



Humanitarian
OpenStreetMap
Team

METEOR: Mapping of Exposure. Report M4.2/P

UKSA IPP2 Grant Programme

Open File Report OR/18/141



HUMANITARIAN OPENSTREETMAP TEAM

UKSA IPP2 GRANT PROGRAMME

OPEN FILE REPORT OR/18/141

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METEOR: Mapping of Exposure. Report M4.2/P

M. O'Hara

Contributor/editor

K. Smith

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British Geological Survey offices

**Nicker Hill, Keyworth,
Nottingham NG12 5GG**

Tel 0115 936 3100

BGS Central Enquiries Desk

Tel 0115 936 3143

email enquiries@bgs.ac.uk

BGS Sales

Tel 0115 936 3241

email sales@bgs.ac.uk

**The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP**

Tel 0131 667 1000

email scotsales@bgs.ac.uk

**Natural History Museum, Cromwell Road,
London SW7 5BD**

Tel 020 7589 4090

Tel 020 7942 5344/45

email bgs_london@bgs.ac.uk

**Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT**

Tel 029 2167 4280

**Maclean Building, Crowmarsh Gifford,
Wallingford OX10 8BB**

Tel 01491 838800

**Geological Survey of Northern Ireland, Department of
Enterprise, Trade & Investment, Dundonald House,
Upper Newtownards Road, Ballymiscaw,
Belfast, BT4 3SB**

Tel 01232 666595

www.bgs.ac.uk/gsni/

**Natural Environment Research Council, Polaris House,
North Star Avenue, Swindon SN2 1EU**

Tel 01793 411500

Fax 01793 411501

www.nerc.ac.uk

**UK Research and Innovation, Polaris House,
Swindon SN2 1FL**

Tel 01793 444000

www.ukri.org

Website www.bgs.ac.uk

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Prepared by: Contributors		
Name(s): Mhairi O'Hara	Signature(s): M. O'Hara (HOT)	Date(s): 01/12/2018
Approved by: Project Manager		
Name: Kay Smith	Signature: K. Smith (BGS)	Date: 07/12/2018
Approved by: UKSA IPP Project Officer		
Name: Connor McSharry	Signature: C. McSharry (UKSA)	Date: 21/01/2019

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Glossary

BGS	British Geological Survey: An organisation providing expert advice in all areas of geosciences to the UK government and internationally
DMD	Disaster Management Department, Prime Minister's Office of Tanzania, focused on disaster risk
DRM	Disaster Risk Management; the application of disaster risk reduction policies and/or strategies
DRR	Disaster Risk Reduction; disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development
EO	Earth Observation; the gathering of information about Earth's physical, chemical and biological systems via remote sensing technologies, usually involving satellites carrying imaging devices
FATHOM	Provides innovative flood modelling and analytics, based on extensive flood risk research
GEM	Global Earthquake Model, non-profit organisation focused on the pursuit of earthquake resilience worldwide
HOT	Humanitarian OpenStreetMap Team, a global non-profit organisation that uses collaborative technology to create OSM maps for areas affected by disasters
InaSAFE	Free open software that produces realistic natural hazard impact scenarios for better planning, preparedness and response activities
ImageCat	International risk management innovation company supporting the global risk and catastrophe management needs of the insurance industry, governments and NGOs
IPP	International Partnership Programme; the UK Space Agency's International Partnership Programme (IPP) is a £30M per year programme, which uses expertise in space-based solutions, applications and capability to provide a sustainable economic or societal benefit to emerging nations and developing economies
KLL	Kathmandu Living Labs; a living lab and non-profit civic technology company based in Kathmandu, Nepal that primarily works on mobile technology and mapping
LDC	Least Developed Country on the Organisation for Economic Co-operation and Development's (OECD) Development Assistance Committee (DAC) list
M	Milestone, related to work package deliverable
Mapathon	Coordinated mapping event where individuals learn about OSM, and make edits to the map through remote digitising of satellite imagery
METEOR	Modelling Exposure Through Earth Observation Routines; a three-year project funded by the UK Space Agency to develop innovative application of Earth Observation (EO) technologies to improve understanding of exposure and multihazards impact with a specific focus on the countries of Nepal and Tanzania
NGO	Non-Governmental Organisation; organisations which are independent of government involvement
NSET	National Society for Earthquake Technology, non-governmental organisation working on reducing earthquake risk in Nepal and abroad
ODA	Official Development Assistance; government aid that promotes and specifically targets the economic development and welfare of developing countries
ODbl	Open Database License; a copyleft license agreement intended to allow users to freely share, modify, and use a database while maintaining this same freedom for others

OPM	Oxford Policy Management, organisation focused on sustainable project design and implementation for reducing social and economic disadvantage in low-income countries
OSM	OpenStreetMap, a collaborative project to create a free and open editable map database of the world
QGIS	Free open source desktop geographic information system
Ramani Huria	A community mapping project based in Dar Es Salaam, Tanzania; Swahili for “open map”
SDGs	Sustainable Development Goals; these goals were set up in 2015 by the United Nations General Assembly and are intended to be achieved by the year 2030
UAV	Unmanned Aerial Vehicle; an aircraft without a human pilot on board, often simply referred to as ‘drones’
UKSA	United Kingdom Space Agency; an executive agency of the Government of the United Kingdom, responsible for the United Kingdom's civil space programme
WASH	Water, Sanitation and Hygiene; universal, affordable and sustainable access to WASH is a key public health issue within international development and is the focus of Sustainable Development Goal 6
WP	Work Package; discrete sets of activities within the METEOR Project, each work package is led by a different partner and has specific objectives

Foreword

This report is the published product of a study by Humanitarian OpenStreetMap Team (HOT) as part of the Modelling Exposure Through Earth Observation Routines (METEOR) project led by British Geological Survey (BGS).

METEOR is grant-funded by the UK Space Agency's International Partnership Programme (IPP), a >£150 million programme which is committed to using the UK's space sector research and innovation strengths to deliver sustainable economic, societal, and environmental benefit to those living in emerging and developing economies. IPP is funded from the Department for Business, Energy and Industrial Strategy's (BEIS) Global Challenges Research Fund (GCRF). This £1.5 billion Official Development Assistance (ODA) fund supports cutting-edge research and innovation on global issues affecting developing countries. ODA-funded activity focuses on outcomes that promote long-term sustainable development and growth in countries on the OECD Development Assistance Committee (DAC) list. IPP is ODA compliant, being delivered in alignment with UK Aid Strategy and the United Nations' (UN) Sustainable Development Goals (SDGs).

The objective of this report is to summarise OpenStreetMap data structure, participatory mapping and remote digitisation procedure for use in Kathmandu (Nepal) and Dar es Salaam (Tanzania) within the METEOR project.



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Summary

This report describes a specific piece of work conducted by Humanitarian OpenStreetMap Team (HOT) as part of the METEOR (Modelling Exposure Through Earth Observation Routines) project, led by British Geological Survey (BGS) with collaborative partners Oxford Policy Management Limited (OPM), SSBN Limited, The Disaster Management Department, Office of the Prime Minister – Tanzania (DMD), The Global Earthquake Model Foundation (GEM), The Humanitarian OpenStreetMap Team (HOT), ImageCat and the National Society for Earthquake Technology (NSET) – Nepal.

The 3-year project was funded by UK Space Agency through their International Partnership Programme, details of which can be located in the Foreword, and was completed in 2021.

The project aimed to provide an innovative solution to disaster risk reduction, through development of an innovative methodology of creating exposure data from Earth Observation (EO) imagery to identify development patterns throughout a country and provide detailed information when combined with population information. Level 1 exposure was developed for all 47 least developed countries on the OECD DAC list, referred to as ODA least-developed countries in the METEOR documentation, with open access to data and protocols for their development. New national detailed exposure and hazard datasets were also generated for the focus countries of Nepal and Tanzania and the impact of multiple hazards assessed for the countries. Training on product development and potential use for Disaster Risk Reduction was performed within these countries with all data made openly available on data platforms for wider use both within country and worldwide.

This report (M4.2/P) is the second report generated by HOT for the work package on Inputs and Validation (WP4) led by HOT. The other 7 METEOR work packages included, Project Management (WP1 – led by BGS), Monitoring and Evaluation (WP2 – led by OPM), EO data for exposure development (WP3 - led by ImageCat), Vulnerability and Uncertainty (WP5 - led by GEM), Multiple hazard impact (WP6 – led by BGS), Knowledge sharing (WP7 – led by GEM) and Sustainability and capacity building (WP8 – led by ImageCat).

1. METEOR Project

1.1. PROJECT SUMMARY

Project Title	Modelling Exposure Through Earth Observation Routines (METEOR): EO-based Exposure, Nepal and Tanzania
Starting Date	08/02/2018
Duration	36 months
Partners	UK Partners: The British Geological Survey (BGS) (Lead), Oxford Policy Management Limited (OPM), SSBN Limited International Partners: The Disaster Management Department, Office of the Prime Minister – Tanzania, The Global Earthquake Model (GEM) Foundation, The Humanitarian OpenStreetMap Team (HOT), ImageCat, National Society for Earthquake Technology (NSET) – Nepal
Target Countries	Nepal and Tanzania for “level 2” results and all 47 Least Developed ODA countries for “level 1” data
IPP Project	IPPC2_07_BGS_METEOR

Table 1: METEOR Project Summary

1.2. PROJECT OVERVIEW

At present, there is a poor understanding of population exposure in some Official Development Assistance (ODA) countries, which causes major challenges when making Disaster Risk Management decisions. Modelling Exposure Through Earth Observation Routines (METEOR) takes a step-change in the application of Earth Observation exposure data by developing and delivering more accurate levels of population exposure to natural hazards. METEOR is delivering calibrated exposure data for Nepal and Tanzania, plus ‘Level-1’ exposure for the remaining Least developed Countries (LDCs) ODA countries. Moreover, we are: (i) developing and delivering national hazard footprints for Nepal and Tanzania; (ii) producing new vulnerability data for the impacts of hazards on exposure; and (iii) characterising how multi-hazards interact and impact upon exposure. The provision of METEOR’s consistent data to governments, town planners and insurance providers will promote welfare and economic development and better enable them to respond to the hazards when they do occur.

METEOR is co-funded through the second iteration of the UK Space Agency’s (UKSA) International Partnership Programme (IPP), which uses space expertise to develop and deliver innovative solutions to real world problems across the globe. The funding helps to build sustainable development while building effective partnerships that can lead to growth opportunities for British companies.

1.3. PROJECT OBJECTIVES

METEOR aims to formulate an innovative methodology of creating exposure data through the use of EO-based imagery to identify development patterns throughout a country. Stratified sampling technique harnessing traditional land use interpretation methods modified to characterise building patterns can be combined with EO and in-field building characteristics to capture the distribution of building types. These protocols and standards will be developed for broad application to ODA countries and will be tested and validated for both Nepal and Tanzania to assure they are fit-for-purpose.

Detailed building data collected on the ground for the cities of Kathmandu (Nepal) and Dar es Salaam (Tanzania) will be used to compare and validate the EO generated exposure datasets.

Objectives of the project look to: deliver exposure data for 47 of the least developed ODA countries, including Nepal and Tanzania; create hazard footprints for the specific countries; create open protocol; to develop critical exposure information from EO data; and capacity-building of local decision makers to apply data and assess hazard exposure. The eight work packages (WP) that make up the METEOR project are outlined below in section 1.4.

1.4. WORK PACKAGES

Outlined below are the eight work packages that make up the METEOR project, which are led by various partners. Table 2 provides an overview of the work packages together with a brief description of what each of the work packages cover.

Work Package	Title	Lead	Overview
WP.1	Project Management	BGS	Project management, meetings with UKSA, quarterly reporting and the provision of feedback on project deliverables and direction across primary stakeholders.
WP.2	Monitoring and Evaluation	OPM	Monitoring and evaluation of the project and its impact, using a theory of change approach to assess whether the associated activities are leading to the desired outcome.
WP.3	EO Data for Exposure Development	ImageCat	EO-based data for exposure development, methods and protocols of segmenting/classifying building patterns for stratified sampling of building characteristics.
WP.4	Inputs and Validation	HOT	Collect exposure data in Kathmandu and Dar es Salaam to help validate and calibrate the data derived from the classification of building patterns from EO-based imagery.
WP.5	Vulnerability and Uncertainty	GEM	Investigate how assumptions, limitations, scale and accuracy of exposure data, as well as decisions in data development process lead to modelled uncertainty.
WP.6	Multiple Hazard Impact	BGS	Multiple hazard impacts on exposure and how they may be addressed in disaster risk management by a range of stakeholders.
WP.7	Knowledge Sharing	GEM	Disseminate to the wider space and development sectors through dedicated web-portals and use of the Challenge Fund open databases.
WP.8	Sustainability and Capacity-Building	ImageCat	Sustainability and capacity-building, with the launch of the databases for Nepal and Tanzania while working with in-country experts.

