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Open Mapping for the SDGs:

A practical guide to launching and growing open mapping initiatives at the national and local levels

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Executive Summary:

Crowdsourced geospatial data, particularly in OpenStreetMap, is helping fill data gaps at the micro level as well as providing insight into SDG progress on a more real-time basis than is possible through annual/bi-annual surveys and periodic censuses. Empowering communities to geo-locate key community assets and vulnerabilities helps decision-makers gauge coverage, gaps, and risks at the ultra-local level. This guide provides a brief compendium of resources for national bureaus of statistics, national mapping agencies, line ministries, and non-government partners to foster the growth of participatory mapping in their countries and develop national roadmaps. It builds on work from Open Cities, Open Government Partnership, Citizen Science initiatives in the White House, the United States Department of State, MapGive, and Missing Maps. Part IV includes a mapping of SDGs and indicators to suggested open mapping projects.

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PART I: INTRODUCTION

What is Open Mapping?

Open mapping is a global movement to create free and open geographic data. Beyond open data, it is a broad community partnership to collaboratively create a critical data resource for monitoring and meeting the Sustainable Development Goals (SDGs) by making available fundamental, detailed, and timely information on where things are in our world.

Centered on the OpenStreetMap[1] (OSM) project, open mapping is transforming how governments and citizens work together by allowing them to co-create and support critical government functions with geographic maps and data. Anyone with geographic knowledge, whether an individual enthusiast or a professional from a public or private sector institution, is invited to contribute map data in an open community. The community openly designs schemas for mapping features as they are encountered in the world, develops new workflows and applications to contribute as technology advances, applies spatial data for an ever-growing array of uses, and supports and advocates for a growing, open collaboration.

The open mapping community is one that cares deeply about quality and use of geographic data and includes people from all parts of society and across the globe, from experts in geographic technologies to those in their own neighborhoods. It is hugely powerful for people from around the globe to work in the same database. To date, more than 3 million people have registered, and approximately 30,000–40,000 make contributions during a given month[2]. This approach has been phenomenally successful at creating maps in under-mapped places, serving critical needs, as in the response to the Nepal earthquake and[3] mapping local schools in informal settlements[4]. Through excellence in data, many OpenStreetMap participants have gone on to become more fully engaged citizens.

Countries around the world have joined the open mapping revolution. The U.S. Government committed to open mapping[5] in its Third Open Government National Action Plan, and has hosted Mapathons at the White House[6] to create data for the SDGs. France's Etalab has shared “La Base Adresse Nationale”[7], combining official and citizen-collected data to create a comprehensive database. In Indonesia, the National Disaster Management Agency (BNPB in

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[1] https://www.openstreetmap.org/
[2] http://wiki.openstreetmap.org/wiki/Stats
[3] http://www.worldbank.org/en/news/feature/2015/10/27/harnessing-the-power-of-the-crowd-reflections-six-months-after-the-gorkha-earthquake-in-nepal
[4] http://innovationsjournal.net/map-kibera-7-erica-hagen
[5] https://www.whitehouse.gov/blog/2015/10/27/advancing-open-and-citizen-centered-government
[6] https://www.whitehouse.gov/blog/2016/07/18/volunteers-unlock-power-maps-sustainable-development
[7] https://adresse.data.gouv.fr/

Indonesian) has worked in cooperation with OSM Indonesia[8] to crowdsource and utilize citizen-generated map data for contingency planning, risk reduction, and decision-making during flooding events in Jakarta.

Who is This Guide For?

This guide is for national and sub-national governments, international organizations, and their partners who are setting policy and plans and/or designing implementation programs, for data needs in meeting and monitoring the SDGs. It gives policy-makers insight on the strategic benefit of open mapping, and program and technical implementers pointers to in-depth guidance and access to an expert community for realizing open mapping projects.

Why Now – What Is the Need?

