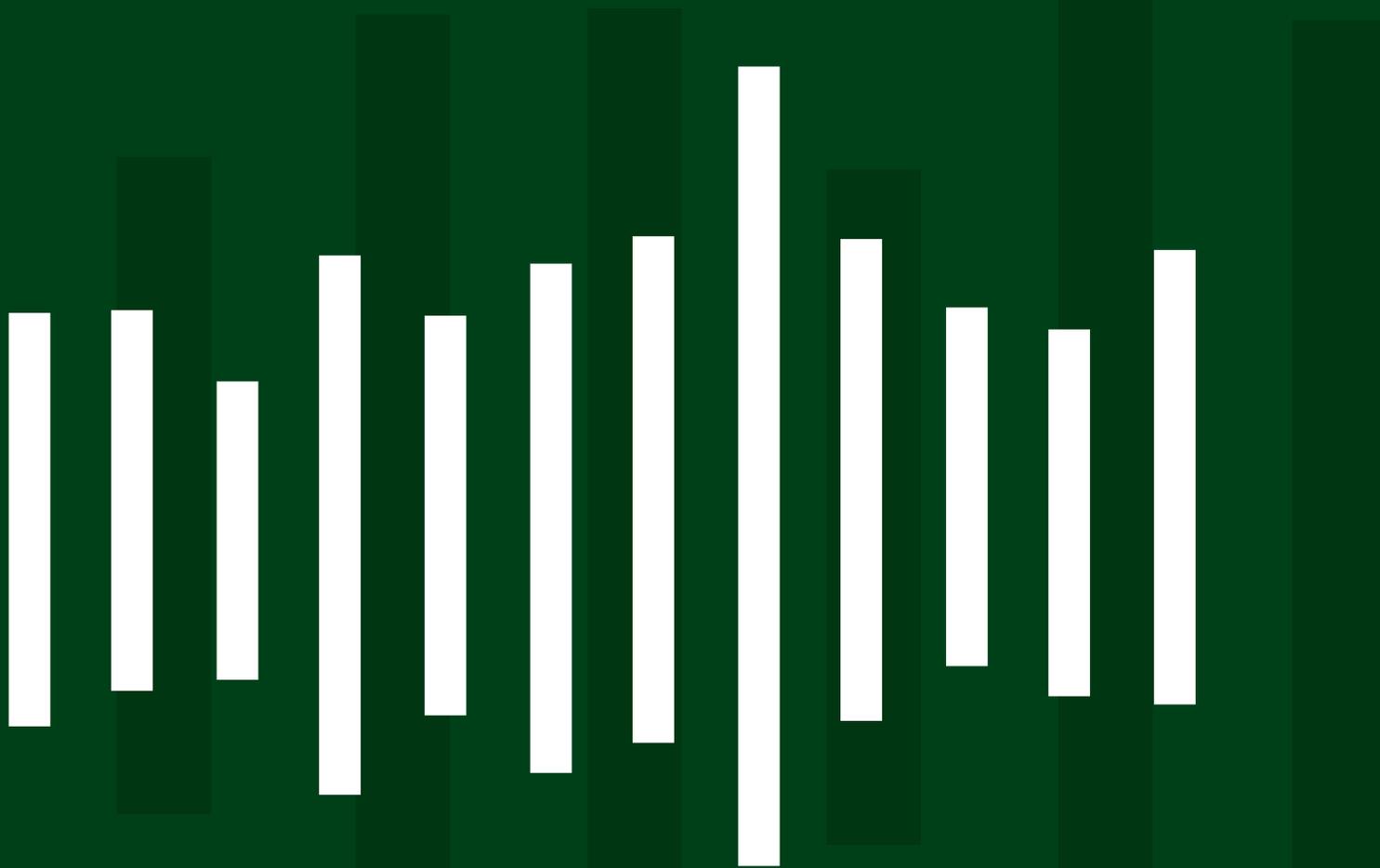




PBL Netherlands Environmental
Assessment Agency

Visualising Knowledge

Lessons from 25 years of policy-related data visualisation



Foreword

A picture is worth a thousand words.

A suitable phrase, at least for images that carry a message. PBL Netherlands Environmental Assessment Agency and its predecessors have a long tradition of visualising the results of scientific research. The graphs, maps, diagrams and infographics collected in this volume show how our visualisation team has developed, over the past 25 years. Over the past 25 years, countless greatly expressive images were created, in those 25 years, and have proved indispensable in communicating PBL's scientific insights to policymakers, politicians, the media and society at large.

Project leaders and authors at PBL greatly appreciate how the visualisation team enhances their work. In consultation with our researchers and authors, the team members search for the most appropriate depiction of the research findings. Seemingly

minor points, such as colour scheme or choice of symbol, turn out to be very important. An incorrectly or unclearly designed graph or infographic may completely mislead the reader. Conversely, well-chosen visualisations can have a surprisingly great impact. Visualisation can instantly clarify a relationship that is rather complex and abstract. Moreover, experience has shown that a clever visualisation can also provide researchers themselves with a new way of seeing the results of their work — images giving rise to fresh insights.

The quality of our visualisations is also noticed, recognised and acknowledged outside PBL. For example, the visualisation team received the 2013 Annual Infographics Award from the Professional Association of Dutch Designers and the Dutch Association of Journalists for their work on the PBL publication '*Nederland Verbeeld*'.

A remarkable achievement. At least as important is the PBL visual identity that the team uses in PBL's defining publications. It contributes to the quality and recognisability of the visualisations and is met with many positive reactions from within and outside the organisation.

But enough said. We invite you to take a look behind the scenes of data visualisation and enjoy this inspiring volume with its rich palette of images. This publication is also instructive as it clearly imparts the lessons learned over the past 25 years. It is written in an accessible way and, needless to say, creatively illustrated. You can acquaint or reacquaint yourself with the members of the current team, the individuals who carry out their work often facing very tight deadlines and who manage to hold quality standards in high regard thanks to the team's solid structure. A team to be proud of!

Rob Weterings,
Head of Integrated
Environmental Policy Analysis

Hans Mommaas,
Director-General of PBL Netherlands
Environmental Assessment Agency

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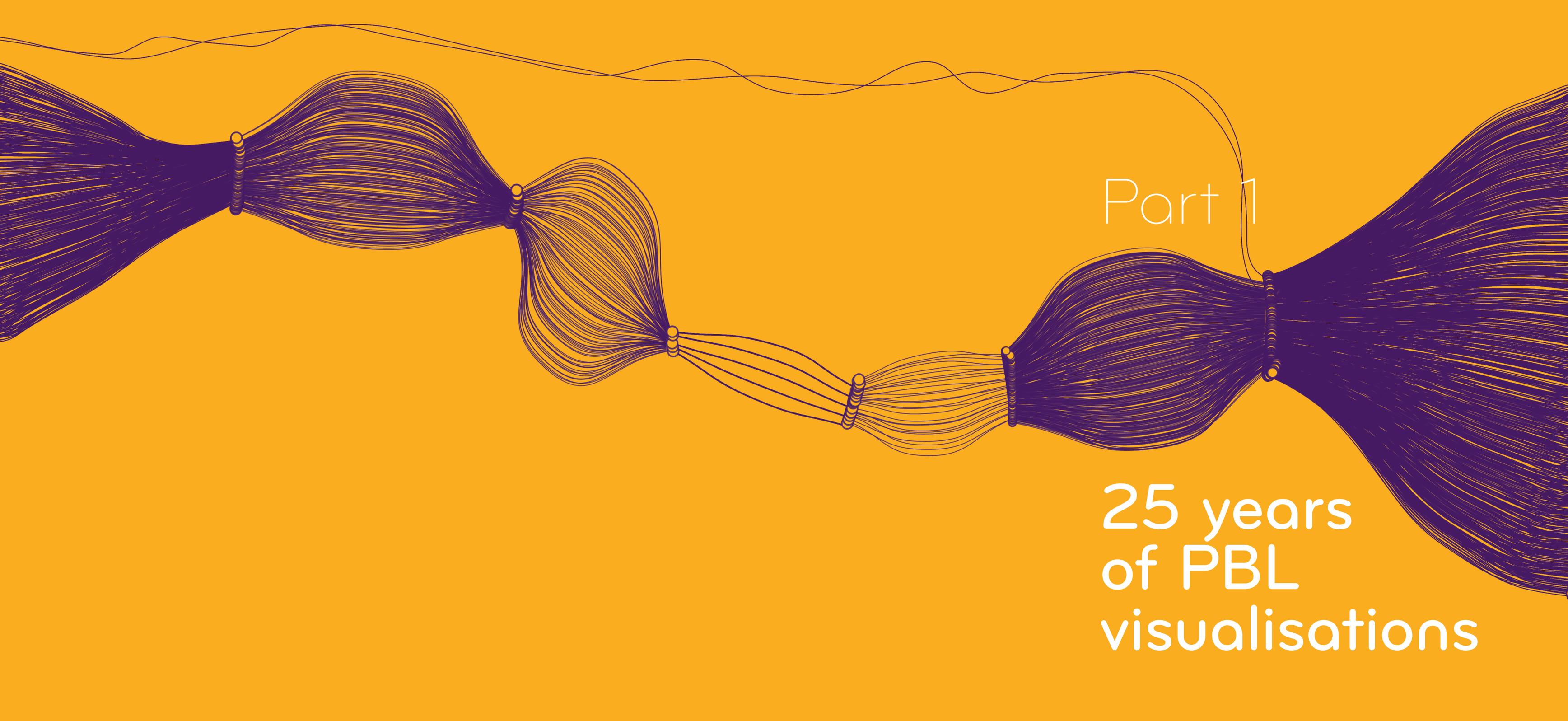
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Part 1

25 years
of PBL
visualisations

This is how we do it

The stepwise approach of the PBL visualisation team

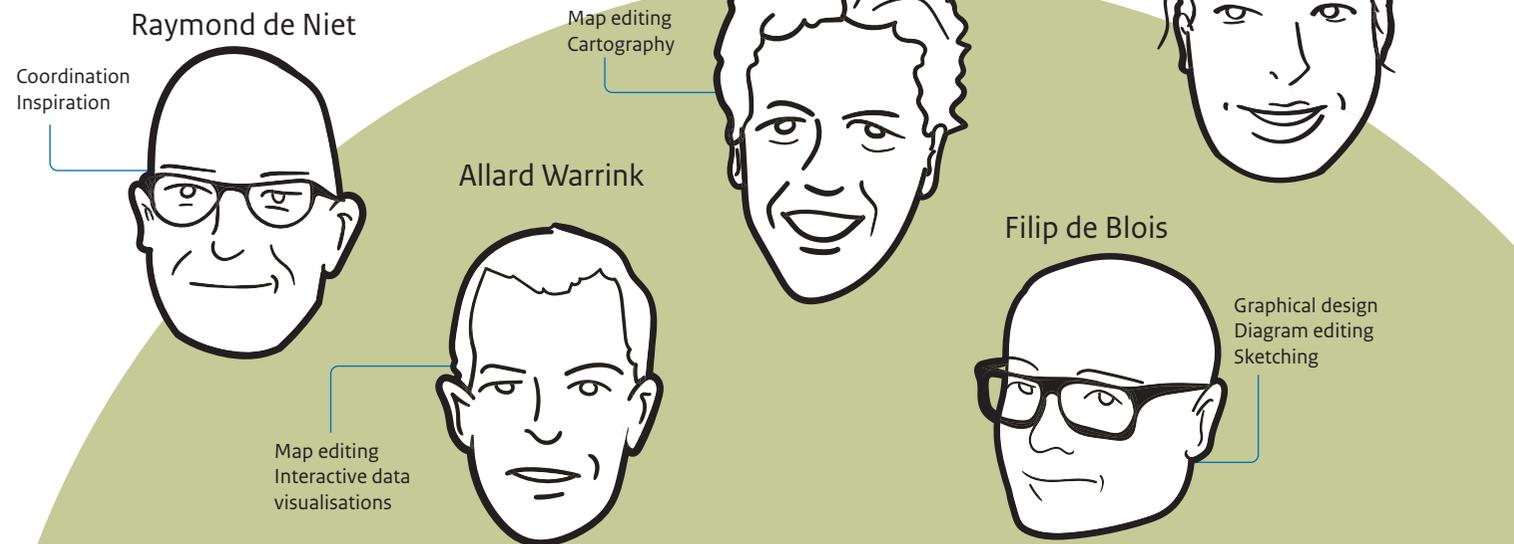
From layout to editing

Twenty-five years ago, graphic image editing was in the hands of two part-time employees, and the work involved a few geographical maps and a number of graphs each year. Because of stricter quality requirements and an increasing demand for graphics, the image editing process was set up more professionally with two image editors and a group of student workers. Eventually, a number of those students became permanent employees. Since 2005, we have been operating with a permanent visualisation team in addition to one image editor per PBL department; together, they make up the image editing team. Over the past 25 years, the nature of the work has also changed; while, in the early years, this mainly involved using house style in layout, at present, the most important activities include providing advice and editing.

Multidisciplinary teamwork — expertise and specialisation

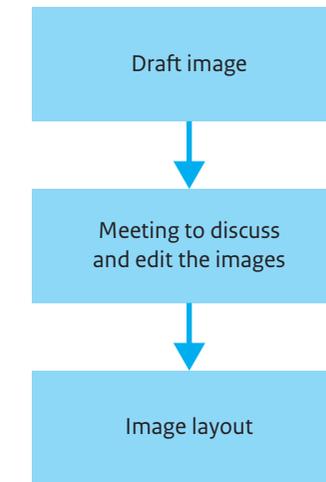
In most cases, the image editors in the individual departments are researchers; in addition to their research work, they dedicate between half a day and one day a week to working on graphics. At present, the permanent visualisation team consists of five people working either full-time or part-time. It is a multidisciplinary team that has expertise in the fields of data visualisation, cartography and graphic design. All team members have their own specialisation, varying from graphs to maps, diagrams or coordination.

Visualisation team in 2021



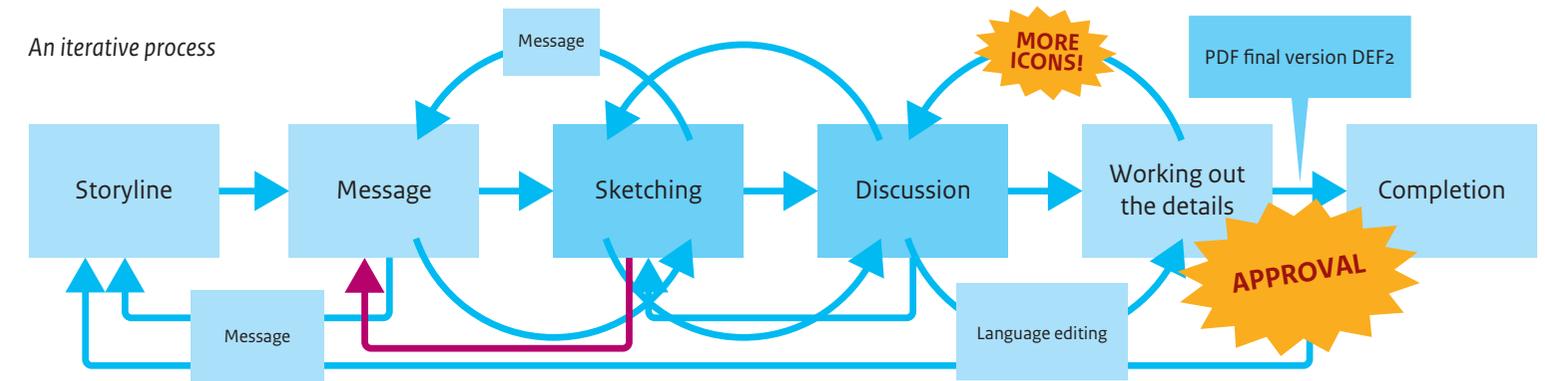
Conveying a clear message: visual editing

Charts and other visualisations need to send a clear message. At PBL, we ensure this by using well thought-out graphic design and a thorough editing process for the images. In the process, we ask ourselves and the researchers two questions: What message should the visualisation convey? How can we make changes to the visualisation to best express that message? We also take into account for whom the visualisation is intended.



For iconic PBL products, such as the Assessment of the Physical Environment and the Climate and Energy Outlook, an extensive layout and editing process is followed. The image editors of the departments take care of the draft image layout, after which the images are handed over to the permanent visualisation team for further processing. The team then discusses the images with the project leader or researcher concerned. The images (i.e. graphs, maps and other illustrations) are subsequently prepared in their definitive form — layout and PBL house style. For the other types of PBL products, the image editors at the PBL departments take care of the layout of the images and a limited editing round.

An iterative process



Special images, such as infographics and dynamic images, are created in a number of phases. This is an extensive and creative process, in which a storyline is developed, various sketches and drafts are made and discussed — often multiple times. The visualisation team is involved in this process at an earlier stage and work together with content writers and researchers on producing the final result.

What about photographs?

In the past, the visualisation team was in charge of editing photographs — setting up image themes and finding photographs that would match the subject, looking at the technical aspects, such as quality in terms of resolution, size and colour. Today, PBL uses commercial image libraries that offer photographs of high technical quality. The challenge is to apply the right search terms to find the right photographs for a certain subject and message. Given the changed nature of the work around photographs, this task was transferred from the visualisation team to PBL's communications department, in early 2021.

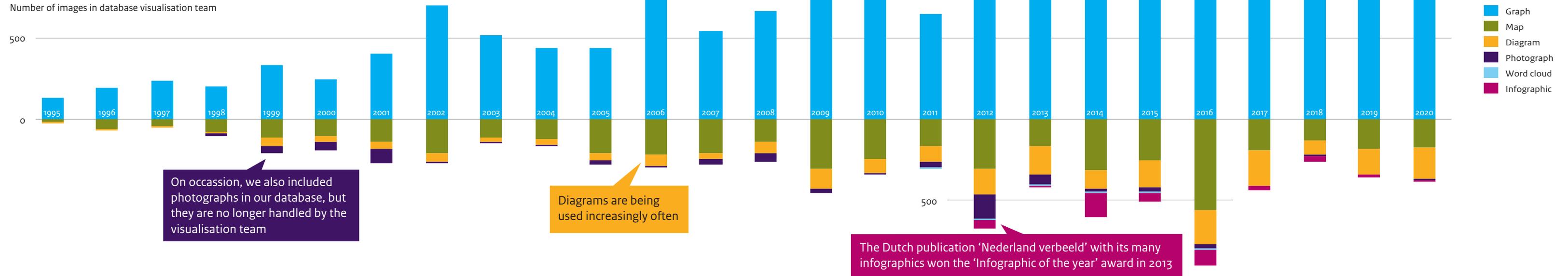
Growth in expertise

25 years of knowledge in images

PBL has worked with a team of image editors since 1995. Over the years, the team has had different names: Redactie- en productieteam (Editing and Production Team), Beeldredactieteam (the Editorial Team for Images), and, since 2019, Visualisatieteam (visualisation team). It consists of five permanent members, and in addition, each PBL sector has appointed a colleague who can help with the creation of figures.

All the images handled by the visualisation team are stored in our IndiBase database. This allows us to reproduce and reuse all figures. Over the years, we have started to produce more and more figures, while always keeping an eye on quality. The IndiBase now contains almost 30,000 figures.

The distribution of the various types of images varies, depending on the type of PBL publication
Number of images in database visualisation team

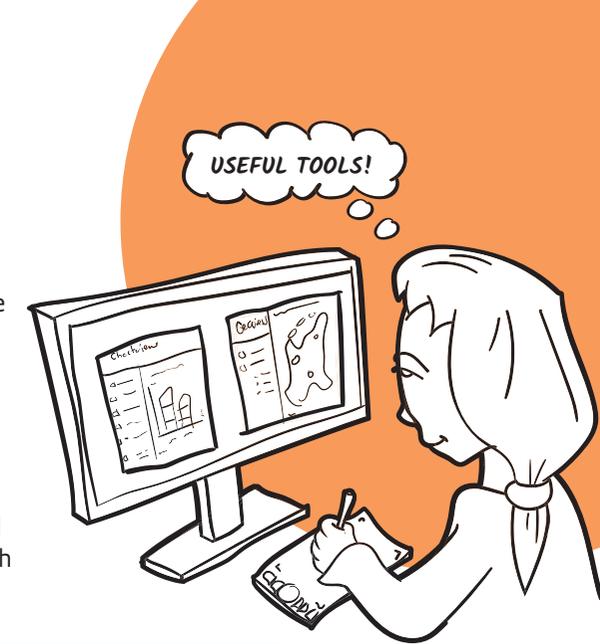


Visualisation tools

In our visualisation work we use various tools and programmes. In addition to commercially available software made by Adobe (including Illustrator and Photoshop) and Esri (including ArcGIS), since 1998 we have been using three applications that were custom-made for our organisation. Chartview is used for graphs, Geoview for maps, and IndiBase for the work flow management. These tools and applications support the work process and make it possible to quickly and easily create figures in the house style. Chartview and Geoview use fixed templates, in which design (the template itself) and content (the data) are kept separate. This means it is possible to change the layout by choosing another

template, without having to compose the data all over again. IndiBase serves to streamline and support the work process, and handle version management of the figures while at the same time acting as the historical archive. As such, the programme also offers the possibility to reproduce figures.

To create dynamic and interactive figures and to automate figure production, we use the programming languages Python, R and Javascript, if necessary, in combination with D3.js and HighCharts.



A link between worlds

From complicated to comprehensible

A rich source of inspiration for PBL's visual work is the production of the Austrian-German couple Otto and Marie Neurath from the mid-20th century. Otto was keen on making scientific knowledge accessible to a wide audience and did so through public exhibitions. He developed the ISOTYPE system to tell stories with icons. After Otto's death, Marie continued the efforts and put their approach in writing. To ensure the creation of proper visualisations, they devised a division of roles, which is what we apply when developing our infographics.

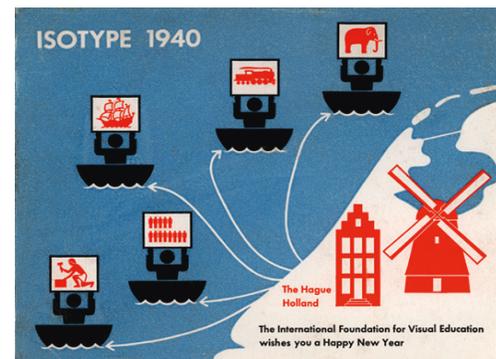
In a simple model, you put a scientist and a designer around the table, and the

designer directly translates the scientific knowledge into a visualisation. The Neuraths propose to also invite to the table what they called a transformer — someone who can turn scientific knowledge into an understandable story, which the designer can then work with.

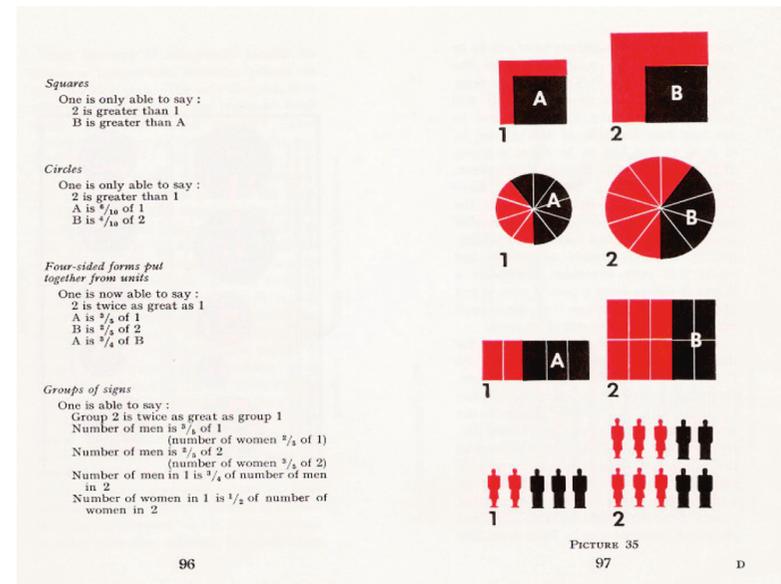
The three roles do not always need to be occupied by three individuals. As a project gets bigger, the group often grows. Having multiple disciplines around the table helps to achieve a better and more inclusive final result. At PBL, we try to be mindful of these

roles. The larger the team and the more important images are for the publication, the more important the composition of the team, with regard to these roles.

To achieve closer involvement with the content, the designer and the transformer need to be engaged in the process at an earlier stage. And the scientist also needs to start thinking about what the publication should look like at an earlier stage.