Table 2: Overview of METEOR Work Packages

1.5. IN-SITU INPUTS AND VALIDATION

The project WP led by HOT is broken down into six deliverables, which are focused on the mapping of exposure data for the cities of Kathmandu and Dar es Salaam in OpenStreetMap (OSM). These involve importing existing data into OSM, the remote mapping of building footprints and road networks, drafting protocols for crowdsourcing exposure data, collecting detailed attribute information on the ground and producing a final report (Table 3).

Deliverable	Title	Overview
M4.1	Import Existing Data into OSM	Review and assess the suitability of existing open datasets for import into OSM for Kathmandu and Dar es Salaam.
M4.2	EO Mapping of Exposure Data	Remote mapping of building footprints and road networks in OSM for Kathmandu and Dar es Salaam.
M4.3	Protocols for Crowdsourcing Exposure Data	Draft protocols for the crowdsourcing of exposure data in OSM, covering data imports, remote mapping and ground data collection.
M4.4	Ground Data Collection using Protocols I	Collect exposure data on the ground for Kathmandu using a data model developed in line with the requirements for WP.3
M4.5	Ground Data Collection using Protocols II	Collect exposure data on the ground for Dar es Salaam using a data model developed in line with the requirements for WP.3
M4.6	Final Report	Deliver a final version of M4.3 along with the resulting data from M4.4. and M4.5.

Table 3: Overview of HOT Work Package

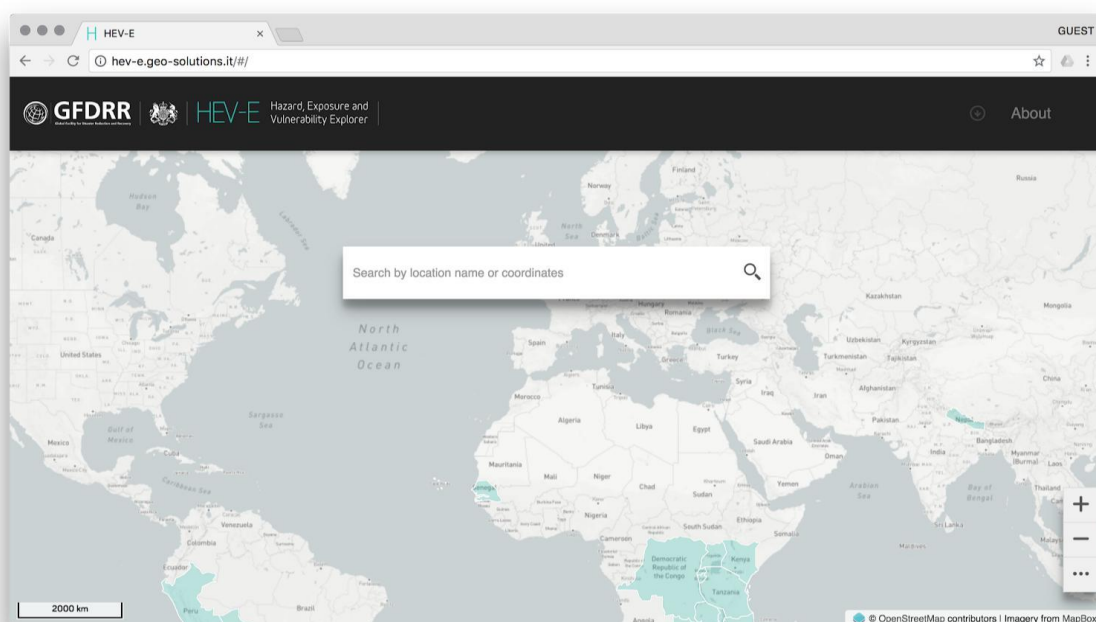


Figure 1: GFDRR Challenge Fund HEV-E Data Platform. Imagery ©OpenStreetMap contributors | Imagery from MapBox

2. OpenStreetMap

2.1. WHAT IS IT?

OSM is a crowdsourced geospatial database of the world built largely by volunteers and professionals digitising aerial imagery, collecting attribute information on the ground and liberating existing public sources of geospatial data. Known as the 'Wikipedia' of maps, the data is freely accessible to all under the Open Database License (ODbL)¹, meaning that it can be queried, used, manipulated, contributed to and redistributed in any form. OSM is the ideal database for humanitarian efforts and disaster management, as it is a great source of geographic baseline data for many cities around the globe, especially in countries with emerging economies that are not always on the map.

2.2. OPEN DATA

The ODbL license is a copyleft ("share alike") agreement intended to allow users to freely share, modify, and use a database while maintaining this same freedom for others. Published by Open Data Commons, part of the Open Knowledge Foundation², the ODbL license enables OSM to be a source of powerful geospatial data to make change, particularly in ODA countries where a potential lack of internal funds and skill sets make it difficult to create up-to-date exposure data themselves. Such data is necessary to conduct hazard impact risk assessments and carry out informed appropriate disaster management decisions. One project may focus on creating data in OSM for a specific purpose, but this data can then be used by anyone for their area of interest. This freedom of use is outlined on the ODbL website (Open Data Commons, 2018):

You are free:

- ❖ To Share: To copy, distribute and use the database
- ❖ To Create: To produce works from the database
- ❖ To Adapt: To modify, transform and build upon the database

As long as you:

- ❖ Attribute: You must attribute any public use of the database, or works produced from the database, in the manner specified in the ODbL. For any use or redistribution of the database, or works produced from it, you must make clear to others the license of the database and keep intact any notices on the original database
- ❖ Share-Alike: If you publicly use any adapted version of this database, or works produced from an adapted database, you must also offer that adapted database under the ODbL
- ❖ Keep open: If you redistribute the database, or an adapted version of it, then you may use technological measures that restrict the work (such as DRM) as long as you also redistribute a version without such measures

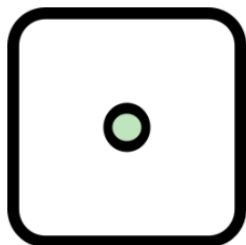
¹ <https://opendatacommons.org/licenses/odbl/>

² <https://okfn.org/>

2.3. DATA STRUCTURE

Geospatial data is stored in OSM as vectors, with three types of elements:

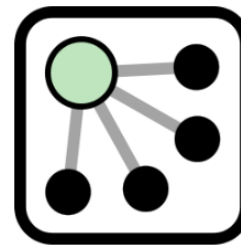
1. **Nodes**, which represent a point on the surface of the earth
2. **Ways**, which are sets of ordered nodes that can form lines or polygons
3. **Relations**, which are sets of nodes, ways and/or relations as members that are used to define logical or geographic relationships between other elements



Nodes



Ways



Relations

Each of these elements can have any number of `key=value` tags, that represents the attribute information for a given feature. For example, a post office may be represented by a way with the tags `building=yes` and `amenity=post_office`, to help identify the purpose of the building.

2.4. WHY USE IT?

The most common question people ask is: *Why would you use OpenStreetMap if there is Google Maps?*³ These platforms have many similarities and address the same basic human of spatially knowing where things are. In short, OSM represents an open approach to how data is collected and distributed, which makes it fast, free, flexible and widespread; an ideal combination for development application among others.

In the case of Haiti, the OSM community needed just a few hours to remotely digitise earthquake affected areas from satellite imagery, in contrast to commercial maps that had no way of responding in such a short period. The thousands of active volunteers around the globe are what made this possible, and the fact that every update is immediately visible to all other users, and is also version controlled. In many cases, the OSM community has been able to achieve even higher detail than any other map source.

The very idea behind OSM was to solve the problem of data restriction by using a Wikipedia model. Each edit made in OSM is owned by the community, whereas each change made in commercial map is owned by the providers. Data in commercial maps is copyrighted and so it can be subject to licensing fees and contractual restrictions. OSM is, and always will be, available for free. This open access to geospatial data makes it easy for researchers, governments, disaster management agencies and policy implementers to work collectively from the same database.

OSM is also ready for any kind of operation. Many major organisations are choosing OSM for their maps because it allows for customisation based on need. It has been used to collect functioning and non-functioning water facilities in northern Uganda, to mapping hundreds of thousands of shelters in Bangladesh, to planning logistics for a Yellow Fever campaign in the Democratic Republic of Congo and mapping the exposure information of infrastructure for

³ <https://welcome.openstreetmap.org/>

hazard impact. It allows access to all of the map offline and can be formatted in local languages, transcending national boundaries.

Most importantly, OSM emphasises local knowledge across the globe. The barrier to entry is low, and there are many ways to contribute that do not require access to the latest technology. The result is a map made by local experts. OSM provides global map data in a unified tagging schema, although there are some local variations, this allows for consistency from country to country, for a truly global map.

3. Participatory Mapping

Participatory mapping a phrase commonly used in the OSM community. It is the creation of maps by local communities. They are visual representations of what a community perceives as its environment and the significant features within it. Participatory mapping is based on the premise that local communities possess expert knowledge of their surroundings.

Often this process is supported by organisations, with a target goal and funds to assist with the research and direction, depending on the purpose of the data creation. The emphasis, however, is always on providing skills for the community to create the maps themselves in order to represent the spatial knowledge of local citizens. Participatory mapping is at the core of HOT and their work, where local teams are the experts to create the necessary data in OSM.

This is also the case for both the remote digitisation of building footprints and the collection of detailed building information in the cities of Kathmandu and Dar es Salaam for the METEOR project. Kathmandu Living Labs (KLL) is a local company who has been involved with the OSM community for years, having worked on numerous projects with the Nepalese government. Ramani Huria is a community-based mapping initiative that began in Dar es Salaam training university students and local community members to create OSM maps of the most flood-prone areas of the city, in an effort to help combat the impact.

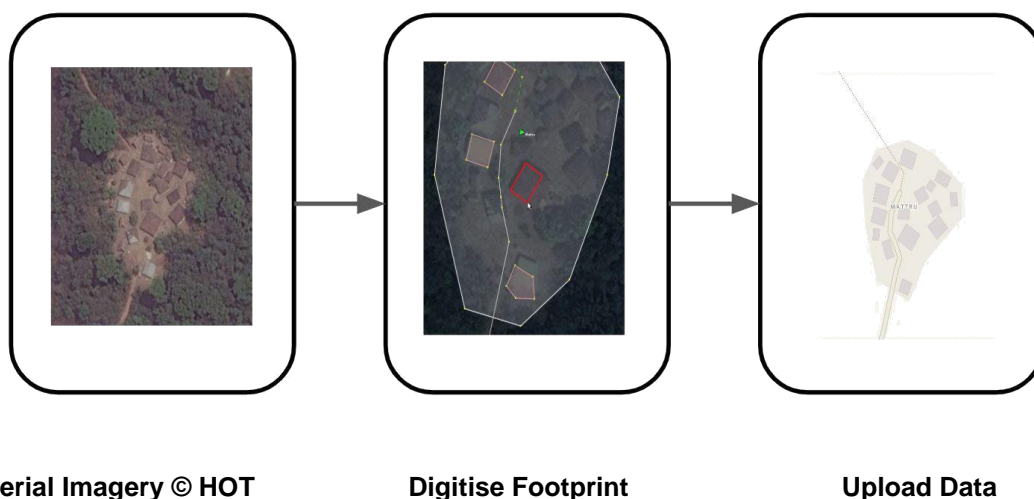
4. Remote Digitisation

4.1. OVERVIEW

Remote mapping is the process of modifying or adding new data to areas from a distance. In OSM this usually involves the use of a software program to trace information from satellite imagery or other earth observation material such as drone footage. All data in OSM is exposure data, as the type of information hosted relates to real objects, generally infrastructure and land use.

Once the data is mapped as vector data from aerial imagery, also known as raster data, this is uploaded to the OSM database, so that the results instantly form part of the global map data and is available to everyone. Using imagery to draw points, lines and shapes on the ground is also called 'digitising', and is generally done remotely. This means it does not have to physically be done in the same area.

Some people also call this process 'armchair mapping' because an individual can contribute without leaving their chair. The objective of remote mapping is to cover a large area quickly, obtaining a high-level overview of what is actually on the ground. It allows people to directly contribute to projects even if they cannot be physically present in the field.



In general, the first step for remote mapping in OSM is often identifying an area that needs to be mapped. Then it is important to determine if there is suitable imagery. A project can be created covering a certain area, the level of detail required should be specified, as well as the urgency. The work is then divided into sections by a gridded, known as tasks which can then be selected by individual remote mappers who each map a part of the overall area. This is checked by a second remote mapper who makes sure it is correct – a process called 'validation'. While there are many advantages to remote mapping, there are also some disadvantages. Data accuracy tends to be lower when users do not physically visit the places they are mapping, hence the emphasis on local mappers.

4.2. TOOLS

4.2.1. Tasking Manager

This tool was designed by HOT for collaborative mapping through the remote digitisation process in OSM, outlined in the previous section. The Tasking Manager divides up a project into smaller tasks that can be remotely digitised rapidly with many people working on the same

overall area. This helps to avoid conflicts or duplication of people working on the same task. It shows which areas need to be mapped and which areas need to be validated. The tasks can then be selected and editing the OSM map can be done with the use of iD Editor, JOSM or another tool of preference.