The SDGs are the largest collective effort in history to improve the lives of billions of people by setting quantitative goals and targets to drive evidence-based policy-making. Improving the quality of data is at the core of meeting and measuring progress against these goals and targets. The 17 SDGs bring with them 169 targets and 230 indicators. A vast breadth of data will be needed. National statistical offices are key, but the resources to measure and report on 230 indicators mean government can't go it alone. Participation is needed from all sectors, including non-governmental organizations (NGOs), academia, faith-based and community organizations, and corporate partners to increase our collective capacity to generate, analyze, and report on the SDGs at the national and local levels. Open mapping can serve as a way to unite resources from multiple sectors towards the common goals articulated by the SDGs.

Leave no one behind: existing data gaps

As the world continues to urbanize, 1 billion people – one-seventh of the world's population – now live in urban informal settlements[9]. Overcrowding, poorly built dwellings, and insufficient infrastructure have left hundreds of millions of people in an increased position of vulnerability to disasters and diseases. World leaders agree we need to end extreme poverty, fight inequality and injustice, and fix climate change. A first step to solving these core problems is to be able to see the full picture in order to efficiently and correctly identify issues and assess data to inform decision-makers. However, over 70% of the world is not currently mapped in any openly accessible data source with any meaningful level of detail. Vulnerable, at-risk communities around the world are not on the map, either literally or figuratively – and are often overlooked. Many existing datasets do not disaggregate data to the ultra-local level as open mapping does, making it difficult or impossible to report on differences across population segments and geographic areas.

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[8] http://openstreetmap.id/en/

[9] http://www.worldbank.org/en/topic/urbandevelopment/overview and Hidden Cities: http://www.who.int/kobe_centre/publications/hiddencities_media/p1_who_un_habitat_hidden_cities.pdf

Heat map showing the edits (in yellow) entered into OpenStreetMap as of 2014. Although detailed maps now exist for much of the U.S. and Western Europe,most places in the world remain largely unmapped.

Benefits and challenges

In order to give decision-makers and communities accurate data and ensure no one is left behind as we pursue the SDGs, we need to fill in data gaps in the datasets required to measure progress towards the SDG indicators. Updated geospatial data and the open mapping process through which it is generated are directly helping by:

- Identifying where the need is greatest;
- Identifying physical assets (and vulnerabilities/gaps) at an increasingly local level;
- Building community datasets;
- Improving logistics and route planning for interventions;
- Monitoring implementation through more frequent data collection;
- Increasing and improving the utilization of data for decision-making, citizen empowerment, innovation, and entrepreneurship.

By filling in these data gaps, communities can develop a clear picture of their assets and vulnerabilities to help decision-makers gauge coverage, gaps, and risks at the ultra-local level. The open mapping concept allows users to constantly make edits to the map, which is particularly useful in rapidly changing urban environments. This also means monitoring SDG progress can happen continuously instead of having to wait for survey results alone. Spatial data collected from open mapping can inform the entire project lifecycle, from the initiation and identification of priorities, to monitoring progress, and finally measuring impact and reporting.

Open mapping can be a powerful tool to supplement and complement official sources of data for measuring progress against the SDGs, but it is not a cure-all. It is especially useful for

assessing “proportion of population” SDG indicators as they relate to observable characteristics of the built or natural environment, such as:

- Indicator 6.1.1: Proportion of population using safely managed drinking water services
- Indicator 7.1.1: Proportion of population with access to electricity
- Indicator 9.1.1: Proportion of the rural population who live within 2 km of an all-season road
- Indicator 11.1.1: Proportion of urban population living in slums, informal settlements, or inadequate housing
- Indicator 11.2.1: Proportion of the population that has convenient access to public transport

However, it is also important to recognize the difference between data captured in platforms such as OSM, which describe the physical world around us, and census or survey data, which may capture personally identifiable information, along with attitudes, behaviors, experiences, opinions, and consumption habits. For example, open mapping and GIS analysis could be used to report on the proportion of schools with access to electricity (Indicator 4.a.1) or forest area as a proportion of total land area (Indicator 15.1.1) but would not be a good fit for determining the proportion of young women aged 18–29 years who experienced sexual violence by age 18 (Indicator 16.2.3). The latter would require a survey and capture personally identifiable information that would not be appropriate to share in an open platform.

