Cartography M.Sc.

Creation of an automated workflow for the production of a printed map

Enock Seth Nyamador

Supervisors:
Prof. Dipl.-Phys. Dr.-Ing. habil. Dirk Burghardt
Mathias Gröbe M.Sc.

Reviewer: Olesia Ignateva (TUW)

24.10.2022

Introduction

- Map production is an essential part of Cartography
- Automated map production workflows is a machine-driven processes, which results in the completion of tasks that relate to the compilation, construction, or output of a map product (Buckley & Watkins, 2007)

Motivation

- OpenStreetMap; global open data and community
- Volunteered Geographic Information use in map production at National Mapping Agencies (Kunz & Bobrich, 2019; Olteanu-Raimond et al., 2017)
- Free/Libre and Open Software Software for Geospatial (FOSS4G)

Research Objectives

RO1 - Create a general workflow for print map production using Open Data and using Open Source tools.

RO2 - Design and implement a method for handling geometry and attribute changes from OSM into a derived geodatabase.

Research Questions

RQ1 - What is required to create a general workflow for print map production using Open Data and Open Source?

- RQ1.1 How can a general workflow for print map production be achieved using OpenStreetMap as the main data source?
- RQ1.2 - Which categories of tools are suitable for the specific tasks in the workflow?
- RQ1.3 - How can various tools for the specific steps identified in RQ1.2 be compared and evaluated according to functions, performance, flexibility, and platform support?

Research Questions

RQ2 - How can updates with data changes and adjustments be integrated into existing map data?

- RQ2.1 - How can a data model be designed for handling changes?
- RQ2.2 - How can a suitable data model be implemented to handle updates using selected tools from RQ1?
- RQ2.3 - Which conflicts can result from updates and manual edits, and how can they be resolved?

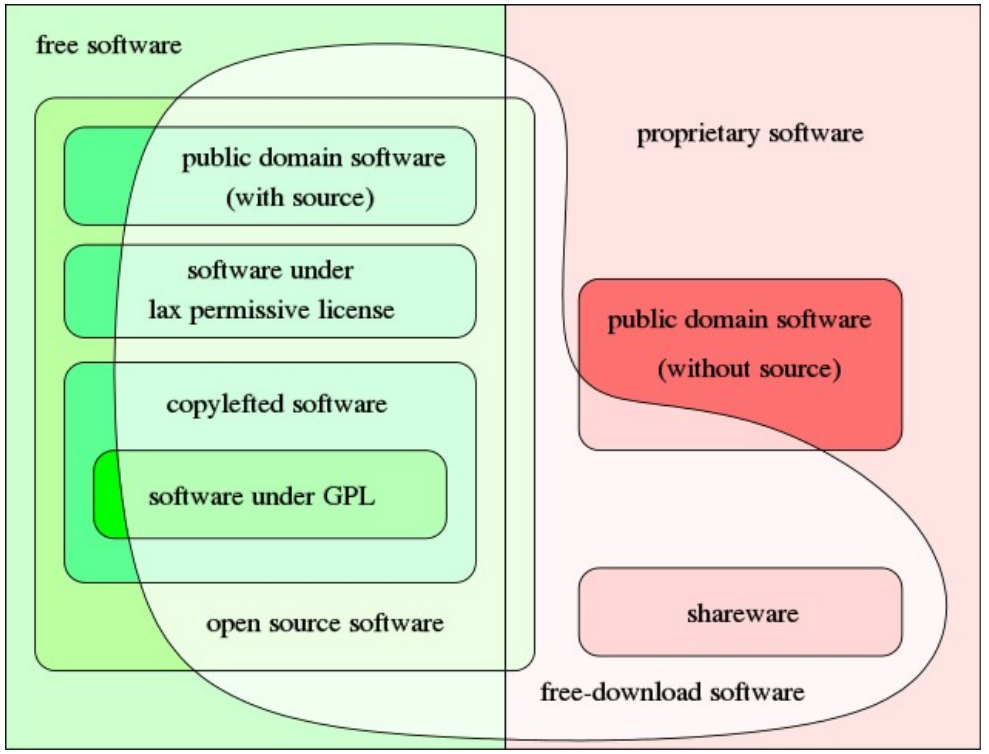
Background: Open Data and Free Software

- **Open Data**: data that is openly accessible, exploitable, editable, and shared by anyone for any purpose. Also **FAIR** principles.

