



Source: GRID3

Geo-Enabled Microplanning Handbook

A product of the WHO-UNICEF COVAX GIS Working Group



Table of Contents

GIS TECHNICAL STAFF PATH
PROGRAMME DESIGNER PATH

Table of Contents

This handbook is designed to meet the needs of two target audiences: public health programme designers, and GIS technical staff. The columns below indicate which sections may be most relevant to a given target audience. Readers can use this hyperlinked PDF to jump to the sections most relevant to their role, and their country's stage of geo-enablement. The distinction between the two audiences begins in Section 5. Icons representing "programme designer" and "GIS technical staff" can be found at the top of the section to indicate if the section falls into that audience's bifurcation.

1 Acknowledgements	5		
1.1 Co-authors and contributors	6	●	●
1.2 Reviewers	7	●	●
1.3 Funding organizations	8	●	●
1.4 Coordinating organizations	8	●	●
1.5 Participating organizations	8	●	●
2 Executive summary	9		
3 About this handbook	12		
3.1 Objectives and target audience	13	●	●
3.2 Background resources	13	●	●
3.3 Document methods and updates	14	●	●
3.4 How to use this handbook	14	●	●
4 Abbreviations	16		
5 Introduction to the geo-enablement of a microplan	18		
5.1 Objectives and key characteristics	20	●	●
5.2 Benefits of geo-enabled microplanning and applications of geospatial data and technologies	20	●	●
5.2.1 Benefits of geo-enabled microplanning	22	●	●
5.2.2 Overview of four applications of geospatial data and technologies	28	●	●
5.2.2.1 Georeferenced master lists overview	28	●	●
5.2.2.2 Population estimates and spatial distribution overview	29	●	●
5.2.2.3 Introduction to geographic accessibility, service location and route optimization models	30	●	●
5.2.2.4 Thematic maps overview	32	●	●
5.3 Summary of use case examples of geo-enabled microplans	34	●	●
5.4 Process	37	●	●
6 Geo-enablement of a digital microplan	39		
6.1 Identifying microplanning challenges to address through geo-enablement	40	●	●
6.2 Understanding a microplan's geographic dimension	40	●	●
6.3 Defining products of applications	45	●	●
6.3.1 Georeferenced master lists	46	●	●
6.3.2 Population estimates and spatial distribution	49	●	●
6.3.3 Geographic accessibility, service location and route optimization models	53	●	●
6.3.4 Thematic maps	55	●	●
6.4 Hardware and software to geo-enable a microplan	57	●	●
6.5 Technical expertise and skills requirements	58	●	●
6.6 Assessing the geo-enablement level of a microplanning process	60	●	●



Table of Contents

	GIS TECHNICAL STAFF PATH	
	PROGRAMME DESIGNER PATH	
6.6.1 Assessing level of geo-enablement across the supporting environment	60	
6.6.2 Assessing availability, quality and accessibility of data and information	61	
6.6.2.1 Assessing master lists	66	
6.6.2.2 Assessing statistical data	66	
6.6.2.3 Assessing geospatial data	69	
6.6.2.4 General data considerations	74	
6.6.2.5 Documenting the data and information assessment	78	
6.7 Developing the workplan	81	
6.7.1 Governance	82	
6.7.2 Implementation: pilots and scaling	83	
6.7.3 Technical skills: needs and capacity building	84	
6.7.4 Hardware and software	86	
6.7.5 Activities, responsibilities and timeline	86	
6.7.6 Budget	88	
6.7.7 Monitoring, evaluation and learning	90	
6.7.7.1 Key steps in MEL framework design	91	
6.7.7.2 Data needs in MEL	95	
6.7.7.3 MEL activities and deliverables	96	
6.7.7.4 Revisiting the MEL framework	97	
6.7.8 Data and products sharing policy	98	
6.8 Implementing the work plan - full scale or pilot	100	
6.8.1 Address input data availability and quality issues	101	
6.8.2 Operationalizing the four applications and generating products	102	
6.8.2.1 Georeferenced master lists	103	
6.8.2.2 Population estimates and spatial distribution	104	
6.8.2.3 Geographic accessibility, service location and route optimization models	107	
6.8.2.4 Thematic maps	110	
6.8.3 Integrating products in the microplanning process	112	
6.8.4 Documenting processes, lessons learned and impact	115	
6.8.5 Sharing products beyond the microplan	116	
6.9 Scaling and sustaining geo-enabled microplans	117	
6.9.1 Storing, maintaining and updating data and products	117	
6.9.1.1 Georeferenced master lists	119	
6.9.1.2 Population estimates and spatial distribution	120	
6.9.1.3 Geographic accessibility, service location and route optimization models	121	
6.9.1.4 Thematic maps	121	
6.9.2 Scaling up the geo-enablement of the microplanning process	123	
6.9.3 Institutionalizing what has been established	123	
6.9.3.1 Long-term investments in technology	124	
6.9.3.2 Evaluating and improving processes	125	
6.9.3.3 Long-term investments in staff and capacity building	127	
7 Future iterations	128	
8 References	130	



Table of Contents

		GIS TECHNICAL STAFF PATH	PROGRAMME DESIGNER PATH
Annexes	134		
Table of contents	134	●	●
Annex A: Glossary of terms	135	●	●
Annex B: Use case examples of geo-enabled microplans	138	●	●
B1: COVAX use case example	138	●	●
B2: Malaria stratification use case example	142	●	●
B3: Routine immunization/expanded programme on immunization use case example Reference document [26]	146	●	●
B4: Polio supplemental immunization activities use case example	151	●	●
B5: Emergency outbreaks: measles vaccination use case example	154	●	●
B6: Co-deployment of Malaria interventions (IRS and ITN) in Zambia	157	●	●
Annex C: Terms of reference	162	●	●
C1: Generic terms of reference for technical expert overseeing geo-enablement	162	●	●
C2: Example terms of reference for technical working group on the management and use of geospatial data and technologies in the health sector	164	●	●
Annex D: Template budget spreadsheet	165	●	●
Annex E: Questions for assessing geospatial data	166	●	●
Annex F: Elements of a geospatial information licence agreement	167	●	●
Annex G: Uses of thematic maps in microplanning	170	●	●
Annex H: Hardware and software technical specifications	172	●	●
Annex I: Data dictionary guidance	179	●	●



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USAID PMI VectorLink Zambia
World Health Organization - Country Office for Nigeria
World Health Organization - Division for Data, Analytics and Delivery for Impact, GIS Centre
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Executive summary

SECTION 2.0

Executive summary

Certain public health interventions need to be implemented at the lowest level of geographic disaggregation in order to reach target populations in a comprehensive, effective and equitable way and, in many cases, in the shortest amount of time possible.

Microplanning is the process through which a detailed, delivery-level operational plan is created for identifying and reaching a target population with specific health interventions, as well as for managing resources and monitoring outcomes. While macroplans are developed at the national level to define overall strategies and approaches for service delivery to targeted populations, microplans are detailed down to the health facility and community levels.

Figure A - On the left is a hand drawn map of Gangara Ward, Jibia Local Government Area, Katsina State, Nigeria for a polio vaccination campaign. On the right is a GIS-based map of the same area developed to support microplanning for COVID-19 vaccination campaigns. (Source: GRID3)



While vaccination campaigns are most commonly equated with microplanning, a multitude of interventions can benefit from microplanning:

- disease prevention (e.g. distribution of insecticide-treated nets, malaria chemoprevention, indoor residual spraying, etc.)
- supplementary immunization activities
- mass drug administration
- nutrition supplementation campaigns
- vaccine distribution
- TB screening or active case detection
- emergency preparedness and disaster response.

An actionable geo-enabled microplan is based on geospatial data from different sources, including population estimates and distribution, health facility locations, boundaries, settlements, travel time, as well as other data points of interest. These data can also be used to inform microplanning teams on health facility catchment areas and travel time.

Despite its benefits, the use of geospatial data and technologies in microplanning, also referred to as “a geo-enabled microplanning process”, is not always simple and straightforward, nor easily adopted in all contexts. For instance, despite past success using geo-enabled microplanning to eradicate polio in several countries, other similar efforts have not been able to adopt a geo-enabled approach. The appropriate supporting environment,

data and information, technology, capacity and financial resources must be available across different levels involved in the microplanning process. It is critical that geo-enabled microplanning not only adds value compared to traditional approaches, but that these processes are also sustainable in the long term, especially in low-resource settings.

The members of the WHO-UNICEF COVAX GIS Working Group, with support from the Bill & Melinda Gates Foundation, have created this handbook as a practical guide to help users develop and implement geo-enabled microplans, and use the resulting data and information products to make decisions that optimize resources for public health interventions¹.



1. covid19giswg.net

3

About this handbook

SECTION 3.0

About this handbook

SECTION 3.1

Objectives and target audience

This handbook focuses on a specific set of applications of geospatial data and technologies in support of microplanning, and thus complements other existing guidelines on the microplanning process.

More specifically, this document has the following objectives:

1. Clarify the concepts behind the geo-enablement of microplans.
2. Describe the objectives, characteristics and key components of a sustainable geo-enabled microplan.
3. Detail the process through which a geo-enabled microplan can be developed, implemented, monitored, evaluated and sustained.
4. Provide use case examples that demonstrate the benefits of geo-enabled microplanning, and illustrate how different countries have applied the process across different health objectives.

Ultimately, this handbook aims to provide health officials with guidance on how to integrate geospatial data and technologies – in particular, geographic information systems (GIS) – into the microplanning process. The handbook also provides evidence on the benefits of geo-enabled microplanning.

The handbook is designed to support readers who are either implementing a geo-enabled microplanning process, or deciding whether to start such a process. The target audiences for this handbook include:

Public health programme managers/designers

- country relevant programme staff (e.g. polio, malaria, TB, HIV, EPI, nutrition etc.)
- health officials at national and subnational level.

Technical experts

- GIS technical staff
- other technical staff supporting microplanning efforts.

SECTION 3.2

Background resources

Microplanning is recognized as an important instrument to support the effective planning and implementation of various public health interventions. While immunization might be the most well-known intervention to use microplanning, especially since the launch of the Reaching Every District/Reaching Every Child (RED/REC) strategies², this is not the only type of intervention for which guidelines and best practices around microplanning have been developed. Increasingly, public health officials are turning to geo-enabled microplanning to improve the effectiveness of various interventions, including: mass drug administration [2], insecticide-treated net distribution campaigns [3], and COVID-19 vaccination [4] (see use case examples in Annex B).

2. The RED strategy encourages districts and health facilities to make microplans to identify local problems and find corrective solutions using their own data. The operational components are built around re-establishing outreach services, supportive supervision, linking services with communities, monitoring and using data for action, and planning and management of resources [1].

This handbook builds on previously published guidelines, as well as on a series of recently released documents about the use of geospatial data and technologies in public health in general [1–15] and immunization programmes specifically [16–19]. In particular, this handbook builds upon the guidance and learnings of the following documents:

- World Health Organization. Microplanning for immunization service delivery using the Reaching Every District (RED) strategy. 2009. Available from <http://apps.who.int/iris/> [1]
- World Health Organization. Guidance on operational microplanning for COVID-19 vaccination. 2021. Available from <https://who.int/publications/> [4]
- Gavi, UNICEF, HealthEnabled. Improving Immunisation Coverage and Equity through the Effective Use of Geospatial Technologies and Data: A Landscape Analysis & Theory of Change. 2020. Available from <https://gavi.org/> [16]
- Gavi, UNICEF, HealthEnabled. Leveraging geospatial technologies and data to strengthen immunisation programmes: Rapid guidance for investment planning. 2021. Available from <https://archive-ouverte.unige.ch/> [17]
- Gavi, UNICEF, ADB, Health GeoLab Collaborative. Guidance on the use of geospatial data and technologies in immunization programmes, overview and managerial consideration for in-country strengthening. 2018. Available from <https://unicef.org/> [18]



SECTION 3.3

Document methods and updates

This handbook aims to provide countries with the technical guidance needed for them to fully benefit from using geospatial data and technologies to develop and implement a geo-enabled microplan. The content has been developed based on a review of publicly available resources, and complemented by a consultation involving the stakeholders mentioned in the acknowledgements section.

It is intended to exist as a living document, with ongoing updates and improvements from contributors across the community of practitioners. The editorial team welcomes readers' input on ways to improve and enhance future editions at gissupport@who.int.



SECTION 3.4

How to use this handbook

It is important to note that the handbook does not cover every possible application or use case of geo-enabled microplans, only those most prominent in the public health field. However, the framework provided in Section 6 is meant to be adaptable to different diseases, geographies and capacity levels. Users are encouraged to adapt the provided guidance in light of their own context and needs.

The handbook is organized to help readers easily find relevant information based on their current context and geo-enabled microplanning goals. Depending on their level of familiarity with geo-enabled microplanning, they may wish to take the following recommendations:

- Readers who wish to gain a comprehensive understanding of geo-enabled microplanning may read the handbook cover-to-cover.
- Readers in need of information on a specific topic or use case can use the handbook as a modular “cookbook”, jumping to the section of interest. Any important dependencies between sections are clearly noted in the text.

- Readers who are new to geo-enabled microplanning and its benefits for microplanning should look to Sections 5.1 through 5.3.
- Readers who are familiar with the benefits of geo-enabled microplanning but are looking for insight on the geo-enablement process should look to Section 5.4.
- Readers who are currently working on a geo-enabled microplanning process and are looking for guidance on how to operationalize or improve it should look to Section 6.

Finally, given the wide range of audience profiles mentioned in Section 3.1, we anticipate differing levels of familiarity with technical concepts underpinning geospatial work and with the design and implementation of public health campaigns. To make the handbook useful to all parties without over-expanding its scope, the handbook references outside materials that explain key concepts and methods in detail. Readers are encouraged to consult these materials to learn more about microplanning fundamentals, data management best practices, geospatial analysis methods and other topics not covered exhaustively in this handbook.



4

Abbreviations



Abbreviations

AEFI	Adverse Events Following Immunization
AOI	Area of Interest
COVAX	COVID-19 Vaccines Global Access
EPI	Expanded Programme on Immunization
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GRID3	Geo-Referenced Infrastructure and Demographic Data for Development
HIS	Health Information System
ICT	Information and Communication Technology
IGIF	Integrated Geospatial Information Framework
MEL	Monitoring, Evaluation and Learning
MOH	Ministry of Health
NGO	Non-Governmental Organization
NPHCDA	National Primary Health Care Development Agency
NSDI	National Spatial Data Infrastructure
RED/C	Reaching Every District/Community
SOP	Standard Operating Procedure
WHO	World Health Organization
UNICEF	United Nations Children's Fund





Geo-enablement of a microplan

SECTION 5.0

Introduction to the geo-enablement of a microplan

The term “microplanning” is used to describe health services delivery planning at the local or point-of-service level. These points of service include house-to-house delivery, health facilities, or temporary outreach points for service delivery (e.g. schools, markets, homes of local leaders, etc.). Possible services to deliver include:

- ⦿ disease prevention (e.g. distribution of insecticide-treated nets, malaria chemoprevention, indoor residual spraying, etc.)
- ⦿ supplementary immunization activities
- ⦿ mass drug administration
- ⦿ nutrition supplementation campaigns
- ⦿ vaccine distribution
- ⦿ TB screening or active case detection
- ⦿ emergency preparedness and disaster response.