How Government Agencies Work with the Open Mapping Ecosystem

In a study published in 2014[10], researchers found examples from all over the world of governments choosing to work with the open mapping ecosystem for a range of purposes, including:

- The need for high quality, spatial data that is updated at a pace consistent with rapidly changing urban areas;
- Shortage of expertise and resources needed to maintain comprehensive maps in many government agencies;
- As part of wider commitments to local, national, and global open data efforts;
- Through initiatives aimed at supporting science and innovation across government and civil society; and
- To increase public engagement with local government.

While data quality is frequently raised as a concern in discussion of open mapping projects, research has repeatedly demonstrated that OSM data is as, and in some cases more, accurate than authoritative datasets produced by official entities. In fact, the dynamic nature of the OSM

[10] Crowdsourced Geographic Information in Government: http://discovery.ucl.ac.uk/1433169/

database can in some cases make it easier to keep map data up to date. This is particularly true in areas with active local mapping communities, pointing to the need for governments to support and engage with these communities. Some of the most commonly found challenges in open mapping projects stem from the failure to build strong relationships between government and local mapping communities, short-term program designs that don't consider project sustainability, and lack of clear goals from the outset of a project. As a result of thoughtful planning, a number of governments have been able to avoid these problems and partner with the open mapping ecosystem to accomplish many of their goals. The next section discusses some of the important issues to consider when beginning a project.

PART II: PRACTICAL STEPS AND RESOURCES FOR GETTING STARTED

Fostering a Collaborative Approach

The primary ingredient in the success of an open mapping project is the cultivation and care of a strong network of partners across the range of communities and institutions that have a stake in the project. These partnerships are critical for the implementation, uptake, and sustainability of open mapping projects. They can lead to shared investment of resources and technical expertise, innovative use cases for open data, increased legitimacy for the project, and stability over time. Because the open mapping ecosystem is a global phenomenon, it's likely that, at the start of any project, there will be a pre-existing group of individuals and organizations already mapping in the target area. With proper outreach and engagement, these groups can be a powerful resource. Including them early in the planning and design phases of a project will help increase their sense of ownership and improve the likelihood of successful collaboration.

Government agencies responsible for areas as diverse as national statistics, urban planning, transportation, public health, environment and natural resource management, and disaster response have all benefited from working with open mapping and can bring valuable resources, expertise, and authority to a mapping project.

The OSM Community is active globally and will, in many cases, have a local presence with experience mapping in the area, technical knowledge about mapping, and a group of passionate volunteers who may be willing to participate. The OSM community often uses mailing lists, Facebook or Meetup groups, or the OSM wiki to communicate and plan activities.

The table below lists other potential groups and how they participate in an open mapping project [11].

Universities	Universities and colleges are great potential collaborators. Participation in a mapping project offers students and faculty an opportunity to learn about cutting-edge open-source methodologies, ideas, and software. Students are often technically minded and have flexible time commitments and enthusiasm to learn new things. Mapping projects that involve academia may also evolve into a permanent part of the university's curriculum or even a course by itself.
Scientific communities	Local scientific communities, whether involved in university research or in civil society organizations, can be called upon to support an open mapping project in several important ways. First, these are important groups to involve in the data modeling process. Civil engineers, planners, and others have experience with relevant data and analysis, so they may be able to provide suggestions as well as important local context. Second, data quality assessment throughout the