Sources: Government, the crowd, etc

Licences: Public Domain (CC0, PDDL, etc),
Attribution (CC-BY v4.0, OGL v2.0, etc),
Share-Alike(CC-BY-SA v4.0, OdbL, etc)

- **Free software** means software that respects users' freedom and community. The users have the freedom to run, copy, distribute, study, change, and improve the software (Free Software Foundation)



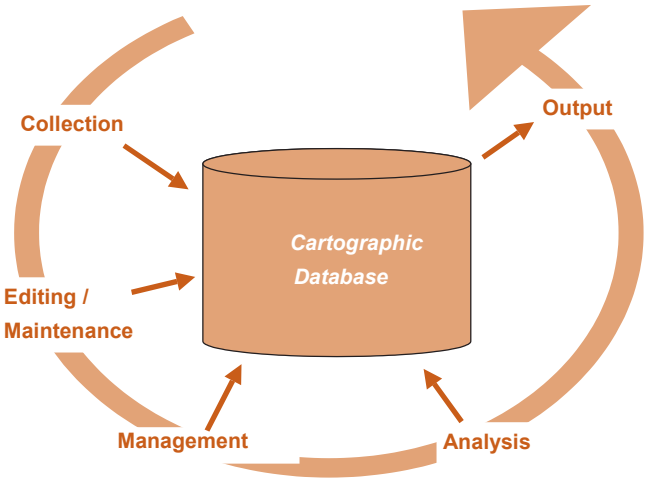
Wikimedia Commons contributors, "File:Categories of free and nonfree software.svg," Wikimedia Commons, the free media repository, https://commons.wikimedia.org/w/index.php?title=File:Categories_of_free_and_nonfree_software.svg&oldid=665746090 (accessed October 23, 2022).

Background: Map Production Process

- Cartographic process: from unmapped to finished map

- Map design process: purpose, reality, available data, map scale, audience, conditions of use, and technical limits (Robinson et. Al (1995))

- Data collection, Editing/Maintenance, Management, Analysis, and Output



Source: Longley et al., 2015

Methods: Requirements Gathering

- Existing literature
- Identification of needs
- The Cartographic process
- Data sources and licenses
- Reusability

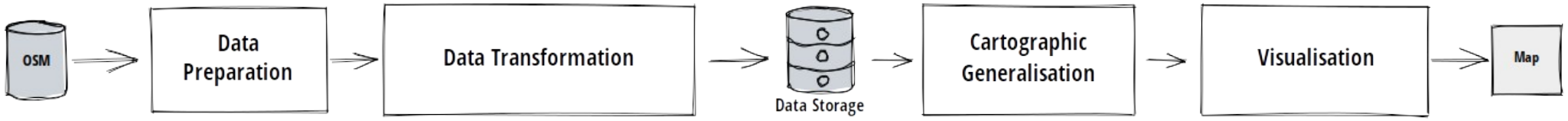
Methods: Requirements for map production

- use open data and free/libre and open source software

- workflow process should to work independently and together

- workflow should result in the output of a general-purpose map at 1:25000

- workflow should account for derived changes modifications

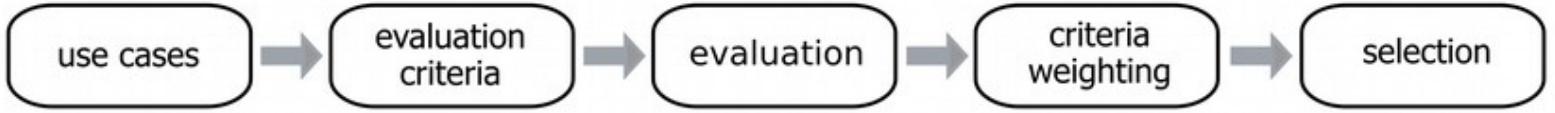


Map production stages identified

Methods: Software Selection

- Multi-Criteria Decision analysis

- Evaluation



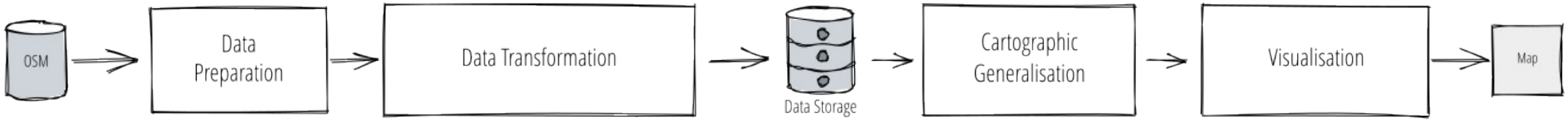
Steiniger, S., & Hunter, A. J. (2013). The 2012 free and open source GIS software map–A guide to facilitate research, development, and adoption. Computers, environment and urban systems, 39, 136-150.