ISOTYPE New Year's card 1940



ISOTYPE instruction from International Picture Language, Otto Neurath, 1936

Scientists/experts

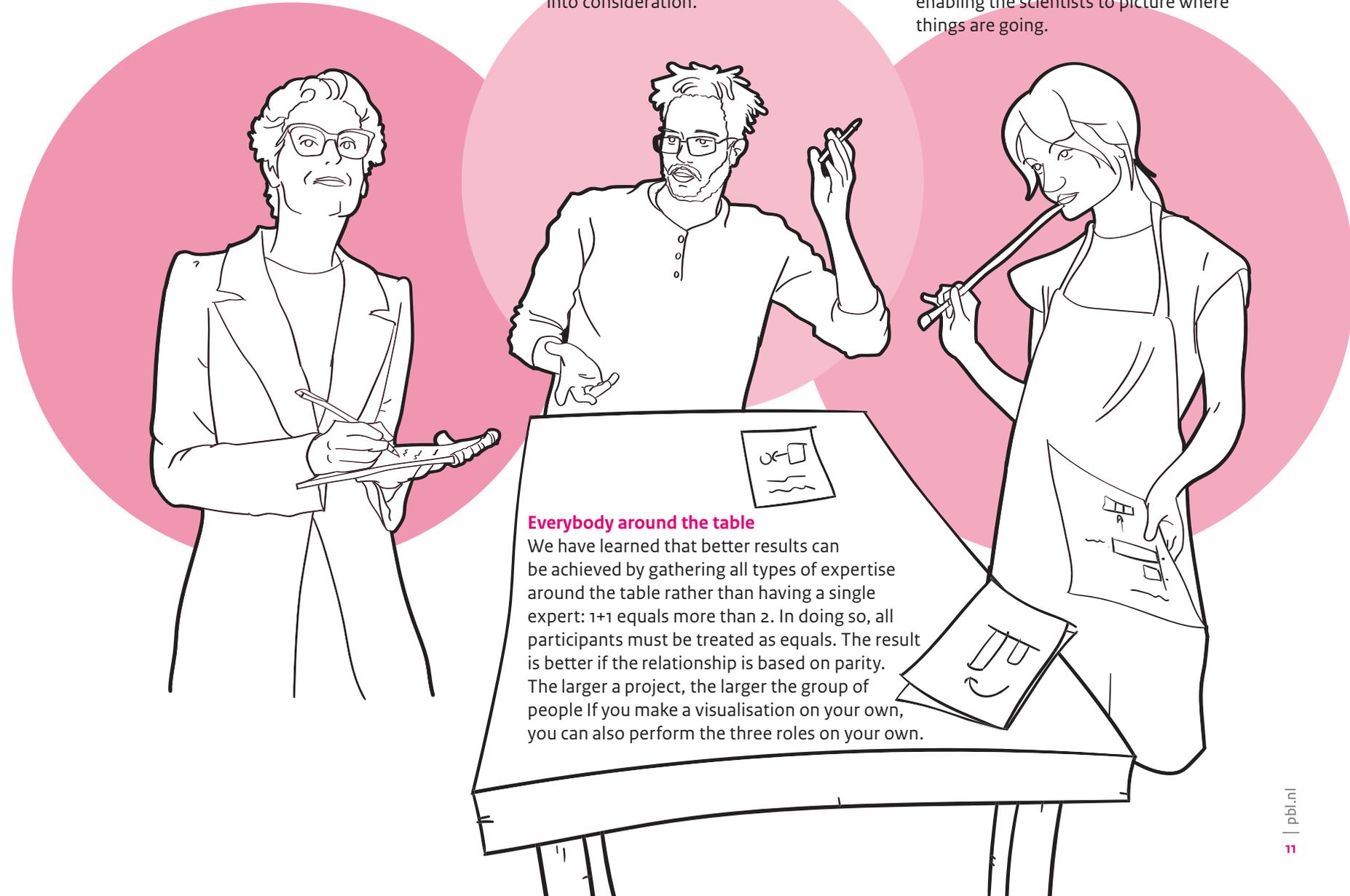
Scientists and experts have scientific knowledge and relationships. They collect data and information. They are often the ones with final responsibility for the results and scientific accuracy.

Transformers

Transformers set up stories by examining and structuring the data. They create a clear narrative based on the scientist's knowledge, know what is needed in the public debate and take the target audience into consideration.

Designers

Designers use creativity to design and produce the infographics. They come up with solutions for visualising complex stories and make sketches that are the basis for sharpening the storyline and for enabling the scientists to picture where things are going.



Everybody around the table

We have learned that better results can be achieved by gathering all types of expertise around the table rather than having a single expert: 1+1 equals more than 2. In doing so, all participants must be treated as equals. The result is better if the relationship is based on parity. The larger a project, the larger the group of people. If you make a visualisation on your own, you can also perform the three roles on your own.

That one is clearly by PBL

The 10 ingredients of a PBL visualisation

After publication, images often take on a life of their own. They are frequently used in other publications, in presentations or on social media.

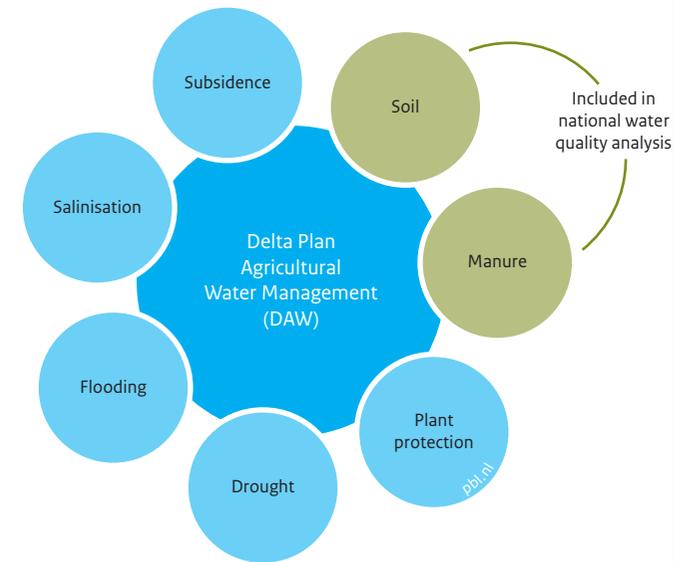
The layout of PBL visualisations is recognisable to everyone. Our starting

point is that visualisations should be enjoyable to read and look uncluttered (by leaving out as many unnecessary details as possible), while at the same time being maximally informative (by having a clear title, a good legend and a reference to the source).

We have established conventions on graphs, maps and diagrams, and apply a standard layout.

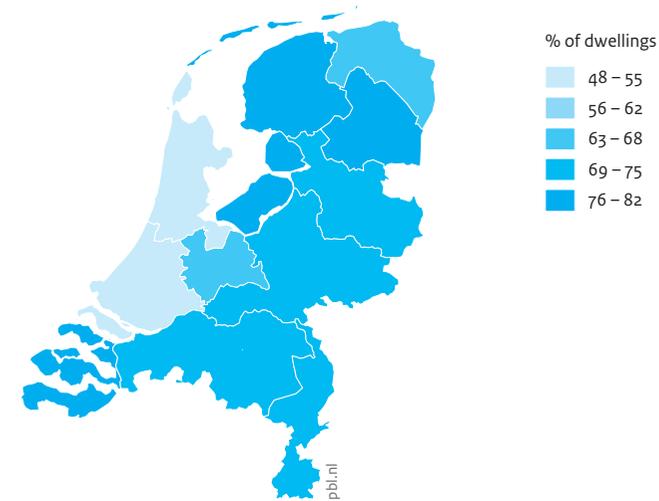
This has resulted in ten typical features by which a figure created at PBL can be recognised.

Focal areas Delta Plan Agricultural Water Management



Source: DAW

Family housing share, 2020



Source: CBS

1 All texts are horizontal, including the name of the unit of the y-axis in graphs.

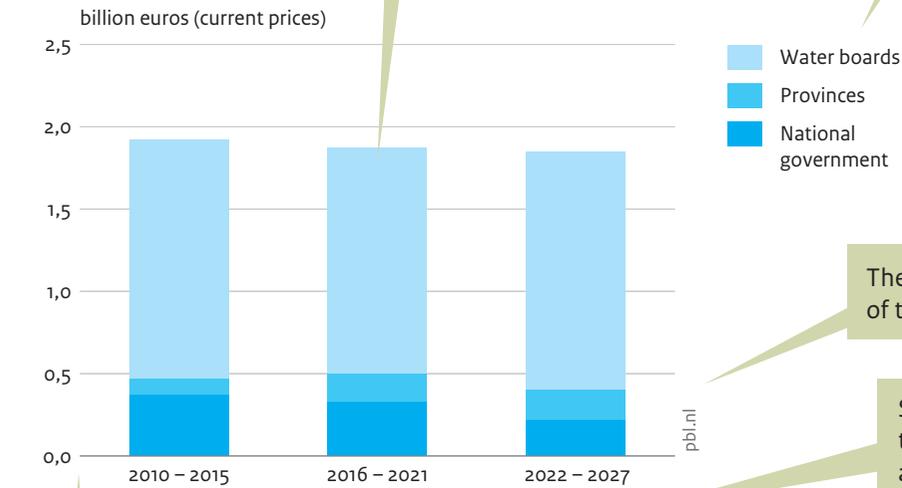
2 Surfaces in the figure are not outlined.

3 A descriptive and concisely worded title appears in moss green at the top left.

4 For colour and font, the visual identity of the Dutch central government is applied. A limited number of colours is used, preferably blue, moss green and violet.

5 The legend is placed, in principle, to the right of the figure.

Figure 2.1
Direct public spending related to Water Framework Directive



6 All texts in the figure (such as title, source and legend) have a fixed relative font size.

7 The term pbl.nl appears in the bottom right of the figure as a recognisable wordmark.

8 Sufficient empty space is left between the various parts, so that the figure has a clean look.

9 A reference to the source of the data or the content is included in the figure.

10 Some figure elements are, in principle, left out, such as the y-axis line in graphs, and the north arrow and the scale bar on maps.

Source: Water boards, provinces, Rijkswaterstaat; adaptation by PBL

Depicting 25 years of change

Evolution of visual identity

Over the past 25 years, our visual identity has undergone several changes. This is mainly due to progressing insights and new developments in visualisation. From the design of our visualisations, it is clear that we have started to think more and more about function and message. Changes to the organisation or to its name, or the

implementation of an organisation-wide visual identity are reflected in designs and in changes in use of colour.

The initial years

Up to 2007, figures were laid out over a grey background so that it was visually clear which layout elements belonged to the figure. From

2002, graph data were drawn on a white background to place more emphasis on the data. On several occasions the title colour changed (black, mint green, dark blue, moss green) to match the visual identity colour.

The PBL house style

In 2004, the Netherlands Environmental Assessment Agency (MNP) was created from the National Institute for Public Health and the Environment (RIVM). This move did not lead to any visible changes in the house style for figures. It was not until the new agency merged with the Netherlands Institute for Spatial Research (RPB) in 2008 that a new visual identity appeared. A new colour palette was developed, based on the colours in the logo. Layouts were renewed through the creation of four variants in four different basic colours, which were used routinely in the design of the figures. Instead

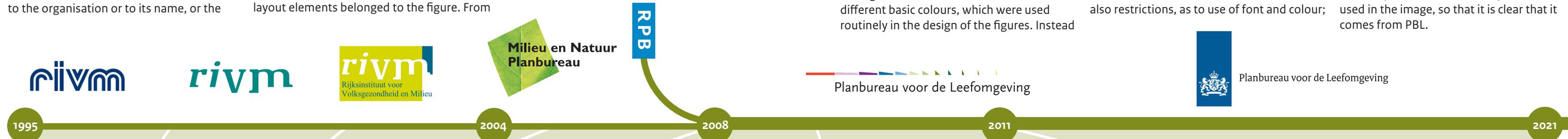
of a coloured background, a line under the figure became the way to separate the visualisation from running text. However, the set guidelines for colour and design also gave rise to limitations in the creation of good visualisations.

The visual identity of the Dutch central government

In 2011, the Dutch Government introduced a visual identity — a common visual identity for all national government organisations, which came with new rules, and therefore also restrictions, as to use of font and colour;

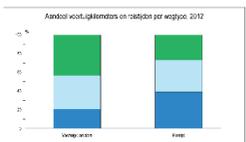
the exclusion of dark shades in particular is felt to be a shortcoming. A change that we implemented ourselves concerns the contour lines — these are preferably white or they are omitted to make the data stand out more prominently.

In the 2010s, it became clear that our visualisations were being distributed more and more outside the context of a publication. Therefore, we include references to the source in the image itself, rather than in the caption. The wordmark pbl.nl is also used in the image, so that it is clear that it comes from PBL.

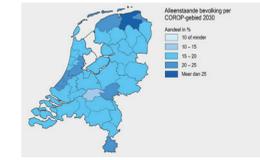
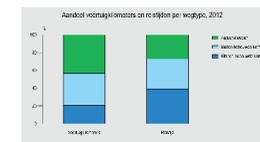


1995

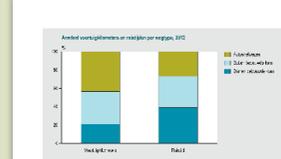
1995–1998
White background (grey for maps)
Black contour lines
Title colour black



1998–2002
Grey backgrounds for all figures

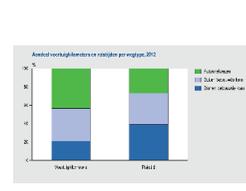


2002–2005
White backgrounds for data areas in graphs
House style colour and title colour mint green



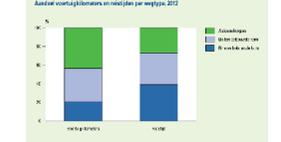
2004

2005–2008
Title colour dark blue



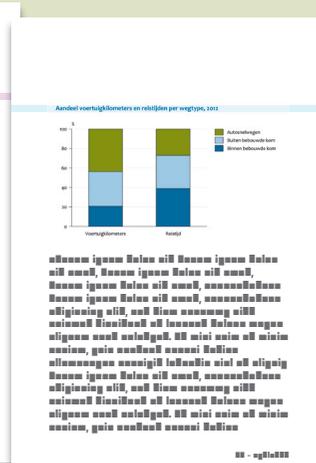
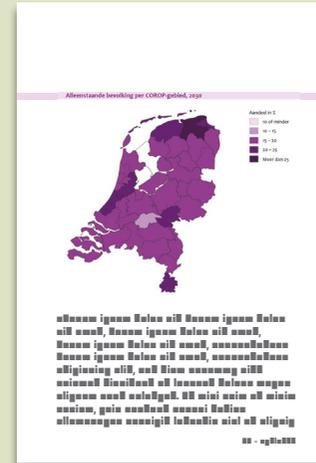
2008

2008–2009
Green backgrounds



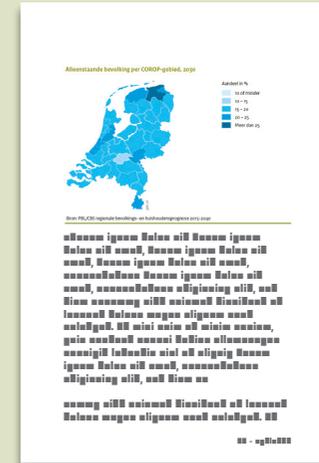
2011

2009–2011
New colour palette based on colours in the logo
Coloured title bar and title (blue, green, violet and ochre)
White background
Font Arial replaced by Candara



2011–2021

Application of Central government visual identity in visualisations (font and colours)
Title colour moss green, no title bar
pbl.nl as recognisable word mark (2012)
Reference to source included in figures (2013)
Contour lines white or are not used (2016)



2021

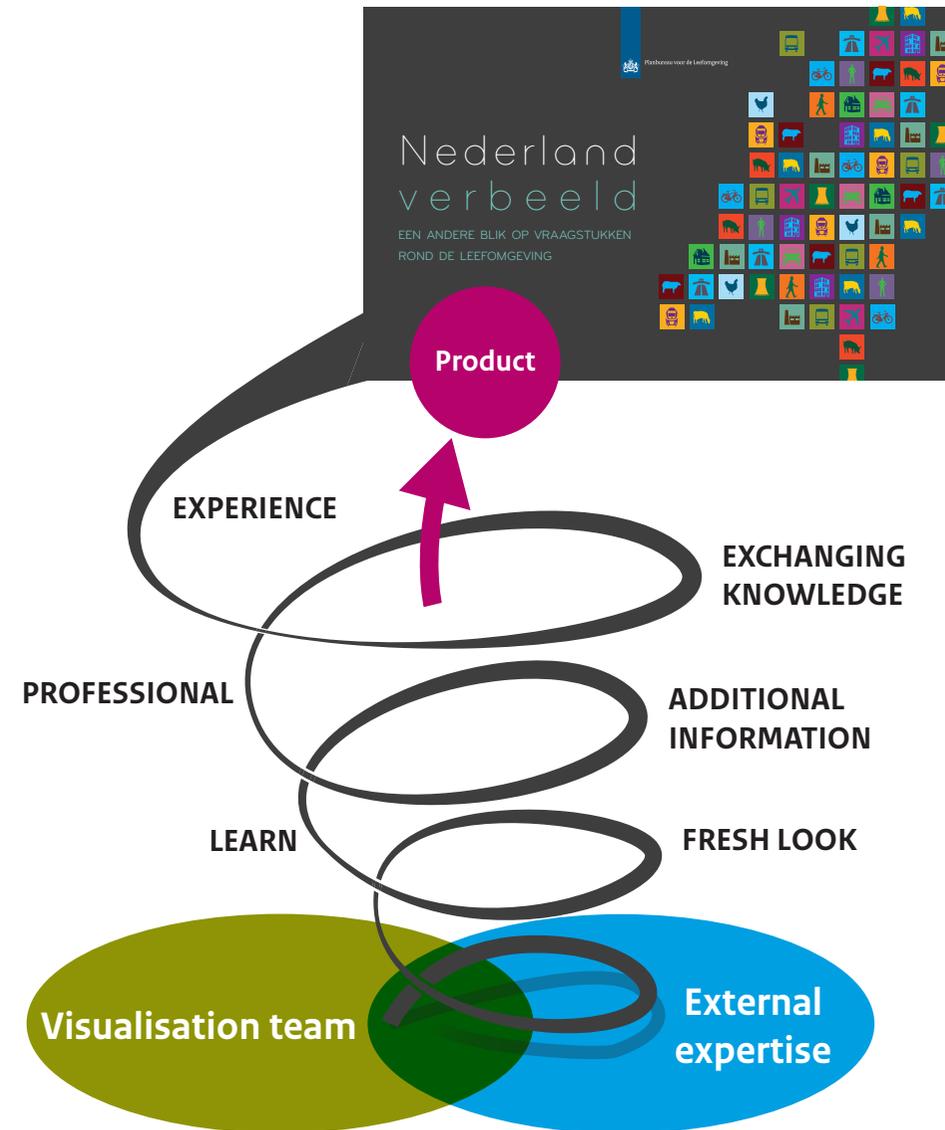
Cooperation equals growth

The contribution of external collaborators to PBL visualisations

We make many of the visualisations for the PBL ourselves. But sometimes you run into your own limits if you are not familiar with a certain new technique or when you have to make a new type of product. We have discovered that by working together, you can learn a lot and deliver better products. Interdisciplinary cooperation works very well. If you bring in people who have expertise that you yourself lack, it has a positive effect on the end result.

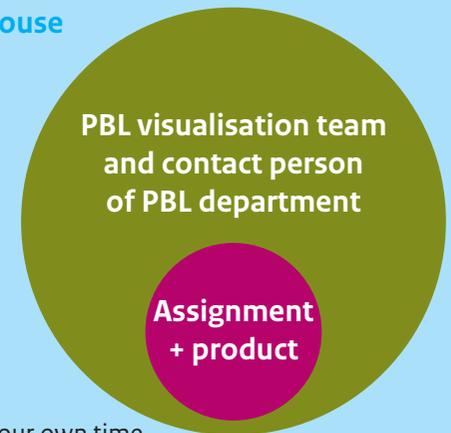
In 2012, we were working on a booklet containing infographics. We knew that we would need outside help to complement our expertise in making such images. We found the right match in Frédéric Ruys. By involving him in that project, we learned a great deal. We learned lessons that we still apply today when we are producing our figures.

With the input of our own knowledge and that of external collaborators, we are making better products and developing our own expertise in the field of data visualisation. We have repeated the method in different combinations on multiple visual products.



Creating images in-house

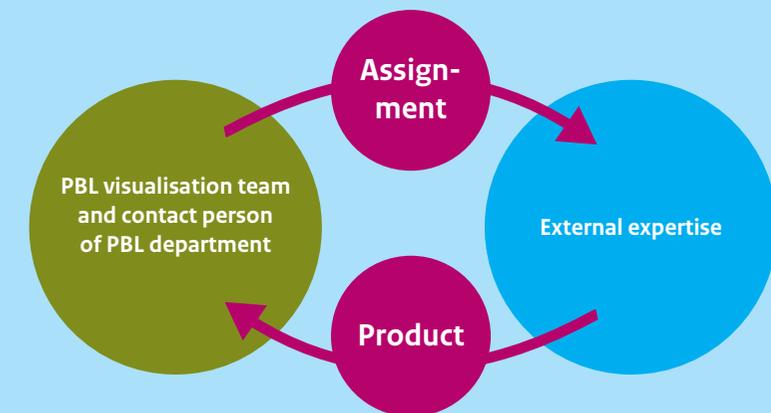
For many PBL publications, the images are created in-house.



Advantages:
Having full control
In-house expertise
Flexibility: in control of your own time

Farming out the creation of images

If we lack the time or expertise ourselves, we farm out the work.



Advantages:
Saves time
Supplement lacking expertise

Marian Abels interview

'Together with colleagues you arrive at a graph with a clear message.'

Of all the colleagues working on visualisations at PBL, Marian Abels has been on the team since the very beginning. A dialogue with an enthusiastic, experienced colleague who is looking back on 25 years of activity.

Marian, what is your background and how did you come to work for the organisation that later became PBL?

I was enrolled in a new study programme in the town of Etten-Leur — advanced laboratory informatics and automation. I got an appealing internship at the RIVM, the National Institute for Public Health and the Environment, where I had the opportunity to contribute to the implementation of an information management system for the laboratory. Directly after my internship, in mid-1988, I started working at the RIVM computer centre. A few years later, I became involved in the production of graphs. At that point, work centred on the first assessment of the physical environment (the 'Milieubalans'), which was published in 1995. Every year, the report describes the quality of the environment in relation to previously implemented environmental policies. From 1997, I worked on the graphics for the report by myself. Eventually there was demand for graphs and other visualisations for an ever-growing number of reports. As the workload increased, I was also able to welcome my current colleagues: Jan de Ruiter, Filip de Blois, Allard Warrink and Raymond de Niet.

So, your training was not directly related to the work you are doing today?

That's right. The theory behind the production of graphs was not part of my studies — I did have a feeling for numbers, of course. I discovered things by doing. Those were pioneering efforts and I have had to develop a lot of things myself. Speaking with project leaders and researchers, and asking probing questions were always very important in forming my insights. It is how the 'theory' behind the creation of graphs gradually developed.

And this theory behind the graphs, do you have it on paper somewhere?

It's mostly in my head. If I write it down, it will all become so definite. What I have is mainly the visual knowledge, but the substantive

knowledge has to come from other people. Being a lay person to some extent, I primarily ask my colleagues questions and try to translate their wishes into easily readable graphs. The ideal graph, for that matter, does not exist. Personal ideas and insights play an important role. Together with your colleagues you arrive at a graph with a clear message.

And there's a fun story to tell: Several years ago, we devised a nice memory game about visualisation work. We played it many times with project teams. During the game, the insights we had gained about visualisation would pop up in entertaining ways. That worked really well. We presented the game at all kinds of meetings, even at a conference in Neuchâtel, Switzerland.



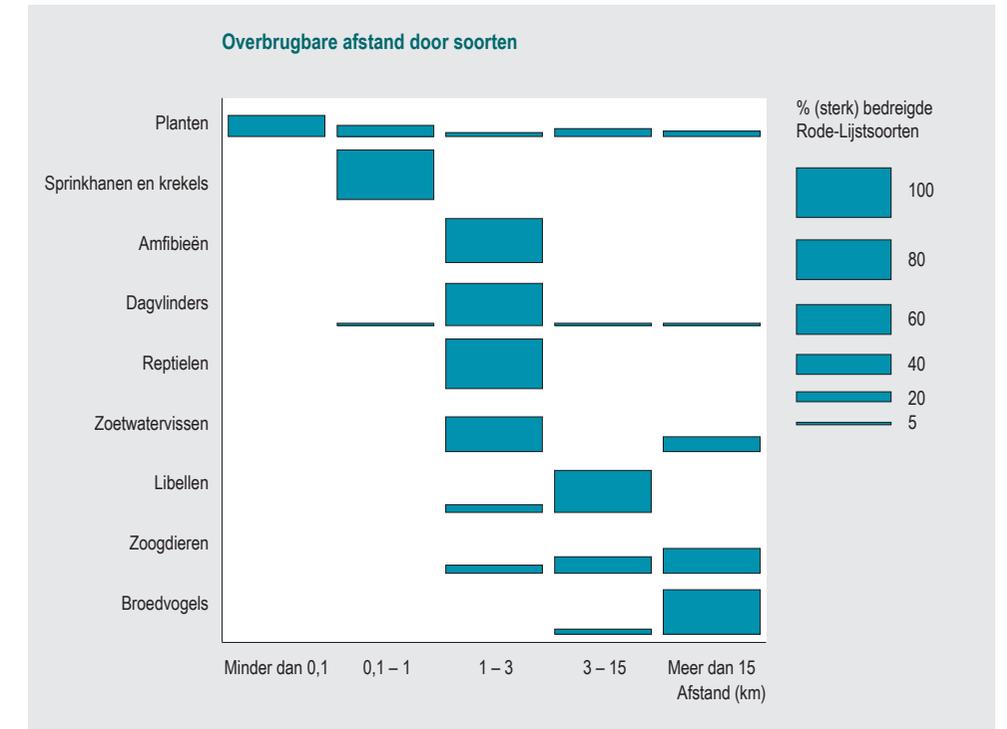
What motivates you to do this work?

