

The New Cartography

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Maps are everywhere these days. From the daily news to scientific reports, geographic information is increasingly part of our everyday understanding of the environment. Traditionally, maps were static images, painstakingly constructed by experts and used primarily as navigation tools. In the digital age, maps have changed dramatically. Today they are easier to create, thanks to the power of computers and the growing availability of digital spatial data. Maps now serve as dynamic, interactive tools for visualization and communication. Digital mapmaking has shaped the way we view our human and natural environments and allowed us to build a deeper understanding of the complex geographic implications of global climate change.

Using satellite imagery, the 2005 United Nations Environment Programme (UNEP) report *One Planet, Many People: Atlas of Our Changing Environment* highlights how spatial data can be used to monitor the environmental impacts of decades of human activities and changes in natural resources around the world. The maps and data show photographic evidence of shrinking glaciers, shifting coastlines, and disappearing lakes. While available in book form, many of the environmental “hot spots” (a geographic term often used to describe areas of high-impact intensity or conservation priority) are also featured online, allowing armchair cartographers to “fly” to specific regions and observe changes first-hand.

Now that these tools and technologies have become more accessible, the speed and accuracy with which we can access and use spatial information has improved enormously, particularly in the field of climate science. Building effective climate policy in the years ahead will require the ability to predict and manage anticipated climate impacts on fundamental aspects of our world, including our food, health, land, livelihood, and water systems. In this new landscape, spatial data are used as inputs to complex models and studies aimed at predicting how, where, and to what extent our climate is changing, while maps are used as communication tools to assist in visualizing their results. Maps can help distill and communicate the results of studies ranging from projections of temperature and precipitation shifts to the impacts of sea-level rise, and are being used both within and beyond the scientific communities that have developed them.

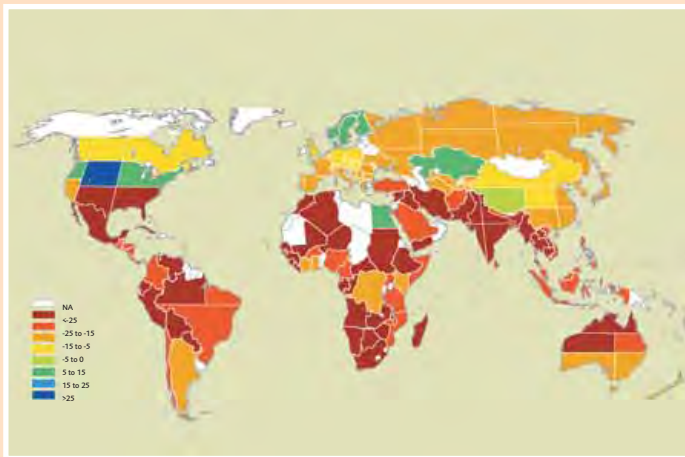


Figure 1. Map of projected climate-induced changes in agricultural productivity from 2003–2080, based on crop- and economic-modeling scenarios without carbon fertilization (Cline 2008). (Source: www.imf.org/external/pubs/ft/fandd/2008/03/cline.htm)

of Climate Change

Although climate maps are being created by mapmakers from diverse disciplines to display increasingly sophisticated data, the gulf between simplified snapshots of environmental changes and the complexities associated with the underlying studies and models has widened. Even the most casual map-reader must carefully consider three overarching elements of nearly all climate maps—scale, scenario, and baseline—which pose new challenges for both cartographers and citizens. Figures 1 through 5 illustrate how these primary map elements vary across five major sectors—food, health, land, livelihood, and water – where natural and social scientists, development practitioners, and policymakers are all working to better understand and respond to climate risks.

Figure 1 displays mapped results of global crop and economic models estimating temperature and precipitation changes on country-level agricultural productivity. Figure 2 highlights the geographic distribution of areas where current climatic conditions could lead to greater susceptibility to malaria in Africa. Figure 3 shows relative risk from sea-level rise by highlighting elevation differences along the coastline of Bangladesh. Figure 4 consists of a portion of a nautical chart from the Gulf of Maine used in a participatory mapping process aimed at understanding how local fishing communities respond to environmental change. Finally, Figure 5 illustrates differences between two global climate models predicting changes in annual water runoff at the grid-cell level across the world.

It is important to note that while each of these maps illustrates an aspect of the potential impacts of climate change, no single one provides a comprehensive view of the overall global climate problem. The maps also vary in how they represent past and projected environmental changes across scales, scenarios, and scientific disciplines. Understanding the strengths and limitations of such different studies and map displays is an essential window into the big picture view of climate science and policy.