  - Weighted Sum Model (WSM) (Chen et al. (2010))

  - Weighted Product Model (WPM)

  - Analytic Hierarchy Process (AHP) (Eldrandaly (2007), Eldrandaly and Naguib (2013))

- Categorisation



Map production stages identified / Software categorisation

Methods: Requirements for Data Model

- An adjustable data model

- Supports point, line, and polygon features

- Account for derived changes

- Adopt measures of similarity

- Handles semantic data

Methods: Data Conflation

- Map matching, data fusion
- Feature types: Points, Lines and Polygons
- Measure of similarity (Samal et al., 2004)
  - Semantic
  - Topological
  - Geometrical (Goodchild and Hunter (1997))
- Approaches: History, Isolation, On-Demand, etc

Implementation: Study Area

- Initial: Mt. Ushba Region, Georgia
- Processing time for sub-setting
- Ghana is small and known
- OSM data model is global

Africa	Asia	Georgia	Ghana
38m	1h 2m	26s	19s

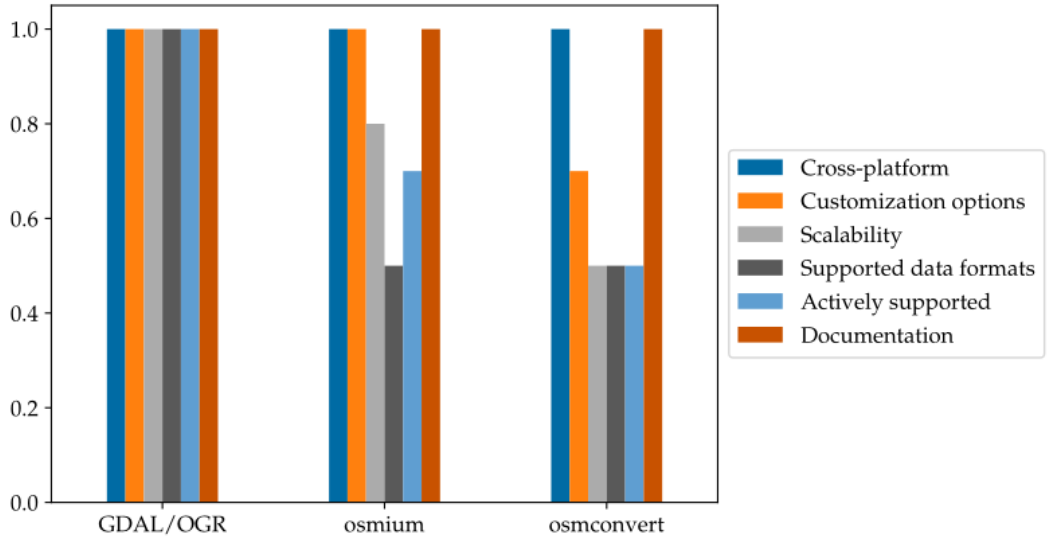
Processing times per region

	Africa	Asia	Georgia	Ghana
Buildings	20G	29G	296M	256M
Landuse	1.8G	2.4G	37M	8.8M
Places	80M	218M	1.4M	1.2M
Traffic	7.2G	16G	152M	121M
Peaks	8.4M	22M	1.4M	1.2M

Storage capacities times per region

Implementation: Software Evaluation

- Shortlisting
- Definition of evaluation criteria
- Performance Scores
- Weighted Product Model (WPM)
- Ranking
- Selection