What I enjoy in my work is helping people think about what exactly they want to say with their numbers. After all, numbers are nothing but numbers. What matters is the story behind the numbers, the message that accompanies them. I work with different project leaders all the time. The lines are short. In the end, with the graphs you supply, you are exerting a great deal of influence on the publication. I also get a fair share of feedback from colleagues afterwards. I am one of the first people they think of, because I am often the last one they speak to before the publication comes out. I may not be responsible for the content, but my work is an essential cogwheel in the whole mechanism. I would love to keep doing this until I retire!

What has changed in your work over the years? And how do you see the future?

Throughout the years, I have witnessed quite a lot of organisational changes. I started at the RIVM. Later my activity was transferred to the Netherlands Environmental Assessment Agency (MNP), which, in 2008, merged with the Spatial Planning Agency (RPB) to become today's PBL Netherlands Environmental Assessment Agency. For me, this meant a broadening of scope as to subject matter. I was no longer only making graphs on environmental and nature-related subjects, but also — to give a random example — for a report on public health in a neighbourhood in the city Enschede after the fireworks disaster. What I find interesting is precisely the range of different subjects that PBL researches.

Aside from making visualisations about a wider variety of subjects, we are taking more and more different approaches and using different media to do so. The proportion of



static graphs will become smaller. The role of graphs in data representation is also going to change. Infographics, animations, interactive tools — more and more options are being added. We often create several types of visualisations for a single publication. What I like is that we are involved in those publications as a team, where I do the graphs, another person takes care of the maps and another works on the infographics.

Do you have any anecdotes to share? Have you ever made a graph that you would make very differently now?

Certainly. A couple of years ago a senior researcher from another organisation

came to work with us. He told me that he had had a graph of mine hanging on his wall for a long time. 'I thought it was so beautiful; it was simply a piece of art', he said. It turned out to be a figure I had made for the 2003 edition of the Nature Assessment series published by the RIVM. The figure shows the distances that species are able to travel, from grasshoppers to dragonflies to nesting birds. The graph had an x-axis that I would never make again in the same way, but I took satisfaction in knowing that someone had had it on their wall for years as a work of art.

Part 2

Lessons from
25 years
of PBL
visualisations

The image features a dark blue background with several overlapping circles in shades of purple and magenta. A network of curved arrows, some solid and some dashed, connects different points across the composition, suggesting a flow or relationship between elements. The text is positioned in the upper right and lower right areas.

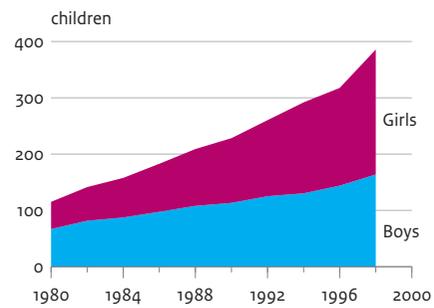
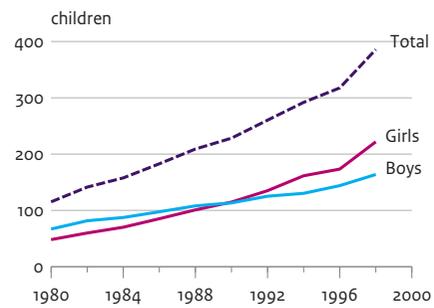
Images support the message

Why the type of data visualisation matters

As a designer, you can choose different types of figures starting from the same data. You can support and strengthen the figure's message by choosing the most appropriate type. There are many different visualisations available, some of which are highlighted here.

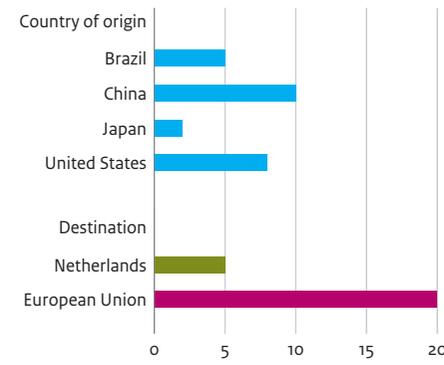
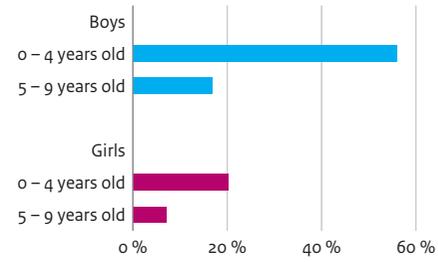
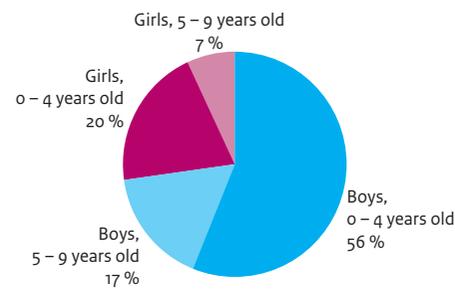
Line or area

An area chart shows the reader, at a glance, the total value and the distribution of the total value over time. The disadvantage, however, is that the exact values of the two areas (the percentages of boys and girls at a school) at a given time cannot be compared directly. If the message you want to convey to the reader has to do with the comparison of numbers of boys and girls, and with the moment when there are more girls going to school than boys, it is better to choose a line graph. If necessary, a line visualising the total can be added as extra information.



Pie or bar

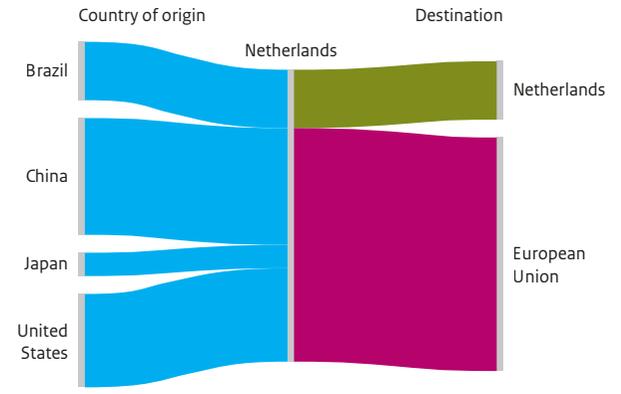
A pie chart quickly gives the reader a general idea of the distribution of the total — in this example, the distribution of age categories of boys and girls at a school. However, a pie chart makes it difficult for readers to accurately estimate the distribution. To do that, they need to look at the percentages. If the message you want to convey to the reader has to do with the difference between the proportion of boys between 5 and 9 years old and the proportion of girls between 0 and 4 years old, then that difference is easier to see in a bar chart. The disadvantage, however, is that the reader will not immediately see that the total is 100%.



Bar or Sankey

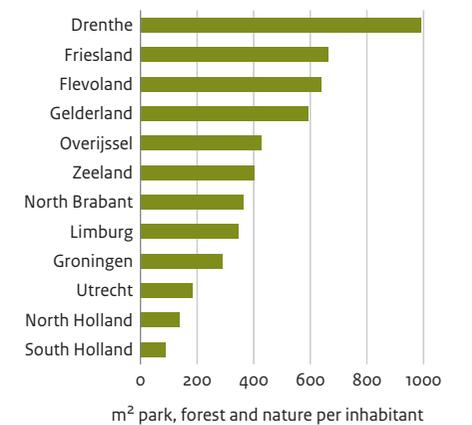
A bar chart is very appropriate for showing exact numbers. In this example, the reader can clearly see volumes arriving in the Netherlands and volumes reaching their destination. But the graph does not make it immediately clear that these flows are related to each other.

An alternative is what is known as a Sankey diagram, named after the 19th century Irish engineer HR Sankey. This type of diagram makes it possible to properly visualise interdependent relationships in a network. Another feature is that the width of the arrows indicates their proportion. A Sankey diagram is very useful for visualising complex processes, flows and networks.



Map or chart

A map gives an impression of the geographical distribution of data. The example here clearly shows how the country's central-western area — what is known as the Randstad conurbation — has less greenery and fewer nature areas. Maps have the disadvantage, however, of being less suitable for delivering more exact amounts. Amounts are grouped into classes and are therefore not as easily deduced from the map itself. In cases where exact amounts are more important than the geographical distribution, using a bar chart is more suitable. The bar chart is much clearer than the map when wanting to show how the amount of green area per inhabitant is only slightly larger in the Dutch Province of Zeeland than in the Province of North Brabant.



Looking ahead and looking back

Producing insight with 'Afpel' chart

Over the past 25 years, we have frequently produced graphs to visualise the effect of policy measures, both after implementation (ex post) and before implementation, as an exploration of possible future policy measures (ex ante). These graphs have proved to be very popular with policy-makers and politicians.

The type of graph we use for this is a sort of line chart with steps, known at PBL as the Afpel chart. It is a line chart that describes the development from a situation without policy to one in which policies have been implemented.

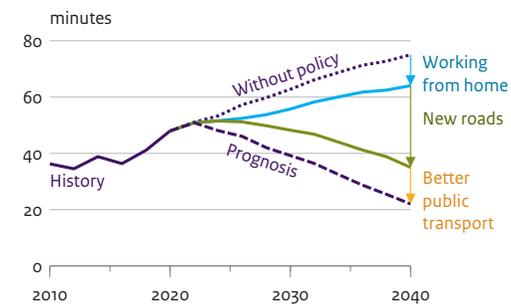
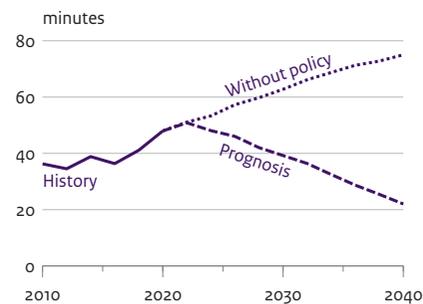
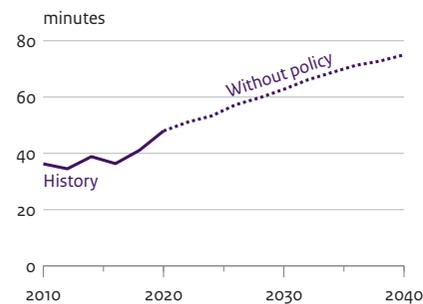
The effect of the various policy measures is presented by individual lines. The difference between two lines represents the contribution of a single measure. An example of such a chart is one that shows the effects of policy measures on travel time. What is the impact of a new road or of people working from home more often?

How should you read such a chart?

First look at the historical situation, the starting point, and at how the situation would develop without policy being implemented. In the example given here, travel time is expected to increase if no relevant policies are implemented. This may be due to population growth, an increase

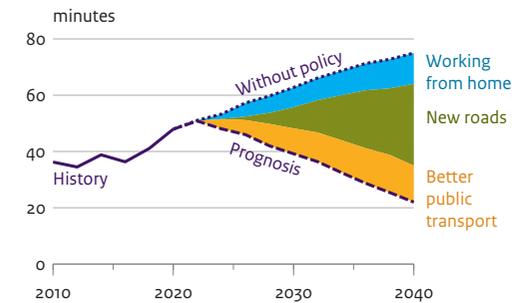
in private car ownership, or a change in oil prices. Then the chart shows what the situation would be after policies have been implemented. The example provides a forecast, in which the difference between a situation with and without policy shows the total effect of the policies.

The chart shows the impact of each change or measure. In the example, you can see the degree to which remote working, new road construction and better public transport will affect travel time.



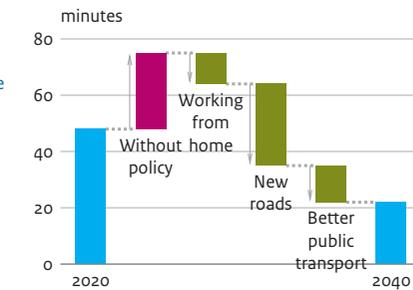
Coloured areas

In some cases, the spaces between the lines are coloured to indicate the contribution of individual measures. As a result, the reader's attention is drawn to the contribution of each measure to the overall change, rather than on the situation at the outset and the end point.



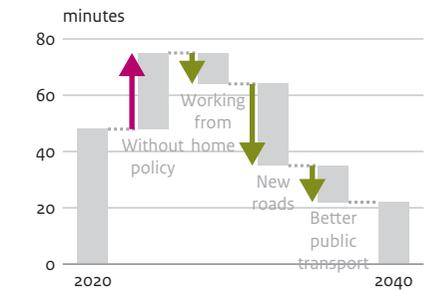
Waterfall chart

The waterfall chart is based on the same principle: it shows an initial situation, a final situation and in-between are the contributions of individual policy measures. If the starting and end points are in different years, this type of graph shows the overall effect of the contribution between the two situations, but not the development over time.



Difference between increase and decrease in impacts

Measures may be intended to both increase and decrease something. Examples include quota measures to stimulate housing construction or to achieve a reduction in livestock numbers, and technical measures to reduce emissions, such as certain standards for vehicles and equipment, catalytic converters, air scrubbers, chimney filters and animal feed modifications. Afpel charts are not suitable for showing any impacts in these types of cases, which is why waterfall charts are used to visualise the effects of such measures.



Influence of order

The order in which measures are introduced is often important for the impact of individual measures. If the government first takes technical measures to reduce emissions, such as the mandatory use of air scrubbers in livestock housing, followed

by quota measures, such as reducing livestock numbers, the emission reduction measures will have a greater effect than if the quota measures are taken first. The more substantial reduction in emissions occurs because the measure is calculated

on the basis of a larger livestock population. This means that it is not possible to change the order in which measures, or potential measures, are introduced when using a Afpel chart to interpret their impacts.

Pluses and minuses

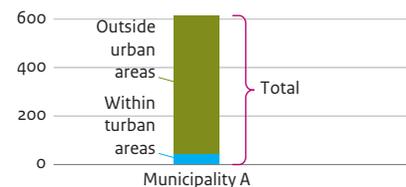
Setting up bar charts in a clear way

Bar charts. At PBL, we have made thousands of them in all shapes and sizes, over the years. Sometimes, they show a target audience the size of an overall change and how different elements have contributed to that change.

For example, they show how the number of inhabitants in a municipality has changed over a given period. The changes within and outside the municipality's built-up area are stacked on top of each other. The total height of the bar then directly indicates the total change in the number of inhabitants in that municipality.

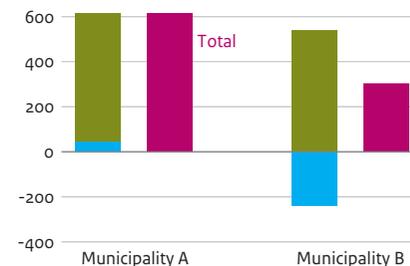
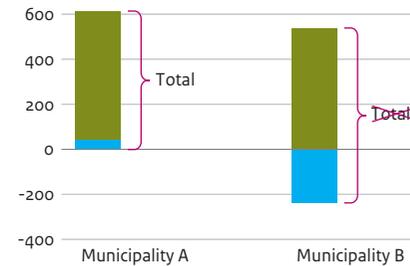
However, it is not always that simple.

Change in number of inhabitants



When does the bar not represent the total?

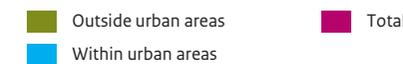
Suppose we want to say something about the changes in population numbers in two different municipalities. The total change in municipality A is the sum of the changes within and outside its built-up area. In municipality B, however, increases did not take place in all its locations; its built-up area, for example, saw a decrease in population. In this graph, this negative value appears under the x-axis, as is common in many visualisation tools, e.g. MS Excel). This, however, has a clear disadvantage. While, for municipality A, the length of the bar also represents the overall change, for municipality B the length of the bar is the sum of the lengths of the positive and the negative bar. The difference is clearly visible when the overall change is shown next to it. Due to the length of the bar for municipality B, the reader could be left with the mistaken impression that the change in this municipality's population was greater.



How do we solve this problem?

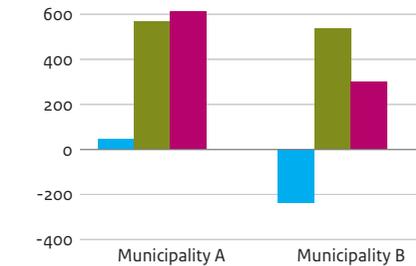
There are several alternatives that may be used to circumvent this problem. Whichever one is chosen, the aim is to prevent readers from interpreting the total length of the bar as the numerical total.

One solution would be to make sure that the negative values are not placed directly below the positive values. This implies slightly shifting the bar segment for negative values. If necessary, the total can be added.

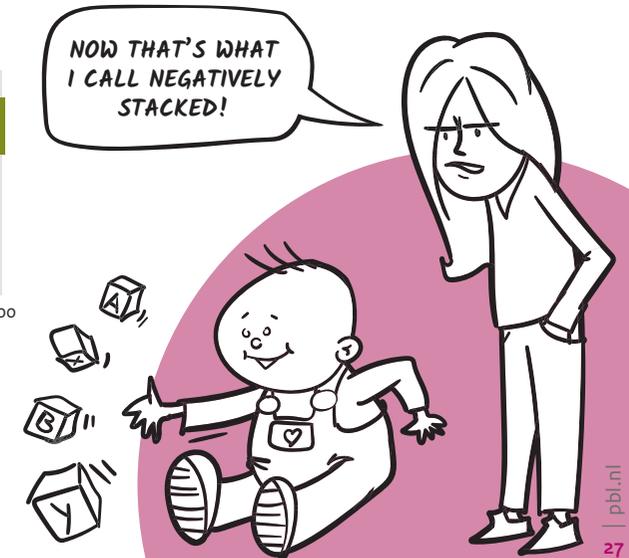
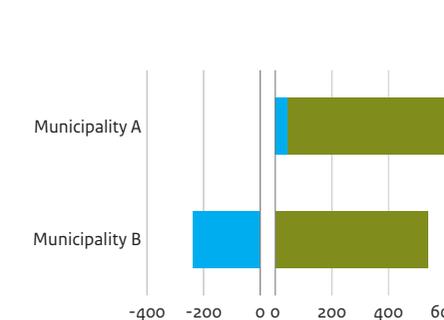
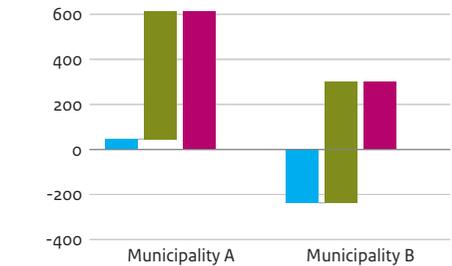


A final variant that PBL has used on occasion is that of splitting the increase and decrease into separate areas using a horizontal bar chart. This means that readers do not see one long bar, but a visualisation of the difference. It is difficult for a reader to understand that the values in a vertical bar do not run from negative to positive, but rather that there is a separating gap between the positive and the negative parts of the axis.

Another solution is to display different categories alongside each other, rather than stacking them. The advantage here would be that it is easy to discern the changes in each category. Here too, the total can be added if considered necessary.



It is also possible to choose a variant in which the various categories are added up, while keeping each category fully visible — a kind of waterfall chart. This would provide the advantage of the end point of the last category also indicating the total.



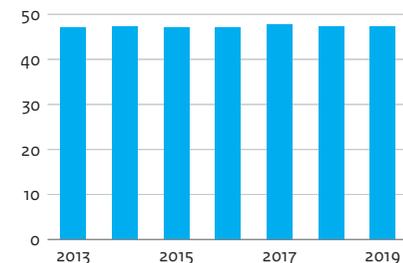
Starting at zero

Playing with the y-axis

In a graph, the value of the dependent variable is displayed on the y-axis (usually the vertical axis). When designing graphs, a frequently discussed question is that of whether the y-axis should always start at zero? In other words, can a y-axis be truncated or is it useful to have it start at 0 — if, for example, none of the data points have a value below 50 and all data points have values between 50 and 55?

Why would you truncate the y-axis?

The main reason for not having a y-axis start at zero has to do with the level of detail; it is useful for making small changes between data points more visible. So, instead of showing the whole axis, the lower part is left out and only the top part is shown. The y-axis shows the corresponding values, so in theory everything is correct.

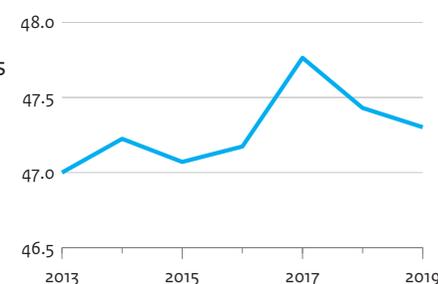
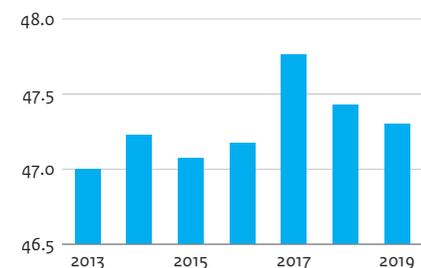


From time to time, this question also crops up at PBL. Many leading names in the field of visualisation have expressed their opinion on the matter, and a considerable number of discussions and blogs are available online that also deal with this subject.

Is there a difference between line graphs and bar charts?

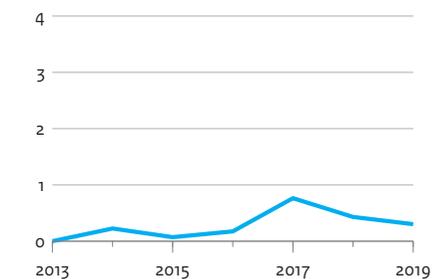
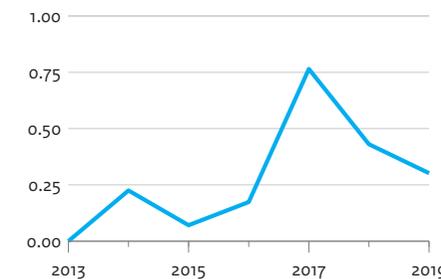
An often-heard opinion states that it is not acceptable to truncate the y-axis in bar charts, but that it is permissible in line graphs because, in a bar chart, the information is communicated in the height of the coloured segment of a bar. If the chart's y-axis does not start at zero, the height of the coloured segment no longer corresponds to the data that is being presented. In a line chart, however, the information is given by the points on the plotted line.

Nevertheless, research has shown that readers, more often than not, interpret data incorrectly when a y-axis is truncated. They are inclined to interpret a bar that is twice as long to represent a value that is twice as large. This problem applies in similar degrees to bar charts and line graphs, and showing how the y-axis has been truncated also appears to make little difference.



What about the final value of the y-axis?

You can have a similar discussion about the end value of the y-axis. Here too, the choice affects how readers obtain their first impression of the data. In some cases, there are logical end values, such as for a division from 0% to 100% or for a target that has been set. But often there is no logical end value, in which case it should be carefully checked whether the end value of the y-axis could lead to misinterpretation. If a plotted line runs well below the end value — as shown in the graph on the far right — readers may get the impression that a certain value is low, and that much higher values could have been possible. Therefore, the choice of end value depends on the intended message.

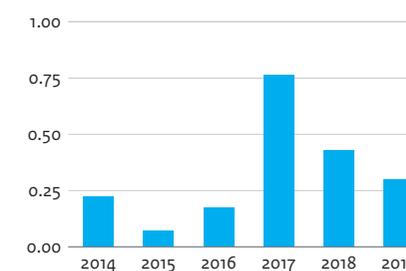


PBL's approach

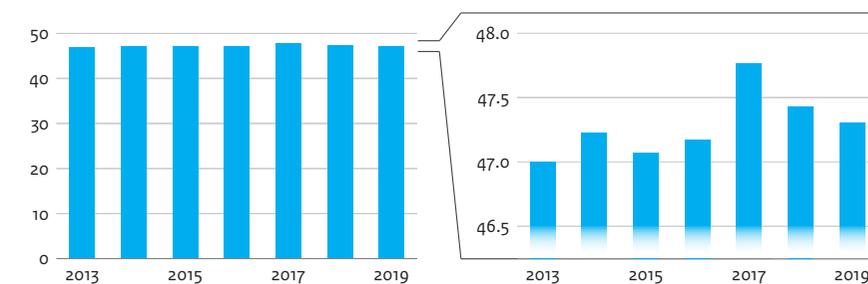
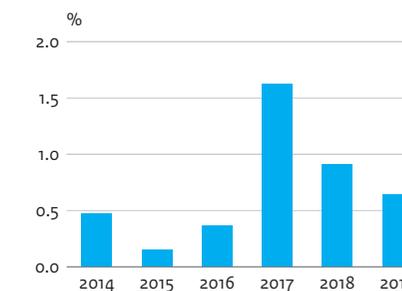
At PBL, we start from the premise of wanting to represent the data as objectively as possible. This means that the y-axis is not truncated and starts at zero. If the value zero is arbitrary (e.g. in temperatures) or non-existent (as on a logarithmic scale), or when its inclusion would hinder the intended message of the graph, we look for alternatives that would better serve the reader.

An example of a frequently used alternative is that of showing the absolute or relative difference in relation to the starting point. Sometimes we enlarge a small part of the graph to highlight a certain section of the data, as in the example on the right.

