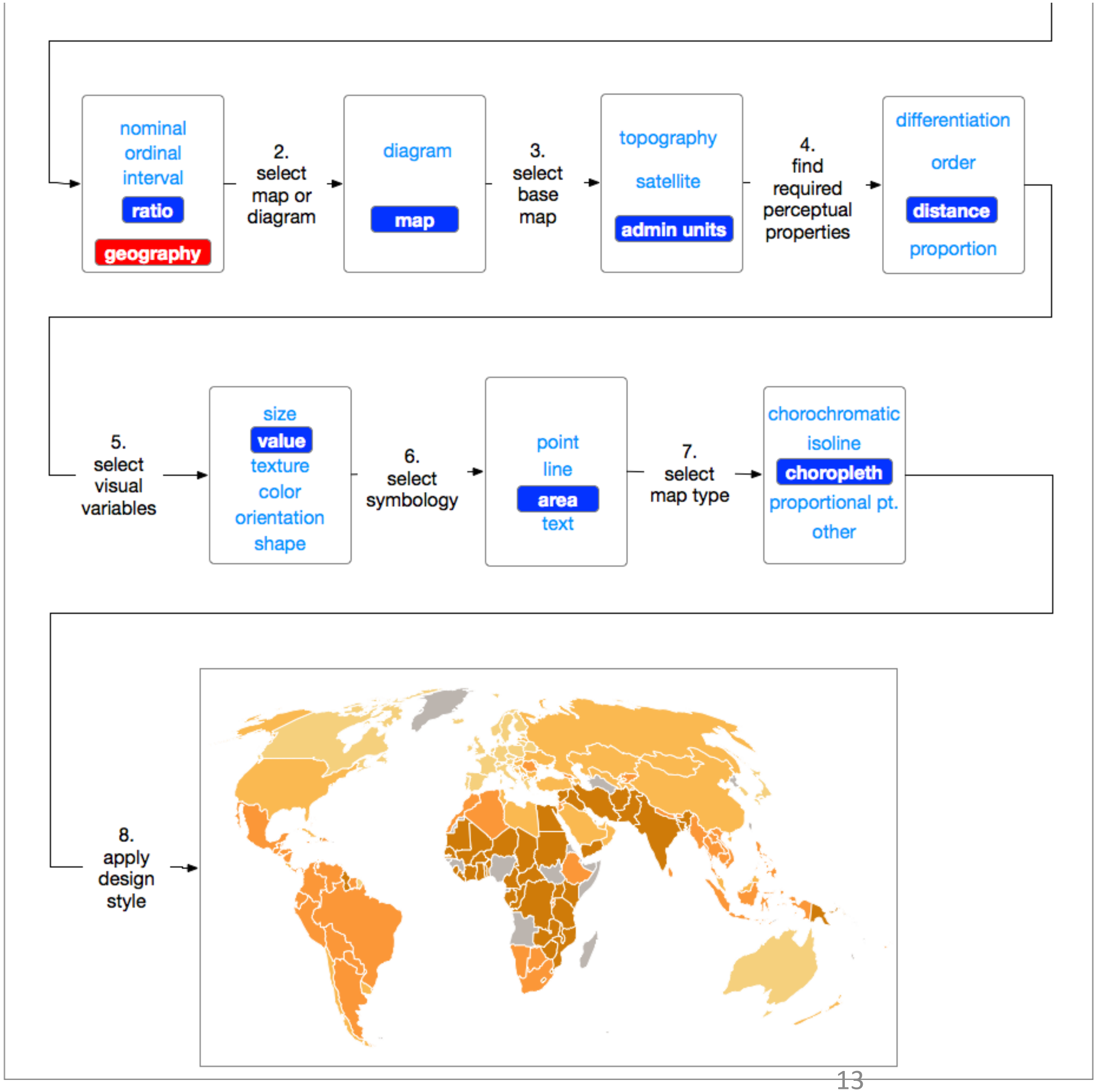


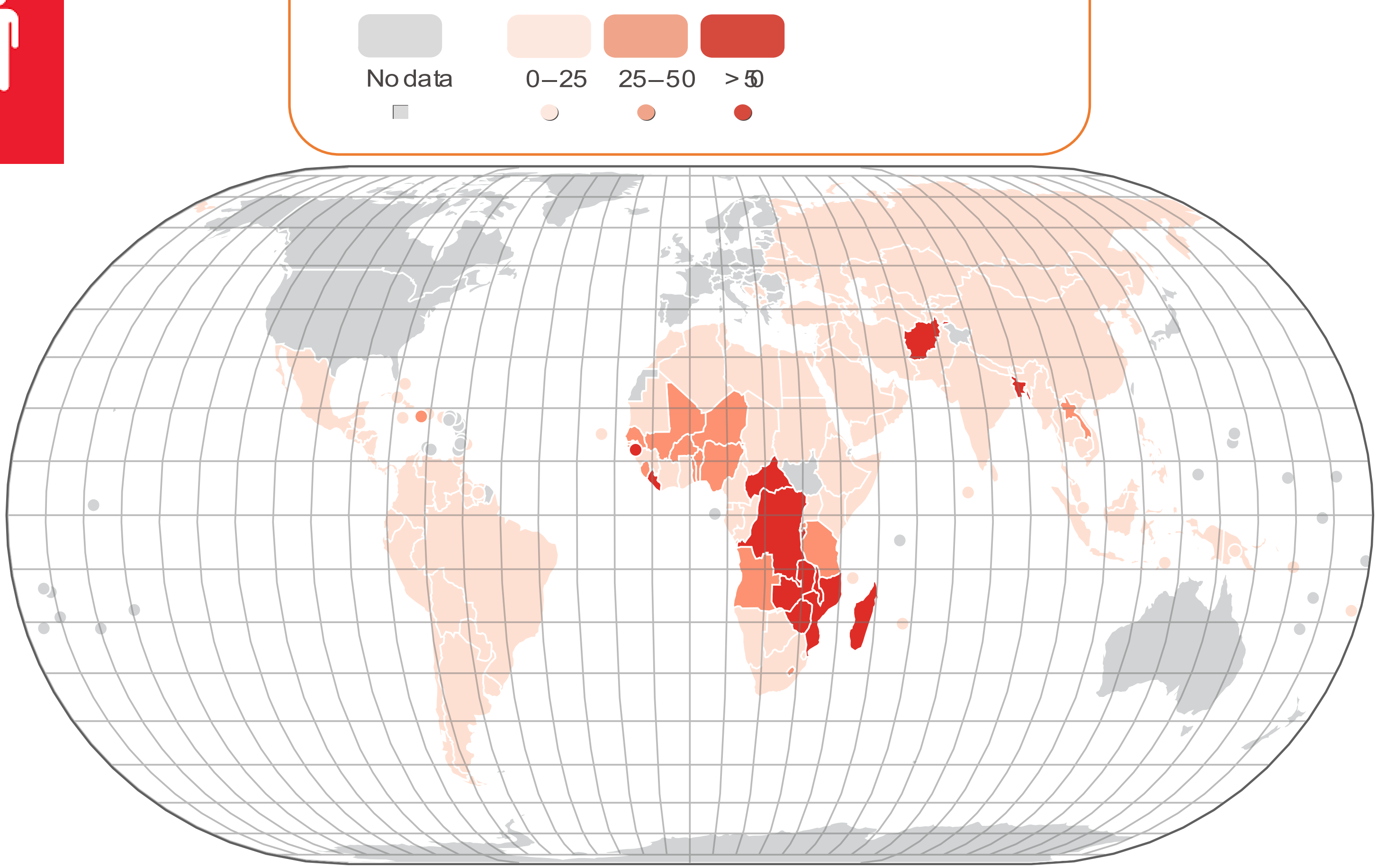
Figure 2.4-2. Some alternative world projections to the Eckert IV. **Top-left:** Robinson (compromise). **Top-right:** Winkel-Tripel (compromise). **Bottom-left:** Molleweide (equivalent). **Bottom-right:** Interrupted Goode Homolosine (equivalent). Note how the changing graticule provides an indication of the projection distortion across the map.