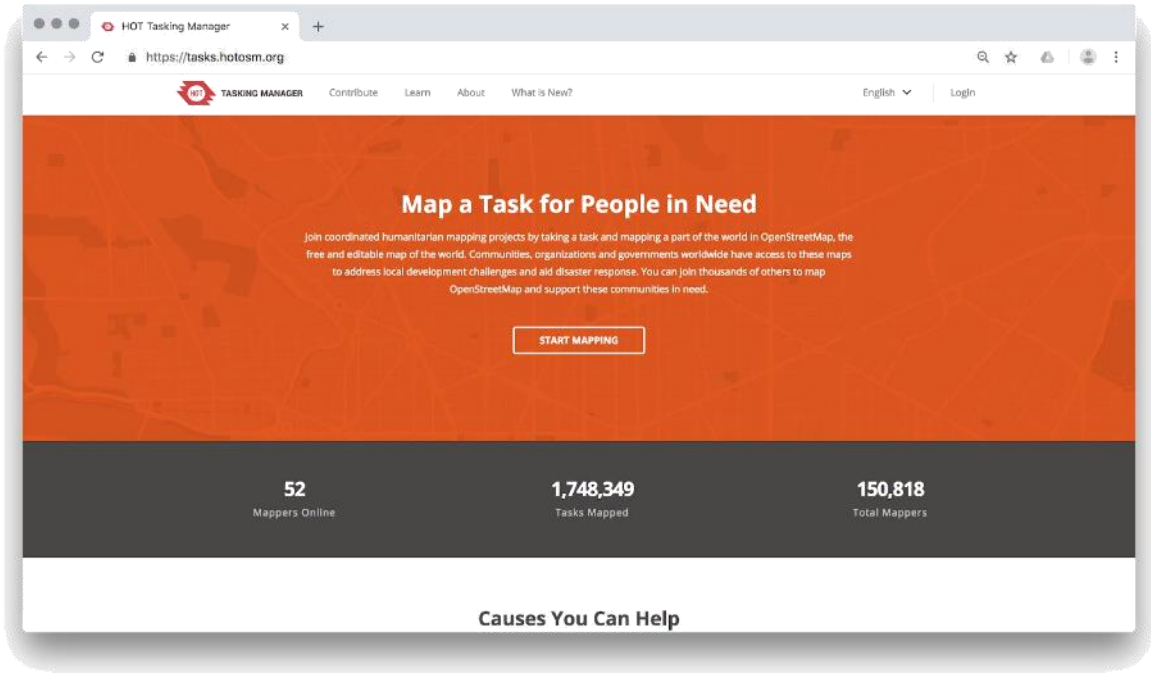


Figure 2: HOT Tasking Manager, as accessed in 2018 (<https://tasks.hotosm.org>)

The Tasking Manager also allows monitoring of the overall progress and helps improve the consistency of mapping. It can be used either by an administrator who manages a project, or by mappers working to complete an area. The guidelines below briefly outline the steps for creating a project by a manager.

1. Open an internet browser, and go to the Tasking Manager at <https://tasks.hotosm.org/>
2. Log in using your OSM account – click the **Login** button on the top right corner, which will ask you to authorise access to your OSM account – click **Grant Access**
3. Now that you have logged in click on the arrow next to your username and select **Create new project**
4. Define your Area of Interest on the map, either by drawing it, importing a file, or using an OSM file; you should be familiar with the geographical area of the task
5. Choose Tasks Type – either select a square grid or arbitrary tasks
6. Set Task Sizes – split the area into larger or smaller tasks. You will need to decide an appropriate size, depending on the amount of features that need to be mapped
7. Trim Project – cut the task grid to only the **Area of Interest**, this is optional
8. Review – here you will be able to see what your project looks like and how many tasks you have created

Now you have created a project. Enter a detailed description and instructions and then publish.

Reference	Link
Learn How to Use the Tasking Manager	https://tasks.hotosm.org/learn
OSM Tasking Manager Wiki	https://wiki.openstreetmap.org/wiki/OSM_Tasking_Manager

Table 4: Tasking Manager References

4.2.2. iD Editor

The iD Editor is a simple in-browser editor, allowing individuals to directly make changes in OSM. This is the editor beginner mappers are encouraged to use, as it is a user-friendly, making it easy to pick up the editing process of OSM. It also provides an initial walkthrough of the editor which is extremely helpful. This is the editor that is also used for quick additions or modifications of data, even by more advanced users who tend to use JOSM.

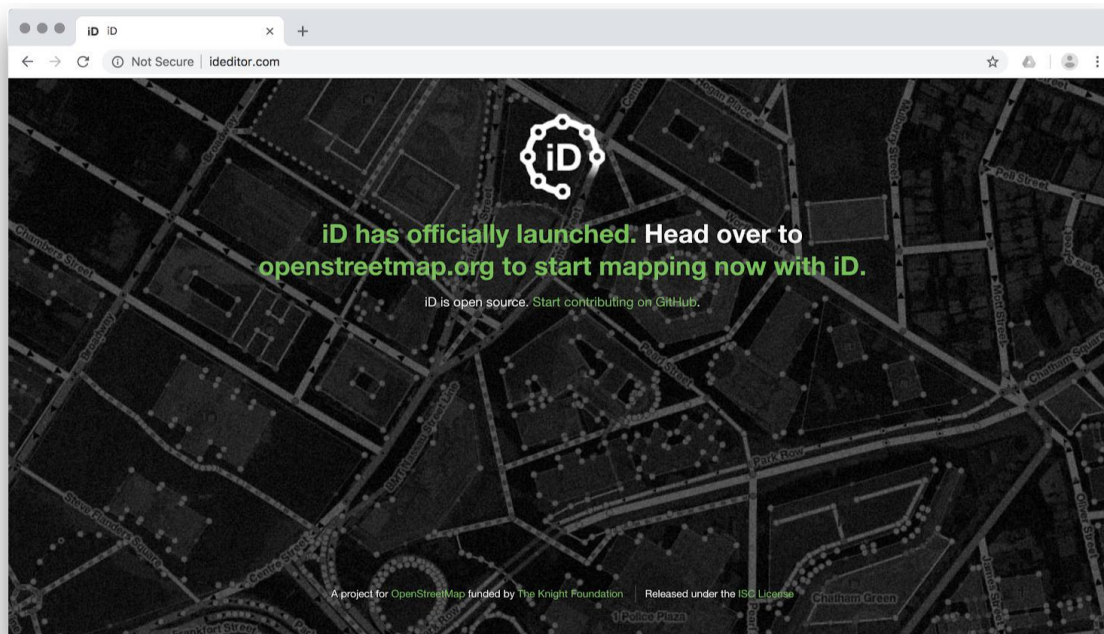


Figure 3: iD Editor, as accessed in 2018 (<http://ideditor.com>)

1. Open your Internet browser, and go to the OpenStreetMap website at <http://www.openstreetmap.org>
2. Log in using your OSM account click the **Login** button the top right corner
3. Go to the place you want to edit – either by entering the location in the search box, or by panning and zooming to the area you wish to edit. You can pan by holding the left mouse button and dragging the map to your desired area
4. Click on the small arrow next to **Edit** – Then click **Edit with iD (in-browser editor)**
 - a. For first-time users there will be a prompt for a walkthrough that begins inside the editor – it is helpful practice for learning the basics, and learning new words and concepts (it is always accessible through the **Help** icon)
5. You can add **points**, for example, placing a well or latrine in your area entering in relevant known details. You can draw **lines**, for example adding a road that hasn't been drawn. Or you can draw **areas**, for example tracing a building that hasn't been digitised
6. Note: nothing will be uploaded to OSM until you click the **Save** button. Enter any comments about your edits, and if you are unsure about the data there is also the option "I would like someone to review my edits" for extra validation

Reference	Link
Learn iD Editor	https://learnosm.org/en/beginner/id-editor/
iD Editor Wiki	https://wiki.openstreetmap.org/wiki/iD

Table 5: iD Editor References

4.2.3. JOSM

A feature-rich editor, JOSM, also known as the Java OpenStreetMap Editor is an open source desktop editor for OSM data. JOSM allows the user to create new data and edit existing data for OSM. The editor works offline, and makes it much easier for larger quantity and more detailed edits in a single sitting. While JOSM can be more intimidating to new users, the program is best suited for field operations and areas where internet is unreliable.

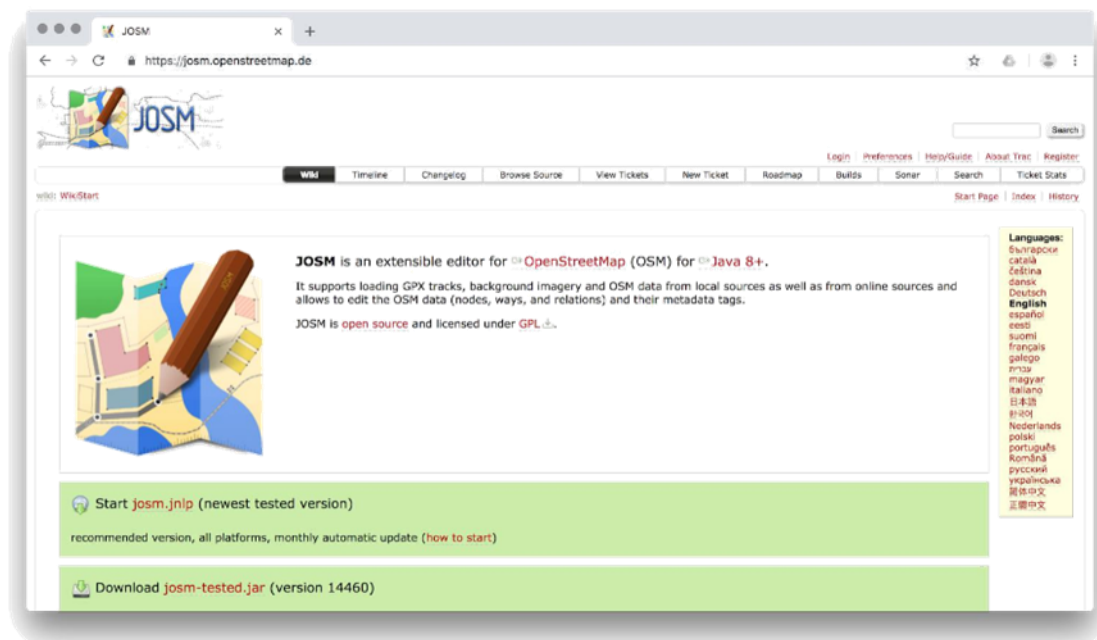


Figure 4: JOSM (Java OpenStreetMap) Editor, as accessed in 2018 (<https://josm.openstreetmap.de/>). JOSM is open source and is licensed under GNU General Public License v2

1. Go to the installation websites for both Java (<https://java.com/en/download>) and JOSM (<https://josm.openstreetmap.de/>)
2. Once download and installation is complete, open JOSM. Connect JOSM to your OSM account to enable data uploads. To do so, access the preferences window by clicking the **Edit** menu and selecting **Preferences**. Click the **Connection Settings** sub-menu, enter your OSM credentials (username and password) and select **Authenticate**.
3. Download data from OSM by clicking on the **Download** button and selecting an area of interest.
4. You can add aerial imagery as a background (if your internet connection is strong enough) by clicking on the **Imagery** menu and selecting an option such as **Bing**.
5. Just like in iD Editor, you can add points, lines, and areas using the add node tool. The difference is that these edits can be made while offline.
6. You should go through all data individually to check for spelling mistakes, incorrect tagging and geometries. To assist with the data cleaning process, you can use the validation tool, filters, and JOSM plugins including todo list.
7. When you're done, you can either save your work for later upload or for review, or immediately upload changes to OSM by clicking on the upload button.
8. Recommended: Have an experienced JOSM user serve as data quality manager, reviewing all data prior to upload.

Reference	Link
LearnOSM Getting Started with JOSM	https://learnosm.org/en/josm/start-josm/
JOSM Wiki Guide	https://wiki.openstreetmap.org/wiki/JOSM/Guide

Table 6: JOSM References

4.3. IMAGERY

Aerial imagery is a term used to describe photographs that are taken from the sky. This can be done from airplanes, drones, helicopters, or even kites and balloons, but the most common source of imagery in terms of mapping comes from satellites orbiting the Earth. These photos can then be manipulated so that they can be used in Geographical Information Science (GIS) software.

One of the most basic questions to ask is what is the state of the available imagery? Is it up-to-date? If there has been a rapid evolution of the situation on the ground, for instance with the emergence of new buildings, new imagery needs to be obtained. If there is not satellite imagery available, does the host country have legislation allowing Unmanned Aerial Vehicles (UAVs), and what permissions are required?

The easiest starting point for finding imagery for digitisation in OSM is to check the imagery available in iD Editor. Simply click on **Background Settings** to see what imagery is available. The imagery available here is provided for free and is licensed. This generally includes satellite imagery from Bing⁴, DigitalGlobe⁵, ESRI⁶ and Mapbox⁷. Sometimes the imagery available through OSM is not suitable for the project, as it may be out of date, has cloud coverage or the resolution is not high enough to distinguish individual buildings from one another.