Absolute difference, compared to 2013



Relative difference, compared to 2013



Proceeding with caution

Visualising uncertainties in bar charts

Bar charts depict data in bars of a certain height. This represents certain problems when values are surrounded by uncertainty, which should be made obvious to the reader. Or how could the actual values be left out, showing only the uncertainty in the chart? Over the years, PBL has used various approaches to communicate these issues.

Uncertainty is often visualised by using a range of values. The starting and end points of such a range are determined by calculating the distribution of plausible values. Along with the uncertainty and where possible, we also indicate the measures that served as a basis for the depicted range — for example, a 95% confidence interval or two times the statistical standard deviation.

It is important to realise that the chosen representation of the range of values is the first impression that readers get when they look at a graph.

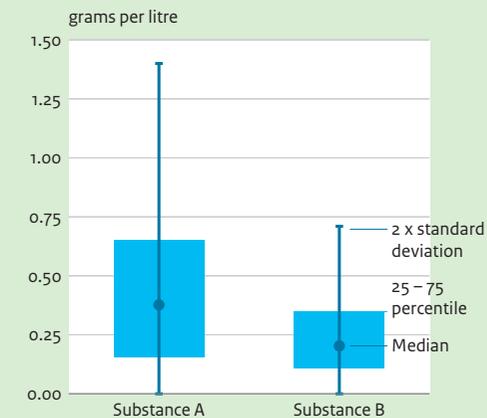
Why not 'simply' use a box plot?

A box plot is a graphical representation of the distribution of data. A box plot is usually based on five figures:

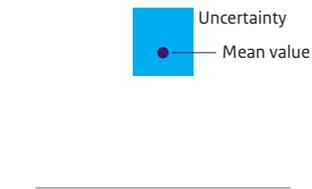
- The minimum (excluding outliers)
- The first quartile
- The median (or second quartile)
- The third quartile
- The maximum (excluding outliers)

A box plot does not always contain these five figures and therefore, as a norm, a legend should be added with an explanation of what exactly is being shown.

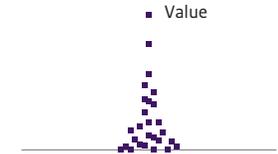
A box plot is appropriate for a scientific audience, but is difficult to understand for the general public.



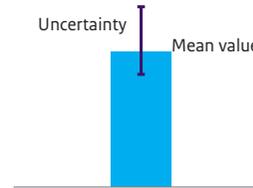
Uncertainty can, of course, be shown by placing the minimum and maximum values next to each other.



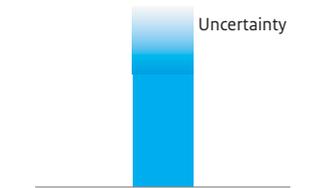
The graph above first gives an impression of the extent of the uncertainty, and readers will look at the absolute value only in the second instance.



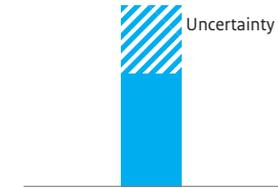
In this graph, all values have been included; overlapping values have been placed side by side, so that the width gives a sense of which values are either less or more likely. This type of representation is also called a beeswarm plot.



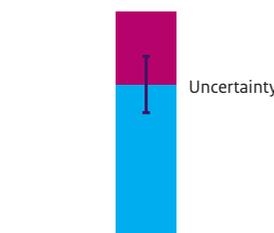
The height of the bar determines the reader's first impression. By adding what is called a whisker you give an impression of uncertainty, without removing the focus from the bar.



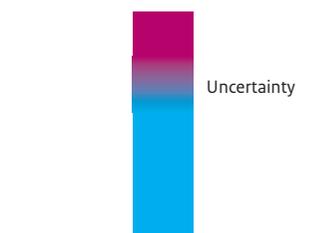
This figure instantly shows the uncertainty, but without giving an indication of the end value.



Using a solid colour for the lowest value gives an impression of the lower limit, while the hatched area indicates which values are uncertain and what the maximum value can be.



This solution can be used with a stacked bar chart, which conveys both an exact value and the uncertainties around it.



The area where two colours are blended indicates that there is a gradient, without showing the exact values.



A hatched area with the two colours of the other parts of a bar communicates that this area can either belong to the bottom part or the top part of the bar.

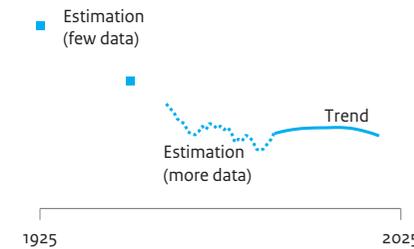
Anything is possible

Visualising uncertainties in line graphs

A line graph shows data as a line that connects various points at a certain value. In some cases, however, you want to show there is uncertainty around one or more points on the line. Or sometimes you only want to show the uncertainty without a line with points. Over the years, PBL has used various methods to represent such uncertainties. It is important to know these methods, and to realise that the intended message determines which method should be chosen.

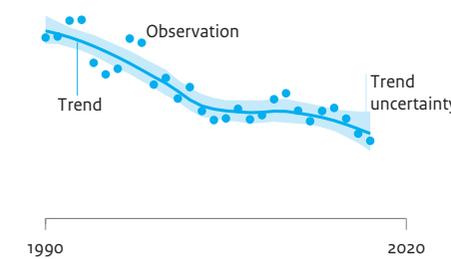
Uncertainty within a line

If a plotted line is based on uncertain values (i.e. estimations), there are various ways of visualising those uncertainties. In this example, individual points were plotted for values based on a rough estimate (i.e. only a limited amount of data). Dotted lines represent estimates based on larger amounts of data, while solid lines indicate values based on observations. This instantly gives the reader an impression of the differences in certainty between the various values.



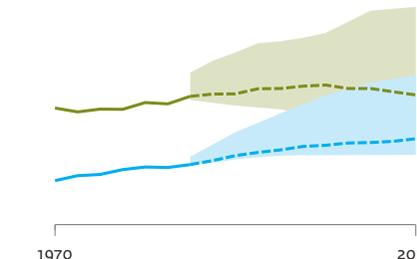
Confidence bands

The uncertainty around a line is often indicated with a wider coloured band: the confidence band. In the example below, the graph shows observations, the trend and the uncertainty in the trend.



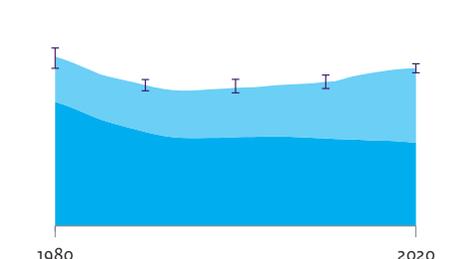
Overlapping confidence bands

Such uncertainty margins can also be indicated in graphs that have more than one line. In cases where the confidence bands overlap, this can be addressed by using transparent coloured margins.



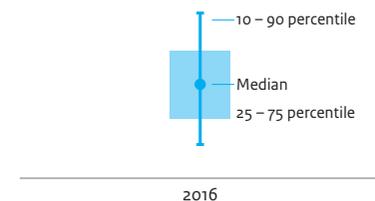
Uncertainty in area graphs

Representing uncertainty in area graphs often proves to be more difficult. The solution we most frequently apply at PBL is to place whiskers over data points that show total values.



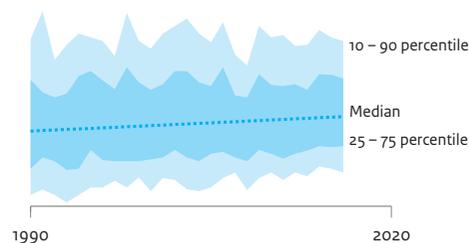
Distribution of values ...

Uncertainty in data often stems from how the values are distributed. This is sometimes depicted using a box plot. The example below shows the distribution of observations made over a period of one year.



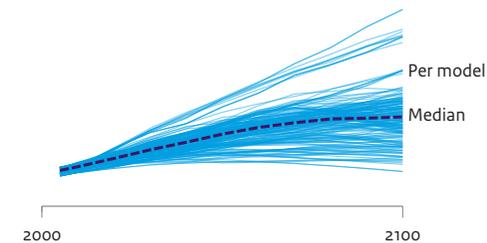
... over time ...

A graph that is based on a box plot can also show the distribution over time.



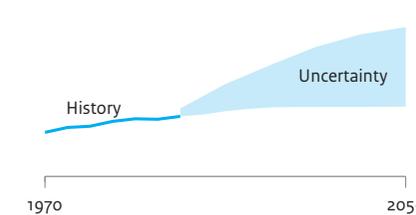
... or showing all values

Why not visualise the full set of values so that the reader can immediately appreciate the distribution? Over the past 25 years, plotting graphs has been done using increasingly more powerful applications, which is why the use of a full set of values is now a feasible option.

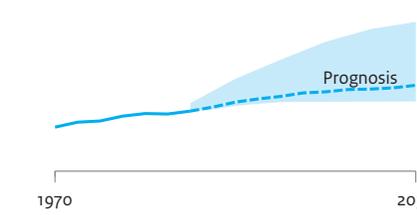


Future uncertainty

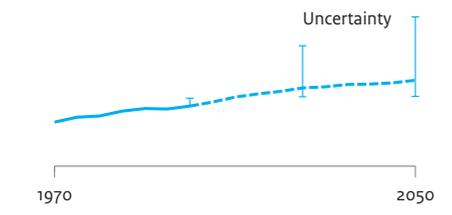
You can also use an confidence band to express future uncertainty. With this method, you can choose to add a forecast line.



By drawing the forecast line in a different style than the historical line, you highlight the difference between the forecast and the historical trend.



If the uncertainty is not known for all years shown in the graph, you can indicate it by placing whiskers over the corresponding data points on the line.



Look twice

Varying the axes in graphs

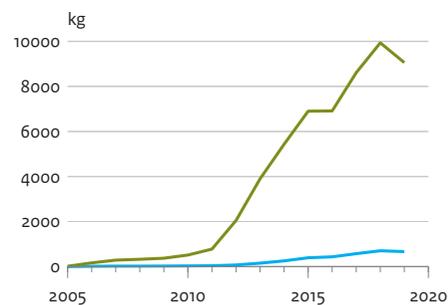
The horizontal and vertical axes that PBL uses in its graphs can have various scales: linear, logarithmic and by category.

Experience over the past 25 years has shown that the chosen scale for the axis can affect how data are displayed in a graph, which thus also affects how readers interpret a graph.

Linear or logarithmic axis

The layout of the y-axis can have a linear or logarithmic scale. The linear axis is almost always the starting point. Choosing a logarithmic axis can be useful to indicate the projected pace of exponential growth, such as in the case of viral infections. It is also a practical layout for comparing changes in data that are markedly different in size, such as values of 100 and 10,000. In such cases, using a linear axis would cause changes in the smaller numbers to become indiscernible.

There is a large difference between the use of axes with a linear or logarithmic scale, as can be seen below.



It is important to realise that many readers may not immediately recognise the axis scale as being logarithmic. Readers who interpret such data in a graph as if they were displayed on a linear scale may draw the wrong conclusions.

Research has also shown that many readers do not understand a logarithmic axis, or that when they do, they often underestimate the values shown.

For these reasons, PBL only applies logarithmic axes if the target audience can be assumed to be familiar with this type of representation.



Category or linear axis

The most commonly used layouts for the x-axis are an array of categories and a linear scale of values. If the labels of the x-axis consist of a description — such as the names of countries or fuels — a category axis is the only available option. However, in the case of numbers, a linear axis could also be used.

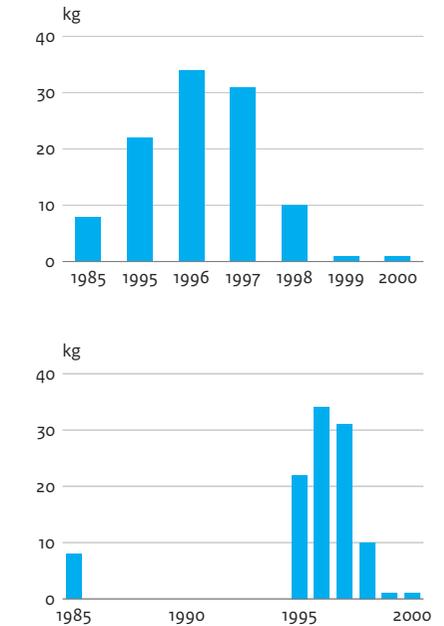
The choice does not necessarily affect how a graph looks, but there are situations where differences do occur, as can be seen in the graphs on the right.

The labels of the x-axes refer to years. The top graph has a category axis, and the one at the bottom has a linear axis. In the top graph, the bars are equally

spaced, regardless of the year they represent. In the bottom graph, the bars for the years are displayed in their corresponding positions on the linear axis.

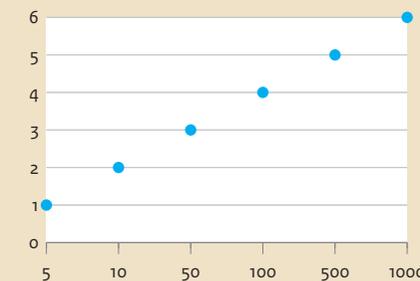
From a category axis, for example, it is not immediately apparent that a series is incomplete, such as when several years are missing. But in the graph with the linear axis, it is clear to the reader that the distance between the first and the second bar corresponds to a period of several years, while the distances between the other bars cover a single year.

The use of a linear axis is therefore recommended if the labels on the x-axis are not evenly distributed.



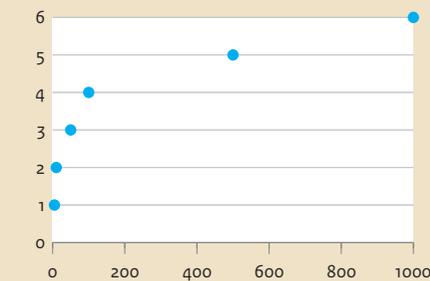
Category axis

On a category axis, values are displayed at a fixed distance from each other, regardless of the value category, which may be text, a number, a date or a period of time. This can be seen on the horizontal axis in the example below. The data points related to the values 5, 10, 50, 100, 500 and 1000 are evenly spaced.



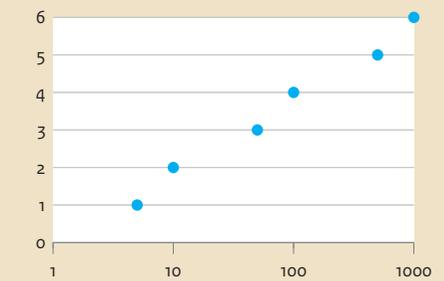
Linear axis

On a linear axis, values are distributed on the basis of an initial value, an end value, and a division into a number of steps. All steps are the same, as in the example below where all steps are spaced 200 units apart. The data points related to the values 5, 10, 50, 100, 500 and 1000 are plotted in the positions corresponding to those values.



Logarithmic axis

On a logarithmic axis, each step has a value that is a factor greater than that of the previous step; along the horizontal axis in the example below. the factor of multiplication is 10 (i.e. each step is 10 times greater than the previous one). The data points related to the values 5, 10, 50, 100, 500 and 1000 are plotted in the positions corresponding to those values.



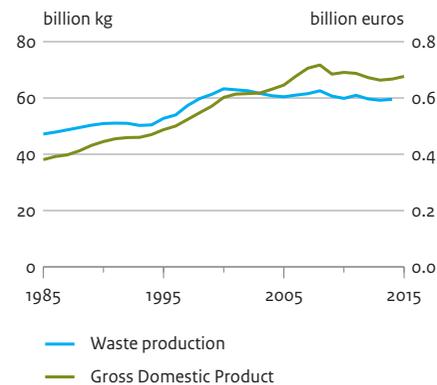
Double vision

Alternatives to using a second y-axis

At PBL, over the years, numerous requests were made for graphs containing a second y-axis. This has regularly led to discussions, because generally there are quite a few disadvantages to using a second y-axis.

The reasons for wanting to use a second y-axis

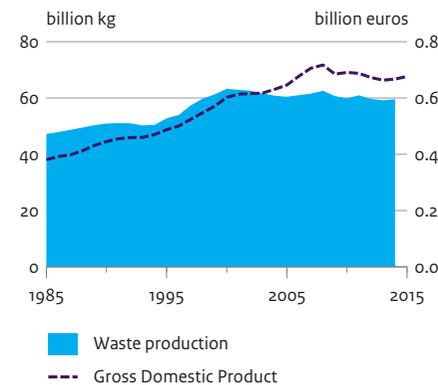
The reason often mentioned is to express a relationship between data. This is the case in the figure below, which shows that, over a certain period of time, GDP grew at a slightly faster pace than did waste generation. Conveying these two messages by putting them together in a single graph may seem logical. But it is a tricky business.



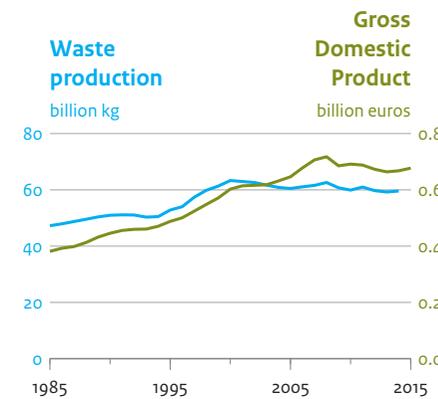
The problem with using a second y-axis

In the first place, not all readers immediately realise that the graph has a second y-axis — they may think that, before 2003, the values shown on one line were lower than those on the other line, and that they were higher after 2003.

In order to clearly communicate to the reader that the different sets of data in the graph cannot be directly compared, there is the option of using different graph types

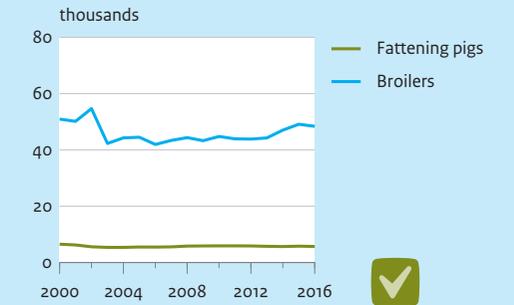
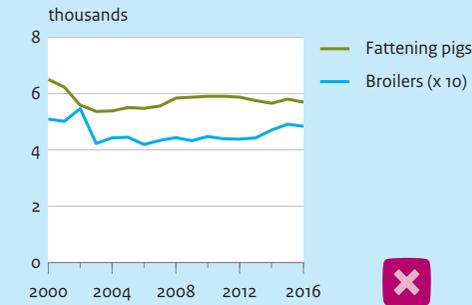


for each set and, for example, combining an area graph with a line graph, or a bar chart with a line graph. Another problem is that of showing which of the plotted lines is related to the left y-axis and which to the right y-axis. This too can be solved by using colours; for example, by also giving each plotted line the same colour as the corresponding texts, y-axis and units on the y-axis.



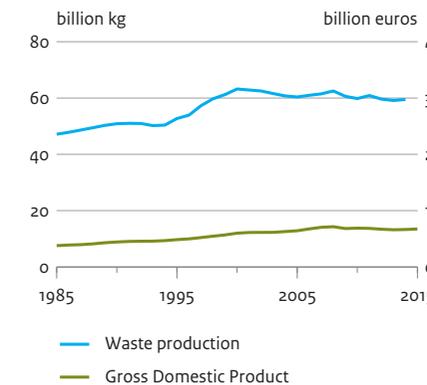
Beware of the hidden second y-axis!

In a graph it is not always immediately clear that data are related to a second y-axis. This may be the case, for example, when two units are given on the axis (e.g. km and kg), or when the legend indicates that a value conversion factor is being used, as in this example. In these cases, too, readers may draw the wrong conclusions.



The greatest problem, however, is that the direct relationship suggested by the graph depends strongly on the scales of the y-axes. Using the same data sets from the example, it is also possible to produce the graph below.

Everything is the same, except for the scale of the second y-axis. From this graph, however, the reader will not conclude that waste generation and GDP were following similar trends, or that GDP was growing faster than waste generation.

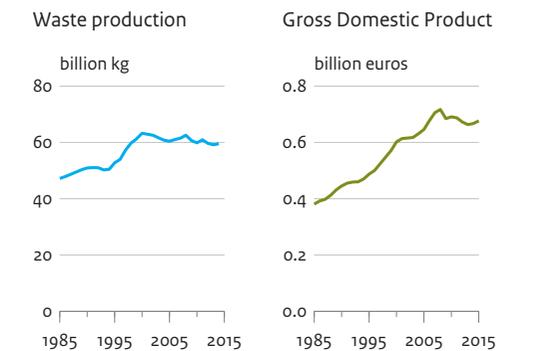
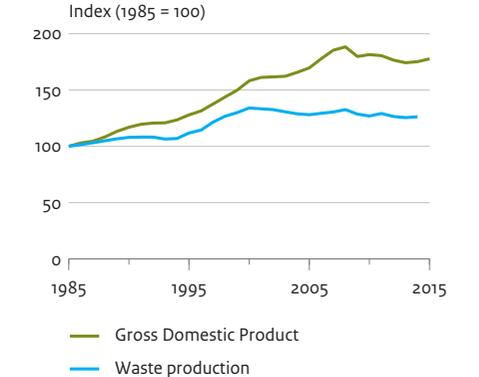


The alternatives

Given these problems, at PBL, we are always looking for alternatives to the use of a second y-axis.

If the message has to do with relative development — the trend — indexing could also be used. Here, this shows that, from 1985 onwards, GDP did indeed grow at a faster pace than waste generation. The disadvantage of indexing is that the graph shows no absolute values for waste generation or GDP.

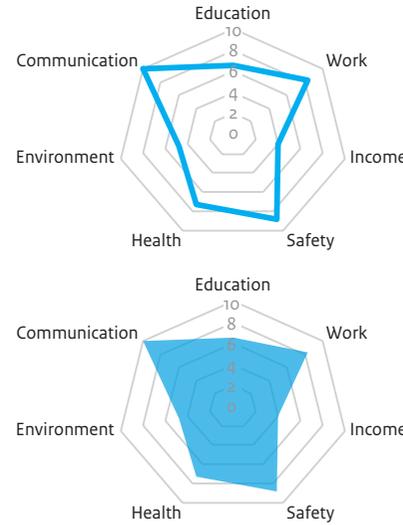
If absolute values are important for conveying the message, the graph can be split in two parts. This immediately shows that two different data sets are being considered, each with its own y-axis and unit.



Caught in the web

Shortcomings of radar charts

Researchers regularly ask PBL's visualisation team to visualise data in the form of a radar chart, for example because they have data subdivided into various categories, or because a radar chart has an eye-catching shape. Radar charts are also known by various other names, such as web charts, spider graphs and spider web charts. Radar charts have a y-axis for each category; they are all arranged radially (like the spokes in a wheel) with the lowest value at the centre and the highest value at the edges of each spoke. A data point is drawn on each radial axis and then all the points are connected to each other with a line. In some cases, the area inside the lines is also coloured.

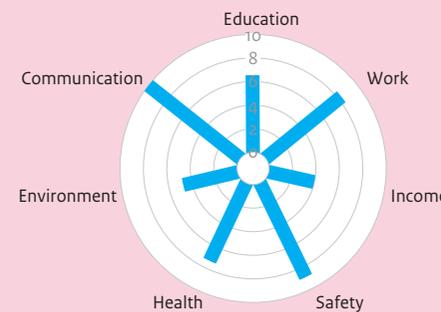


Radar charts were originally developed as a simple way of showing outliers. All axes have the same scale and the data on all axes are interpreted in the same way; a point further toward the edge is read as larger or higher in value.

Many people like the look of radar charts, especially because of their round shape. But, do radar charts really express what readers think they are seeing? In radar charts, the lines and coloured surfaces catch the eye, but the actual information lies at the intersections on the axes. For this reason, radar charts have a number of shortcomings.

Alternatives

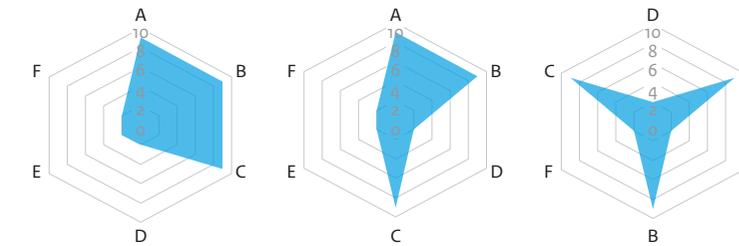
Because of their round shape, radar charts are considered attractive and draw attention. However, at PBL, we mostly try to find alternatives to using them. Use of a radar chart is only possible if the order of the axes is fixed and meaningful (ordinal) and if the order is circular, i.e. the last item is somehow related to the first, as is the case with wind directions and cyclical events, such as the hours in a day, months in a year or the tides.



Shortcomings

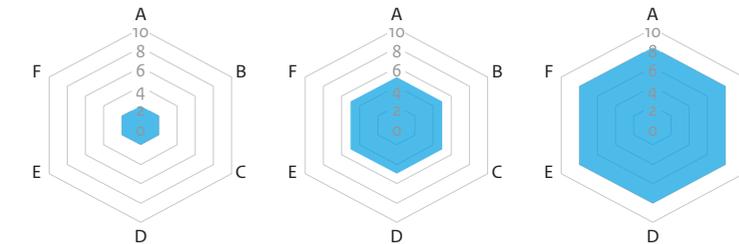
The shape is determined by the order rather than the data

The shape that emerges when all data points are connected has no real relationship to the message as it is mainly determined by the order of the axes. Various shapes could be constructed using the same data set, depending on how the axes are ordered.