Decision making in the cartographic workflow



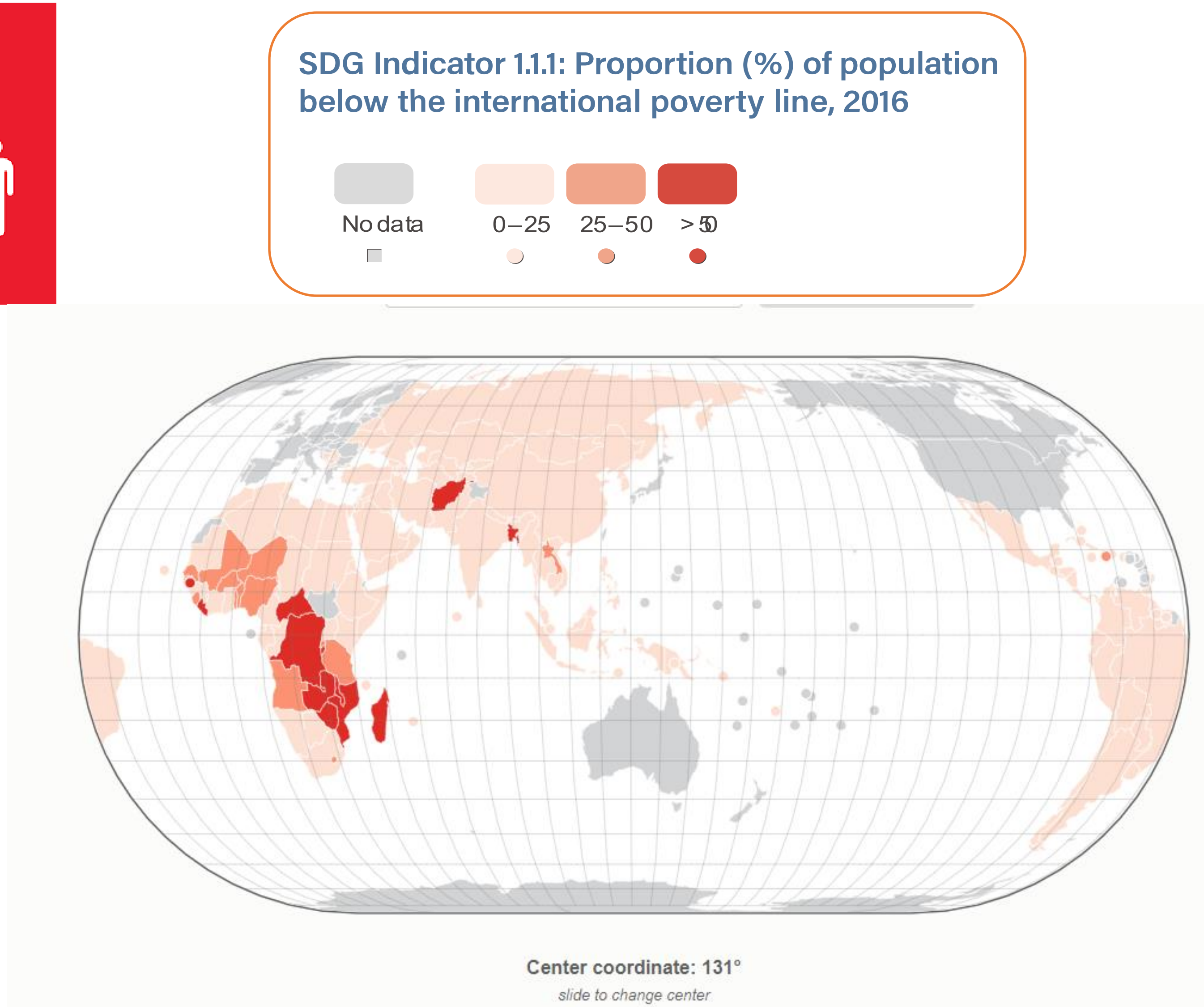
1 NO POVERTY

SDG Indicator 1.1.1: Proportion (%) of population below the international poverty line, 2016



https://gip-itc-universitytwente.github.io/SIDS/

1 NO POVERTY

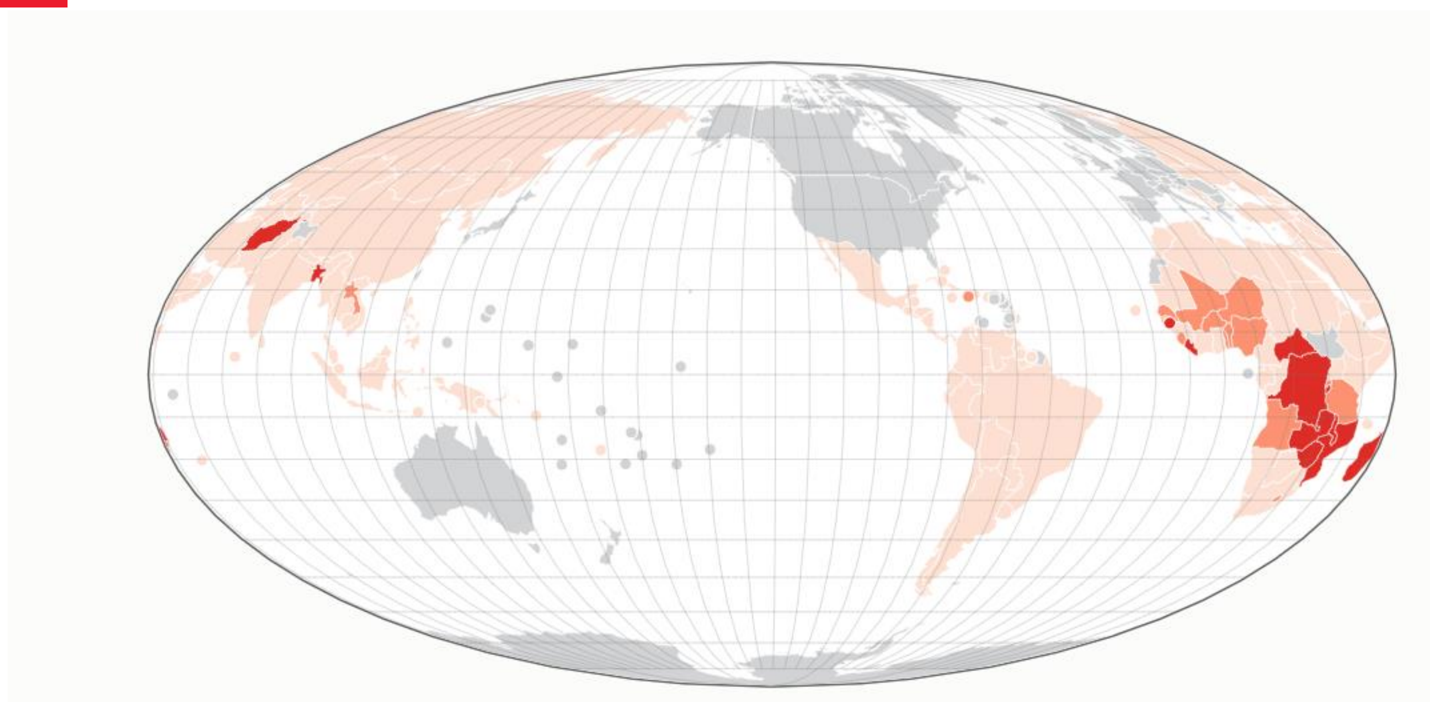


https://gip-itc-universitytwente.github.io/SIDS/

1 NO POVERTY

SDG Indicator 1.1.1: Proportion (%) of population below the international poverty line, 2016