This is when it would make sense to look at other sources of aerial imagery. You can start by using the Discover DigitalGlobe⁸, which is an online catalog service of satellite imagery. Another option is to either capture imagery with the use of a drone or by finding aerial imagery uploaded by others.

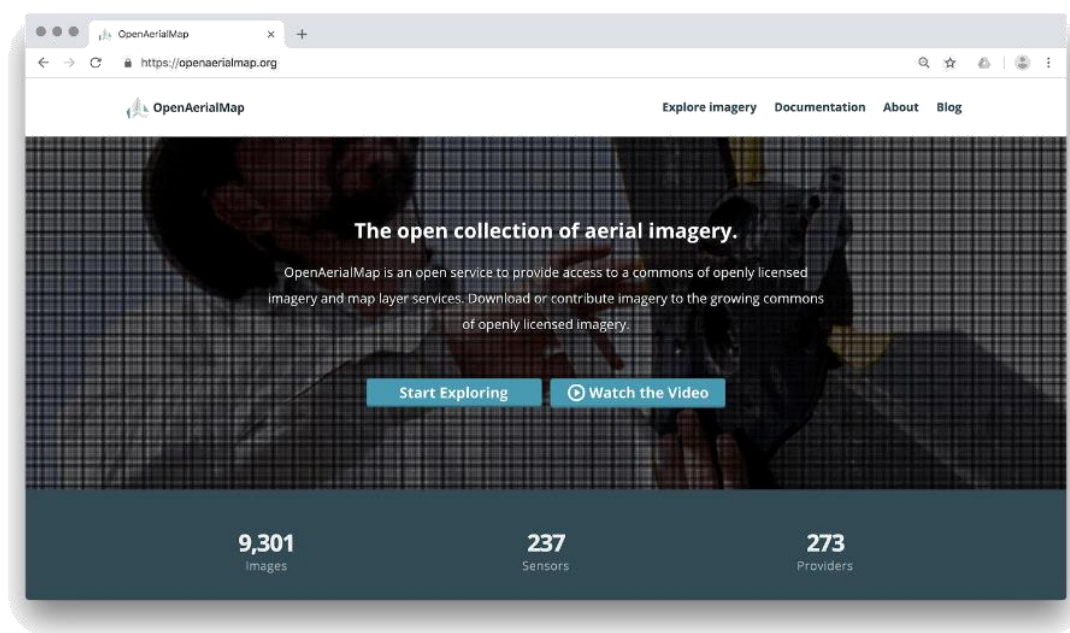


Figure 5: OpenAerialMap, as accessed in 2018 (<https://openaerialmap.org>)

⁴ <https://www.bing.com/maps/aerial>

⁵ <https://www.digitalglobe.com/>

⁶ <https://www.esri.com/en-us/arcgis/imagery-remote-sensing/content>

⁷ <https://www.mapbox.com/maps/satellite/>

⁸ <https://discover.digitalglobe.com>

OpenAerialMap (OAM) is a set of tools for searching, sharing, and using openly licensed satellite and UAV imagery. OAM offers a worldwide canvas on which various organisations can contribute to a patchwork of imagery. Open imagery can be critical for responding to crises and OAM makes it easy to host and access imagery for humanitarian response and development purposes, which is custom and up-to-date.

Reference	Link
LearnOSM Aerial Imagery	http://learnosm.org/en/josm/aerial-imagery
Discover by DigitalGlobe	https://discover.digitalglobe.com
OpenAerialMap	https://map.openaerialmap.org
GEOSS Portal	http://www.geoportal.org
USGS Earth Explorer	https://earthexplorer.usgs.gov
Map Compare	https://tools.geofabrik.de/mc/

Table 7: Aerial Imagery Resources

4.4. QUALITY ASSURANCE

Quality assurance is a large part of any dataset and is true with OSM data. It is also known as the maintenance of a desired level of quality in a product. The higher quality your data is the more useful it is, so it is essential to manage the process along the way.

OSM is often more up-to-date and of a higher quality than other commercial maps in the least developed countries, but this requires mappers to be actively cleaning the data. While validation and quality control can be and should be performed at all stages of mapping, the main objective is to catch any mistakes in the data before uploading it to OSM or using it for any maps.

As there are many different possible workflows for data collection, there is no one way to perform validation and quality control. There are several tools that assist with this process while digitising in OSM, such as the 'Validator Tool' in JOSM. This helps highlight any errors in the data, such as intersecting geometries, unconnected nodes and missing tags, so that the mapper can correct them before uploading the data.

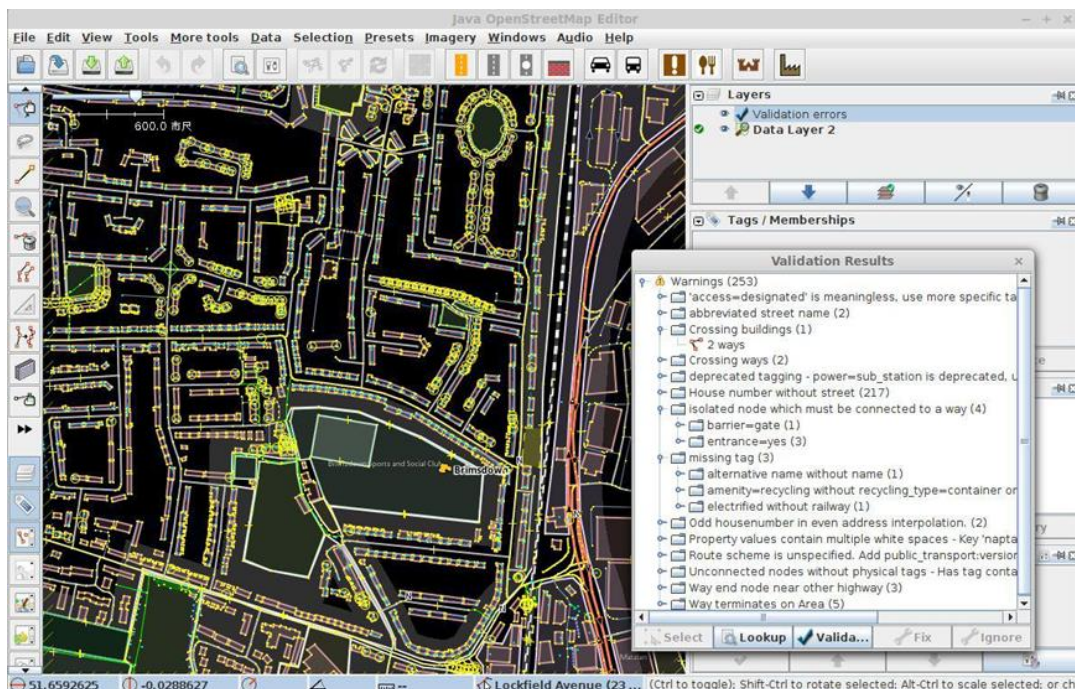


Figure 6: JOSM Validation Tool for quality assurance of digitised data in OSM

Reference	Link
Quality Assurance Wiki Page	https://wiki.openstreetmap.org/wiki/Quality_assurance

Table 8: Quality Assurance Resources

5. Kathmandu

5.1. KATHMANDU LIVING LABS

Kathmandu Living Labs⁹ (KLL) is a civic technology company, who aim to activate, inspire, and lead local communities using high impact technology to help transform societies. KLL creates the digital infrastructure so that government, non-profits and businesses can use current tools to provide citizens with better services. KLL was formed in 2013 following a successful OpenDRI project with the World Bank, when the institution was registered as a non-profit civic technology company in Nepal.

Since their establishment, KLL have gone on to do numerous mapping initiatives including the National Housing Reconstruction Programme¹⁰, Secondary Cities¹¹, QuakeMap.org¹², Mapping and Opening Data for Local Governance and Citizen Engagement (MODEL4G) and a Structural Integrity and Damage Assessment project with the Department of Education in collaboration with the World Bank.

Using the KLL Collect SIDA application, data on the structural damage of 3,200 educational institutions was collected. This included over 10,000 buildings that were surveyed and the data validated. The collected data serves as a baseline for informing repairs, retrofitting and the reconstruction of the schools. Attribute information surveyed included the GPS coordinates of each school, number of pupils studying there, the different kinds and quantities of WASH facilities present, as well as the various risks associated with their infrastructure and surroundings

5.2. HOMOGENEOUS ZONES

Kathmandu was divided into zones and classified by development patterns by the team at ImageCat. These homogeneous zones correspond to what the sensors should be able to detect, rather than who does what on the ground. ImageCat will then use these zones for an Artificial Intelligence (AI) module to capture the rest of the country. There are seven homogeneous zones identified in Kathmandu by ImageCat, this includes Dense Residential, High Urban, Industrial, Informal, New Industrial, Residential and Urban (Figure 7).

⁹ <http://www.kathmandulivinglabs.org/>

¹⁰ <https://www.nepalhousingreconstruction.org/>

¹¹ <https://secondarycities.state.gov/>

¹² <https://www.usahidi.com/case-studies/quakemap>

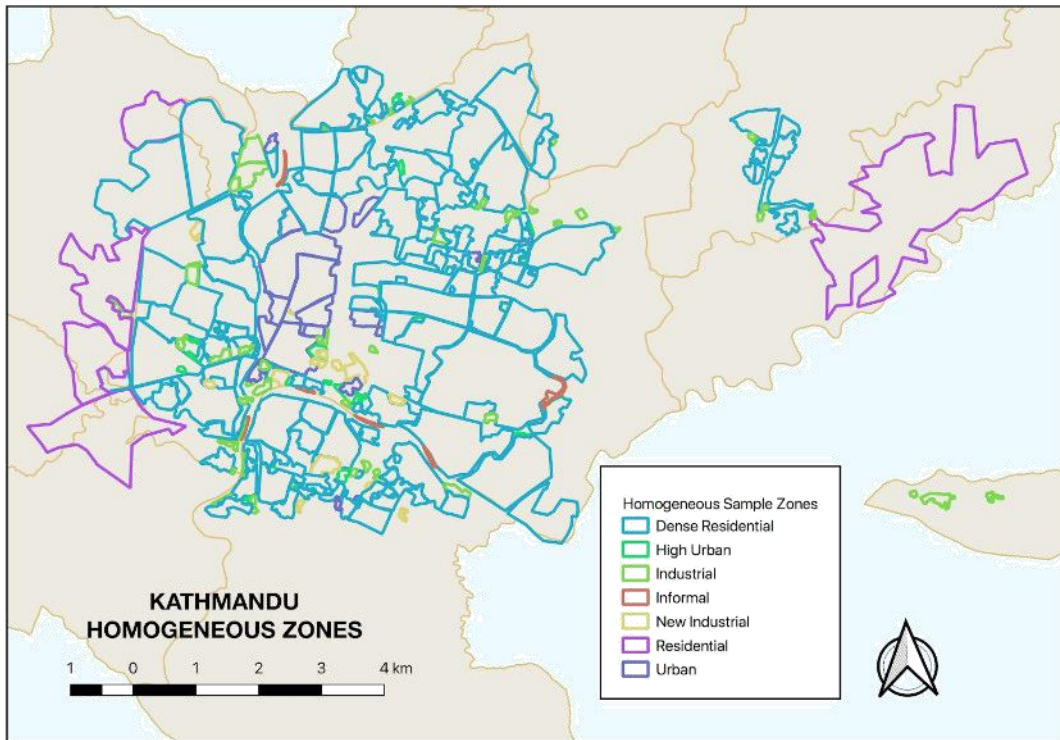


Figure 7: Kathmandu Homogeneous Zones © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL.

The geospatial dispersion of the homogenous zone displays a concentration of urban settlement types towards the centre of city, surrounded by dense residential, with industrial, new industrial and informal settlements scattered in between. The residential homogeneous zones are situated on the outskirts of the city. The total number of zones per homogenous type can be found in Table 9.

Homogenous Zone Type	No Zones Identified
Dense Residential	143
High Urban	23
Industrial	51
Informal	7
New Industrial	13
Residential	5
Urban	19
Total	261

Table 9: Kathmandu Homogeneous Zones

5.3. TASKING MANAGER PROJECTS

KLL setup a project in the HOT Tasking Manager to carry out the remote digitisation of the building footprints found within the identified homogeneous zones in Kathmandu. The tool helps to coordinate and manage the large-scale mapping of features required for the work package. The Tasking Manager project (Figure 8) was set up as private so that only the local KLL team could access the task for mapping. This was done due to the restrictions on the satellite imagery which was kindly provided by the United States Agency for International Development (USAID)¹³. The details of the imagery are covered in the following section.

¹³ <https://www.usaid.gov/>

MEDIUM 1 - Active Mappers

#5432 - MODELLING EXPOSURE THROUGH EARTH OBSERVATION ROUTINES: METEOR KATHMANDU

[SHARE](#)

[EDIT PROJECT](#)

Download: Aoi as [.geojson](#), Tasks as [.geojson](#), [.osm](#), [.gpx](#)

The escalating impacts of natural hazards are caused mostly by increasing exposure of populations and assets. It is estimated that the world will see the construction of 1 billion new dwellings by 2050 and this growth may lead to rapid increase in risk. Kathmandu Living Labs is working together with the Humanitarian OpenStreetMap Team, British Geological Survey, ImageCat, and the Global Earthquake Model on a UK Space Agency International Partnership Programme, focused on developing innovative applications of earth observation (EO) technologies to improve understanding of exposure to help minimise these risks.