The microplan’s components will vary depending on the activity involved. However, developing an effective microplan will always require knowledge of the locations, numbers and characteristics of target populations and resources (e.g. health facilities, vaccination points, warehouses, supplies, etc.). Microplan development may also require estimated distance and accessibility to populations. During microplanning, this information is used to identify potential coverage gaps caused by areas with poor access or low utilization of services. These gaps can often be addressed through establishing additional service delivery points or reallocating resources. Microplans that are based on incomplete or outdated information can result in inefficient resource allocation and the inability to reach target populations most in need. These gaps can result in inequitable health outcomes, and poor accountability and transparency of service delivery.

In the health sector, the launch of the Reaching Every District (RED) strategy by WHO and UNICEF in 2002, and the subsequent first guide on microplanning for immunization service delivery in 2009 [1] has contributed to the growing use of maps to support microplanning.

Historically, information gaps, positional errors and temporal inaccuracies may have generated persisting distrust in using geospatial data for microplanning efforts. However, the maps used in microplanning had predominantly been drawn by hand and were based on local knowledge that was not reproducible. This made it difficult for these maps to have the key characteristics critical to developing an effective microplan, listed below (expanded from [16]):

- ⦿ **Correct scale:** Inaccurate map scales make it difficult to properly estimate distances and therefore the level of effort needed to deliver services, or to identify barriers to access.
- ⦿ **Completeness:** Incomplete maps miss features such as new settlements or mobile populations, leading to chronically underserved areas and zero-dose children.
- ⦿ **Accuracy:** If the locations of settlements are not spatially accurate, this leads to inefficiencies when assigning teams or planning routine immunization outreach work.
- ⦿ **Inclusive of key information:** Maps may not display critical data used in decision-making, such as immunization coverage rates or population figures.
- ⦿ **Aggregated:** Traditional maps cannot be easily combined to obtain a district or higher-level picture.
- ⦿ **Updatable:** New information cannot be added to traditional maps without redrawing them.
- ⦿ **Archivable:** Paper maps risk degradation in long-term storage.

- ◉ Shareable: Traditional maps cannot be easily replicated and shared, leading to duplication of efforts or contradictory information.
- ◉ Dynamic: Traditional maps cannot be compared and analysed across time and interventions.
- ◉ Clearly defined borders: Disjointed borders or catchment areas in traditional maps can lead to overlaps and gaps in coverage.
- ◉ Accurate population estimates: Target populations at the local level can be inflated due to financial incentives, leading to inefficient allocation of resources.
- ◉ Locally verifiable: Most data are collected on paper and cannot be verified after the fact, leading to a lack of local accountability for the accuracy of traditional maps.

The use of geospatial data and technologies across the microplanning process offers an opportunity to address the above challenges. Geo-enablement also allows microplanning teams to improve population distribution estimates, measure physical accessibility to health services (distance, travel time) or find optimal supply chain routes. This is possible through combining different data sources and using advanced spatial analysis and modelling methods. Geo-enabling the microplanning process also provides a framework for strengthening the health system by improving systems for data, logistics and monitoring and evaluation. All of this contributes to more equitable, accountable and transparent campaigns and routine services, while also improving health outcomes, as demonstrated in several countries [17, 20–26].

The subsections below detail the objectives, key characteristics, applications and benefits of a geo-enabled microplan. This is followed by the process countries can take to geo-enable microplanning for their own health interventions in Section 6.

SECTION 5.1

Objectives and key characteristics

Programme Designer	GIS Technical Staff
	

The primary objective of geo-enabling a microplan is to establish the spatial location of relevant geographic objects and associated data in order to operationalize specific applications of geospatial data and technologies, which will ultimately be used to improve the effectiveness of the planned intervention. Geo-enablement allows health programmes to overcome challenges in the current microplanning process by combining the science of geography, the content of geospatial data and the tools of geospatial technologies.

Consider the following nine elements that support the success of a geo-enabled microplan [5,18]:

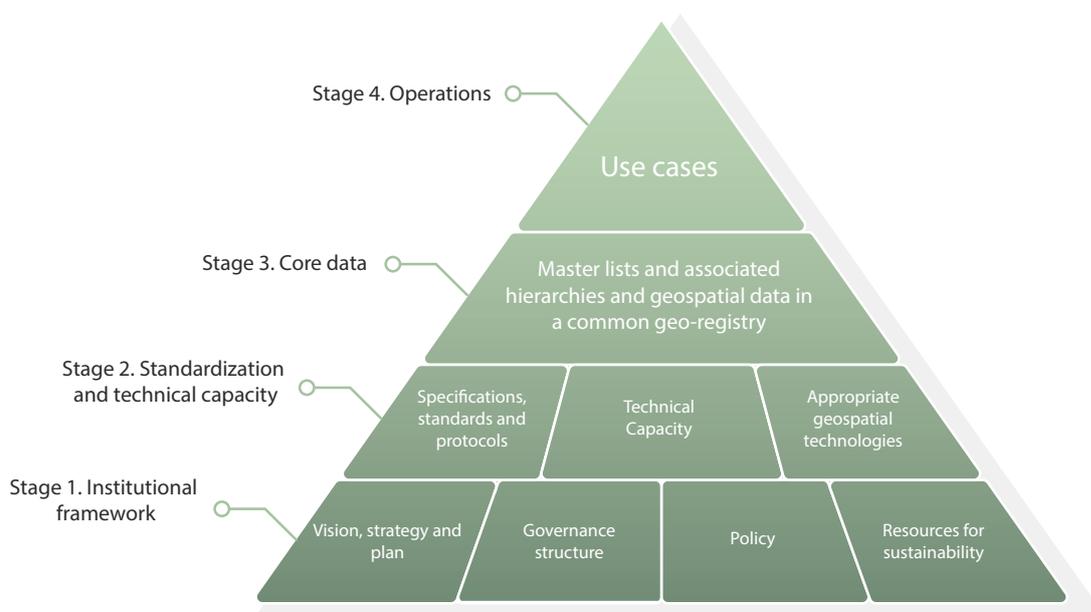
1. A clear vision, strategy(ies) and action plan for the management and use of geospatial data and technologies have been defined.
2. A governance structure supporting the vision, strategy(ies) and action plan has been established.
3. Sufficient technical capacity has been developed.
4. Geospatial data specifications, standards and protocols have been defined and are being implemented to ensure the availability and quality (completeness, uniqueness, timeliness, validity, accuracy and consistency) of geographic information across the whole data lifecycle.
5. The master lists for core geographic objects (e.g. health facilities, administrative divisions, villages) and their associated hierarchies and geospatial data have been developed, made accessible, and an updating mechanism has been put in place for each of them using a geo-registry.

6. The appropriate geospatial technologies have been identified and are being used in accordance with good geospatial data management practices.
7. Use cases operationalizing the use of geospatial data and technologies to support health programmes (e.g. communicable diseases surveillance, malaria elimination, health service coverage, disaster management) towards reaching SDG 3 are being implemented and documented.
8. Policies supporting and enforcing all the above as well as geospatial data accessibility have been released.
9. The necessary resources to ensure long-term sustainability have been identified and secured.

These elements are organized according to four stages/levels (Figure B), building upon each other towards the operational management and use of geospatial data and technologies to support implementation of health interventions.

It is important to note that a geo-enabled health information system can be critical in supporting the operational use of geography and geospatial data and technologies in microplanning for health interventions.

Figure B - Hierarchical organization of the geo-enabling framework used to geo-enable a microplan. (adjusted from [5, 18]).



Please refer to guidance on the use of geospatial data and technologies in immunization programmes and the HIS geo-enabling toolkit [5,18] for more details on how this framework can be adapted for programmes developing and implementing microplans. These documents also cover how the framework should be aligned with expected activities at the ministry of health as well as at the cross-sectoral level.

In addition to the above, it is important for the geo-enablement of a microplan to be guided by the following principles:

- Strategic enablement: Promote a geospatial data and programme governance model that aligns with the programme's strategic direction and priorities, as well as builds upon and reinforces its capacities and responsibilities at national and subnational levels.
- Actionability: Focus on actionable data and products needed to support planning and decision-making.
- Quality: Promote the use of standardized methods, processes and data to ensure that quality outputs and plans are generated.

- Effective coordination, collaboration and cooperation: Promote coordination, collaboration and cooperation among all partners with a stake in the creation, maintenance and sharing of the geo-enabled microplan.
- Strong ethics: Promote transparency, responsibility and accountability while protecting data privacy and security [27].
- Openness: Promote broad access to, and use of the data and products generated.
- Sustainability: Promote a cost-effective and sustainable approach and use resources efficiently.

SECTION 5.2

Benefits of geo-enabled microplanning and applications of geospatial data and technologies

5.2.1 Benefits of geo-enabled microplanning

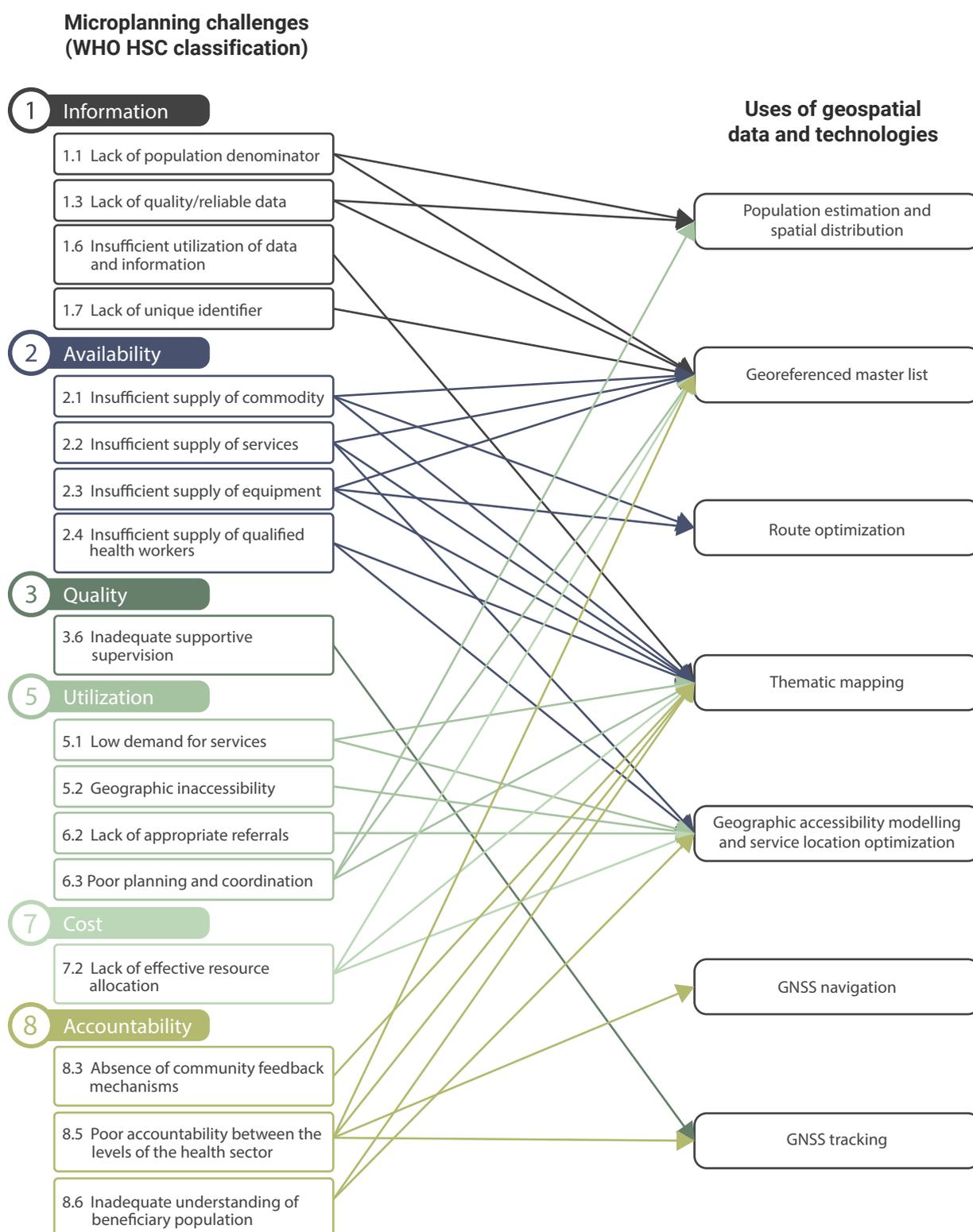
Programme Designer	GIS Technical Staff
	

The use of geospatial data and technologies can help address a variety of challenges faced during the development, implementation or monitoring of a microplan.

Several of the common health system challenges classified by WHO [28] are considered relevant to the geo-enabled microplanning process. Figure C lists these relevant challenges along with links to potential solutions provided by geospatial data and technologies.

Additional perspective can be gained by examining where in the microplanning process these applications of geospatial data and technologies could be useful prior to identifying specific challenges.

Figure C - Links between microplanning challenges and applications of geospatial data and technologies [18, 28].



The most commonly used applications of geospatial data and tools in the microplanning process are:

- Georeferenced master lists
- Population estimates and spatial distribution
- Geographic accessibility, service and route optimization models
- Thematic maps.

These four applications are the main focus of this handbook and are detailed in the following sections.

The products generated through these four applications support different phases of microplanning operations as outlined in Table 1. The table also lists potential challenges for these phases. Thematic maps and georeferenced master lists are useful across all the phases of the generic process. Thematic maps provide visual support for planning, decision-making and monitoring. Georeferenced master lists help ensure that all decisions and interventions are based on a common, complete, consistent and up-to-date geography.

In contrast, population estimates, geographic accessibility, service location and route optimization models support specific planning and implementation phases. These applications can help identify target populations and assess service coverage in general (Phase 1), or identify target populations located in specific hard-to-reach areas to help estimate service delivery requirements (Phase 2). Microplanning teams should develop or adjust service delivery plans based on estimates generated by the applications for target population count and location, as well as estimates for service delivery requirements, supplies and human resources.

Using geospatial data and technologies for service location and route optimization models can be particularly valuable in planning for commodity and equipment storage (e.g. vaccines, bed nets, etc.) (Phase 3), as well as for distributing human resources (Phase 4) when establishing or scaling up service delivery networks (Phase 5).