[11] For further detail, see http://opencitiesproject.org

	project, particularly at the end of the data collection period, is critical, and these groups may be well placed to support it.
Technical communities	Open-source software communities (user groups and private companies) are often closely linked with OSM communities. Freelance software developers,GIS specialists, and private software companies may be interested in providing software that assists the project as well as services for the community. The technical community also can share its collective professional expertise when hosting a skills workshop, and service providers can rent office space or equipment. For example, the widespread Open Source Geospatial Foundation (OSGeo, at osgeo.org) is closely related to OSM.
Civil society organizations	The advantages that collaborating with a civil society organization or local NGO can bring to projects include in-depth understanding of local context and important issues, data-sharing and collection, youth outreach, and well-developed networks in the local community.
International organizations	Many development projects are funded by international organizations that have significant datasets from previous projects. Their interests focus on a variety of areas and potential synergies may exist. Offices such as the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) often have existing mapping capacity and already have knowledge of the local context and existing data.
Youth and adult community groups	Community groups, by their nature, attract members of society who are interested in volunteering their time for the benefit of the community. A great example comes from Indonesia, where Humanitarian OpenStreetMap Team (HOT) worked with the Scouts to map thousands of buildings in the Bengawan Solo River Valley.
Private sector corporations	In recent years, corporations have contributed greatly to open mapping initiatives through provision of financial resources, in-kind donations of services, and donation of employee time to work on mapping projects. Corporate social responsibility (CSR) and philanthropy initiatives often lead corporations to sponsor mapping and mapping technology development projects aligned with their geographic areas of operation and expertise

Designing a Project

Designing and implementing an open mapping project can be complex, especially if there are ambitious mapping goals or a large group of partners involved. As part of the Open Cities Project[12], the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR) and Humanitarian OpenStreetMap Team (HOT) published a guide that helps teams navigate this process. The full guide can be downloaded at http://www.opencitiesproject.org/guide/. Here we provide a brief overview of some of the most important steps.

Deciding what to map

Once the partners have been assembled, the next step is deciding what to map. This involves answering three questions about what the project is attempting to accomplish. A helpful way to think about this to ask, what problem is this project seeking to address or what question(s), or SDG indicator(s), are we hoping this data will answer once it has been collected?

1. Geographic extent:Does this mapping project involve gathering information about a city, a neighborhood, a whole country? Do the questions that the project needs answering logically connect to a particular administrative scale? Or another sort of boundary?
2. Features: What, within the geographic extent, needs to be mapped? Roads? Buildings? Particular kinds of buildings such as schools or health facilities? Is there other information such as land-use or natural features like rivers and forests that will also require mapping?
3. Attributes: What information about each feature will the team collect? For example, is knowing the width or surface of roads important to the questions the project seeks to answer? The number of stories of each building? The number of beds in each hospital?

The answers to these questions will help determine if there are any existing datasets that could be used and the amount of time and resources necessary to complete the project. In some cases, it can be helpful to run a small pilot project in order to determine the best approach to data collection and develop an estimate of the level of effort required.

Building a team

A great team is essential to the success of any mapping project. Partnerships with civil society organizations, universities, and the local OSM community can help recruit mapping staff or volunteers. Young people with some technology experience often make good mappers, as do residents of the area being mapped. What are the incentives for the mappers to be involved?

[12] http://opencitiesproject.org

Can students receive course credit for their participation? Are there other roles, such as organizers or quality control, that need to be filled besides mappers?

Logistics

The team will need a workspace with reliable electricity and internet where it can conduct trainings, upload the information that has been collected in the field to OSM, or make beautiful maps using the newly open data. Workspace can sometimes be made available to the project by one of the partners. Local libraries, government headquarters, and schools close to the area being mapped have been used as workspace by many projects. Depending on your method of field data collection (see below), your team might also need laptops, GPS devices, printers, and transportation to the site.

Supervision and quality control

It is essential that project organizers develop a system to track progress toward the mapping goal and monitor the quality of data as it is being collected. Quality control measures could include targeted re-surveying of particular areas, using photographs of field sites to ensure proper assessment, and examination of the OSM database to validate data entry processes. These steps should begin early in the mapping process in case changes to mapping practices or further training of the mappers is required. Some organizing teams have chosen to work with third-party experts to develop formal reports on the quality of data collected as a way of increasing public trust in the project.