METEOR aims to build and strengthen local and global resilience through complete, up-to-date, accurate exposure data in order to better identify risk and enable more effective decision-making, through capacity-building of local decision makers to apply data and assess hazard exposure. The country-wide datasets developed by ImageCat will be tested for their suitability of purpose against OSM data surveyed on the ground within Kathmandu and Dar es Salaam. Detailed attribute information following the GED4ALL taxonomy developed as part of the GFDRR Challenge Fund, will be collected for buildings randomly selected within homogenous zones by Kathmandu Living Labs and Raman Hari.

Status:	PUBLISHED	Created by:	Gaurav Thapa
Last updated:	16 hours ago	Difficulty:	BEGINNER
Priority:	MEDIUM	Type(s) of mapping:	BUILDINGS
Organisation:	N/A	Campaign:	N/A
Mapper level required:	No	Validator role required:	No

Instructions Map Validate Questions and Comments

Instructions

Entities to map
Buildings

Changeset Comment
#hotsm-project-5432 #KLL #METEOR #digitizingkathmandu #HOT

Imagery
https://imagegeoecenter.org/image/rest/services/Nepal_2018_63202_v2/MapServer/tile/{Z}/{Y}/{X}

MAPPING: To get started with Mapping watch this video <https://www.youtube.com/watch?v=r-3hrVpkD8> **VALIDATION:** If you are working with validation watch this video <https://www.youtube.com/watch?v=k-5Vr7lePM> You will be using free satellite imagery to map roads. For a guideline on remote mapping please refer to this wild <https://wiki.openstreetmap.org/wiki/Nepalremotemappingguide>

Ready to get started?
Contribute by mapping or validating work that has already been done.

[MAP](#) [VALIDATE](#)

Legend
 Ready
 Mapped
 Bad imagery
 Validated
 Invalidated
 Locked
 Locked by you

5 km
© OpenStreetMap contributors

Figure 8: Kathmandu Tasking Manager Project (accessible within <https://tasks.hotosm.org/> in 2018). Image © OpenStreetMap contributors

The setup of the METEOR Kathmandu project in the Tasking Manager, follows the same layout as all projects. This includes a description of the projects and the mapping instructions, which detail the entities to map (buildings), the changeset comment (#KLL, #METEOR, #digitizingkathmandu #HOT), the imagery link (GeoCenter TMS) and instructions to get started.

No	Mapping Area	Project Link	Homogeneous Type
1	Kathmandu	https://tasks.hotosm.org/project/5432	Multiple

Table 10: Kathmandu Tasking Manager Project

5.4. IMAGERY

The imagery provided for the remote digitisation of building footprints within the homogeneous zones identified in Kathmandu was kindly provided by USAID in Nepal. It was provided through a Tile Map Service (TMS), which was hosted at their dedicated GeoCenter¹⁴. The satellite imagery was captured by the WorldView-4 sensor in December 2017, making it a little under a year old.

Ideally it would be better to have even more recent data, since there has been a fair amount of construction going on in Kathmandu following the 2015 earthquake. However, this was the best imagery dataset overall taking into account the high resolution, absence of cloud coverage and low off-nadir angle (16). Buildings that were potentially not digitised from this dataset will be captured during the validation phase of mapping, when the footprint data is compared to other imagery datasets.



Figure 9: Digitised Buildings in Bhaktapur Dense Residential Zone. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL. Image data: WorldView-4 © 2017 Maxar Technologies.

Satellite Imagery Details	
Product	WorldView-4
Acquisition Date	30-12-2017
Off-Nadir	4.4
Cloud Coverage	0%
Resolution	30 cm

Table 11: Kathmandu Imagery Specifications

¹⁴ <https://geocenterusaid.org/remotesensing/index.html>

5.5. STATISTICS

Following the successful remote digitisation of all the footprints in OSM for the buildings located within the identified homogeneous zones, it can be seen that there is an overall increase in 33% of building stock (Table 12). This can be due to a number of factors, such as the development and building of new infrastructure across the city, as well as the fact that perhaps a lot of the buildings were not yet mapped in OSM. Although they have now been mapped for the purposes of the METEOR project, this data is freely available to everyone. Hopefully this data will be used for a variety of research and development initiatives that benefit the citizens of Kathmandu and Nepal.

Homogeneous Zones	Building Count		
	Before	After	Increase
1 Residential	8,909	16,564	46%
2 Dense Residential	71,310	104,945	32%
3 Urban	8,829	10,671	17%
4 Industrial	1,274	2,259	43%
5 Informal	175	752	77%
6 High Urban	595	749	21%
7 New Industrial	510	675	24%
Total	91,602	136,615	33%

Table 12: Kathmandu Buildings Count Pre and Post Digitisation

Along with the increase in the quantity of building stock in OSM and the identified homogeneous zones in Kathmandu, it is also important that the quality of the data has also be improved. To assess the accuracy of the data, in particular the building footprints digitised, the team at KLL focused predominantly on geospatial errors such as intersecting geometries and nodes that are not connected. It is important to also check that the features have the required minimum tag of `building=yes`, so that the feature can be identified as a building in the OSM database. Once the team has gone on the ground to collect detailed information on that building, the tag will be changed to represent the functionality of the building, such as `building=hospital`.

There was a decrease of 0.18% in errors and a decrease of 5.46% in warnings of the building footprints, when comparing the final digitised data to the original data in OSM. These numbers were determined with the used of the *Validator Tool* in JOSM, which uses an algorithm to detect common errors found in OSM data. The detailed output errors and warnings from the Kathmandu analysis can be found in the Appendix.

Before					After				
Buildings	Error	Error (%)	Warning	Warning (%)	Buildings	Error	Error (%)	Warning	Warning (%)
91,602	174	0.19	7,214	7.88	136,615	14	0.01	3,308	2.42

Table 13: Kathmandu Building Quality Pre and Post Digitisation

5.6. DATASETS

The exposure data created as part of M4.2 was stored in OSM as vector data, as soon as the building footprints were digitised through the Tasking Manager. This data is created by tracing the building outlines on top of the satellite imagery provided by USAID, converting the raster data information into vector data, which can easily be used by other GIS software, including hazard impact models.

The final OSM building data will be shared with ImageCat as a Geopackage file, but it should also be noted that this data is available to anyone through OSM and can be downloaded using a variety of tools. The easiest tool to use is the HOT Export Tool, which allows a user to upload their area of interest as a GeoJSON file. This means that ImageCat or any other partner can simply upload the homogeneous zone file of their interest into the Export Tool and select the `building` tag, to easily extract all the building footprints along with their attribute data for download, into a number of various file formats, such as Geopackages, Shapefiles and PBFs.

A couple of the Kathmandu homogeneous zones and their final OSM buildings footprints can be seen below. This includes the Namuna Chowk, which was identified as a dense residential (Figure 10). The Chhuani industrial zone (Figure 11), the informal settlement zone in Thapathali (Figure 12), the new industrial zone in Maitighar (Figure 13) and the urban zone in Balaju Machhapokhari (Figure 14). These provide a brief overview of the building patterns per development types as identified by the homogenous zones of ImageCat.

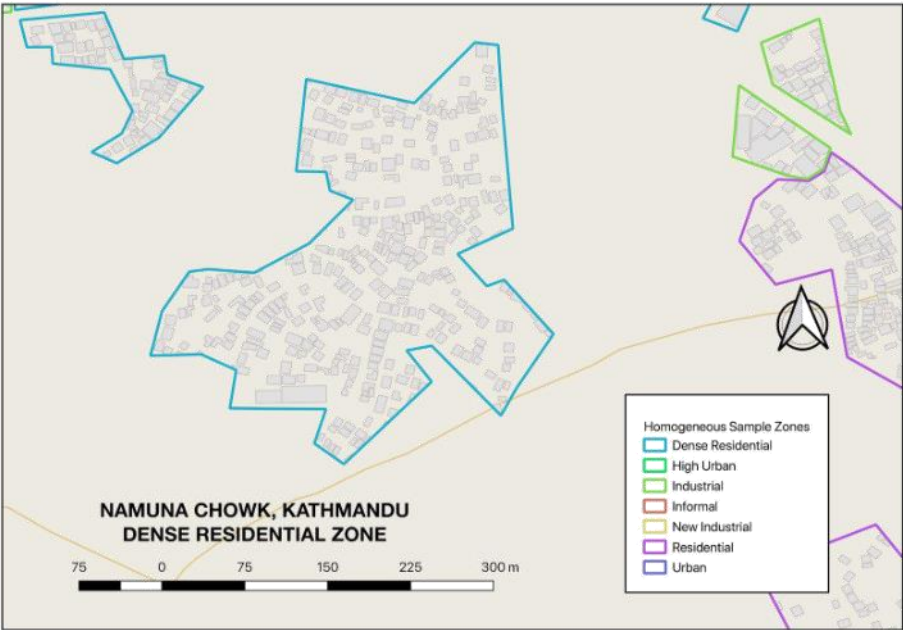


Figure 10: Kathmandu Dense Residential Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

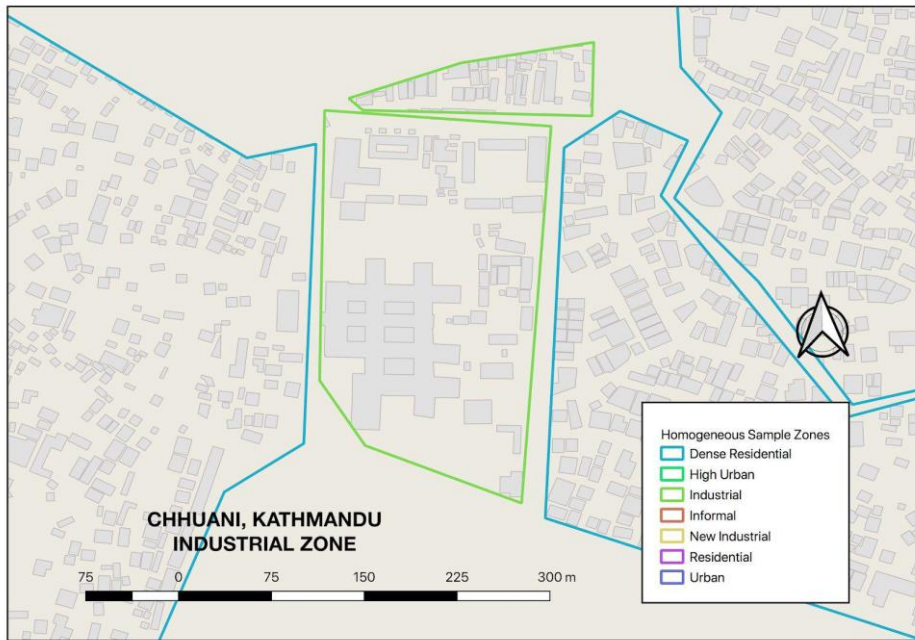


Figure 11: Kathmandu Industrial Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

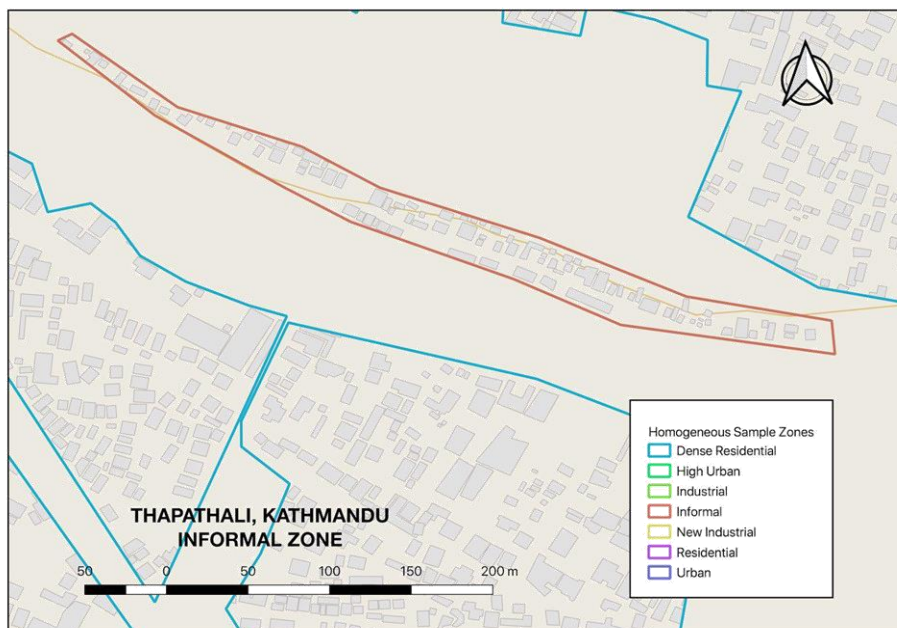


Figure 12: Kathmandu Informal Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

