USING VISUAL TOOLS AND SPATIAL INFORMATION TO SUPPORT DECISIONS FOR REDD+ IMPLEMENTATION

# HOW TO PRESENT COMPLEX DATA ON A MAP AND OTHER VISUALS FOR EFFECTIVE POLICY COMMUNICATION

UN-REDD PROGRAMME

The UN-REDD Programme is the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

The UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) is a global Centre of excellence on biodiversity. The Centre operates as a collaboration between the UN Environment Programme and the UK-registered charity WCMC. Together we are confronting the global crisis facing nature.

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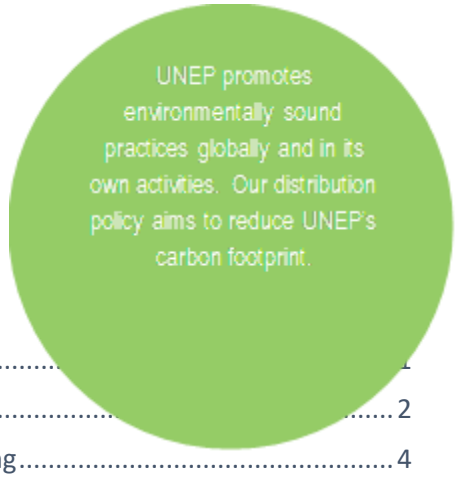
We welcome comments on any errors or issues. Should readers wish to comment on this document, they are encouraged to get in touch via: ccb@unep-wcmc.org.

**Citation:** Ravilious, C., de Lamo, X., Juffe Bignoli, D., Salvaterra, T., McDermott Long, O., Arnell, A., Gosling, J. and Miles, L. (2020) How to Present Complex Data on Maps and other Visuals for Effective Policy Communication: Using visual tools and spatial information to support decisions for REDD+ implementation. Prepared on behalf of the UN-REDD Programme. UN Environment Programme World Conservation Monitoring Centre, Cambridge, UK.

**Acknowledgements:** These training materials have been produced with additional support and materials developed by UNEP-WCMC's data management group, and build on our experience in working with UN-REDD Programme collaborators from numerous developing countries. Diego Juffe Bignoli acknowledges funding from the UK Research and Innovation 's Global Challenges Research Fund (UKRI GCRF) through the Development Corridors Partnership project (project no. ES/P011500/1).

UN environment programme WCMC




## Contents

## 1. Introduction

Spatial analysis has become a key tool to inform area-based planning and decision-making, such as national REDD+ planning. This is not a new phenomenon. Humans have used spatial information, summarised in maps, to make decisions for centuries (see Box 1). What has changed in the past decades is the coming of the digital era and an explosion of technical innovations in digital spatial mapping, analyses and communication. The capacity of spatial analysis to investigate and visualize spatial patterns makes it an extremely useful tool to inform decision-making processes related to the use of land or sea. Geographic Information Science (GIS) offers the possibility to create, manipulate, analyse and present spatial datasets to help identify suitable locations for specific interventions, based on spatial variation in combinations of relevant factors.

The results of spatial analysis are often displayed through 'thematic maps', this is, special purpose maps that, as opposed to general reference maps, display a single theme of information (Field, 2018). Maps are useful tools for effective sharing of findings, at their best summarising a large amount of information in a small space and with a high visual impact. Well-designed maps can convey spatial information and findings that are difficult to express verbally in a way that is accessible to policy makers and a wide range of other stakeholders. Despite their many advantages, maps should be used

**Box 1- Mapping cholera in the 19th century**

Dr. John Snow's map of cholera outbreaks from nineteenth century London is a classic example of the power and usefulness of maps to understand and communicate spatially explicit phenomena. The map, which overlaid the locations of all community water pump wells in Soho on a map (circled in red) on which he had marked the deaths from cholera (each death represented by a black bar), helped not only to locate the source of the outbreak (a pump in London's Broad Street) but also contributed to the scientific discovery that cholera was carried by water.


Source: The John Snow Society

together with – not in lieu of – other communication approaches including documents, discussions, tables and graphs. Different individuals are better able to absorb information presented in different ways.

Poorly considered maps can create biased messages and restrict a user's ability to scrutinise the underlying data and processing. Thematic maps should be designed and produced as a part of a wider analytical and cartographic process. The analytical process involves both the collection of data to be included in the analysis, and the design and implementation of the analytical workflow to produce the output needed. The cartographic process involves the decisions taken by the map maker to present the analytical results in the most effective way. This includes decisions on whether to include or omit information, and how to combine and symbolise it.

Some authors have summarized the map creation process in 3 major steps:

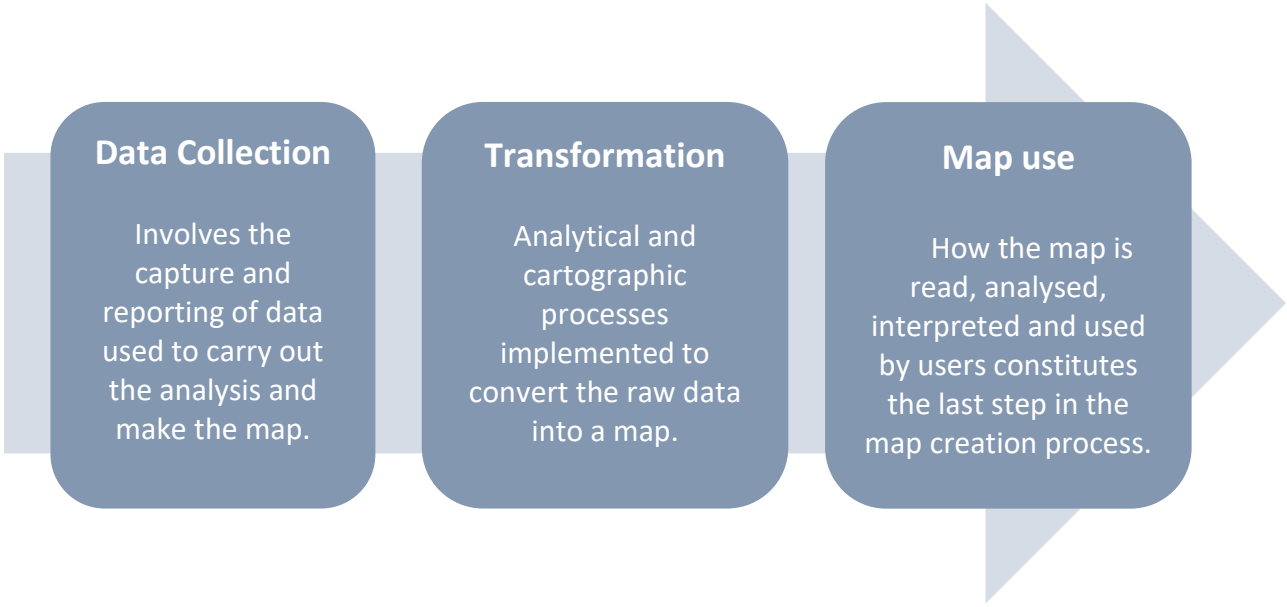



**Figure 1.** Map creation process, adapted from Field (2018).

Each of these steps can introduce error, bias and uncertainty into the final map. The role of the map maker is to make the most appropriate decisions to minimize bias so that the final map can effectively inform decision-making processes.

### 1.1 Purpose of this guidance document

Maps can support REDD+ planning by identifying suitable areas for REDD+ strategy options that lead to reduced emissions or increased sequestration, in a way that delivers selected co-benefits. This guidance document focuses on the production of maps for clear policy communication using examples of maps produced under the UN-REDD Programme in different countries. It provides guidance on techniques for visualising complex data, when and how to use different classification methods, the use of insets, colour-blind safe palettes and advice on the use of different map projections. Furthermore, it describes ways in which bias can be introduced and avoided. Several checklists are provided to help with map design and quality control, for example highlighting important elements that should be included on a map and other elements that should checked before a map is signed off

and published. These simple quality control checks are intended to ensure that the maps produced meet a required standard and are fit for purpose (see Annexes).

This document accompanies a series of tutorials which have been used to build capacity in a number of countries to produce datasets and maps relevant to their spatial planning for REDD+, and to develop such map products (see bit.ly/gistools-redd). Maps developed using these approaches appear in a number of publications whose aim is to support planning of strategy options that enhance biodiversity and ecosystem services as well as delivering climate change mitigation (see http://bit.ly/mbs-redd for country materials). Please note that the approaches described in these tutorials or this guidance document are offered for use on a voluntary basis and are not requirements of the UN-REDD Programme.

## 2. A framework to develop maps to support decision making

As mentioned in the prior section, maps are the end result of a multistage process. This section guides you though the key issues that should be considered to ensure that a map is effective at communicating information to support decision-making.

### 2.1. How can maps influence decision making?

A map or series of maps can be an effective way to present information, particularly if the geographic nature of the data is key for getting a message across to the target audience. A map should be unambiguous and understandable by a non-expert audience, although the complexity of the map may depend on who it is targeted at. **The reader should not have to ponder over the map for longer than a few minutes to understand what it is trying to say - the message of the map should be clear from the outset.** This is essential for decision makers who have limited time to digest complex information. Too much information on a single map may obscure the message, whilst too little may not provide enough detail to the reader. There is a skill in deciding what information to include and what to omit to make it a clear and effective communication tool (see Box 2).

Anyone making a map for decision making is responsible for both dealing with the underlying data and deciding how to present it. Many choices have to be made, from how to process and simplify the data (e.g. through grouping data to show trends and patterns), to choosing which symbols, colours and depths of colour are used to map different aspects. Based on these choices, **two maps using entirely the same data could present totally different messages.** How the map is perceived may influence decisions differently. Consider Figure 2 for example. Understanding the distribution of a country's natural forests is important in the REDD+ planning process. The UNFCCC Conference of Parties in 2010 state that REDD+ actions should be: "consistent with the conservation of natural forests and biological diversity, ensuring that [REDD+] actions (...) are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits". Figure 2 illustrates how the precise biophysical definition of forest used in an analysis can have very different implications for the area to which the safeguard applies (Runsten et al., 2013).

Choices on how to present data can also introduce an element of bias in a map, especially as the data presented are often simpler than the raw data used to create the map, e.g. when continuous data are summarised into classes. Intentional or unintentional bias can result in a misleading map or provide a false representation of the data or subject being mapped (Axis Maps, 2017). **In a decision-making environment, clear and accurate presentation of materials is essential, and maps must provide a valid, unbiased representation of the data**. Data should not be modified to fit a particular agenda. One way to improve transparency is to provide a visual methodology or workflow (Figure 3). The reader can quickly see how that map was derived by looking at the smaller input maps on the right hand of the layout (note how choices made on the natural forest definitions in Figure 2 will also influence the output produced in this analysis).

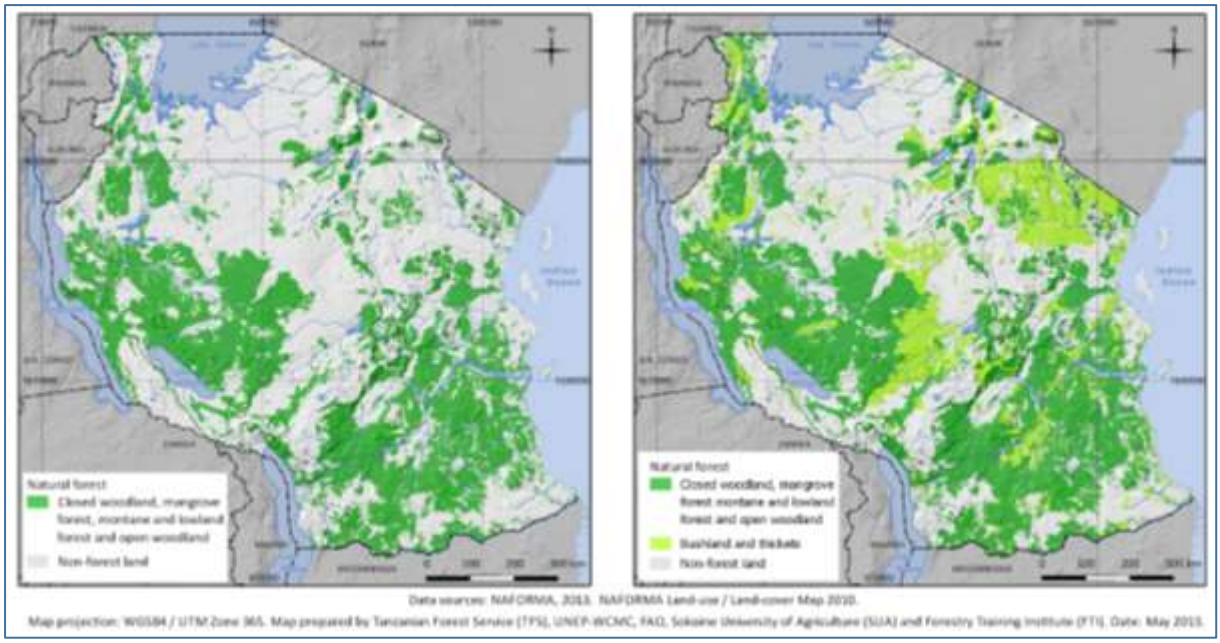



**Figure 2:** Example maps showing how different filtering on data can result in different outcomes. In this example, different distribution of natural forest depending upon which definition is used. The map on the left assumes a forest definition with 5m tree height and include montane and lowland forest, open and closed woodlands, and mangroves, but excludes thickets and bushlands. The map on the right assumes a forest definition with 2m tree height and includes thickets and bushlands in addition to the other forest types (Runsten et al., 2013).

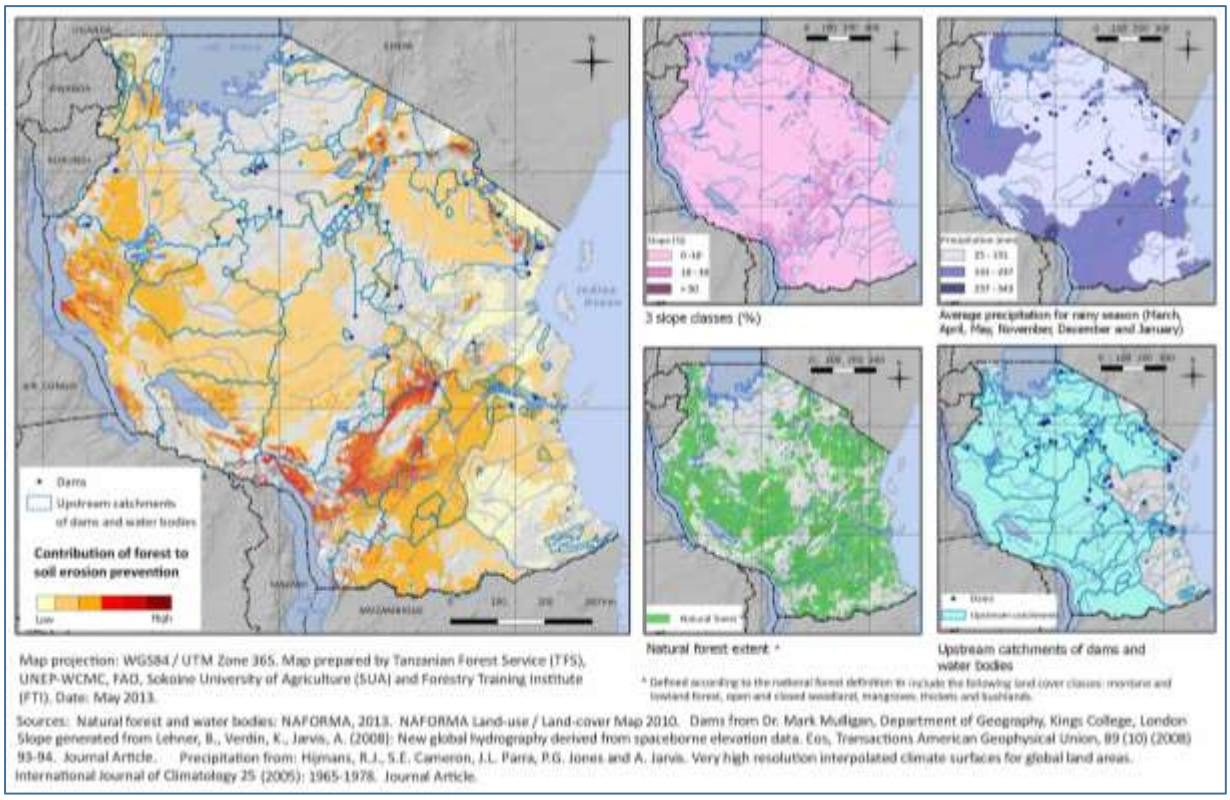
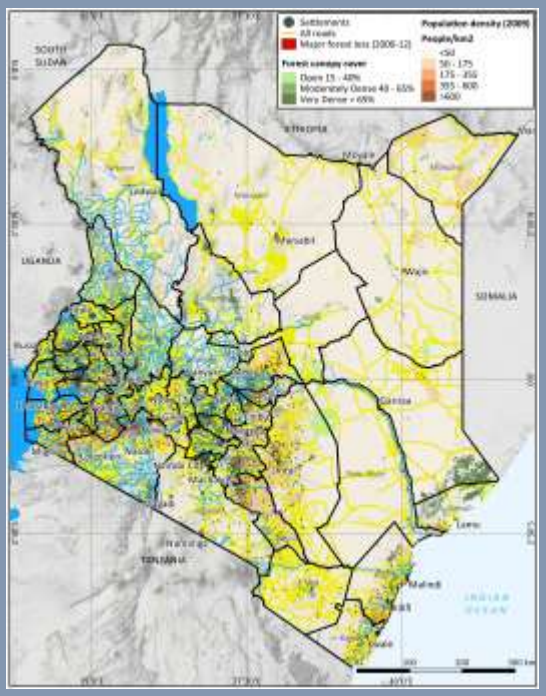


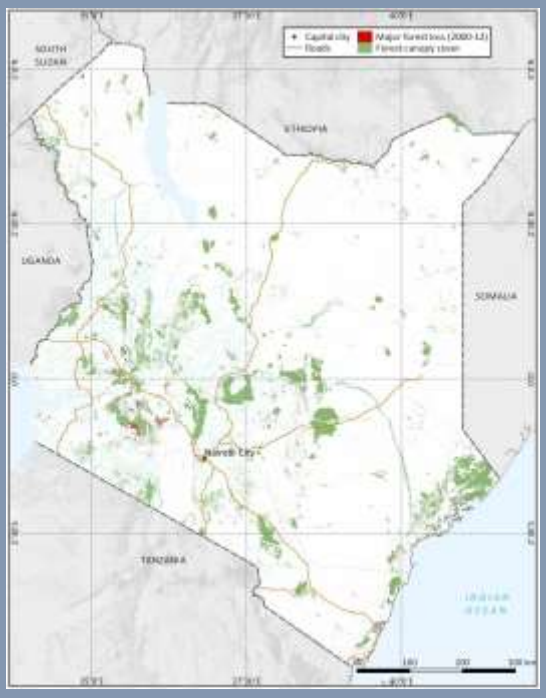

**Figure 3:** Example map showing where forests are particularly important for limiting soil erosion that might cause sedimentation problems for dams in Tanzania (above left). Methodology based on four parameters shown in the smaller maps on the right: Slope, precipitation, natural forest and catchments of dams (Source: Runsten et al., 2013).