Sustainability

A frequent concern about open mapping programs is their ability to have sustainable impact after the end of the project cycle. In this case, sustainability can take on multiple meanings, including continuing use and maintenance of the data, continued activity of the local mapping community, or ongoing investment in the project by new participants. Defining at the start of the process what goals are most relevant will help ensure organizers can design and implement the project in the ways most likely to achieve them. It is also important to take stock at the end of a project of what was learned during implementation in order to guide continued work or new efforts in other locations.

Collecting Data: Quick Start Guide

Planning a mapathon

Humanitarian and development organizations and governments host virtual and in-person mapathon events to engage volunteers in contributing to crowdsourced mapping projects. The typical objective of a mapathon is to provide humanitarian and development efforts with improved access to data in OSM. A typical mapathon asks participants to edit OSM for a target area, provides training for new mappers, and may feature remarks or a presentation on the purpose and goals of the mapping project.

Volunteers in Washington, DC map Vanuatu after Tropical Cyclone Pam in 2015.
Photo credit: Courtney Clark

Organizations frequently host mapathons after natural disasters or humanitarian crises in order to quickly provide maps and data to humanitarian organizations deployed to the affected countries. For example, 2,182 members of the OSM community came together in the wake of the 2015 Nepal earthquake to identify 3,128 damaged buildings in just 48 hours. However, mapathons can also focus on longer-term development projects related to SDG focus areas such as public health, climate change, economic development, and disaster risk reduction.

Mapathons also provide an excellent opportunity to increase citizen participation in open government and open data initiatives. For example, the White House and several agencies within the U.S. government have hosted annual or semi-annual mapathons not only to provide data to US development projects overseas but also to celebrate the role of open geographic data in open and transparent governments.

Mapathon planning resources include:

- MapGive in a Box;
- Missing Maps' Event Hosting guide; and
- HOT's How to Host a Mapathon video.

Learning how to map

Open mapping techniques, particularly editing OSM, are easy to learn and present a low barrier to entry for new contributors. Volunteer mappers can learn through in-person trainings, while attending a mapathon, and/or from a variety of online tutorials and videos.The OSM community has created a wide variety of online tools to learn how to map, including:

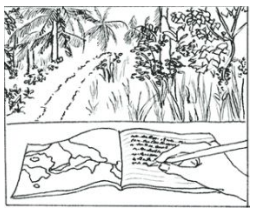
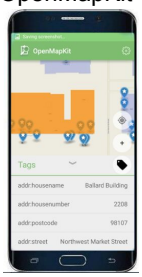
- LearnOSM.org, which includes instructions for learning how to map in 17 languages;
- HOT's Learn to Map! Youtube playlist;
- MapGive, which offers extensive video tutorials on mapping for humanitarian efforts;
- Missing Map's Beginner's Guide;
- Mapbox's visual guide to editing OSM; and
- The OSM Wiki page to find out more about the communities in your area.

Tools for on the ground data collection

Collecting data on the ground is an integral part of editing OSM. This data is typically richer in detail and more accurate than map data that is generated solely by remote tracing. Mappers can choose from a number of free and open tools that facilitate on-the-ground data collection in both online and offline settings.

Note: this list is not exhaustive. Please visit the OSM wiki for a more detailed list of software and services.

Data collection tool	**Description**
GPS units 	GPS units allow a user to collect coordinates and take notes for the features they are surveying. Additionally, they can display the current location of the user on a basemap (which may be derived from OSM). After surveying, the resulting data can be loaded into an editor and traced onto OSM. For example, the iD editor for OSM makes it easy to upload a GPX file for tracing. Mappers can choose to make their GPS layers public by adding their data to OSM's GPS database, which is one of the world's largest collections of GPS data.
Field Papers	Field Papers enable mappers to create a printable atlas of the OSM view of an area to conduct pen-and-paper street mapping. Mappers walk the streets of their community, labeling roads