No data | 0–25 | 25–50 | > 50

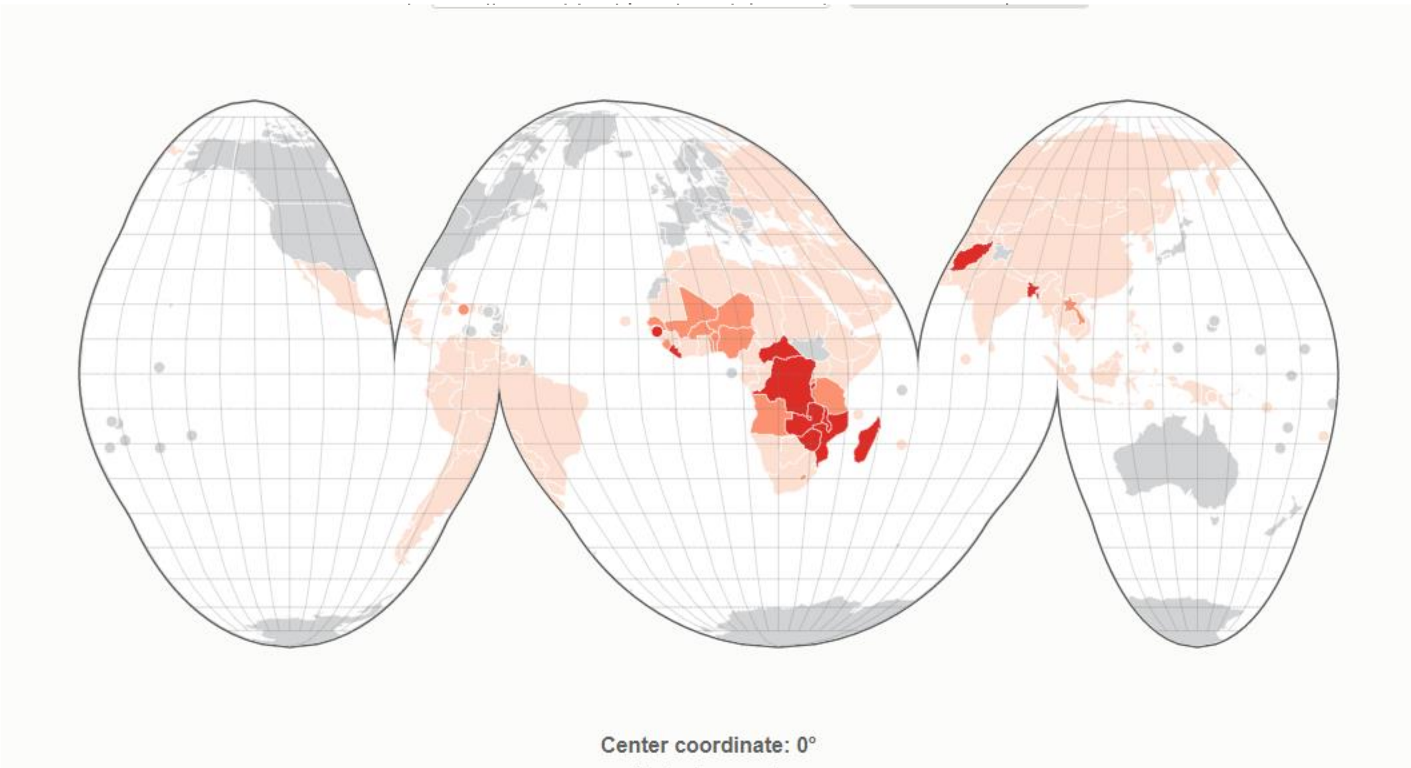


https://gip-itc-universitytwente.github.io/SIDS/

1 NO POVERTY

SDG Indicator 1.1.1: Proportion (%) of population below the international poverty line, 2016

No data | 0–25 | 25–50 | > 50



https://gip-itc-universitytwente.github.io/SIDS/

Color Scheme

Figure 2.10-2: Sequential colour scheme. Indicator 8.1.1 (2016) on the annual growth rate of real GDP per capita is mapped using a sequential colour scheme. Use a sequential colour scheme for ordinal data or classed numerical data with an apparent increase from low-to-high in one direction.

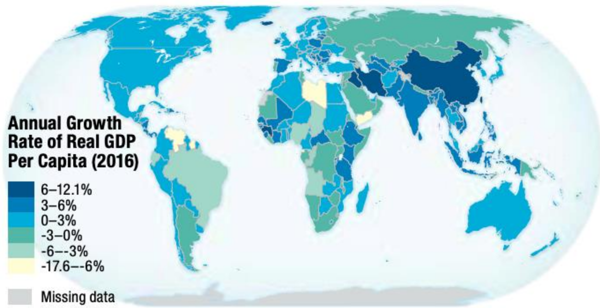


Figure 2.10-3: Diverging colour scheme. Indicator 8.1.1 (2016) is remapped with a more appropriate diverging colour scheme using zero per cent change as the critical midpoint. Use a diverging colour scheme for ordinal data or classed numerical data with an increase in two directions away from a critical value (e.g., zero, the mean or median).

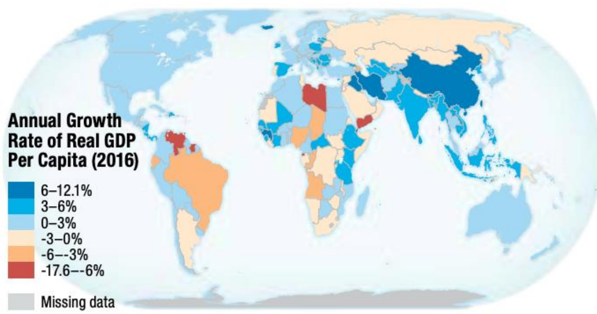
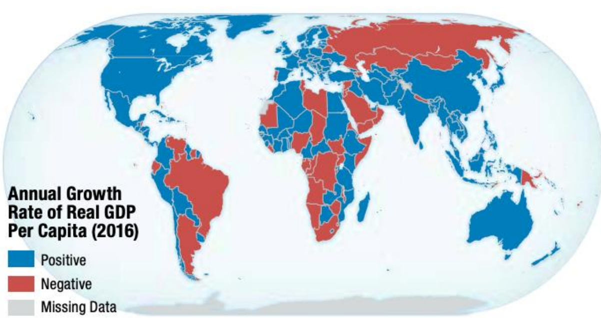


Figure 2.10-4: Qualitative colour scheme. Indicator 8.1.1 (2016) is transformed to a binary positive or negative change. Use a qualitative colour scheme for nominal data with no apparent ranked order (e.g., mode). Do not use a spectral colour scheme to map ordinal or numerical data, unless removing greens, to account for colour vision deficiency.

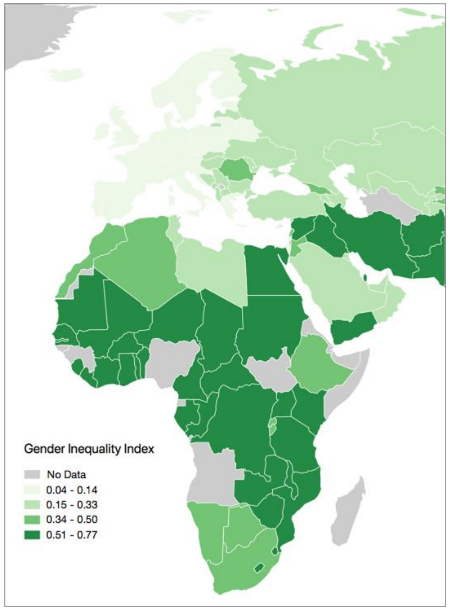


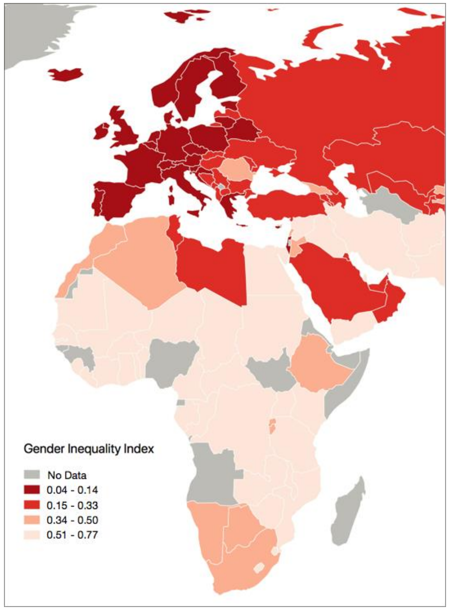
- Sequential
- Diverging
- Qualitative
- Ramp versus interval
- Need Help? Color Brewer

