

# Data Visualisation

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## ELEMENT 1: CLIMATE CHANGE VISUALISATIONS

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## Introduction

This report focuses on the most important aspects of graphical representation of data a creator must consider when visualising data. These flow from the big idea or story behind the data down to the smallest component present in the visualization.

It was created in form of rubrics with scores used to rate quality of visualisation based on human perception of visuals. Principles have been put together from notable authors to form all encompassing standard/guidelines for the most widely used data visualisation methods.

## Quality Criteria

### Criteria 1: Appropriate Chart Type Used

A visual designer should ensure that data is displayed using a chart type that is appropriate for the relationships that exist among variables within the data. Knowledge about context of the visualisation and the relationships of the data variables is a critical step to achieve any effective visualisation.

#### Rational for Inclusion

In the book *The Visual Imperative* (Ryan, 2016, p. 222), the author emphasises the use of ONLY relevant visuals that is based on a diagnostic of visualizations best suited for specific analytic needs. The visual designer must employ charts best suited for the data type to convey the story simply and clearly. If the chart representing a dataset is wrong or inadequate, facts about the data may be lost or misrepresented.

### Criteria 2: Key Findings Highlighted

Key findings in charts should be obvious or highlighted to ensure that the audience can make meaning of the visualisation. A useful visualisation would be one that communicates visual representation of information to an audience. If the key finding is not understood, then the visualisation is meaningless.

#### Rational for Inclusion

Edward Tufte said, “data graphics should draw the viewer’s attention to the sense and substance of data, not to something else” (Tufte, 2001).

In agreement with this, others (Myatt, Johnson and Myatt, 2009) believe that a designer must select the graphic that most efficiently highlights significant finding or conclusion. So, it remains best practice to show the data over aesthetics like grids, tick marks on scales, reference lines that point out key events, legend keys, or explanatory text adjacent to outliers.

### Criteria 3: Arrangement of Chart Elements (Eliminate clutters)

Best practices demand that charts are arranged in a way that is free from clutters. When creating a visualisation, elements that do not represent data should be avoided or limited so that they do not get in the way of data. These elements could be text, graphs, tables, lines, etc. which are likely to be interpreted following the Gestalt Principles of Visual Perception; enclosure, similarity, proximity, closure, continuity and connection (**Knafllic, 2015, p.74**).

#### Rational for Inclusion

The book *Storytelling with Data* (**Khaflic, 2015, p. 71**) has a whole chapter dedicated to eliminating clutter in charts. It demonstrates clutter experience as “cognitive load” which is an “enemy” of any visualisation, given that humans have finite amount of that mental processing power.

Ryan supported this design criteria in *The Visual Imperative* (**Ryan, 2016**) with the quote; “when building a visualization, distracting elements should be avoided so, they do not get in the way of the data”.

**Tufte (2001)** and **Duarte (2011, p. 170)** have described this criterion as *data-ink ratio* and *signal-to-noise ratio*, respectively. The *data* and *signal* being the important graphical components, while *ink* and *noise*, the clutter.

### Criteria 4: Consistent Colour Scheme and Patterns

Colours in within a project must be consistent across elements while maintaining culture-based colour connotations. Effective use of colours will help direct the audience’s attention to where you want them to focus. Elements with different colours should be distinct when shown in black-and-white to suit a colour-blind audience.

#### Rational for Inclusion

**Knafllic (2015, p. 117)** describes four ways to use colour as a powerful tool to grab audience’s attention: “use it sparingly, use it consistently, design with the colour-blind in mind, be thoughtful of the tone colour conveys, and consider whether to leverage brand colours”.

The book explains how colours or the lack of it have some generally accepted meanings which are perceived by different humans, differently.

### Criteria 5: Use only 2-Axis covering full range of data values

Graphs should have horizontal(x) and vertical(y) axis depicting, no third-dimension axis. Poor axis selection and labelling such as adding 3D to graphs introduces unnecessary chart elements like side and floor panels which are unnecessary to the key message passed to the audience. Also, data with true zero can be easily be misrepresented when axis is improperly chosen and labelled.

#### Rational for Inclusion

In the book *Storytelling with Data*, **Knafllic (2015, p. 65)** demonstrates how poor axis in charts can skew data and make it hard to interpret or compare relationships. Only two axis is recommended: the x-axis representing the independent (predictor) variable, and the y-axis representing the dependent (outcome) variable with the full range of value represented on the both axis.

### Criteria 6: Ethical Data Representation

Visualisation should not intentionally or unintentionally mislead the audience. This is to say that graphical elements should not be used to manipulate the data just to push an agenda.

#### Rational for Inclusion

In the book *The Visual Imperative* (**Ryan, 2016, pg. 222**), the author emphasised the need to avoid distortion and misrepresentation by being sensitive to biases and other factors such as axis ranges, skew, aspect ratio and wrong charts.

Ethically, the choices and use of all individual chart elements must work together to reinforce the takeaway message and not to force the data to fit a message that is untrue.

