International Journal of
Geo-Information

Communication

Challenges of Mapping Sustainable Development Goals Indicators Data

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Received: 31 August 2018; Accepted: 3 December 2018; Published: 17 December 2018

Abstract: The global population is growing at an incomprehensible rate and with it come complex environmental consequences that often result in social injustices. The United Nations has established a set of Sustainable Development Goals (SDGs) in an attempt to ameliorate inequality and promise safety for the masses. To reach these goals, a set of indicators have been identified and their associated data for each country are publicly available to measure how close each country is to each goal. Multifaceted social and environmental processes that are difficult to understand are causing threats to these goals. Maps help reduce complexity. Now, arguably anyone with access to the Internet and time can make a map. However, not all maps are effective accurate communication vessels. Well-designed maps tell a story that truthfully represents the data available. Here we present a synthesis of the cartographic workflow pointing out specific considerations necessary when mapping SDG indicators. Along the way we illustrate the cartographic workflow as it relates to visualizing SDG indicators. Common mapping pitfalls are described and a range of suggestions to avoid them are also offered. Map makers have a unique opportunity to use these data to illuminate and communicate injustices that are documented therein to inspire creative localized solutions to eradicate inequality.

Keywords: cartography; Sustainable Development Goals; maps; cartographic workflow

1. Introduction

The United Nations (UN) has identified a set of seventeen Sustainable Development Goals (SDGs) in an effort to collectively address social and environmental challenges facing our world. These goals are related to social, economic and environmental challenges and provide a framework for shared action. Each of the seventeen goals has a set of targets and indicators to show how close or far each country is to meeting each goal. To achieve these goals, governments and people need to understand each challenge and monitor progress towards alleviating it.

Well-designed maps and diagrams can assist in this process, since they effectively reveal spatio-temporal patterns such as global population growth and the environmental and social challenges that come with it. Maps help us better understand the relationship between humans and their environment [1–3]. Especially interactive and dynamic online maps will engage the user in ways to spark their attention [4]. They offer insights into geographical patterns at multiple scales and display trends over time [3,5]. Cartographers modify their map designs to meet the communication goals and the needs of the intended audience [6–8].

All SDG indicator data can be visualized and many of the indicators have a clear geospatial component, meaning they can be mapped. However, for such a wide range of goals and indicators, each with its specific data characteristics, it is difficult to offer specific advice to represent each one cartographically, yet established cartographic rules apply and here we will describe them in the context of SDG indicators.

The SDG data can be considered part of the open data movement. These are data openly offered and shared for everyone to use. The open data movement is seen as a positive one, suggesting government transparency, opportunity for economic development through creative reuse of data and advocacy effort [9–11]. Increasingly open data portals offer Software as a Service (SaaS) including browser-based visualization tools. It is thus becoming increasingly feasible and easy to interact with and to analyse open data.

As a result, many (online) maps and diagrams are being produced and distributed to better understand and monitor SDG indicators. These visualizations are intended for decision making by authorities and by the public, to influence and encourage authorities to act. However, this has not led to the perpetuation of necessarily efficient and accurate information designs. Without awareness of established cartographic design guidelines and skills to fully utilize affordances of software packages, default visualization choices are commonly applied which may or may not appropriately match the data type. Flawed and misleading designs often result. Problems also regularly originate from inappropriate data handling, selecting distracting basemaps or inappropriate map design elements. Proper cartographic data analysis and the appropriate application of cartographic design guidelines are needed.

With this in mind and in the context of this special issue, it is urgent to highlight the cartographic workflow with a specific focus on the SDG indicators. While the mapping principles discussed here are also applicable to other large global datasets, it is necessary to address these principles in the SDG context because of the societal attention given to these goals and the importance of reporting truthfully about the indicators and their development. Particularity since many new 'mapmakers' are taking the opportunity to access the open indicator datasets but are not necessarily aware of cartographic opportunities and pitfalls. For the map maker it is also important to be mindful of potential problems or misinterpretations by the end user of a map.

Here in this manuscript we will not only illustrate and discuss these pitfalls, such as the mismatch between data characteristics and symbology/map types and the choice of basemaps-but will also discuss the design space of alternative visualizations for the same data, focusing on the effective choices for the basemap, the data handling and different visual encodings. We describe key considerations in the cartographic workflow, associated with both data analysis and design criteria, that are particular to the data pertinent when mapping SDG indicators. We present a number of decision tree schematics and highlight key decision points when interacting with SDG indicator data, having specifically the global nature of the indicators in mind but not losing a local perspective. We are not suggesting that there is a one unique correct map for each of the SDG indicators and fully acknowledge that there is no single correct choice at each decision point during the flow of the cartographic design process but there are (multiple) chances to make mistakes which are not always realized. Textbooks about cartographic principles delineate established guidelines but they have not been presented in a single workflow as we do here in the context of the SDGs. We do not aim to offer a comprehensive synopsis of the workflow but instead describe how it specifically applies to the visualization of SDG indicator data.

In this paper, we first provide background on the SDG indicators, then we describe data format conversions and basic analysis functions as they relate to cartographic design decision making. We also highlight a range of considerations for the mapmaker. We present a cartographic work flow suggesting best practices for mapping SDG indicators. The aim is to empower mapmakers to make effective communication tools, to be aware of the potential pitfalls and to avoid them and to come up with creative alternatives to the default maps that are perpetuated on the web. We hope to encourage more people to share their interpretation of the world related to the SDGs. Finally, we address interaction possibilities that can in many cases aid the users' exploration process and understanding of the data. Strategies and considerations offered here will help with the mapping process.

2. United Nations Sustainable Development Goals and Their Indicator Data

Humans have made and continue to make a significant negative impact on the natural environment. The negative ramifications of these threats are significant and cause crisis situations including famine, genocide and war. Population growth has been linked to extreme weather conditions, water shortages, constraints on food production, loss of ecosystem services and sea-level rise. These are only a few of the current significant threats posed to the global population [12–17].

Efforts including policy improvements can and should be made at a global level to attempt to mitigate the negative consequences of these threats [12,13]. The United Nations (UN) have identified and agreed upon the Sustainable Developments Goals (SDGs) which are a collective effort aimed at coordinating and stimulating environmental sustainability, social inclusion and economic growth at a global level. They include themes from 'no poverty,' 'gender equality,' 'climate action' among others. Some goals focus on a stable functioning of earth system including atmosphere, oceans, forests, to support a thriving global society, while others focus on the security of people [14]. The aim of this effort is to guide global development, to facilitate global collaboration, shifting policy and practice [15]. The SDGs that have been identified are ambitious and not perfect. The goals sometimes conflict in their aims which is a significant challenge [14] for politicians trying to implement them.

