

Introducing a QGIS technical supplement for *Mapping for a Sustainable World*

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Introduction: We present a set of open-source QGIS technical mapping tutorials to support instruction about cartographic design: <https://github.com/uwcartlab/MappingSDGsTechnicalSupplement> (Houtman & Roth 2021). The technical tutorials directly supplement the joint International Cartographic Association and United Nations publication *Mapping for a Sustainable World* (Kraak et al. 2020), which synthesizes cartographic principles and recommendations for mapping the United Nations Sustainable Development Goals (SDG) global indicator framework (United Nations 2015). Specifically, the technical supplement reconstructs the workflow conducted by the University of Wisconsin Cartography Lab for the creation of three SDG maps in the book: a choropleth map (p. 62), a proportional symbol map (p. 64), and a nominal map (p. 60). Here we describe background on the SDGs and the *Mapping for a Sustainable World* book, design and organization of the technical supplement, and instructional use cases for adopting *Mapping for a Sustainable World* and the technical supplement for classroom or workshop instruction.

Background: In 2015, the United Nations Member States adopted 17 *Sustainable Development Goals* as part of the 2030 Agenda for Sustainable Development (United Nations 2015). Each goal is organized by a shifting number of *targets* that monitor progress towards the broader goal and *indicators* that provide data measures for each target (Kraak et al. 2018). The global completeness and quality of these indicator datasets are highly variable, and an ongoing effort by the United Nations is underway to compile these data and make them publicly available through the Global SDG Indicators Database: <https://unstats.un.org/sdgs/indicators/database/>. Maps of SDG indicator datasets are essential for monitoring progress towards these goals, focusing discussion and policymaking about the SDGs upon global inequalities, interdependencies, and alternatives, and supporting public awareness about our planet's most pressing challenges. Accordingly, mapping the SDGs is drawing increasing attention by the cartographic community (Kent et al. 2020; Pirani et al. 2020), including establishment of an ICA Working Group on Cartography and Sustainable Development.

The *Mapping for a Sustainable World* book project began as a partnership between the United Nations Geospatial Information Section and the International Cartographic Association to respond to the challenges of mapping the SDG indicator datasets (see Kraak et al. 2019 for the original design concept). Published in 2020, the book serves as both an overview of cartographic design principles and a guide for mapping the SDGs, and comprises four sections and 51 chapters on the topics of geospatial data, map design considerations, map and diagram techniques, and map use environments. The book itself was designed and produced by the University of Wisconsin Cartography Lab (Cart Lab), with UW faculty, staff, and students joining the editorial team and United Nations designers to create 227 unique maps and graphics. The technical supplement we present here brings conceptual design principles from *Mapping for a Sustainable World* into practice, walking through the cartographic design workflow used by the Cart Lab to create three of the maps included in the book.

Design: The objective of the technical supplement is to enhance the cartographic design thinking described in the book with the technical knowledge needed to actually create SDG maps. Accordingly, the technical supplement follows several design tenets to make them as accessible globally as possible.

First, we designed the tutorials to pair with, but not replicate, information included in *Mapping for a Sustainable World*. Accordingly, we followed the recommended cartographic design process and design guidelines outlined in the book and included the open-source definitions and figures from the book within the tutorials to reinforce connections between the book and the tutorials.

Second, we prepared and formatted the text of the technical supplements as simply as possible to empower students and other readers with no prior cartography or GIS experience. We use direct language and italicized commands to provide step-by-step technical guidance, allowing the tutorials to be repurposed and extended for variable instructional settings. The simple, task-oriented language also improves in-browser translation for an international audience.

Third, we focused entirely on open-source data and software to remove the cost of making SDG maps. We use open access datasets provided by the United Nations and render them using the open-source mapping software QGIS: <https://www.qgis.org/en/site/>. QGIS is freely available to download and can be used on a Mac, Windows, Linux, or BSD operating systems. Because QGIS is in continuous development and updated regularly, we include only one screenshot per lesson to enable regular maintenance of the technical supplement in the UW Cart Lab. Finally, we host the technical supplement on the UW Cart Lab GitHub page, making them freely available to fork or download for repackaging as needed: <https://github.com/uwcartlab/MappingSDGsTechnicalSupplement>.

Organization: The technical supplement is divided into three sections, each demonstrating how to design a different type of thematic map: choropleth map (p. 62), proportional symbol map (p. 64), and nominal map (p. 60). Each tutorial walks through creation of a map from the book, providing a clear reference and end goal (Figure 1). Each tutorial opens with a screenshot demonstrating the intended state of the project by the end of that tutorial. The tutorials reference the cartographic design principles detailed in *Mapping for a Sustainable World*, referring to section numbers when needed for additional information.

Each of the three tutorials is increasingly less specific. The choropleth tutorial, designed to be completed first, provides detailed, step-by-step instructions for every aspect of map compilation and design. The second and third tutorials on proportional symbol and nominal maps are less detailed and asks users to refer back to specific steps in the choropleth tutorial. This design encourages users to build knowledge in mapping software and geospatial data management, with the intended goal that they can take these skills to produce their own maps of other SDG indicators after completing all three tutorials.

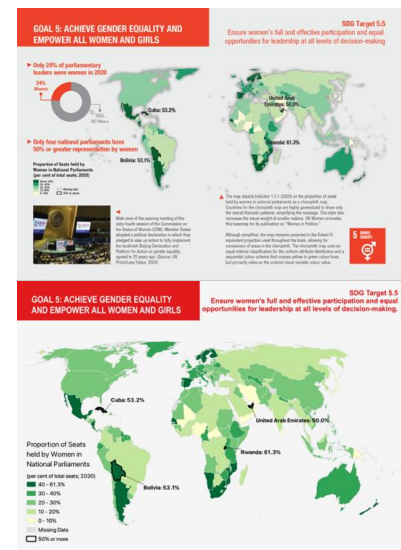


Figure 1: (Top) Map from Mapping for a Sustainable World. (Bottom) The same map reproduced using the technical supplement.

Name	Subjects	Active Time	Prep Time	Technology
World Projections	Anthropology, Geography, History	Short	Short	One computer with QGIS
Bias and Design	History, Journalism, Politics	Short	Short	One computer with QGIS
Choropleth Map Design	Cartography, GIS, Journalism	Moderate	Short	Multiple computers with QGIS
Complete Curriculum	Cartography, GIS	Long	Moderate	Multiple computers with QGIS

Instructional Use Case: All tutorials, as well as contents of the *Mapping for a Sustainable World* cartography book, are available for classroom or workshop use following a CC BY-NC license. Those intending to use *Mapping for a Sustainable World* and associated tutorials in a workshop or classroom should consider the following: (1) What subject is being taught? (2) How much classroom/workshop time can be dedicated to cartographic lessons? (3) How much preparation time can be dedicated to cartographic lessons? (4) What are the technological capabilities of the students? Tutorial 4.2 provides four recommendations for classroom use (Table 1). Each option varies in the breadth of material, relevant subject, classroom time, preparation time, and technological capabilities. Users are also encouraged to develop their own lesson plans based on *Mapping for a Sustainable World* and the associated technical tutorials.

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