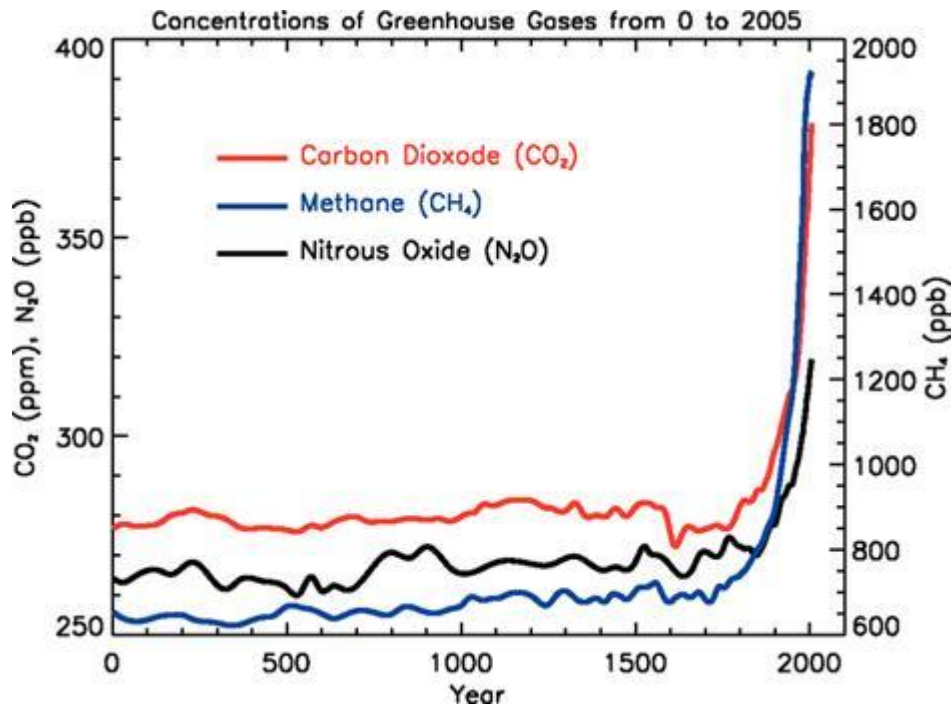
## Portfolio

### Graph 1: Temperature vs Solar Activity

This graph was used to illustrate the trend in the atmospheric concentrations of greenhouse gases up till 2005. The double y-axis represents CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>, while the x-axis represents time in years.

The chart below was retied from the California Governor's office of planning and research, that works towards reducing the effects of climate change in California communities. The link to chart is given below.

<https://opr.ca.gov/facts/common-denier-arguments.html>



### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	Appropriate chart was used to represent time series/trend.	3
2	Key Findings Highlighted	The trend lines directions demonstrate the key findings which is the rise in GHG concentrations.	3
3	Arrangement of Chart Elements (Eliminate clutters)	Legends were appropriately placed to avoid clutter. The tick lines and borders neither add to nor highlight key findings, they form unnecessary clutter around chart.	2
4	Colour Scheme and Patterns	Colours used adequately represented data with appropriate distinction.	3
5	2-Axis covering full range of data values	Axis adequately represented the data. Axis title has appropriate units.	3
6	Ethical Data Representation	There was no misrepresentation of data.	3

### Recommendations

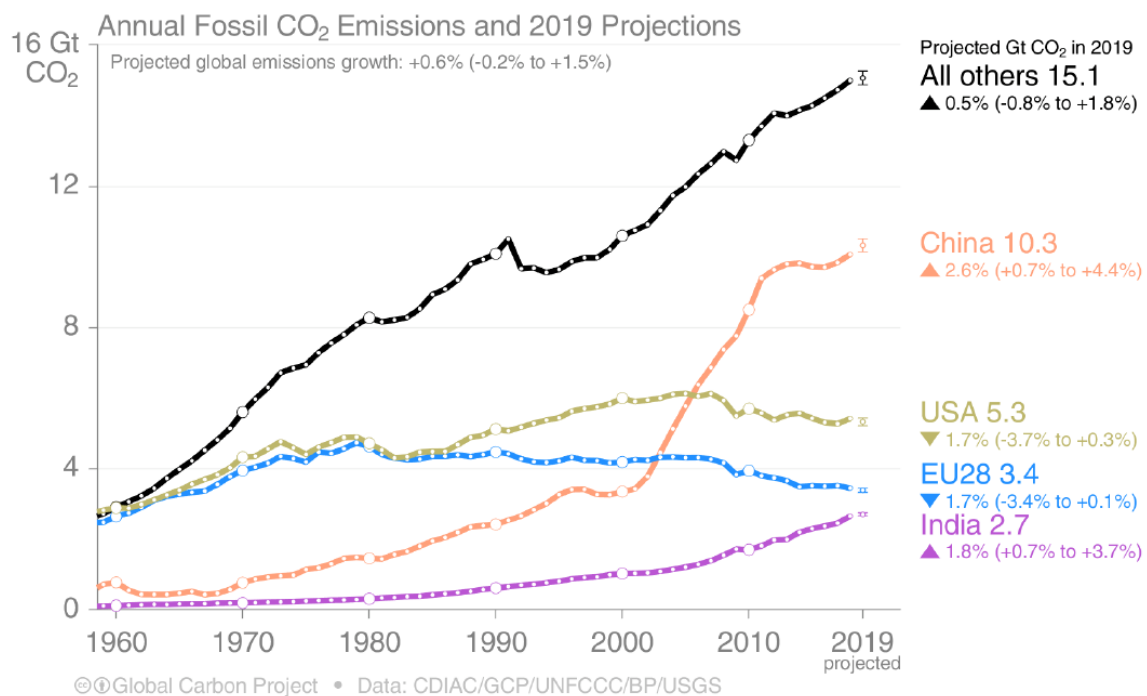
Tick marks on both axis as well as borders should be removed to avoid clutter.