For each of the goals a set of targets has been defined. These targets are monitored based on 232 indicators. This framework of indicators should help "monitor progress, inform policy and ensure accountability of all stakeholders" [16]. The official indicator data can be found online via the UN SDG Global Database, a public data portal providing numbers on country level [17]. This is considered governmental open data and is significant because anyone with access to the internet can interact with this official dataset, to make representations and inferences about them. The UN and the World Bank host the SDG indicator data on a spatial data portal through which maps and diagrams can be created to more easily interpret the data, converting it into information. The UN offers the data linked to a point (latitude and longitude coordinates) associated with each country, political boundaries in the form of polygons are not offered [18]. These portals sometimes offer multiple data types for the same indicator. For example, Indicator data 9.4.1 CO2 emissions is offered as an absolute number (metric tons) as well as a rate (metric tons per Gross Domestic Product).

Not for all of the 232 indicators data is currently available, because some data are not collected or shared for each country, while other indicators have not been coherently defined. This makes it almost impossible to monitor the current global distribution of phenomena targeted by each goal. For these reasons, the UN have divided the indicators into three tiers (https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/) and are described as follows:

- **Tier I:** Indicator is conceptually clear, has an internationally established methodology and standards are available and data are regularly produced by countries for at least 50 per cent of countries and of the population in every region where the indicator is relevant.
- **Tier II:** Indicator is conceptually clear, has an internationally established methodology and standards are available but data are not regularly produced by countries.
- **Tier III:** No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested.

As of mid-May 2018, there are 93 Tier I indicators, 72 Tier II and 62 Tier III indicators and 5 indicators that are classified in more than one Tier making a total of 232. By definition, only Tier I data are complete enough to work with on a global scale, yet even in Tier I some data are not collected or shared for each country or even coherently defined. Figure 1a offers a schematic representation of all 17 goals representing each of the indicators per goal displaying how many indicators each goal has and of what Tier. From the diagram it becomes clear that for some goals, such as Goal 12: Responsible Production and Consumption or Goal 13 Climate Action, almost no data are available, whereas Goal 3: Good Health and Well Bring and Goal 9: Industry, Innovation and Infrastructure have the most Tier I datasets available. Five different indicators have data from multiple tiers. These graphics help with identifying usable data associated with each goal.

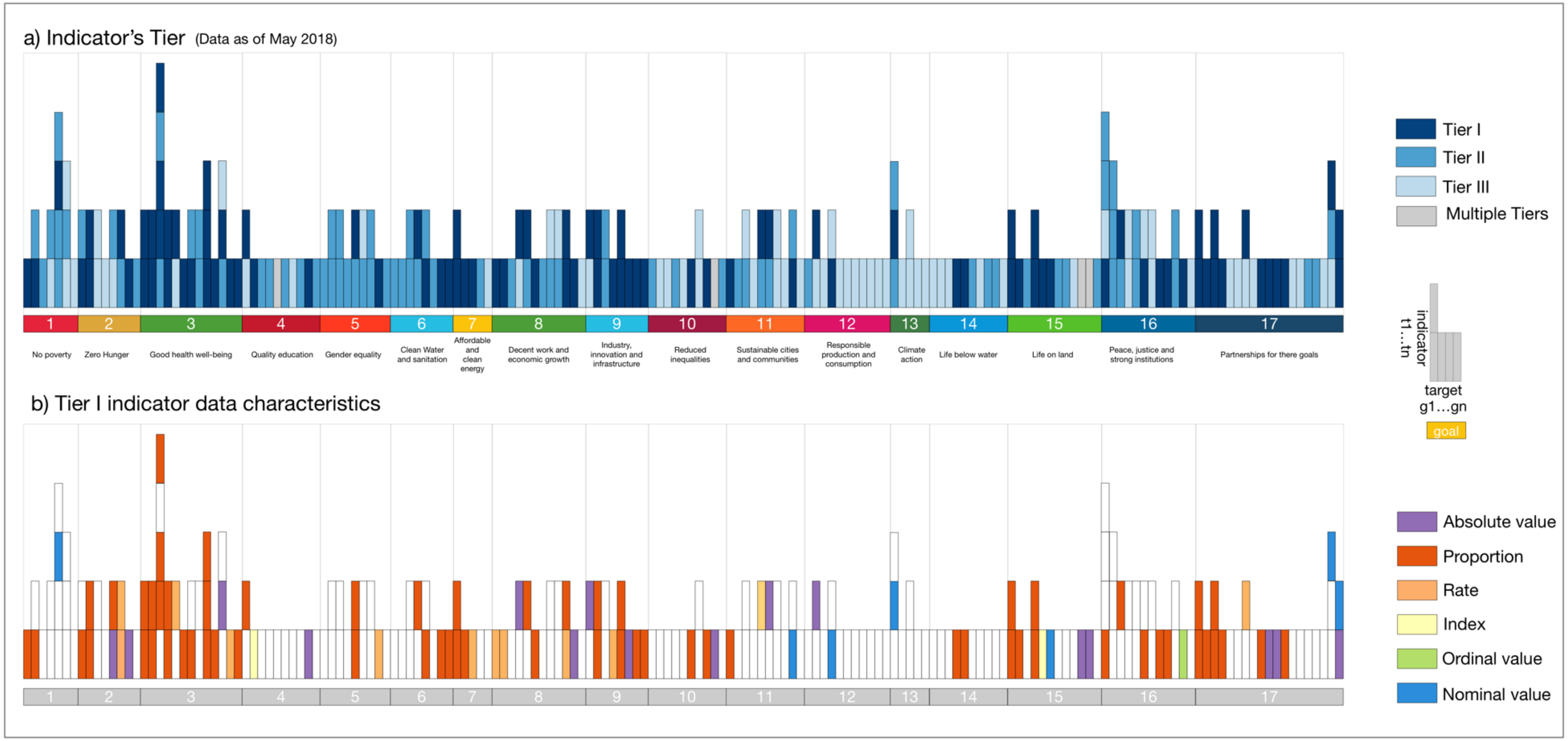


Figure 1. The Sustainable Development Goal (SDG) names and number of indicators for each including representation of tier level: (**a**) the indicator's tier; (**b**) the tier I indicator's data type.

Now that SDG indicator data has been discussed, in the next section, we will introduce considerations related to data transformations associated with available SDG data that significantly influence the final visualization.

3. SDG Data Transformation

Before data can be visualized the nature of the data must be known, to inform the selection process of a map type and a symbology with appropriate perceptual properties for representing the data. SDG indicator datasets may comprise absolute values, proportions, ratios, ordinal values or nominal values. Both Figures 1b and 2a provide a more detailed perspective on SDG indicator characteristics—the colours in both figures correspond to data type.