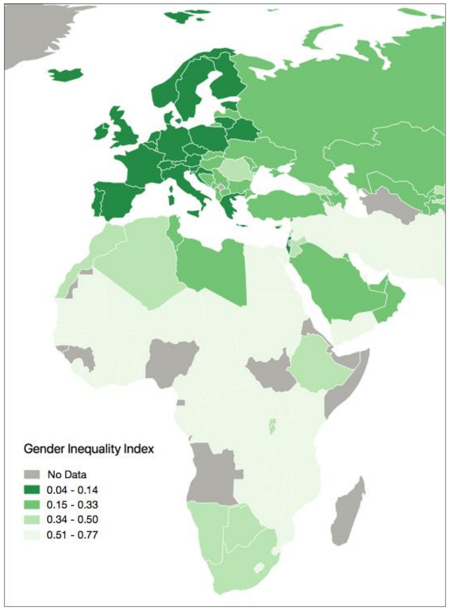
Choice of color

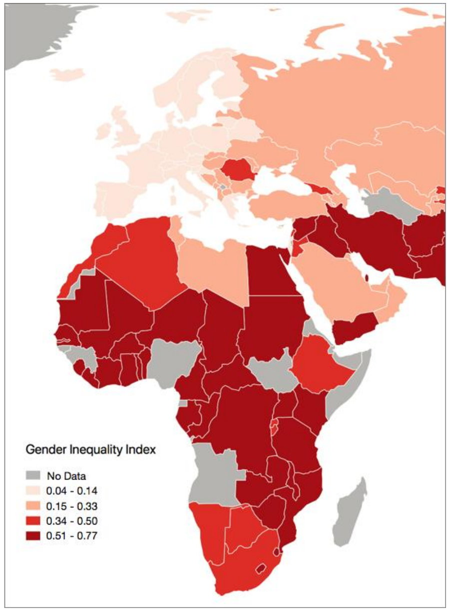
0 means there is no inequality

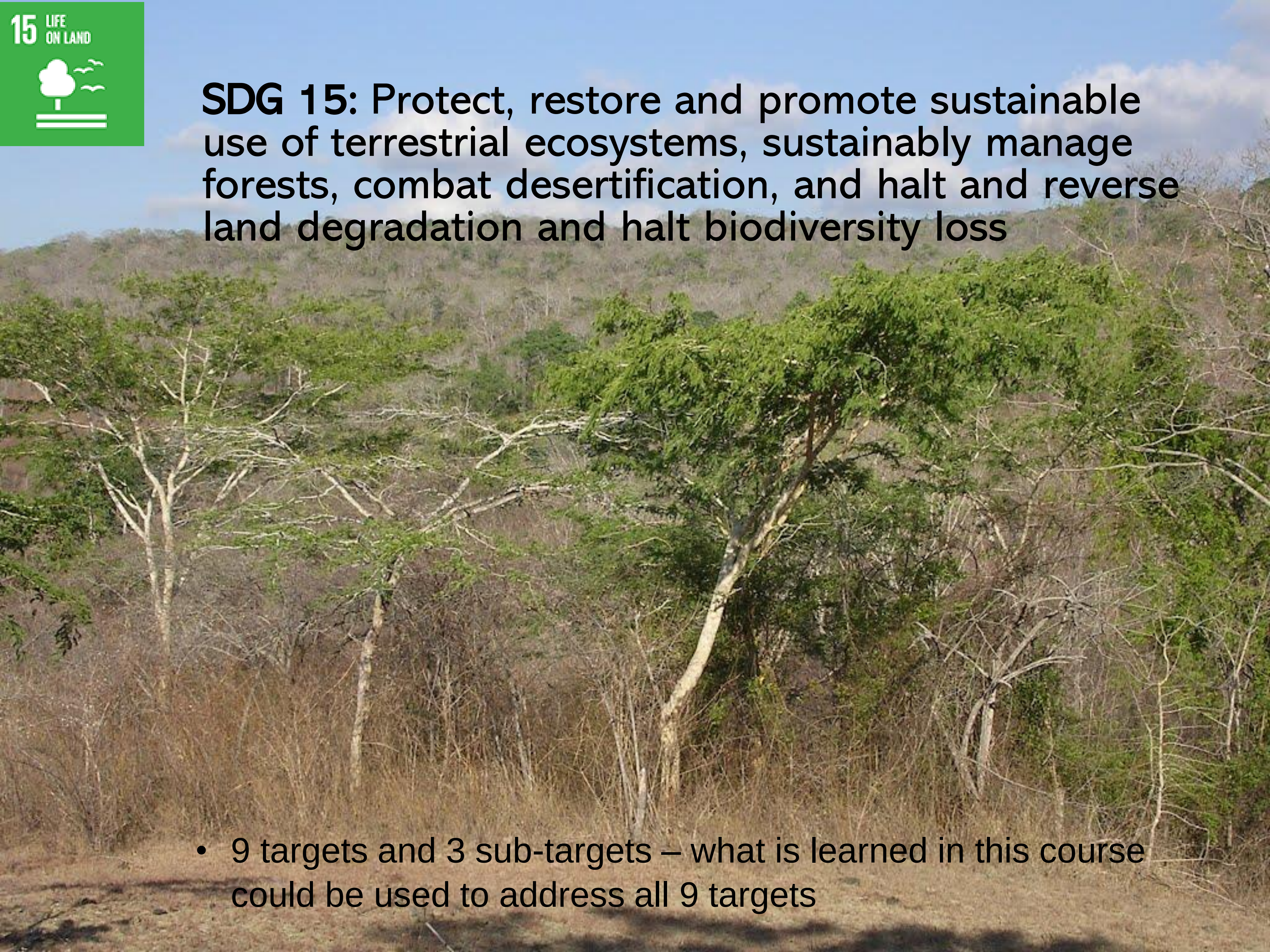
1 means a lot of inequality







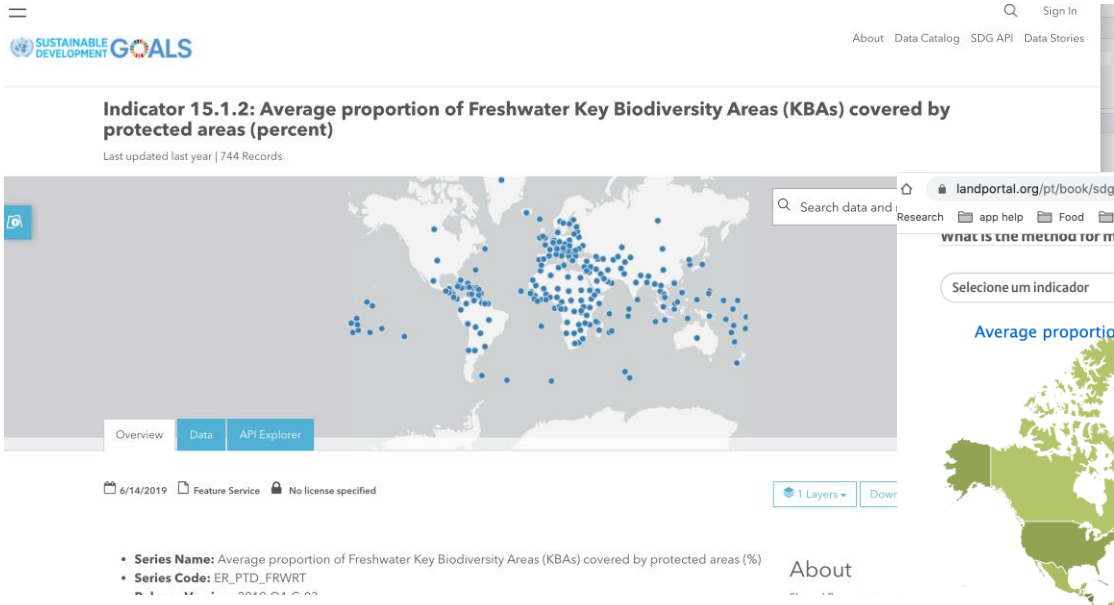


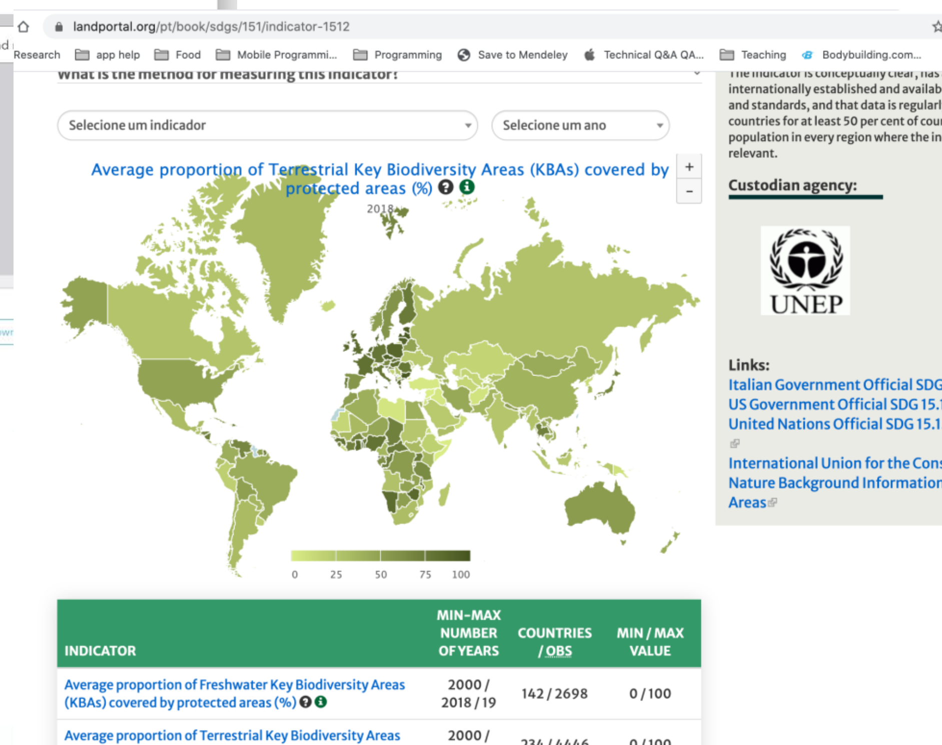


SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

- 9 targets and 3 sub-targets – what is learned in this course could be used to address all 9 targets

Goal 15: Life on land
Target 15.1: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