Graph 2: Annual Fossil CO<sub>2</sub> Emissions and 2019 Projections

This graph uses trendlines to represent the increase in CO<sub>2</sub> emissions over time. It comprises of five trendlines that represent China, USA, India, EU28 and Rest of the world. It is aimed at exposing the general public to the past, current and projected Fossil CO<sub>2</sub> emissions from 1960 down to 2019. It has CO<sub>2</sub> in Gt represented on the y-axis and time in years on the x-axis.

The chart was retrieved from the website -

<https://blog.iese.edu/doing-business/2019/12/16/four-graphs-to-understand-the-facts-on-carbon/>



### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	Appropriate chart was used to represent time series/trend.	★ ★ ★
2	Key Findings Highlighted	Key findings were clearly represented	★ ★ ★
3	Arrangement of Chart Elements (Eliminate clutters)	Chart elements were organised without cluttering the highlight of the chart.	★ ★ ★
4	Colour Scheme and Patterns	Chart colours were used sparingly and consistently which satisfies criteria 4.	★ ★ ★
5	2-Axis covering full range of data values	The data was well represented in the chart on the x and y axis.	★ ★ ★

6	Ethical Data Representation	The graph was ethically constructed with data clearly represented.	★ ★ ★
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### Recommendations

This chart was represented with an appropriate chart and all quality criteria were met.

### Graph 3: Global Carbon Emissions in 2018

The chart has global emissions represented on a tree map that displays countries with area variations that indicates the emission quantities. It aims at informing the general public about the main causes of climate change.

The chart was retrieved from a page from the Vox website below.

<https://www.vox.com/energy-and-environment/21428525/climate-change-cause-charts-china-us-responsible>

**Exhibit 7:** Global carbon emissions in 2018; total area = 36.6 billion tonnes of carbon dioxide



Source: Global Carbon Project

Morgan Stanley

### Evaluation

Measure your graph against your quality criteria here. Try to keep them in the same order that you described them in on page 1.



SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	A tree map is not the best to represent categorical data for so many variables.	0
2	Key Findings Highlighted	The top emitting counties were noticeable, but no values. Names of other countries were not visible.	1
3	Arrangement of Chart Elements (Eliminate clutters)	Chart element like the legend was poorly displayed as it did not represent all the datapoints on the chart.	1
4	Colour Scheme and Patterns	Colours used fairly to represent data with appropriate distinction.	1
5	2-Axis covering full range of data values	No third-dimension axis	NA
6	Ethical Data Representation	Poor data representation as some comparative values were missing from the chart.	1

#### Recommendations

A table is recommended to adequately represent all the countries and their emission quantities. Highlights will be clearer when countries capture the exact emission quantities or values being compared with another country.

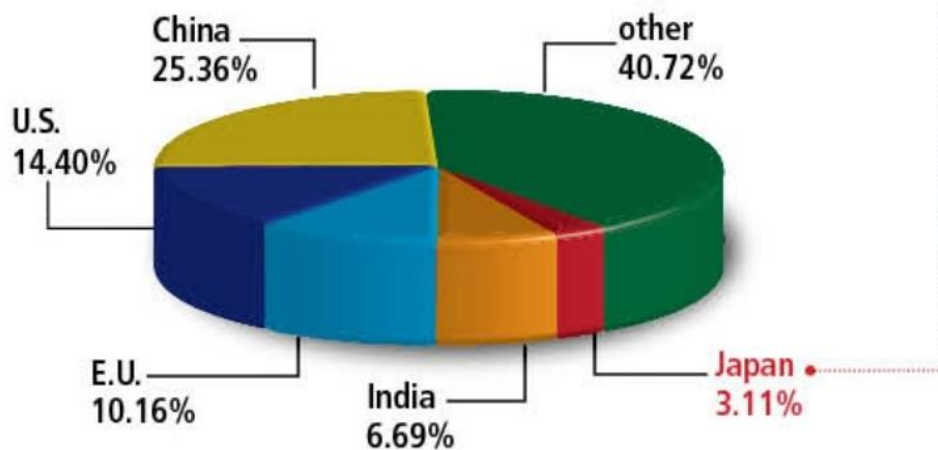
#### Graph 4: Global Contributions to Greenhouse Gas Emissions (2012)

This graph aims to display part-to-whole relationships among countries. The sections of the shape represent the respective countries' contribution to the global emissions. The chart was retrieved from the website below which is accessible to the general public at the foreign policy website below.