## Box 2: What is the right amount of information on a map?

Given the question "How do infrastructure and settlements relate spatially to forest extent and recent deforestation?", which map would provide a decision maker with an understanding of the human pressures on forests and the potential drivers of change?

Map (a) below, contains all the relevant data layers but looks very cluttered and dominated by heavy use of symbols and colour. The legend provides information on the data layers presented, but the map is overpowered by the yellow road lines obscure most of the other data. There is too much information on the map for the reader to understand what the map is trying to show.



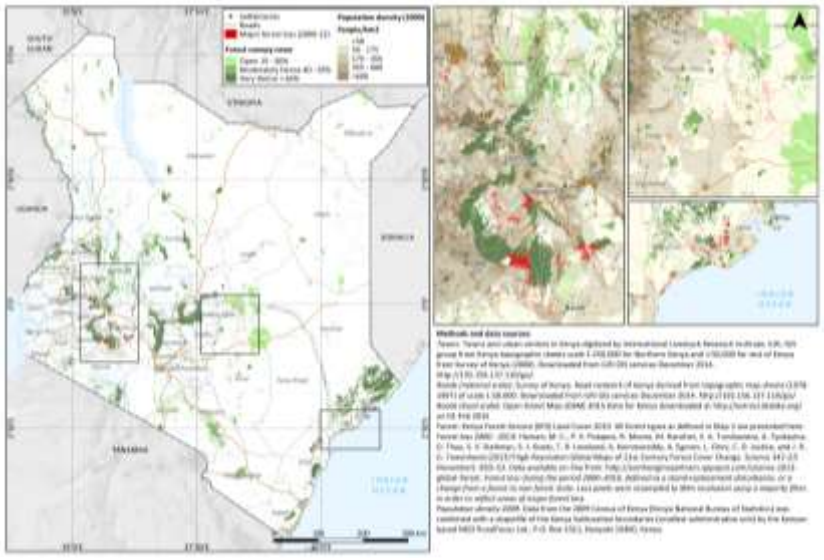


Map (b) above, provides more visual clarity by softening the colours, but by omitting some key information, the message of the map is again lost.

Map (c) below also omits information from the main map but the clever use of insets draws the reader's attention to key areas. This highlights the relationship between deforestation and population pressure and infrastructure. A clear title and a further descriptive caption enable the reader more quickly understand the map. Importantly, data sources are provided to clearly show what data was used to create the map.

**How do infrastructure and settlements relate spatially to forest extent and recent deforestation?**

These maps show forest extent together with three strong predictors of deforestation: recent deforestation, population density and infrastructure. Population density is an indirect driver that exerts pressure in different ways, while infrastructure development can be both a direct and indirect driver. Past deforestation has been shown to be strongly correlated with future deforestation.



## 2.2. When should a map be chosen as a visualisation technique?

Maps can be simple or complex and are often the favoured visualisation technique for geographical data. However, before deciding to go down a mapping route it is worth considering whether a map will be the most effective way to represent your data for your purpose and your target audience. **Data should not be mapped just because 'it can', as another visualisation technique such as a graph or table may be equally good and sometimes more effective** (Axis Maps, 2017).

**Maps** are indeed better than tables and graphs for some purposes:-

- They are spatially informative
  - Provide context of place, the distribution of values across space (i.e. representing the real world)
  - show how thing relate to each other spatially
  - show precise boundaries
  - can show spatial overlaps between different variables
  - enable visualisation of detailed spatial patterns across a landscape
- represent scale in terms of distance and area
- provide static or interactive environments to show place
- can present spatial temporal data (i.e. map data over time and space)

However, a map is not the only means of visualising spatial data. In many cases a map might be supported and or enforced by other visualisation methods and combining them is often the best option to effectively reach, inform and influence your audience.

### 2.2.1. Use of other visualisation methods to present spatial data

When deciding on a visualisation technique for spatial data, think about the following four questions:

1) **Who is it for?** (your audience may be more receptive to certain types of visualisation)
2) **What do you want to accomplish, what is the purpose?**
3) **Can the data be represented in other ways more or as effectively as a map?**
4) **What is the delivery method?** (e.g. paper, presentation, pdf, website)

Before going into greater depth on the use of maps for effective communication, we briefly touch on the use of other presentation methods such as tables, charts and graphs (e.g. pie charts, bar graphs, histograms, line graphs) to represent spatial data.

There is no definitive rule for choosing a visualisation method but some key considerations are the type of information you aim to present and how quickly the reader can interpret and process that information. Use of pre-attentive attributes (such as shading a table or boldening of text) can quickly focus a reader's attention (Knaflic, 2015).

> "If we use pre-attentive attributes strategically, they can help us **enable our audience to see what we want them to see** before they even know they're seeing it" (Knaflic, 2015)

When thinking about data with a spatial element, ask whether mapping the data will add any value to the reader, i.e. does the reader need to understand the distribution of features in space? Is a map necessary, for example, when all you want to do is convey the magnitude of a variable? Figure 4 simply and clearly demonstrates the size of estimated peatland carbon stocks in the Congo compared to the whole of the tropics and of the world.

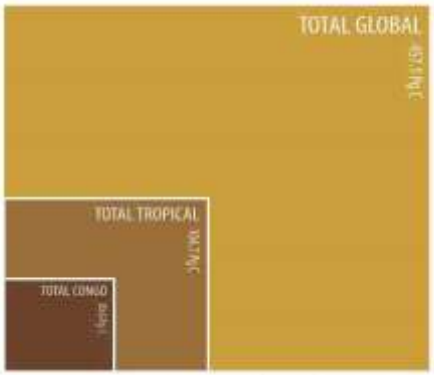



**Figure 4:** Soil organic carbon stocks estimates in Central Congo Basin, Tropical and Global Peatlands (source: Miles et al., 2017)

Tables and graphs can provide a useful way of presenting and visualising trends and patterns in data. They can be ideal for presenting both summary information or statistics generated from spatial data analysis. They can complement more detailed spatial patterns presented in a map, for example, comparing mean values between regions, using boundaries that are meaningful to the audience.

**Formatting is key to presenting data in a digestible form and how quickly the reader can understand its messages.** Figure 5 presents two tabular visualisations of data on biomass carbon and species richness. Figure 5 (b) is formatted to help the reader understand the data quickly, with region 2 immediately standing out as a small region with very high biomass carbon and species richness.

(a)

| | Area (ha) | Mean above and below-ground biomass carbon (tonnes/ha) | Mean Species Richness |
|---|---|---|---|
| Region 1 | 187200 | 100 | 416 |
| Region 2 | 125 | 400 | 386 |
| Region 3 | 10870 | 37 | 357 |
| Region 4 | 101300 | 15 | 126 |
| Region 5 | 33090 | 3 | 63 |
| Region 6 | 198100 | 155 | 51 |
| Region 7 | 7691 | 13 | 175 |
| Region 8 | 68460 | 3 | 65 |
| Region 9 | 187900 | 18 | 216 |
| Region 10 | 118600 | 27 | 286 |

(b)

| | Area (ha) | Mean above and below-ground biomass carbon (tonnes/ha) | Mean Species Richness |
|---|---|---|---|
| Region 1 | 187,200 | 100 | 416 |
| Region 2 | 125 | 400 | 386 |
| Region 3 | 10,870 | 37 | 357 |
| Region 4 | 101,300 | 15 | 126 |
| Region 5 | 33,090 | 3 | 63 |
| Region 6 | 198,100 | 155 | 51 |
| Region 7 | 7,691 | 13 | 175 |
| Region 8 | 68,460 | 3 | 65 |
| Region 9 | 187,900 | 18 | 216 |
| Region 10 | 118,600 | 27 | 286 |

**Figure 5:** Two ways to present the same tabular data. Table (b) makes it much easier for the reader to understand the data and quickly visualise the patterns of biomass carbon and species richness.

Figure 6 illustrates the use of graphs to visualise spatial data. In this example, projected increases and decreases of different land-use types are displayed, distributed across different ecoregions in Cameroon. The advantage of presenting summary data in this way rather than on a map is that amounts of increase and decrease can be clearly visualised. Patterns in the data can be seen, for example highlighting that agriculture is the main driver of land use change for most of the ecoregions, but in the mangrove forests of Central Africa and the Cross-Sanaga-Bioko coastal forests, degradation is also very important. This insight may be more difficult to derive from a map, particularly if changes are scattered across the ecoregion.

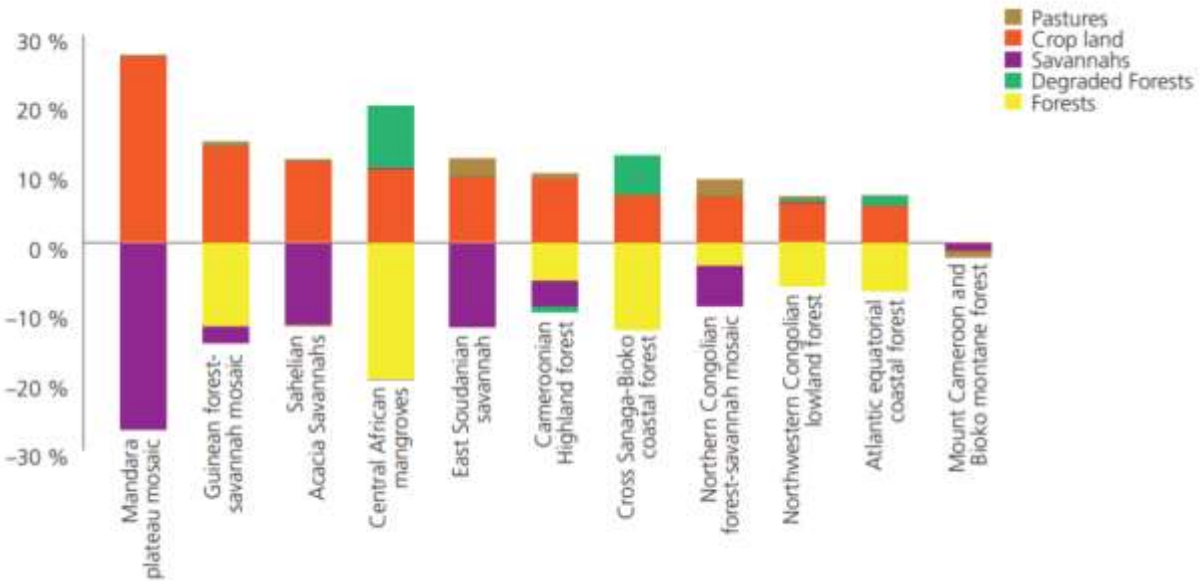
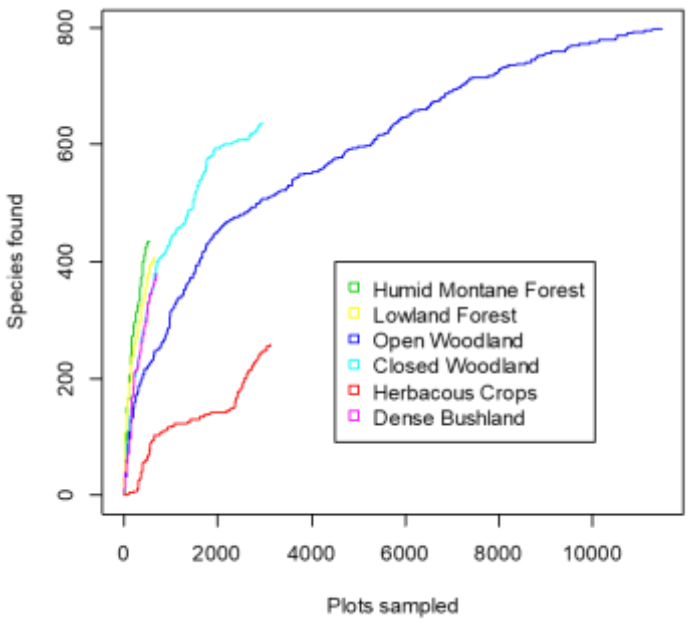



**Figure 6:** Modelled land use changes over the period 2010-2030 in the ecoregions of Cameroon (source: Mosnier et al. 2016)

Sometimes it is necessary to gain a better understanding of data before deciding on how and if to map it. Statistical analysis can be used to present data on *x*- and *y*-axes to investigate an association between two variables. When analysts wanted to find out if it were possible to generate a wall-to-wall map of tree species richness from the National Forest Resources Monitoring and Assessment (NAFORMA) of Tanzania, species accumulation plots were developed to test how well this extensive survey had captured tree species richness in different types of vegetation. The results showed that the total number of species recorded in a vegetation type increased with the number of plots surveyed for that vegetation type (Figure 7(a) and that for all vegetation types, additional species continued to be found in new plots. As the NAFORMA sampling was insufficient to record total species richness, it would not have made sense to use these data alone to develop a wall-to-wall map of tree species richness.

**Figure 7: (a)** Cumulative number of species found in selected vegetation types as more plots were sampled. If this curve flattened out it would indicate that the survey has recorded most of the richness in that vegetation type. As the figure shows, the curve of the humid montane forest is the steepest, showing that if more plots were sampled, many more species would have been found (source: Runsten, et al., 2013).



These are just a few examples to show that graphs and tables can be as useful as maps for visualising data with geospatial content.

Consider using **tables**: -

- for presenting data in a simple format where a graph or map add little extra value
- where reference to precise values is required e.g. raw data values
- where the information has been also presented in an associated map or graph to provide additional clarity
- for summary sets of values, particularly where there may be several variables to present across a summary unit. e.g. summaries by country or administrative units (as in the example present in Figure 5)

and consider using **charts and graphs** for: -

- visualising how different variables vary or relate to each other.
- visualising large volumes of data to quickly and easily show trends and patterns
- understanding distribution of values which can in turn help to correctly classify and map data to show trends and patterns
- validation of data prior to processing it for inclusion in a map or spatial analysis.

There are many different types of charts and graphs and it can be difficult to select the most appropriate one for your data. Figure 9 provides a flowchart for guiding appropriate selection of common graphs and charts. Some general **good design practice** for graphs includes:

- Avoiding too many colours
- Avoiding clutter - only present the data you need to illustrate - remembering less is more
- Using colour to highlight specific points
- Using contrasting colours for greater clarity or varying colours or saturation.
- Removing distracting chart elements e.g. grids
- Using clear and simple legends that enable that help user quickly understand the data and overall trend.
- Clearly labelling your axes
- Always presenting a clear title to enable the reader to understand what they are evaluating.

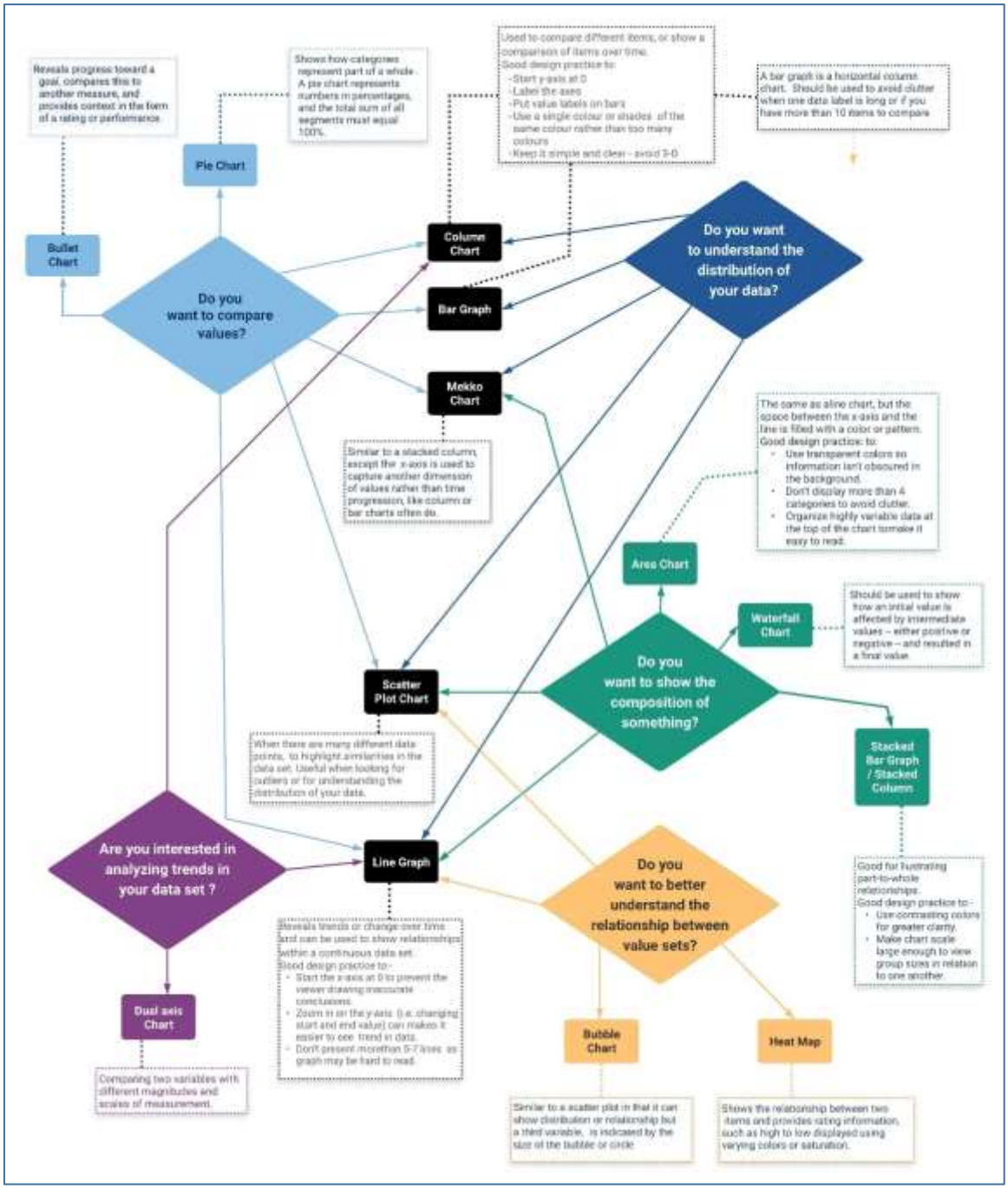



**Figure 9:** Flowchart guiding selection of common graphs and charts for presenting data (adapted from Oetting (2020) and Krystian (2016)).