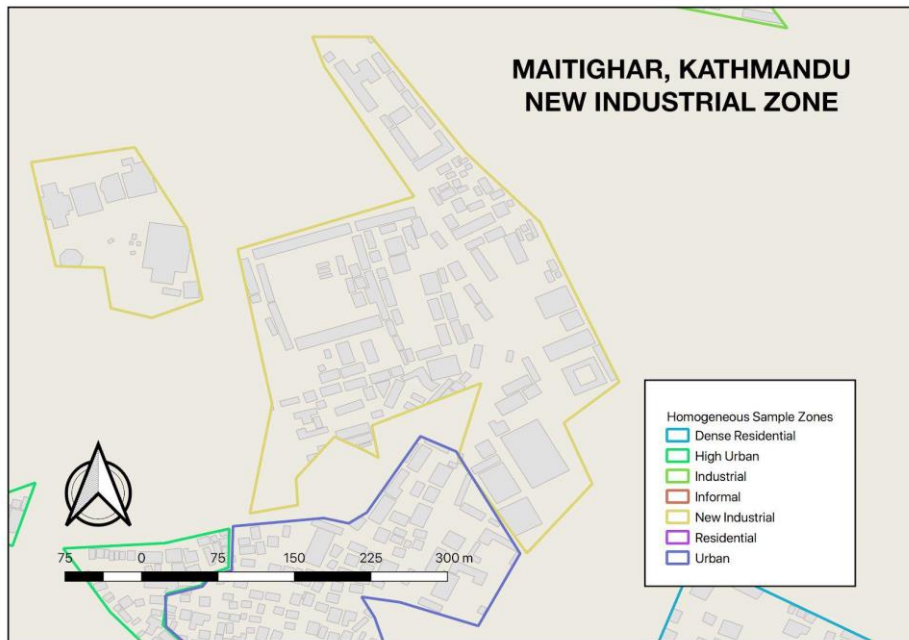


Figure 13: Kathmandu New industrial Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

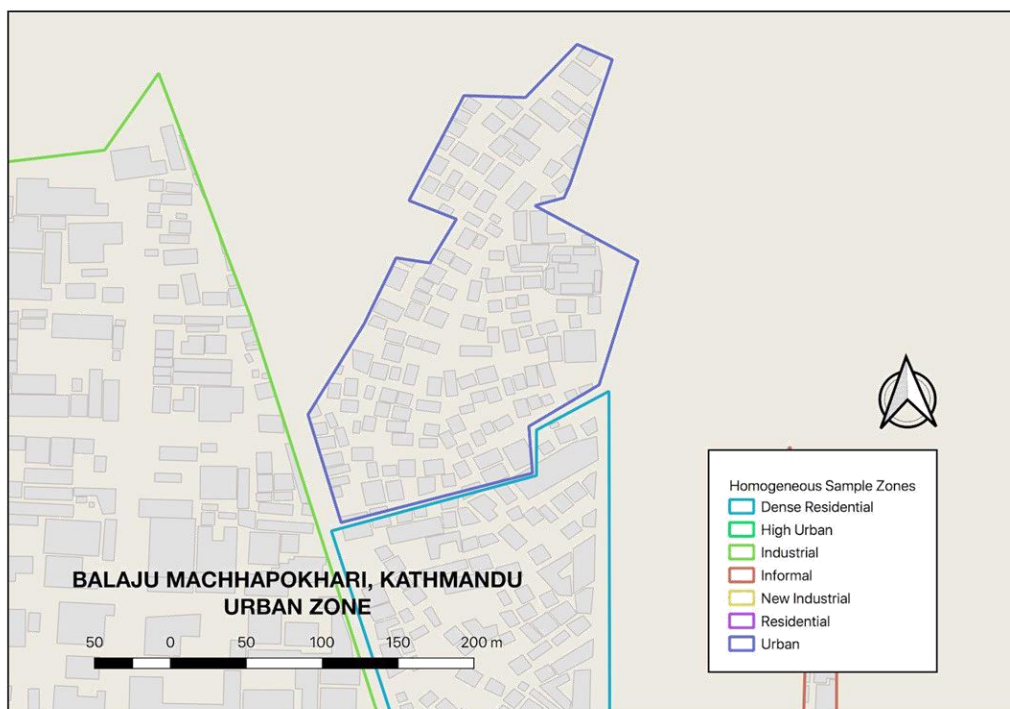


Figure 14: Kathmandu Urban Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

6. Dar es Salaam

6.1. RAMANI HURIA

Ramani Huria¹⁵ is a community-based mapping initiative that began in Dar es Salaam, Tanzania, training university students and local community members to create OSM maps of the most flood-prone areas of the city. This was the result of a collaboration with the Tanzanian Commission of Science and Technology (COSTECH), the Government of Tanzania, the City Council of Dar es Salaam, University of Dar es Salaam and Ardhi University, supported by HOT, the Red Cross and the World Bank.

To date, Ramani Huria has trained over 450 community mappers, while mapping 26 wards, 1,254 kilometres of waterways, 3,396 kilometres of road networks and 949,655 building footprints. The impact of the initiative and the power of community mappers was evident when an additional 443,347 buildings were added in OpenStreetMap for the city of Dar es Salaam in the space of 6 months, between August and December 2017.

The Ramani Huria initiative really put Dar es Salaam onto the map, which is home to approximately 1.3 million residents. As the map evolved over time, the benefits have multiplied as they are now serving as foundational tools for development within all socio-economic spheres beyond flood resilience, such as include health care services, which are key to reducing illnesses and mortality during flooding events, as well as toilets, water sources, and building infrastructure.

6.2. HOMOGENEOUS ZONES

There are six homogeneous zones of development patterns identified across Dar es Salaam by ImageCat. These include high urban development, industrial development, natural forest land, rural settlement, single family residential and urban development. The geospatial spread of these zones is much more scattered and sparse compared to the zones identified in Kathmandu, with some high urban development zones located in the centre and towards the northwest of Dar es Salaam. Industrial development zones are also located in the centre, as well as towards the west of the city. Zones of natural forest land are located on the outskirts of the cities as expected, same as the rural settlements. Single family residential zones are scattered throughout the city, with the urban development following a similar geospatial pattern as the high urban development zones in the city centre and towards the northwest (Figure 15).

¹⁵ <http://ramanihuria.org>

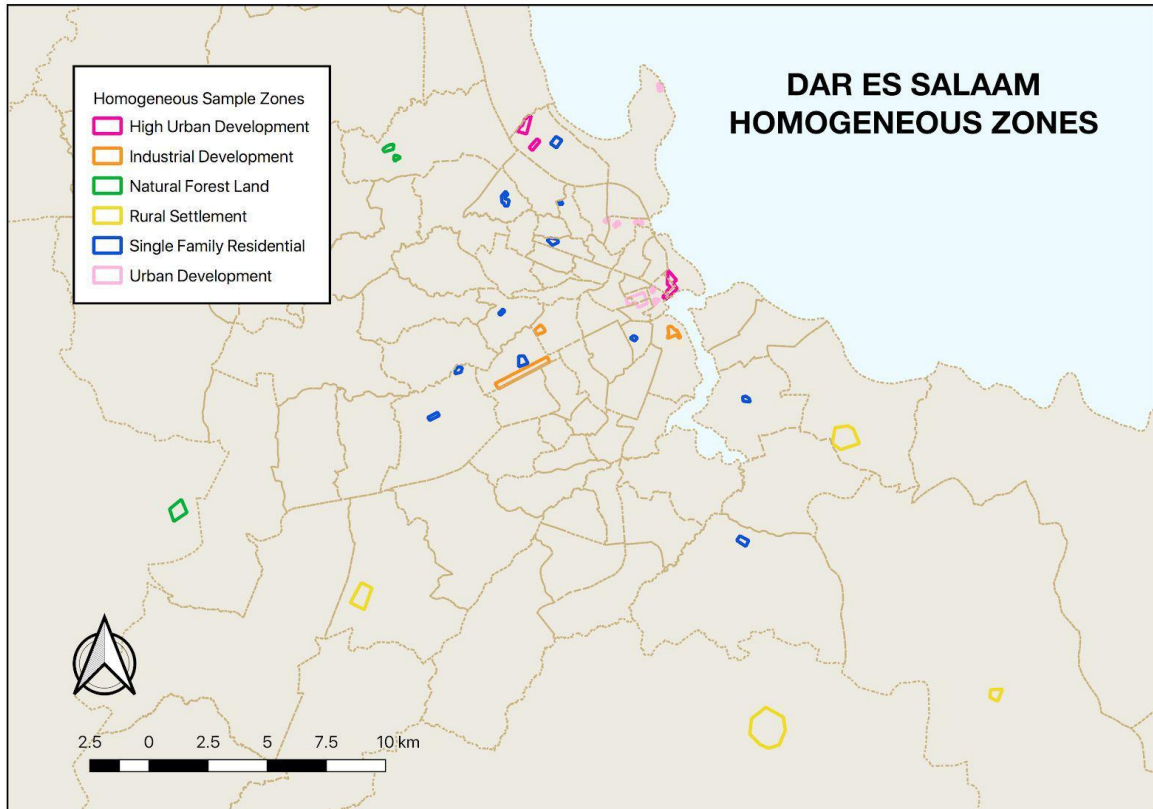


Figure 15: Dar es Salaam Homogeneous Zones © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

Homogeneous Zone Type	No Zones Identified
High Urban Development	3
Industrial Development	3
Natural Forest Land	3
Rural Settlement	4
Single Family Residential	11
Urban Development	7
Total	31

Table 14: Dar es Salaam Homogeneous Zones

6.3. TASKING MANAGER PROJECTS

The projects in the Tasking Manager for the remote digitisation of building footprints in Dar es Salaam, were set up a little differently than they were for Kathmandu. Although the project pages have the same standard Tasking Manager layout, with the project description and mapping instructions (Figure 16), it is the number of projects created that differ. Whereas KLL chose to use a single project to map all of the homogeneous zones, the Ramani Huria team chose to split their mapping across 14 Tasking Manager projects (Table 15).

There is no recommended way how this should be done, and generally this is left up to the local team to decide, so that they can select the method most effective for their mapping process. One of the reasons a team may choose to have multiple Tasking Manager projects as opposed to a single one, is the ability to divide the tasks to separate mapping teams for ownership.

This is particularly useful if the team conducting the remote digitisation of the building footprints within certain projects, will also be responsible for the data collection on the ground for the attribute information. This is because the Tasking Manager is also an effective tool for the coordination and monitoring of mapping efforts on the ground, as the projects area of interest can be identified and pulled into other HOT tools such as OSM Analytics¹⁶, MapCampaigner¹⁷ and the Export Tool¹⁸. These tools will be covered in detail during the ground data collection portion of the work package.

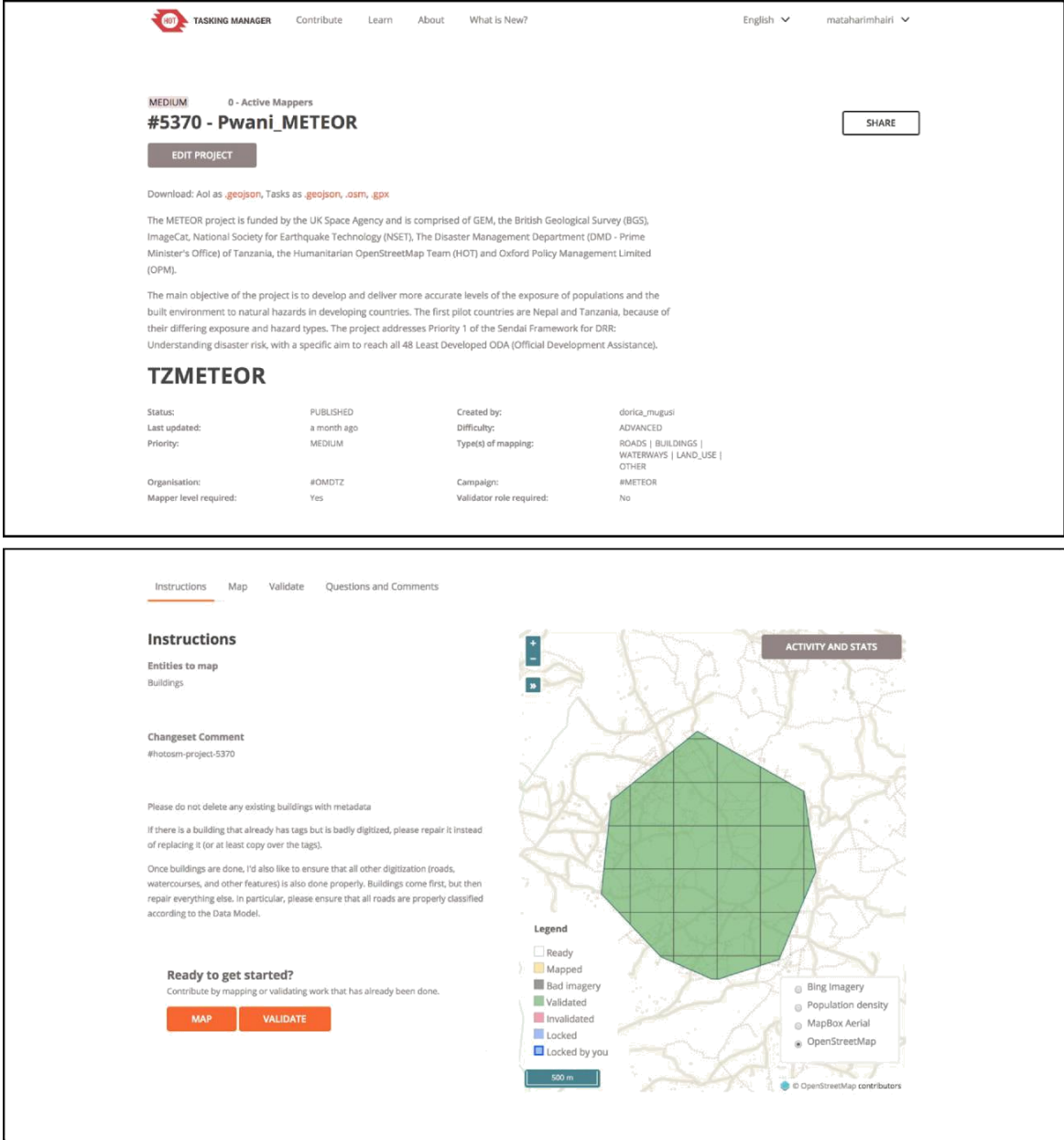


Figure 16: Dar es Salaam Tasking Manager Project (accessible within <https://tasks.hotosm.org/> in 2018). Image © OpenStreetMap contributors