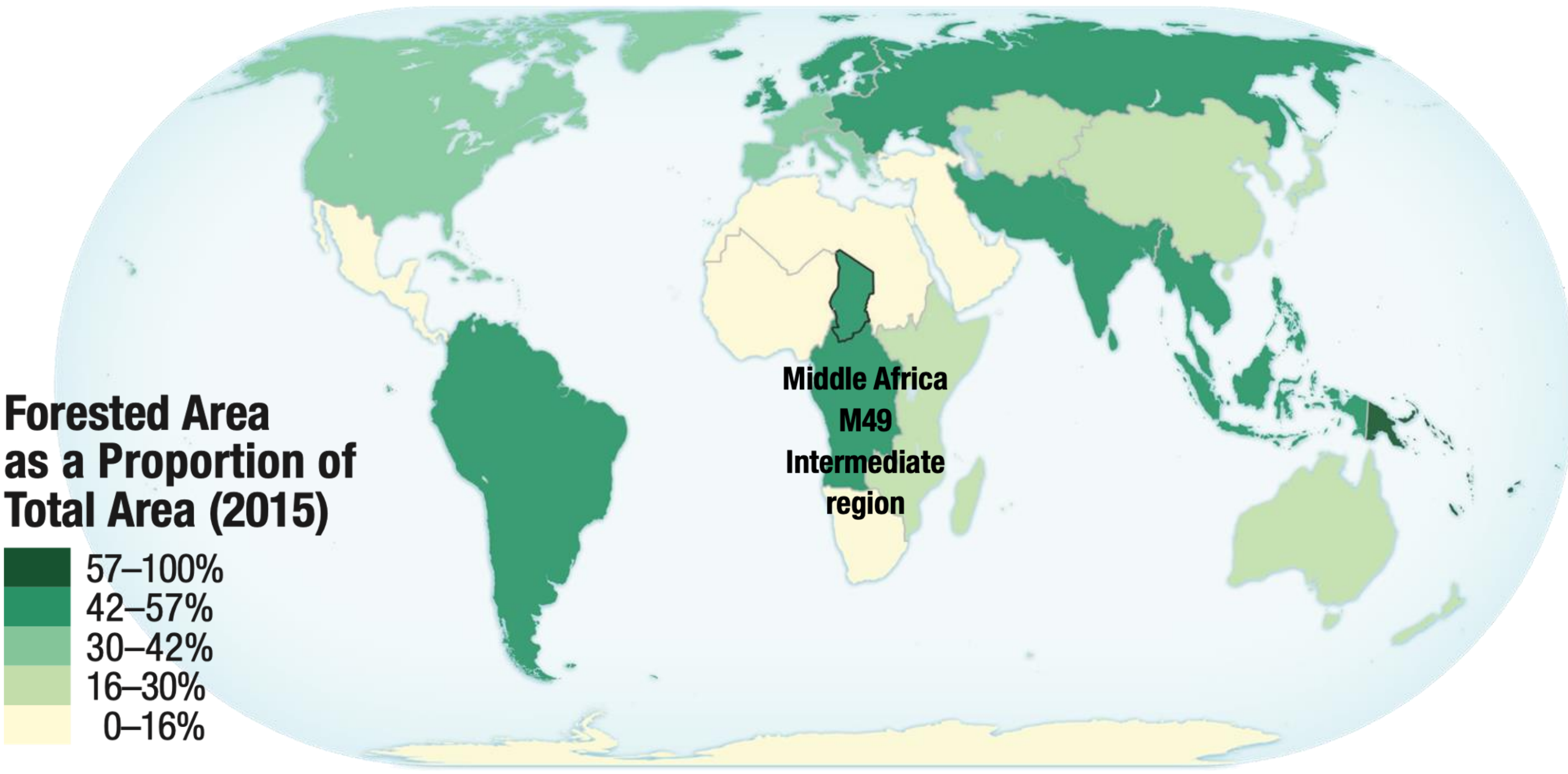




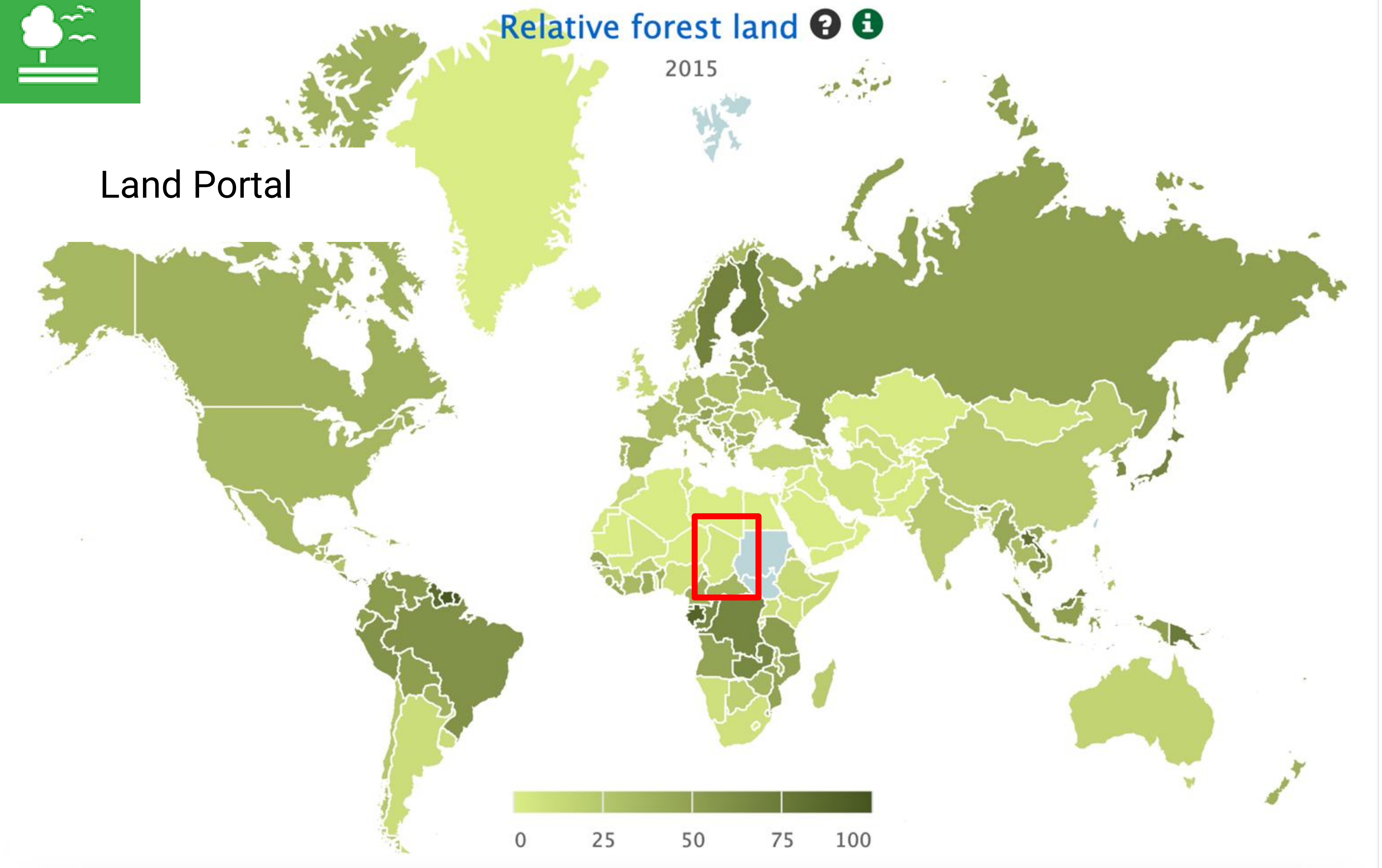
Indicator 15.1.2: Average proportion of Freshwater Key Biodiversity Areas (KBAs) covered by protected areas (percent)

15 LIFE ON LAND

15.1.1

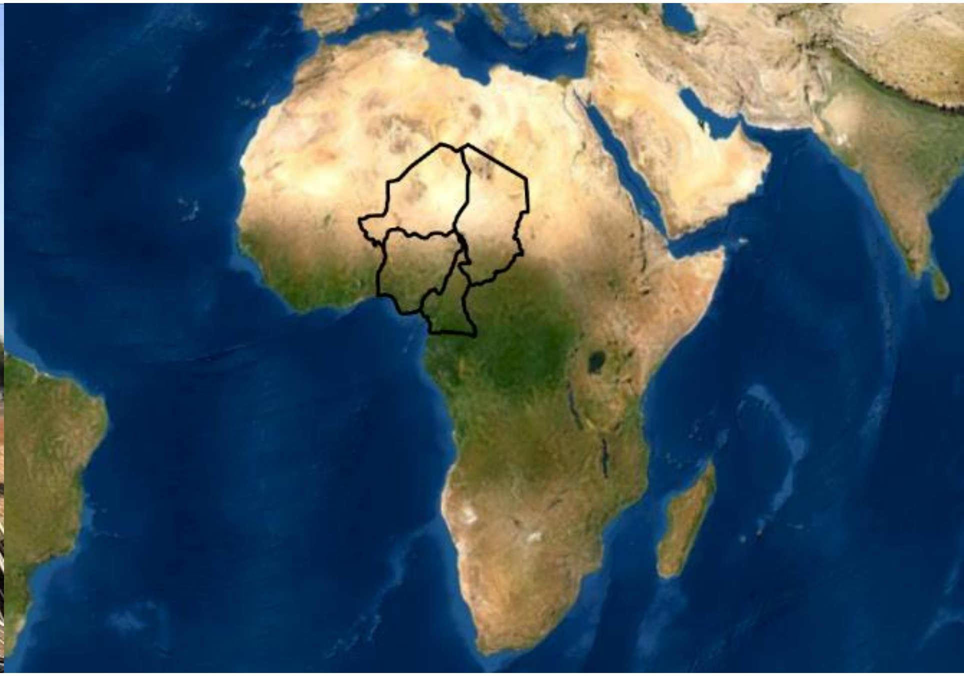


Land Portal



15 LIFE ON LAND

Global Percent Tree Cover 2000



Region of interest: Boko Haram activity

2.1.1 Undernourished people per Sq KM

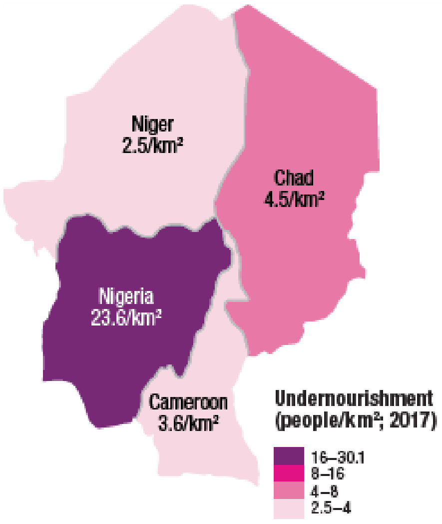


Figure 3.5-1: Original choropleth map. Indicator 2.1.1 (2017) on the number of undernourished people per km² is mapped for four countries in Sub-Saharan Africa.