**Additional resources:**

http://www.storytellingwithdata.com/blog/2011/11/visual-battle-table-vs-graph

https://gss.civilservice.gov.uk/wp-content/uploads/2017/01/GUIDANCE-document-Effective-charts-and-tables-in-official-statistics-Version-2.0-Jan2017.pdf

https://trumpexcel.com/learn-excel/

https://infogram.com/blog/dataviz-chart-guide-101-dos-and-donts/

https://blog.hubspot.com/marketing/types-of-graphs-for-data-visualization

## 2.3. What type of map is required: static vs interactive maps?

The general principle when creating any map is to aim for clarity, ensuring that the map is relevant, does not misrepresent data and is designed appropriately for the target audience. Maps can broadly be grouped based into interactive and static types. Costs for data analysis and development of datasets in both categories will be similar but costs for the development of the static or interactive maps will vary depend both on the complexity of the maps and level of interactivity required. Generally speaking, interactive map can be more time consuming and therefore expensive to create than a static map. However, it can be much more effective in attracting the target audience and achieving the intended impact.

There are additional tools called story maps, which are online blogs or web pages that combine spatial data and media to convey a story in a compelling and engaging way. They usually combine interactive or static maps with text, photos and video, allowing to showcase a piece of work, for example communicating the outcomes of research or a report, in a more engaging way.

In the context of REDD+ planning, maps can quickly help visually convey a message or highlight an area of importance to different stakeholders during various decision-making phases, at national or sub-national level scale. For example, maps can help these actors to understand the relationships between carbon stocks, ecosystem services, biodiversity, social and economic factors and land-use and pressures on natural resources. Maps can support countries to identify and locate REDD+ policies and actions, as well as where actions can be planned to secure additional social and environmental benefits. This is likely to involve understanding the main drivers of deforestation and forest degradation and their distribution and the barriers to forest conservation, enhancement of forest carbon stocks and sustainable management of forests, as well as the likely impacts of specific REDD+ interventions on carbon and non-carbon benefits and how this varies through space. The type of maps required will vary depending on the stage in the planning process (Figure 10), the purpose of the map(s), and resources available. Precise requirements will also vary between countries, and both static and interactive maps can be used for different purposes (see Box 3).

A set of questions designed to help identify what type of output and where and when different types of map might be required is presented in Annex 1.


**Figure 10:** Indicative steps used to develop spatial analysis for REDD+ decision-making (also available within the story map presented in section 3.3.)

## Box 3: Static vs Interactive maps

**With a static map,** what you see is what you get. A map in a document, poster or a stand-alone picture file can be either printed or viewed digitally but the content and extent cannot be queried or changed by the user. A simple static map might show the boundaries of projected areas whereas a more complex map might present the results of an analysis with multiple layers.

| Pros | Cons |
|---|---|
| • Users presented with clearly designed maps for a particular purpose<br>• Does not require any additional software to view outputs<br>• Simple format which can easily be embedded into reports and presentations either digitally or printed<br>• Can be less costly to produce than interactive maps. | • User cannot zoom into map to obtain more detail (beyond the resolution of the map)<br>• Cannot turn on and off data layers<br>• Underlying data has to be presented separately<br>• Cannot query data<br>• Maps are not automatically updated0 |

**Interactive maps** allow users to connect with the data. A simple interactive map may allow users to turn layers on and off and navigate around the map by panning or zooming in or out. More complex interfaces may allow users to change parameters and dynamically run simple analysis. Some even allow a user to upload their own data.

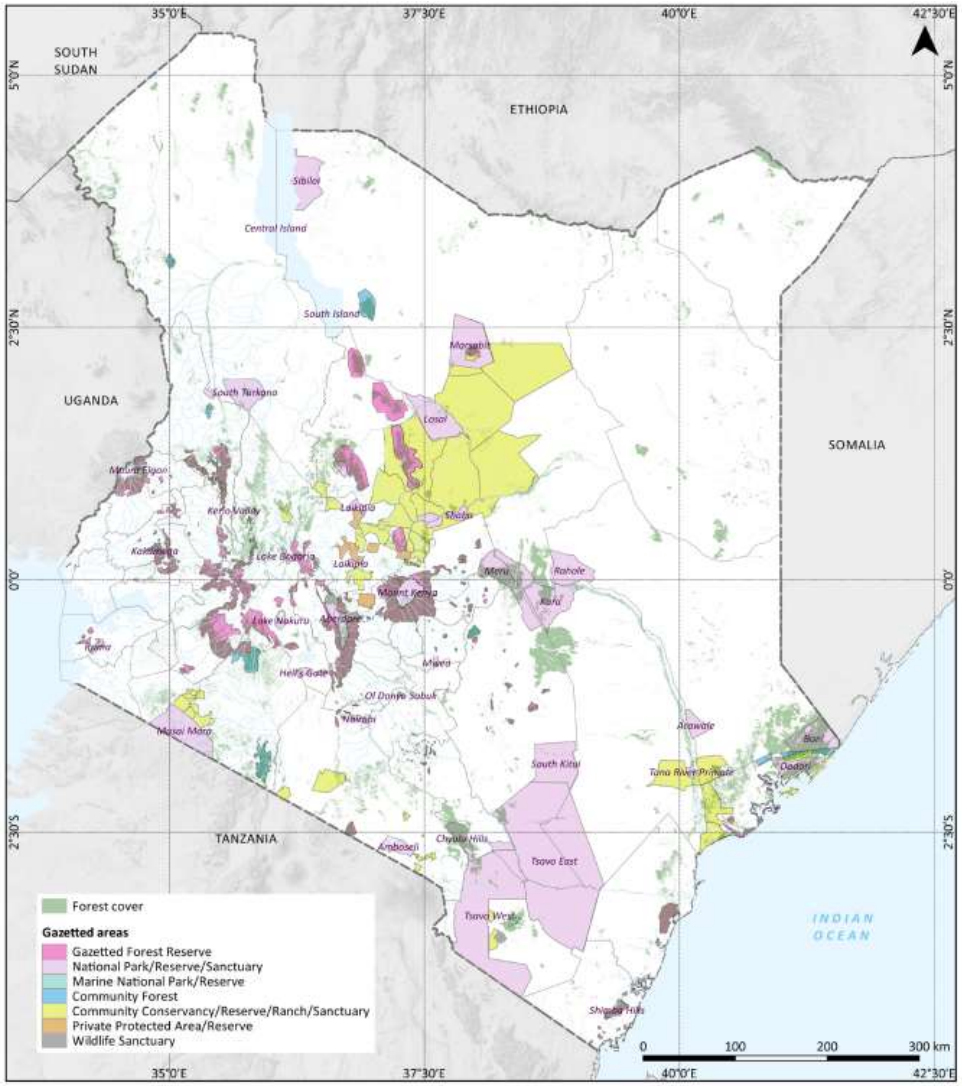
| Pros | Cons |
|---|---|
| • Can zoom in and query underlying data<br>• Users can explore options and scenarios<br>• Users can benefit from live data updates<br>• User can customise the maps and choose what information they want to view | • Usually requires internet connection to be viewed (not always)<br>• Requires mapping library or Application Programming Interface (API) to run<br>• Can be difficult to understand if not designed well<br>• Users may choose to ignore certain layers and introduce bias<br>• Can be more costly to produce than static maps as additional cost for development of a tool, user interface, and host data in servers. |

## 3. Example maps for effective policy communication

This section provides a few examples of different types of maps designed under the UN-REDD Programme which aim to provide effective policy communication.

### 3.1. Static maps

Static maps are often developed as part of the planning process. These can range from simple maps showing the spatial distribution of one or more factors to the results of more complex analysis. Figure 11 is a map developed as part of Kenya's REDD+ process. It simply shows the distribution of land management within the country. Its objective is to help to identify forests lacking protection, which may help to target appropriate interventions to areas under different forms of management.




**Methods and data sources:**
*Protected areas:* IUCN and UNEP-WCMC (2014), The World Database on Protected Areas (WDPA) [On-line]. Cambridge, UK: UNEP-WCMC. *Available at: www.protectedplanet.net Accessed 12/2014. Additional information from the Kenya Forest Service (KFS) was used to supplement this data. National parks and reserves are labeled on this map.*
*Forest:* Kenya Forest Service (2013) Report on National Forest Resource Mapping and Capacity Development for The Republic of Kenya. KFS; Nairobi, Kenya. Data created by the Kenya Forest Service in 2010. All forest types are represented in this map.

**Figure 11:** Map of Kenya identifying which forest land is under public, community and private management. The map shows forest inside and outside protected areas, as well as the management classification of Kenya's protected areas: public, community and private land (Source: Maukonen et al., 2016).

A more complex type of static map is a multivariate map (sometimes described as having a matrix legend). This style of static map shows two or more variables on an axis. Figure 12, a map developed as part of Panama's REDD + process, shows how the climate mitigation effect of conserving forests at risk depends on their carbon stocks. Areas of high biomass carbon that are also potentially at a high risk of deforestation are shown in dark brown (top right-hand corner of the legend). Areas at high risk of deforestation but which contain low carbon stock are shown in bright red (top left-hand corner of the legend) and areas of high carbon stocks with a low risk of deforestation are light brown (bottom right-hand corner of the legend. See Box 4 (section 4) to access a tutorial on producing a map with a matrix style legend.

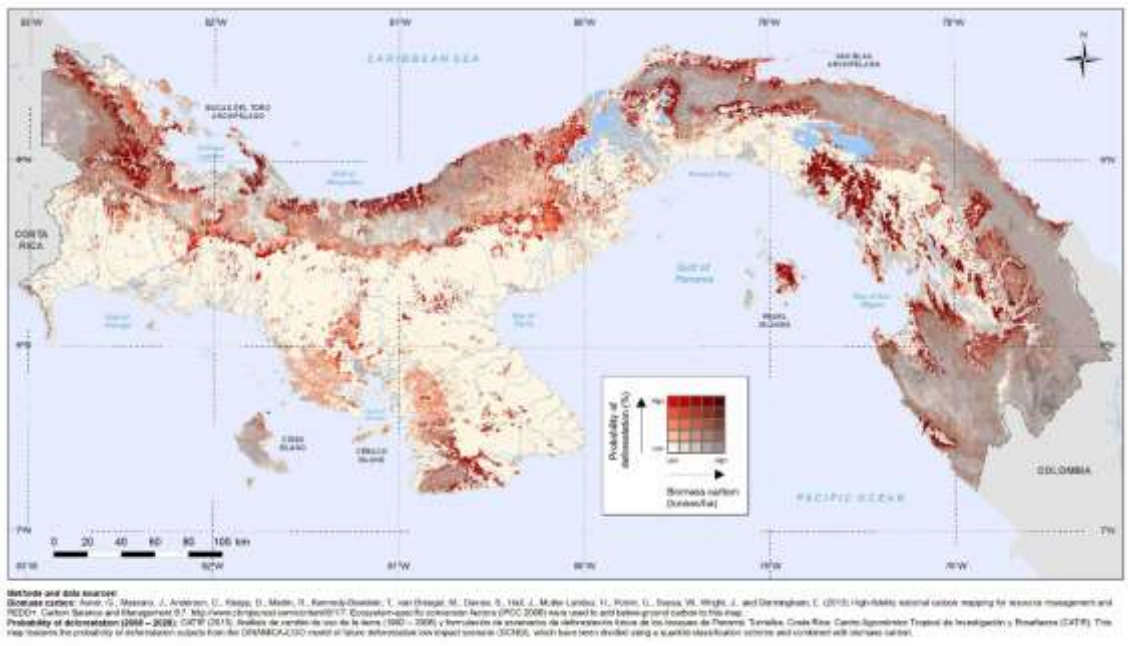
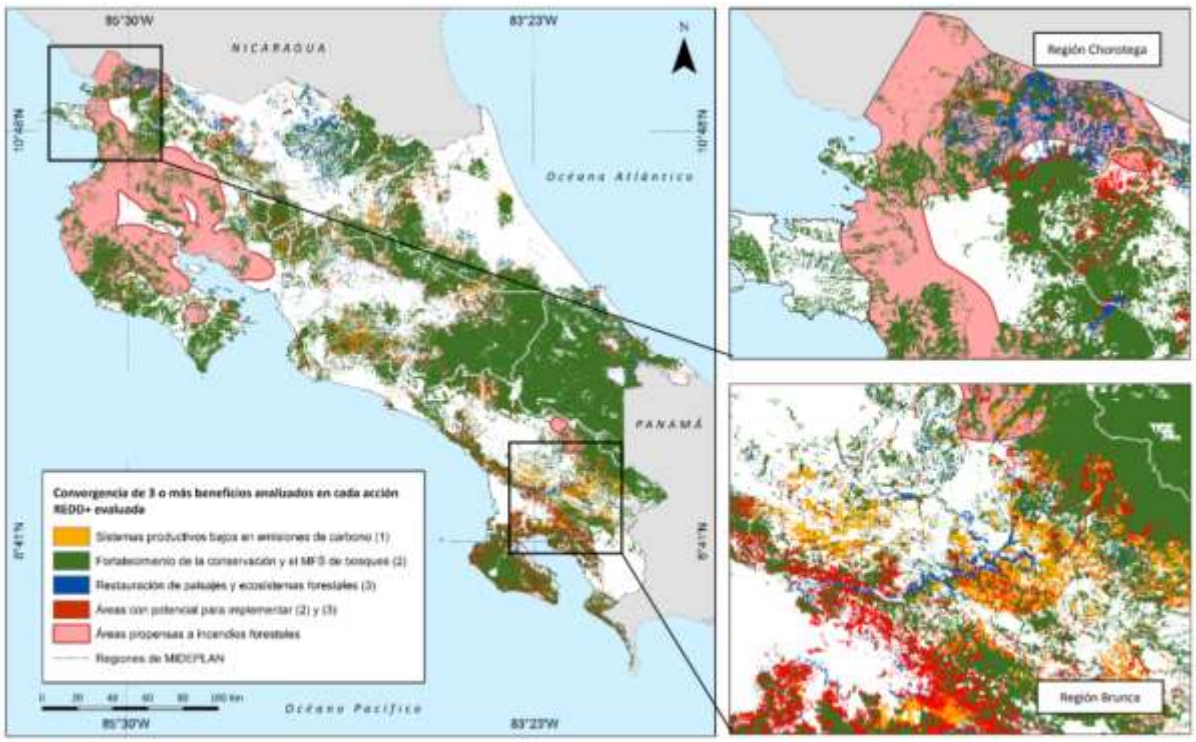



**Figure 12:** Example multivariate map (map with matrix style legend) showing where carbon stocks may be at risk by combining biomass carbon with the probability of future deforestation (Source: Kapos et al., 2015).

Static maps are often used to present summary results to policy makers. In Costa Rica for example, the Secretaría REDD+ - Costa Rica, together with National Forestry Financing Fund (FONAFIFO) and the UN-REDD Programme, carried out a series of spatial analyses evaluating the potential of four implementation options derived from its National REDD+ Strategy. This resulted in the presentation of five static maps for policy support. Figure 13 presents one of these final summary maps. The annexes of the final report for Costa Rica provide further information about the data and additional maps highlighting the input datasets that were used to derive the final policy maps.




[13] **Fuentes de datos: Sistemas productivos bajos en emisiones de carbono:** Elaboración propia mapa 1a. **Fortalecimiento de la conservación y el MFS de bosques:** Elaboración propia mapa 3a. **Restauración de paisajes y ecosistemas forestales:** Elaboración propia mapa 4. **Áreas con potencial para implementar 3 y/o 4:** Elaboración propia mapas 3a y 4. **Áreas propensas a incendios forestales:** Elaboración propia mapa 2. **Regiones de MIDEPLAN:** Ministerio de Planificación Nacional y Política Económica (2013).

**Figure 13:** Summary of areas with potential for the provision of multiple benefits, showcasing areas where the introduction of one or more REDD+ implementation options could strengthen the provision of three or more prioritised benefits in Costa Rica. (Source: García-Rangel et al., 2017[2])

## 3.2. Interactive maps

Dynamic maps in the form of a web-portal have been established for some UN-REDD countries, with a different objective to the static maps illustrated above. Although the portal can be used by policy makers, the main purpose of the portal is for disseminating forest and land use information to the public for ensuring the transparency of the REDD+ process within a county. Users can explore and overlay the spatial information within the portal to understand the complex land use of the country. See example for Papua New Guinea at [http://png-nfms.org/portal/.](http://png-nfms.org/portal/)

## 3.3. Story maps

Story maps are online blogs or web pages that combine spatial data and visual media to convey a story in a compelling and engaging way. They usually combine dynamic maps with text, photos and video, to communicate findings in a more engaging way.