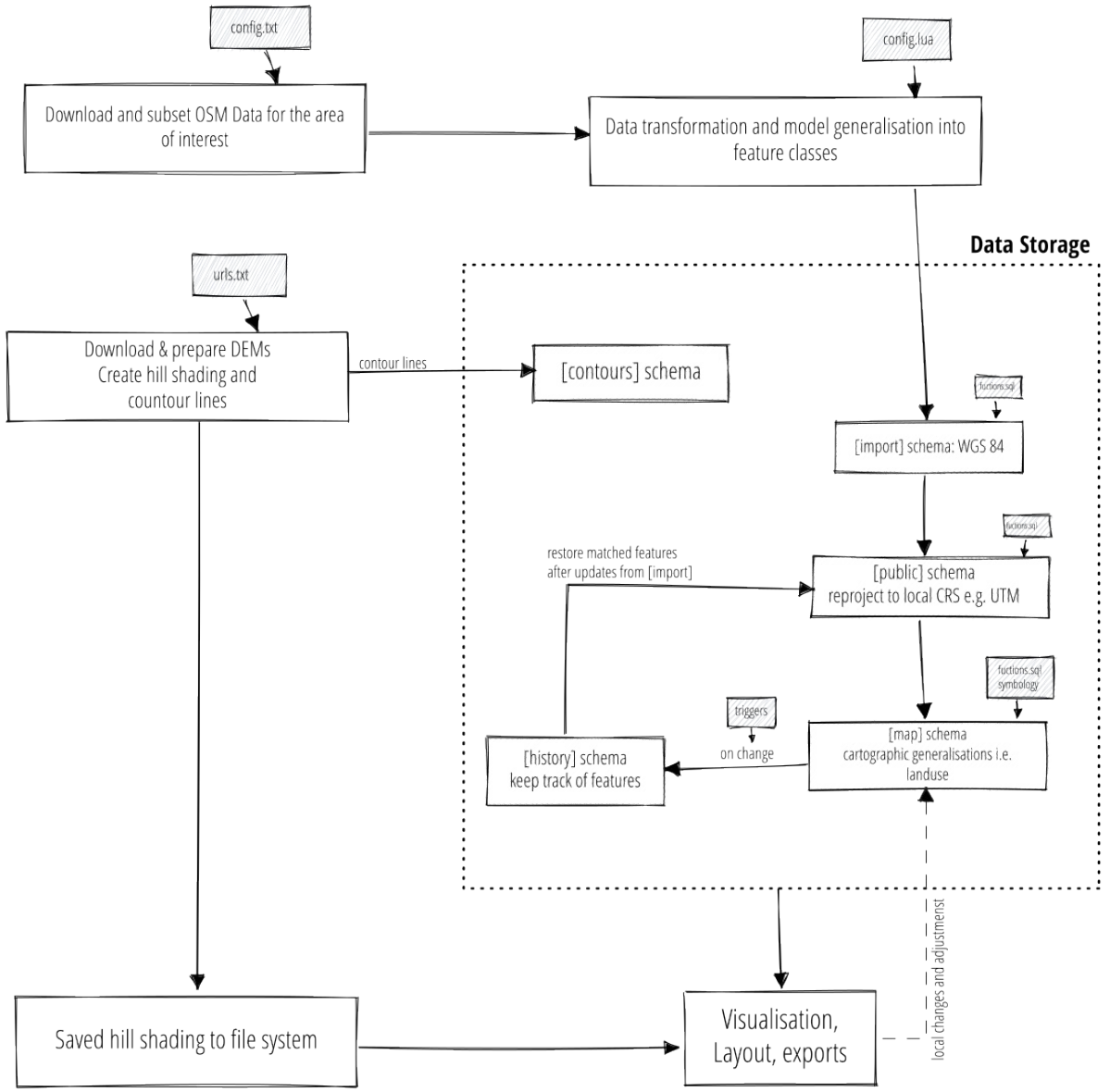


$$P(A_K) = \prod_{j=1}^{n} (a_{Kj})^{w_j}, \text{ for } K = 1, 2, 3, \ldots, m. \quad (1)$$

Alts. / Criteria	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*WPM*	*Rank*
GDAL/OGR	1.0	1.0	1.0	1.0	1.0	1.0	1.000000	1
osmium	1.0	1.0	0.8	0.5	0.7	1.0	0.821510	2
osmconvert	1.0	0.7	0.5	0.5	0.5	1.0	0.680953	3