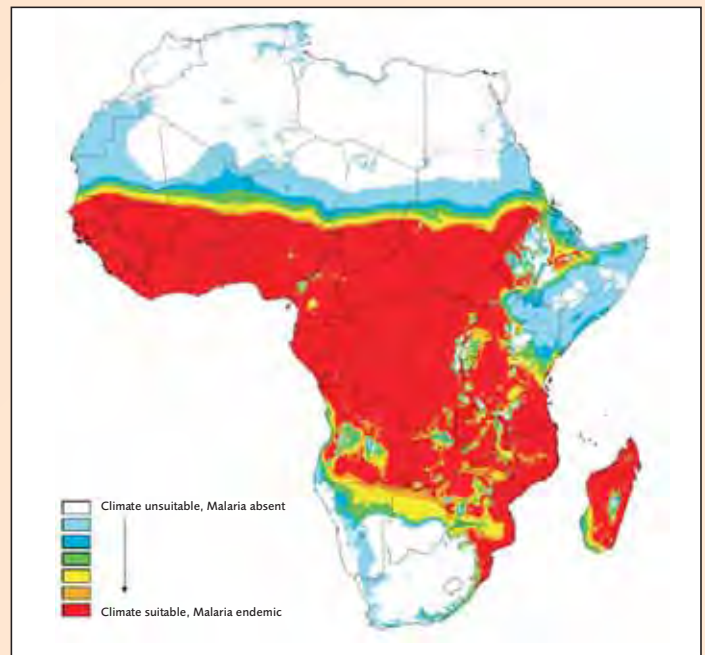


Figure 2. World Health Organization map of climate conditions necessary for malaria transmission in Africa (MARA/ARMA Project 1998). (Source: www.who.int/heli/tools/maps/en/index1.html).

Map Reading 101

Now let's take a closer look at these figures to see how three particular primary map elements mentioned above—scale, scenario, and baseline—can vary and influence the interpretation of climate change research.

Scale and Resolution: Perhaps the most visible differences between climate maps lie in the scale at which data are presented. Maps can be displayed at the global scale, representing the entire world (Figures 1 and 5) or be displayed at the regional, national, and local scales (Figures 2–4 respectively). While many studies focusing on the impacts of climate change on natural systems are large scale, other studies focusing on social and natural impacts of climate change can reach down to the small scale of a single community or ecosystem. Maps at any scale can also vary in the resolution, or level of detail, at which data are displayed. Some spatial data are based on an assembly of grid cells that are consistent across a given scale but whose resolution can vary between datasets, from a coarse 50-kilometer grid resolution to a fine 1-kilometer grid resolution, for example. While some spatial climate data are mapped on a grid, other spatial data are displayed as polygons representing administrative, ecoregional, or watershed units, to name a few.

Scenario and Forecast: A second major element of interpreting climate change maps lies in understanding the scenario, or alternative future, represented by a map. The Intergovernmental Panel on Climate Change (IPCC) has developed several scenarios portraying how climate change could occur under different pathways of human development. Most mapped global climate model results are presented based on these different scenarios and predicted ranges of global average temperature changes. For example, Figure 1 combines the results of several studies that encompass temperature change scenarios with increases ranging from 2.6 to 3.7 degrees Celsius. In contrast, Figure 5 shows the extent to which estimated climate impacts on water systems vary using an older and newer version of a major global climate model for the same scenario.

Baseline and Assumptions: The third essential component of evaluating climate maps is understanding the baseline from which any environmental change is forecasted. Projections of climate changes and the uncertainty surrounding the projections can vary depending on which baseline year is selected and how far into the future a study goes. Figures 1 and 5 show how baselines can vary across sci-