Visual storytelling is easier to digest and can increase both knowledge retention and stakeholder engagement, as well as being effective at communicating results to a broader audience.

A number of different story map software tools are available, some of which require a subscription. A few common examples are:

- **Esri Storymaps** - platform that allows users to combine maps with narrative text, images and multimedia content. Free public account or subscription for advanced features. (https://storymaps-classic.arcgis.com/en/)
- **StoryMapJS** – Completely open source and similar to ESRI Storymaps allowing users to combine maps with other multimedia content. http://storymap.knightlab.com/
- **Shorthand -** visual storytelling platform. Subscription required (https://shorthand.com/)
- **Medium** - visual storytelling platform. Subscription required (https://medium.com/)

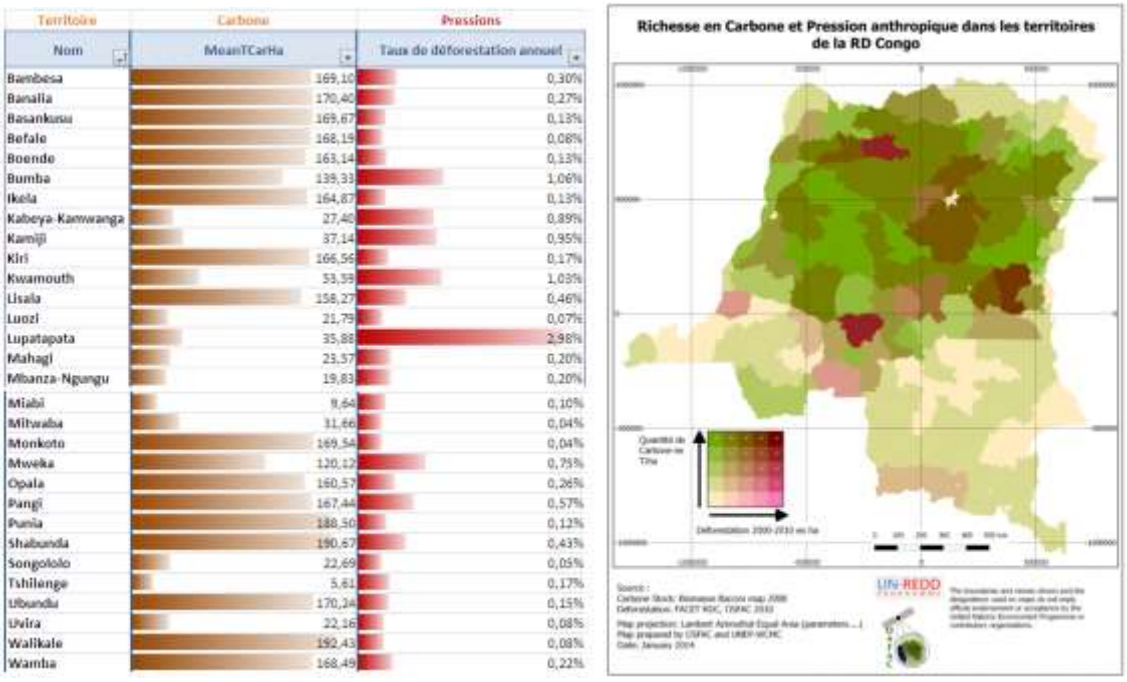
A story map using the Esri Storymaps platform was developed to communicate the work led by the UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) on planning for REDD+ beyond carbon. The UN-REDD Programme has supported over 20 developing countries to build capacity and analyze where REDD+ actions could result in non-carbon benefits. This has helped countries to better plan for and implement REDD+, and identify places suitable for a range of forest conservation, sustainable management or restoration actions. The story map can be accessed at bit.ly/planningbeyondcarbon.

## 3.4. Flexible Tool

Maps, tables and graphs used together can form powerful and complementary visualisation tools. In the Democratic Republic of the Congo (DRC), one approach to inform the national REDD+ framework strategy, especially with regard to investment decisions, was to develop a flexible Excel-based tool presenting the results of REDD+ multiple benefits analysis (Figure 14). This flexible tool contained static maps, graphs and tables to allow policy makers to explore the results of spatial analysis in a simple but interactive way. Values could be displayed for each administrative territory, and maps allowed visual assessment of the spatial variation of one or more values across the country. The use of colour bars rather than just presenting the raw data values helped to visualise the data.

The tool aimed to help policy makers to select priority territories based on a number of benefits and potential risks. Different filters could be used to find potential priority territories suitable for specific REDD + actions or those with high susceptibility to deforestation or forest degradation.

(a)




(b)

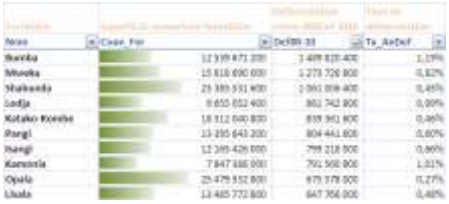


**Figure 14**: Example output from the flexible tool : (a) Combination of carbon and deforestation variables and (b) Comparison of 10 territories most exposed to deforestation (Bodin and Goodman, 2014)

## 3.5. Posters

Posters can make a quick and visual impact and if done well can make information accessible to stakeholders and decion makers. Figure 15 communicates the role of Cross River State's forests in supporting development and well-being and Figure 16 presents the results of spatial analysis in Mongolia, examining pressures on forests and forest values and where REDD+ actions could deliver the greatest potential benefits.

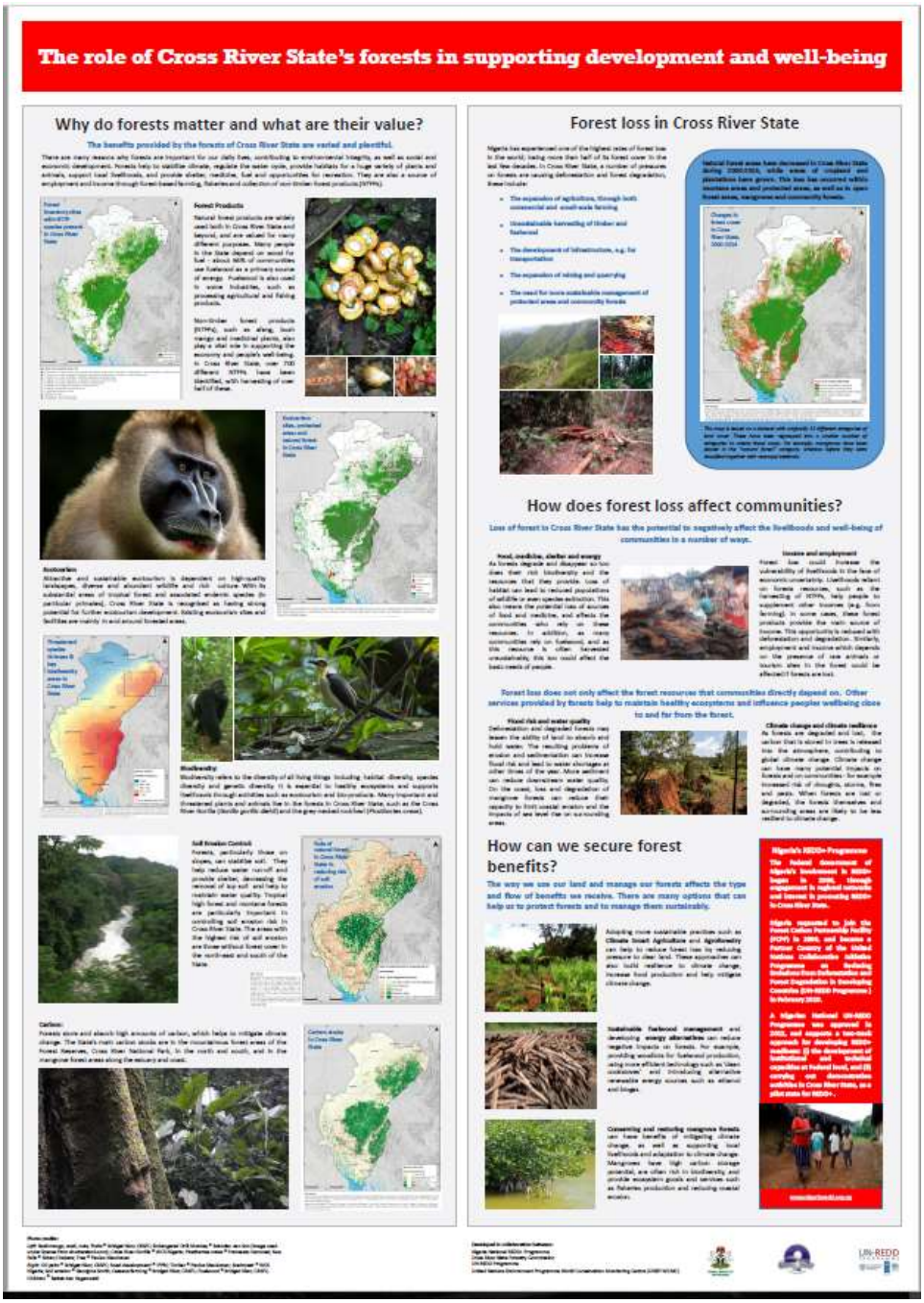



**Figure 15:** An example poster: the role of Cross River State's forests in Nigeria in supporting development and well-being (developed in collaboration between the Nigeria National REDD+ Programme, Cross River State Forestry Commission, UN-REDD Programme, United Nations Environment Programme World Conservation Monitoring Centre (Maukonen et al., 2017)

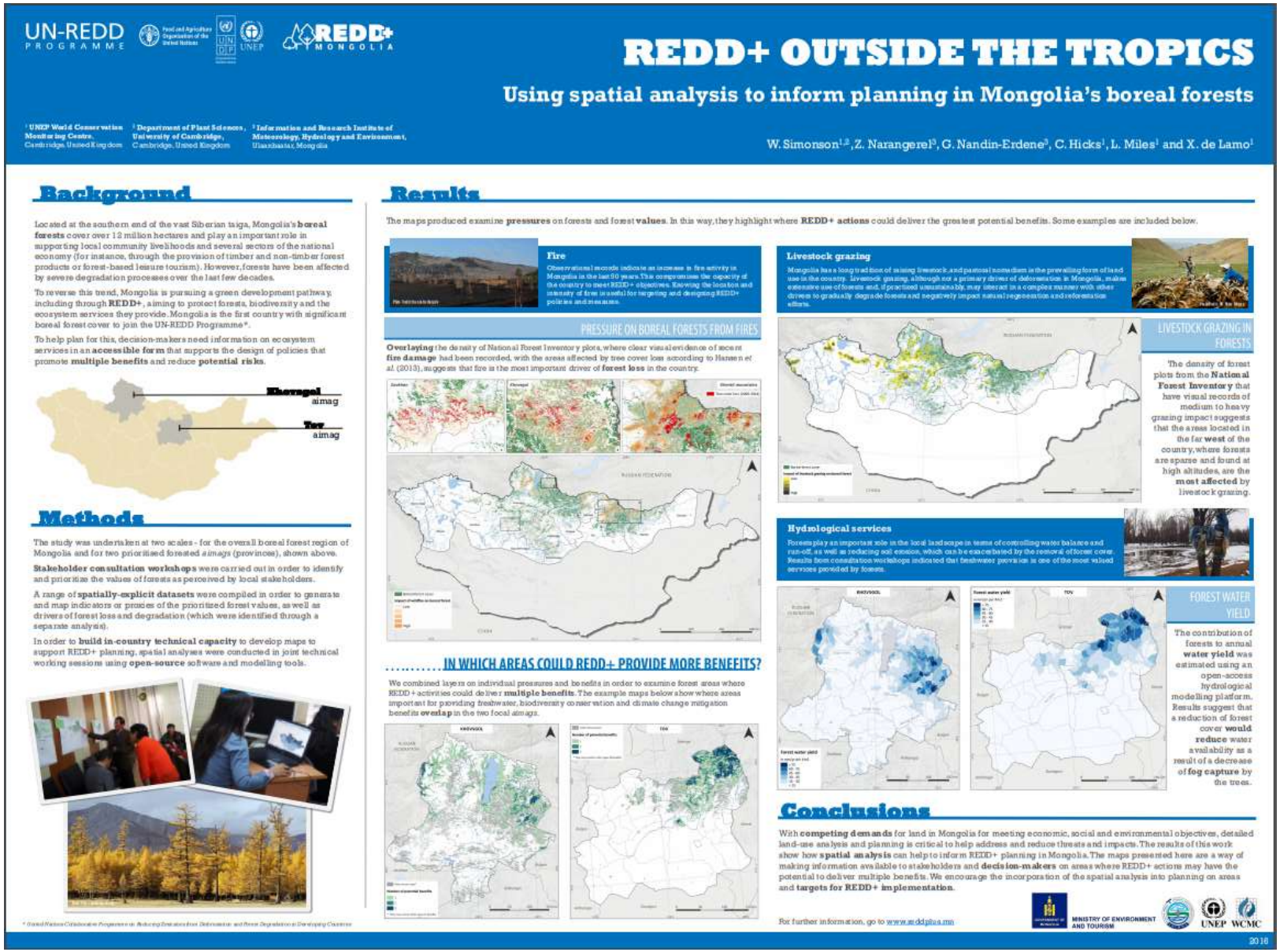



**Figure 16:** An example poster providing an additional communication tool to inform planning in Mongolia's boreal forests (Simonson et al, 2016).

# 4. Techniques and considerations for visualising data and map production

This section provides some guidance for presenting data on a map, beginning with some cartographic design principles that will help present data clearly and appropriately. In general, the following should be considered when preparing a map:

- Map projections and scale
- Data processing, generalisation and classification of data
- Making a map with appropriate data layers and a visual hierarchy
- Using colour and making maps colour-blind friendly

## 4.1. Map Projections and scale

Understanding map projections is fundamental to producing a good map and obtaining correct analysis results. In projecting the world from a sphere to a flat surface there is always going to be compromise as a sphere will not neatly open to fit onto a flat page. Figure 20 provides a useful illustration of how the globe can be mapped onto a 'developable surface' in the form of a geometrical object such as a cylinder, cone or plane. In the projection process there are standard lines which are tangential to the globe. In general, accuracy is greatest along these lines and is distorted the further you move away (Cairo, 2016).

There are **five properties that can be distorted,** shape, area, angle, distance and directions. Any projection **can respect one or two** of these properties but not more (regardless of projection).

- Conformal projections favour preserving shape over area (equivalence) therefore size is often distorted and vice Vera.
- In equal-area projections the further from the standard lines, the greater the distortion
- There are no projections that are conformal and equal area at same time
- Some projections are neither conformal nor equal-area (e.g. Robinson)
- Most projections distort distance but there are some that try to preserve it (e.g. equidistant projections)

(Cairo, 2016; Field, 2018)

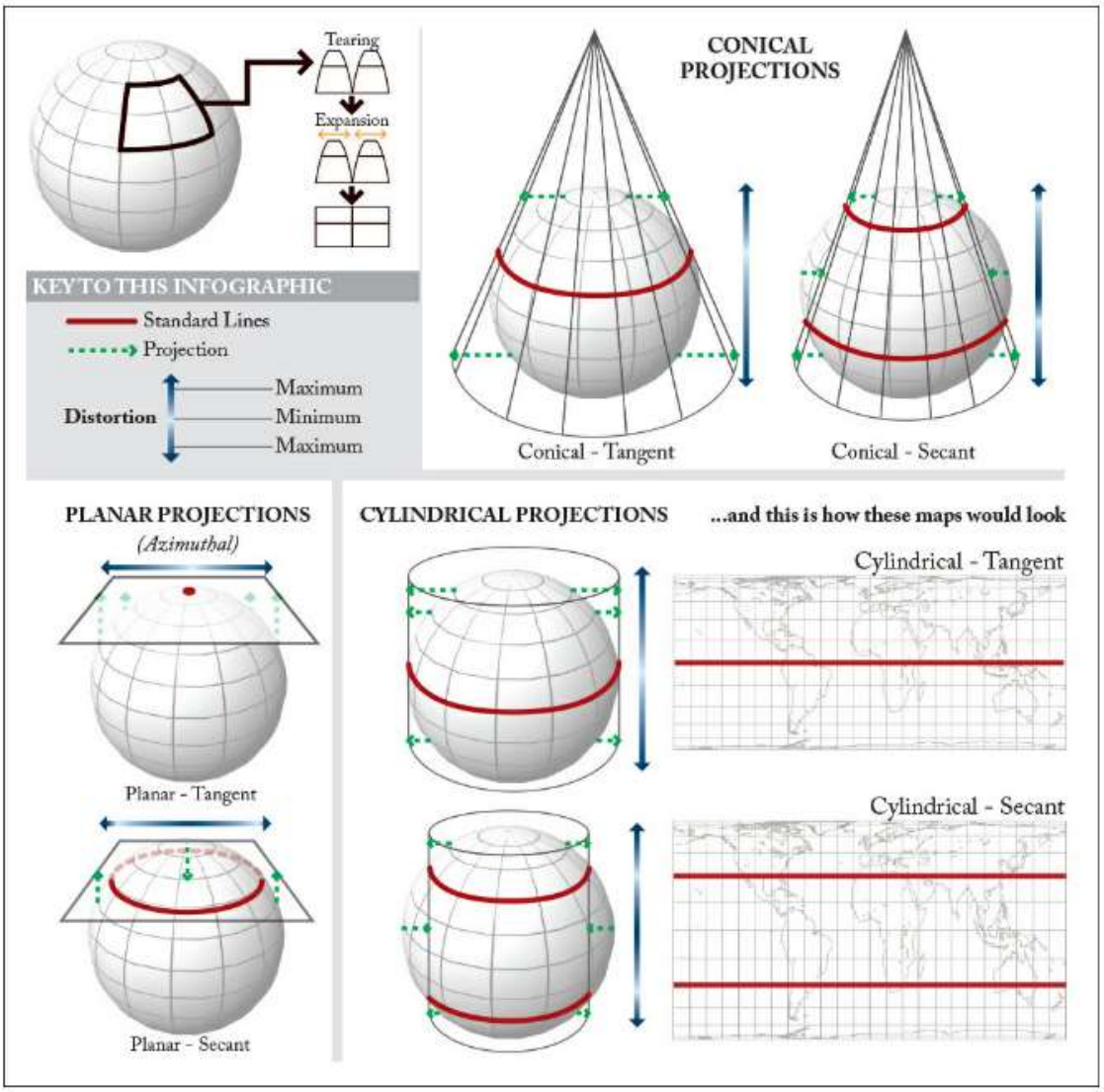



**Figure 20: How the most common map projections work (Source: Cairo, 2016)**

The purpose and scale of your map will often determine what projection to use. For example, for a global analysis calculating areas of forest you would need the data to be in a global equal area projection (e.g. Mollweide) for calculating the statistics but for displaying a global map you may choose Robinson or Winkel Tripel (which tries to minimise distortion of area, distance and direction).