	and buildings, and then reference their completed Field Papers once they have internet access and can directly edit the digital map.
OpenMapKit 	OpenMapKit is an open source tool that is used to create professional quality mobile data collection surveys for field data collection. OpenMapKit launches directly from OpenDataKit and allows users to add tags for OSM, points of interest, and other survey questions that can all be securely collected, saved, and uploaded to your public data to OSM.
Maps.Me	Maps.Me is a mobile application that is based on OSM data, allowing offline use of the map. Drop points, edit their names, and reference them when you are editing the digital map using the Bookmarks function.
Portable OpenStreetMap	Portable OpenStreetMap (POSM) was created to use in remote communities and parts of the developing world that lack reliable internet connectivity. It combines an offline OSM API, Field Papers, and OpenMapKit, so users are able to download an area of interest, easily configure the portable server, work offline in the field (using OpenMapKit, iD, and JOSM to edit OSM), and then return to a connected environment and sync all changes back to OSM.
Mapillary	Mapillary enables people to collect street-level photos by using simple tools like smartphones or action cameras. By connecting photos across time and use, Mapillary creates an immersive street-level photo view for people to virtually explore different places in the world.

Volunteers using Field Papers to collect data in Ushirombo Tanzania.
Source: American Red Cross, CC

Surveying mobile money agents in Uganda with OpenMapKit.
Source: HOT, CC-BY

Colombian Red Cross using OpenMapKit to collect building information in Riohacha, Colombia to help monitor an urban risk resilience program.
Source: American Red Cross, CC

Mappers in Quelimane, Mozambique collect geographic data using Field Papers, which are then scanned as part of a process of digitizing data into OSM.
Source: Peace Corps

A spray operator applies insecticide to the walls of a home in Yekepa, Liberia, during an indoor residual spraying campaign. Public health interventions such as this one for malaria elimination are increasingly relying on detailed geospatial data from OSM.
Source: USAID

Using Open Map Data for Analysis, Display, and Decision-Making

A number of free tools are available to GIS and statistics professionals to extract and utilize OSM data for decision-making. By using OSM data in conjunction with free population data sets from WorldPop[13] and GPW v4[14], or other thematic datasets from the Humanitarian Data Exchange[15] and other sources of open data, GIS professionals and statisticians can produce datasets for SDG monitoring on a national and local level.

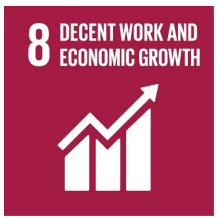
Tool	**Description**
Overpass Turbo https://overpass-turbo.eu/	Overpass turbo is a web-based data filtering tool for OSM. With overpass turbo you can run queries and analyse the resulting OSM data interactively on a map. There is an integrated Wizard that makes creating queries easy.

[13] http://www.worldpop.org.uk/
[14] http://sedac.ciesin.columbia.edu/data/collection/gpw-v4
[15] https://data.humdata.org/

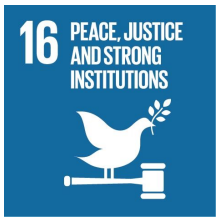
HOT Export Tool http://export.hotosm.org/en/	Extract data in many common file formats for GIS analysis. This platform allows you to create custom OSM exports for various regions. You can specify an area of interest and a list of OSM feature tags for the export. There are a number of file formats available for exporting the data, which include Esri SHP, Garmin IMG, Google KMZ, OSM PBF, and SQlite SQL. The OSM data available from the Export Tool is updated at one-minute intervals.
QGIS http://qgis.org/en/site/	A Free and Open Source Geographic Information System, which can handle a variety of data formats for geospatial analysis. Create, edit, visualise, analyze, and publish geospatial information on Windows, Mac, Linux, and BSD.
InaSAFE http://inasafe.org/	InaSAFE is free software plugin to QGIS that produces realistic natural hazard impact scenarios for better planning, preparedness, and response activities. It provides a simple but rigorous way to combine data from scientists, local governments, and communities to provide insights into the likely impacts of future disaster events.
OpenStreetMap Analytics *beta* http://osm-analytics.org/	This tool lets you analyse interactively how specific OSM features are mapped in a specific region.