The data classification is based on the measurement level of data: ratio, interval, ordinal and nominal. Interval is not addressed here since it is not presented in the SDG indicator data. For ratio we distinguish between absolute and relative values. Absolute values are measured or counted and concern a single variable. Relative values are calculated, based on one, two or multiple variables. Two values belonging to the same variable result in a proportion (a percentage), two values belonging to two different variables lead to a rate (e.g., a count of something per population) and multiple values belonging to multiple variables result in an index (based on formula). Even finer distinctions can be essential for making effective visualization choices, for example, a proportion may be a percentage of the population or a percentage of a non-population variable. Similarly, a rate may be calculated with respect to population, with respect to time or with respect to another variable. Indices can be based on different formulas, usually involving several variables. Each of the above require a different handling in the visualization process, to guarantee that the graphics will express the nature of the indicator data.

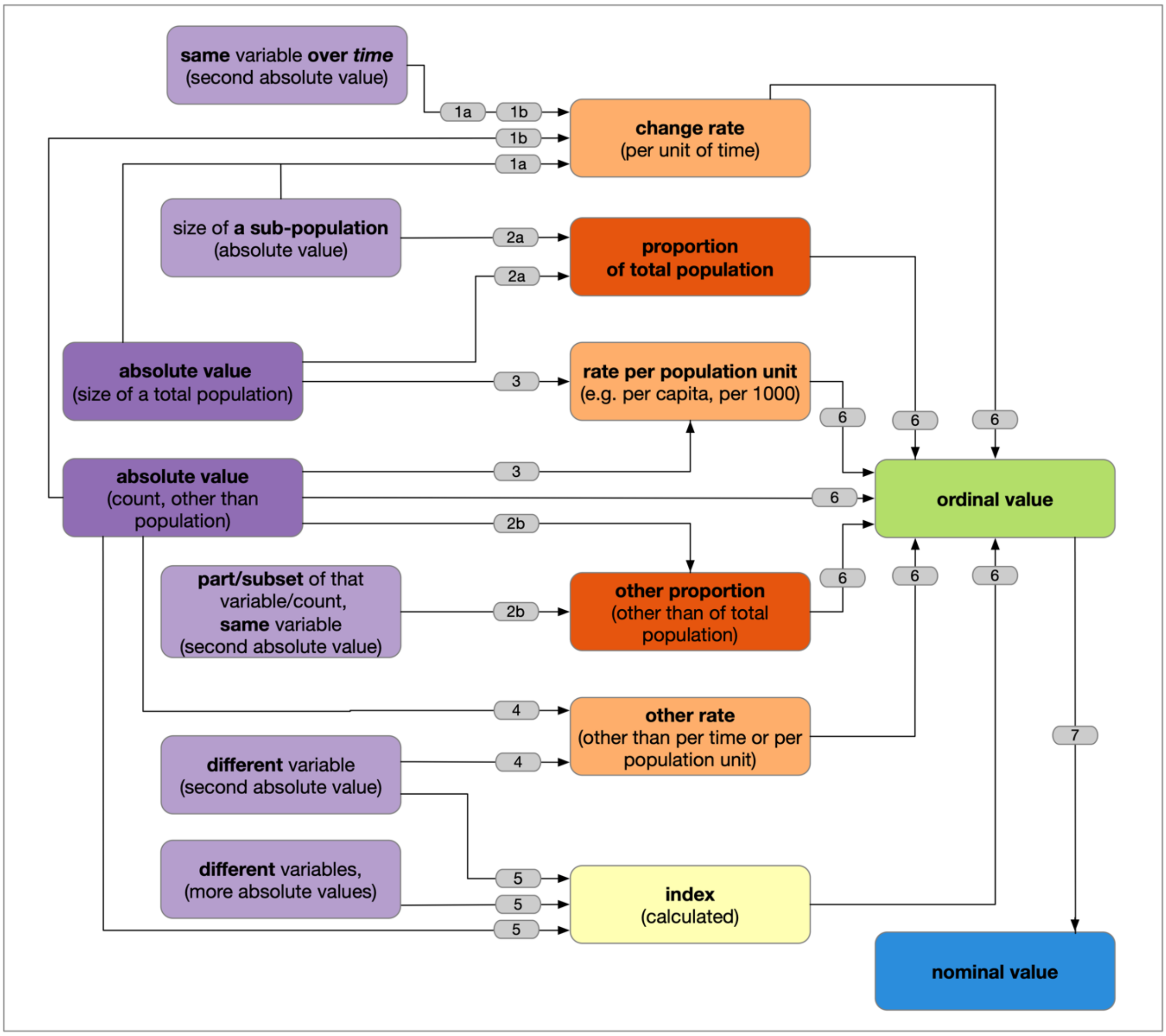
It is possible to convert data types to communicate the same data in a different way. These conversions could be helpful to harmonize indicators, to encourage comparison or use in new or alternative indices. Transformation should be dictated by the communication goals of a map. For this reason, in Figure 2b pathways for potential data transformations are provided, these are options and not requirements. It is possible to start at different points within the schematic but only in the directions of the arrows in Figure 2b. Absolute values can be transformed into relative, ordinal or nominal values. Relative values (proportions, rates, indices) can be transformed into ordinal or nominal values and ordinal values can be transformed into nominal values. This data conversion schematic is applicable to other datasets but particularly useful to SDG indicator data since all of these different data types are available for one overarching initiative.

Transformations based on absolute numbers often involve multiple variables. Comparing population size over two years can result in a change rate (Figure 2b arrows 1a). This works analogously for counts other than population (arrows 1b). Comparing the total population to a subset of the population (e.g., children between age 12 and 18) can lead to a proportion of the population (arrows 2a). Similarly, this can be done with counts other than population (e.g., GDP of a region and a sub-region) (arrows 2b). The combination of population and counts other than population can result in rate per population unit (e.g., doctors per 100.000 inhabitants) (arrows 3). A combination of two different variables with counts other than population can lead to other rates (e.g., SDG indicator 9.1.2 number of cars per 100 km road) (arrows 4). The combination of multiple variables in a formula can result in an index (e.g., gender inequality index, based on health, empowerment and labour market data) (arrows 5).