Other applications of geospatial data and technologies, such as GNSS navigation and tracking, also play an important role in microplanning. They can provide near real-time data during campaigns, assess coverage by field teams, monitor supplies and measure team performance. These additional applications of geospatial data and technologies will be covered in a future version of this handbook.

Other intervention-specific applications such as equity mapping, vaccination coverage modelling and disease surveillance are not covered in this iteration of the handbook³. All the applications listed can contribute directly or indirectly to microplanning and resulting programmes.

3. GNSS tracking, vaccination modelling and disease surveillance in the immunization context are described in [16]

Table 1 – Possible use of geospatial data and technologies applications across the microplanning process

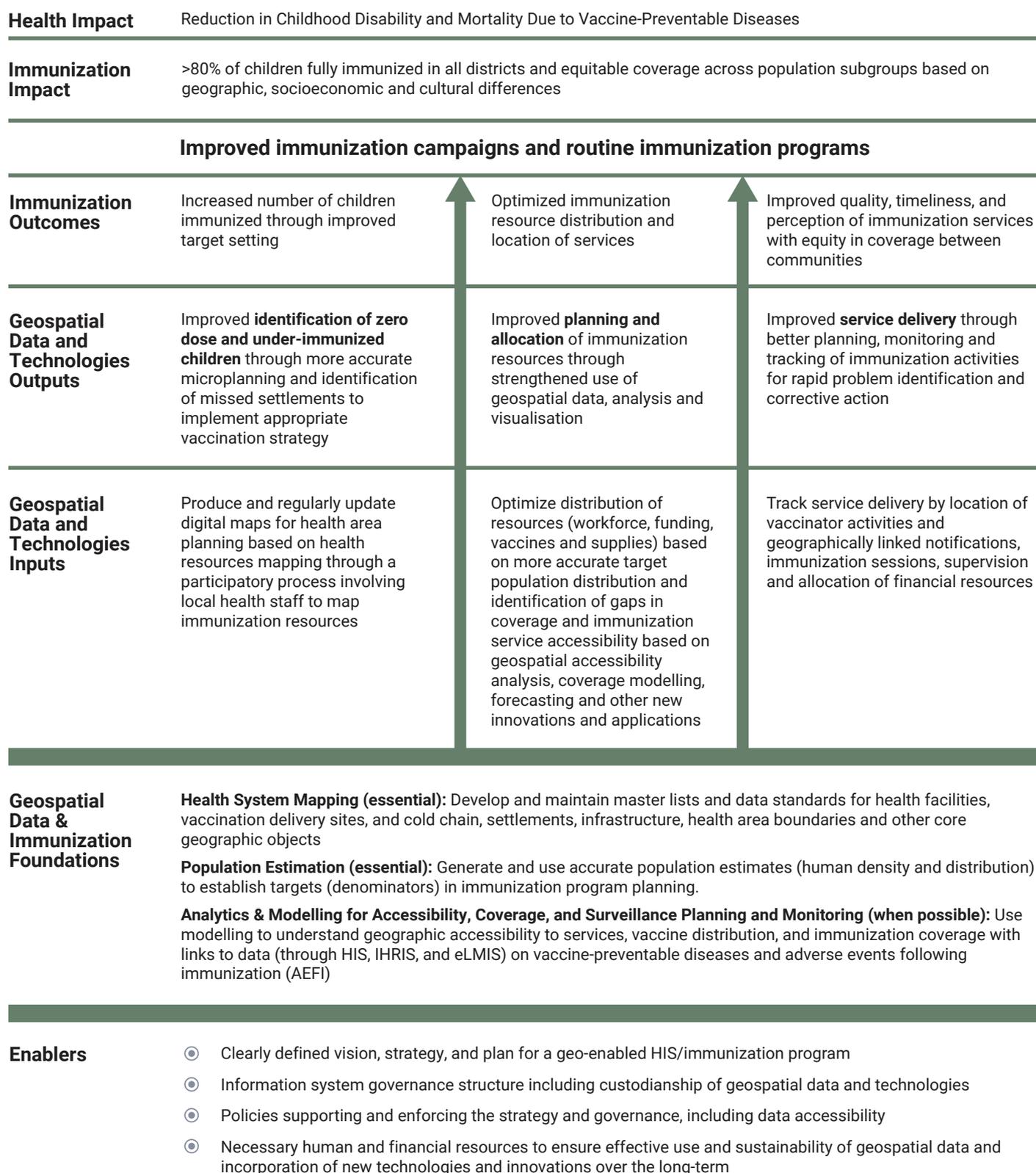
Microplanning process phase	Common challenges to non-geo-enabled microplanning	Geospatial Data and Technology Solutions				
		Georeferenced master list	Population estimates and spatial distribution	Geographic accessibility, service location and route optimization models	Thematic maps	*GNSS navigation and tracking
1. Determine target population and its current service coverage	<ul style="list-style-type: none"> ⊙ Lack of population denominator ⊙ Insufficient utilization of data and information ⊙ Lack of unique identifier ⊙ Geographic inaccessibility ⊙ Lack of, or inappropriate, referral ⊙ Inadequate understanding of beneficiary population 	✓	✓	✓	✓	
2. Estimate service delivery requirements	<ul style="list-style-type: none"> ⊙ Lack of population denominator ⊙ Insufficient utilization of data and information ⊙ Lack of unique identifier 	✓	✓	✓	✓	
3. Plan for commodities and equipment storage (e.g. vaccines, bed nets, etc.)	<ul style="list-style-type: none"> ⊙ Lack of population denominator ⊙ Insufficient utilization of data and information ⊙ Lack of unique identifier ⊙ Insufficient commodity supply ⊙ Insufficient equipment supply 	✓	✓	✓	✓	
4. Identify and manage human resources	<ul style="list-style-type: none"> ⊙ Lack of population denominator ⊙ Insufficient utilization of data and information ⊙ Lack of unique identifier ⊙ Insufficient supply of qualified health workers 	✓	✓	✓	✓	
5. Plan service delivery, including preparation of an operational map, and identifying special activities for the hard-to-reach and problem areas	<ul style="list-style-type: none"> ⊙ Lack of population denominator ⊙ Insufficient utilization of data and information ⊙ Lack of unique identifier ⊙ Insufficient supply of services ⊙ Geographic inaccessibility ⊙ Lack of appropriate referral ⊙ Poor planning and coordination ⊙ Lack of effective resource allocation 	✓	✓	✓	✓	

6. Generate demand and ensure communications, by collaborating with community stakeholders	<ul style="list-style-type: none"> ⦿ Insufficient utilization of data and information ⦿ Low demand for services ⦿ Absence of community feedback mechanisms 				✓	
7. Support and monitor implementation, and track defaulters	<ul style="list-style-type: none"> ⦿ Insufficient utilization of data and information ⦿ Inadequate supportive supervision ⦿ Poor accountability between the levels of the health sector 	✓			✓	✓
8. Re-evaluate the microplan	<ul style="list-style-type: none"> ⦿ Lack of quality/reliable data ⦿ Insufficient utilization of data and information 	✓	✓	✓	✓	✓

Note: For a sequence of steps at the district level (as opposed to health facility level), where GIS maps can be used for monitoring of the microplanning outcomes, see Part 2 of the 2009 WHO Reaching Every District (RED) strategy [1].

The theory of change in Figure D is an example of desired outcomes related to the use of geospatial technologies in a microplanning process, and their relationships to the drivers of equitable health service delivery and health outcomes, such as immunization coverage. The theory of change is a sound model for identifying geo-enabled strategies to address microplanning challenges. It also outlines the geospatial data foundations and enablers that can influence health outcomes. Readers are encouraged to look to existing theories of change used in relevant health interventions for guidance in developing their geo-enabled microplans.

Figure D – Example of theory of change related to immunization extracted from [16].



Monitoring, evaluation, and learning (MEL) are a critical part of a microplan's geo-enablement. Tracking progress toward a geo-enabled microplan's intended results should involve adaptive learning processes during planning and implementation, such as those outlined in Figure D. This will typically include developing and implementing learning questions to identify what is, and is not working, making mid-course corrections and improving the microplan's impact.

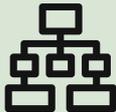
Effective MEL planning (Section 6.7.7) requires a clear understanding of the purpose of the geo-enabled microplan. Begin by determining the primary outcome of interest. For example, in Figure D, a primary outcome of interest includes increasing the number of children immunized through improved target setting. This primary outcome of interest, and the secondary outcomes of interest stemming from it, will guide the theory of change (see Section 6.7.7.1 for more on outcomes of interest). The workplan (Section 6.7) is the roadmap of geo-enablement activities intended to move users toward these primary and secondary outcomes. MEL planning can also include the real-time performance monitoring of service delivery. Ultimately, the MEL plan will measure if the geo-enablement of the microplan actually moved the team closer to these outcomes.

5.2.2 Overview of four applications of geospatial data and technologies

This section introduces the four applications of geospatial data and technologies discussed throughout this handbook.

Programme Designer	GIS Technical Staff
Continue to next section	Continue to next section

5.2.2.1 Georeferenced master lists overview

Programme Designer	GIS Technical Staff
	

A master list is an authoritative, complete, up-to-date and uniquely coded list of all active and previously active records for a selected geographic feature that is officially curated by the mandated agency.

Georeferenced master lists ensure that all data collected and products generated during the microplanning process are interoperable by being based on the same set of health service delivery points, logistical infrastructure, administrative units or any other relevant features. All microplanning stakeholders should use the same master list for core geographic features to ensure a common understanding of its geography, including precise locations and spellings.

During the microplanning process, most team members in managerial or planning roles will make use of master lists, from field team coordinators to project directors, and their supervisors. In some cases, the needed georeferenced master lists are already available and accessible at the time of developing the geo-enabled microplan. However, this is often not the case and the geo-enablement of the microplan provides an opportunity to address these gaps. If working in this scenario, it is important that the data elements to be included in the master list for each geographic feature are identified through an inclusive consultative process that involves workshops and/or interviews.

For further information on georeferenced master lists see Section 6.3.1. For further information on developing a community health worker master list in particular, please see the following guidance: Implementation support guide: Development of a national georeferenced community health worker master list hosted in a registry [8]

Figure E - Example of a georeferenced health facility master list.

Health_Facility_ID	Health_Facility_Name_EN	OP_Date	Health_Facility_Type_EN	Health_Facility_OWN	Lat	Long
HF000062	Ywar Thar	2001-07-27	Sub Rural Health Center	Public (MOH)	16.8	96.15
HF002135	Zee Pin Hla	1998-03-27	Sub Rural Health Center	Public (MOH)	21.9769	96.0869
HF004754	Myo Thit	1972-04-29	Sub Rural Health Center	Public (MOH)	19.7475	96.115
HF003336	Ya Thit	1983-07-01	Sub Rural Health Center	Public (MOH)	16.8906	97.6333
HF003302	Let Wea	2005-06-17	Sub Rural Health Center	Public (MOH)	17.3433	96.4981
HF000008	Let Pan Taw	1934-06-15	Rural Health Center	Public (MOH)	12.4394	98.6003
HF002212	Mei Ni ma Kone	1969-06-06	Sub Rural Health Center	Public (MOH)	16.4847	97.6258

While this example master list focuses on health facilities, georeferenced master lists may also contain logistical infrastructure, settlement locations, administrative units or other relevant features.

5.2.2.2 Population estimates and spatial distribution overview

Programme Designer	GIS Technical Staff
	

Population estimation is defined as the use of statistical models, remote sensing datasets, and sampled census or household survey information to create spatially accurate estimates of population density and distribution, often including age and sex disaggregation.

In the context of microplanning, population count estimates and spatial distribution often provide the most accurate and disaggregated information possible regarding the size and locations of a target population. While recent census data matched to relevant boundaries can be the best source of population estimates, they are often outdated, built using coarse spatial scale forecast models, or not sufficiently detailed for effective microplanning. Use of other traditional population data sources in microplanning, such as household surveys and projected population estimates, exhibit similar limitations.

Geospatially modelled population estimates are increasingly integrated into microplanning to address these limitations, and help increase microplanning effectiveness and efficiency. These estimates use geospatial data and technology with statistical models to disaggregate census and survey data to finer scales, with more detail and regularity, and to calculate estimates between censuses. This process is particularly crucial for accurately and inclusively estimating remote, displaced or marginalised communities, and for capturing population changes over time.

While the construction of reliable estimates using these approaches can be time-consuming and complex, there are various off-the-shelf products available from organizations such as WorldPop, GRID3, Flowminder, and others.

The microplanning team uses population estimates throughout the various phases of planning, especially when defining targets, allocating resources and measuring progress. Population estimates and spatial distribution data products can include GIS layers containing the population denominators by administrative or operational boundaries, spatial distribution of target populations, as well as tables, graphs and charts containing or displaying data on the target population.

Figure F – To create the most accurate and up-to-date population estimates for microplanning, official population estimates (e.g. census data) can be updated using other geospatial data such as building footprints to estimate number of households since the official dataset was collected. Below is an illustrative example using building footprints in Eritrea. (Data source: WHO GIS Centre for Health; Satellite imagery source: Maxar).



For further information on population estimates and distribution see Section 6.3.2 and Section 6.6.2.2

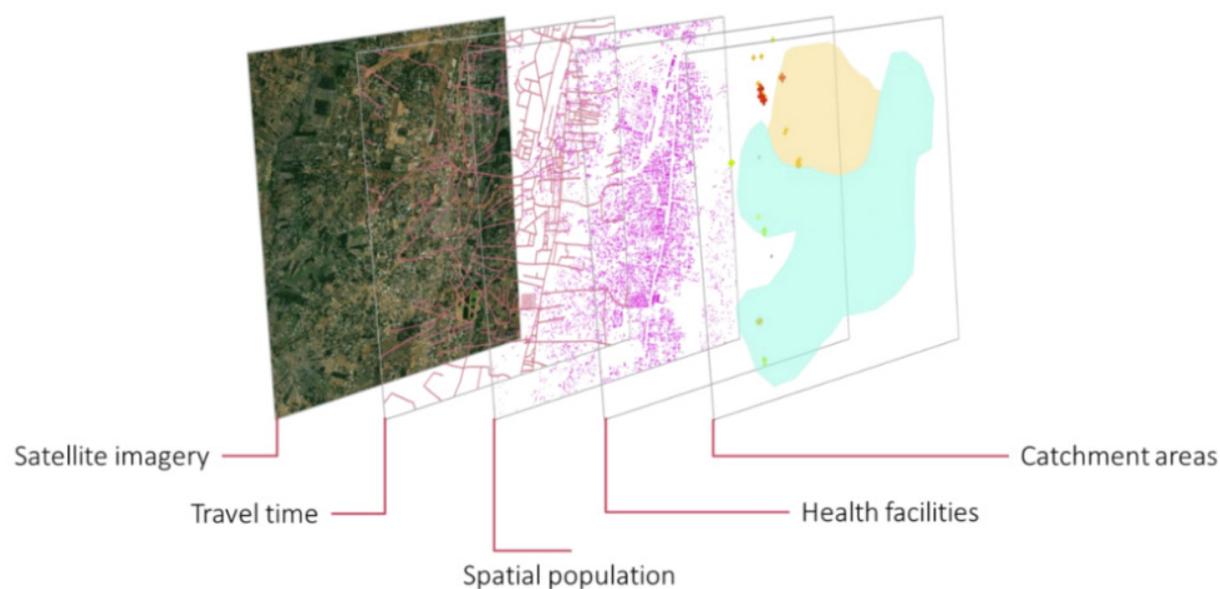


5.2.2.3 Introduction to geographic accessibility, service location and route optimization models

Programme Designer	GIS Technical Staff

Geographic accessibility, service location and route optimization models are the product of advanced modelling approaches that help microplanning teams assess and improve the planning, allocation and delivery of resources. These models can serve many purposes, including assessing service coverage, identifying the quickest travel routes, and optimizing resource distribution across areas or routes. This type of modelling can also help planners ensure that health service access is more equitable and cost-effective by identifying where to add service delivery points, redirect resources or alter supply routes to better serve target populations.