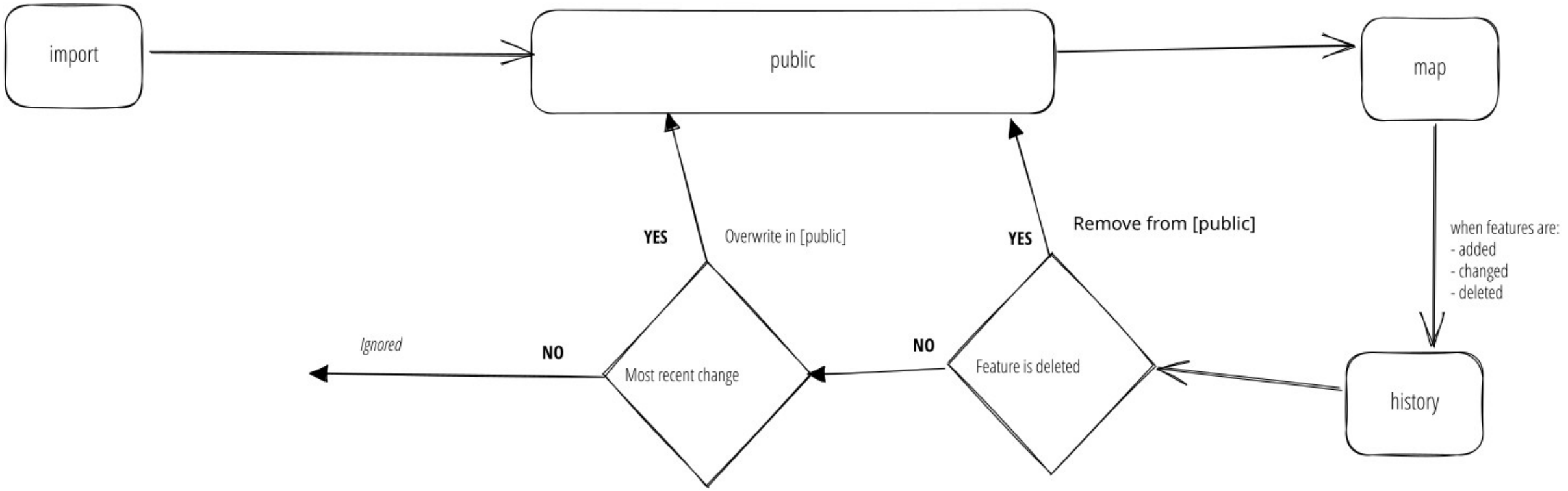
Implementation: Workflow

- Bash scripting
- Text based configurations
- Sequential process
- Independent stages
- Terminal based



Implementation: Adjustable Data Model

- Spatial SQL and Triggers
- History based method
- One measure of similarity (ID)
- Features: Points, Lines and Polygons

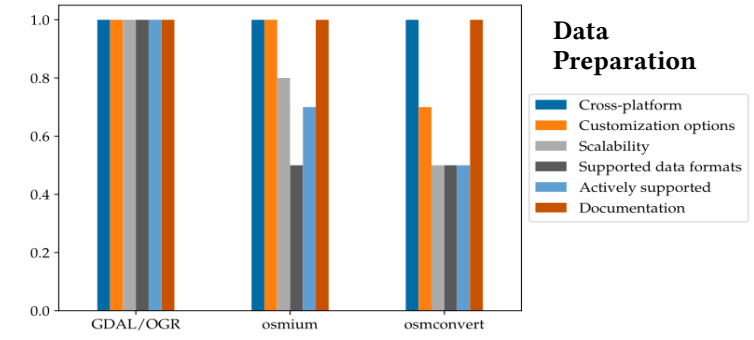


Discussion: Software Selection and Workflow

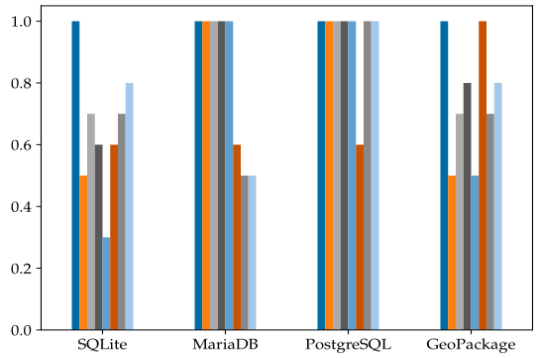
RQ1.1: How can a general workflow for print map production be achieved using OpenStreetMap as the main data source?

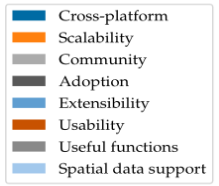
RQ1.2: Which categories of tools are suitable for the specific tasks in the workflow?

RQ1.3: How can various tools for the specific steps identified in RQ1.2 be compared and evaluated according to functions, performance, flexibility, and platform support?