Another data transformation is aggregation. SDG indicator data are sometimes aggregated at the regional level for different reporting purposes. The consequences of uneven data completion are shown in the maps in Figure 3. The top map (Figure 3a) shows the global regions as defined by the UN. The choropleth map in the bottom shows (Figure 3b) the index of a theoretical indicator. The indicator values are aggregated from country to regional level.

scale type	absolute / relative	variables	data type (name)		description (X and Y are variables)
ratio	absolute (one value)	one variable	absolute value		count X
	relative (calculated using two or more values)	one variable	proportion	proportion of total population	% of total population
				other proportion	% of X, other than population
		two variables	rate	rate per population unit	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 variables	index (calculated)		formula
ordinal			ordinal value		level or rank
nominal			nominal value		in SDG indicator all: yes/no

a) SDG indicator characteristics



b) SDG indicator conversion options

Figure 2. SDG indicators: (**a**) data characteristics; (**b**) data conversion options.

The map is effective, global patterns can be distinguished. However, considering administrative units by which data were collected and then classified, concentrate on the inset which enlarges Western Europe (Figure 3c). We see a homogeneous region but in reality, it should be depicted as the bottom inset map (Figure 3c bottom). As the table between both inset maps tell us: four of the nine countries are missing, home of a little less than half of the entire population for the region, almost 95 million people. The regional world map is correct according to cartographic rules but here we have explained that what is displayed on a map is not necessarily the whole story and can be misleading.

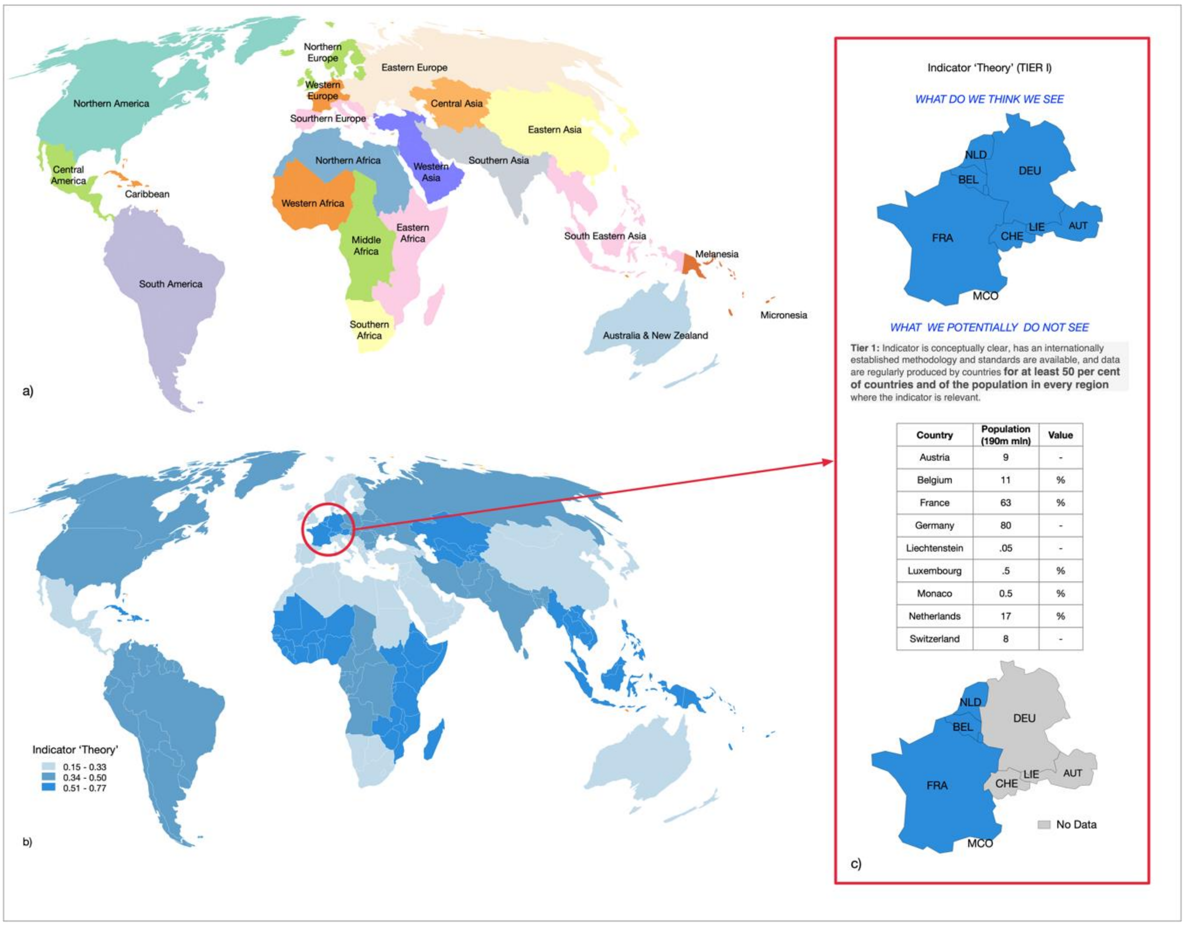


Figure 3. This is an example dataset of a fictional Tier I indicator: (**a**) Global regions as defined by the United Nations (UN); (**b**) choropleth of a synthetic Tier I indicator at the global scale by regional level; (**c**) Zooming in on Western Europe showing the perceived situation (**top**) and the potential real situation (**bottom**).

In this section considerations related to data transformations were discussed. These ideas will now be contextualized into the greater cartographic workflow, including design decisions.

4. Cartographic Workflow

Creating maps may seem easy, as we have seen above, data selection and manipulation alone is already difficult. Software as a Service (SaaS) visualization tools linked to open data portals are making the process easier but are not necessarily producing better maps. Anyone with Internet access can simply access and upload data into a mapping software package installed locally or available in their Internet browser, follow a few default options and an attractive map appears. Yes, this might work but nice-looking does not mean that the map is effective or efficient in conveying relevant information to the end user.

The cartographic workflow implies a whole series of decisions that will influence the appearance of the final map. Two major phases can be distinguished: data analysis and cartographic design. Before a cartographer embarks on these phases, important preliminary work must first be done. In Figure 4 the objective is making a map of global Gender Inequality Indices. Elementary questions have to be answered: what is the purpose of the map? Comparing all countries with the global average;

emphasizing the low values; or comparing multiple variables. Another important question is: Who is the audience of the map? Examples could be the general public reading a newspaper, fellow scientists or politicians. And the environment where the map will be used will play a role too. Is the map to be published on paper or online? If online, is it for a fixed large display or for a mobile device? Answers to these questions will influence design and decision making while navigating the cartographic workflow as displayed in Figure 4.