Figure G - Visualization of how different components come together to create a thematic map. (Source: WHO)



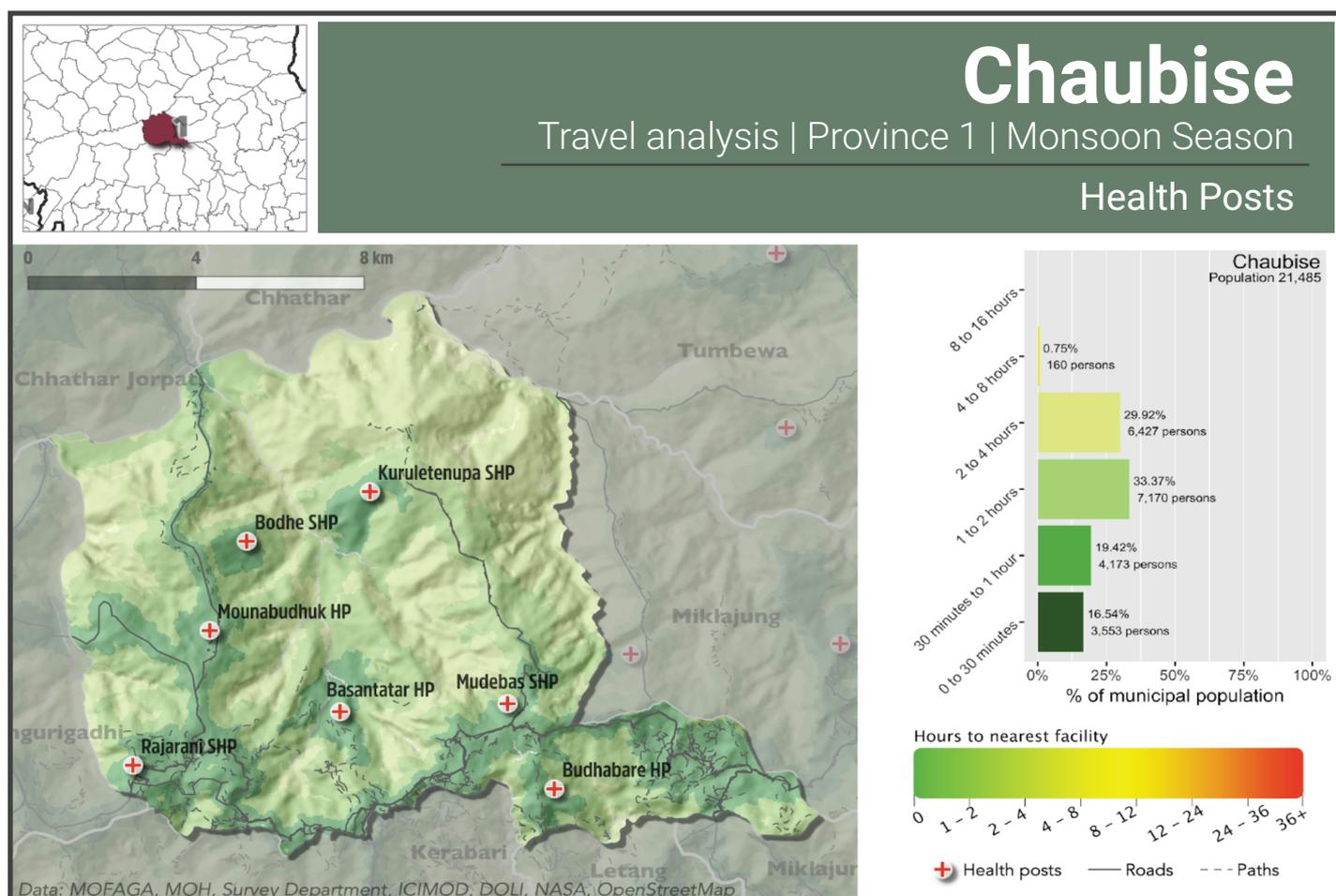
The use of hand-drawn maps and reliance on community members for estimated travel times between two points can lead planners to choose suboptimal routing and inaccessible service location points. Geographic accessibility, service location and route optimization models help to overcome these hurdles by automating route optimization and providing accurate visualizations of coverage areas, target populations and more. It is important to note that approximations may need to be made in cases in which quality data are not available at the beginning of the modelling process.

The products obtained through the modelling process are primarily used by teams developing the service delivery strategy, such as logistical staff, district-level health coordinators and project managers. The products can include GIS layers as well as tables and charts.

In Figure G, catchment areas and health facilities (georeferenced points and polygons stored in a master list), used in conjunction with spatial population data (derived from population estimates) and travel time (accessibility and route optimization models based on catchment areas and health facilities), are overlaid on a basemap satellite image. All these components come together to create a thematic map that is useful for microplanning teams.

For further information on geographic accessibility, service location and route optimization see Section 6.3.3

Figure H - A map showing the geographic accessibility of health posts to the population in a municipality of Nepal.
(Courtesy of Robert Banick)



5.2.2.4 Thematic maps overview

Programme Designer	GIS Technical Staff

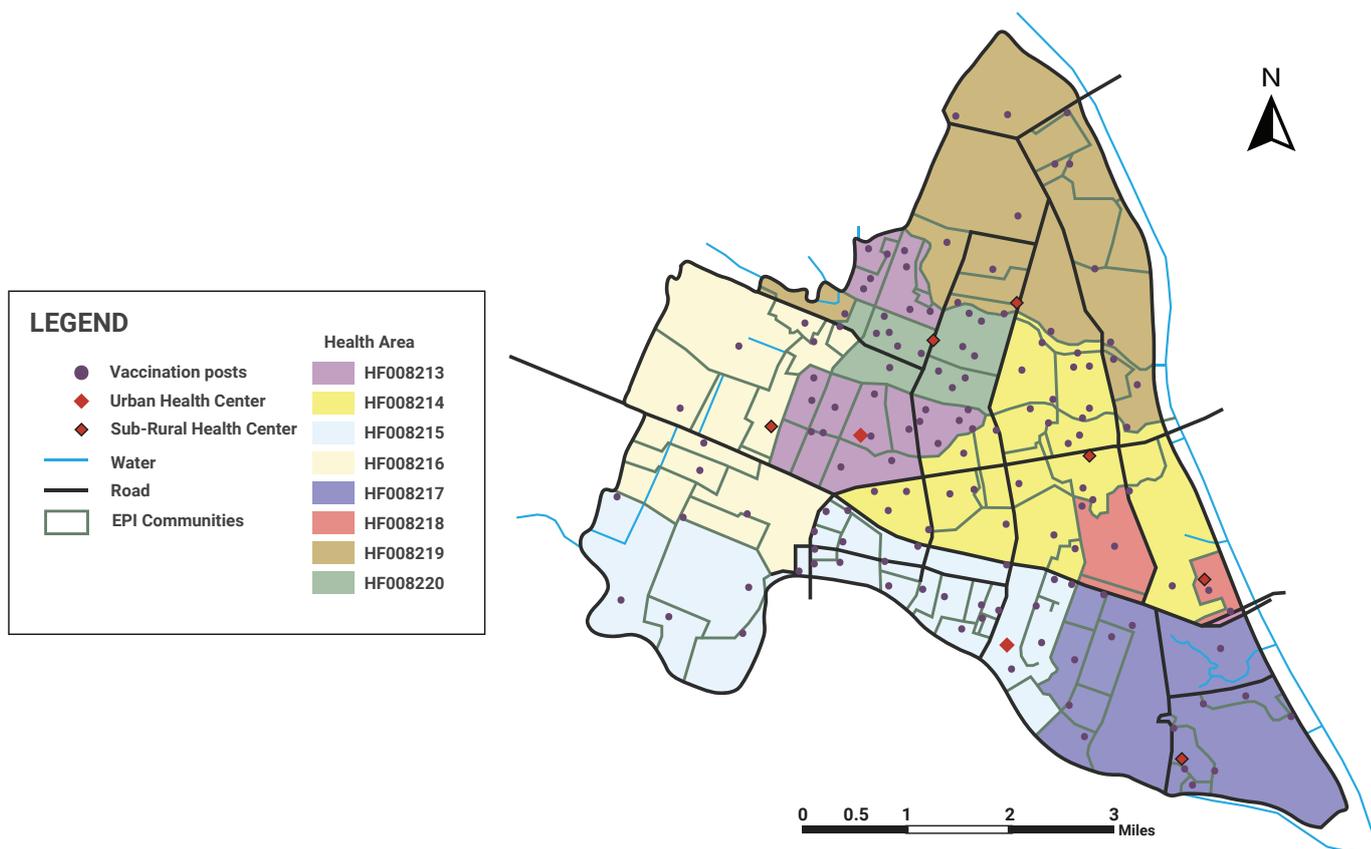
Thematic maps combine geospatial data and attribute data (e.g. information, statistics) to convey information about topics or themes in visual form. This could include maps that visualize the spatial distribution of a target population, available health services or changes in terrain. These maps can be useful to microplanning teams, as the geographic dimension of a microplan is often easier to understand if represented on a thematic map rather than in spreadsheets or through text.

These maps can be used to visualize and combine products from the other applications of geo-enabled microplanning. For example, a thematic map could be created to show the location of objects from master lists, the distribution of an estimated population and/or the result of an accessibility optimization modelling exercise.

Thematic maps can be used as a coordination tool to benefit all members of a microplanning team. Maps for coordinating activities or developing daily plans are most useful to field teams and their supervisors, while operational overviews tend to be most useful to project managers and high-level planners. These maps are useful in different phases of the microplanning process, including to help define or iterate a service delivery strategy, or to monitor progress during implementation. An example of a thematic map can be seen in Figure I below.

For further information on thematic maps see Section 6.3.4.

Figure I - Example of thematic map used to support microplanning in Myanmar. (Source: UNICEF)



5.3 Summary of use case examples of geo-enabled microplans

Programme Designer	GIS Technical Staff
	

The following use case example summaries demonstrate how geo-enabled microplanning was applied to various health interventions in different countries. The use case examples can be read in full in Annex B.

COVAX COVID-19 vaccination use case example

When Nigeria received its first 4 million AstraZeneca vaccine doses from the COVID-19 Vaccines Global Access (COVAX) initiative, the government wanted to prioritize vaccinating at-risk populations, including frontline health workers, persons over 50 years of age and persons with comorbidities. However, officials lacked updated population data and accurate settlement maps to locate target populations and allocate resources accordingly at the local level.

The National Primary Health Care Development Agency (NPHCDA) turned to geo-enabled microplanning to identify where target populations were concentrated, and to determine where to locate vaccination sites in close proximity. Health officials at various levels collaborated with international organizations to collect information and generate ward-level maps that provided demographic age information and comorbidity risk scores at a detailed local level. The geo-enabled process also allowed officials to set clear vaccination catchment boundaries, and to develop strategies for reaching settlements based on their distance to a health facility.

The NPHCDA in partnership with GRID3 and the National Space Research and Development Agency (NASRDA) successfully mapped all of Nigeria's 774 local government areas with the corresponding data points, producing detailed and up-to-date maps. Local officials used these maps for microplanning to better allocate COVID-19 immunization resources and to establish new vaccination sites where they were needed most, ensuring that all settlements received coverage. To further increase demand for COVID-19 vaccines, officials established mass vaccination sites (MVS) to take the vaccines directly to the target population. The MVS locations were based on the geo-enabling products, and enabled officials to select optimized vaccination sites for reaching densely populated areas at the ward level.

Read more in Annex B1.

Malaria stratification use case example

Cambodia's National Center for Parasitology, Entomology, and Malaria Control (CNM) sought to combat the spread of artemisinin-resistant malaria by leveraging geo-enabled microplanning. The Center recognized that much of the artemisinin-resistant malaria transmission was occurring among populations that lived in and around forests where the main mosquito vectors breed. To target the most at-risk groups with interventions such as insecticide-treated bed nets, and village malaria workers, officials needed to stratify villages by malaria incidence, proximity to forest and distance from health facilities. Partnering across government agencies and working with international organizations, officials collected and verified multiple datasets, some of which required deploying field teams to work with local officials and record GPS coordinates. By combining the data layers, CNM was able to produce maps that showed correct village and health facility names and locations, updated village population counts and accurate forest coverage.

Health officials used the maps along with a stratification scoring system to create a microplan for targeting malaria interventions at the village level. After implementing the plan, reported malaria cases decreased significantly. In addition, the updated health facility location and village population data collected as part of the geo-enabling process helped officials to better measure the performance of village malaria workers and health facilities.

Read more in Annex B2.

Routine immunization/expanded programme on immunization use case example

Health officials in the city of Patna, India recognized that the city's annual cohort of 50 000 newborn infants were grossly underserved by routine immunization services. Only around one third of children received all basic vaccinations by their first birthday, with rates particularly low among impoverished and marginalised populations. Health officials decided to leverage geo-enabled microplanning to improve routine vaccination reach. Working across government agencies, the team collected data and deployed field teams to verify and gather information. The efforts resulted in updated maps that included recently developed areas of the city and provided more accurate population counts. City health officials used this information to determine additional vaccination sites, demarcate catchment areas, plan more efficient vaccine delivery routes and better allocate human resources.

Following the geo-enabled microplanning and subsequent vaccination campaigns, officials saw substantial improvement in the reach of routine immunization services. This included a significant increase in the number of children receiving their full suite of recommended vaccines by one year of age, reduced delivery time for vaccination supplies and improved vaccination coverage.

Read more in Annex B3.