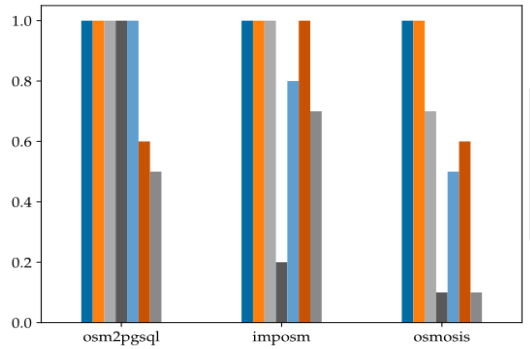


Data Preparation

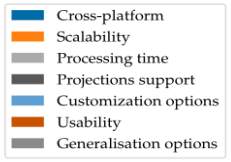


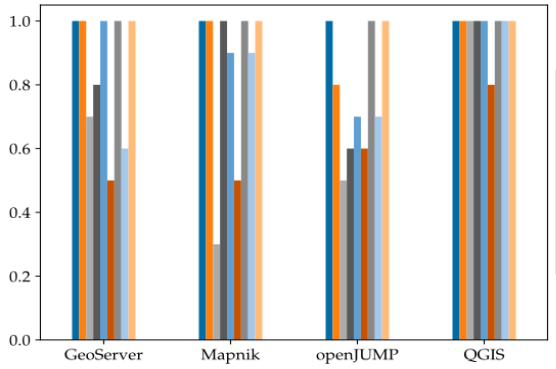


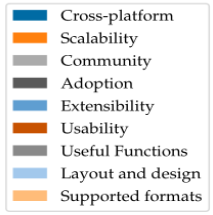
Data Storage / Cartographic Generalisation



Data Transformation







Visualisation

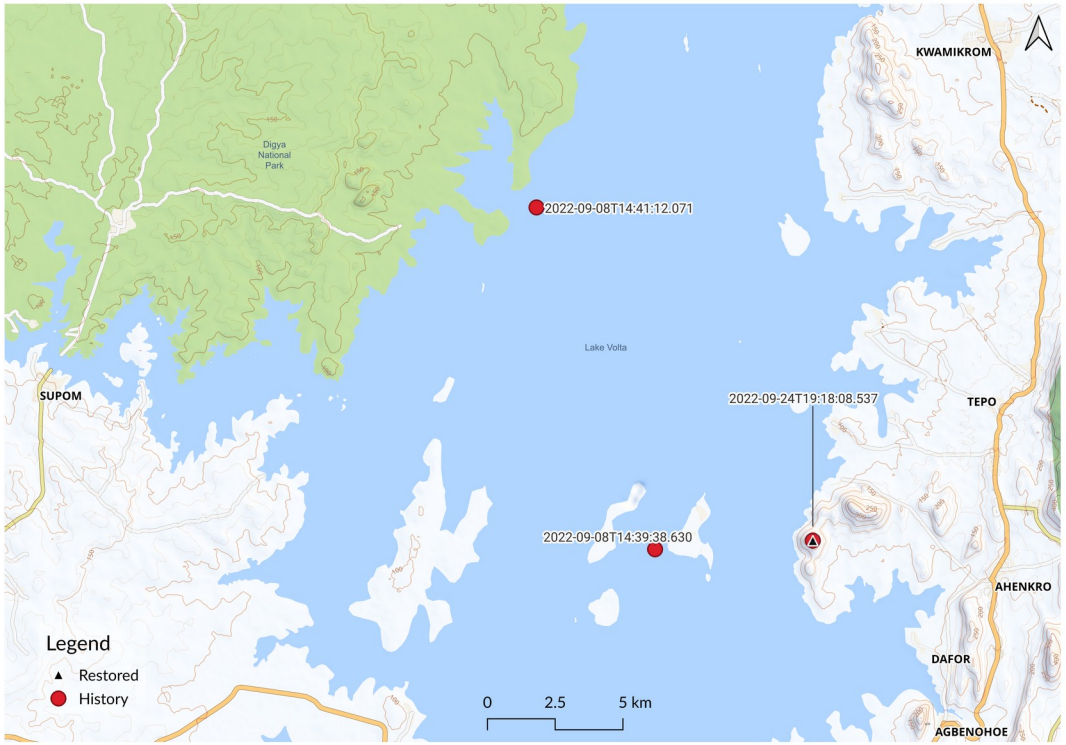
Discussion: Data Model and Handling of Updates

- RQ2.1: How can a data model be designed for handling changes?

- RQ2.2: How can a suitable data model be implemented to handle updates using selected tools from RQ1?

- RQ2.3: Which conflicts can result from updates and manual edits, and how can they be resolved?