Choropleth map

2.1.1 Undernourished people per Sq KM

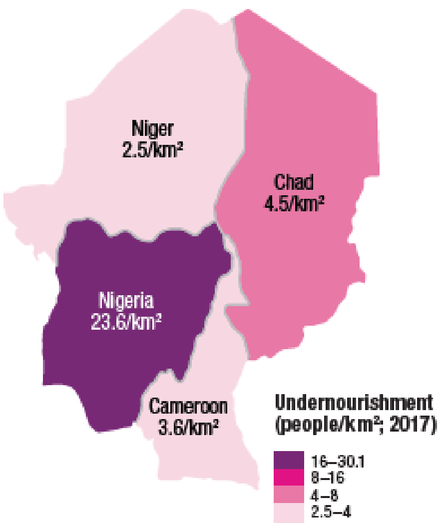


Figure 3.5-1: Original choropleth map. Indicator 2.1.1 (2017) on the number of undernourished people per km² is mapped for four countries in Sub-Saharan Africa.

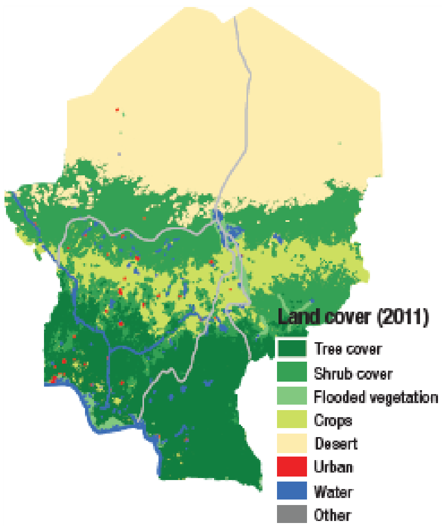


Figure 3.5-2: Exclusionary data. Classified land cover (2011) processed from satellite imagery is used to identify areas where people do not live: desert and water.