Polio supplemental immunization activity use case example

Geo-enabled microplanning played a critical role in supporting Nigeria's National Primary Health Care Development Agency (NPHCDA) to finally eliminate wild poliovirus from the country. In 2012, health officials realized that a lack of vaccination coverage in new and unrecorded settlements was allowing the poliovirus to spread in these unvaccinated communities. The gaps in vaccination coverage were a result of using outdated hand-drawn maps of settlements to plan house-to-house polio vaccination campaigns. The NPHCDA worked with various government agencies and international organizations to use high-resolution satellite imagery to identify all settlements in target areas. Field teams with GPS devices verified the coordinates of catchment areas, boundaries and key landmarks. This data was used to create maps for 2000 wards in 11 states that included accurate locations for settlements, health facilities and other points of interest, as well as ward-level catchment boundaries and spatially precise population estimates. Officials relied on these updated and accurate maps for polio vaccine microplanning, enabling better allocation of vaccine supplies, more efficient vaccinator routes and improved tracking of vaccination teams. As a result, the vaccination campaigns that utilized geo-enabled microplanning led to fewer missed children and no missed settlements. Ultimately, the geo-enabled process was a key contributor to the elimination of wild poliovirus from Nigeria.

Read more in Annex B4.

Emergency outbreak: measles vaccination use case example

When a series of measles vaccination campaigns in Nigeria repeatedly missed households and settlements, officials recognized that to improve vaccination coverage, it would need to create more accurate settlements lists with updated population data. The agency also saw a need to reduce travel time to vaccination sites for community members by placing the sites closer to settlements.

To address these data gaps and more effectively plan the next measles vaccination campaign, Nigeria adopted a geo-enabled microplanning approach. Health officials collaborated with a diverse set of national and international partners to gather needed data. This included leveraging advanced modelling methods to generate accurate population estimates and demographic data for target areas based on building footprints and micro-census sample data.

Health officials used the resulting geospatial data to create maps for target northern states to support vaccination microplanning. The maps provided health officials with clearly defined catchment areas and population estimates, including the approximate number of children in a catchment area that came within the target age ranges for measles vaccination. The maps also enabled planners to ensure that all settlements had an assigned vaccination site within walking distance.

After implementing the microplanned measles vaccination campaign, health officials reported an increase in coverage compared to previous campaigns. They also saw better vaccination coverage rates in the targeted northern states that used geo-enabled microplanning, compared to southern states that did not use the process in their campaign planning.

Read more in Annex B5.

Geo-enabled Microplanning co-deployment of malaria interventions

Zambia utilizes a variety of malaria interventions including indoor residual spraying (IRS) and insecticide treated nets (ITN). Each type of intervention campaign relies on understanding population distribution in order to plan commodities, human resources required for deployment, and actual deployment of those large-scale, intensive campaigns. In Zambia, the need to plan and monitor vector control coverage was particularly acute during the 2021/22 season as the government implemented a “mosaic” approach where 50% of communities were to receive IRS, and 60% were to be covered by ITNs, with a 10% overlap. This mosaic approach proved difficult to implement, as it requires precise planning to ensure each community is allocated one of the two types of vector control. Health officials and partners utilized a combination of approaches to address three primary (and common) challenges around campaign deployment: (1) poor estimates of population and structures for microplanning, (2) limitations in planning and monitoring campaign coverage at village level, and (3) limited resources for digitally monitoring programmes.

To initiate this process, Health Facility Catchment Area (HFCA) boundaries for all 116 districts in Zambia were digitized and Georeferenced Infrastructure and Demographic Data for development (GRID3) data were used to derive settlement-level and health facility-level population estimates. Further refinement of population and structure count estimates was conducted using field-verified data captured in previous years via the Reveal platform, a geospatial microplanning and data collection tool used during campaign and routine service delivery. The resulting, detailed maps with the latest structure and population estimates at the HFCA-level were provided to districts (digitally and in print) as well as a microplanning template to guide the planning process. The granular data, consistent process, and digital and print-based approach was well received by district planners. In specifically identified districts, the Reveal platform was also used alongside IRS operations to enhance accountability for high vector control coverage in 2019 and 2020. Outcomes indicated that digital tooling to ensure plans are actually deployed accurately and all target areas/houses receive the intervention is extremely beneficial. Further, field teams utilizing Reveal were able to consistently find target households and spray those found, increasing household visitation rates and spray coverage to above 90%.

Read more in Annex B6.

Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.1 Identify the micro planning challenges that may be addressed through the geo-enablement



SECTION 5.4

Process

Programme Designer	GIS Technical Staff
	

The process to geo-enable a microplan is outlined in Figure J. While the process has been contextualised to support planning at the micro level, the steps would remain the same if used at the macro level to geo-enable a public health programme or an entire health information system (HIS). As such, the process presented here is similar to those captured in other documents [5, 17, 18].

Step 1

involves identifying challenges faced throughout the microplanning process and determining if geospatial data and/or technologies could be used to address them (Section 6.1). If this is the case, the geography behind the microplan should be identified and documented (Section 6.2) and the purpose, audience, content and format for GIS data products should be defined (Section 6.3). Following that, hardware and software requirements (Section 6.4) should be defined along with the technical expertise (Section 6.5) needed to generate the geo-enabled data and information products.

Step 2

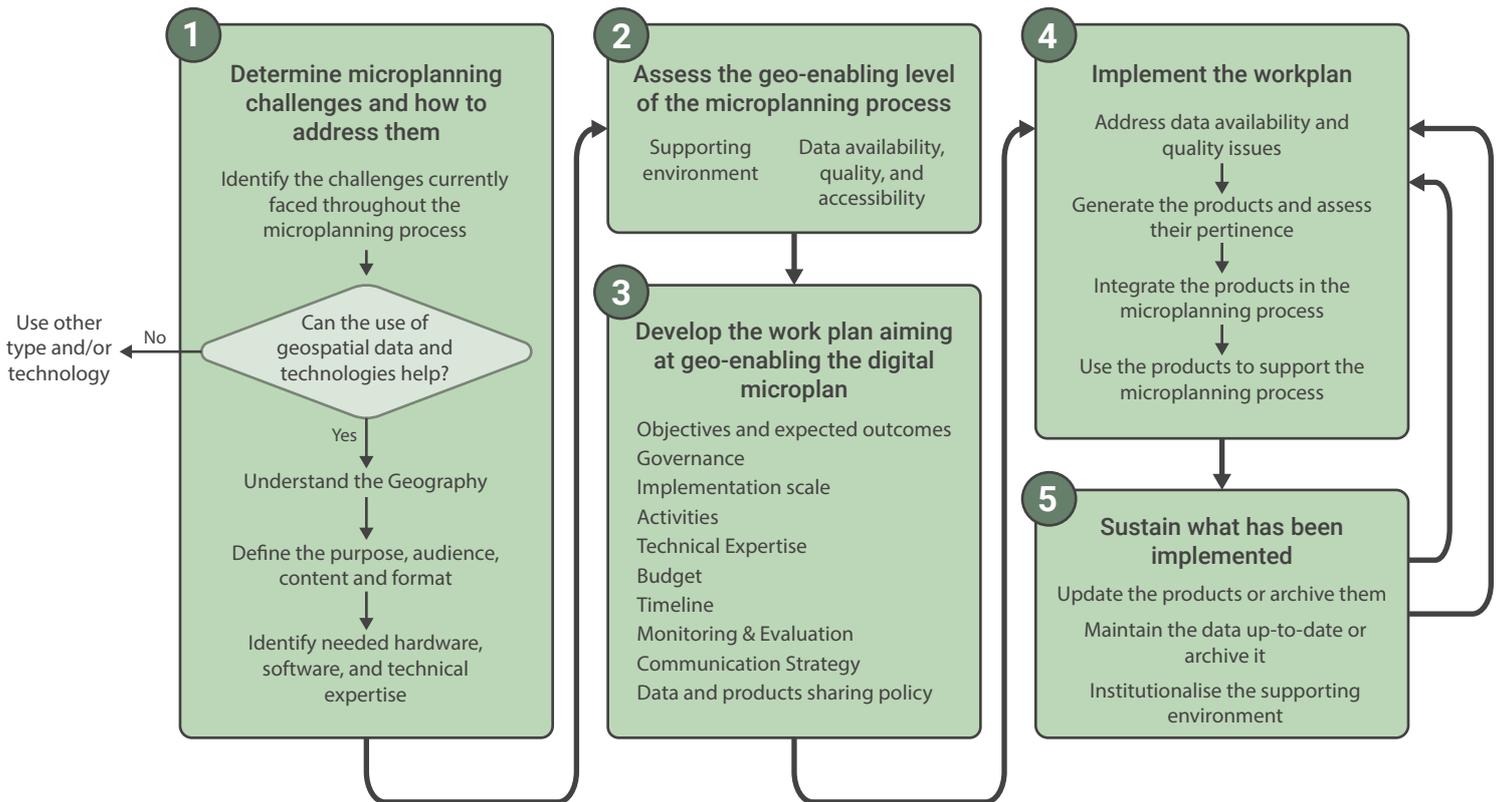
requires assessing the current geo-enablement level of the HIS and the programme developing the microplan. This is particularly important for microplans that require regular updating. This process involves examining the elements that form the supporting environment in the geo-enabling framework: vision, strategy, plan, governance structure, policies, financial resources, technical capacity, available technology (Section 6.6.1). In parallel, teams should assess the data to be used in implementation for availability, accessibility and quality, completeness, uniqueness, timeliness, accuracy, validity and consistency (Section 6.6.2).

Step 3

involves developing the workplan, including the monitoring, evaluating and learning (MEL) framework, to measure the effectiveness of the geospatial data and technology applications being implemented (Section 6.7).

The project workplan should develop a coherent plan for how to meet high-level objectives identified in Step 1 through a cascading series of outcomes, outputs and activities. The workplan should describe how to implement these activities based on the result of the assessment done in Section 6.2, with the objective of addressing microplanning challenges identified in Section 6.1. The workplan should cover governance, implementation scale, technical expertise and skills, hardware and software, activities, timeline, budget and MEL activities.

Figure J - Process to geo-enable a microplan.



Step 4

involves implementing the activities included in the workplan for each application of geospatial data and technologies. This includes addressing data availability and quality issues (Section 6.8.1), generating defined products and assessing their pertinence to the microplanning process (Section 6.8.2). Teams will then integrate and use these products to support the microplanning process (Sections 6.8.3).

Step 5

aims to sustain what has been implemented. Sustainability can take place at different levels, depending on the type of microplan and on the benefits realised through its geo-enablement. This sustainability may involve institutionalising the supporting environment established during the process (Section 6.9.1), as well as institutionalising processes to maintain, regularly update or archive data and products generated from the microplan (Section 6.9.2).

In an ideal situation, the products generated through implementing the geo-enabling process (Step 4 in Figure J) would be available at the start of the microplanning process (Table 1) to support planning and decision-making. This might be possible if the ministry of health has already geo-enabled its HIS, making the required data, hardware, software and technical capacity for geo-enablement available from within the ministry before starting the microplanning process. If this is not the case, it may take several rounds of implementing microplans for a routine intervention (e.g. routine immunization) for a programme to fully benefit from geo-enablement.

It can be more complex and challenging to fully geo-enable a microplan in an emergency context (e.g. disease outbreak) without an already geo-enabled HIS, or without knowledge and data from a similar geo-enabled programme. This situation may result in generating products through a more improvised process aimed at answering programme needs as best as possible, rather than precisely following the process illustrated in Figure J.

The above emphasizes the importance of beginning the geo-enablement process for a microplan as early as possible. Conducting the HIS and microplanning geo-enabling assessment is a critical first step in that direction (Section 6.1).



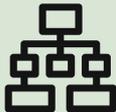
Geo-enablement of a digital microplan

SECTION 6.0

Geo-enabling the microplan

SECTION 6.1

Identifying microplanning challenges to address through geo-enablement

Programme Designer	GIS Technical Staff
	

The challenges faced during the non-geo-enabled microplanning process may either be already known, common for routine interventions (e.g. routine immunization); anticipated, for first-time interventions (e.g. first-time distributing insecticide-treated bed nets); or in emergencies (e.g. outbreak). Teams should document known or anticipated challenges through an inclusive consultative process using workshops, key informant interviews and/or focus groups. This process should include stakeholders across different levels that will be involved in planning and implementing the microplan, including representatives from targeted communities.

Once the challenges are identified, stakeholders and teams can reference Figure C and Table 1 to identify which applications of geospatial data and technologies are appropriate to address these traditional microplanning challenges through geo-enablement. Teams may also be directed to use a microplanning template, in which case it is critical to make sure that template requirements are understood and addressed throughout the entire geo-enabling process.



Note:

Note that Figure C and Table 1 may not cover all challenges encountered during the non-geo-enabled microplanning process. If additional challenges have been identified, then the exercise should aim at defining if there is a geographic dimension to them. If this is the case, then it is likely that geospatial data and technologies may help address them.

SECTION 6.2

Understanding a microplan's geographic dimension

Programme Designer	GIS Technical Staff
	

Understanding a microplan's geography is an important step towards its geo-enablement. This requires identifying and defining key geographic features for the microplan development and implementation process, as well as how they relate to each other hierarchically.

Geographic features are natural features (e.g. hills, rivers) or man-made features (e.g. buildings, roads). These features can be separated into four groups when captured in a GIS (Figure K).

Figure K – Type of geographic features according to how they can be captured in a GIS (extracted from [7]).

	Fixed Features		Mobile Features	Continuous features (elevation, temperature, etc)
	Point	Polygons & Lines		
Examples				
Way to capture the object in a GIS	Geographic coordinates (Latitude, Longitude)	Topology (location, size, shape) captured in a GIS vector format layer	Attached to a fixed feature (point or polygon) or geographic coordinate taken at a given time	Values captured in a GIS raster format layer

This step of identifying key geographic features requires a strong understanding of the target population (e.g. non-vaccinated children), service delivery strategy (e.g. door-to-door delivery) and expected outcomes (e.g. 80% of population aged under five years vaccinated). Each of these elements directly influence the list of geographic features that will be taken into account. As such, the exercise of identifying and defining key features should include all stakeholders involved in the planning and implementation of the microplanned intervention. Building this common terminology is important to ensure the effective implementation of the four applications of geospatial data and technologies covered in this handbook. See Annex 2 of [7] for instructions on creating a data model.

The following products should ideally be obtained as a result of this exercise:

- list of the geographic features forming the geography behind the microplan, with an agreed upon definition (example in Table 2)
- visual representation of different hierarchies (geographic, health-related, administrative, etc.) needed to develop and implement the microplan (examples in Figure L)
- conceptual data model resulting from merging hierarchies obtained under point 2 (example in Figure M).

Table 2 – Example list of geographic features with associated definition.