PART III: PROJECT IDEAS, GOAL BY GOAL

Goal		Project ideas
	**Goal 1: End poverty in all its forms everywhere**	• Mapping financial services to identify gaps and advocate for increased access to basic financial services, including microfinance.
	**Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture**	• Map access to food, such as household garden plots, outdoor markets, and grocery stores in order to identify food deserts. • Identify unused urban spaces that can be transformed into community garden plots.
	**Goal 3: Ensure healthy lives and promote well-being for all at all ages**	• Map areas affected by disease outbreaks to more effectively track new cases and transmission on the ground, aimed at ending the epidemics of AIDS, tuberculosis, malaria, and neglected tropical diseases. • Use OSM for mapping communities in Mozambique (houses, roads, water bodies, etc.) for indoor residual spraying with insecticides and insecticide-treated mosquito nets distribution. This action helps in the identification of settlements and houses and access ways leading to them for the spraying and mosquito net distribution with the aim of decreasing and ending malaria outbreaks, reducing maternal, neonatal, and under-five deaths, and improving developing nations' capability to face health risks like malaria. • Map incidence of households displaying healthy behaviors; for example, sleeping under a long-lasting insecticide-treated bednet in malarious countries or seeking timely care when ill. • Map barriers to healthcare services, such as the distance people must travel for healthcare and the cost of transportation. • Map spaces that are accessible or inaccessible to people with disabilities.
	**Goal 4: Ensure inclusive and quality education for all and promote lifelong learning**	• Provide vocational training in the latest open source GIS tools to substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship. • Map barriers to education, such as the distance students must travel to school and unsafe or vulnerable areas en route to or near schools.

		• Create detailed maps of schools in a given community, along with information about school size, number of teachers, number of bathrooms available, etc., to empower parents when they choose a school for their children. • Engage students in on-the-ground geographic data collection to improve map literacy and spatial awareness, as well as empower students to have a say in how their community is represented on the world map.
	**Goal 5: Achieve gender equality and empower all women and girls**	• Engage girls and women in mapping areas of their community that are unsafe or pose serious risks and empower them to advocate for change by working with community leaders, local government, police, and civil society. • Create asset maps of services and resources, such as women's health clinics and women's vocational training centers. • Provide opportunities to young women through hiring practices (e.g. Outreachy interns) and training opportunities to enhance information and communications technology skillsets to promote the empowerment of women. • Protect girls at risk of female genital mutilation
	**Goal 6: Ensure access to water and sanitation for all**	• Provide training and mapping water and sanitation to strengthen the participation of local communities in improving water and sanitation management; map locations where lack of access or broken equipment is a problem.
	**Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all**	• Add infrastructure such as powerlines and plants to the map and make it accessible, allowing for accurate assessments of the proportion of population that is connected to the grid.
	**Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all**	• Provide vocational training in the latest open source GIS tools to substantially reduce the proportion of youth not in employment, education, or training and help achieve full and productive employment and decent work for all women and men, including for young people. • Map financial services to encourage and expand access to banking, insurance, and financial services for all.