Binary Method

2.1.1 Undernourished people per Sq KM

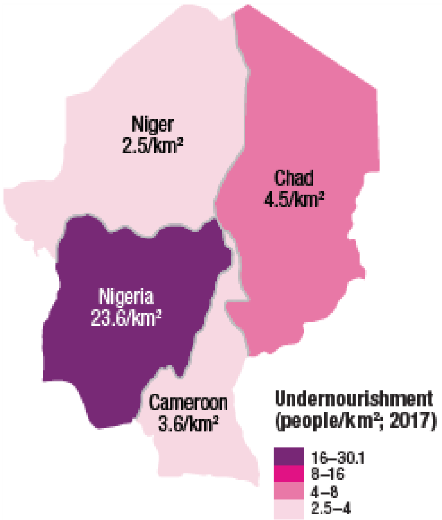


Figure 3.5-1: Original choropleth map. Indicator 2.1.1 (2017) on the number of undernourished people per km² is mapped for four countries in Sub-Saharan Africa.

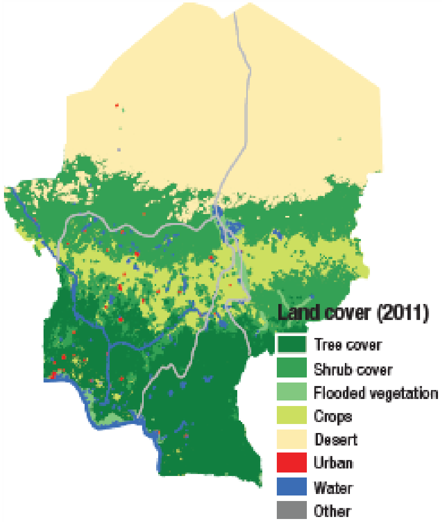


Figure 3.5-2: Exclusionary data. Classified land cover (2011) processed from satellite imagery is used to identify areas where people do not live: desert and water.

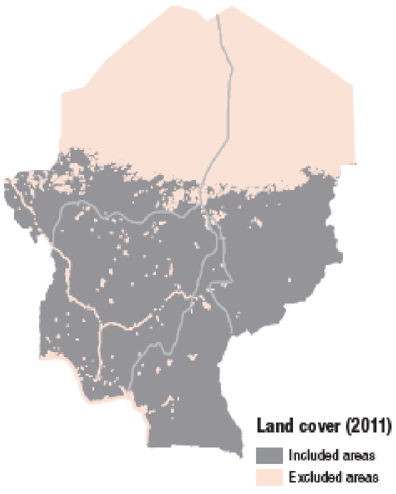


Figure 3.5-3: Vector math. Vector math is applied to remove the desert and water classes from the enumeration unit. Large areas in the north are removed due to the location of the Sahara Desert as well as smaller water bodies such as Lake Chad and the Niger River.

Binary Method: **Omit** area where people do not live

2.1.1 Undernourished people per Sq KM

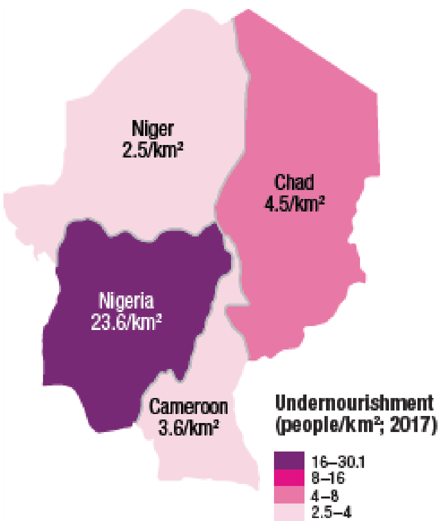


Figure 3.5-1: Original choropleth map. Indicator 2.1.1 (2017) on the number of undernourished people per km² is mapped for four countries in Sub-Saharan Africa.

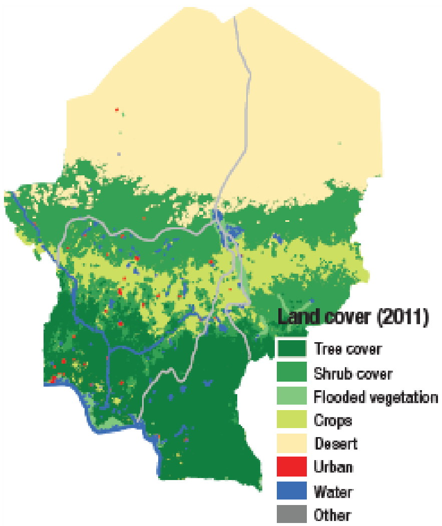


Figure 3.5-2: Exclusionary data. Classified land cover (2011) processed from satellite imagery is used to identify areas where people do not live: desert and water.

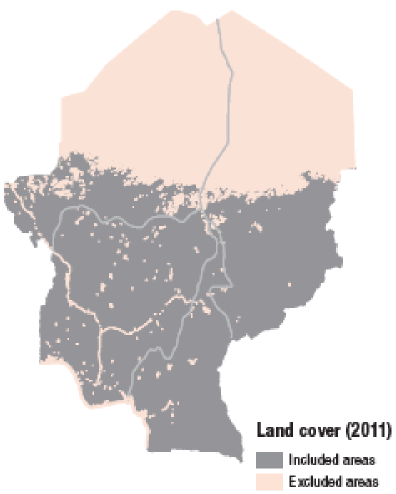


Figure 3.5-3: Vector math. Vector math is applied to remove the desert and water classes from the enumeration unit. Large areas in the north are removed due to the location of the Sahara Desert as well as smaller water bodies such as Lake Chad and the Niger River.

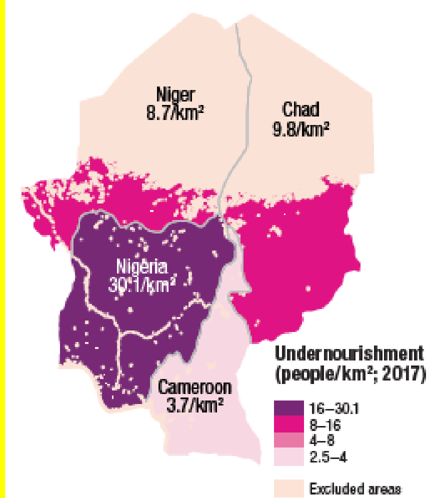


Figure 3.5-4: Resulting dasymetric map. Indicator 2.1.1 (2017) on the number of undernourished people per km² is remapped with a new area denominator. As a result, Niger and Chad have a much greater density, pushing them into higher choropleth classes.

remote sensing

MDPI

Article

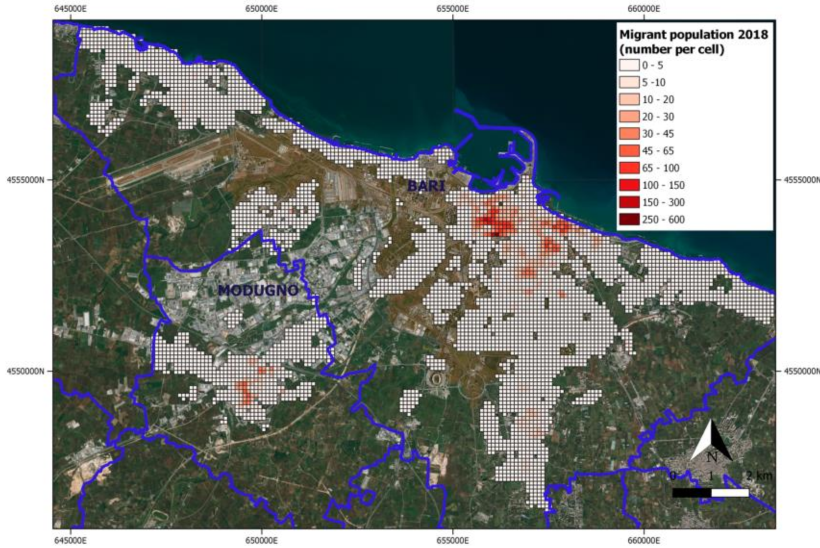
Earth Observation for the Implementation of Sustainable Development Goal 11 Indicators at Local Scale: Monitoring of the Migrant Population Distribution

Mariella Aquilino [1,2,*], Cristina Tarantino [1], Maria Adamo [1], Angela Barbanente [2] and Palma Blonda [1]

1 Institute of Atmospheric Pollution Research (IIA), National Research Council (CNR), c/o Interateneo Physics Department, Via Amendola 173, 70126 Bari, Italy; tarantino@iia.cnr.it (C.T.); adamo@iia.cnr.it (M.A.); blonda@iia.cnr.it (P.B.)