¹⁶ <https://osm-analytics.org>

¹⁷ <https://campaigns.hotosm.org/>

¹⁸ <https://export.hotosm.org/>

No	Mapping Area	Project Link	Homogenous Type
1	Dar Wards	https://tasks.hotosm.org/project/5371	Multiple
2	Pwani	https://tasks.hotosm.org/project/5370	Rural Settlement
3	Pwani II	https://tasks.hotosm.org/project/5395	Natural Forest Land
4	Gerezani	https://tasks.hotosm.org/project/5386	Urban Development
5	Kagera Mikoroshoni	https://tasks.hotosm.org/project/5387	Single Family Residential
6	Karakata	https://tasks.hotosm.org/project/5389	Single Family Residential
7	Kisutu	https://tasks.hotosm.org/project/5390	High Urban Development
8	Kivule	https://tasks.hotosm.org/project/5391	Rural Settlement
9	Miembeni	https://tasks.hotosm.org/project/5392	Industrial Development
10	Mtakuja	https://tasks.hotosm.org/project/5394	Single Family Residential
11	Sinza	https://tasks.hotosm.org/project/5396	Single Family Residential
12	TPDC	https://tasks.hotosm.org/project/5397	Single Family Residential
13	Ungindoni	https://tasks.hotosm.org/project/5398	Rural Settlement
14	Keko Magurubasi	https://tasks.hotosm.org/project/5405	Single Family Residential

Table 15: Dar es Salaam Tasking Manager Projects

6.4. IMAGERY

The imagery used for the remote digitisation of the building footprints within the homogeneous zones of Dar es Salaam was provided by the consulting firm COWI¹⁹. The data was acquired by a piloted fixed-wing aircraft, commissioned by the Tanzanian Ministry of Lands²⁰ and the World Bank²¹. This imagery was provided to Ramani Huria for use on several of their projects focused on the mapping of infrastructure in Dar es Salaam. Although the data is almost 2 years out of date, it is still the best imagery available for digitisation at 10 cm resolution. The Tanzanian government are currently planning to re-digitise the entire city with the imagery.

Piloted Imagery Details	
Product	COWI
Acquisition Date	2016
Off-Nadir	0
Cloud Coverage	0%
Resolution	10 cm

Table 16: Dar es Salaam Imagery Specifications

¹⁹ <https://www.cowi.com/>

²⁰ <https://www.tanzania.go.tz/>

²¹ <https://www.worldbank.org/>



Figure 17: Dar es Salaam Industrial Zone. Imagery © COWI 2016



Figure 18: Digitised Buildings, Dar es Salaam Industrial Zone. Imagery © COWI 2016

6.5. STATISTICS

Looking at the final numbers of the digitised building footprints in OSM within the homogeneous zones of Dar es Salaam, it can be seen that there is an overall increase in 26% of building stock (Table 17). This is slightly lower compared to the 33% increase in Kathmandu, which can be attributed to the large digitisation efforts of Ramani Huria in 2017 to map a large extent of the city. Although the overall building stock number did not increase greatly, the quality of the building footprints was greatly enhanced with the use of the 10 cm resolution imagery for digitising.

Homogeneous Zones	Building Count		
	Before	After	Increase
1 High Urban Development	331	443	25%
2 Industrial Development	418	489	15%
3 Natural Forest Land	0	0	0%
4 Rural Settlement	790	1767	55%
5 Single Family Residential	3939	4923	20%
6 Urban Development	1167	1416	18%
Total	6,645	9,038	26%

Table 17: Dar es Salaam Building Count Pre and Post Digitisation

While comparing the quality of the building footprints pre and post digitising for the METEOR project in OSM, there were several factors highlighted. This includes the increased accuracy of building alignment, building shape and the inclusion of absent buildings.

The alignment of numerous building footprints was noticeably off in the older OSM data, most likely due to the use of multiple imagery sources. The re-digitisation of these footprints with the 10 cm resolution imagery allowed for all the buildings located within the homogeneous zones to be properly aligned. Similarly, with the older OSM data, most building shapes were inaccurate due to the use of poor resolution imagery used for digitisation as this makes the outline of the buildings hard to detect. With the COWI imagery, the buildings can be seen clearly and the building footprints clearly defined. Finally, one of the biggest issues with the use of poor imagery for digitising in OSM, is how easy it is to completely miss features.

When the resolution is poor, or there is cloud coverage in the imagery, it greatly reduces the ability to detect buildings. Since the imagery had a resolution of 10 cm and zero cloud cover, it enabled the Ramani Huria team to detect buildings that were potentially missed during the last phase of digitisation, as well as pick up new buildings.



Figure 19: Dar es Salaam OpenStreetMap Buildings Pre Digitisation. Image data: DigitalGlobe Premium ©2017 Maxar Technologies. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL



Figure 20: OpenStreetMap Buildings Post Digitisation, Dar es Salaam. Image data: DigitalGlobe Premium ©2017 Maxar Technologies. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

6.6. DATASETS

The OSM building stock in some of the homogenous zones in Dar es Salaam help to demonstrate the geospatial layout of the development patterns. Maps of the high urban development zone in Kisutus, as well as the industrial development zone in Kurasini, the rural settlement zone in Kisarawe, the single family residential zone in Karera Mikoroshoni and the urban development zone in Gerezani.

The full dataset of the digitised building footprints will be shared directly with ImageCat as Geopackage file. Same as the Kathmandu exposure data, this geospatial vector information is hosted in OSM, and can be extracted with the use of the HOT Export Tool. These downloads have already been set up and can be accessed through the following links:

Kathmandu | <https://export.hotosm.org/en/v3/exports/bf3c20c6-dc0e-423a-a9b9-97b53cd7a8da>

Dar es Salaam | <https://export.hotosm.org/en/v3/exports/841859fc-4e3e-4f13-95f9-787ee868786f>

* Please note that these links will become inactive after 3 months from December 1, 2018

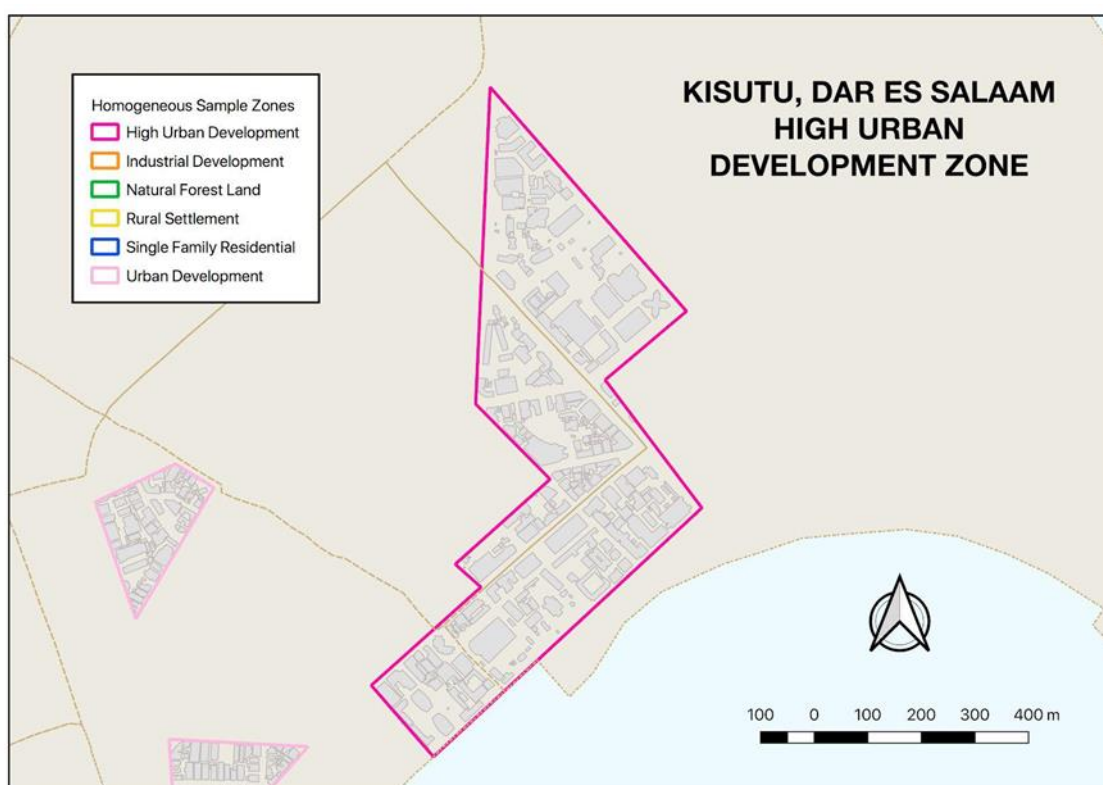


Figure 21: Dar es Salaam High Urban Development Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

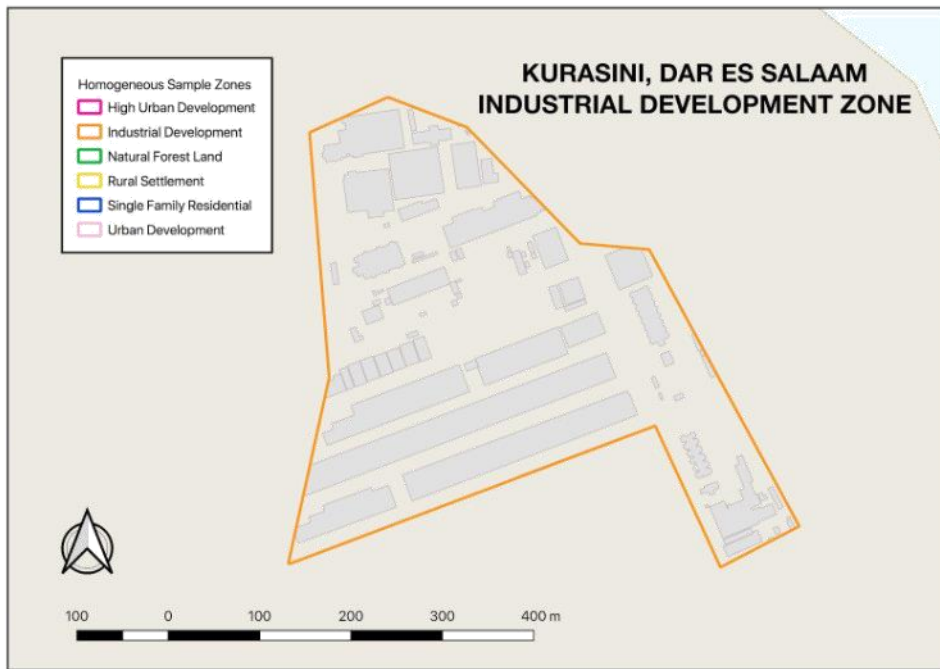


Figure 22: Dar es Salaam Industrial Development Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