<https://foreignpolicy.com/sponsored/japanus/global-commitment/>

## Global Contributions to Greenhouse Gas Emissions (2012)

Despite having the world's third-largest economy, Japan's greenhouse gas emissions account for only 3.11% of global emissions



Source: World Resources Institute

### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	A pie chart is appropriate to represent a part-to-whole relationship, but without a 3 <sup>rd</sup> dimension.	1
2	Key Findings Highlighted	One key finding was clearly represented i.e., Japan's economy being compared to its emissions.	3
3	Arrangement of Chart Elements (Eliminate clutters)	Chart elements were organised without cluttering the highlight of the chart.	3
4	Colour Scheme and Patterns	Colours wouldn't be fit for a black/white copy of the chart.	1
5	2-Axis covering full range of data values	3D representation can lead to misrepresentation.	0
6	Ethical Data Representation	The graph was not ethically constructed with data clearly represented.	2

### Recommendations

A chart that would best represent the part-to-whole relationship could be column chart, tree map, or 2D pie chart.

### Graph 5: Number of Reported Disasters by Decade and by Hazard Type (1971 – 2010)

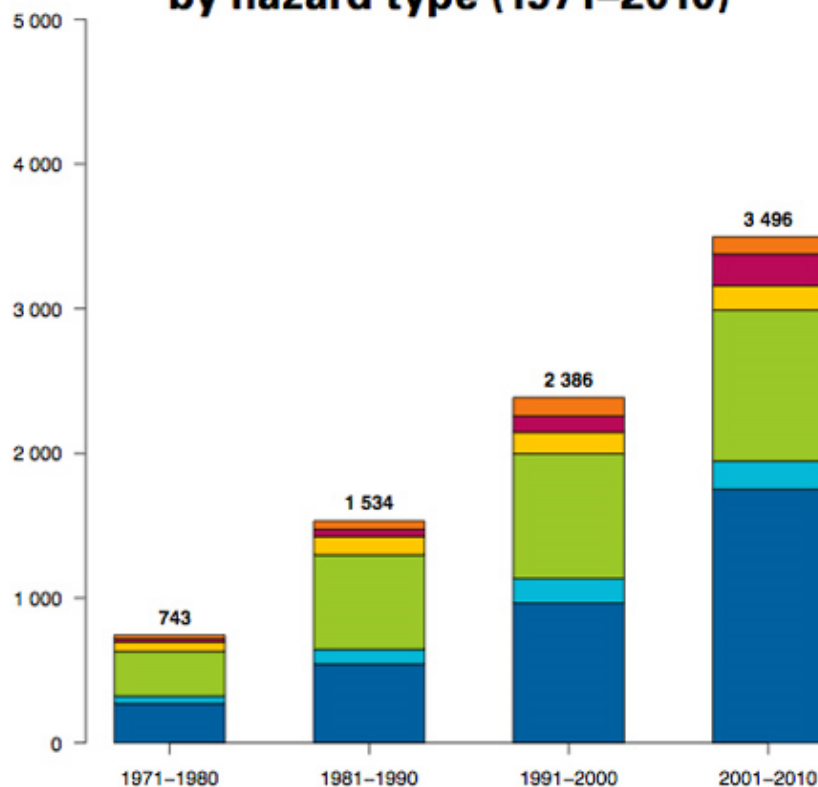
This stacked bar chart shows how climate change is making the world more dangerous. The bars represent time frames, while the different colours represent different types of disasters. The y-axis represents the frequency of occurrence of these natural disasters.

The chart was retrieved from an environmental blog “Mother Jones” via the link below. Audience is the general public and relevant leaderships.

<https://www.motherjones.com/environment/2014/07/8-charts-show-how-climate-change-making-world-more-dangerous/>

Insert the Graph 5.