	**Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation**	• Map roads in rural areas and monitor the development of road networks over time allows better estimates of the percentage of the population with nearby roads that are accessible year-round. • Increase access to ICT and the internet through provision of equipment, software, and training in the places that HOT works.
	**Goal 10: Reduce inequality within and among countries**	• Map communities at the micro level to ensure the poorest are counted and population data is released publicly, leading to policies to make societies more equal.
	**Goal 11: Make cities inclusive, safe, resilient and sustainable**	• Map the number of households, housing conditions, and access to basic services in slums and informal settlements to inform government decision-makers and advocate for improved service delivery. • Involve slum/informal settlement residents in mapping the places they live in and making it available in OSM to enhance inclusive, sustainable urbanization, and capacity for participatory, integrated and sustainable human settlement planning. • Create printed bus and transport maps that encourage use of safe, affordable, accessible, and sustainable transport systems. • Map water and drainage to inform urban planning and significantly reduce the number of people affected by disasters, including water-related disasters. • Map communities for easy access towards indoor residual spraying with insecticides and distribution of insecticide-treated mosquito nets to help in the combat and elimination of malaria and mosquitoes thereby creating a conducive/resilient environment free of mosquito infestations.
	**Goal 12: Ensure sustainable consumption and production patterns**	
	**Goal 13: Take urgent action to combat climate change and its impacts**	• Undertake community asset and vulnerability mapping to strengthen resilience and adaptive capacity to climate-related hazards. • Collaborate with national and sub-national disaster risk management agencies to improve disaster preparedness and disaster response plans. • Curb increased prevalence of malaria owing to climate change through mapping for the rural communities to improve logistics for indoor spraying and distribution of insecticide-treated nets, which are measures of adaptation to the changes in climatic conditions.

	**Goal 14: Conserve and sustainably use the oceans, seas and marine resources**	
	**Goal 15: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss**	• Use OSM and earth observation data to monitor land use to reduce degradation of natural habitats and deforestation.
	**Goal 16: Promote just, peaceful and inclusive societies**	• Use open mapping as a platform to bring together refugees and host communities or bridge religious or ethnic gaps by developing projects that include multiple segments of society working together toward a common goal.
	**Goal 17: Revitalize the global partnership for sustainable development**	• Provide training to government officials in the least developed countries on OSM to significantly increase access to high-quality, timely, and reliable disaggregated to the local level for better monitoring of the SDGs. • Using open source GIS and data analysis techniques to evaluate progress towards the SDGs and inform measures of accountability. • OSM is a data community that sustains beyond any institutional involvement, invites very easy partnership, and takes advantage of active and growing ecosystem of software tools and analysis processes. • Outside of geographic data, the model and experience of building purposeful data communities in OSM can be an inspiration for other kinds of data for SDGs.

PART IV: CASE STUDIES AND MEDIA

OSM Stories: http://osmstories.org/

Finding the way: Geomatic Support Team created maps in Nepal by Lucy Ellis, National Defence and the Canadian Armed Forces, http://www.forces.gc.ca/en/news/article.page?doc=finding-the-way-geomatic-support-team-creates-maps-in-nepal/i99x64lh

Missing Maps: nothing less than a human genome project for cities by Chris Michael, The Guardian, http://www.theguardian.com/cities/2014/oct/06/missing-maps-human-genome-project-unmapped-cities

Data vs. Mosquitos (Devex) by Ann Mei Chang, chief innovation officer at the U.S. Agency for International Development and executive director of the U.S. Global Development Lab, https://www.devex.com/news/data-vs-mosquitoes-88526

DRC: Saving Lives with Remote Mapping by MSF, http://www.msf.org.uk/article/drc-saving-lives-with-remote-mapping

APPENDIX 1: LIST OF RESOURCES

- Crowdsourced Geographic Information Use in Government, GFDRR, https://www.gfdrr.org/sites/gfdrr/files/publication/Crowdsourced%20Geographic%20Information%20Use%20in%20Government.pdf
- Missing Maps, How to Contribute, http://www.missingmaps.org/contribute/
- MapGive in a Box, http://mapgive.state.gov/box/en/, http://mapgive.state.gov/box/en/process/
- Missing Maps, Organize an Event, http://www.missingmaps.org/host/
- Citizen Science Toolkit, USG, https://crowdsourcing-toolkit.sites.usa.gov/
- Open Cities Project Guide, https://opendri.org/resource/planning-an-open-cities-mapping-project/
- How-to Interactive Community Mapping, https://openknowledge.worldbank.org/bitstream/handle/10986/18937/890870WP0Box380munity0Mapping0final.pdf?sequence=1
- OpenStreetMap in the classroom: TeachOSM, http://teachosm.org/en/
- YouthMappers student groups at universities, http://www.youthmappers.org/