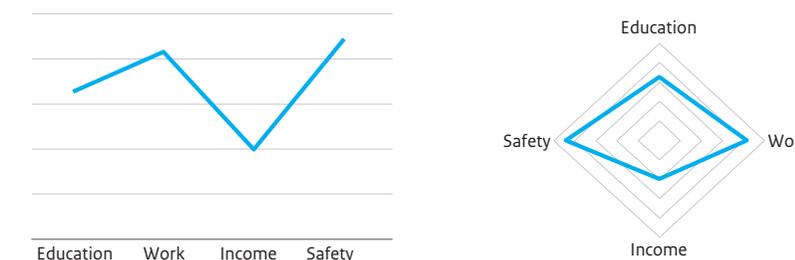
Overestimation of high values

Because of the larger distance between the axes at the edge of the chart, larger data point values become overestimated and smaller values are more difficult to estimate.



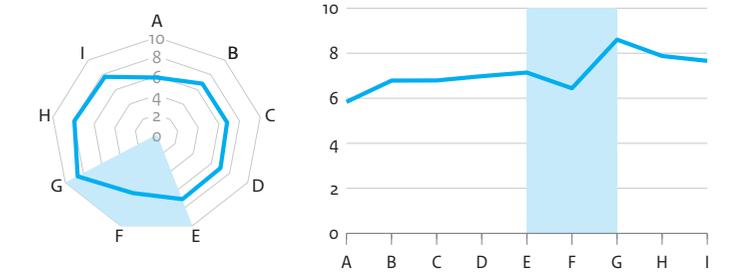
Unjustified links between different categories

Line charts connect data points and, therefore, cannot be used to visualise data-containing categories, because there is no transition between them. Radar charts, however, do make this connection.



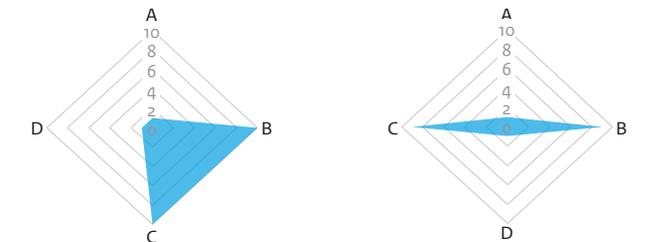
Direction of lines unclear due to circular shape of the chart

Because of the circular shape of the radar chart, the direction of the lines is not always easy to see. It is therefore more difficult to discern an increase or a decrease than when looking at a line graph.



Plane size does not depict the average

The coloured two-dimensional plane of a radar chart can be misleading, as it seems to give an indication of the average value. However, an estimation based on plane size would be incorrect. In the example below, 50% of the data points have the maximum value, but only a quarter of the total area is coloured. And, if the order of the axes were to be changed, then not even 10% of the plane would be coloured.



The art of omission

The map and its story

A map never perfectly reflects the actual situation. This is not just because the reduction in scale makes it impossible to reveal all the details, but also and mainly because maps are made with a certain goal in mind: to deliver a spatial message. A map that is meant to be used for navigation, therefore, mainly contains information about roads or waterways and is supplemented with landscape features. Maps can also be

used to show geographical distribution, such as that of average house price per municipality or number of poultry farmers per province. These are known as 'thematic maps' and contain markers to indicate values and elements to identify geographical locations, such as borders between countries and regions. Sometimes, these maps also depict other topographically recognisable elements, such as cities, roads and rivers.

These then serve as references which allow the reader to easily identify the location. It is important that the amount of visual information is well-balanced. Too much information can push the map's message into the background. Several techniques exist to strike a balance in this relationship.

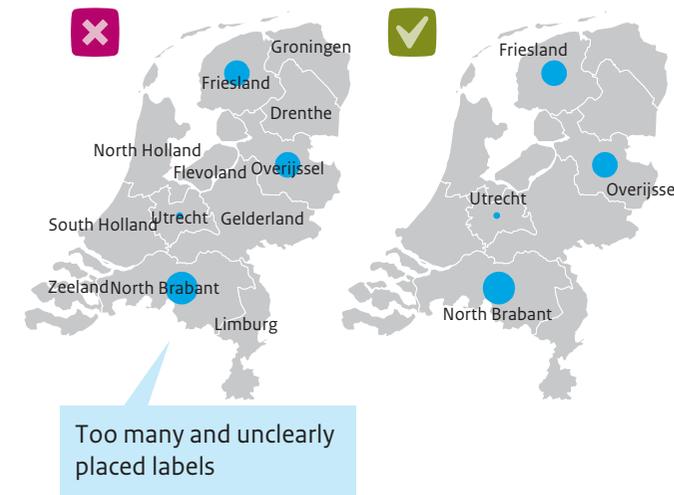


Generalisation

Maps are depicted on a scale that is smaller than reality. This requires simplification of the information to be visualised. The degree of simplification depends on the scale. The smaller the scale, the more you need to omit or combine to keep the image clear. However, if you take things too far, the elements on the map will become difficult to recognise.

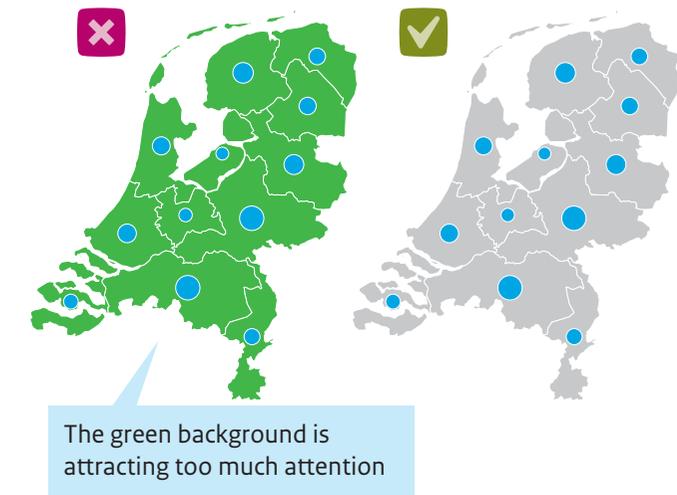
Labels

Labels can help to identify information on the map or direct attention to parts of the map that are important. The positioning of the labels is crucial, especially when there are many, because incorrectly placed labels can clutter the image rather than make it clearer.



Composition

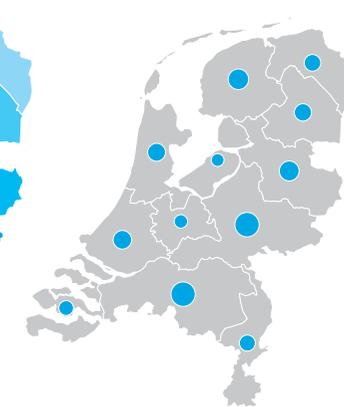
The way in which the various parts of a map are put together — their composition — has a significant effect on the map's readability. For example, it is important to use a visual hierarchy. This enables you to highlight the message and enhance readability. One way of achieving this is by not applying any striking colours to background layers.



Colour



Size



Amount



Symbology

A data set can be visualised in various ways. The choice for a certain kind of visualisation can greatly influence readability. Colours can be used to highlight distinctions. Varying the size of circles or other symbols may provide insight into differences in absolute size. Varying the number of symbols on a map may be used to express distribution and density.

Difficult to estimate

How to produce a reliable image using circles

Maps containing circles are common. They are useful for representing quantities and differences between quantities. Circles are easy to grasp, intuitively: the larger the area of the circle, the larger the value it represents. They are also very suitable for displaying data sets that contain large ranges, because the range is spread over two dimensions: the area increases quadratically. Another advantage of circles is that they are very useful for indicating geographical distribution: regardless of the circle's size, you can always clearly locate its centre and thereby the point on the map that refers to

the related value. This is in contrast to, for example, bars with varying lengths, which do not immediately show which part of a bar corresponds to a location on the map. Is it the bottom end, the middle or some other part?

There are also disadvantages to the use of circles. Circles may end up overlapping or even cover each other completely, if large numbers of data need to be visualised or if their geographical distribution is very clustered — such a map then becomes illegible. Another disadvantage is that it is

difficult to estimate differences between circles of areas of various sizes. Readers are known to often underestimate the area of large circles. There are several methods for solving this problem, all with their own pros and cons. In any case, it is most important to ensure that the size of the circle — or any other symbol replacing it — is directly in proportion to the value it represents.

Radius is not scale

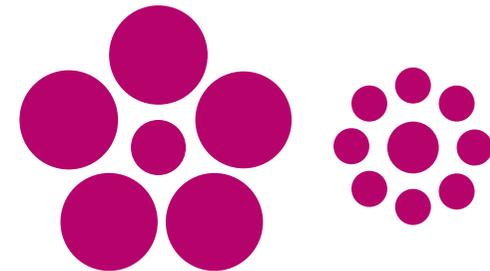
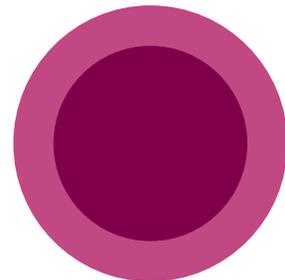
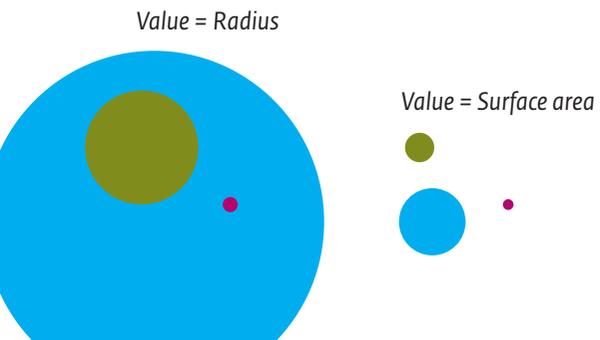
A mistake that is sometimes made when designing circles is that the value to be shown is linked to the circle's radius rather than its area. In that case, the area increases exponentially with an increase in value. This leads to extreme disparities when dealing with a wide range of values.

Seemingly smaller

The larger the circle, the more its area is underestimated compared to that of smaller circles. The area of the outer circle is twice as large as the area of the inner circle. And yet, most people will say that the outer circle is much smaller than that.

Optical illusion

Estimations of the size of a circle are influenced by other circles surrounding it. In this example, the circles at the centre of the two sets are exactly the same size; nevertheless, most people will believe the circle on the left to be smaller.

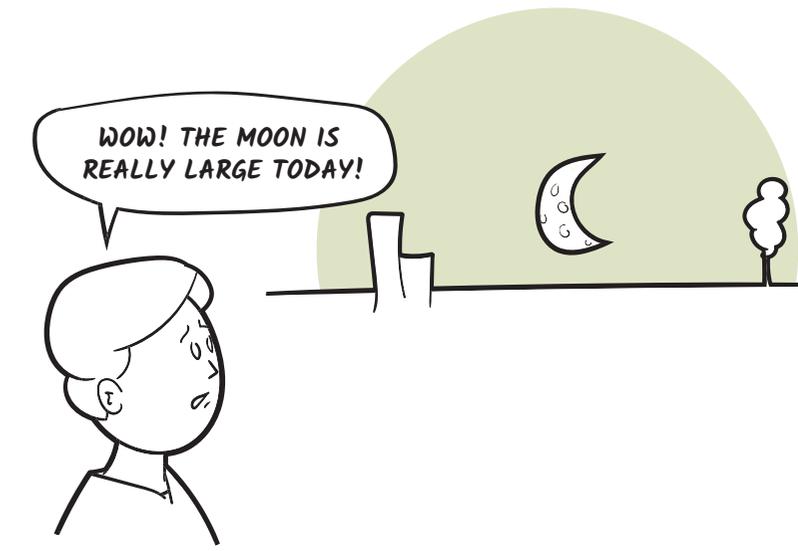
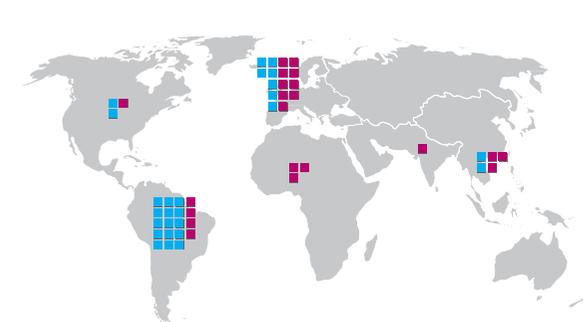
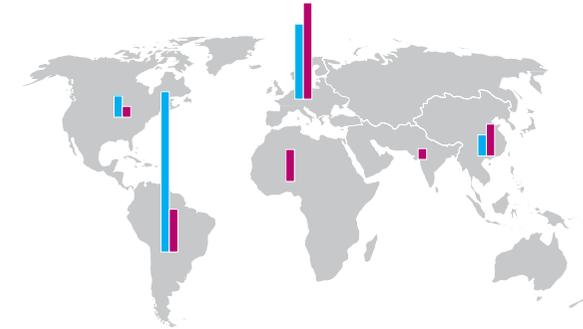
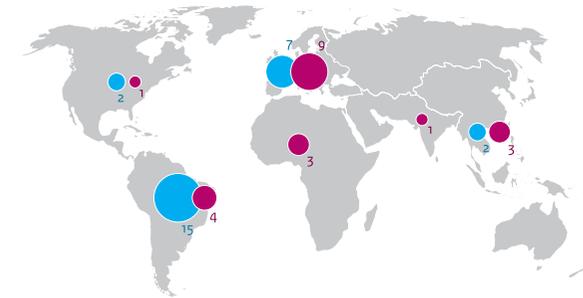


Providing help when using circles and several alternatives

A simple tool to help with the estimation of circle areas is that of displaying the values next to the circles. This is suitable for maps that do not present a great deal of data, and provided that the relationship between the values and the circle involved is clear to the reader.

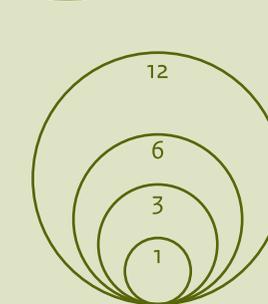
Another possibility is to replace the circles with small bar charts. Most people can gauge differences in length better than differences in area. A disadvantage, however, is that bar charts that show high values usually need to be drawn outside their corresponding location on the map.

A third possibility is to visualise the data with arrays of icons that represent a certain amount. Readers can easily count such icons — using this method will make differences more easily discernible and the visualisation remains compact.

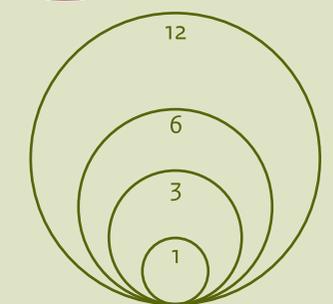


Compensate?

As early as in the 1920s, research was being conducted into how circles were being interpreted. In 1956, geographer James Flannery developed a method for adjusting the size of circles, so that the depicted areas would be estimated more correctly. The serious disadvantage of this method is that of the areas of the circles in the figure no longer directly corresponding to the data they represent. This can lead to wrong estimates and, if readers would measure the circles, the effort would produce inaccurate results. PBL, therefore, always visualises data in circles that are exactly proportional.



Absolute scale



With compensation

Absolute or relative

How do you get that on the map properly?

What is a choropleth map?

The municipalities of Ede and Delft have approximately the same number of inhabitants, but because Ede has a larger land area than Delft, its population density is lower. How could this be depicted on a map? To show this type of thematic information, a so-called *choropleth map* is often used.

The word choropleth is a combination of the Greek words choros (area) and plethos (value). A choropleth map shows each region in a colour that corresponds to the value

of a variable for that region. In a correctly produced choropleth map, absolute data (i.e. number of occurrences within a certain area) are converted into relative data (i.e. the number of occurrences per area size). This is also known as normalisation.

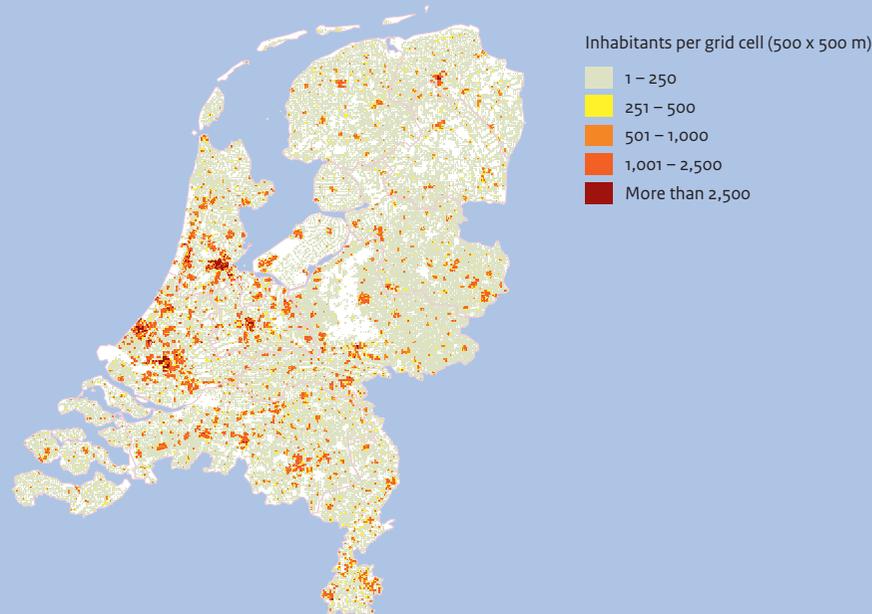
The importance of normalisation

If normalisation is not applied in this type of map, a small region with value x will have the same colour as a large region with value x. When looking at the map, the large

region would be far more conspicuous than the smaller region, while they should both be equal with respect to the theme being visualised. If the theme is normalised (i.e. divided by the region's area), the larger region will have a lower value (different tone of colour) than the smaller region. This approach gives readers a better impression.

A map with data in grid cells

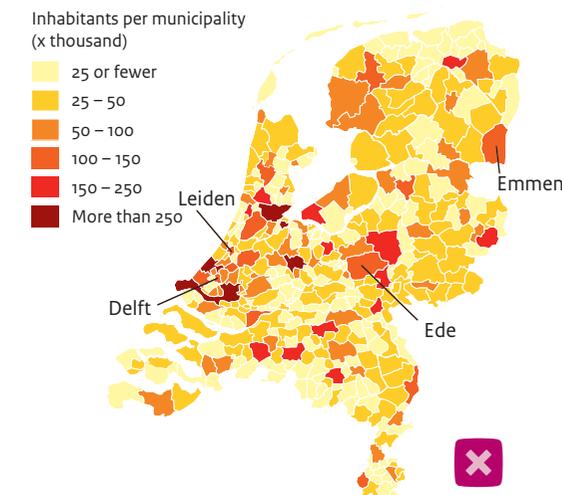
This map shows the population distribution within the country. The total number of inhabitants is shown per grid cell and is divided into 5 classes. In this map, grid cells are 500 x 500 metres. It is clear that normalisation has no effect on this visualisation. The map shows both the absolute number (inhabitants per grid cell) and the relative number (density, or number of inhabitants per 0.25 km²).



Not like that...

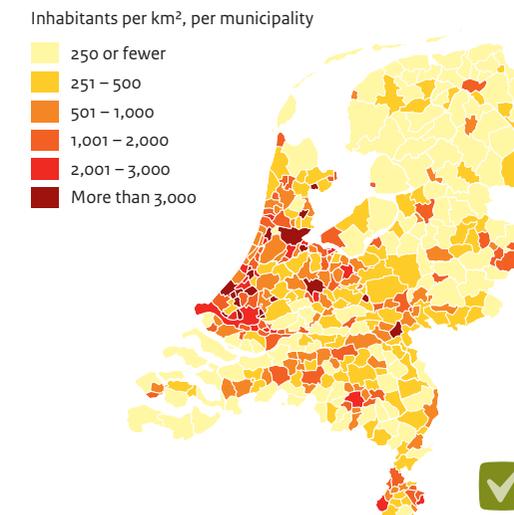
The importance of normalisation becomes apparent when population numbers per municipality need to be visualised. Adding up all the values of grid cells in a municipality provides its total number of inhabitants. This can be visualised by applying colours. Then it becomes clear that municipalities with roughly the same number of inhabitants do not all appear as equivalents on the map. Municipalities that have a larger surface area are more conspicuous than municipalities with a similar number of inhabitants but on a smaller surface area.

The Dutch municipalities of Emmen, Ede, Delft and Leiden all fall into the category of 100,000 to 150,000 inhabitants, but Emmen and Ede are more prominent on the map than Delft and Leiden.



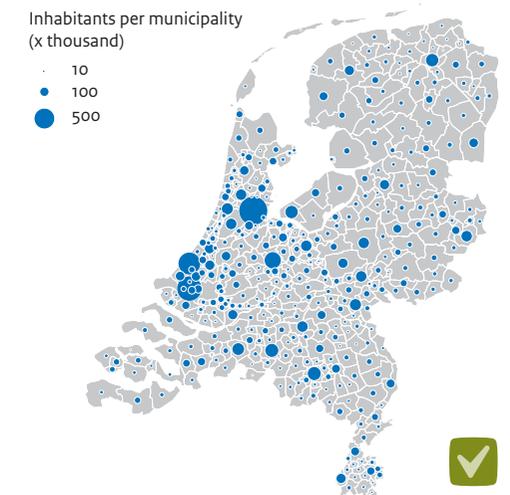
Normalised data in a choropleth map

Representing population figures in a choropleth map requires normalising the data. That type of map will thus no longer be about absolute numbers, but rather about relative numbers (densities). To do this, for each municipality, the number of inhabitants need to be divided by its area. In this map, the normalised visualisation gives the number of inhabitants per square kilometre. The spatial distribution of this map now corresponds more precisely to the grid map than to the misleading choropleth map above.



... but like this!

If the intention is to display absolute data without being able or willing to normalise the data, a better solution would be to produce what is known as a figurative map. This type of map represents absolute numbers with a proportional symbol. In the map shown here, this is a circle with an area that is proportional to the number of inhabitants. The spatial distribution of this map corresponds more precisely to the grid map than the misleading choropleth map on the left.

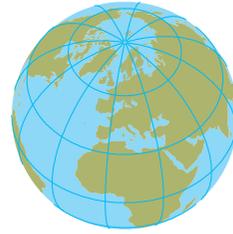


Absolute data: figurative map — relative data: choropleth map

No misleading readers when displaying absolute data means a figurative map should be chosen. Alternatively, data can be normalised and made relative and then constructed into a choropleth map. However, a choropleth map should never be based on absolute data. This would create a deceptive image.

The earth is round

The limitations of a two-dimensional planet



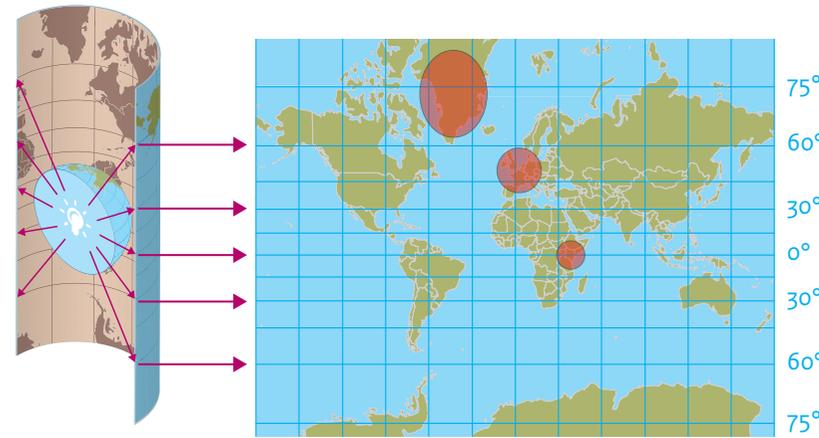
All maps are wrong. PBL regularly makes maps of the Netherlands, Europe or the world, for its publications. It is impossible to transfer the surface of a sphere onto a two-dimensional surface without any distortions.

No matter which projection method is chosen, angles, distances and shapes will be incorrect. For regional maps, too, the curvature of the Earth's surface will need to be corrected for,

although the effect will be smaller and less visible than on a world map. In all cases, the point is that not just any projection can be chosen.

The Mercator map

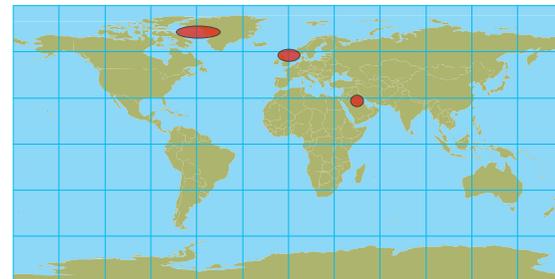
The most well-known world map is the Mercator map. The biggest disadvantage of this map is that the further an area is located from the equator, the larger it will appear. In reality, Greenland and Saudi Arabia are roughly the same size, but on the Mercator map Greenland is even bigger than the whole of Africa! Still, this variant is widely used in online maps, such as Google Maps, because shapes and angles are preserved. Google Maps is used mainly on a local level and, there, it is important that right angles are not distorted. Determining distances is possible by using smart algorithms and fine-tuning the scale bar to the latitude concerned. When zooming out to the global scale, however, the distortions become so large that a different projection would be preferable.