**Number of reported disasters by decade  
by hazard type (1971–2010)**



## Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	Good choice of chart to represent categorical relationship and distribution.	3
2	Key Findings Highlighted	Numbers on the bars are key information adequately highlighted.	3
3	Arrangement of Chart Elements (Eliminate clutters)	No legend. Y-axis is irrelevant as the information is already represented on top each bar. Tick on both axes are also irrelevant and cause clutters.	1
4	Colour Scheme and Patterns	Colours are useful in showing the distribution of disasters in a time frame (bar)	3
5	2-Axis covering full range of data values	Both axes properly represent the data	3
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

## Recommendations

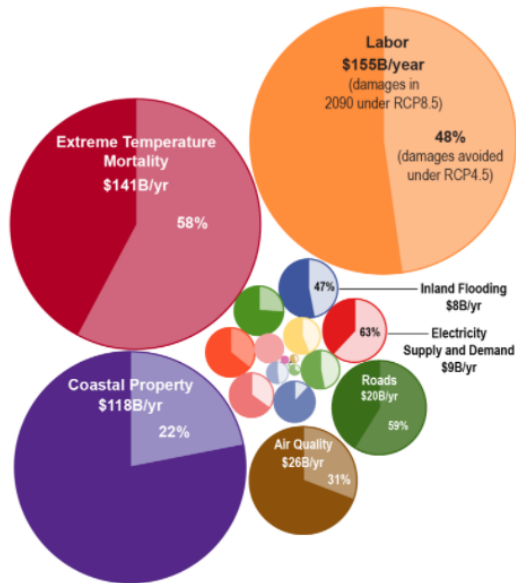
Remove the y-axis and ticks on the x-axis. Also include a legend to show what the different colours mean.

## Graph 6: Annual Economic Damages of Climate Change in 2019

The graphical illustration is a combination of pie charts and a table to show the annual economic damage of climate change in the United States.

The intended audience is the general public, US government, and other action takers to see reasons for immediate actions to prevent irreversible impending climate disaster (according to the report on the website below).

<https://techcrunch.com/2018/11/23/new-u-s-report-says-that-climate-change-could-cost-nearly-500-billion-per-year-by-2090/>



Annual Economic Damages in 2090		
Sector	Annual damages under RCP8.5	Damages avoided under RCP4.5
Labor	\$155B	48%
Extreme Temperature Mortality	\$141B	58%
Coastal Property	\$118B	22%
Air Quality	\$26B	31%
Roads	\$20B	59%
Electricity Supply and Demand	\$9B	63%
Inland Flooding	\$8B	47%
Urban Drainage	\$6B	26%
Rail	\$6B	36%
Water Quality	\$5B	35%
Coral Reefs	\$4B	12%
West Nile Virus	\$3B	47%
Freshwater Fish	\$3B	44%
Winter Recreation	\$2B	107%
Bridges	\$1B	48%
Munic. and Industrial Water Supply	\$316M	33%
Harmful Algal Blooms	\$199M	45%
Alaska Infrastructure	\$174M	53%
Shellfish*	\$23M	57%
Agriculture*	\$12M	11%
Aeroallergens*	\$1M	57%
Wildfire	-\$106M	-134%

### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	The table was appropriate to represent the data. However, the pie charts are repetition of the table contents, which makes them irrelevant.	2
2	Key Findings Highlighted	Key findings were properly highlighted in the table and not the pie charts.	2
3	Arrangement of Chart Elements (Eliminate clutters)	Pie chart are clutters in the case. Colours on the first column of the table are irrelevant and hence, clutters.	1
4	Colour Scheme and Patterns	Too many colours which are unnecessary. Only figures would communicate the same information.	0
5	2-Axis covering full range of data values	NA	NA
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

### Recommendations

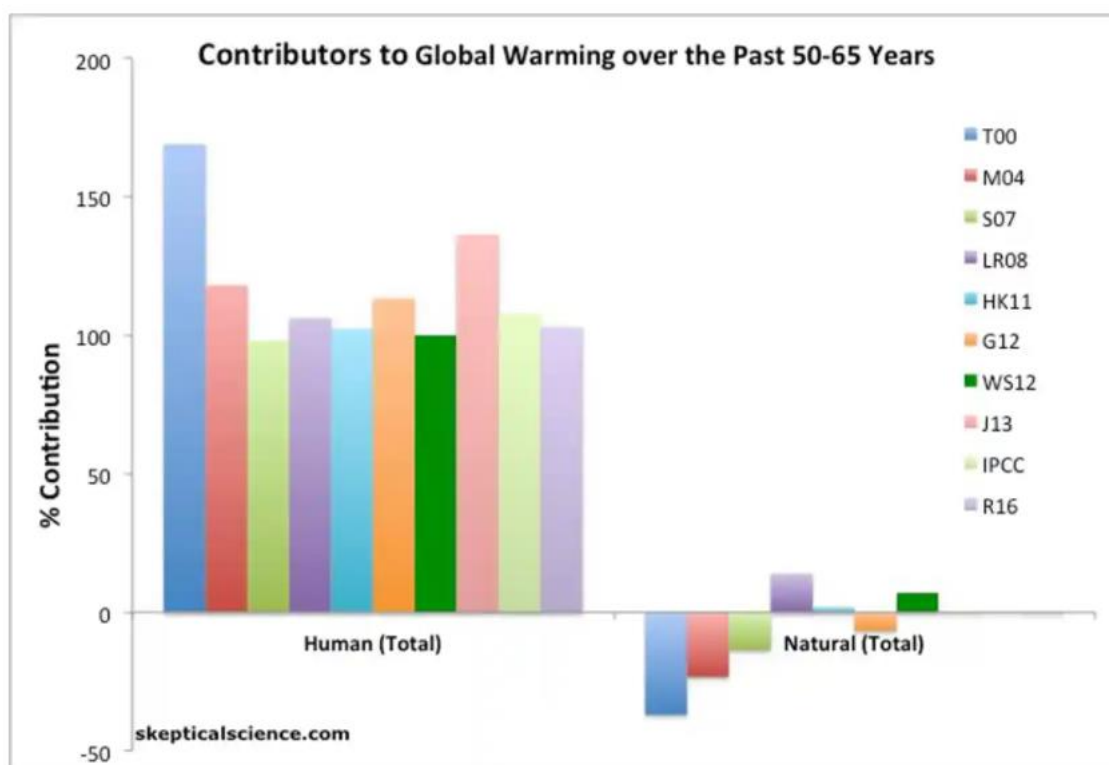
Use only the table (no pie chart nor multi-colours) to represent the data.