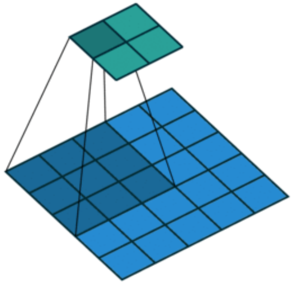
2 Department of Civil, Environmental, Land, Building Engineering and Chemistry (DICATECh), Polytechnic University of Bari, Via Orabona 4, 70125 Bari, Italy; angela.barbanente@poliba.it

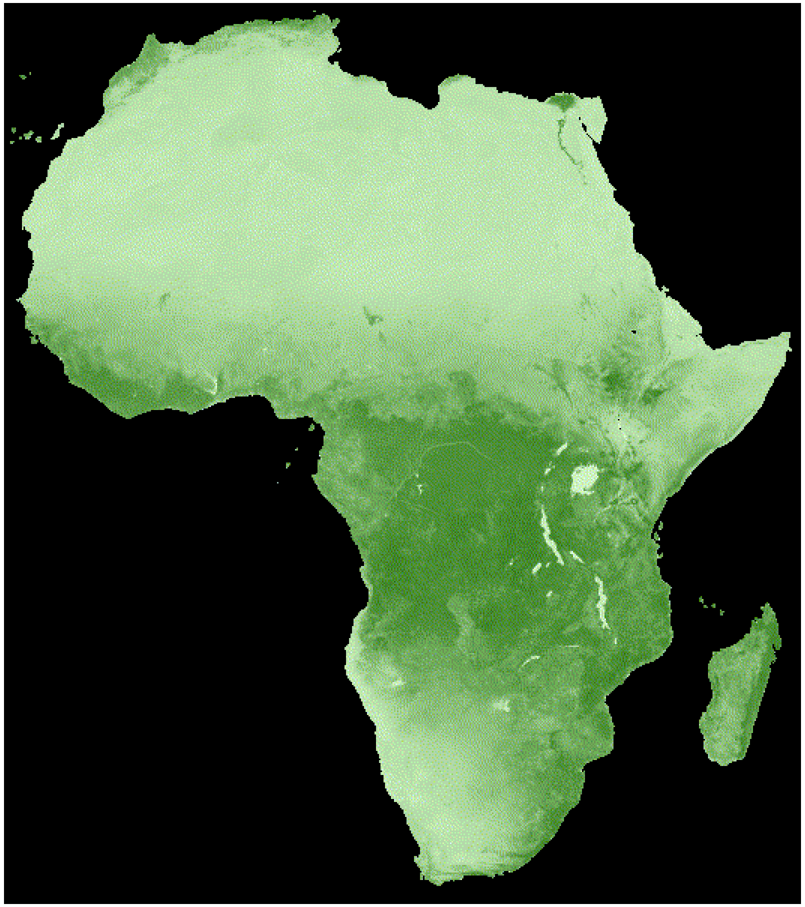
* Correspondence: aquilino@iia.cnr.it



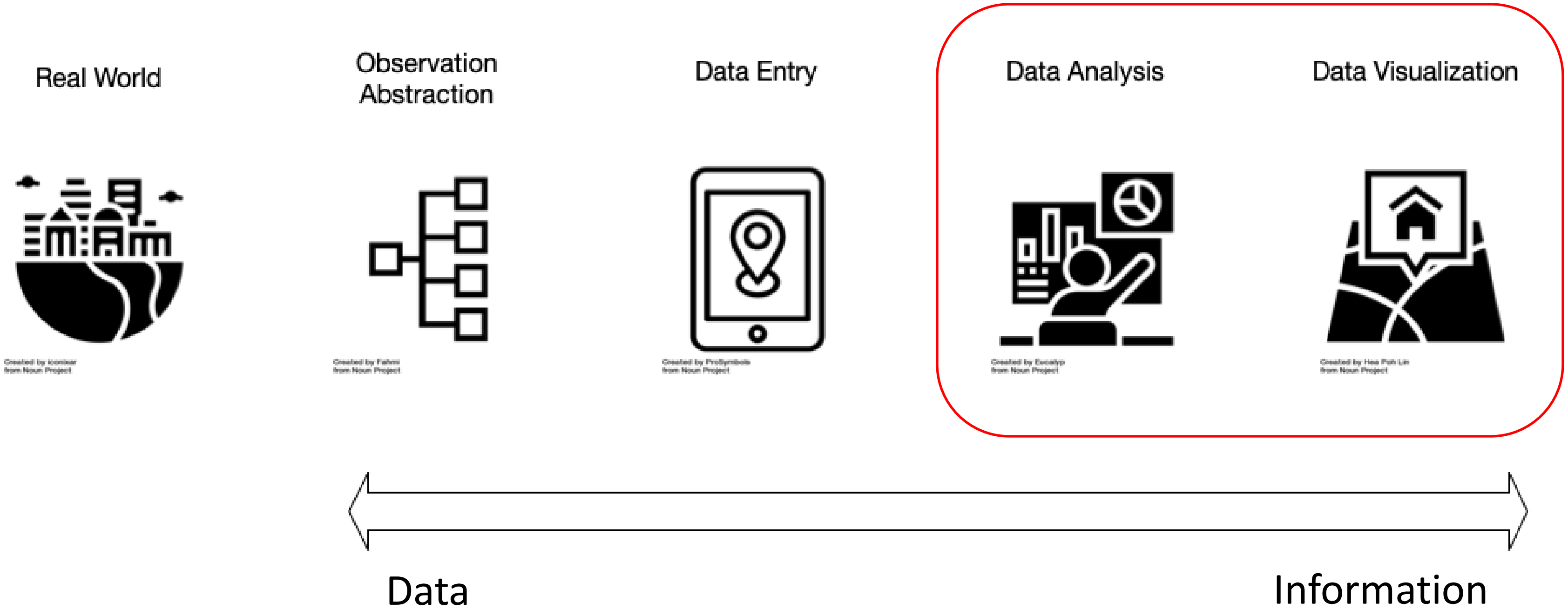
Possible ancillary data to combine with SDG data

NDVI over one year



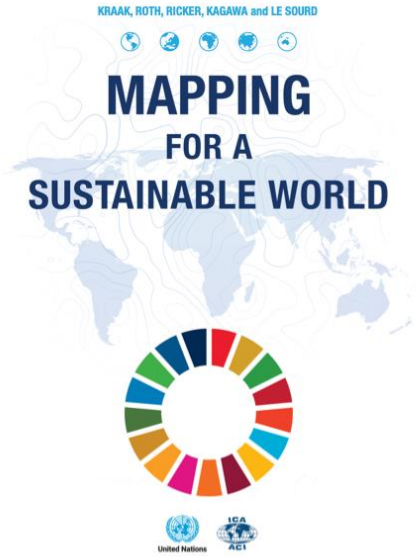


Data Provenance:
How spatial indicators are collected and then mapped



Recent Publications

- Children’s Cartography Publication by the National Institute of Spain



In print
or
As an eBook
[Mapping for a sustainable world / (un.org)]

Thank you!

Britta Ricker @bricker