The principle of map projection The Mercator map is an example of a cylinder projection: the coordinates of the Earth are projected onto a cylinder (left). The unrolled cylinder shows the coordinates on a flat surface (right). In this type of projection, the distortion at the poles is large: the red shapes drawn here correspond to equally sized circles on the globe.

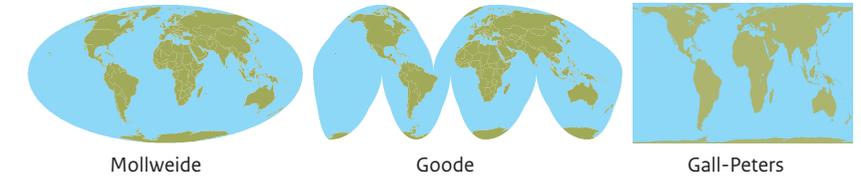
World maps containing grids: lat/lon projections

When making calculations, the so-called equirectangular projection is often used. Also known as the lat/lon projection (derived from latitude and longitude), it uses longitudes and latitudes as x- and y-coordinates within a two-dimensional plane. In this projection, each 1 x 1 degree area of the Earth's surface is rendered as a square; all squares have the same area size, which allows the Earth to be depicted as a rectangular grid. Since calculations are made on square grid cells, it is not necessary to perform a reprojection during calculations. There are, however, severe distortions in shape and size at higher latitudes. For this reason, PBL prefers to not use this projection in the final figure. The red ellipses shown in this map would appear as equally-sized circles on the world globe.



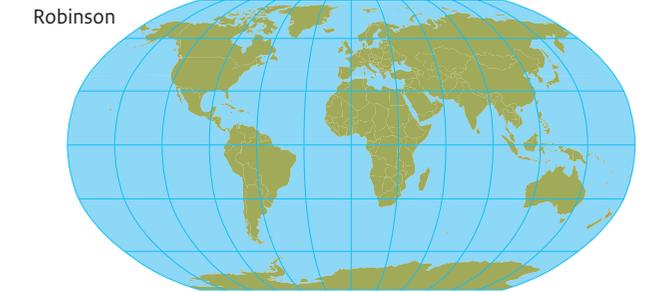
Equal-area

For objective representations of the distribution of phenomena across the globe, it is crucial to ensure the map preserves area measure. The Mercator projection, given its severe size-related distortions, is highly unsuitable for this purpose. There are projections that are more or less equal-area (Mollweide, Goode, Gall-Peters), but these come with serious misrepresentations of angles and shapes.



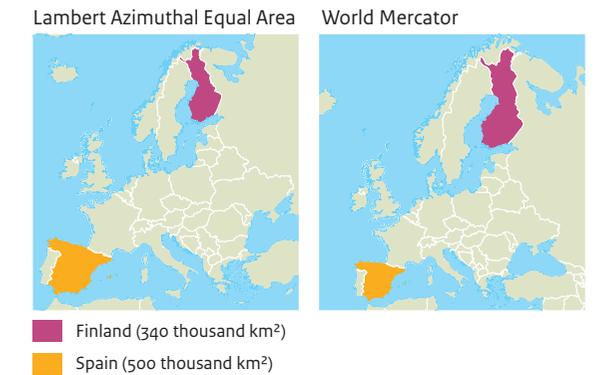
World map projection at PBL

At PBL, the Robinson projection is used to make world maps. This projection produces a visually appealing image in which a compromise has been made between distortions in shape, distance and size. An interesting fact is that the American cartographer Robinson, who devised the map in 1963, first worked out the kind of image he was after and then figured out the mathematical factors needed to achieve it. Most projections work the other way round and start from mathematical formulas which are the basis for the calculation of a map image.



Europe

For maps of Europe, PBL uses a true-to-size projection recommended by the European Environment Agency (EEA): the Lambert Azimuthal Equal Area. The maps shown here compare the surface areas of Finland and Spain in this projection with the same areas in a Mercator projection. It is obvious that the Mercator projection also exaggerates the surface areas of the northern countries on the European scale.



Netherlands

For maps of the Netherlands, PBL uses a projection that produces hardly any distortion (RD New); the distortion in distance varies between -10 and +18 centimetres per kilometre. The maps on the right show the Netherlands in the RD New and lat/lon projections. In the lat/lon projections, shape and distance are both severely distorted.



Am I seeing this correctly?

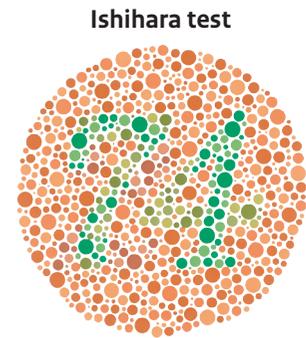
On colour vision and colour blindness

PBL always tries to make illustrations and images legible for the widest possible audience. This means that people with visual impairments are also taken into account — for example, readers who are unable to perceive certain colours. Many people are probably familiar with the test based on a circle with coloured dots, the Ishihara test. People will see different numbers in the circle, depending on which colours they can or cannot see. There are different types of colour blindness, but the most common are problems with green-red, as shown in this example.

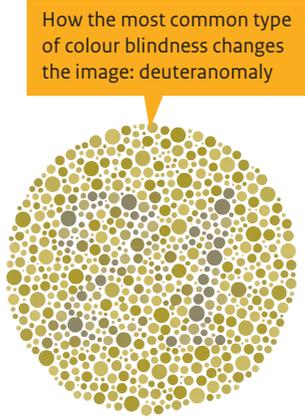
Is it important to take this into account? One in twelve men is red-green colour blind. This means that in an audience of 100, half of which men, about four individuals will not or only partially grasp the message contained in a map that uses the colours red and green. And please note that violet is sometimes perceived as grey, which should be kept in mind when using this in combination with shades of grey.

Map using red-green
In this map, the colour intensity of the red and the green is so similar that colour-blind people can hardly distinguish between the two.

Map using violet-moss green
Violet and moss green (house style colours of the Dutch Government) are easily distinguishable, even for colour-blind people.



People who are not colour blind will see '74'.



Most red-green colour-blind people will see '21'.

How the most common type of colour blindness changes the image: deuteranomaly

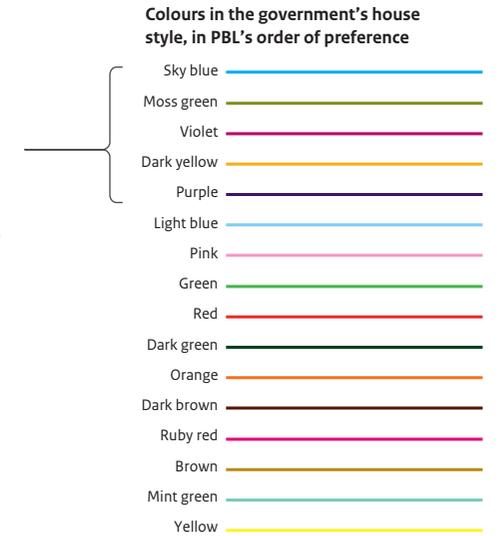


Colour for all: tips from PBL practice

1 Avoid using red-green series in maps whenever possible. From violet to moss green is an excellent alternative, and so is violet-yellow-moss green.



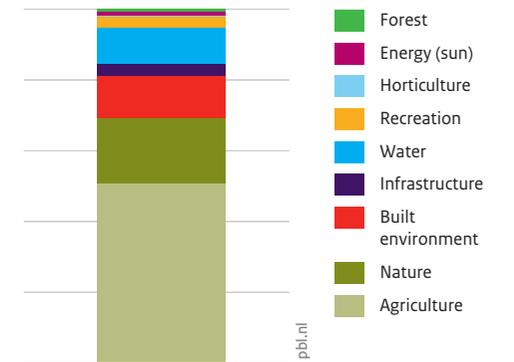
2 The use of red and green lines in line graphs should be avoided. The first five colours commonly used by PBL in its line graphs are properly distinguishable. Red is the ninth colour of PBL's colour scheme.



3 In addition to colours, shapes can also be used in colour series. The traffic light rating table in PBL's assessment of the physical environment (Balans van de Leefomgeving) is a good example of this.



4 The order of the legend should match that of the image. In line graphs, the order should match the end points of the lines; in stacked or clustered bar charts, the order should match that of the various segments of the bars. This makes the graphs easier to read.

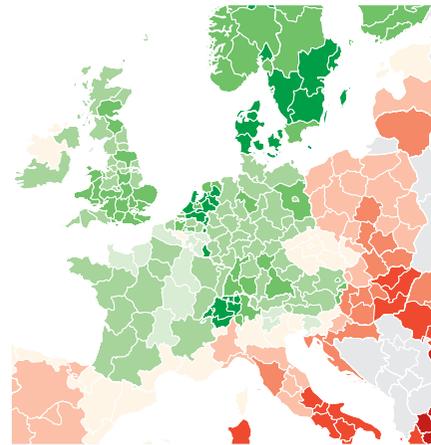


Red for danger, green for safety

What colours may convey

The colour red catches the eye. Red is often associated with danger and therefore works very well for emphasising something. Red also stands for love, warmth and closeness. Green stands for nature, calmness, peace and security. The context of colour is important. A colour can take on a radically different meaning when it is combined with other colours. The interpretation of colour is culturally determined. In South Africa, red is the colour

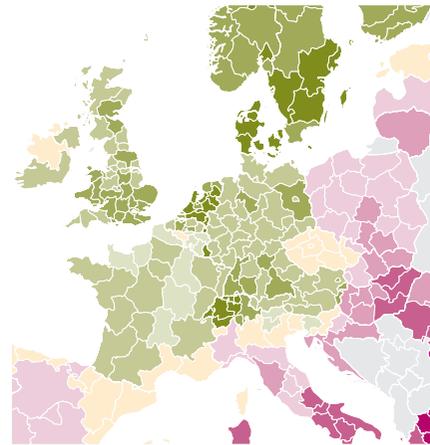
of mourning, but in China red is felt to have a positive meaning and is associated with happiness. Therefore, on the Chinese stock exchange, red is used for rising shares, while green points to a drop in value. Precisely the opposite to the practice in the Netherlands. In Dutch politics, red is often used to express 'leftist' and 'revolutionary' aspects, whereas in the United States, red is the colour of the conservative Republican party.



Lower Norm Higher

From red and green...

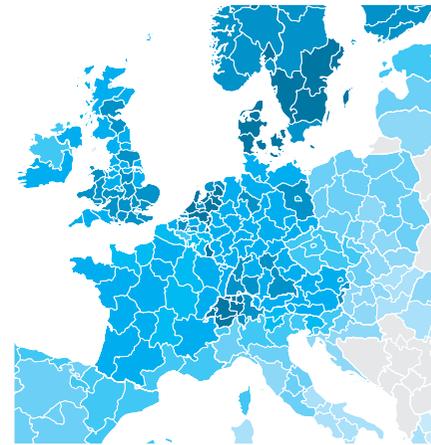
In the past, PBL often used red and green as signal colours. Shades of red represented values above a reference value, or served to show that policy objectives had not yet been achieved. Shades of green indicated a safe value below a reference value, or showed that a goal had been achieved.



Lower Norm Higher

...to violet and moss green

Today, to highlight normativity with signal colours in a certain image, PBL prefers to use violet and moss green. Colour blind people can distinguish these colours better than red and green.



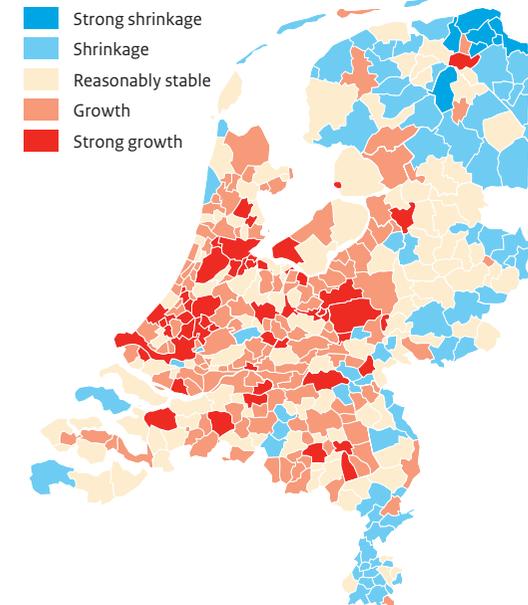
Lower Higher

... or in shades of a single colour

Red and green are vibrant, high-contrast colours that can function well, precisely because of the notions they are associated with, but, often, the intention may be to avoid normativity. The map above in shades of blue places far less emphasis on the fact that a value is above or below a reference value or average value.

Hot and cold, high and low

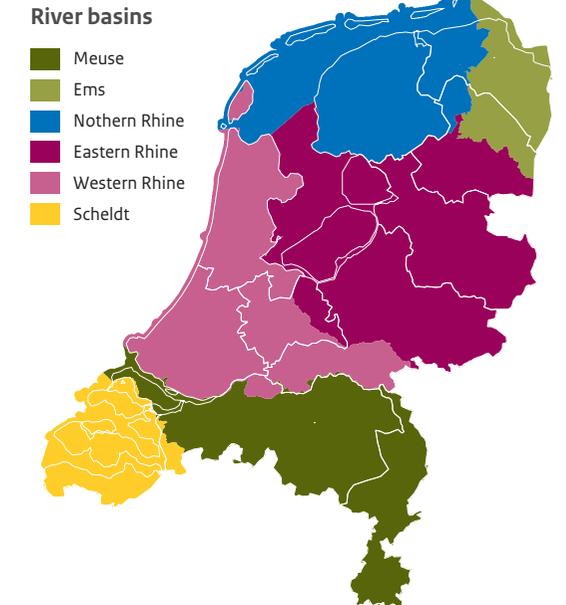
Blue stands for quietness, calmness and serenity. The combination of blue and red can be put to good use when visualising a range of temperatures from warm (red) to cold (blue). Or, as in this map, when showing positive and negative values (increase and decrease). Here, a light, less conspicuous shade was used for the middle or neutral value.



Strong shrinkage
Shrinkage
Reasonably stable
Growth
Strong growth

Context determines emotional value

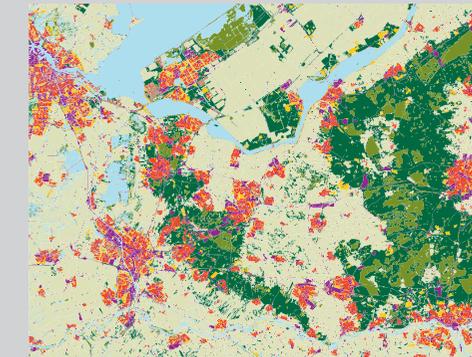
By using other colours in addition to red and green — such as blue and yellow in this map — the value-ladenness of red-green changes. This will reduce the sense of normativity.



River basins
Meuse
Ems
Nothern Rhine
Eastern Rhine
Western Rhine
Scheldt

Colour conventions for qualitative data

When representing qualitative data, for example in land use maps, the colour green is often used for rural areas or nature, red for buildings and blue for water. If red and green are the only two informative classes in a land-use map, it is better to choose other colours, so that you can take aspects of normativity and visibility of colour into account. For example, you can choose violet instead of red and mossgreen instead of green. Depending on the type of emphasis that needs to be given, one of these can be replaced by grey or another less dominant colour.



Red space
Residential area
Construction developm
Other built-up areas
Green space
Recreational area
Agricultural area
Forest
Nature area
Blue space
Water

Words and images in one

The power of infographics

PBL also creates infographics, in addition to graphs, maps and diagrams. What distinguishes infographics from other types of figures? For PBL, infographics are truly different products.

The infographic needs to contain a message in itself, without the surrounding text — unlike the typical practice for figures in traditional reports. In those, the message is usually conveyed by the text and the figure is kept as neutral as possible in its representation of the data.

With an infographic, the explanation is part of the visualisation. And the title presents the message of the whole. This is to ensure that readers will pick up the main message, even if they cannot remember the details of the image.

Infographics can contain all other types of visualisations — maps and graphs, diagrams and illustrations. Precisely the things the story needs to tell. PBL's aim is to ensure that an infographic without context is still understandable.

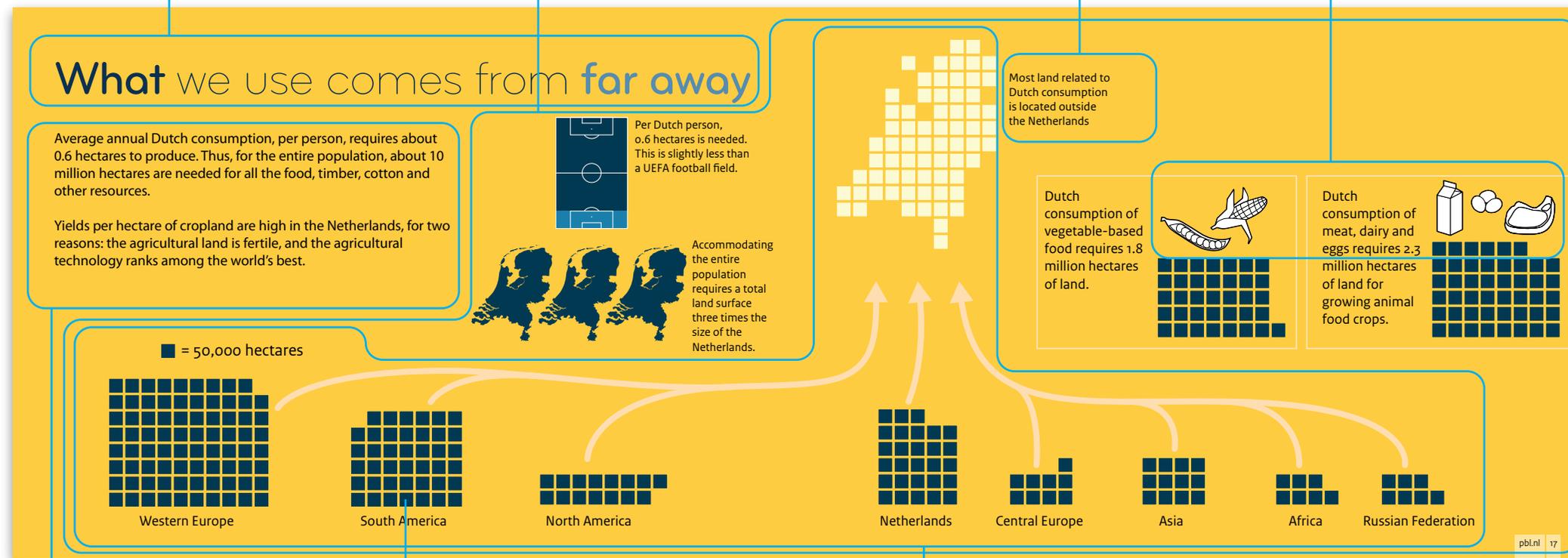
PBL chooses to create infographics when, for example, the main messages of previous research need to be summarised for a wider audience, or to address an urgent subject that requires extra attention.

Title: The title of an infographic contains the main message. If readers remember nothing but the title, they will still have picked up the most important thing.

Overall image: The image confirms the title and supports the message. The image may be layered; the reader does not need to read the box of icons, but it does provide additional information.

Annotations: An additional layer of information to help with the interpretation of data and images. Explanation is needed to properly grasp a complex story, even if it is a visual one.

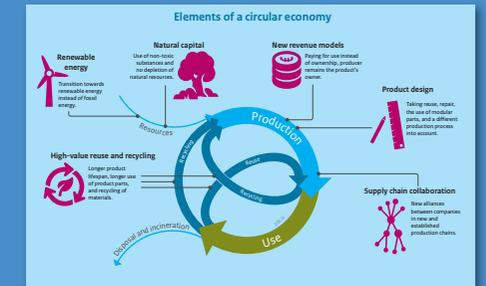
Icons and pictograms: Visual introductions to the subject and readily identifiable examples of the subject.



Text: A short text that explains the title, introduces the subject and provides additional information.

Colour: Using colours serves to guide the reader to the things that matter. Intense colours and sharp contrasts catch the eye.

Data: Data serve to support the message and add more detail to the visualisation of the message.



When creating infographics for websites, it must be taken into account how they will look on different screen formats (such as a smartphone) and produce separate versions for each of those formats. The wide sized infographics that cover two pages in PBL reports are not always easy to translate into a form that is suitable for websites.

I need to be able to picture it

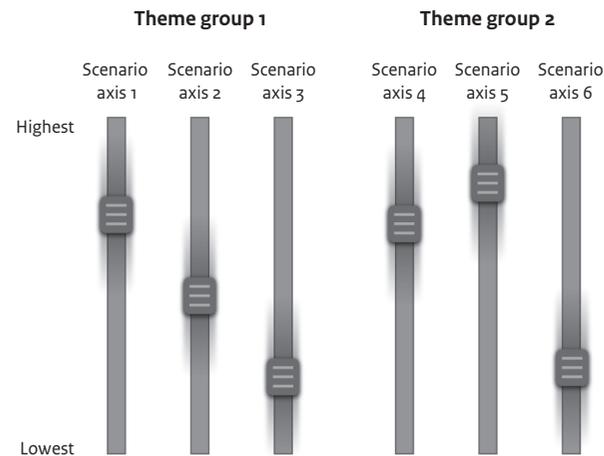
The art of visualising scenarios

Policymakers like to make use of scientific input when they are devising their plans for the future. As the future cannot be predicted with complete certainty, scenarios are developed that enable us to look ahead. Such scenarios can be compared and contrasted to show policymakers which options they would have for measures on, for example climate policies, housing and environmental issues.

Conceptual issues such as scenarios require appropriate illustrations. There are different types of visualisations to provide a clear overview of what these scenarios are based on.

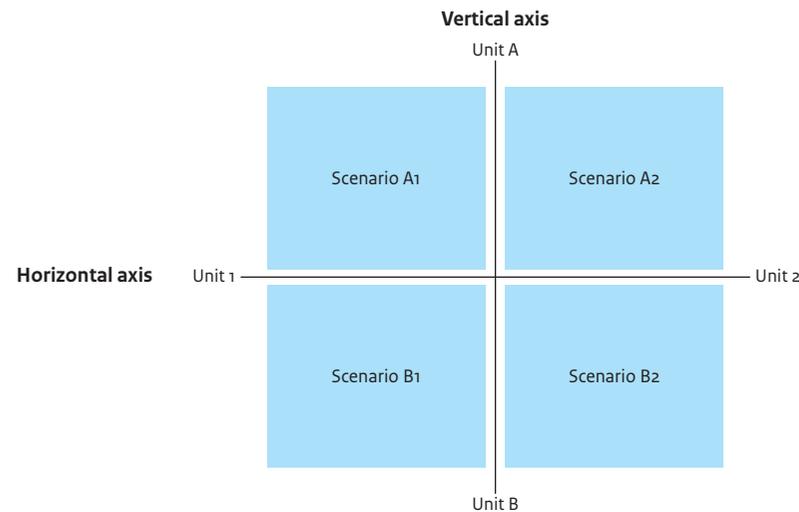
Scenarios containing variables

Scenarios that use several variables can be depicted in a table-like visualisation or with sliders.



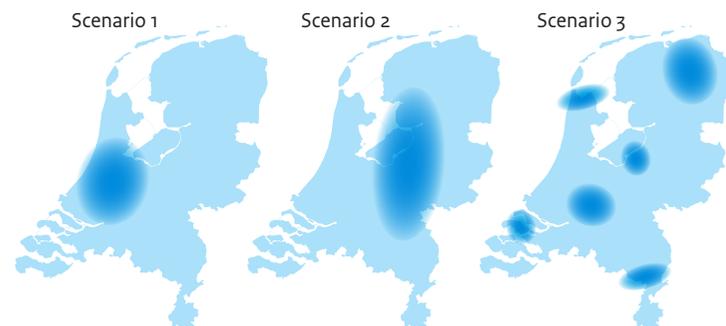
Coordinate systems

Coordinate systems work really well to show contrast between diametrically opposed ideas. They are especially suitable for illustrating scenarios that contrast along two dimensions.



Spatial effects

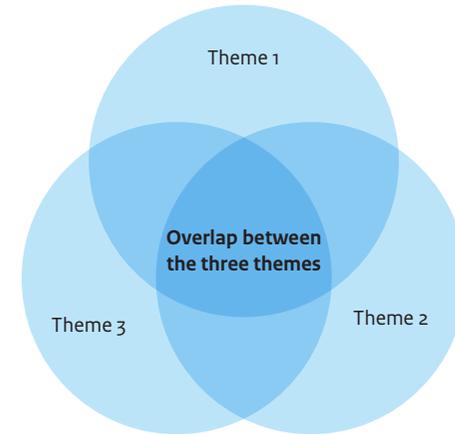
Maps can be used for visualising the spatial impact of scenarios. When applying this method, the uncertainty around the data must be clear. People tend to look for their own city or village and, if this falls in the area covered by the scenario, will they be able to draw the correct conclusions?