Geographic feature	Definition
Health facility	Infrastructure where health care is provided, may be limited to fixed infrastructures or include mobile ones
Health area	Area around a health facility defined for the purpose of cataloguing, budgeting and managing health resources
Catchment area	A geographical area delineated around an institution or business, such as a health facility, from where the population utilizes its services
Administrative unit	Delineated geographical areas within a particular sovereign state or territory created for the purpose of administration
Community	A group of people living in the same place or having a particular characteristic in common
Vaccination point	Place used to vaccinate people, other than a health facility

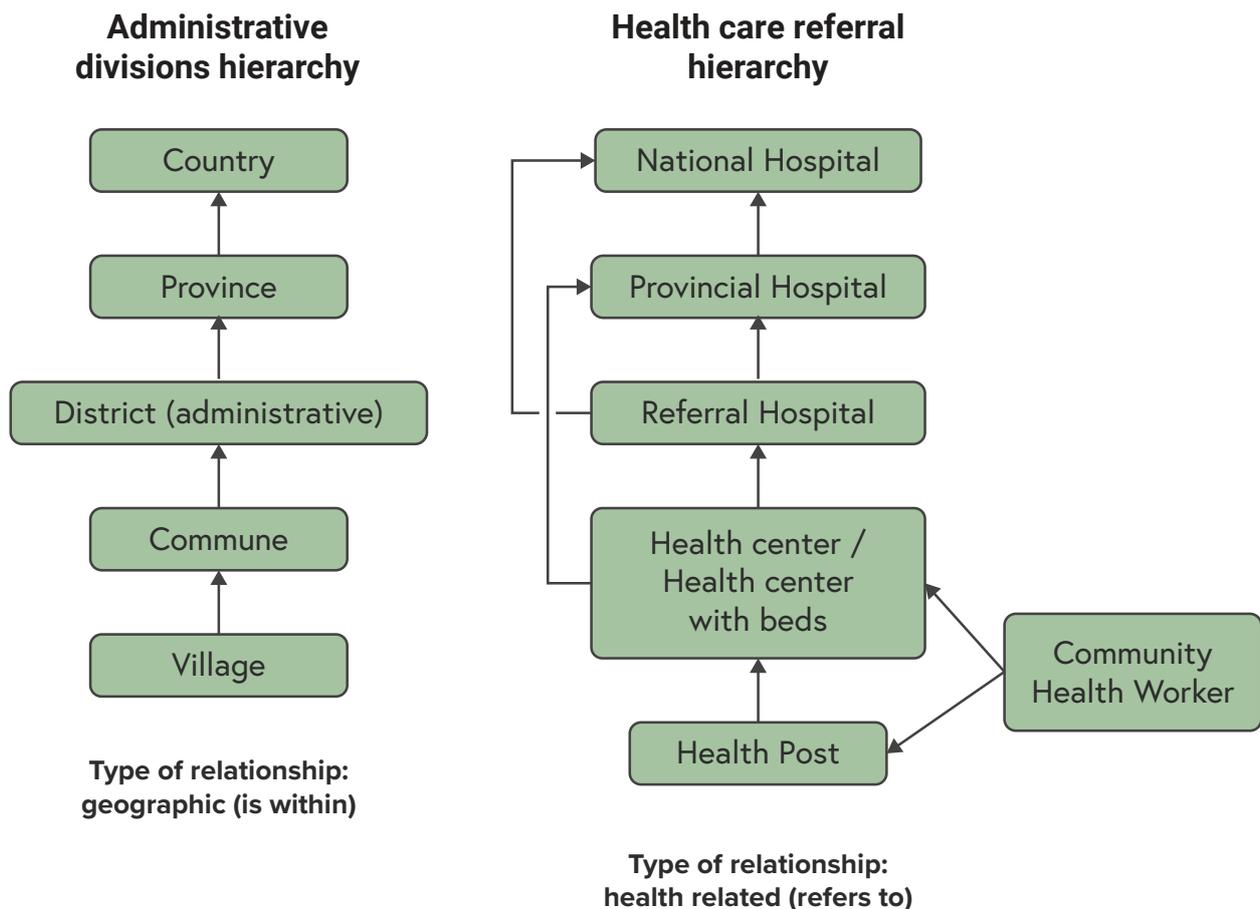
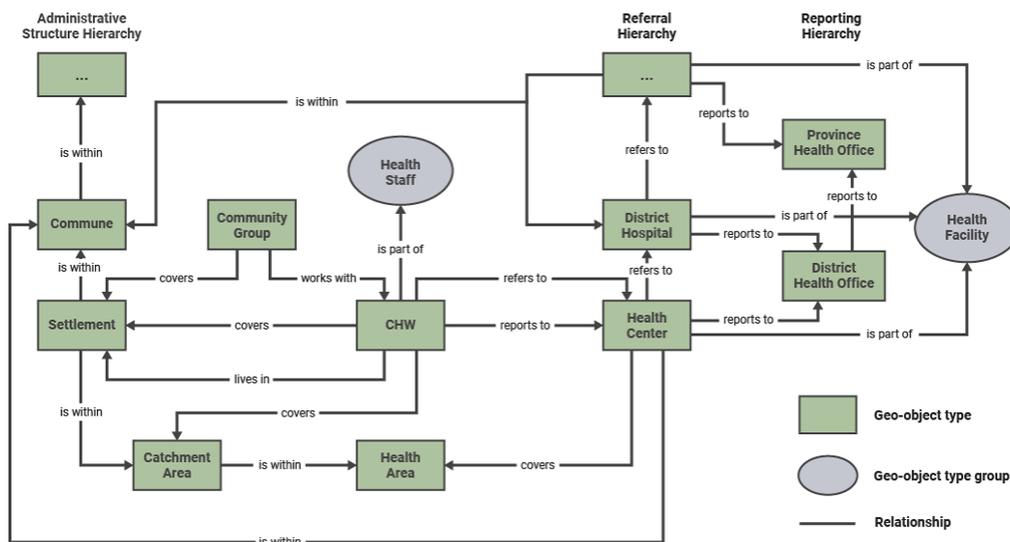
Figure L – Example of hierarchies.

Figure M – Example of conceptual data model.



Note: The type of infrastructures (health facilities, offices, ...) and administrative units might differ from one country to the other

A conceptual data model is defined as a visual representation that organizes types of geographic objects and captures how they relate to one another. The conceptual data model in Figure M above is an example of a conceptual data model for developing a community health worker master list [8].

A conceptual data model exercise helps establish a common understanding around selected geographic features. For example, it is necessary to carefully define the different “areas” that are referred to when microplanning a service delivery programme. In this situation, the following four types of areas may be considered⁴. Note the level of clarity and distinction in each definition. See Figure N for visual examples.

1. **Health area:** Area around a health facility defined for the purpose of cataloguing, budgeting and managing health resources. These areas are delineated by the ministry of health, often in collaboration with the concerned populations to ensure no overlaps or gaps. These areas do not reflect service-seeking behaviour, as people might visit facilities outside the health area within which they are located or may not visit facilities at all. These areas are a synthetic boundary indicating where the “territory” of one facility ends and where another begins.
2. **Proximity basins:** Area around a service delivery point defined so that any location inside this area is closer to that service delivery point than to any other service delivery points. These areas can either be defined based on distance (Thiessen polygon, also known as Voronoi diagrams) or travel time. They are contiguous (no overlap) and not based on a maximum distance or travel time like modelled catchment areas. This type of area is used to guide the population to the nearest service delivery point.
3. **Real catchment area⁵:** Area around a service delivery point based on the place of residence of the patient that received care at that service delivery point. This can be used for estimating stock or human resources based on past patient visits/past outreach. Missed areas (comparison of facility catchments within a district) can also be used to determine gaps and possibly overlooked communities. While this data is not typically used for official reporting, it is used to guide service delivery, including campaigns.
4. **Modelled catchment area⁶:** When information about the real catchment area is not available, or there is a need to estimate the population size that can reach a service delivery point within a given distance or travel time, then the corresponding catchment area can be modelled based on the following factors:

4. The term associated with each of these types of areas might vary from one country to the other.

5. A catchment area is defined as a geographical area delineated around an institution or business, such as a health facility or a vaccination point, from where a population utilizes its services.

6. See Table 13 for more detail on modelled catchment area methodologies.

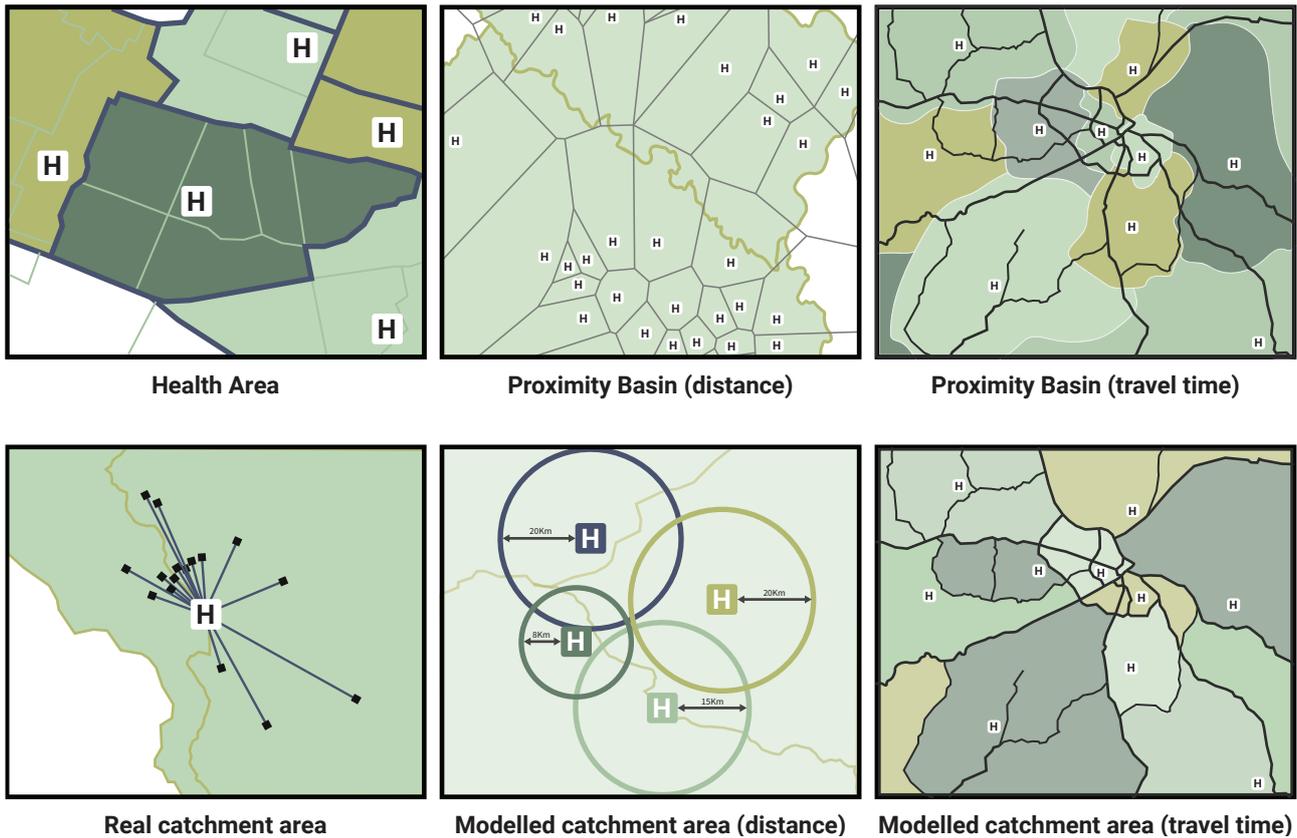
- a. *Distance (buffer)*: This method is often used when there is a need to delineate catchment areas quickly. These models should be labelled as modelled catchment areas or draft catchment areas in maps or tables. In some countries, this method has been used to create draft maps that were then updated in consultation with facility and district staff.
- b. *Travel time*: This method uses multiple datasets, including roads, elevation, walking/driving speed, and land use type to model the geographic extent reachable by a population in a given travel time.
- c. *Population*: This method uses population (generally the maximum coverage capacity of a health facility), rather than distance, as a limiting factor to define a catchment area's geographic extent.
- d. *Combined population and travel time*: This method uses both travel time and population as limiting factors to model the geographic extent of a catchment area.

Modelled and real catchment areas for a selected service delivery point can overlap, unlike health areas, which do not overlap. Overlaps of areas indicate possible or actual use of multiple service delivery points by target populations within overlapping areas.

Depending on a microplan's objective, more than one type of area may be considered to support planning. For example, while the planning of resource management for health facilities could use health areas defined by travel time, the volume of commodities needed for facilities could be based on their real catchment areas and on the proportion of the target population with physical access within a given time (estimated using modelled catchment areas).

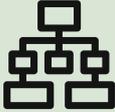
In addition, visualizing and comparing different types of catchment areas (Figure N) can provide insights into underlying social patterns and trends for a specific population. For example, a visual comparison between a modelled catchment area and a real catchment area could reveal that a subset of the population with reasonable access to a health facility does not make use of it, prompting inquiry into whether that population subset is experiencing another type of barrier.

Figure N – Examples of common catchment area types.



SECTION 6.3

Defining products of applications

Programme Designer	GIS Technical Staff
	

The four applications of geospatial data and technologies as introduced in Section 5.2.2 generate products that support the development and implementation of the microplan. Documenting the purpose, audience, content and format of these products is a crucial step towards effective project planning and implementation. This section provides guidance for defining these elements across the four key applications. References to external materials are provided in the text for readers who would like more detailed information. Teams using a microplanning template should ensure that the chosen data products will effectively synchronize with the template.



6.3.1 Georeferenced master lists

Programme Designer	GIS Technical Staff
	

A master list is an authoritative, up-to-date and uniquely coded list of all active and previously active records for a selected geographic feature, and is officially curated by the mandated agency.

Purpose

Georeferenced master lists ensure that all data collected, and products generated during the microplanning process are interoperable by being based on the same set of health service delivery points, logistical infrastructure, administrative units or any other relevant features. A master list prevents mishaps, such as allocating resources to closed health facilities, and enables advanced spatial analysis, such as calculating catchment areas around health facility points. All microplanning stakeholders should use the same master list for core geographic features to ensure a common understanding of its geography, including precise locations and spellings.

Audience

Master lists are intended to coordinate all stakeholders involved in microplanning. Target audiences may include managers, planners, field team coordinators and project directors, among others. However, the products generated from a master list's data (e.g. catchment areas, optimized delivery routes, thematic maps, etc.) may have niche audiences. As such, it is important to consider the needs of audiences that will use products generated from master list data prior to data collection. For example, field team coordinators may wish to have the contact information of each health facility's manager, while project managers may not need this much detail.

Content

The master list's data elements should be identified through inclusive consultative workshops or interviews. This process should include all stakeholders involved in microplan development and implementation, as well as representatives from other health programmes that use the same geographic features to plan their interventions. The consultative process should ideally be facilitated by those in charge of geo-enabling the health information system, and should take place prior to quality assessment (See step 3 of [8] for a description of such a process).