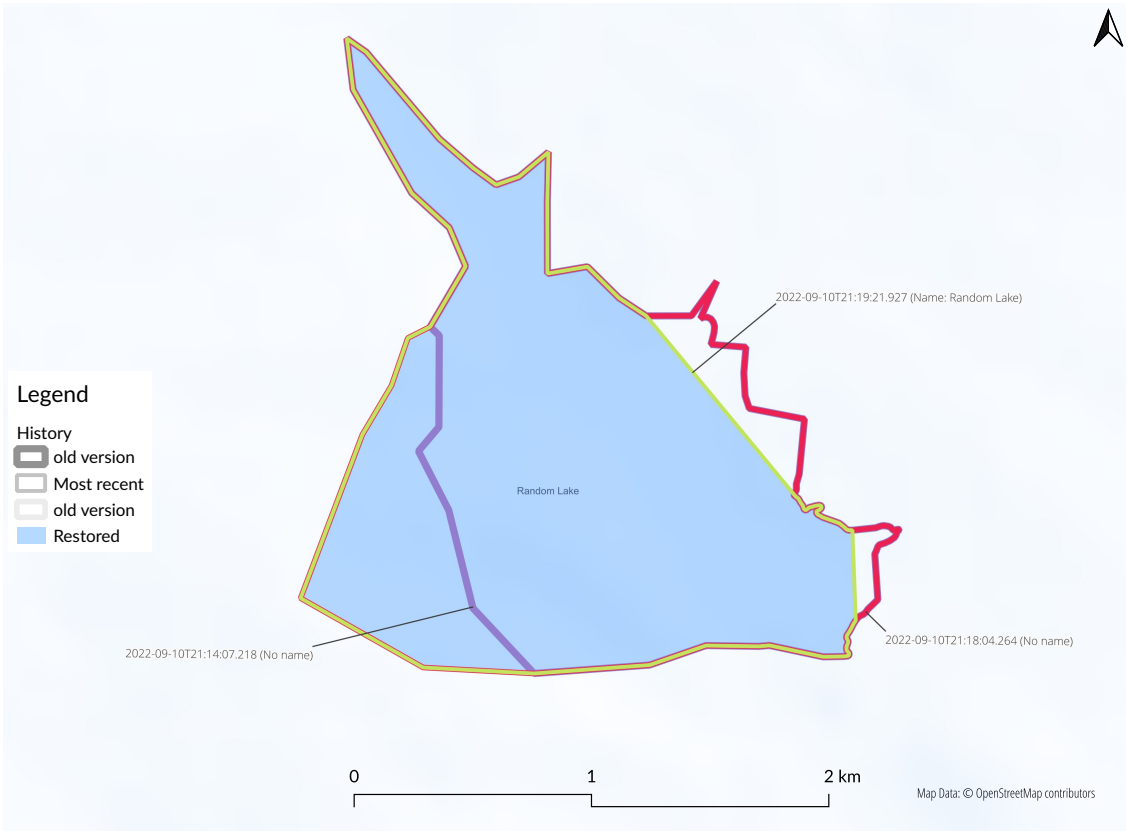
Points



Discussion: Data Model and Handling of Updates

- RQ2.3: Which conflicts can result from updates and manual edits, and how can they be resolved?

Lines



Polygons

Conclusions

- A general workflow for print map production using Open Data and Free Software was created