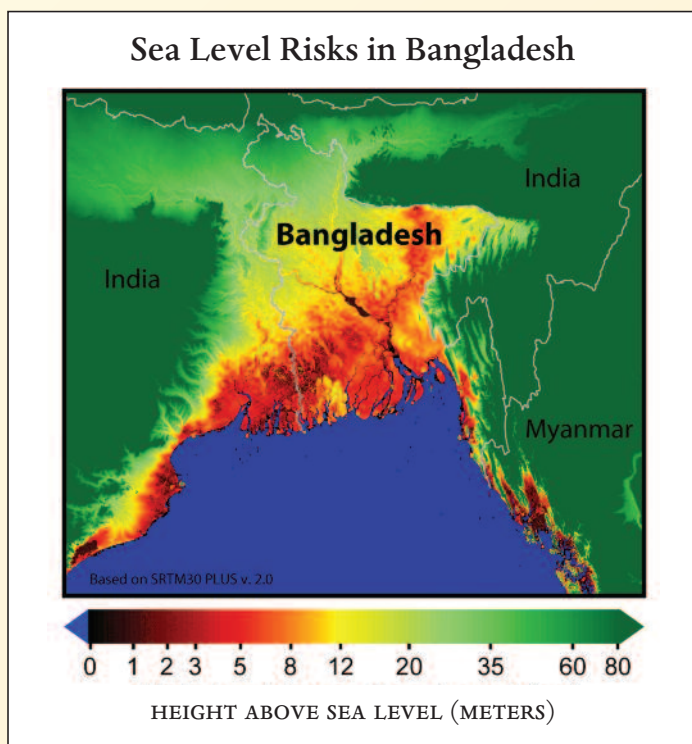


Figure 3. Low-elevation areas in coastal Bangladesh at risk of inundation from climate change induced sea-level rise (Source: www.globalwarmingart.com/wiki/Sea_Level_Rise_Maps_Gallery).

entific studies and maps. Figure 1 illustrates changes in agricultural productivity from 2003–2080, while Figure 5 assumes a baseline period from 1961–1990 with forecasted changes extending to the year 2050. Similarly, many studies contain certain assumptions that determine which variables are included in a modeled climate projection, and which ones are not. Understanding the differences in assumptions across different climate studies and their spatial models and maps is key, as these assumptions often strongly influence a study’s results. For example, some climate studies that predict impacts on agricultural systems do not take into account future changes in water systems. Other climate studies consider multiple stressors or feedback loops between simultaneous impacts on more than one sector.

The differences illustrated above highlight the extent to which modeling and mapmaking decisions can change how maps should be interpreted and if, or to what extent, data and results from different studies might be aggregated. Despite the focus on variations between maps here, mapping has the potential to play a unifying role across the many fields of climate science, policy, and practice. Climate change is inherently a spatial problem, where the locations of impacts, people, and resources are critical.

As climate scientists around the world are redrawing familiar landscapes, we need to remind ourselves that maps are limited by the quality and accuracy of the underlying studies and data that they represent. The necessary simplifications that are often an implicit part of making maps can obscure the uncertainty surrounding many studies and cloud the ways in which different maps are interpreted, compared, and combined.

Because climate change is a global problem, climate information needs to be accessible to a global audience. Making good use of this information will require scientists, policymakers and increasingly all of us to be aware of seemingly small variations in scales, scenarios, and baselines in the maps that are created and interpreted. With greater map literacy in these particular areas related to climate change, we can develop a more common understanding of the problem and further harness the power of maps to communicate the ideas that shape the many lenses through which we view both climate science and policy. ■

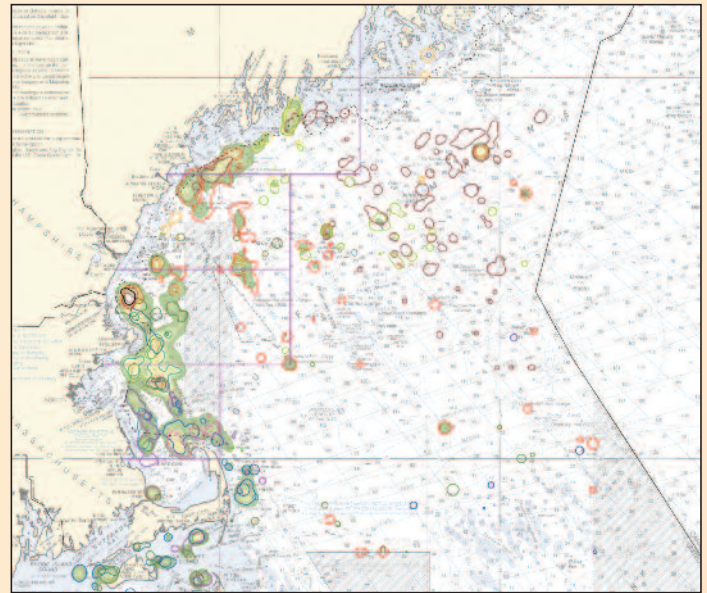


Figure 4. This nautical chart is being used by St. Martin and Hall-Arber (forthcoming) in a National Oceanic and Atmospheric Administration (NOAA) funded project involving a series of participatory interviews to better understand how local fishing communities are affected by environmental changes. For more information, see <http://geography.rutgers.edu/people/faculty/stmartin/St.%20Martin%20and%20Hall-Arber%20%20Creating%20a%20Place%20for%20Community.pdf>

Figure 5. Change in annual runoff estimated using the global climate models HadCM2 (a) and HadCM3 (b) from IPCC Working Group II, 2001. (Source: www.grida.no/climate/ipcc_tar/wg2/figts-3.htm).