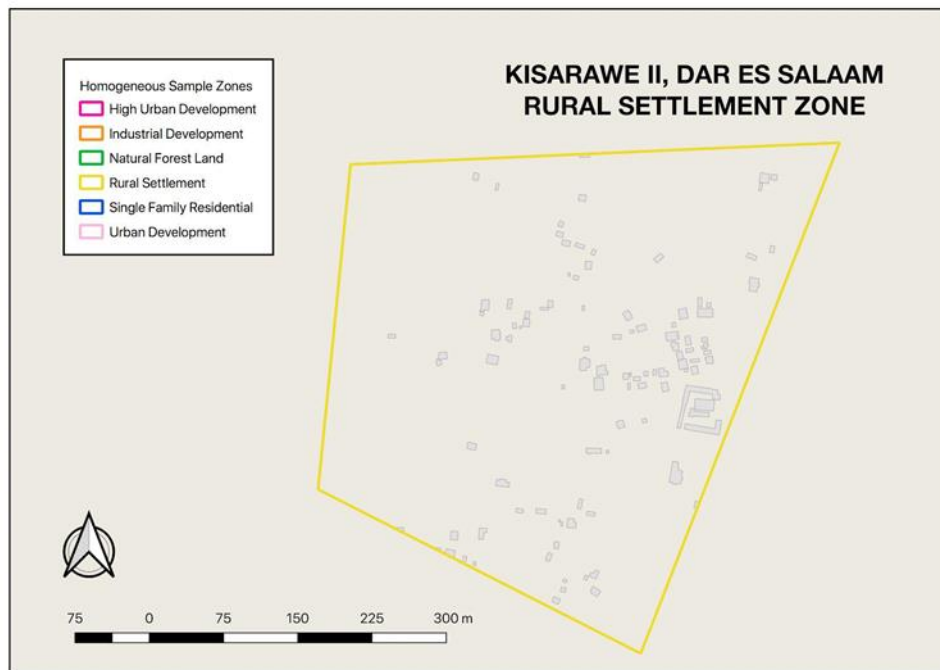


Figure 23: Dar es Salaam Rural Settlement Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

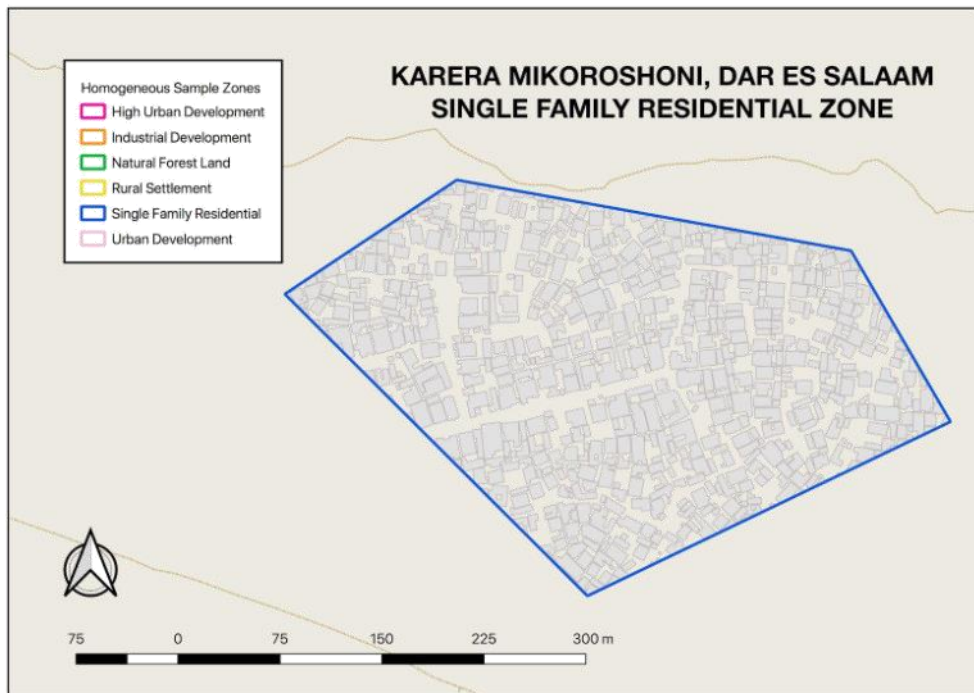


Figure 24: Dar es Salaam Single Family Residential Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

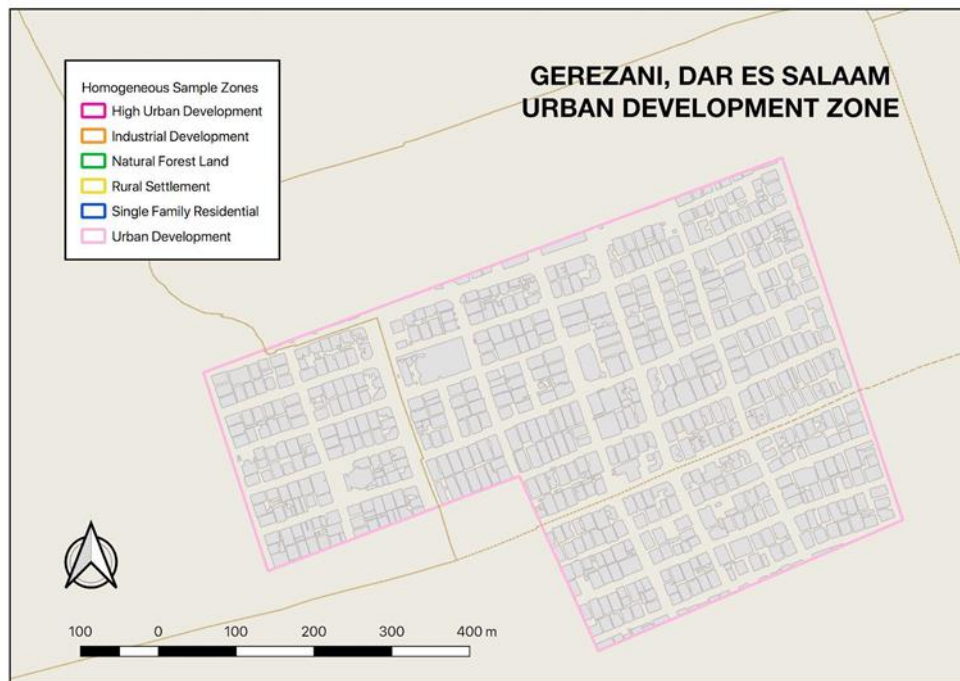


Figure 25: Dar es Salaam Urban Development Zone © ImageCat, inc., zones defined by ImageCat as part of the METEOR project. Data displayed within OSM © OpenStreetMap contributors, licensed under ODbL

7. Conclusion

The successful mapping of building exposure data in OSM with the use of EO data can be attributed to the amazing teams in both Kathmandu and Dar es Salaam. KLL put together a team of students from Pokhara and partnered with Paschimanchal Campus Institute of Engineering, who kindly provided them with the space to run the mapping 'camp'. Check out the blog by the KLL team to read more about their experiences during the remote digitisation portion of the project. Similarly, the team in Dar es Salaam was a mixture of Ramani Huria members and students from the University of Dar es Salaam and Ardhi University to carry out the mapping.

Kathmandu Living Labs

<https://www.hotosm.org/updates/kathmandu-from-above/>



Figure 26: Kathmandu Living Labs Digitisation Team. Images © Kathmandu Living Labs

Ramani Huria

<https://www.hotosm.org/updates/building-disaster-resilient-countries-slash-cities-through-open-spatial-data-and-exposure-analysis/>



Figure 27: Ramani Huria Digitisation Team. Image © Ramani Huria

Appendix

PRE DIGITISATION

Errors (174)
Building duplicated nodes (87)
Duplicated relations (1)
Duplicated ways (19)
Highway duplicated nodes (4)
Landuse duplicated nodes (4)
Multipolygon is not closed (2)
Opening hours syntax (14)
relation without type (11)
Role verification problem (13)
wrong value: area=apartment, use area=yes or area=no instead (1)
wrong value: area=college, use area=yes or area=no instead (3)
wrong value: area=school, use area=yes or area=no instead (15)

Warnings (7,214)
access=designated' is meaningless, use more specific tags, e.g. 'bicycle=designated' (1)
addr:street with multiple values (11)
amenity inside amenity (30)
amenity node connected to a highway (10)
area=yes on a node. Should be drawn as an area. (5)
Area style on outer way (5)
Barrier entrance not set on a barrier (2)
building:levels should have numbers only with optional .5 increments (5)
building node connected to a highway (1)
deprecated tagging (65)
ele must be a numeric value, in meters and without units (1)
Email validator (4)
House number without street (2,497)
Invalid white space in property key (2,717)
isolated node which must be connected to a way (15)
key with uncommon character (4)
landuse=cemetery on a node. Should be drawn as an area. (1)
leisure=park on a node. Should be drawn as an area. (4)
leisure inside leisure (4)
leisure node connected to a highway (1)
missing tag (385)
Misspelled property key - Key 'aminity' looks like 'amenity'. (4)
Misspelled property value (9)
name with multiple values (12)
natural=beach on a node. Should be drawn as an area. (1)
natural=water on a node. Should be drawn as an area. (1)
Node connects a power line or cable with an object which is not related to the power infrastructure. (7)
node connects highway and building (104)
Nodes at same position (36)
Nodes duplicating parent way tags (7)
Non-Way in multipolygon (3)
No outer way for multipolygon (1)
office node connected to a highway (1)
Opening hours syntax (383)

Other duplicated nodes (32)
Overlapping Identical Landuses (2)
Overlapping ways (77)
place=yes is unspecific. Please replace 'yes' by a specific value. (4)
Property values contain multiple white spaces (42)
Property values start or end with white space (45)
Relations with same members (1)
Relation type is unknown (60)
Role verification problem (51)
Route scheme is unspecified. Add public_transport:version (2=public_transport; 1=legacy) (35)
Same value of addr:housenumber and addr:housename (2)
shop inside shop (4)
shop node connected to a highway (11)
suspicious tag combination (9)
Tags with empty values (2)
Tag value contains character with code less than 0x20 (8)
tourism inside tourism - tourism=hotel inside tourism=hotel (9)
Unclosed way (3)
Unconnected nodes without physical tags (149)
unnecessary tag (97)
Unspecific highway type (25)
Untagged ways (commented) (118)
unusual value of direction (4)
unusual value of height: meters is default; point is decimal separator; if units, put space then unit (1)
unusual value of width: meters is default; point is decimal separator; if units, put space then unit (2)
URL validator (11)
Value of 'footway' should either be 'sidewalk' or 'crossing'. For sidewalks use 'sidewalk=left right both no' instead. (1)
waterway=ditch is the tag for the linear waterway. To tag the water area use natural=water + water=* instead. (1)
Waterway ends without a connection to another waterway or the direction of the waterway is wrong. (1)
Way end node near other highway (22)
Ways with same position (38)
Way terminates on Area (8)
Wrong highway tag on a node (2)

POST DIGITISATION

Errors (14)
Role verification problem (14)
Warnings (3,308)
access=designated' is meaningless, use more specific tags, e.g. 'bicycle=designated' (1)
addr:street with multiple values (11)
area=yes on a node. Should be drawn as an area. (5)
Area style on outer way (5)
Area style way is not closed (3)
building:levels should have numbers only with optional .5 increments (5)
ele must be a numeric value, in meters and without units (1)
Email validator (3)
House number without street (2,466)
isolated node which must be connected to a way (17)
key with uncommon character – infrastructure facility (1)
landuse=cemetery on a node. Should be drawn as an area. (1)
leisure=park on a node. Should be drawn as an area. (4)
leisure inside leisure (3)
name with multiple values (11)
natural=beach on a node. Should be drawn as an area. (1)
natural=water on a node. Should be drawn as an area. (1)
Node connects a power line or cable with an object which is not related to the power infrastructure. (3)
node connects highway and building (76)
Nodes at same position (28)
Nodes duplicating parent way tags (7)
Non-Way in multipolygon (4)
No outer way for multipolygon (1)
office node connected to a highway (1)
Opening hours syntax (3)
Overlapping ways (45)
payment:credit_cards=yes is inaccurate, use payment:mastercard=yes or payment:visa=yes or ... instead (3)
place=yes is unspecific. Please replace 'yes' by a specific value. (4)
Relations with same members (1)
Relation type is unknown (60)
Role verification problem (49)
Route scheme is unspecified. Add public_transport:version (2=public_transport; 1=legacy) (35)
Same value of addr:housenumber and addr:housename (1)
Self-crossing ways (2)
shop inside shop (3)
shop node connected to a highway (7)
suspicious tag combination (15)
Tag value contains character with code less than 0x20 (6)
tourism inside tourism - tourism=hotel inside tourism=hotel (9)
Unclosed way (3)
Unconnected nodes without physical tags – Has tag containing 'fixme' or 'FIXME' (3)
Unspecific highway type (18)
unusual value of direction (4)
unusual value of height: meters is default; point is decimal separator; if units, put space then unit (1)

unusual value of width: meters is default; point is decimal separator; if units, put space then unit (2)
URL validator (12)
Value of 'footway' should either be 'sidewalk' or 'crossing'. For sidewalks use 'sidewalk=left right both no' instead. (1)
waterway=ditch is the tag for the linear waterway. To tag the water area use natural=water + water=* instead. (1)
Waterway ends without a connection to another waterway or the direction of the waterway is wrong. (1)
Way end node near other highway (65)
Ways with same position (32)
Way terminates on Area (2)
Wrong highway tag on a node (3)