The art of visualising concepts

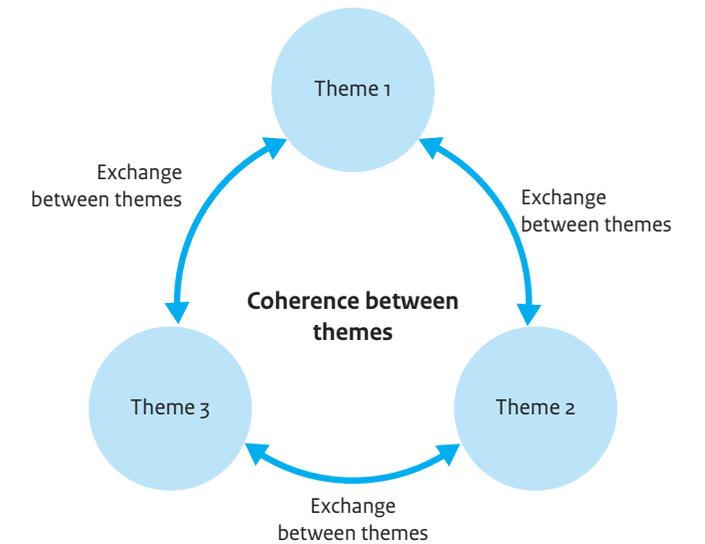
Coherence between themes

If there is a certain overlap between themes and if showing this overlap would benefit the concept, a Venn diagram can be used to illustrate the situation.



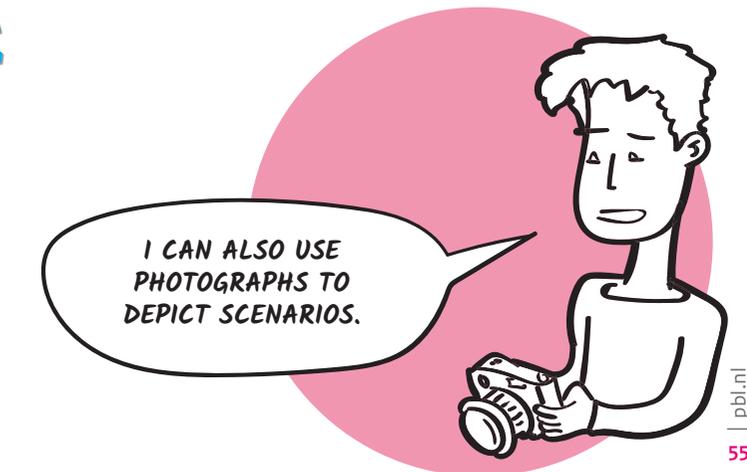
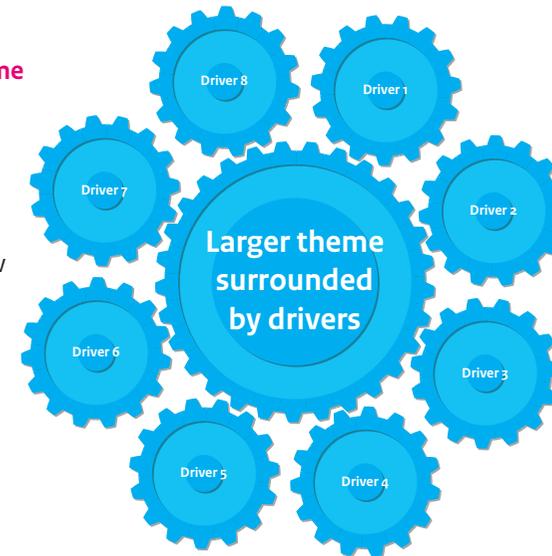
Relationships between themes

In other cases, there may be a relationship between various subjects. In visualising the situation, these relationships must be evident, while also maintaining the individual characteristics of the subjects.



Influences on a theme

When several subjects are affecting the same theme, this can be visualised by using cogwheels that show these relationships — in an online presentation the movement can be animated.



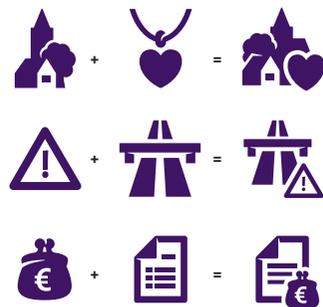
At a glance

Clever use of pictograms

Pictograms are images that are used in place of language. The word 'pictogram' is a combination of the Latin word *pictus* (painting) and the Greek word *gramma* (letter). Some languages included pictograms as part of the text and others consisted solely of pictograms, such as the Egyptian hieroglyphs. In the world of data visualisation and infographics, pictograms are used as a way of giving a quick impression of the subject under consideration.

Pictograms are also referred to as icons. In semiotics (i.e. the study of sign processes), icons depict a message. For example, an image of a chicken refers to the subject of chickens. Symbols are a different type of sign; there is consensus about a certain image representing a certain subject or conveying a certain message. They require the reader to know this convention in order to understand the message. Examples include traffic signs to indicate various situations on the road, and the skull and crossbones as a warning sign related to hazardous materials. There are also index signs, which provide a reference to a subject. For example, an image of smoke could refer to the subject of fire.

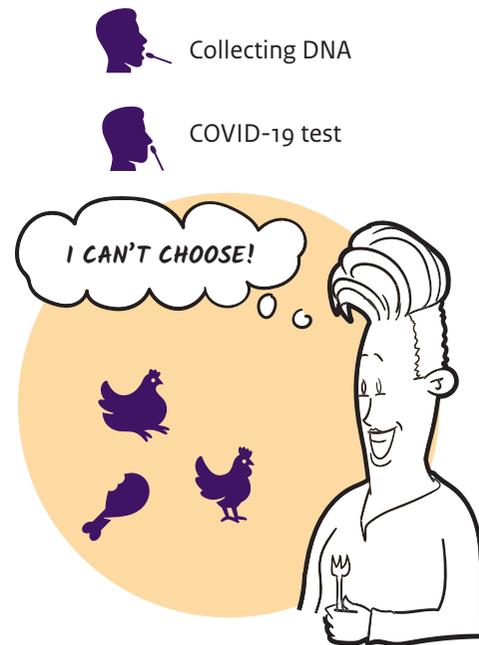
Photographs can also be used as icons to introduce certain themes. Often, the cover of a report shows a photograph of something related to the subject to indicate what the report is about.



Combinations
Images can be given a new meaning by combining several icons.

Subtle differences can change the theme

Readers need the right context to correctly interpret a pictogram. This means that the subject needs to be obvious, in order to achieve the correct association. Subtle differences may change the meaning.

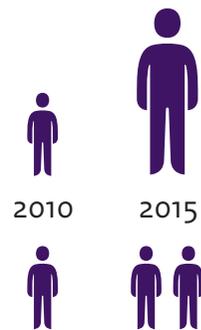


Choosing the right icon

The choice of icon determines the framing of a subject. It depends on the story that needs to be told. In the case of, say, chickens, the icon may reveal if the story is about broilers, healthy free-range animals or merely a type of meat product?

Scaling icons

Sometimes, it may be tempting to scale icons to illustrate a certain development. For example, area size may be important when making accurate comparisons — which can be difficult to do by scaling icons; area size is likely not in proportion to the data represented in the image. In those cases, it would be better to repeat icons, instead.



Large collection of icons available

PBL is able to tap into the extensive collection of icons in the visual identity of the Dutch central government (*Rijkshuisstijl*), which can also be combined to create new ones. Context is crucial when using icons. They should only be used if they help to omit repetition or can quickly identify a subject. Turning a visualisation into a rebus should always be avoided.



The concept of 'government' can be represented in various ways. It all depends on the level of government or the required connotation.

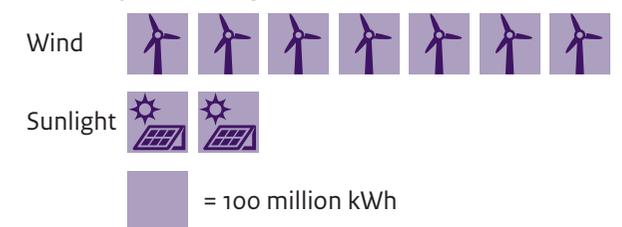
There are icons that can be used for several themes. A wind turbine may symbolise wind energy, but it can also stand for sustainable energy generation.

Sustainability icons come in many shapes and sizes, and they may mean completely different things. A caterpillar can be a symbol for biodiversity, but also stands for pest control.

Quickly distinguish and identify subjects

Here, all the icons were squared, because the different images they contain have differently sized surface areas. In this way, readers are able to compare the icon areas and, thus, see the relative shares of solar and wind energy in the overall production of renewable electricity.

Electricity from sunlight and wind



This is what it looks like

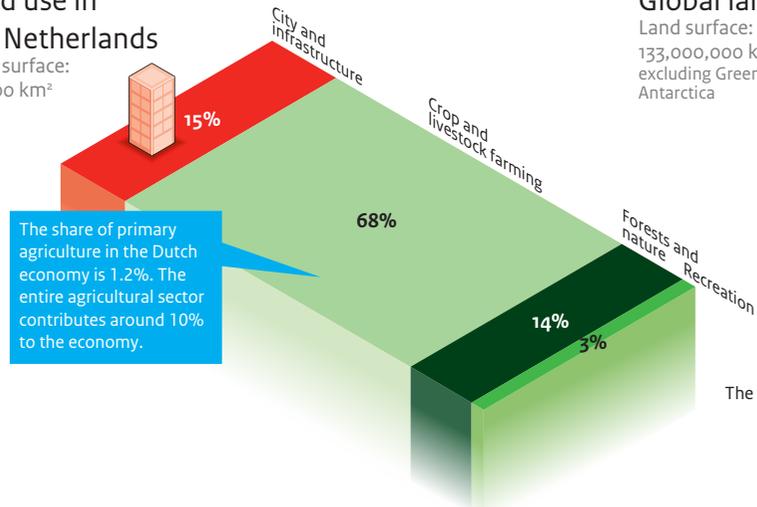
Every message has its own landscape

A bar chart can be used for easily comparing different situations or quantities and to offer insight into the distribution of values (quantitative comparison). But, in the example here, readers will not immediately see that the comparison concerns surface area. Readers can be helped to grasp the subject by modifying the image or visualisation in such a way that the subject becomes immediately clear. The infographic below is an example of such modifications. The text in the infographic also helps to quickly pass on a message to the reader, although it may be more difficult for readers to see the comparison itself in these kinds of visualisations. And producing an infographic takes more time.

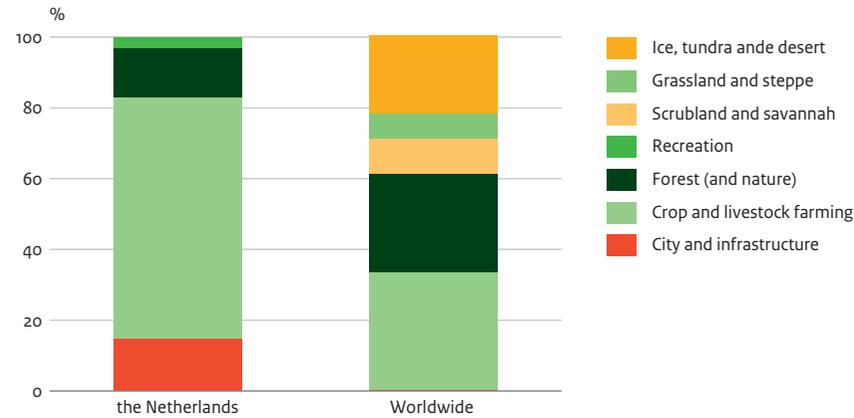
Creating an image of the subject helps to highlight the message and reveal the relationships. This also presents the choice of what message to convey with this visualisation and whether it will suit the publication for which it is being produced.

The Netherlands: a sparsely populated city

Land use in the Netherlands
Land surface: 34,000 km²

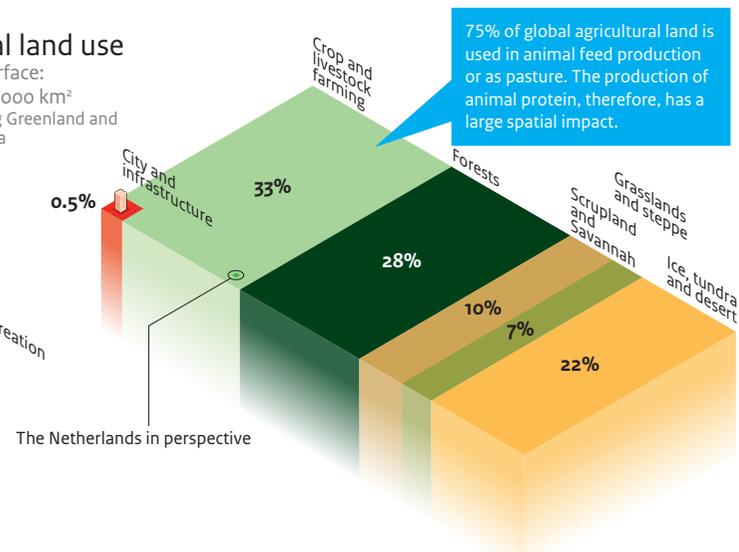


Land use



Global land use

Land surface: 133,000,000 km² excluding Greenland and Antarctica



List or illustration

Qualitative information can also be visualised, in addition to quantitative information. In text, this already occurs by grouping related subjects in the form of lists. Sorting subjects in such a way is the only visual aid for readers. However, long bulleted

lists do not make it easy for readers to form a mental picture of all the items presented and how they are related. Adding visual information makes it easier to understand the topics and their interrelationships.

Examples of ecosystem services

Cultural services

- Science and education
- Symbolic value
- Green recreation
- Natural heritage

Provisioning services

- Food
- Drinking water
- Water for other uses
- Biomass for energy
- Wood, fiber, genetic sources

Regulating services

- Coastal protection
- Water buffering
- Mediation of noise, wind and visual impacts
- Water, soil and air quality regulation
- Pest and disease control
- Soil erosion
- Carbon sequestration
- Prevention of heat islands
- Pollination
- Soil fertility



IT'S SO NICE - IT MUST BE TRUE!



Inconceivably large amounts

The human scale in PBL visualisations

For every infographic that PBL creates, several questions must be answered: What is the scale? How can readers be shown what the covered themes are all about? What subject should be chosen? How can the subject be put into perspective? How can the message be projected onto the world of the reader? Making a connection to a widespread, common notion will often work very well.

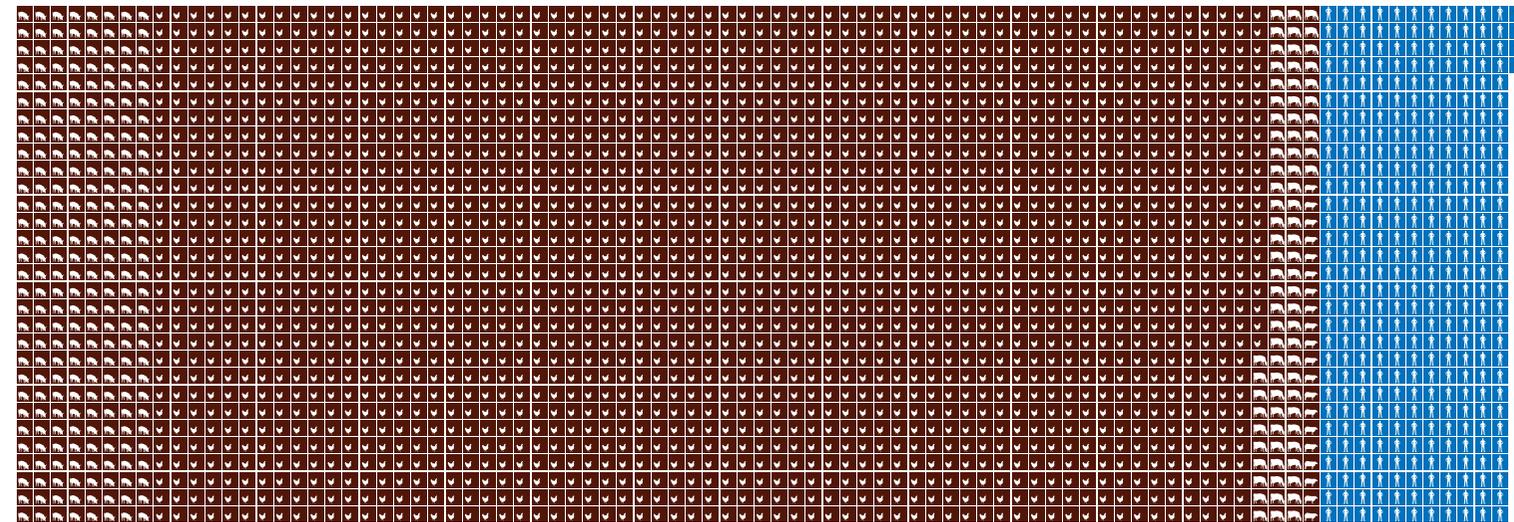
It is important for such a 'metaphor' to match the subject. A soccer field is often used as a unit of measurement to give readers an idea of area size. It is true that soccer fields are not all the same size and cannot be used to deliver precise results (soccer fields can vary from 6,400 to 7,140 square metres), but they do capture the imagination so vividly that the metaphor is used rather often.



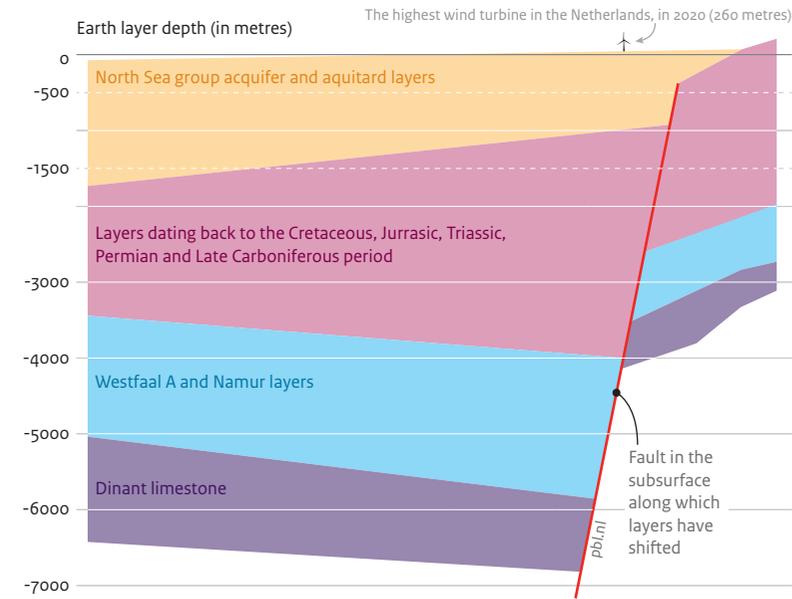
On a given day in 2011, the Netherlands contained:

- 
 12 million pigs
- 
 97 million chickens
- 
 4 million cows
- 
 1 million sheep
- 
 16.7 million people

One square represents 50,000

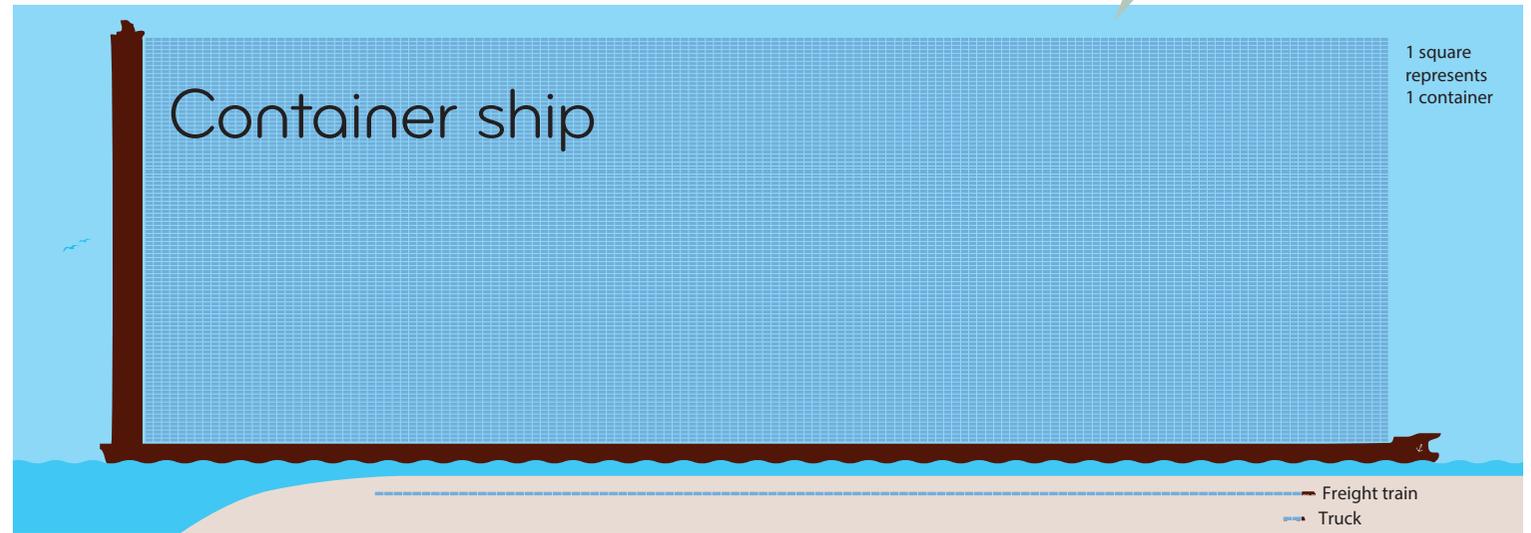


And how could you give people an idea of how many heads of livestock there are in the Netherlands? We decided on an infographic, showing the numbers of cows, pigs, chickens and sheep next to the 17 million people in the Netherlands. This provides a greater perspective on the number of animals.



When we talk about earth layers, readers may find it difficult to imagine their related depth. In such cases, a landscape object may put things in proportion, such as the seemingly small wind turbine – which is actually 260 metres tall – in this illustration of earth layers.

That a container ship carries many containers is a well-known fact. But how many are there, in relation to a train or a truck? This is illustrated in this image, showing the load of tens of thousands of containers on one ship in comparison to the dozens on a goods train and the two on a semi-trailer truck.



It is mind-boggling

How an image becomes useable through interaction

What is interaction?

The fact that an electronic image responds to touch no longer surprises anyone, these days. It is more likely to be the other way around: young children react with perplexity when a picture in a book or magazine fails to 'do' anything. Images that respond to interaction are far from exceptional, especially on websites.

This interaction offers many possibilities for communicating through visualisations, without filling them with lines, symbols and other signs that become visible at the same time. An example of a simple form of interaction is that of revealing information

only when a mouse pointer hovers over a certain part of a visualisation (i.e. displaying exact values for a certain part of a graph). In the case of maps, the same method can be used for displaying interesting information that increases or adds to understanding them (e.g. showing the name of a region or some derived data).

Interaction also offers the opportunity for making many more data accessible than could be included in a static image. If there are data available for all the municipalities in the Netherlands with regard to a certain period, they cannot all be included, one on top of the other, without creating a

confusing figure. Interactive images can offer users the option of viewing one type of information at a time — for example, how a certain issue is developing in their municipality — without the picture becoming cluttered with information from hundreds of other municipalities.

With these tools, interaction helps to present large amounts of data in a user-friendly way.

Interaction without action

Not all readers will make use of the possibilities offered by an interactive image. Sometimes, this is because the options

are not sufficiently clear, but it may also be that readers are only interested in its main message. It is therefore important for interactive figures to be set up in such a way that they express this message without requiring any action from the reader. Interaction is a valuable addition, but cannot be a requirement to understanding an image. Interaction is therefore particularly suitable for exploring more detailed data, rather than telling a story from A to Z.

Is it still correct?

Interactive images can be designed in such a way that readers are able to switch information, layers or ranges of data on and off. The order in which information is presented is then no longer fixed, but is determined by the reader. It is crucial to take this into account when creating such an interactive image. For instance, does the title match the content even if the reader changes the displayed information? Is the legend of a map still correct when another layer is switched on? And can the information displayed be comprehended by itself, before any other pieces of information have been shown? The creator of an interactive visualisation must ensure that readers cannot adjust an image in such a way that the message becomes partially or wholly incorrect.

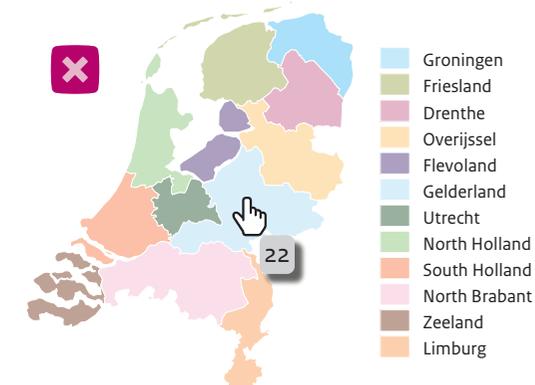
Showing additional information

Number per province

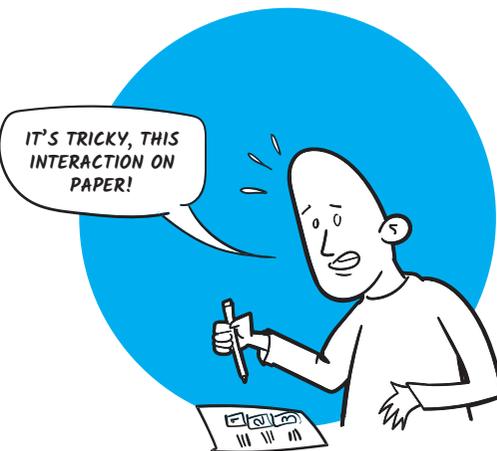
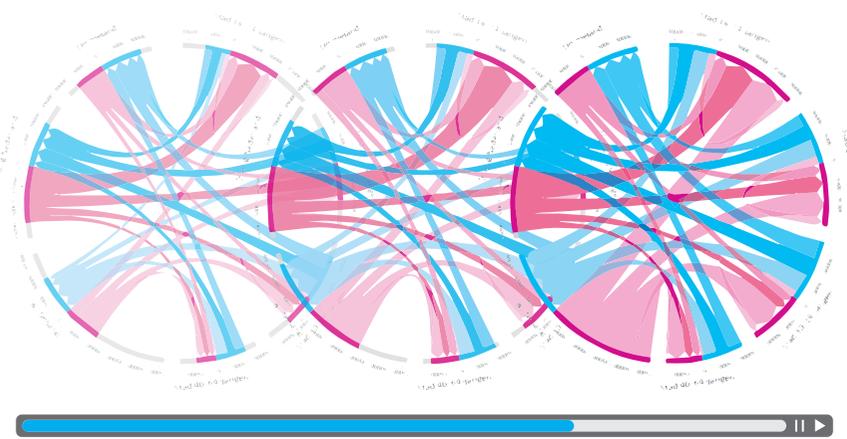


Ensure that the main message is clear, also without using any interaction.