### Graph 7: Contributors to global warming over the past 50 – 65 years

This is a clustered column chart used to compare the result of different studies on who/what the contributors to global warming are (humans and nature). The height of the columns to represent the percentage contribution (according to axis labels) while the x-axis represents human and natural contributors to global warming according to different studies.

The chart was retrieved from The Guardian website via the URL below.

<https://www.theguardian.com/environment/climate-consensus-97-per-cent/2016/apr/19/study-humans-have-caused-all-the-global-warming-since-1950>



📷 The percentage contribution to global warming over the past 50-65 years in two categories: human causes (left) and natural causes (right), from various peer-reviewed studies. The studies are Tett et al. 2000 (T00, dark blue), Meehl et al. 2004 (M04, red), Stone et al. 2007 (S07, green), Lean and Rind 2008 (LR08, purple), Huber and Knutti 2011 (HK11, light blue), Gillett et al. 2012 (G12, orange), Wigley and Santer 2012 (WG12, dark green), Jones et al. 2013 (J13, pink), IPCC AR5 (IPCC, light green), and Ribes et al. 2016 (R16, light purple). The numbers are best estimates from each study. Illustration: Dana Nuccitelli

### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
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1	Appropriate Chart Type Used	Correct chart for part-to-whole relationship	3
2	Key Findings Highlighted	Key findings were properly highlighted	3
3	Arrangement of Chart Elements (Eliminate clutters)	No clutters	3
4	Colour Scheme and Patterns	Too many colours in one chart. The colour green seems to be stand out among other colours.	1
5	2-Axis covering full range of data values	The axis represents the information adequately.	3
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

### Recommendations

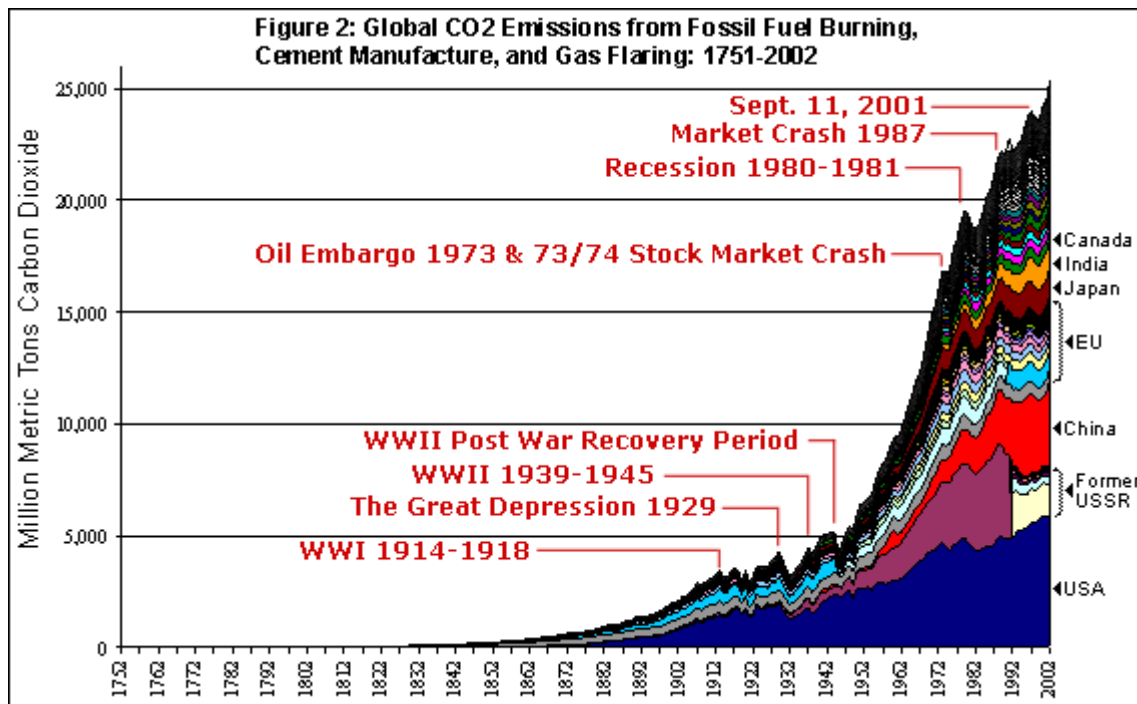
Replace chart with a table or a clustered column chart where each cluster of 2 bars represent one study. This would require only 2 colours to be used across the chart.