If this is not possible, another option is to conduct consultations at the same time as generating the master list (Section 6.8.2.1). However, this can result in underestimating resources needed to develop the master list when creating the workplan (Section 6.7).



Note:

Table 3 provides examples of data elements to include in the master list for a selected set of geographic features. The table provides these examples across the four groups of data elements that the master lists should cover (uniquely identify, classify, locate and contact). Additional examples can be found in documents covering master lists for health facilities [10] and for community health workers [8].

Table 3 – Examples of data elements to be included in a master list for different geographic features

Group	Example of data elements for different geographic features		
	Health facility	District	Vaccination post
Uniquely identify	<ul style="list-style-type: none"> ⦿ Official unique identifier ⦿ Official name 	<ul style="list-style-type: none"> ⦿ Official unique identifier 	<ul style="list-style-type: none"> ⦿ Official unique identifier ⦿ Official name
Classify	<ul style="list-style-type: none"> ⦿ Health facility type ⦿ Ownership 	<ul style="list-style-type: none"> ⦿ Not applicable 	<ul style="list-style-type: none"> ⦿ Vaccination post type ⦿ Vaccination strategy
Locate	<ul style="list-style-type: none"> ⦿ Administrative unit in which health facility is located (unique identifier and name) ⦿ Address (e.g. street name and number) ⦿ Geographic coordinates (latitude and longitude) 	<ul style="list-style-type: none"> ⦿ Upper-level administrative unit in which district is located ⦿ Geometry stored in a GIS vector format layer (link with the master list through the unique identifier) 	<ul style="list-style-type: none"> ⦿ Administrative unit in which the vaccination post is located ⦿ Geographic coordinates (latitude and longitude)
Contact	<ul style="list-style-type: none"> ⦿ Full name of health facility head ⦿ Phone number (health facility, head) ⦿ Email address (health facility, head) 	<ul style="list-style-type: none"> ⦿ Not applicable 	<ul style="list-style-type: none"> ⦿ Not applicable

How a master list reflects location information depends on the type of geographic object being recorded. Table 3 provides examples of ways this information can be captured for different geographic objects. Table 4 shows details that can be captured for fixed geographic objects, depending on their geometry type.

Table 4 – Location information that can be captured in a master list for fixed geographic objects, depending on the mode of representation

	Point	Polygon	Line
Official unique identifier and name of the administrative unit within which the geographic object is located	✓	✓	✓ (if completely within it)
Geographic extent stored in a GIS vector format layer (link with the master list through the unique identifier)		✓	✓
Address (e.g. street name and number)	✓		
Geographic coordinates (latitude and longitude)	✓		

For mobile objects (e.g. person, vehicles), it is common practice to attach them to a fixed geographic object corresponding to their place of residence (settlement for a person), place of work (health facility for medical staff), place of care (health facility for a patient) or place of highest presence (official parking lot for a vehicle). In these cases, the geographic coordinates of the fixed geographic object can be captured in the master list and associated with the mobile object.

If there is a need to associate multiple locations to a mobile geographic object, two options can be used:

1. Include multiple sets of coordinates in the master list for that geographic object (one for each location). This is appropriate when the number of locations is limited (e.g. places of residence and treatment for a patient).
2. Associate the unique identifier and name of the mobile geographic object to the master list of the geographic objects corresponding to these locations. This is appropriate when the number of locations is high for a mobile object (e.g. associating the unique identifier and name of a mobile team to each vaccination post they cover, in the master list for posts).



Note:

Note that these methods of association are also applicable when trying to capture relationships between fixed geographic objects (e.g. villages that are part of a health facility's catchment area).

The list of data elements to be included in each master list should be accompanied by a data dictionary [8]. A data dictionary holds the following information about each data element:

- a clear, contextual definition
- its applicability (applied to all or some records in the list)
- its format (alphanumeric, numeric, date, other)
- its maximum character length or the values that the data element can take (especially when options are limited)
- whether a data element is considered mandatory for new records.

For detailed guidance on information to include in a data dictionary and best practices for formatting, see Annex I.

Format

Master lists are typically set up in spreadsheets in which each column represents one data element, as per Figure AT. A summarized version of the data dictionary (described above), the metadata and the classification tables should accompany the master list. These items should be included in the same file as the list when possible. See Section 6.8.2.1 for more details on operationalizing georeferenced master lists.

Depending on internet connectivity and the need to use master lists in different information systems or applications, the master list could be shared as a standalone spreadsheet file (e.g. Excel), through a registry (e.g. the National Health Facility Registry maintained by the Department of Health of the Philippines⁷), or as a geo-registry (Section 6.4).

7. <https://nhfr.doh.gov.ph/>

SECTION 6.3.2

Population estimates and spatial distribution

Programme Designer	GIS Technical Staff
	

Population estimates and spatial distributions use statistical models, remote sensing datasets and sample enumeration data, to create spatially accurate and precise estimates of population density and distribution that can include age/sex breakdowns and measures of uncertainty in the estimates.

Purpose

Population estimates and spatial distribution can provide highly accurate, disaggregated information regarding the size and locations of the microplan's target populations. This process can be especially crucial for accurately and inclusively estimating remote, displaced or marginalised communities, and for capturing population changes over time.

Population data serve as both data inputs and data products throughout the phases of the microplanning process, and can be used in different spatial and tabular formats. Some of those uses might include:

- Generate population denominators (total number of target population), and divided by age and sex.
- Visualize population distribution, count, and density in thematic maps, including age and sex where available and depending on the target population.
- Population distribution at the individual or settlement level might be used as origins or destinations in models of geographic accessibility, service location optimization, or route optimization.
- Population estimates at the individual or settlement level might be used for weighting and normalization, while population distribution may be used as origins.
- Summarize and visualize population distribution, count, and density by health facility, administrative area or other catchment areas.

See Section 6.8.2.2 for more information on the implementation and operationalization of population data in the microplanning workflow.

Audience

Age and sex-disaggregated population estimates can be used by the microplanning team throughout the entire process. During the microplan development phase, data analysts should review existing population datasets and, if needed, create and use population estimate data products to serve as inputs to thematic maps or to define catchment areas. Analysts may integrate the population estimate data into other geospatial applications as well. Project managers and planners at the district and national levels will likely rely on population estimate numbers and resulting thematic maps to define targets, allocate resources and measure progress.

Beyond the microplanning team itself, national statistical agencies provide the base input data from censuses, surveys, forecasts and population estimates, and should therefore be consulted when these estimates are modified or updated. This ensures that the modelling team is aware of any methodological nuances, limitations or known errors in the base datasets, and helps secure statistical agencies' buy-in for the end products.

Content and format

There are three types of population estimate and spatial distribution data products:

1. **GIS layers** containing the spatial distribution of the target population. These layers are generally stored in gridded raster format, as it facilitates the largest number of uses (e.g. geographic accessibility modelling in Figure O). They can also exist as vector layers (e.g. thematic maps in Figure P).
2. **Tables** containing the total or percentage of a target population by a selected scale or level of disaggregation. This disaggregation may be by administrative unit, health division or health catchment area. It can be helpful to provide tables/tabular printouts alongside maps so that they can be used together. In such cases, tables should contain the unique identifiers and names for units, divisions or areas. As interpreting information visually is more difficult with tables than with maps, make tables free of extraneous columns and concentrated on key data points. If possible, use formatting and colours to highlight data patterns.
3. **Graphs and charts** allow for easier visualization of data and can facilitate trend analysis or identification of high-need areas. In addition, graphs and charts are more easily understood by non-technical audiences.

Figure O – Population estimates, per 90m x 90m grid square, for a region in Kano State, Nigeria. (Source: GRID3)

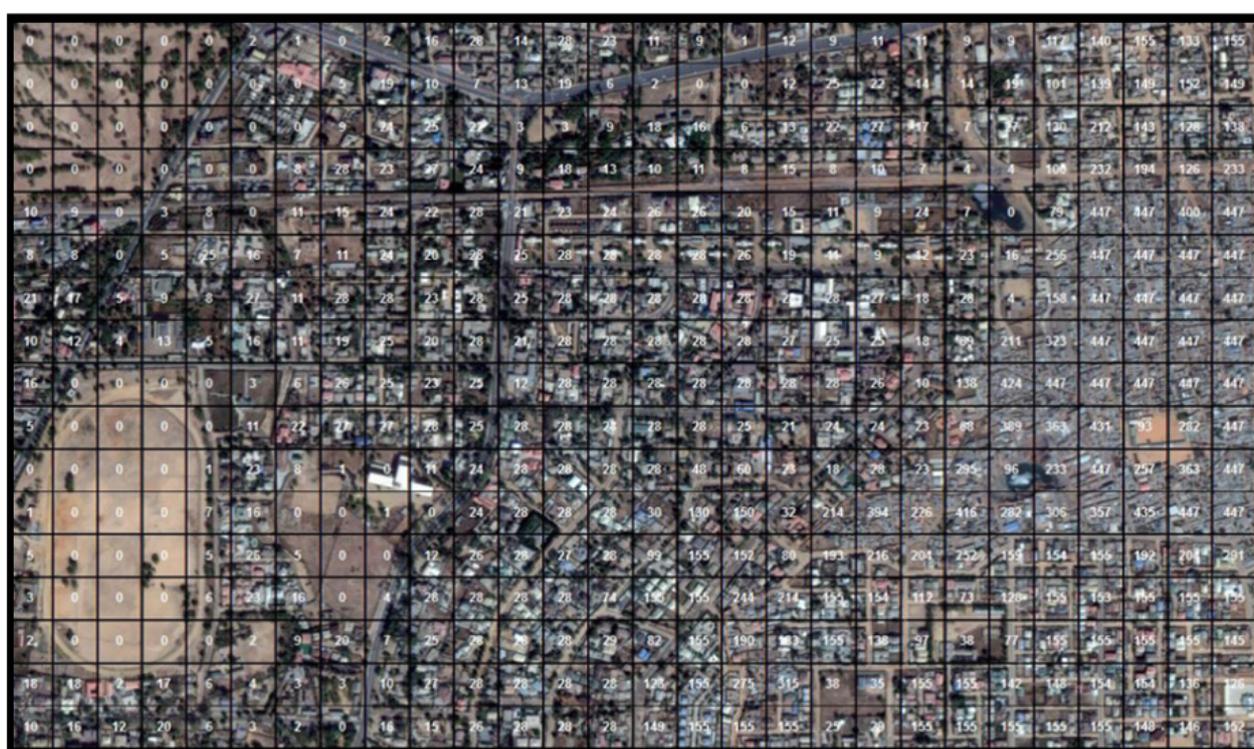
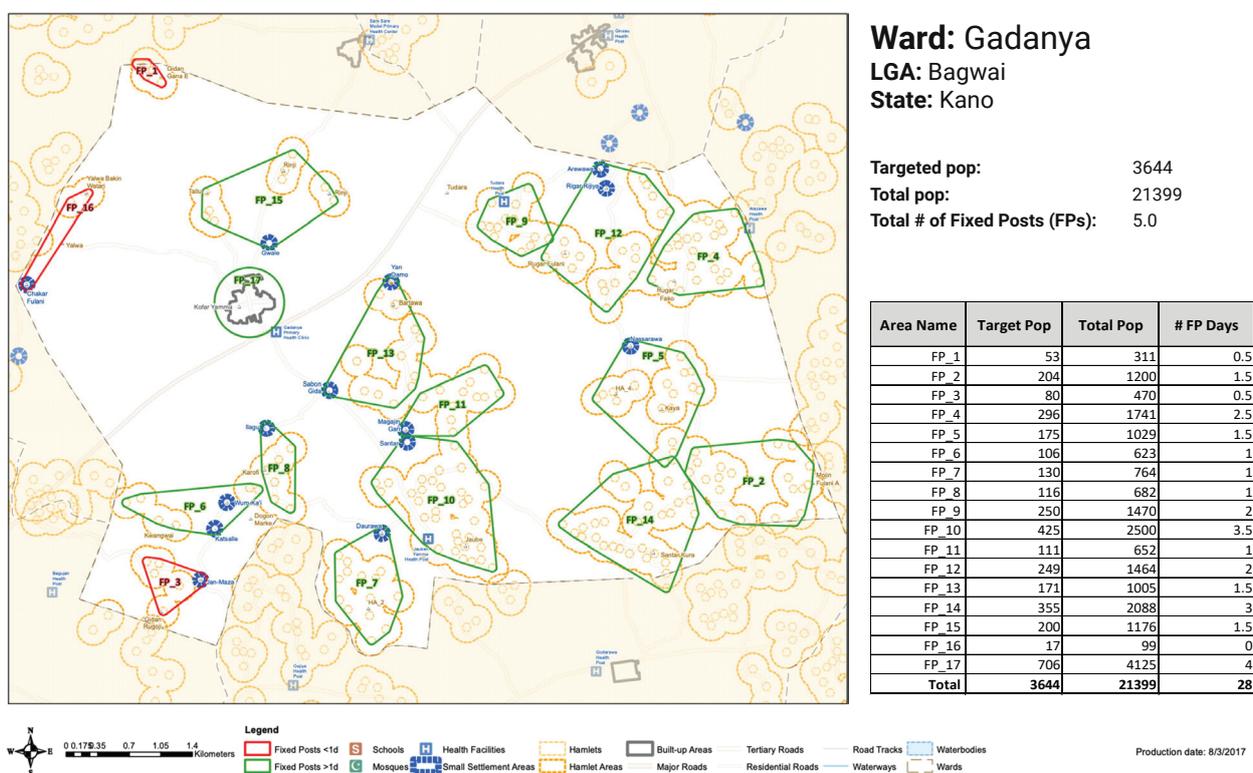


Figure P – GIS-generated ward map showing distribution of type of settlements, estimated total target population under five years, and number of teams and location of vaccination posts. Red-bordered areas require less than one day to cover, while the green-bordered areas require one day or more. Gadanya ward, Bagwai LGA Kano MVC 2017. (Source: GRID3)



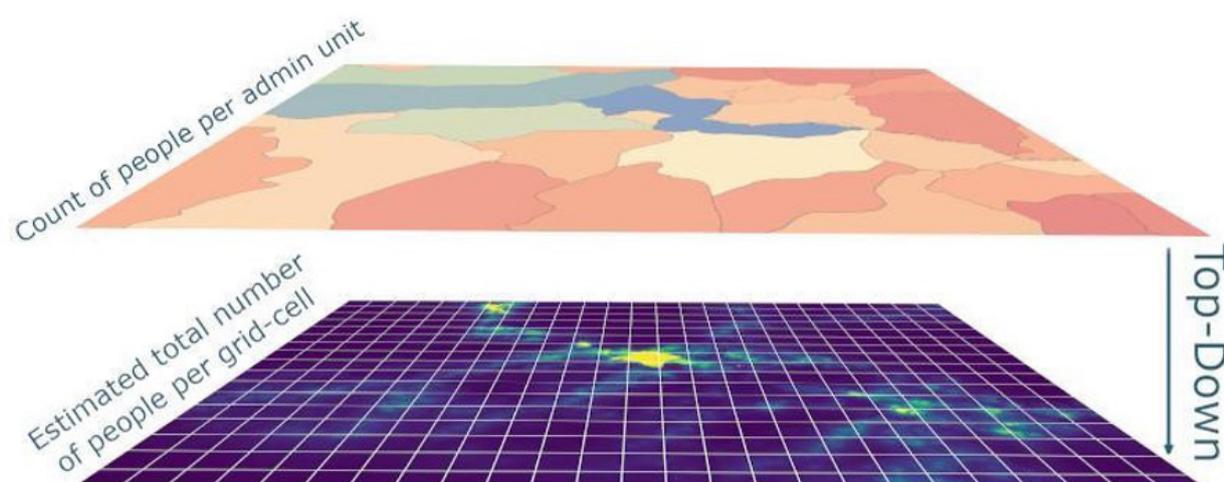
Geospatial Modelling Methodologies

There are two primary methodologies for generating population estimates and spatial distributions: top-down and bottom-up estimation.