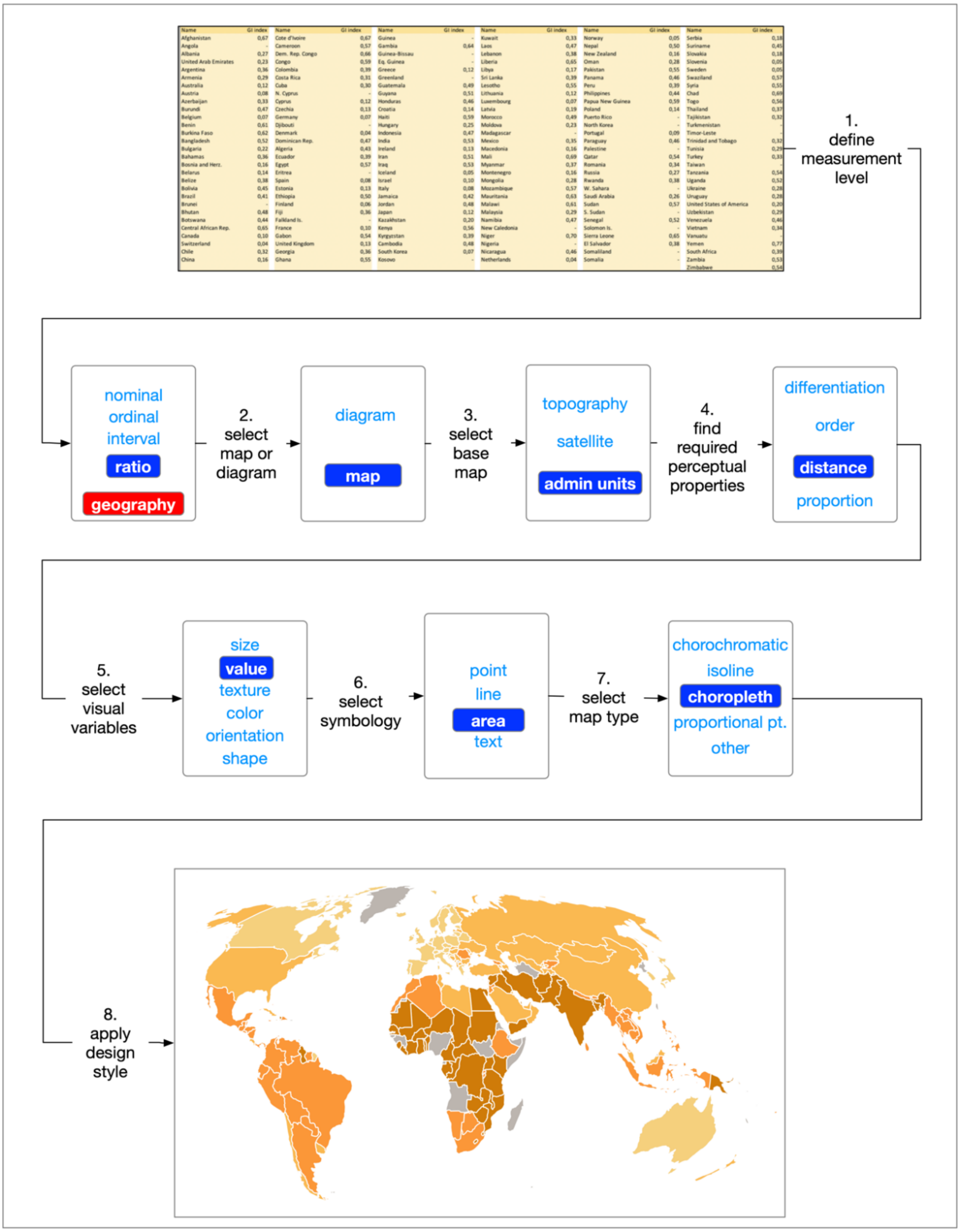


Figure 4. Major step in the cartographic workflow applied to visualizing the Gender inequality Index which is made up of multiple variables, many of them SDG indicators.

In Figure 4, the entire workflow is presented including possible options and with final decisions that were made are highlighted. As the first step of the cartographic data analysis, the character of the data must be established (step 1). In the example presented here the Gender Inequality Index established by the United Nations is visualized. The gender inequality index offers a value between zero and one for each county and has been calculated based on multiple variables, including variables related to men and women's health, empowerment and roles in the labour market [19]. The closer to zero, the more equality between females and males. This is an example of relative ratio data: a calculated number (see also the yellow boxes in Figure 2). With this information in mind, the next step is to decide between a map or diagram (step 2). Since we are interested in the spatial distribution a map is selected. A basemap is required to provide context to the map reader, in this example administrative units (countries) are used (step 3). Choosing a diagram could be an appropriate option as well. Instead of a map a bar graph displaying the order of the countries from high to low or the other way around. Even a choice like these influences how readers will perceive the data. In case of the gender index it will go from bad to good or the other way around, which sets the tone of the story. The choice depends on the communication goals set for the graphic. In step 4 the appropriate perceptual property needs to be selected that fits with this kind of data. Here it is distance, all values can be placed in an unambiguous order.

By selecting appropriate visual variables that will evoke the required perceptual properties we start the cartographic design process (step 5). In this example we choose the visual variable 'value.' With this we can express the index values from low to high.

An area symbol (the administrative units) is selected to depict the index values (step 6), which then results in a choropleth map (step 7). The individual index values are classified and grouped in four classes, where by the high classes gets a dark value of orange and the low classes a light value. Countries with no value are given a grey colour. With the choice of colours, we enter the art realm of cartography. Here orange was selected as a base for the colour ramp, but this could have been any colour. All choices related to the appearance of the symbols, like boundary lines and fill are free, although the aim should be a harmonized design which facilitates message delivery (step 8).

5. Additional Cartographic Considerations

In addition to the data selection, transformation and aggregation and the different representation choices as a result thereof, it is important to consider the implications of the choice of the basemap and administrative units.

Basemaps: In case of mapping the indicators on a global scale the choice of the map projection can have a dramatic effect on how the mapped phenomena are perceived. However, often the user does not have an option to change the map projection without making a significant effort in further data transformations. That is because many web services by default only make the Web Mercator projection available. The Mercator projection preserves angles but these characteristics result in significant distortions along the poles, which makes it less suitable for global representations [20]. Especially if the objective of the map is to compare countries and the theme is linked to area such as population density, the Web Mercator should be avoided. Figure 5 shows the classic example of area distortion by comparing Greenland and Saudi Arabia, which are about the same size in square kilometres. Figure 5a shows the world in the equal area Mollweide projection and 5b in the conformal Mercator projection.