### Graph 8: Global CO2 Emissions from Fossil Fuel Burning, Cement Manufacture, and Gas Flaring: 1751 - 2002

This is a stacked area chart that represents CO2 emissions over time by countries from 1752 – 2002. This chart created by the Environment Protection Agency has been notated with specific events to show how events that impact social economics systems impacts growth of industrial greenhouse gases

The chat was part of a project called “THE HUMAN CAUSED GLOBAL WARMING FINGERPRINT” that explores the human contribution to global warming which can be accessed via the URL below.

<http://ossfoundation.us/projects/environment/global-warming/human-caused>



### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	Too many variables in one chart	1
2	Key Findings Highlighted	Key findings were properly highlighted	2
3	Arrangement of Chart Elements (Eliminate clutters)	Too many clutters – tick marks, grid lines and borders	1
4	Colour Scheme and Patterns	Too many colours in one chart.	0
5	2-Axis covering full range of data values	The axis represents the information adequately. However, the vertical label in the x-axis is inappropriate.	2
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

### Recommendations

Reduce the number of variables, a summary would suffice for this representation. Remove clutters such as ticks, make grids lines more transparent. Change orientation of the vertical labelling of x-axis.

### Graph 9: Climate Change Attitudes Show Little Variance by Region



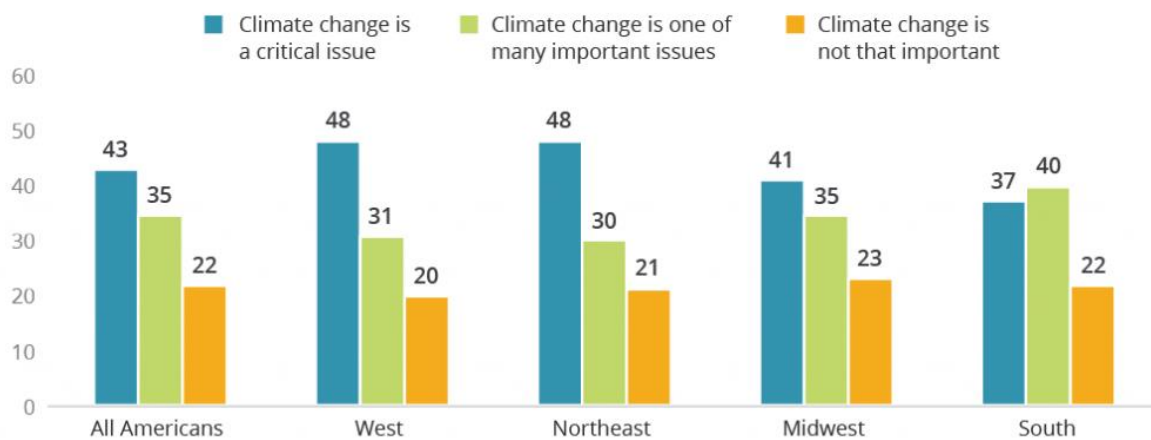
This is a clustered column chart based on an American survey that ranks the attitude of Americans to climate change. Each cluster represents a section of Americans based on location, while the heights of the columns represent the percentage of the cluster with a given attitude towards climate change which is either “critical”, “important” or “not that important”.

The chart is available on the Public Religion Research Institute website via the URL below.

<https://www.prri.org/spotlight/despite-varying-regional-effects-americans-agree-on-the-severity-of-climate-change-and-the-importance-of-combating-it/>

**FIGURE 1. Climate Change Attitudes Show Little Variance by Region**

Percent who believe:



Source: PRRI 2020 American Values Survey.