Number per province



Changes depicted in time



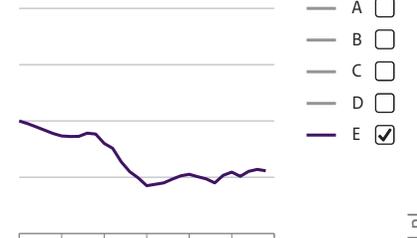
Making your own selection

Nearly everything increases!



All parts of an image must still be correct after the reader makes adjustments.

Nearly everything increases!



The reader in control

Digital techniques to engage the reader

A picture is worth a thousand words. Visualisations convey a message to the reader more clearly than can be done by words alone. The message becomes even clearer if readers can truly get involved in the story. If people are challenged to think about what they are seeing, the message is easier to understand and to remember.

Readers can be challenged in various ways. A simple method of doing this is to use an

intriguing title, one that makes the reader think about what it could mean.

Titles in the form of a question provide food for thought. Readers will impulsively want to discover the answer. A title containing a question will also stimulate readers to think about the purpose of the visualisation: why is this information interesting?

On websites and in apps, there are even more ways to involve readers in the story. If not all the information is shown at once, if a visualisation modifies itself according to the progress of the story, or if readers themselves can be at the 'dashboard' of a model behind the image, then they become more than readers. They become participants.

Over the past few years, at PBL, we have applied these techniques on several of our websites.

Questions and answers

A webpage can be longer than will fit on one screen. If readers first see only the title's question and need to scroll down to see the corresponding image, they will tend to think about what message it may contain. This means that they will be more likely to look for this answer in the image.

Dynamic

On a website, visualisations can change and be adjusted to reveal information, step by step, or exactly match the part of the story the reader is looking at, at a given moment. This can be done, for example, by keeping the central visualisation in a fixed state while only allowing the text to scroll, or by using buttons to navigate to the next step.

Interactive

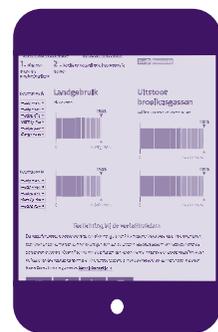
When readers are allowed to adjust an image to suit their own interests or environment, they may gain a better understanding of how the model works, or how various factors influence a particular outcome.



For the annual data on global CO₂ emissions, PBL created a website that uses data visualisations to answer frequently asked questions.

PBL designed a dynamic animation that, in a stepwise structure, provides insight into the complex flows of people moving house between cities, the peri-urban countryside and the rest of the country.

What is the impact of a particular diet on land use and greenhouse gas emissions? This is demonstrated with the help of an interactive model that allows readers to adjust all the parameters themselves.



Aligning image and medium

Reach the target audience through customisation

Target audience and medium

At PBL, we focus on various target audiences, such as the Dutch Government, the House of Representatives, policymakers, scientists, the informed public and the general public. We use various tools to reach these audiences, varying from paper to digital, and from text to image. There is no golden rule about what works best where and for whom. Would people rather have a coffee table book? Are they travelling on a train, holding a tablet in their hands? Or are they behind a desk looking at a larger monitor or reading from a paper report? Therefore, in addition to personal needs, situations and places also play a role. It is a case of 'and, and, and', of using multiple means of communication per target audience, as each communication channel has its own opportunities and limitations when it comes to visualisations.

Customised images for each medium

Publishing only physical reports is a thing of the past. Nowadays, there is a whole range of tools and media to disseminate knowledge, such as books, articles, brochures and flyers, smartphones, tablets and desktop computers, social media apps and websites, as well

as live meetings and video conferences. Images are made to suit a particular medium, each of which offering its own possibilities. PBL and its predecessors are not amongst the early adopters. Physical reports have dominated our output over the past 25 years. The production process for visualisations is therefore strongly influenced by paper as the

medium of choice. For example, we create images using the CMYK model for colour printing and the layout is tuned to our 170 by 240 mm page size for books. The physical report is also the criterion for choice of colour and font size. Our online PDF files are the digital variant of the paper report: they can be printed directly in report format.

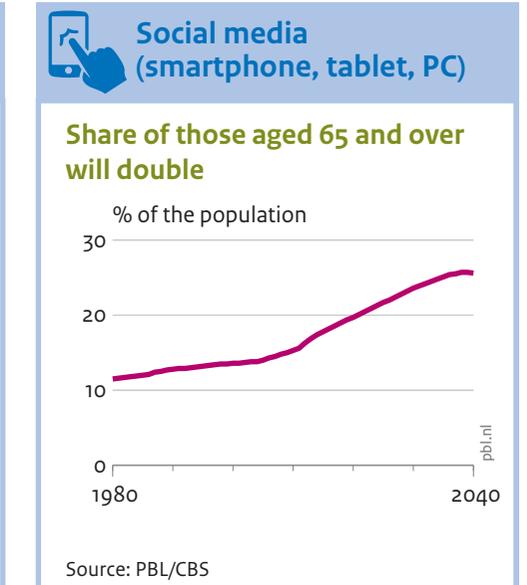
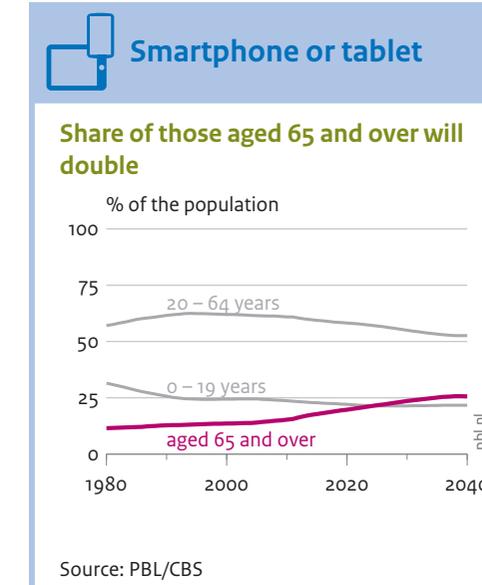
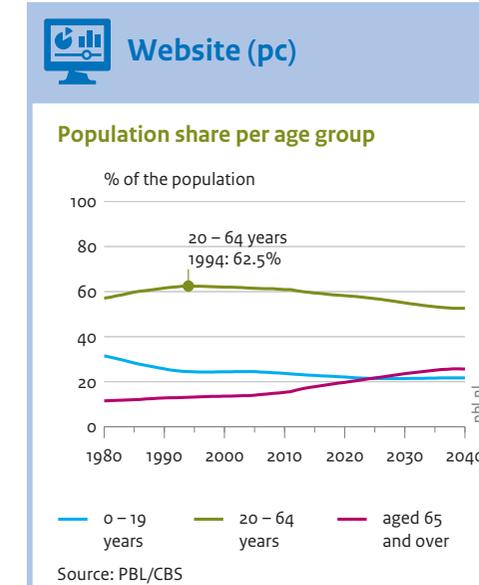
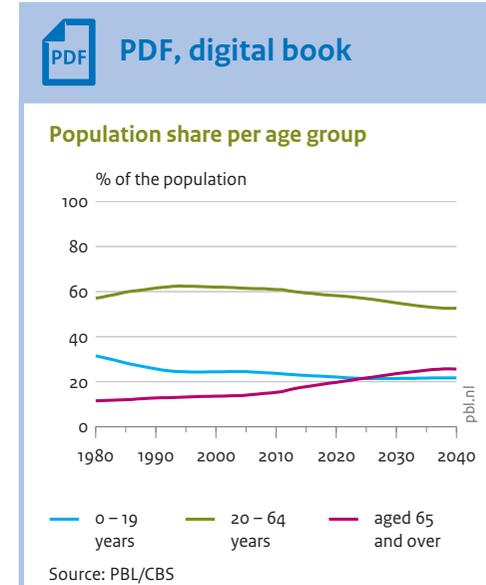
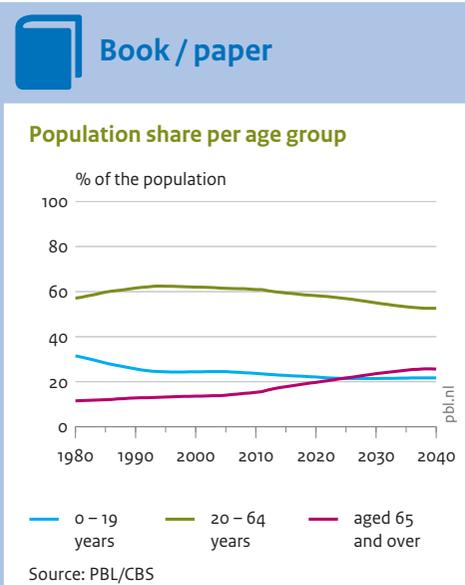
High-quality images that convey the right message

What do we consider a high-quality image? This depends on the medium; books, whether printed on paper or as a digital (PDF) file, require sharp images with clear, easily distinguishable colours and details. There are limitations, though. For example, plotting more than eight lines in a graph will result in too much information. And B5-sized maps call for national borders with less detail. On a website, dynamic images can be used: hovering with a computer mouse over a certain area on a screen can provide more

details about lines in a graph or a region on a map. With pop-ups, additional information can be shown at a moment of choice. These, however, do have the disadvantage of readers possibly overlooking the information or even missing it altogether — for example, when they use a smartphone, as this does not have mouseover functionalities.

'Mobile first' is a much-heard remark in communication. Mobile device, such as smartphones, have a relatively small screen and the attention span of its users is generally shorter. This means that images

for these types of devices should be further generalised. For example, rather than displaying eight coloured lines, use only one coloured line and keep the others grey or leave them out altogether. There is also less space for text, so keep titles 'short and sweet'. But apart from such limitations, digital media also offer opportunities. Animations are a good example. Changes can be visualised in a dynamic way, with gradually appearing lines, rising bars, shifting planes or changing colours. In this way, each medium has its own limitations as well as new possibilities.



Characteristics and impact of medium

- Static, details, business-like title
- No stress, you have time to study the image
- Fixed structure, leafing through
- No internet connection needed
- Paper is pleasant to read from
- Room for elaboration

- Static, details, business-like title
- No stress, you have time to study the image
- Leafing through
- No internet connection needed
- Room for elaboration

- Dynamic and interaction, pop-up at data points
- Motion is added dimension
- Stepwise construction and explanation
- Audio supports the depiction
- Easy to update
- Room for elaboration

- Dynamic and interaction, pop-up at data points
- Motion is added dimension
- Easy to update
- Audio
- Always with you

- Simple yet captivating
- Short and sweet
- Links to more information
- Always with you
- Useful for rapid distribution of information amongst target audience

The image's journey

Impact, influence and framing

The image is ready, the report has been published... does that mean we are done? Not always. Both at and outside PBL, discussions arise in which the published image plays a crucial role. Sometimes, this only leads to a new story; in other cases, we produce new variants of the image. In that way, the image is both the reason for and the means of debate.

A telling example is that of a visualisation about influence in the food chain. It was originally produced by Wageningen University & Research for the *Voedselbalans 2011* (Food Assessment report). Later, in 2012, PBL took the image and edited it, initially for the publication *Balans van de Leefomgeving 2012* (Assessment of the Human Environment 2012) and subsequently for *Nederland verbeeld* (The Netherlands in 21 infographics).

Framing

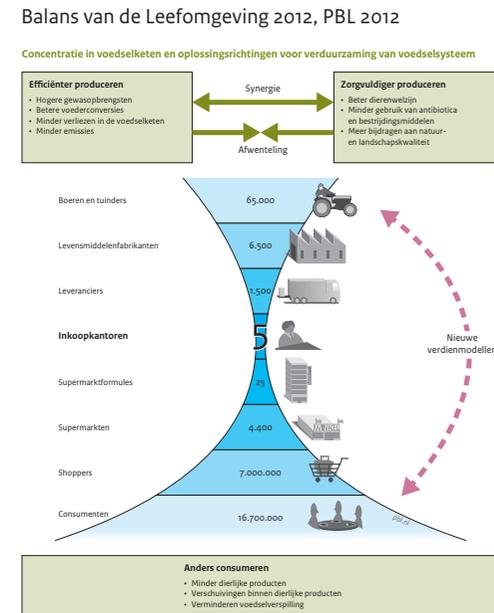
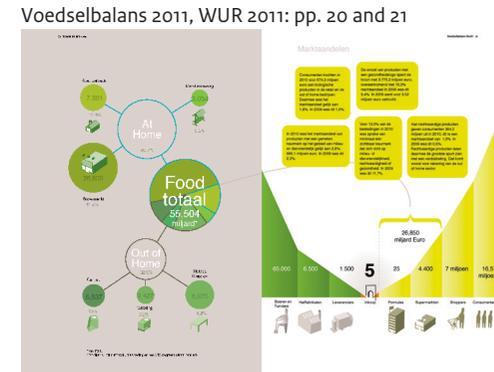
Making a well thought-out trade-off between content and design is an important task for the specialist — in Neurath's terms: the transformer — who brings together the knowledge of the scientist and the graphic skills of the designer. The result is an image that is based on real data and at the same time pleasing to look at. There is no such thing as a completely objective approach, but one based on knowledge is certainly possible. The important thing to remember is that the way in which an image is created always frames the production in a certain way.

Influence by design

Images can visualise what otherwise would remain hidden in a mountain of words. An example is the image about the five procurement offices that play a central role in the food chain from producer to consumer. The image also makes it clear that there are many parties involved, between consumer and farmer, and that this reduces the direct influence of consumer behaviour on farmers, and, if a change in food production or consumption is advisable, this should also — or perhaps especially — take place in the chain.

The image's attractive design and accessibility ensure that a wide audience will be able to identify their position in the food chain. This then means that the image can play a role in a broader discussion. Circumstances and timing are also involved: at the time of the image's publication, there was public debate on sustainable food and influence in the chain, to which the image clearly relates.

This is an example of how we sometimes see a discussion in images arising alongside a discussion in words: organisations who adapt the image to suit their own perspective and thereby reframe the image in line with their own position in the discussion.

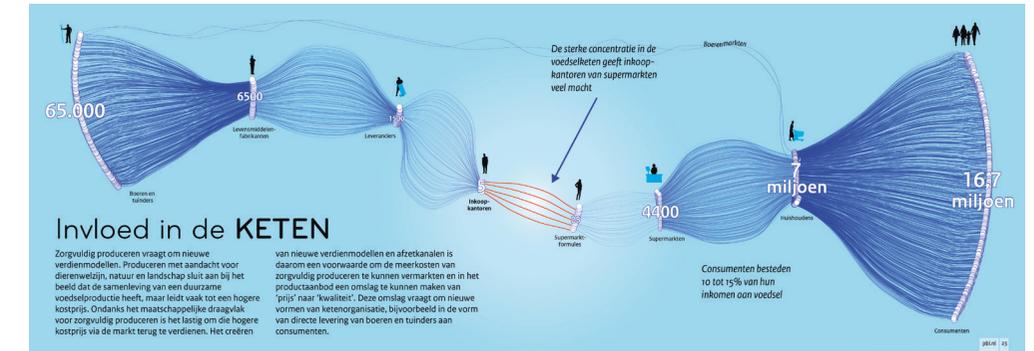


New product, new visualisation

To turn the diagram into a fully-fledged infographic, a number of adjustments were made:

- Turn the image 90 degrees to represent the chain
- Represent quantity using 'strings' and knots
- Emphasise the part of the chain with few connections by using a lighter colour (spotlight effect) and a speech bubble
- Add a title that expresses what you are seeing
- Ensure all readers can recognise themselves in the image; for example, a consumer may think: 'Yes, I am one of those 16.7 million people. That very thin line over there, that is my Saturday shopping at the farmers' market twice a year.'

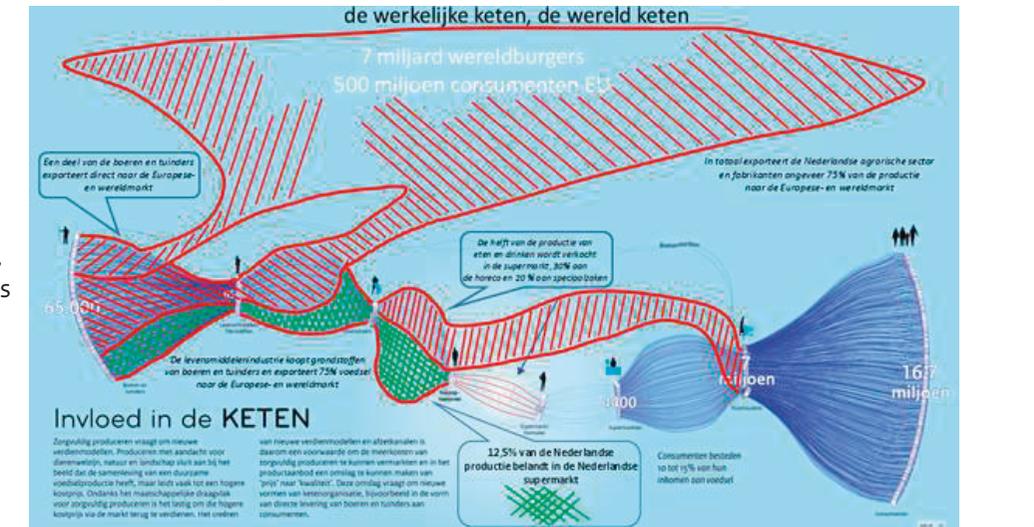
Nederland verbeeld, PBL 2012



Annual report Wakker Dier 2014



The real chain is on a global level, CBL 2015



Foresight

How PBL is keeping up with the times

The profession of creating visualisations and graphic images is not a static field of expertise. This publication describes what we have learned and applied over the past 25 years, when depicting knowledge for policy purposes. We take this valuable experience with us, as we head towards the future — as this is, and will continue to be, a solid basis for our work.

Trends come and go, but visualisation remains the same, at heart: clear

communication of information using graphic tools. There is an ever-growing number of channels for sharing information, and we respond to those developments. How can visualisations be used more effectively other than using the traditional printed forms? How can researchers without specific knowledge of image creation use visualisations in exploratory phases of research? Another aspect is that it is becoming easier and easier to create more complex graphic presentations

of data thanks to the democratisation of visualisation tools. However, these tools, in themselves, are not a guarantee for a good result. Brainwork and creativity are still needed to visualise information in such a way that the message is clearly conveyed. We also keep searching for new forms of visualisation — not just at PBL, but also in active collaboration with other organisations and networks that are engaged in this line of work.

With a powerful combination of image, sound and text, target audiences can be told a complex story in an instant, with explanations of how intricate visualisations should be read, what message they are conveying and where the supporting information can be found. Creating an animation requires a variety of expertise on images, sound and communication. Even more important in developing a proper visualisation is that of having a well-structured story, in which the right information comes into view at the right time. This requires intensive cooperation with content writers, voice-over artists, sound designers and video editors.

Animations

Visualisations that look good are not necessarily effective. To be able to continue to create appealing, high-quality visualisations, it is important to share and acquire the related knowledge, both within PBL and with external colleagues in the same area of expertise. The increasing availability of tools to create visualisations is leading to a steady expansion in the offering of images. This means that it is becoming more and more important to separate the wheat from the chaff. Visualisations should not unintentionally tell the wrong story. That is why, at PBL, we are developing knowledge on how to frame visualisations, and invest in expanding the knowledge on the impact of visualisations and how they come across to a particular target audience.

Visualisation science

Social media are an inseparable part of PBL communications. A key advantage of social media is the straightforward and rapid dissemination of our messages to and by third parties. Through social media, PBL's messages can be put across quickly and to the point, with a link to extensive information that substantiates the content. Often, the available space to visualise information is limited. This means it is important to be concise. In other words, to communicate the core of your message while omitting as much non-essential information as possible. Social media are continuously evolving; new possibilities and new platforms come and go. We continue to explore the possibilities and make use of them whenever they can serve PBL's objectives.

Social media

Over the past 25 years, we mainly created visualisations to communicate a message from science to policy. However, visualisations can also be used to improve the understanding of data in the initial phases of research. Technically, it is becoming easier and easier to present large complex data sets in images. Visualising the results under various assumptions and then showing their effect makes it possible to uncover patterns in the data. This technique can also help to better understand how a scientific model works.

Another powerful tool for the early phases of research is that of making sketches; these can serve to elaborate initial ideas and concepts or to streamline chains of thought, and be used as input for discussions or brainstorming sessions.

Exploratory visualisations

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Colophon

Visualising Knowledge. Lessons from 25 years of policy-related data visualisation

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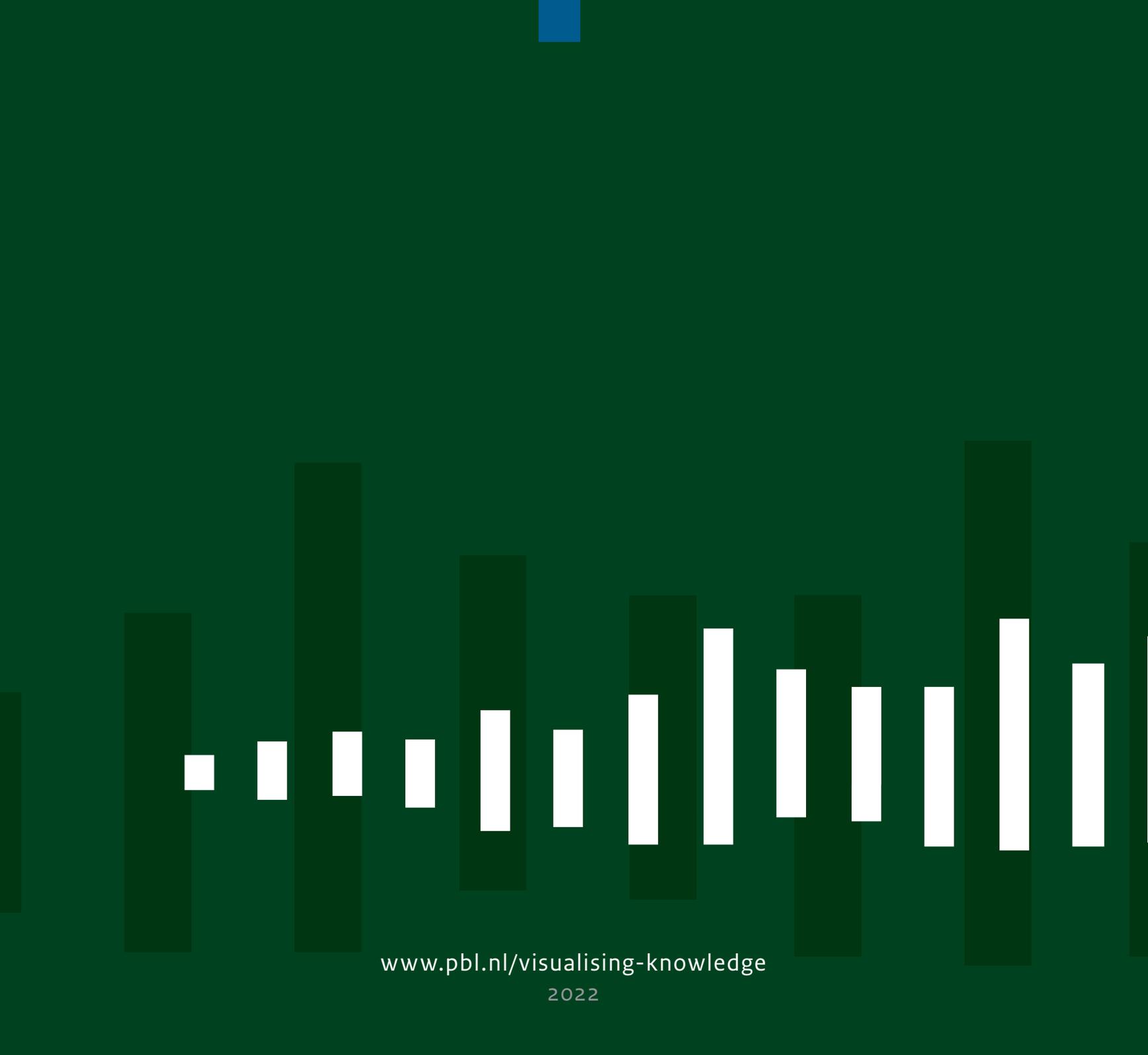
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