Thematic maps like a choropleth map only need the boundaries of the administrative units depicted. Boundaries are a sensitive topic, because due to different political viewpoint these lines on maps are cause of controversy. Different cartographic techniques, such as blurred or dotted lines exist to visualize uncertain and disputed boundaries, but no single map will be able to honour all viewpoints regarding any political issue or boundary dispute. Additional context is often helpful when conveying information related to particular topics. For example, a map displaying the distribution of hydroelectric power stations will benefit from having the river network in it too. Available basemaps like OpenStreetMap—also in Web Mercator—do change their level of detail depending on the map scale selected but do not allow you to select and view individual layers, like the hydrography network only. The consequence is that the map becomes overwhelming to the viewer with irrelevant topographic information.

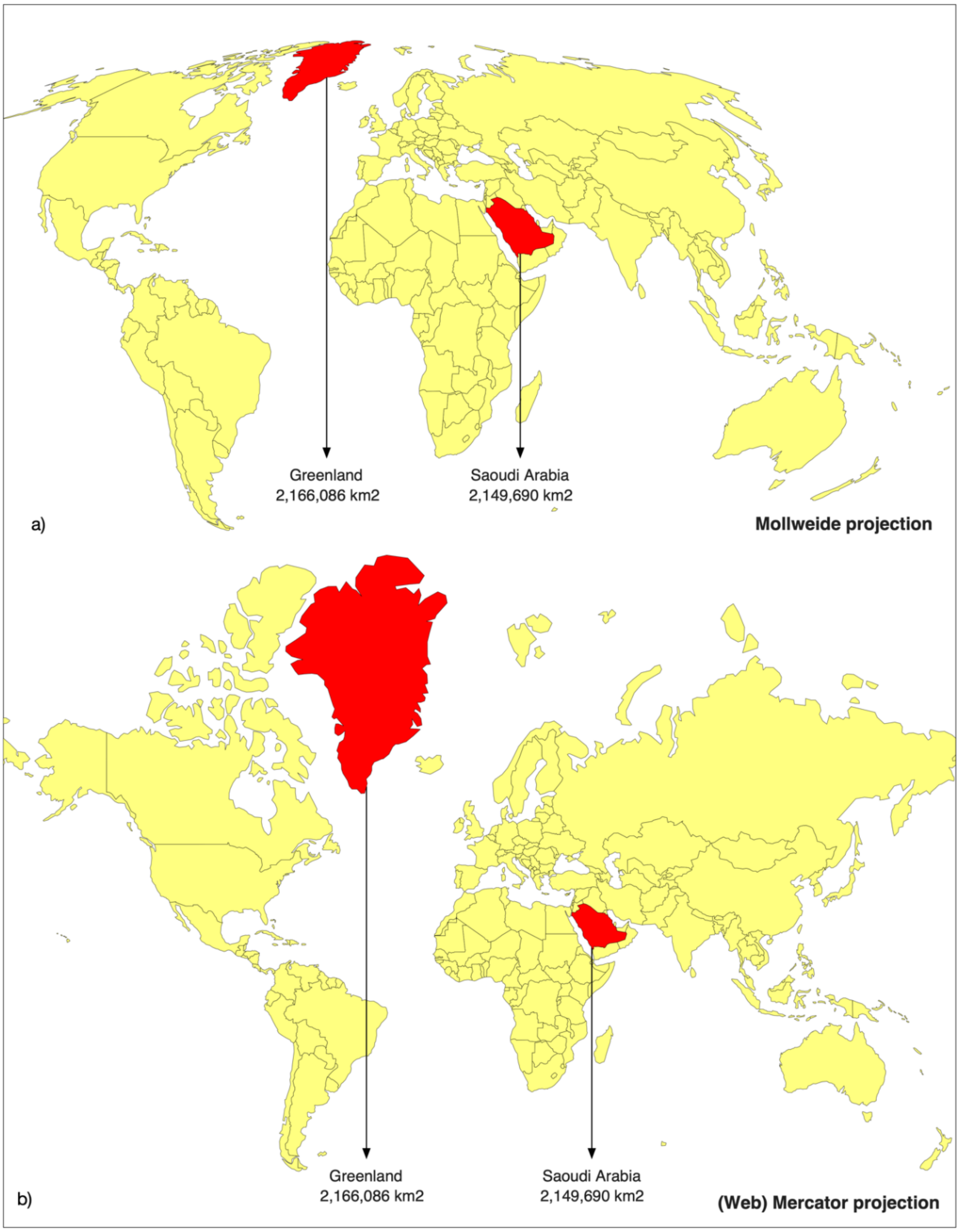


Figure 5. Basemap considerations including projections. Here is an example comparing the size of Greenland and Saudi Arabia displaying differences resulting from projection choices: (**a**) Mollweide; (**b**) Mercator.

Administrative units: Countries have different sizes and shapes. Map readers are likely to have a 'local' perspective on their country and a particular worldview. This could directly influence how they interpret the map. In some situations, the map projection might be of a greater importance than the data representation. Figure 6a, where Canada is highlighted in three maps, illustrates this. All three world maps are displayed in the Mollweide projection but with different central meridians. On the top a focus on North America, in the middle a focus on Europe and on the bottom the central meridian goes through central China. For Canadians, the lower map might appear unfamiliar and hamper the interpretation of the map. For global topics like those associated with the SDGs, it could be beneficial to offer more localized viewpoints, like the three maps in Figure 6a.