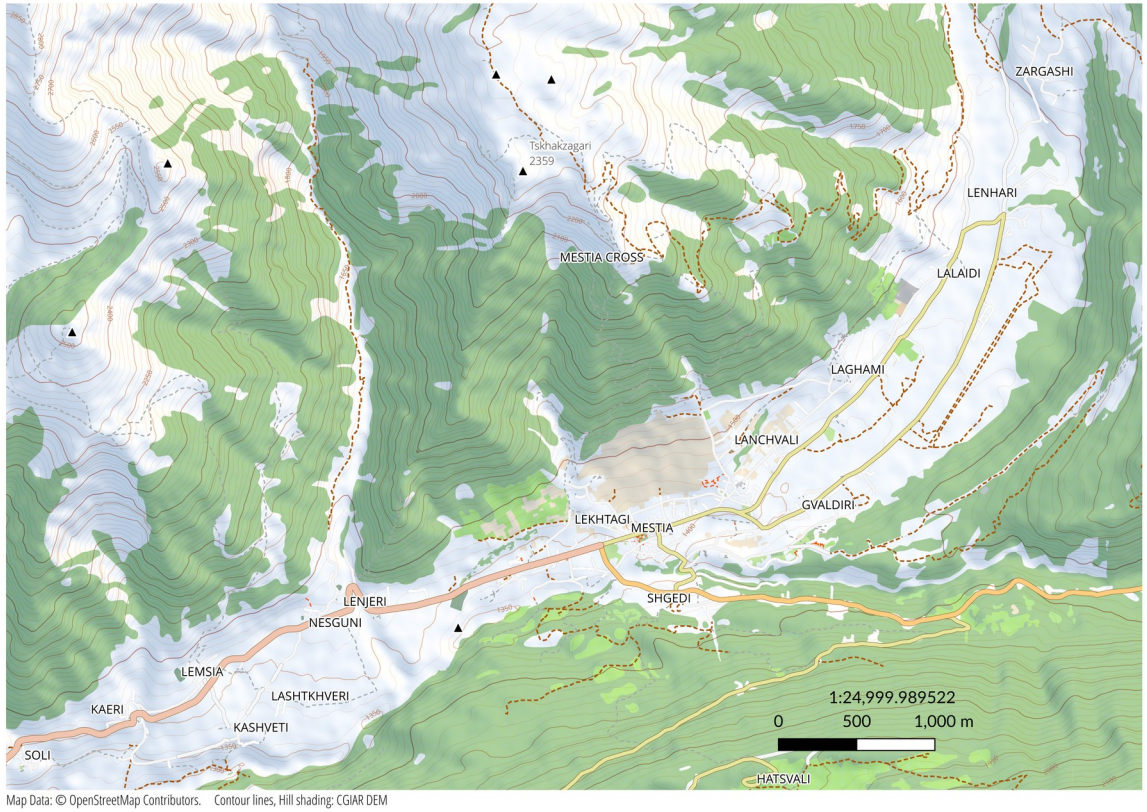
- A set of pair-wise criteria were developed

- Weighted Product Method (WPM) for MCDA was implemented for evaluation

- Data model was implemented for handling derived changes and updates

- FOSS and OSM offers freedom and opportunity, local authorities and institutions should take advantage

- OpenStreetMap data processing is time-consuming, system intense and requires technical skills



Result of workflow in Georgia

Future Work

- Produce a multi-scale output

- Engage users/local stakeholders during software selection

- Use a more advanced MCDA method such as AHP.

- Implement multiple measures of similarity

- Automate the output of maps

References

Buckley, A., & Watkins, D. (2007). Automated Map Production Workflows. 24th International Cartographic Conference.

Chen, D., Shams, S., Carmona-Moreno, C., & Leone, A. (2010). Assessment of open source GIS software for water resources management in developing countries. Journal of Hydro-environment Research, 4(3), 253–264. https://doi.org/10.1016/j.jher.2010.04.017

Eldrandaly, K. (2007). Gis software selection: A multi-criteria decision making approach.

Eldrandaly, K., & Naguib, S. (2013). A knowledge-based system for gis software selection. Int. Arab J. Inf. Technol., 10(2), 152–159.

Free Software Foundation. (2022). What is Free Software? - GNU Project - Free Software Foundation [[Online; accessed 12. Sep. 2022]]. https://www.gnu.org/philosophy/free-sw.html

Goodchild, M. F. [Michael F], & Hunter, G. J. (1997). A simple positional accuracy measure for linear features. International journal of geographical information science, 11(3), 299–306.

Kunz, P., & Bobrich, J. (2019). Multiscale cartographic visualization of harmonized datasets. International Journal of Cartography, 5(2-3), 178–194. https://doi.org/10.1080/23729333.2019.1610931

Olteanu-Raimond, A.-M., Hart, G., Foody, G. M., Touya, G., Kellenberger, T., & Demetriou, D. (2017). The Scale of VGI in Map Production: A Perspective on European National Mapping Agencies. Transactions in GIS, 21(1), 74–90. https://doi.org/10.1111/tgis.12189

Samal, A., Seth, S., & Cueto 1, K. (2004). A feature-based approach to conflation of geospatial sources. International Journal of Geographical Information Science, 18(5), 459–489.

Steiniger, S., & Hunter, A. J. (2013). The 2012 free and open source GIS software map – A guide to facilitate research, development, and adoption. Computers, Environment and Urban Systems, 39, 136–150. https://doi.org/10.1016/j.compenvurbsys.2012.10.003

Robinson, A. H., Morrison, J. L., Muehrcke, P. C., Kimerling, A. J., & Guptill, S. C. (1995). Elements of Cartography. Wiley.


ITC
UNIVERSITY OF TWENTE.
TECHNISCHE
UNIVERSITÄT
DRESDEN
Technical
University
of Munich
TU
WIEN
TECHNISCHE
UNIVERSITÄT
WIEN
Vienna University of Technology

Thank you