Scale is important in all aspects of a mapping exercise, from the scale of the data, the scale of analysis to the scale of the mapped outputs. Scale is also often referred to as resolution, particularly when referring to raster datasets. Large scales show great detail and cover a small area e.g. site level or local scale mapping. Small scales cover a much larger area in less detail. I.e. the scale decreases going from local to national to regional and to global scale. The scale of a spatial analysis will usually be determined by the objectives (e.g. it might be contributing to National or subnational REDD+ planning) but it also might be influenced by the type and availability of data. For example, you may wish to run an analysis at 1km resolution (i.e. in a raster analysis with 1 x 1km pixels) but the data you can obtain is only at 10km resolution. Sometimes metadata accompanying a dataset will indicate any limitations relating to the scale for which the dataset is valid.

Scale is important in map projections and different projections are suitable for use at different scales. A global projection will always have more distortion associated with it than a projection suitable for national scale mapping. For example, areas generated from a global analysis using an equal area projection will not be as accurate as areas generated at national scale using a projection suitable for national scale mapping.

Countries often have a preferred national map projection and many use Universal Transverse Mercator. The problem with the latter is that whilst it is good at minimising distortion, countries often cross more than one UTM zone so it is not convenient for analysis at the whole country level. Figure 21 provides more detail on some common map projections used at different scales.

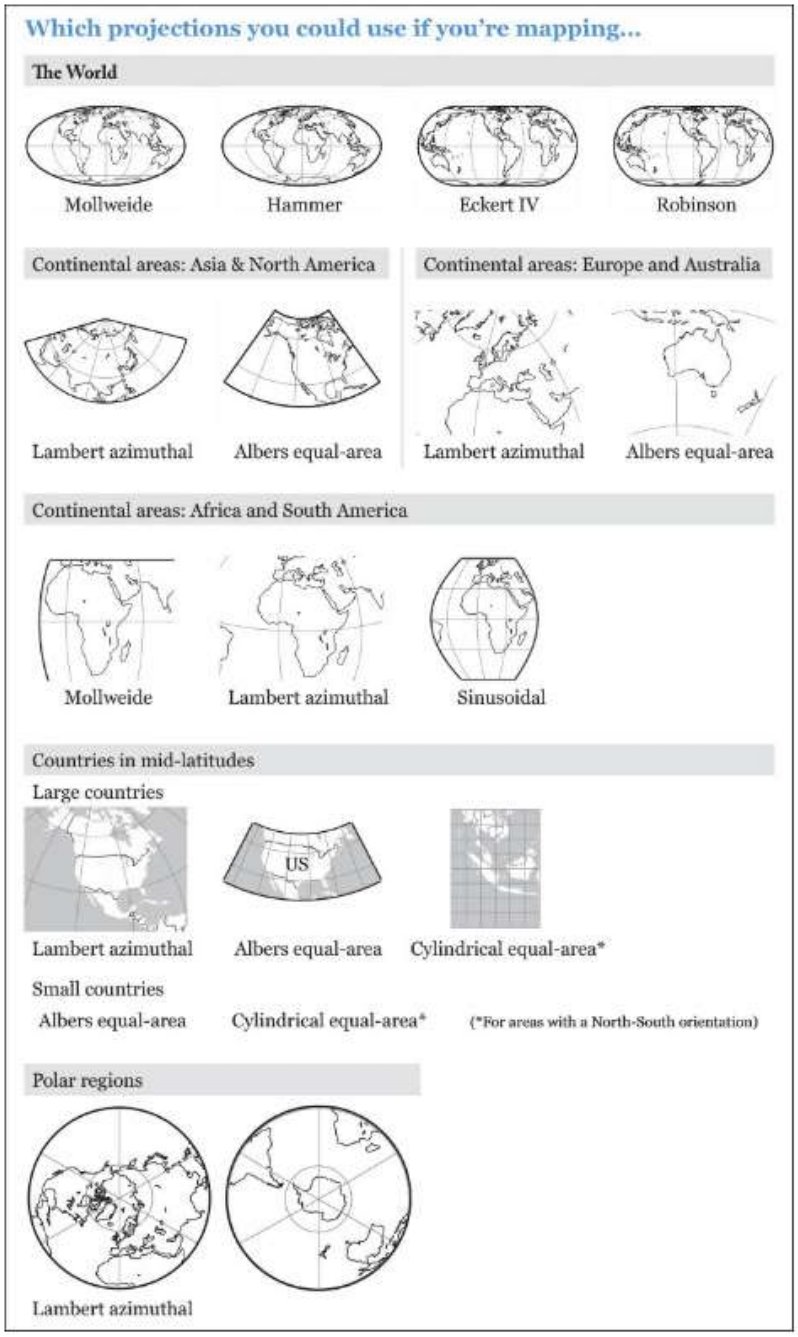



**Figure 21:** Commonly used map projections at different scales (Source: Cairo, 2016).

Projection information is stored with a dataset. It can be stored in different ways, depending on which software the dataset was generated in. Common formats include EPSG reference (e.g. a format used by QGIS software), WKT ("Well Known Text" as HTML) or in .PRJ files (used by ESRI's ArcGIS software)). Projection information is also stored in the dataset's metadata file.

**Additional resources:**

https://pro.arcgis.com/en/pro-app/help/mapping/properties/list-of-supported-map-projections.htm

http://www.epsg.org/

## 4.2. Data processing, generalisation and classification of data

Data are either mapped qualitatively, whereby features are simply mapped according to their location or area, or quantitatively, showing magnitude or concentration of a variable (Figure 17). This section of the document focuses on key things to consider when mapping quantitative data.

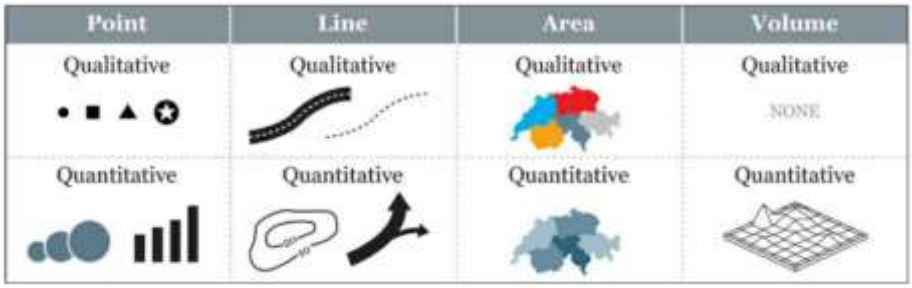



**Figure 17:** Symbols to encode data on maps (taken from Cairo, 2016)

Quantitative data can be presented using proportional symbols or shades of colour, the later are often referred to as choropleth maps. Unless these data come in a small number of classes (such as species of great ape), you will need think carefully about how data should be classed in maps and charts. The data may need to be grouped, simplified or sub-set (understand your data and accurately represent it), you will need to choose an appropriate classification scheme, justify any thresholds used and limit the number of classes. When presenting quantitative data on a map it is often necessary to group or classify the data into simpler classes to present spatial patterns of a particular attribute or statistic. For example, population density, species richness or biodiversity importance. Data can easily be misrepresented by using an inappropriate classification scheme. In choropleth maps, presenting raw data values can mislead if the summary units are not of a consistent size. That is, values within larger polygons may be high purely because the area is larger: therefore consider normalising data to a comprehensible scale such as 0-1 or 0 -100%. Using a common scale between datasets is important if comparing between or combining datasets and can be more comprehensible to your reader – but this needs to make sense for the question being asked of the data. When comparing tonnes of carbon per hectare between two regions, the scale needs to be the same in both cases.

Understanding your data when creating a map is essential. Figure 18 illustrates how different classification schemes are appropriate depending on how the data are distributed. Further details are provided in Table 1.

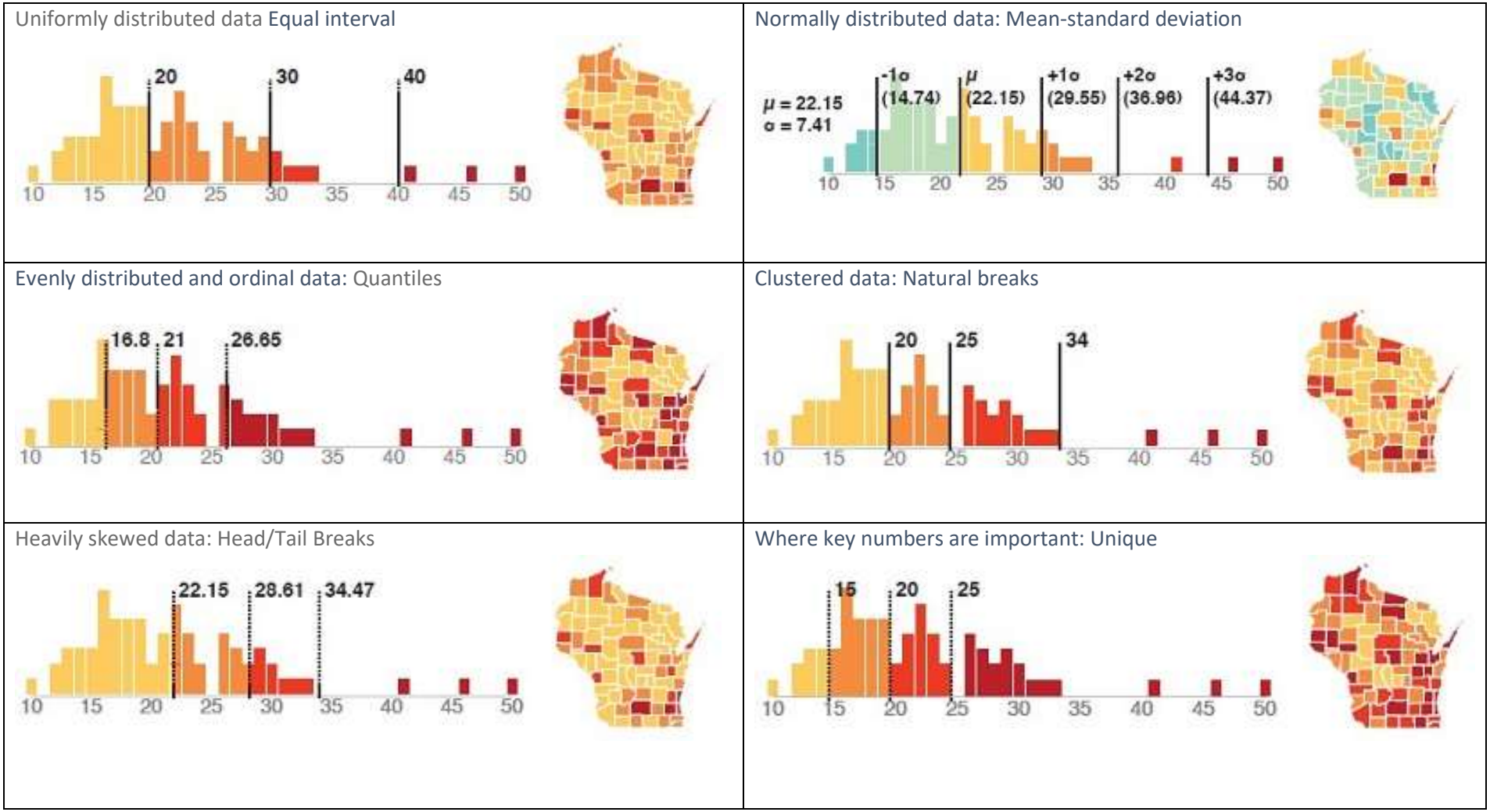
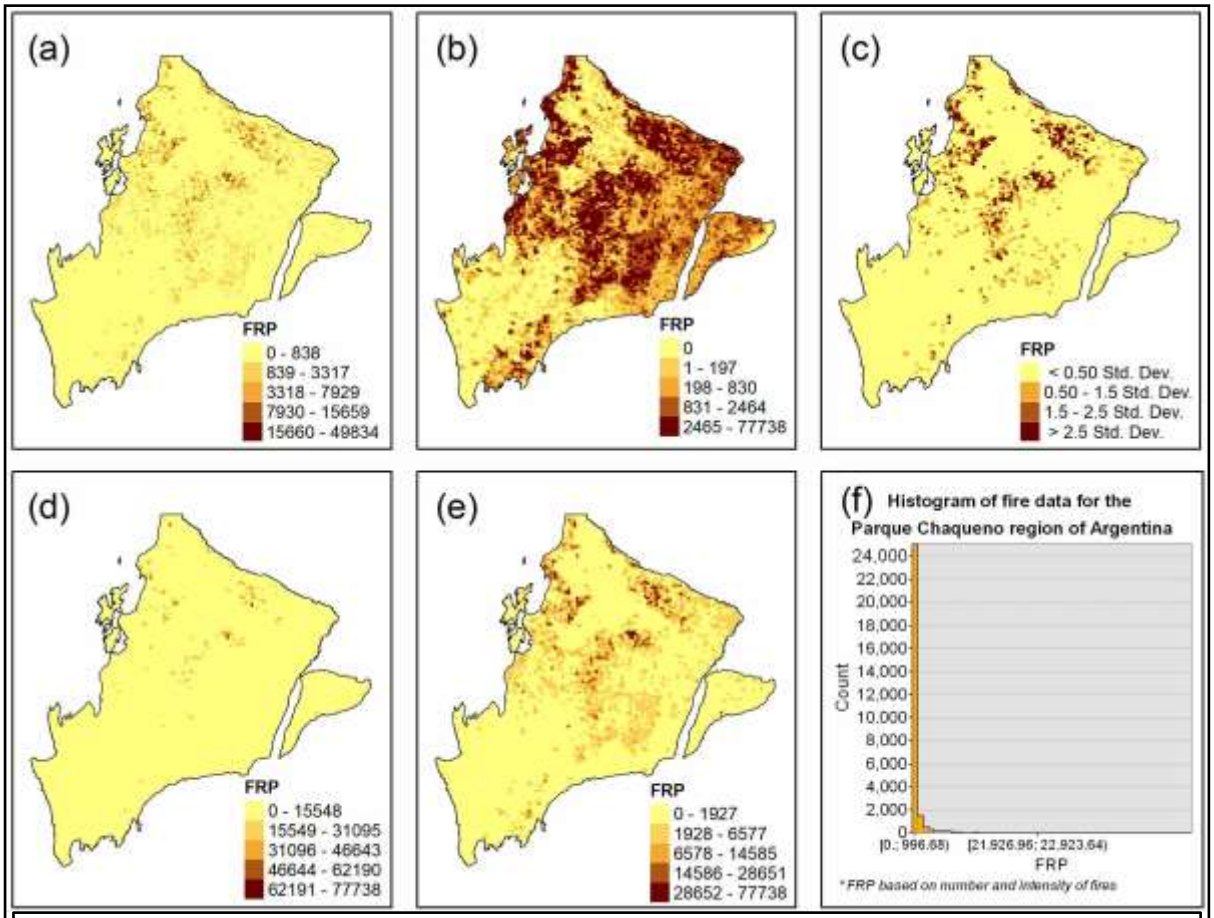



**Figure 18:** Recommendations for common classification methods for quantitative spatial data based on statistical distributions (Source: Foster, 2019)

| Method | Class breaks | When to use | When to avoid |
|---|---|---|---|
| **Equal Interval** | Divides attributes values into equal size ranges. Intervals defined by **interval size and number of classes**<br>**Example use:** mapping temperature and specifying you want 5 classes. | - to emphasise amount of an attribute relative to other values.<br>- for data that is on defined scale where there is order & the difference between two values is meaningful<br>- for data with familiar data ranges and a uniform (rectangular) distribution | - Avoid if your **data are skewed** to one end or if you have one or two really **large outlier** values. |
| **Defined Interval** | Intervals defined by **interval size**.<br>**Example use:** mapping temperature with intervals of 10 C. | - where specific interval size desired & no. of classes not an issue<br>- for displaying data that is on defined scale where difference between values is meaningful or when using recognisable intervals e.g. 25%, 50%, 75% and 100%<br>- for familiar data ranges with a uniform (rectangular) distribution | - Avoid if your **data are skewed** to one end or if you have one or two really **large outlier** values. |
| **Quantiles (equal count)** | Same number of values in each class. Values ordered sequentially, then divided into chosen number of classes<br>**Example use:** If you want to rank data into categories such 5 classes with 20% of values in each class or mapping quantity/area where you want class breaks to reflect quantity. | - if data are **unevenly distributed** e.g. many features have the same/similar values and there are gaps between groups of values or for **evenly distributed** data<br>- shows **no empty classes** and **no classes** with **too few** or **too many values** and shows **relative position of values**<br>- for evenly (linearly) distributed or ordinal data (i.e. with a clear order of values & distance between values is not known) | - Avoid **if differences between each class is important** as **results can be misleading** e.g. similar features can be places in adjacent classes or widely different values in the same class (more classes will reduce the problem but not resolve it). Outliers are lost |
| **Natural Breaks (jenks)** | Intervals defined by relative distinction in values, statistically minimising variation within each group<br>**Example use:** Choropleth maps to show natural groupings inherent in the data where comparison with other maps is not required | - minimising variation within each group and boundaries between classes are where there is relative distinction in values<br>- variance within each class is minimal<br>- Useful for clustered and skewed data | - Avoid if you need to **compare across maps built from different underlying information** as the **classes** only **relevant for the data that the classes were based on** & if data are evenly distributed it can be hard to find optimal number of classes. |
| **Geometric al interval** | Same number of values in each class (compromise method between natural breaks, equal interval and quantiles methods)<br>**Example use:** specifically designed for use with continuous data | - only use if presented with histogram to explain classification.<br>- same number of values in each class &changes between intervals fairly consistent<br>- Useful when data are spread over large area and not normally distributed or extremely skewed but use with caution | - **Avoid** for final presentation as **difficult to explain how classification system works** |
| **Standard Deviation s** | Intervals defined by how much values deviate from the mean<br>**Example use:** if you want to highlight which features are above or below average values | - for seeing which features are above or below an average value<br>- Ranges are defined at intervals of 1 0.5 or 0.25 standard deviations away from the mean<br>- When data have a normal distribution curve | - Avoid if there are **very high or low values** in the map as these can skew the mean. Also **avoid if actual values are important** as the map does not show actual values only how far away from the mean they are. |
| **Manual (unique)** | Data are manipulated to user's preferred pattern<br>**Example use:** classes where thresholds are defined by external criteria e.g. nationally defined breaks for poverty data. | - **Use only for minor tweaks of classes** (e.g. removing decimal places to create 'pretty breaks') or where class breaks can be justified by other means **and key values are important** | - Avoid in most cases as it is inaccurate and can introduce a lot of **intentional or unintentional bias**. Hard to select classes appropriate for the data. No validity as the **pattern selected may have nothing to do with the data** |

**Table 1** - Main data classification methods for grouping quantitative spatial data and when to use them (Sources: Axis Maps, 2017; ESRI, 2019; Foster, 2019; Frye, 2017 ; GISGeography, 2015 and Wiki.gis.com, 2018).