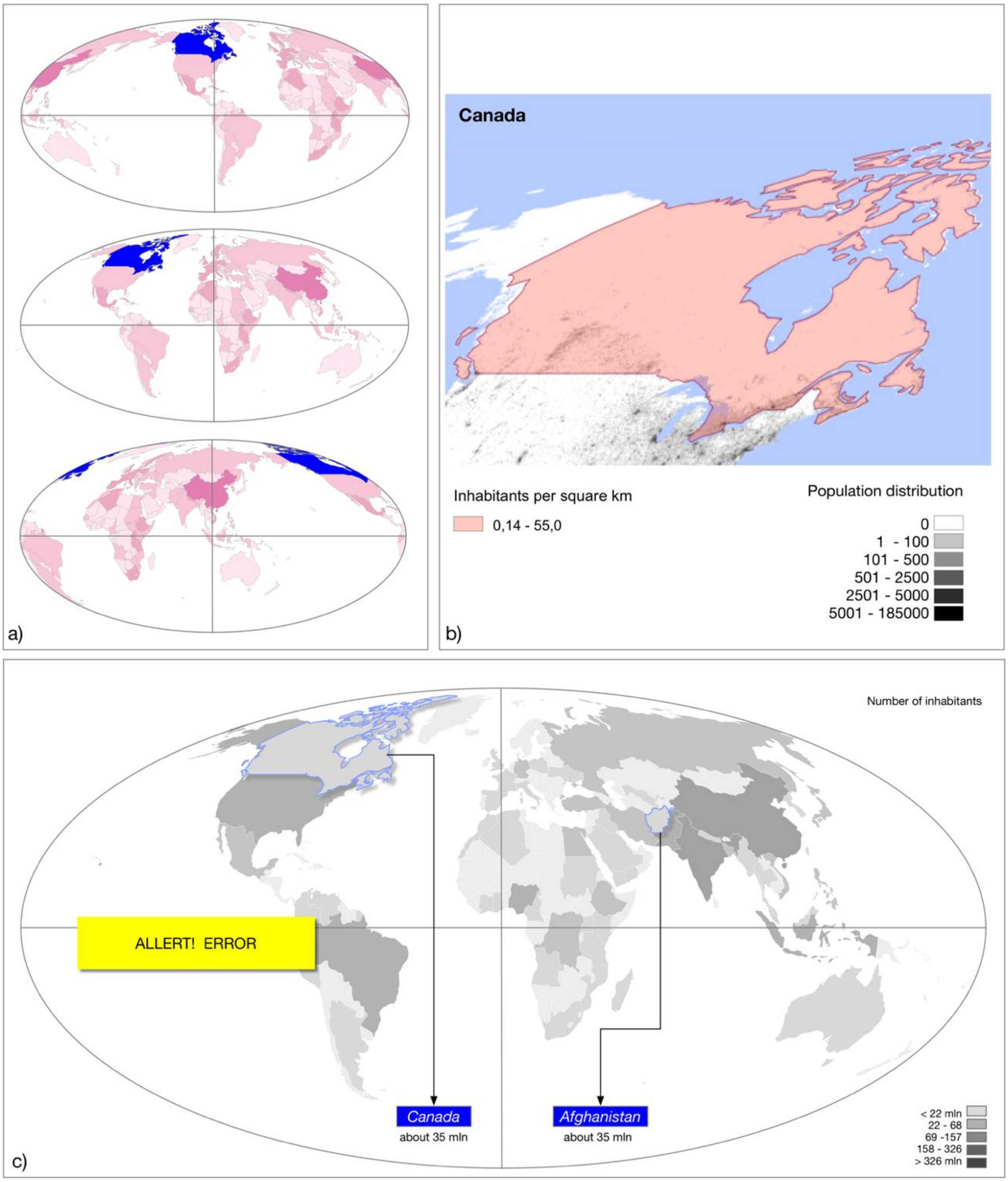


Figure 6. Administrative units: (**a**) Different perspectives on the Mollweide projection and the effect on the shape of a unit (Canada); (**b**) Transparent choropleth with population distribution as basemap (non-homogeneous distribution of Canadian population) (**c**) The most common error with choropleth maps: use of absolute numbers (here inhabitants per country—Canada and Afghanistan have about same population but this will not be perceived like this because of size differences.

For some topics it is relevant to indicate whether the variables have a direct link to the land area of the country. A gender index is independent of a country's land area, but the population density is not. Choropleth maps give the impression that the phenomena are equally distributed over an administrative unit. This is seldom the case and in for example Canada the population is distributed extremely unevenly. Most people live in the south near the US border. In Figure 6b a population distribution map is used in combination with a transparent choropleth map to avoid the impression of equally distributed phenomena. Alternatively, one might consider lower level administrative units or convert the units to a regular grid, for example hexagons. However, this is only possible if one has the data available on the more detailed level, which is not the case for the SDGs. Some alternatives are discussed in the next section.

Figure 6c presents the most common error in thematic mapping: the use of absolute numbers in a choropleth map. This is considered wrong because the sizes of the administrative units, which are rarely equal, will perceptually influence the interpretation by the map user. It is a common mistake because the map maker might not be aware of the problem and/or the software has this map type as a default and is not considering the data type (see Figure 2). In the example in Figure 6c where Canada and Afghanistan are highlighted, each having a population size of about 35 million people. Because of its size the map reader might think Canada has far more inhabitants than Afghanistan, despite that both countries belong to the same colour value.

6. Map Options and Alternatives

From Figure 1b displaying all of the indicator datasets by data type, it can be deducted that the most common SDG indicator data type is proportion, and this means the obvious map choice for this type of data is a choropleth map. This map type has its disadvantages and is prone to some common mistakes of which have been discussed in the previous sections.

To augment traditional choropleth maps and to avoid some of the perceptual problems with them 'improvements' or alternatives are suggested. Figure 7a presents an example of an interactive and linked environment related to indicator 3.2.1, infant mortality. In addition to the default choropleth map, two different cartograms and an adapted choropleth map are offered. In the cartograms the size of each country is related to its population. Brazil remains relatively large, while Ecuador increases in size, and Bolivia shrinks in size. The indicator is now directly related to the population. The left cartogram maintains the topology among the countries, which might lead to very 'strange' country shapes. The right cartogram is a schematic cartogram where the administrative units have been generalized to squares and do not necessarily maintain topology. The alternative choropleth tries to reveal the non-homogeneous nature of the population distribution as it relates to the phenomena within each administrative unit. Here a spy glass tool reveals the global light distribution map for the user to compare to the choropleth map in an interactive fashion. However, the night-time light map or the population distribution map in Figure 6c and are not necessary an image of reality. The latter often depends on estimates and home addresses and the former might include industrial, agricultural lights and/or forest fires.

Interactive linked views are not only useful for choropleth maps but also for other map types as there is no single perfect map. These alternative graphic representations might shed a different light on the data, offering the user alternative ways of knowing. Figure 7b shows Indicator 9.4.1, emissions of carbon dioxide by metric ton. On the left these absolute numbers are presented in a proportional point symbol map. On the right the topic is represented in a cartogram connected to a line graph with ten years of data. In the cartogram the size of the countries is related to the emissions-note for instance how Venezuela increases in size, and Paraguay shrinks. The slider below the line graph can be moved along the timeline. The cartogram will adapt to the values corresponding to the respective years. The small map with names functions as a colour legend. The menu allows to focus on a particular country and highlight the absolute values. These are possible alternative visualizations to assist end users understanding of the data presented.