### Evaluation

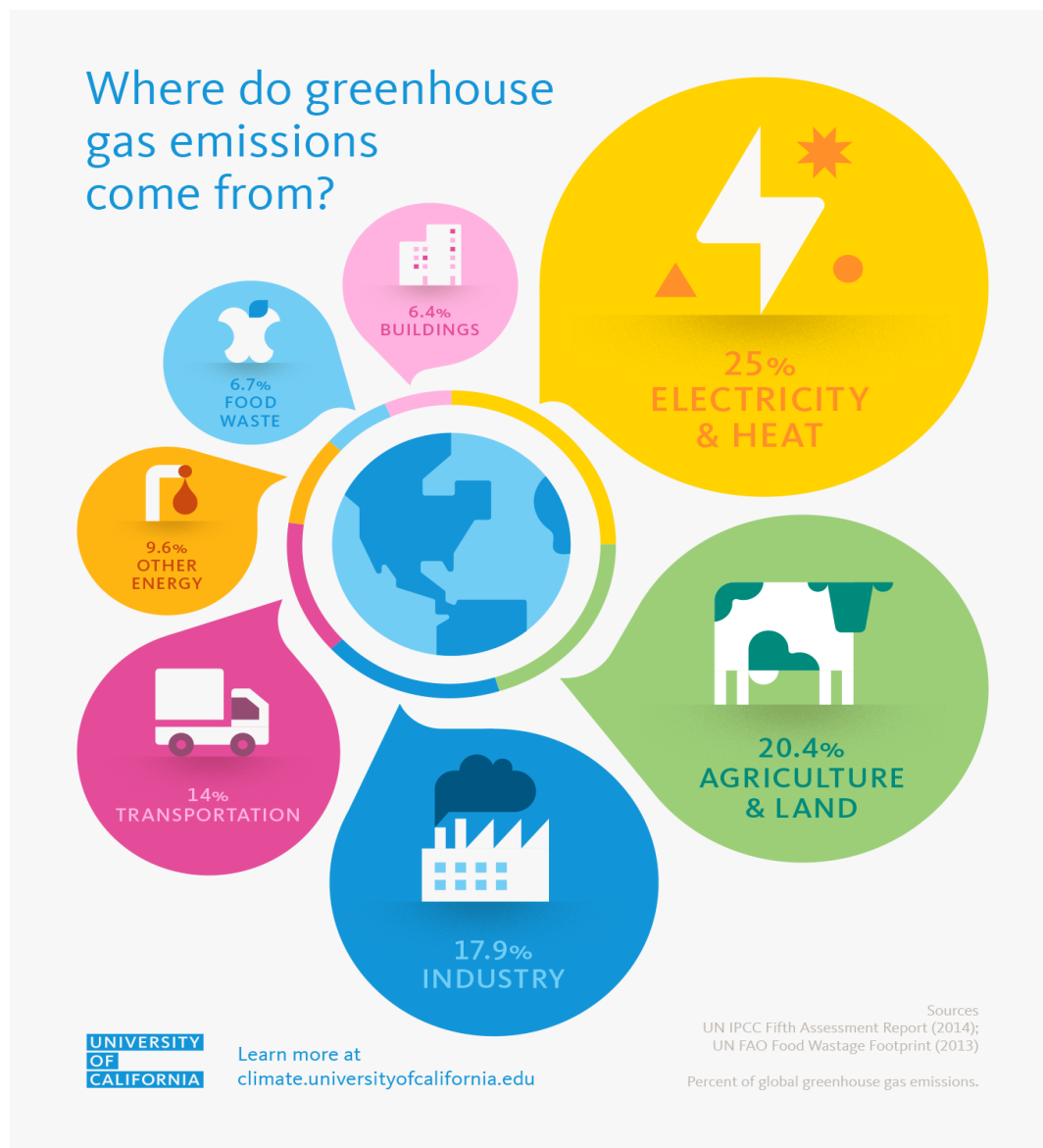
SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	Correct chart for ranking	3
2	Key Findings Highlighted	Key findings were properly highlighted	3
3	Arrangement of Chart Elements (Eliminate clutters)	No clutters	3
4	Colour Scheme and Patterns	Appropriate colours which would also fit a black/white chart.	3
5	2-Axis covering full range of data values	The axis represents the information adequately.	3
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

### Graph 10: Where do some greenhouse gases come from?

This is an infographic that represents the contribution of different sectors to greenhouse gases emissions. The part-to-whole relationships demonstrated by icons shows percentage contribution of each sector to the global quantities. The chart is part of a research carried out by the “carbon neutrality initiative” of the University of California.

The general public is the audience for the research and publicly available on the initiative’s website as shown via the URL below.

<https://www.universityofcalifornia.edu/longform/where-do-greenhouse-gas-emissions-come>



### Evaluation

SN	Criteria	Evaluation	Rating (0-3)
1	Appropriate Chart Type Used	The infographic was appropriate for the represented information	3
2	Key Findings Highlighted	Key findings were properly highlighted	3
3	Arrangement of Chart Elements (Eliminate clutters)	No clutters	3
4	Colour Scheme and Patterns	Good use of colours	3
5	2-Axis covering full range of data values	The axis represents the information adequately.	3
6	Ethical Data Representation	Data was not misrepresented and does not mislead the audience	3

### Summary

Based on the evaluated charts and graphs in this report, the quality criteria compiled has been effective in improving non-verbal communication using charts and graphs. It can be concluded that with these criteria, the aim of every chart or graphical representation of information - the key takeaways - are not missed by the intended audience.

One learning point is that there is a story behind every chart, which can be easily missed by the intended audience who are exposed to large amounts of information. However, if these criteria are followed strictly, then charts and graphs would be an effective communication medium, and not one to mislead or cause misunderstanding.

All criteria represented here would be applied to the climate change project in element 2, as these are the very basic quality metrics that make charts good communication methods across all backgrounds.

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