Point data can pose other problems. When you have a large number of points, many of which are located close to one another, it may be difficult to correctly present them on a map without undertaking some kind of aggregation. Summarising data into logical units, such as hexagons or squares (referred to as bins) can enables a more accurate representation of the data (Figure 19). This is referred to as binning. The most basic binning function can be to count the number of points in each bin, but sum, minimum, maximum, range, mean, standard deviation, and variance can also be used. The histogram **(f)** shows that the data present a skewed (non-normal) distribution and therefore map **(e)** presenting the data using natural breaks might be the best approach. Map **(c**) displays standard deviation from the mean, which captures a similar pattern to **(e)** in this case. Skewed data is not usually represented well by standard deviations but may be fine for visualisation purposes.




**Map (a)** shows raw point data presented using natural breaks with highest intensity (FRP value) displayed last. **Maps (b) to (e)** use a binning approach to summarise the point data onto a vector grid of hexagons, each with an area of 100km$^2$.FRP values were summed for all the points falling within each hexagon to give a measure of intensity and density of fire points over the period. The resultant data are presented using quantiles **(b),** standard derivation **(c),** equal intervals **(d),** and natural breaks **(e)**. The **histogram (f)** shows the distribution of the data, presenting a skewed (non-normal) distribution.

**Source:** Fire data for Argentina were downloaded from the Fire Information Resource Management System (Firms) for a 5 year period (1/1/2011 - 31/12/2016) from the MODIS Collection 6 Active Fire Product. These data are point data representing the centre longitude/latitude of 1km pixels flagged as containing one or more fires. Each point contains an attribute FRP (Fire radiative power) showing the amount of heat output from the fires within the 1km pixel. This is measured in MW (megawatts).

**Figure 19:** Maps assessing fire impact for the Parque Chaqueno region of Argentina, highlighting how using different methods for summarising and classifying data may lead to different interpretations or understanding of the data.

Depending on the software you are using to create your map, there are help pages providing technical advice on how to apply different classification schemes. The ArcGIS Pro help and the QGIS help provide some guidance on styling vector and raster data, as well as some third party websites such as the GIS Lounge and Axis maps which go into more detail on the basics of data classification.

There is not always a definitive answer to which classification scheme is best. The following additional notes may help you to prepare maps that your reader can understand and interpret correctly.

- Clearly label the legend. Avoid ambiguity around thresholds between classes, and think about the data type. E.g. for classes 0-10, 10-20..., where does 10 sit? For classes 0-10, 11-20, where does 10.5 sit?
- Document which classification scheme is used and ensure this is transparent to the reader.
- Classification schemes may produce statistically relevant class breaks (e.g. 23, 58, 83), but a rounded scale (e.g. 25, 50, 75) will be less distracting to the reader.
- Similarly, you may want to round numbers in your ranges to reduce or remove decimal places, sometimes called 'pretty breaks'.
- Do represent zero and no-data appropriately (no data is different from 0 value and should be correctly represented).
- On the legend key, should the highest values be placed at the top or the bottom of the scale? Which values represent an outcome that you want to draw attention to?
- Consider placing (n=) next to each interval so reader can see the distribution of data points between classes.
- Think about the number of data classes, which may depend on your data:
    - what are too few vs too many? Unless using a pre-defined threshold, we suggest a minimum of 3 and a maximum of 10 classes. More than 10 starts to make distinction between colours difficult.
    - consider a continuous ramp rather than defined class breaks, where the break values are not important to the reader.
- How you choose to classify the data may depend on:
    - whether thresholds are being chosen to display data e.g. a class might be required to represent data above a certain value. A threshold may be derived from stakeholder input or known accepted values.
    - The distribution of your data. Looking at data histograms can sometimes help determine an appropriate number of classes.
    - Your audience – and how much detail you need to retain to get your message across.

**Box 4: Resources for processing complex data for REDD+ planning**

Before a map can be produced there are often complex data analyses to be undertaken - to generate a data layer or run a set of analysis steps on the raw data, in order to effectively visualise trends and patterns.

The UN-REDD Programme has developed a range of GIS training materials and tools for use in planning REDD+ activities. These resources are designed to assist technical staff to undertake spatial analysis to identify areas suitable for specific REDD+ policies and measures, and which are likely to yield multiple benefits. Materials have been developed for both QGIS (open-source) and ArcGIS software, according to the needs of individual partner countries. The materials continue to be developed and tested with country partners, with tutorials shared in different languages as available.

Some tutorials provide step-by-step guidance on guidance on how process complex data. For example, one demonstrates how individual species range data from the IUCN Red List can be processed, grouped and classified to show species richness. Another covers producing a dataset and map for evaluating the importance of forests for soil stabilization and limiting soil erosion. Other tutorials focus on data visualisation techniques such as how to produce a map with a matrix style legend, by grouping and classifying two sets of data to show on a legend with 2 axes. Other tutorials, like the one on processing and visualising fire data to identify potential pressures from fires on forest, show how large quantities of point data can be processed and effectively displayed to show patterns in the data.

You will find these tools at http://bit.ly/GIStools-redd where it is also possible to join our low-volume mailing to receive information on tutorial updates and other relevant content.

## 4.3. Making a map with appropriate data layers and a visual hierarchy

When creating a map, avoid including too many data layers. Focus on what you want/need to show including enough information to ensure that the message is conveyed and the reader understands the purpose of the map. Make sure that correct boundaries are used and labelled correctly (e.g. UN boundaries and labelling of disputed territories) as this could determine whether a map is accepted or rejected by a decision maker. Think about what other features need to be labelled and the size of labels, making sure not to over-clutter the map. The use of transparency, depth of colour and boldness of lines and features can help, promoting features into the foreground or background on a map to create a visual hierarchy where some features are prominent and others less so (AxisMaps, 2019). Background features may include a base map with reference features, a light shading distinguishing for example forest vs non-forest land, a sea shading, administrative boundaries, major towns and rivers. The most prominent features need to be those the map aims to communicate, such as values of forest or boundaries of protected areas. There are no real rules to determine the visual hierarchy other than identifying those elements which are helpful as reference material and those that are the purpose of the map, and which elements are most significant for your target audience.

Think about the drawing order and which elements need to be displayed on top. A map that will be used for policy communication at a particular administrative level for example may benefit from having bolder symbology depicting those administrative boundaries in the foreground. For a map

identifying important areas for biodiversity you may wish to show forests and existing protected areas in the background so as not to distract the reader from the main purpose of the map. Use insets to illustrate or zoom in on a particular area of interest. Include a sensible legend which clearly describes the data presented on the map along with an appropriate map title describing the purpose of the map. It is important not to obscure important data with insets and legend boxes.

### 4.4. Using colour and making colour blind friendly maps

In map making, colour provides a means of distinguishing between different features. Creating a map without colour is a much more difficult task as there are a limited number of shades of grey that can be distinguished by the human eye and there is much more reliance on the use of hatching, which is much harder to distinguish when small features are symbolised. Colour is also helpful in being able to represent some features with natural colours e.g. blue water bodies, and green forests.

Cartography is an artform and the colour wheel, the use of complementary colours and choice of colour schemes are important in creating aesthetically pleasing maps. Hue (degree of colour), saturation (% of colour) and lightness (% based on how much black vs white) can all be adjusted. The choice of which colour to place next to or on top of another along with the depth of colour can make a feature appear less visible or more prominent. The choice of colour is particularly important when displaying quantitative thematic data.

There are two types of colour scheme:

1) **sequential colours**, where colour remains the same but depth of colour increases or decrease with changes in data values) and
2) **diverging colours**, where colours diverse around a mid-point. E.g. positive and negative difference and the centre value with no difference at all.

There are millions of shades of colour to choose from, but colour blindness is an important consideration when creating maps. According to Colour Blind Awareness, as many as 1 in 12 men (8%) and 1 in 200 women (0.5%) have some colour vision deficiency. This means that for a significant proportion of the world's population many maps become useless. In the worst case, maps that have not been designed with colour blindness in mind could accidentally present the wrong message or cause a wrong decision to be made, due to unintentionally grouping or confusing distinct features. A report or map could also be disregarded because of its illegibility to a colour-blind policy maker.

Whilst the range of colour combinations is reduced, it is possible to select colours that are both aesthetically pleasing and distinguishable by people with different types of colour-blindness (Figure 22).

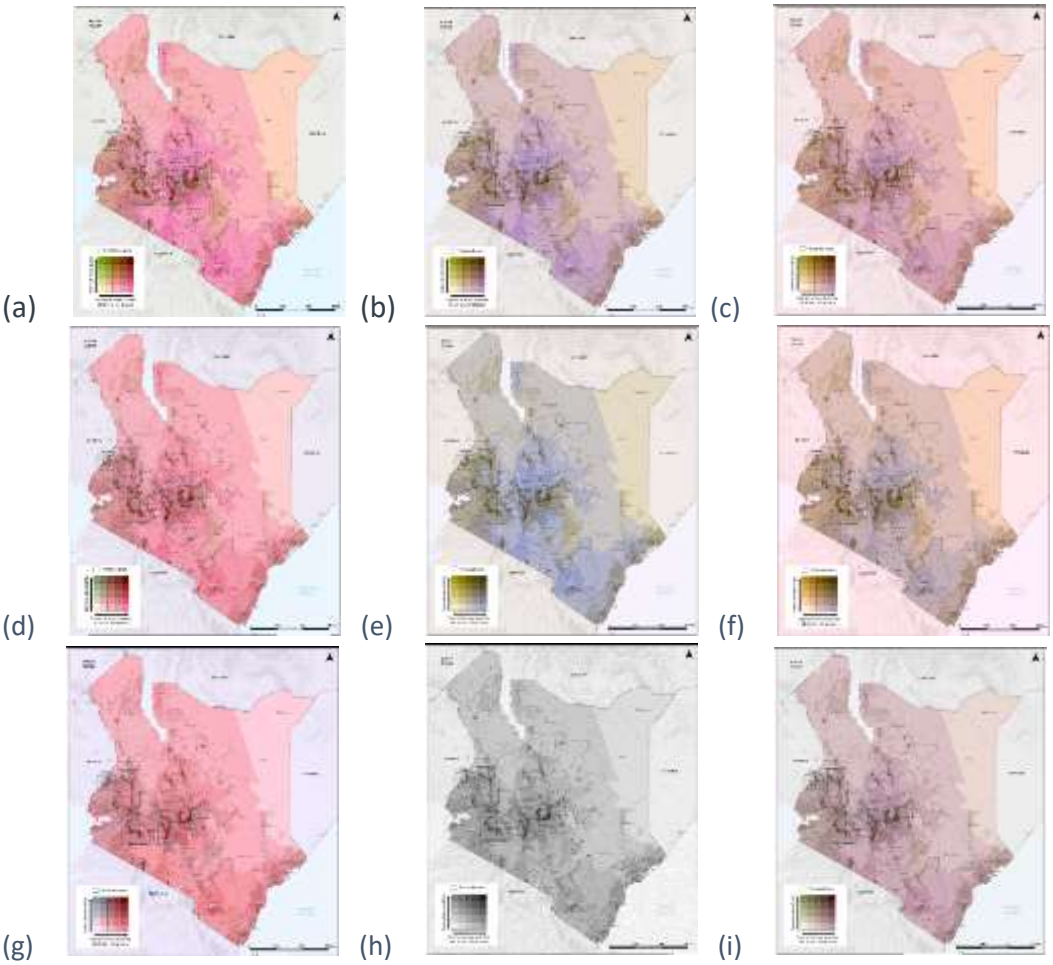



**Figure 22:** Example REDD+ planning map shown in different colour-blindness views (a) Normal view ; **Anomalous Trichromacy:** (b) red-weak protanomaly, (c) green-weak deuteranomaly, (d) blue-weak tritanomaly ; **Dichromatic view:** (e) Red-Blind/Protanopia, (f) Green-Blind/Deuteranopia, (g)Blue-Blind/Tritanopia ; **Monocromatic view:** (h) Monochromacy/Acromatopsia, (i) Blue Cone Monochromacy

There are many websites now that help map makers make colour ramps, select colour blind friendly palettes and others which enable upload of an exported map to check it for colour blind compatibility. In QGIS software, they have made it easy to automatically produce colour blind friendly maps with an inbuilt colour-blind visualisation previews.

**Some useful online resources include:**

https://github.com/tolomaps/resources
https://www.axismaps.com/guide/general/using-colors-on-maps/
http://www.rain.org/gis/map-classroom/
http://colorbrewer2.org/
https://www.color-blindness.com/coblis-color-blindness-simulator/
http://colororacle.org/resources/2007_JennyKelso_ColorDesign_lores.pdf

## 5. References:

Axis Maps (2017). *Cartography Guide: A short, friendly guide to basic principles of map design*. https://www.axismaps.com/guide/ (Accessed December 2019).

Bodin B., Goodman L. (2014). *Tutoriel pour la construction d'un outil flexible d'analyse des données spatiales à l'échelle du territoire*. Préparé pour le compte du Programme ONU-REDD. UNEP-WCMC : Cambridge, UK.

Cairo, A. (2016). *The truthful art: data, charts, and maps for communication*. Indianapolis, IN: New Riders.

Environmental Systems Research Institute (ESRI). (2019). *ArcGIS Pro version 2.5 Help*. https://pro.arcgis.com/en/pro-app/help/mapping/layer-properties/data-classification-methods.htm. (Accessed December 2019).

Foster, M. (2019). Statistical Mapping (Enumeration, Normalization, Classification). *The Geographic Information Science & Technology Body of Knowledge* (2nd Quarter 2019 Edition), John P. Wilson (Ed.). Washington, D.C.: Association of American Geographers.

Frye, C. (2017). *About the Geometrical Interval classification method.* https://www.esri.com/arcgis-blog/products/product/mapping/about-the-geometrical-interval-classification-method/ (Accessed December 2019).

García-Rangel, S., Hicks, C., Ravilious, C., Williamson, A., and Nguyen, T.P. (2017[1]). *Integrated land-use planning for REDD+: lessons from combining spatial analysis and participatory approaches at the sub-national level in Viet Nam*. Hanoi: UN-REDD Viet Nam Phase II Programme. http://bit.ly/vnmsubnatluplanning

García-Rangel, S., J. Walcott, X. de Lamo, C. Epple, L. Miles, V. Kapos, D. Carrión, M.E. Herrera Ugalde, T. López Lee, M. Ballestero, E. Vega-Araya, G. Quirós Ramírez y A. Gómez Román (2017[2]). *Beneficios múltiples de REDD+ en Costa Rica: análisis espaciales para apoyar la toma de decisiones. ONU Medio Ambiente - Centro mundial para el seguimiento de la conservación*. Cambridge, UK: UNEP-WCMC). https://bit.ly/3kwDZH8

GISGeography (2015). *Choropleth Maps – A Guide to Data Classification*. https://gisgeography.com/choropleth-maps-data-classification (Accessed December 2019).

Kapos, V., Walcott, J., Thorley, J., Mariscal, E., Labbate, G., Ravilious, C., Miles, L., Narloch, N., Trumper, K., Bertzky, M. (2015) *Planning for REDD+ in Panama: securing social and environmental benefits*. Cambridge, UK: UNEP-WCMC. http://bit.ly/pnmreddplanning

Knaflic, C. N. (2015). *Storytelling with data: A data visualization guide for business professionals*. Hoboken, NJ: John Wiley & Sons.

Krystian, M. (2016). *Chart Do's and Don'ts: The Ultimate Data Visualization Guide.* https://infogram.com/blog/dataviz-chart-guide-101-dos-and-donts/ (Accessed May 2020).