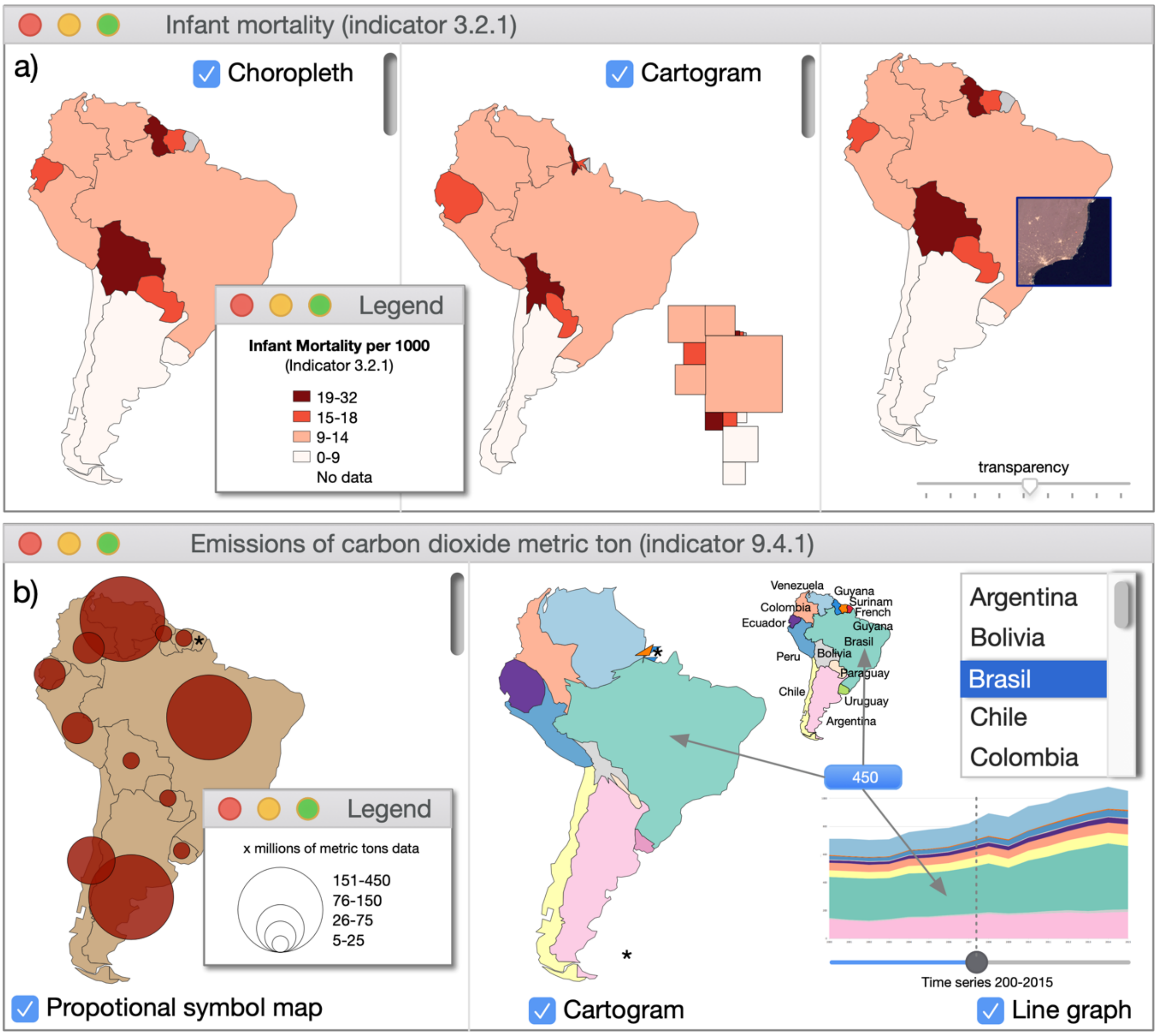


Figure 7. Alternative mappings: (**a**) Infant mortality (indicator 3.2.1): left: a traditional choropleth; centre: two types of cartograms; right: transparent choropleth with night-time light basemap; (**b**) Emissions of carbon dioxide (indicator 9.4.1): left: a proportional point symbol map; right: linked cartogram, line graph of time series and basemap.

7. Conclusions

The Sustainable Development Goals have been established to help mediate environmental and social injustice at the global scale integrating social, economic and environmental dimensions. The first step for approaching this challenge of mapping them is to break down each goal and identify where each country presently is in relation to each indicator. One way to help decompress the problem and identify solutions is through mapping indicator data. However, even though known problems with the data exist, map makers may introduce additional errors or unintentional misconceptions by applying inappropriate cartographic designs. For this reason, we have presented considerations to be made specifically while generating maps using SDG indicator data.

Here we presented an overview of the United Nations Sustainable Development Goals and associated indicator data. We first covered the nature of SDG data and presented data transformation possibilities to best visualize and map the data. We then presented additional considerations related to basemap selection, enumeration units, effects of projection and central meridian choices and influence of population distributions on meaning making from maps. All these considerations related to the cartographic workflow have been individually discussed in the cartographic literature but not in the context of the SDGs. These principles are particularly important to this audience, this new generation of map makers who are not necessarily cartographically trained or aware of these considerations and when using online mapping software, often with peculiar defaults.

The workflow of best practice discussed here is a basic approach exemplified with single variable maps. At times there is a need to compare multiple indicators in a single map to better understand relationships between indicators. This will make the maps more complex and might require alternative approaches, not necessarily in design only but in the working environments. Similar to the solution offered in Figure 7 multiple linked maps, each with its own indicator, can support understanding. Interactive dashboards offering exploratory options to answer user questions could be useful to visualize SDG indicator data. This will require usability studies to test interactions in web environments and communication effects.

In this contribution we have advocated executing proper data analysis and creating effective (alternative) designs based on data characteristics, with the intended audiences in mind. More research is needed in respect to interactive web mapping services available through SaaS. We (the contemporary cartographic research community) have a responsibility to influence the software developers' choices of map defaults. As a start we have to have more knowledge about the inner workings of SaaS, the specific algorithms and classifications that make respective defaults. Over time many improvements have already been implemented in mapping software. We have to train "new" map makers who do not necessarily have a background in cartography and who are likely not going to read textbooks about the basic principles of cartography. We encourage these new map makers, who are passionate about the SDGs, to be alert and question default settings, to avoid maps and diagrams that result in false understandings of the indicator data leading to misinformed decision making. Additionally, we aim to encourage map users to be more aware of what is being presented to them. They should be able to comprehend and be critical about what they see. We suggest adding annotated map reading instructions within interactive web map. Finally, we suggest improved communication strategies between SDG indicator data collectors, statisticians, policy makers and map makers. Maps can communicate the complex web of social and environmental challenges facing our world by identifying spatio-temporal trends, leading to localized solutions, which is coincidentally also the goal of the SDGs.

Author Contributions: Writing–original draft, M.J.K. and B.R.; review and editing, Y.E.; Visualization, M.J.K.

Funding: This research received no external funding.

Acknowledgments: Thank you to the reviewers and editors for their thoughtful recommendations.

Conflicts of Interest: The authors declare no conflict of interest.

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