Maukonen, P., Runsten, L., Thorley, J., Gichu, A., Akombo, R., Miles, L. (2016). *Mapping to support land-use planning for REDD+ in Kenya: securing additional benefits*. Prepared on behalf of the UN-REDD Programme. Cambridge, UK: UNEP-WCMC. https://bit.ly/35EuHCF

Maukonen, P., Nkor, B., Ama, M., Guth, M., Williamson, A., Okeke, F., Hicks, C., Effiom, E., Adekola, R., Ekwu, A. (2017). *The role of Cross River State's forests in supporting development and well-being***.** Poster prepared on behalf of the UN-REDD Programme. Cambridge, UK: UNEP-WCMC. https://bit.ly/34A67DK

Mosnier, A., Mant, R., Pirker, J., Makoudjou, A., Awono, E., Bodin, B., Tonga, P., Havlík, P., Bocqueho, G., Maukonen, P., Obersteiner, M., Kapos, V., Tadoum, M. (2016). *Modelling Land Use Changes in Cameroon 2000–2030.* A report by the REDD-PAC project. http://pure.iiasa.ac.at/id/eprint/13771/ (Accessed October 2020)

Miles, L., Ravilious, C., Garcia-Rangel, S., De Lamo, X., Dargie, G., Lewis, S. (2017). *Carbon, biodiversity and land-use in the Central Congo Basin Peatlands*. Cambridge, UK: UNEP-WCMC. bit.ly/congopeat

Oetting, J. (2020). *Data Visualization 101: How to Choose the Right Chart or Graph for Your Data. Originally published Mar 20, 2018 10:27:00 PM, updated April 09 2020. https://blog.hubspot.com/marketing/types-of-graphs-for-data-visualization.* (Accessed May 2020).

Runsten, L., Ravilious, C., Kashindye, A., Giliba, R., Hailakwahi, V., Kashaga, L.R.A., Khalid, S., Mbilinyi, B., Mwampashi, Y., Pastory, M., Mant, R., Osti, M., Crête, P., Pekkarinen, A., Leppanen, M., Miles, L. (2013). *Using spatial information to support decisions on safeguards and multiple benefits for REDD+ in Tanzania*. Prepared by UNEP-WCMC. Dar es Salaam: Ministry of Natural Resources & Tourism. https://bit.ly/2HHtFhl

Simonson, W., Narangerel, N., Nandin-Erdene, G., Hicks, C., Miles, L., de Lamo. X. (2016). *REDD+ Outside the tropics: Using spatial analysis to inform planning in Mongolia's boreal forests.* Poster prepared on behalf of the UN-REDD Programme. Cambridge, UK: UNEP-WCMC. https://bit.ly/3oHvETJ

Wiki.gis.com (2018). *Classification*. http://wiki.gis.com/wiki/index.php/Classification. (Accessed December 2019).

# 6. Annexes

## Annex 1: Map Design Checklist

The following set of questions are designed to help users think about the design considerations of the map to meet an intended purpose.

1. **Who is the map for?**

2. **What is the purpose of the map?**
   *(be clear about the objectives, why a map is needed and what it will be used for)*

3. **What scale will the map be produced at?**
   Local ☐ Sub-national ☐ National ☐ Regional ☐ Global ☐
   **and do the data support this scale of mapping?**
   Yes ☐ No ☐ Don't know ☐

4. **What information will be displayed?**
   Reference ☐ Thematic (e.g. habitat map, land cover map, etc) ☐
   Scenarios ☐ Other ☐

   If Other please specify:

   Please provide a list of potential layers:

5. **What type of map is required?**

Static map ☐ Digital dynamic map *(e.g. interactive pdf)* ☐ Interactive map ☐

**Are there other visualisation techniques that could be used alongside/or part of the map?**

Graph ☐ Table ☐ Pictures / Images ☐ Diagrams ☐ Other ☐

| If Other please specify: |
|---|
| |

6. **If a static map**

**What size map is required?**

A5 ☐ A4 ☐ A3 ☐ A2 ☐ A1 ☐ A0 ☐ Other ☐

| If Other please specify: |
|---|
| |

**What format(s) are required?** *(Think about the purpose of the map and the best format to achieve that. The level of detail, symbology and text sizes and fonts may be influenced by where the map will ultimately be presented)*

Static map in online report or policy brief ☐

Static map in a printed report brief ☐

Static map on a Poster ☐

Static map on a scientific manuscript ☐

7. **If a digital map**

**What format(s) are required?** *(Think about the objectives and the best format to achieve them)*

Digital maps with animation ☐ Digital maps without animation ☐

8. **If an interactive map**

**What format(s) are required?** *(Think about the objectives and the best format to achieve them)*

Interactive map in a web platform ☐ Interactive map in an app ☐

**What level of interaction is required (this may depend on target audience)?**

Basic *(e.g. pan and zoom)* ☐

intermediate *(e.g. turn on and off layers)* ☐

advanced *(e.g. chose layers and undertake some basic analysis)* ☐

**What type of interface is required?** *(Please describe the functionality. Think about that functionality your user will need to fulfil the purpose. interfaces with complex interaction could obscure the message you are trying to get across or too simpler an interaction may not give the user what they require).*

| |
|---|
| |

**How do you intend to present the map / what communication materials will be developed?** *(the purpose of this question is that different presentation methods will require different text sizes and fonts, and thus different versions of the same map)*

Presentation on large screen *(e.g. projector screen)* ☐
Presentation on small screen *(e.g. laptop screen)* ☐
Presentation on a tablet or mobile ☐

**Could the map benefit from being presented as a story map?**
Yes ☐ No ☐

**Will any other communications materials be developed?**
Yes ☐ No ☐

| If Yes please specify: |
|---|

9. **Are there any time constraints that may restrict the type of map produced?**
   Yes ☐ No ☐
   If yes please give reasons:

10. **Are there any budget constraints that may restrict the type of map produced?**
    Yes ☐ No ☐

| If Yes please give reasons: |
|---|

11. **Do you have access to all the data needed?**
    Yes ☐ No ☐

| If No please specify missing datasets: |
|---|

12. **Will the map need regular updates?**
    Yes ☐ No ☐
13. **If an interactive map**
    **Have hosting costs been included?**
    Yes (within project lifecycle) ☐ Yes (with maintenance into future) ☐ No ☐

| If Yes please specify the number of years/months: |
|---|

**Have updates been costed for system maintenance?**
Yes ☐ No ☐

| If Yes please specify the number of years/months: |
|---|

## Annex 2: Data Management Quality Assurance checklist

NB this checklist may require modification to suit your own structure and processes

| **Data Management Quality Assurance checklist** | |
|---|---|
| **Project Title:** | |
| **SECTION 1: Map analysis kick-off meeting** | |
| Identified the project level **"data manager"** and **"data team"**<br>*(i.e. the person responsible for any data and methods used in the project and responsible for ensuring they comply with organisational standards and procedures)* | Project data manager (please specify): |
| Identified the organisational level **"data focal point"**<br>*(i.e. to approach with problems as they appear or to advise on any organisational standards/approaches. This may be the same as the project level "data manager" depending on expertise)* | Data focal point (please specify):<br>☐ Not required |
| Other technical focal point e.g. web/database development /informatics<br>*(i.e. to approach for website or web-mapping development and support, database design and development and other technical problems not covered by the "data manager". This should reflect organisational structure and standards/approaches).* | Other technical focal point (please specify):<br>☐ Not required |
| Identified required **statistical, analytical and visual output(s)** of the project | ☐ Yes ☐ No |
| **Data and analysis needs:** Identified what data and analysis is required to achieve the above outputs | ☐ Yes ☐ No |
| Agreed on **standard naming conventions** for tabular data and methods to assign these? (e.g. for collating data in excel with standard country codes chosen from a drop-down list) | ☐ Yes ☐ No |
| Organisational **standards**: Any organisational standards explained, and efforts made to match dataset to existing schemas where appropriate | ☐ Yes ☐ No |
| **Formatting procedures** explained (e.g. best practice such as separating multiple values by ";" rather than "," (to avoid issues with conversion of tables to csv format)) | ☐ Yes ☐ No |
| **Have Licencing and IP requirements been checked with Contracts manager?** | ☐ Yes ☐ No |
| Carried out kick-off meeting to understand project data needs<br>*(This is the project kick-off meeting)*<br><br>**Attendees should include:**<br>*(project level data manager, organisational level data focal point and Informatics focal point* | Attendees :<br><br>Date held: |
| | |

| **Data Management Quality Assurance checklist**<br>**SECTION 2: Project data team meeting(s)**<br>*(to be held regularly throughout the duration of the project)*<br><br>**Attendees should include:**<br>*Project lead, project level data manager, organisational data management focal point, other technical focal points (if determined needed in kick-off meeting)* | **Actioned** |
|---|---|
| Identified and changes to **statistical, analytical and visual output(s)** of the project | ☐ Yes ☐ No |
| Have the required file formats of the dataset for **data analysis** and **web development and database design** been explained and understood? (e.g. as web developer teams often require different formats to GIS analysts**)** | ☐ Yes ☐ No |
| Are there **any known issues with data that need resolving** (or is any data availability unknown) **that will impact project delivery or deadlines**? | ☐ Yes ☐ No |
| Are there any datasets with **existing licencing/restrictions** required for using or processing data intended for use in the project | ☐ Yes ☐ No |
| Has **data quality** for each dataset been evaluated for intended data been evaluated for intended use in project | ☐ Yes ☐ No |
| Do any **dataset require feedback from data providers**? | ☐ Yes ☐ No |
| Is there likely to be any issues with the way administrative boundaries are presented in any of the datasets (e.g. disputed territories, unclear property rights, etc) or with the way they will be mapped (e.g. according to UN guidelines) | ☐ Yes ☐ No |
| Has **metadata been compiled for derived / newly created datasets** and updated for updated datasets? | ☐ Yes ☐ No |
| Are **all data providers correctly acknowledged** in outputs? | ☐ Yes ☐ No |
| Have **data providers given approval for future use** of the derived or updated dataset? | ☐ Yes ☐ No |
| Are **all data providers correctly acknowledged** in outputs? | ☐ Yes ☐ No |
| Do **data providers require a copy of outputs** for use of their dataset(s)? | ☐ Yes ☐ No |
| Have **data providers been sent a copies of outputs**? | ☐ Yes ☐ No |
| **Carried out close down meeting** to check **project data correctly documented**? | ☐ Yes ☐ No<br>Date held: |
| **Project data folders correctly archived and data correctly stored along with metadata for future access and use. (e.g. according to data management procedures)** | ☐ Yes ☐ No |
| Organisational data manager signoff<br>*(at end of project when all above items complete)* | Signed:<br><br>Date: |

## Annex 3: Map Quality Assurance checklist

This checklist is produced for quality control purposes to make sure important visualisation and interpretation elements on a map are checked before publishing.

**Instructions for reviewers**
When reviewing the map think critically about it. What does the map show, what does it omit, and why? Is the legend clearly explaining the map? How were the data collected and manipulated to produce the end result? How will it be interpreted by its readers?

Click on the appropriate checkbox in **QA Answer column** for each question. Please highlight (in the **QA Answer column**) in **Red** when there is something that **must be fixed** or in **yellow** when there is a **recommended action** to help the map author to quickly see any issues.

Add any specific comments or suggestions related to the answer using the **'Comments'** box in the right hand column. Any other more general comments that don't refer to a single specific checklist item can be put in the '**Additional comments / advice'** box on the last page. Map authors can also respond to reviewers comments in the same boxes.

| **Map Quality Assurance checklist** | | | | |
|---|---|---|---|---|
| **Map for review:** | Enter Full path and filename | | | |
| **Is it part of a map series?** | ☐ Yes – this is the first map in the series and will be used as the template<br>☐ Yes – this is NOT the first map in the series<br>Please provide path to template map:<br>☐ No | | | |
| **Type of map for review:** | ☐ Single Static map ☐ Static map(s) in map series<br>☐ Digital dynamic map *(e.g. interactive pdf)* ☐ Interactive map | | | |
| **Comments by author:** | (please provide any relevant information for the reviewer. Also indicate if map is part of a series and which is the map in the series to be used as the standard to compare with) | | | |
| **Requested by:** | **Enter Name and email please** | | **Project name / code** | |
| **Review request notes:** | | | | |
| **Request date:** | | **Review deadline:** | | |
| **Overall comments / advice by reviewer:** | | | **Reviewer comments addressed** | ☐ Yes<br>☐ No |
| **Map QA check** | **Date:** | **by:** | | |
| **QA sign-off** | **Date:** | **by:** | | |

| Map Quality Assurance checklist continued ……. | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue Flagged /fixed** |
| 1. Title<br><br>*(should clearly describe what the map is showing)* | Does the map have an appropriate title? | ☐☐ Yes<br>☐☐ Title needs to be clearer<br>☐☐ Title has spelling mistakes<br>☐☐ Inconsistencies in maps in series<br>☐☐ No – but would be helpful<br>☐☐ No – but not needed as has appropriate figure caption | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has appropriate text-size and font been used for size of map? | ☐☐ Yes<br>☐☐ Inconsistencies in maps in series<br>☐☐ No – too small<br>☐☐ No – too big | | ☐ Issue Flagged<br><br>☐ Fixed |
| 2. Subtitle<br><br>*(should describe purpose and/or other essential information required to understand the map)* | Does the map have an appropriate sub-title? | ☐☐ Yes<br>☐☐ Subtitle needs to be clearer<br>☐☐ Subtitle has spelling mistakes<br>☐☐ Inconsistencies in maps in series<br>☐☐ No – but would be helpful<br>☐☐ No – but not needed | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has appropriate text-size and font been used for size of map? (making sure font matches with Title font) | ☐☐ Yes<br>☐☐ Inconsistencies in maps in series<br>☐☐ No – too small<br>☐☐ No – too big<br>☐☐ N/A | | ☐ Issue Flagged<br><br>☐ Fixed |
| 3. Legend and boxes<br><br>*Note: the word legend is unnecessary text and does not add to the clarity. Suggest removing or replacing with more useful text* | Does the map have a legend? | ☐☐ Yes<br>☐☐ No – but is required<br>☐☐ No – but would be helpful<br>☐☐ No – not needed | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Does legend text clearly describe what map is showing, including units where necessary? | ☐☐ Yes<br>☐☐ No – more detail needed | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are proportions of text size and boxes within legend appropriate? | ☐☐ Yes<br>☐☐ Inconsistencies in maps in series<br>☐☐ No – too small<br>☐☐ No – too big | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Is anything missing from the legend that should be there? | ☐☐ Yes – need to add missing items<br>☐☐ No – missing items not required<br>☐☐ No – all items present & correct | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has word 'Legend' been removed or replaced with more useful text? | ☐ Yes<br>☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| 4. Spelling, Acronyms and text fonts | Has all text on map been spell checked? | ☐☐ Yes<br>☐☐ No<br>☐☐ Uncertain | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have any acronyms or project related terminology or jargon been clearly explained? | ☐☐ Yes<br>☐☐ Explanation needs improving<br>☐☐ No – need to add<br>☐☐ N/A | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has a consistent font been used throughout map? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |

| Map Quality Assurance checklist continued ……. | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 5. Map Projection and map extent | Has an appropriate map projection been used? *(see section 4.1)* | ☐☐ Yes<br>☐☐ No – but not needed<br>☐☐ No – but required | | ☐ Issue Flagged<br>☐ Fixed |
| | Has appropriate extent of country or region been included? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Is the projection labelled on the map? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Are extents consistent between maps in a map series? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Has the extent been cropped badly so that areas of data that should be there are cut off (e.g. on a global map is top of Greenland or Antarctica missing?) | ☐☐ Yes - accidentally cropped<br>☐☐ Yes - cropped but extent appropriate for map<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| 6. Data visualisation checks | Has the correct classification scheme been used when grouping data for display on map?<br><br>(see *section 4.2*) | ☐☐ Yes<br>☐☐ No<br>☐☐ Uncertain<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Is it clear how any derived data have been produced? | ☐☐ Yes - methods described<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Have areas of No data / 0 value been correctly symbolised? | ☐☐ Yes<br>☐☐ No<br>☐☐ Uncertain<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Have appropriate selections been made on datasets e.g. for IUCN data recommended presence/origin selections, WDPA data status etc. | ☐☐ Yes<br>☐☐ Not clear<br>☐☐ No – needs modifying<br><br>*Reviewee please specify what selections have been made:* | | ☐ Issue Flagged<br>☐ Fixed |
| | Have correct / latest versions of data been used? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Are there any missing datasets that could help improve the data content or clarity of the map? | ☐☐ Yes (Please specify):<br><br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |

| Map Quality Assurance checklist continued ……. | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 7. Administrative boundaries<br><br>*(Note: boundaries are often wrong. Ensure you are using an official source for your organisation)* | Is your organisation required to use a specific source for boundaries? | ☐☐ UN boundaries<br>☐☐ Official country boundaries from country<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have official UN boundaries (ClearMap) or official boundaries (from country) been used? | ☐☐ Yes - UN Clear Map boundaries<br>☐☐ Yes – official country boundaries used (but same as UN)<br>☐☐ Yes – official country boundaries used (but different to UN)<br>☐☐ No<br>☐☐ N/A – no boundaries presented | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have advised UN boundary symbology been used to represent different types of administrative boundary lines? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are disputed boundaries correctly symbolised to be distinguishable from other boundaries? | ☐☐ Yes – symbolised correctly<br>☐☐ Yes – symbolised incorrectly<br>☐☐ Yes – not distinguished from other boundaries<br>☐☐ N/A - No disputed areas | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have countries and disputed territories been labelled according to UN guidance? | ☐☐ Yes – all labelled correctly<br>☐☐ No – disputed labels omitted<br>☐☐ No – labelled incorrectly<br>☐☐ N/A - No disputed areas<br>☐☐ N/A - No labelling of countries | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have correct spellings been used for other labels e.g. places and seas etc.? | ☐☐ Yes – all labelled correctly<br>☐☐ No – some spelling or labelling incorrect | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Does the basemap used also comply with the above standards for boundaries and labelling | ☐☐ Yes - basemap complies with standards for organisation<br>☐☐ Yes - but incorrect borders or labels<br>☐☐ N/A - No basemap used | | ☐ Issue Flagged<br><br>☐ Fixed |
| 8. Colours and symbology<br><br>(see section 4.3 & section 4.4))<br>Note: Check maps in either in preview mode in QGIS or uploading image to *https://www.color-blindness.com/coblis-color-blindness-simulator/* | Has a good choice of colours been used? | ☐☐ Yes<br>☐☐ No – needs modifying | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are class breaks between colour ramps distinguishable? | ☐☐ Yes<br>☐☐ No – needs modifying | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Have appropriate symbologies been used for all layers? | ☐☐ Yes<br>☐☐ No – needs modifying | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has the map been checked as colour-blind friendly? | ☐☐ Yes – OK<br>☐☐ Yes – needs modifying<br>☐☐ No - needs checking | | ☐ Issue Flagged<br><br>☐ Fixed |

| Map Quality Assurance checklist continued ……. | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 8. Colours and symbology continued… | Is there consistency in colours, symbology labelling, style etc. across a map series | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 9. Other map elements | Does the map have a North Arrow? | ☐☐ Yes<br>☐☐ No – needs adding<br>☐☐ No – Not needed | | ☐ Issue Flagged<br>☐ Fixed |
| | Does the map have an appropriate scale bar? | ☐☐ Yes<br>☐☐ Yes – but too small<br>☐☐ Yes - but too big<br>☐☐ No – but required<br>☐☐ No – Not needed | | ☐ Issue Flagged<br>☐ Fixed |
| | Does map have appropriate graticule? | ☐☐ Yes<br>☐☐ Yes – Needs modifying<br>☐☐ No – but required<br>☐☐ No – Not needed | | ☐ Issue Flagged<br>☐ Fixed |
| | Are borders and boxes around maps, textboxes and legend evenly spaced? | ☐☐ Yes<br>☐☐ No – needs modifying | | ☐ Issue Flagged<br>☐ Fixed |
| | Has anything else been omitted that could help improve the map? | ☐☐ No<br>☐☐ Yes - Please specify: | | ☐ Issue Flagged<br>☐ Fixed |
| 10. Map insets | Has the map got any **map insets** and have they appropriately used? | ☐☐ Yes - inset appropriate & clear<br>☐☐ No - inset needs modifying<br>☐☐ No inset - but would be helpful<br>☐☐ No inset required | | |
| | Does inset have a scale bar? | ☐☐ Yes<br>☐☐ Yes – but too small<br>☐☐ Yes - but too big<br>☐☐ No – but not needed<br>☐☐ No – but required<br>☐☐ N/A | | |
| | Does inset have a legend? | ☐☐ Yes<br>☐☐ No – as same data as main map<br>☐☐ No – but would be helpful<br>☐☐ N/A | | |
| 11. Permissions, disclaimers, logos, citations and methods | Does the map have appropriate logos and at high enough resolution? | ☐☐ Yes<br>☐☐ Yes but too low resolution<br>☐☐ No - missing so needs adding<br>☐☐ N/A – as part of wider report<br>☐☐ No – Uncertain | | ☐ Issue Flagged<br>☐ Fixed |
| | Are required logos appropriately displayed | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A as part of wider report | | ☐ Issue Flagged<br>☐ Fixed |
| | Has permission to use logos been sought and received? | ☐☐ Yes<br>☐☐ No<br>☐☐ Awaiting permission<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |

| Map Quality Assurance checklist continued ……. | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 11. Permissions, disclaimers, logos, citations and methods continued…<br><br>*(see UN disclaimer http://undocs.org/ST/AI/189/Add.25/Rev.1.* | Does map have UN map disclaimer (or another organisational disclaimer if you are not a UN organisation) | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are all data sources correctly cited? | ☐☐ Yes<br>☐☐ No – needs modifying | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Is there a clear description of methods (if appropriate) | ☐☐ Yes<br>☐☐ Yes –but needs modifying<br>☐☐ No - Needs adding<br>☐☐ No - Not needed | | ☐ Issue Flagged<br><br>☐ Fixed |
| 12. Additional permissions questions specific to online / interactive maps | Has permission been granted by the data owner to display the data online in an interactive map? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Has permission been granted by the data owner to allow download of data from the interactive map? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are licencing terms & conditions displayed & applied appropriately on the interactive map website? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| 13. Non-static / interactive map checks relating to functionality | Does the map display correctly on all internet browsers | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Does the map function correctly on all internet browsers? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Is the speed of draw acceptable? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Is the speed of analysis acceptable? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Is the user interface easy to navigate? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are there user instructions? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Do all navigation buttons tabs and links work correctly? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |

## Annex 4: Data Quality Assurance checklist

| Data Quality Assurance checklist | | | |
|---|---|---|---|
| **PROJECT DATA CHECKS (fill out for each individual dataset to be reviewed)** | | | |
| Title of dataset: *(i.e. descriptive name)* | | | |
| Location of file: *(i.e. full path & filename)* | | | |
| **Review type:** | ☐ Internal / derived data generated by project<br>☐ external data | | |
| **For review of EXTERNAL DATA obtained for use by project**<br>(Project data level data manager to undertake review) | | | |
| Dataset licence: | | | |
| Dataset provider: | | Date provided: | |
| Dataset providers require copy of outputs: | ☐ Yes ☐ No | | |
| Dataset download link (if available): | | | |
| **For review of INTERNAL / DERIVED data generated by project**<br>(organisational level data manager or identified data focal point to undertake review) | | | |
| Comments by author of internal or derived data: | | | |
| Requested by: *(i.e. Enter Name and email)* | | Project/ project code: | |
| Request date: | | Review deadline: | |
| **Data QA check** | **Date:** | **by:** | |
| **QA sign-off** | **Date:** | **by:** | |

| **Section 1:** | **Provides an overall summary. Answers should be based on answers to questions in sections 2 and 3, which should be completed first.** | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| Overall Assessment | How can data quality best be categorised? Please tick those that apply | ☐☐ Complete<br>☐☐ Incomplete<br>☐☐ up to date<br>☐☐ out of date<br>☐☐ Consistent<br>☐☐ High Precision/resolution<br>☐☐ Low Precision/resolution<br>☐☐ official (e.g. government accepted source)<br>☐☐ non-official<br>☐☐ complete<br>☐☐ Accurate<br>☐☐ Inaccurate | | ☐ Issue Flagged<br>☐ Fixed |

| Data Quality Assurance checklist: Section 1 continued …… | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| Terms and Conditions | Are there any restrictions of use or access to the data? | ☐☐ Yes<br>☐☐ No<br>☐☐ Don't know | | ☐ Issue Flagged<br>☐ Fixed |
| | Have terms and conditions of access and use been abided by? | ☐☐ Yes<br>☐☐ No<br>☐☐ Don't know | | ☐ Issue Flagged<br>☐ Fixed |
| Data Quality Assessment | Does the dataset have Metadata? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Has dataset been published and peer reviewed? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Are there any existing known data quality issues | Known issues: ☐☐ Yes ☐☐ No<br>Perceived issues: ☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Will data quality support your intended use? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Ensure datasets comply with data standard: | ☐☐ Checked for complete set of fields & they DO comply<br>☐☐ Checked for minimum set of fields and they DO comply<br>☐☐ Not checked<br>☐☐ Do NOT comply | | ☐ Issue Flagged<br>☐ Fixed |
| | How difficult is it to fix identified issues and what will impact be on project?<br>*Please specify in the comments box details regarding impact in terms of time and budget and inform project leader:* | ☐☐ quick and easy<br>☐☐ easy but not quick to fix<br>☐☐ Difficult but possible to fix but not quickly<br>☐☐ Very difficult to fix and very time consuming<br>☐☐ Not able to fix therefore dataset can't be used. | | ☐ Issue Flagged<br>☐ Fixed |
| Uniqueness | Are there any alternative datasets that could be explored/used? | ☐☐ Yes<br>☐☐ No - Please specify: | | ☐ Issue Flagged<br>☐ Fixed |
| Data correction process / feedback | Have any QA processes, scripts or tools been run to check quality of data? | ☐☐ Yes<br>☐☐ No<br>*If yes: please summarize in the comments box how checks were undertaken, and which scripts/tools were used (if any).* | | ☐ Issue Flagged<br>☐ Fixed |
| | Can corrections been made internally/ or does this have to have to go back to data provider for correction? | ☐☐ Yes – can be done internally<br>☐☐ No – needs to be done by data provider<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Has feedback been provided to data providers | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |

| **Data Quality Assurance checklist: Section 2: Spatial checks** | | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 1.Data transformation checks | Does the dataset have a coordinate reference system defined? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Do the data fall in the correct place i.e. *check it appears in the correct place in the world and not misaligned* | ☐☐ Yes<br>☐☐ No – there is a shift in the dataset compared to other boundary layers<br>☐☐ No – the data fall in completely the wrong place | | ☐ Issue Flagged<br>☐ Fixed |
| | Can the dataset be opened? And is there data present? | ☐☐ Yes – can be opened and data present<br>☐☐ No - can be opened but data not present<br>☐☐ No – cannot be opened | | ☐ Issue Flagged<br>☐ Fixed |
| | When data are projected did it transform correctly i.e. number of vertices to bend lines, shifting of data to incorrect place | ☐☐ Yes – data all present and fall in correct place<br>☐☐ No – straight lines did not project correctly<br>☐☐ No – data now misaligned due to transformation Process | | ☐ Issue Flagged<br>☐ Fixed |
| 2. Area and distance calculations | Were any area calculations carried out on the data? | ☐Yes<br>☐No<br><br>If area was calculated:<br>Were correct units used?<br>☐☐ Yes ☐☐ No<br>Were geodesic algorithms used to do calculation?<br>☐☐ Yes ☐☐ No<br><br>OR<br><br>Was an appropriate equal area projection used to do calculation?<br>☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Were any distance calculations carried out on the data? | ☐Yes<br>☐No<br><br>If area was calculated:<br>Were correct units used?<br>☐☐ Yes ☐☐ No<br>Were geodesic algorithms used to do calculation?<br>☐☐ Yes ☐☐ No<br>OR<br>Was an appropriate equidistant projection used to do calculation?<br>☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |

| **Quality Assurance checklist:** | **Section 2: Spatial checks continued ….** | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 3. Vector specific data checks | Do polygon datasets contain polygon features? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Do point datasets contain point features? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Do polyline datasets contain polyline features? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Has the data been provided in a format that allows functionality without errors between ArcGIS and QGIS | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Has any data exceeded the 180 degrees line? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Have repair Geometries been applied? Please tick those that apply: | ☐☐ Yes - ArcGIS (ESRI)<br>☐☐ Yes – ArcGIS (OGC)<br>☐☐ Yes - QGIS (fix geometries)<br>☐☐ Yes - Other<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| *Tip: For detecting and fixing slivers suggest looking at the method documented here (https://teres henkov.word press.com/20 14/04/08/fig hting-sliver-polygons-in-arcgis-thinness-ratio/) to identify slivers. You may need to adjust threshold to identify slivers for your dataset. Once slivers identified use the eliminate tool in ArcGIS or 'Eliminate selected polygons' in QGIS tool to fix them* | Has dataset been checked after repair Geometry | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Was anything missing in the attributes or spatial data following repair geometry (compared to the original dataset) | ☐☐ Yes<br>☐☐ No<br>*Please specify reasons for anything missing in the comments box* | | ☐ Issue Flagged<br>☐ Fixed |
| | Can missing or corrupted data be fixed and reinstated? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Does the dataset contain any duplicate features? | ☐☐ Yes<br>☐☐ No<br>Were duplicate features removed before performing any area calculations or summaries?<br>☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Does the dataset contain single part or multipart features | ☐☐ Singlepart<br>☐☐ Multipart<br>And is this the best way to store the data in this particular dataset:<br>☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Does the dataset contain any sliver polygons (small thin error polygons<br>← see tip shown left) | ☐☐ Yes<br>☐☑ No | | ☐ Issue Flagged<br>☐ Fixed |

| **Quality Assurance checklist:** | **Section 2: Spatial checks continued ….** | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 3. Vector specific data checks continued… | Does dataset contain expected number of features | ☐☐ Yes<br>☐☐ No<br>☐☐ Don't know | | ☐ Issue Flagged<br>☐ Fixed |
| 4. Raster specific data checks | Do values in the dataset look correct *(e.g. look at range of data and minimum and maximum values)* | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Can you distinguish between no data and data in the dataset | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Is it clear what the values means and what units they are in? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Does the raster have a raster attribute table and can it be viewed (only viewable in ArcGIS) | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Has appropriate cell size been used for intended application? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Are all data present following running of any geoprocessing tool. Do outputs look correct? Are any values/data missing? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | If data have been correctly aggregated or resampled? What method was used? | ☐ Aggregation strategy<br>☐ Sum ☐ Min ☐ Max<br>☐ Mean ☐ Median<br><br>☐ Resampling strategy<br>☐ Bilinear<br>☐ Nearest<br>☐ Cubic<br><br>**Was method correct for type of data?**<br>☐☐ Yes ☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| | Are cells aligned with other raster datasets and original raster dataset?<br>(check cell size and alignment between layers and of outputs) | ☐☐ Yes – no change in alignment of original dataset<br>☐☐ Yes – aligned with a template raster for consistency in analysis<br>☐☐ No - dataset is mis-aligned | | ☐ Issue Flagged<br>☐ Fixed |

| **Quality Assurance checklist:** | **Section 3: Attribute checks / tabular data checks** | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 1. Formatting | Are all inputs in the correct format (spelt correctly, accents (utf-8), consistent in their formatting, Leading and trailing white spaces removed) | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| 2. Units | Is there consistency of units for numerical data (e.g. all values in metres) | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 3. Duplication | Is there any duplication of values in look-up tables | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| 4. Order | Has the order of columns changed or name of columns changed from the skeleton provided? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 5. Multiple selections | Are multiple selections/values separated by ";" ? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 6. Missing entries | Are missing values recorded with consistent value? (e.g. value for no data or missing values e.g. is it "9999 or -9999" for numeric fields or "Not Reported" for text fields). | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 7. Values not in look up table | Check completeness. Are there any values not in look-up table. | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| 8. Calculation units | Have calculations been made correctly?<br><br>Does order of magnitude / units in data make sense for data? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A<br><br>☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| 9. Field types<br><br>(Note: *choose the field type that takes up the least storage space when choosing between short and long integer or between double and float)* | For numerical data (whole numbers), are all inputs numerical and field types either short or long integer, depending on the range of data? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | For numerical data (with decimal point) are all inputs numerical and field type is either double or float, depending on the range of data? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | For fields containing ratios, are field types text/string and all inputs in Ratio to 1 form (e.g. do all cells which contain a "1:")? | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | For data containing dates has a consistent date format been used unless storing just part of a date e.g. if only recording 'year' then consider using a text field with 4 characters | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |
| | Have restriction rules have been correctly applied (e.g. emails have "@", resource links have "http://" | ☐☐ Yes<br>☐☐ No<br>☐☐ N/A | | ☐ Issue Flagged<br>☐ Fixed |

| **Quality Assurance checklist:** | **Section 3: Attribute checks / tabular data checks** | | | |
|---|---|---|---|---|
| **Element** | **Question** | **QA Answer**<br>☒ reviewee answer<br>☑ reviewer confirmation | **Comments (by reviewer /reviewee)** | **Issue flagged / fixed** |
| 10. Field content / completeness rules | Have all fields been checked for completeness based on the following rules?<br><br>*Please tick those that apply*<br><br>Please also provide review with frequency/summary tables to evidence the summary of values for each field. | ☐☐ Valid values, range, data type, pattern, and domain.<br>☐☐ Evaluating completeness of optional versus mandatory fields How many "Not Reported" or missing values in each field?).<br>☐☐ Reasonable/sensible distribution of values within field.<br>☐☐ Valid values when values in one column depend on values in another.<br>☐☐ Valid values when optional becomes mandatory when other columns contain certain data.<br>☐☐ Valid values when mandatory becomes null when other columns contain certain data.<br><br>**Confirmation all fields checked for the above rules:**<br>☐☐ - Yes<br>☐☐ - No | | ☐ Issue Flagged<br><br>☐ Fixed |
| **Quality Assurance checklist:** | **Section 4: Specific country checks based on standard LUT values** | | | |
| 1. Quality Checks for **Country ISO3 codes** (if Applicable)<br><br>***Good practice:*** *Country codes should be used rather than country names to avoid mis-spelling and to enable efficient joining by country code to other spatial or non-spatial datasets* . | Has an ISO3 code been assigned to all geographic observations? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are there any incorrect or old ISO3 codes present? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are there inaccurate associations of ISO3 codes with Parent ISO code? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Geographical vs Political ISO3 codes – check that countries are labelled according to organisational guidance e.g. UN guidance (*see https://geoportal.dfs.un.org/arcgis/home/item.html?id=541557fd0d4d42efb24449be614e6887*) | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are there discrepancies between the assigned ISO3 code and its geographical location using GIS (within x buffer / tolerance)? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are any disputed area ISO3 codes present? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |
| | Are all expected ISO3 codes present? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br><br>☐ Fixed |

| **Quality Assurance checklist:** | **Section 5: Metadata checks / creation** | | | |
|---|---|---|---|---|
| Metadata standard | Has metadata been compiled according to organisational standard (e.g. INSPIRE) | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| Completeness | Are all the required (mandatory) metadata fields populated? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| Validity / Accuracy | Is the metadata from a verifiable source, and does it accurately describe the data? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| Accessibility | Is the data correctly attached to the data and accessible to the user? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| Transparency | Has the spatial logic and workflow been properly documented so that someone else could replicate the analysis and understand why different steps were taken | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |
| **Quality Assurance checklist:** | **Section 6: Storage of spatial methods, code, scripts and models** | | | |
| Script / Workflow and code storage | Has the code been properly stored on a network so that others can easily access the code and reuse it? | ☐☐ Yes ☐☐ No ☐☐ Don't know<br>**Please specify whether it is on:**<br>☐ Personal computer/drive<br>☐ Organisational network<br>☐ GitHub repository<br>☐ Other | | ☐ Issue Flagged<br>☐ Fixed |
| | Link to location of code: | Please specify location: | | ☐ Issue Flagged<br>☐ Fixed |
| | Link to workflow and method documents | Please specify location: | | ☐ Issue Flagged<br>☐ Fixed |
| | Is it clear which is the final code and workflow i.e. is there proper version control? | ☐☐ Yes<br>☐☐ No | | ☐ Issue Flagged<br>☐ Fixed |