Top-down population estimation

A top-down approach to population estimation uses trusted recent administrative population totals (e.g. census results or projections) and various geospatial datasets (e.g. building footprints, night-time lights, topography, infrastructure) to disaggregate the population over an area of interest. In order to use this methodology, the input population estimates must cover the entirety of the country or area of interest. The spatial distribution of population can also be weighted or aggregated based on catchment areas, or constrained by administrative boundaries or settlement extents. Note that some top-down approaches do not provide sufficient detail or resolution, and off-the-shelf products may be constrained or weighted by municipality boundaries that are different from those used by the microplanning team.

Figure Q – Illustration of the top-down population estimation approach, using census data and administrative-level population denominators. (Source:[29])

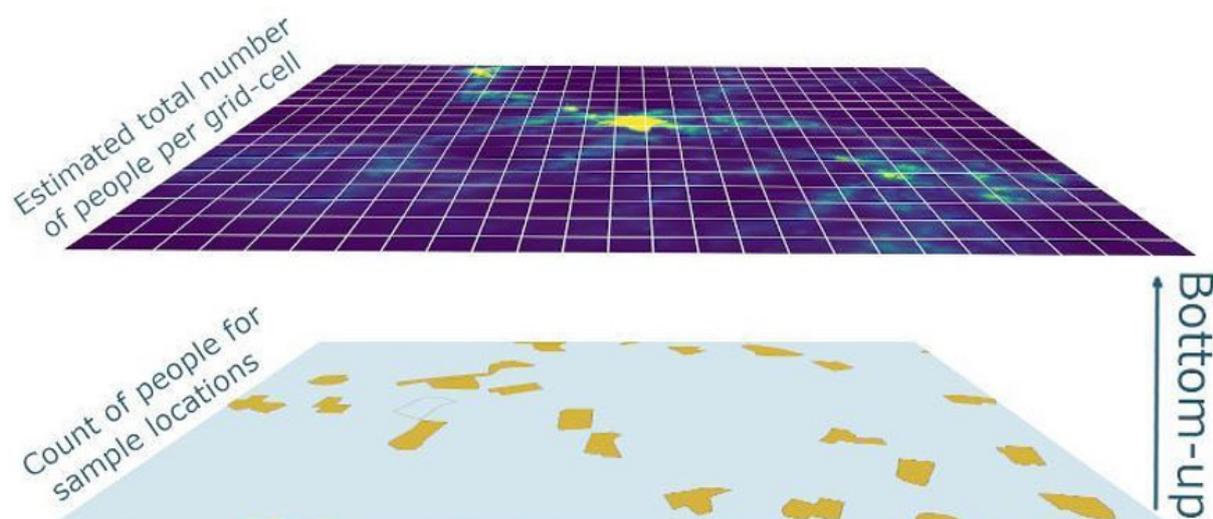


Bottom-up population estimation

When recent or reliable national population or census data are unavailable or lack sufficient coverage, estimates may be made using a bottom-up modelling approach. This method combines microcensus⁸ and/or recent household survey datasets along with geospatial data covariates, and applies Bayesian statistical models.

Bottom-up models provide uncertainty estimates, thus enabling more reliability and confidence in microplanning. For example, these population estimates from bottom-up models may allow the microplanning team to design vaccine distributions using a 95% credible interval instead of the most likely value. Bottom-up estimates are usually generated on an as-needed basis for the period in which the microcensus data were obtained, as they are based on bespoke statistical models, and thus require significant technical capacity, time and resources [18, 30, 31]. Further details on assessing and implementing such data can be found in section 6.6.2.2 and 6.8.2.2 respectively.

Figure R – Illustration of the bottom-up population estimation approach, using localized population counts and other geospatial data. (Source:[29])



8. A microcensus is a set of complete population counts collected within small areas that are sampled from across a country [32].

SECTION 6.3.3

Geographic accessibility, service location and route optimization models

Programme Designer	GIS Technical Staff
	

Geographic accessibility, service location and route optimization modelling are advanced modelling approaches that help microplanning teams assess and improve the planning, allocation and delivery of resources. This type of modelling can also help planners ensure that health service access is more equitable and cost-effective by identifying where to add service delivery points, redirect resources, or alter supply routes to better serve target populations.

The use of hand-drawn maps and reliance on community members for estimated travel times between two points can lead to sub-optimal routing and service location points, resulting in ineffective outreach plans that are based on inaccurate information. Geographic accessibility, service location and route optimization models help to overcome these hurdles by automating route optimization and providing accurate visualizations of coverage areas, target populations and more.

Purpose

The products resulting from the geographic accessibility, service location and route optimization models can serve many purposes:

- ⦿ Assess the coverage level of an existing service delivery network, for example, measuring the percentage of population located within one hour of a health facility.
- ⦿ Measure potential improvements in population coverage from proposed interventions, such as adding service delivery points or re-allocating personnel and resources.
- ⦿ Estimate the shortest travel time between different levels of health facilities, or redefine vaccination post strategies (e.g. outreach, mobile team). These models may identify alternative travel routes by taking into account road conditions and impediments (e.g. waterways, steep terrain).
- ⦿ Identify the most effective routes for routine operations along a transportation network, for instance transporting vaccines between warehouses and vaccination sites.
- ⦿ Optimize the placement of resources along a new service delivery network established to respond to an emergency or to implement a new programme.
- ⦿ Assess gender, age or ability equity in route optimization.

Audience

The products developed through modelling exercises are primarily used by the team developing the service delivery strategy, including logistical staff, district-level health coordinators and overall project managers. These team members should be involved in the modelling process regardless of their level of technical expertise with geospatial data and technologies. In some cases, modelled data may not be accepted by upper and lower levels of government. Involving government stakeholders in the modelling process can mitigate this risk. This could include allowing officials to help verify the accuracy of results, and participate in iterating data models.

Content and format

The products generated through the geographic accessibility, service location and route optimization models can include the following formats:

GIS layers containing:

- ⦿ spatial distribution of travel times from/to the nearest service delivery point (example in Figure I)
- ⦿ geographic extent of a modelled catchment area associated to a service delivery point (travel time or distance-based)
- ⦿ potential locations of service delivery points resulting from scaling up or optimization exercises
- ⦿ optimized route along a transportation network.

Tables and charts containing:

- ⦿ percentage of the population able to reach the nearest service delivery point within a given travel time or distance by administrative unit, health division or health area
- ⦿ travel time along the shortest path between two locations.



SECTION 6.3.4

Thematic maps

Programme Designer	GIS Technical Staff
	

Purpose

Thematic maps combine geospatial data and attribute data (e.g. information, statistics) to convey information about topics or themes in visual form. This could include maps that visualize the spatial distribution of a target population, available health services or changes in terrain. These maps can be especially useful, as the geographic dimension of a microplan is often easier to understand when represented on a thematic map rather than in spreadsheets or through text.

Thematic maps can be used to visualize and combine products from the other applications of geo-enabled microplanning. For example, a thematic map could show the location of objects from master lists, the distribution of an estimated population and/or the result of an accessibility optimization modelling exercise.

Thematic maps can be used throughout the entire microplanning process. Refer to the table in Annex G to learn more about how thematic maps can be used to address challenges in each phase of microplanning.

Audience

Thematic maps can assist various groups involved in microplanning as a coordination tool (see Annex G for examples). Maps for coordinating activities or developing daily plans will be useful to field teams and their supervisors, while operational overviews will be useful to project managers and high-level planners. In addition, well-made thematic maps can be useful beyond their intended audiences. A high-level overview map may help field teams understand how they fit into the larger strategy. It can be beneficial to distribute and display non-sensitive thematic maps to improve an operation's cohesiveness.

Content and format

The geospatial and statistical data for thematic maps should be adequately defined during planning. This ensures that the proper data is collected and assessed (see Section 6.6.2), and ensures that maps will be useful and relevant when produced. It is important to define the scale at which geographic objects will be represented on thematic maps, as well as the level of disaggregation at which indicators should be represented.

Scale refers to the geographic scope of information displayed on the map. If an intervention's point-of-service is at the household level, village-level scale maps showing buildings and landmarks may be necessary to create efficient daily plans and identify disease clusters. Meanwhile, maps at the regional- and district-scale level may be needed by programme managers to provide an operational overview of aspects such as security threats and logistical considerations. Note that higher-scale (more zoomed-in) maps, such as village maps, require more detail. As such, if there is a need to print maps visualizing a wide geographic area at a high scale, this may require large format printers, or printing and taping together multiple smaller pages.



Note:

For further examples of scale and disaggregation, see Section 6.6.2.3.

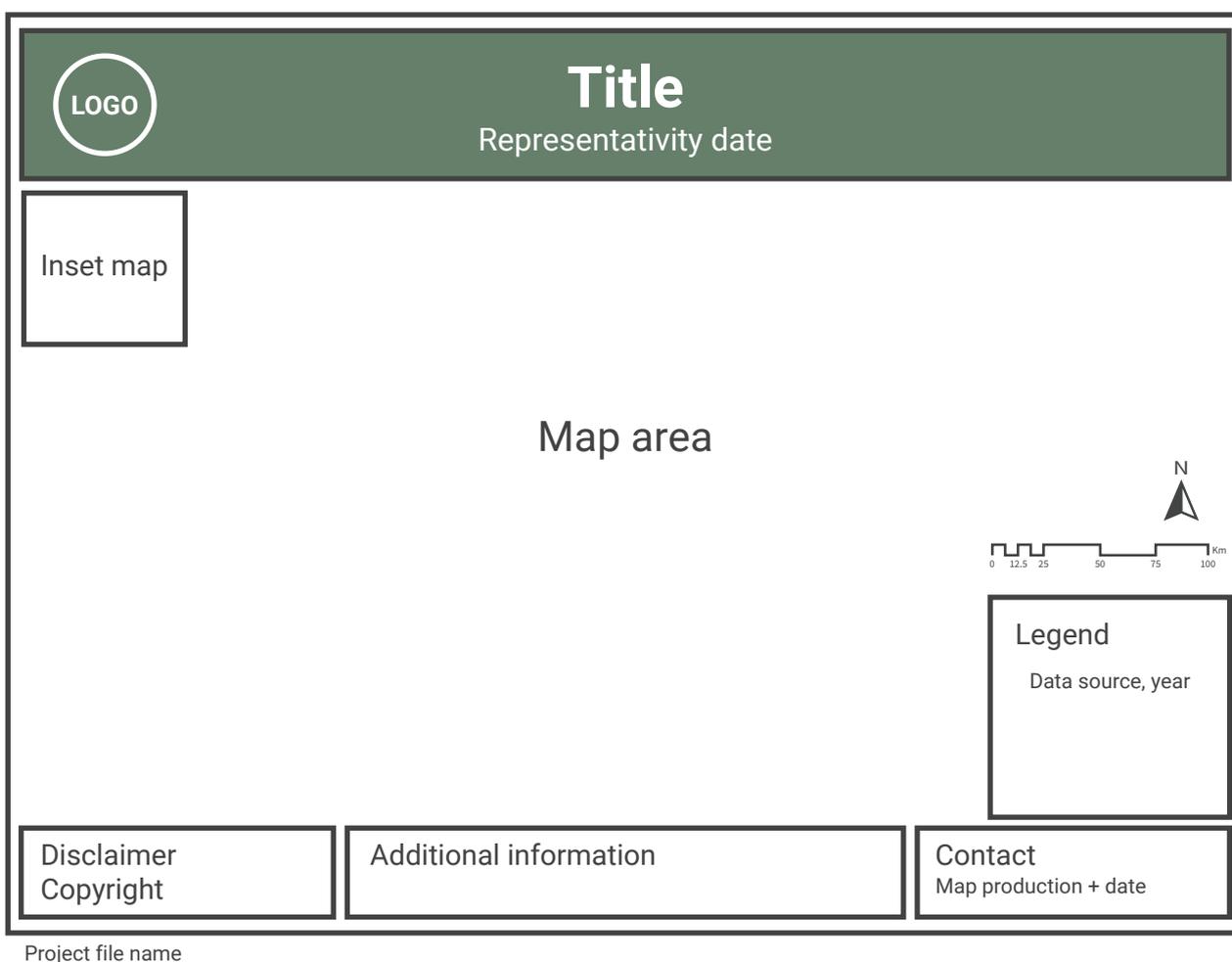
Disaggregation refers to the geographic level at which data is represented within or alongside maps. Disaggregation requires selecting a level (e.g. administrative units, health facility, household) and indicators to be represented (e.g. immunization status, nutrition).

The format for saving and sharing thematic maps depends on the map's purpose and the target audience's capacities:

- Paper:** A printed version of the map is useful when devices or Internet access are not available to view a digital version, such as during fieldwork, or when it is more practical for teams to discuss a large-size map on a wall or table.
- Digital:** Digital files are useful for sharing and saving thematic maps. PDF is the preferred file format for digital thematic maps, as the format enables any vector data on the maps to retain clarity and detail while zooming in or out, and because the files are often easier to print. Teams may also wish to export JPEG files of thematic maps for use in reports or sharing on social media.
- Webmaps:** Depending on technology used and access, dynamic versions of thematic maps can be shared in the form of webmaps. These webmaps may exist as standalone products or a dashboard component. Webmaps can be designed to allow users to turn layers on and off, change symbology colours and edit map data. They can also allow users to easily select and view particular districts or catchment areas within a larger map. Webmaps are different from geo-enabled microplanning platforms discussed in Annex H.

Regardless of their format, thematic maps should contain relevant data and information based on the microplanning phase for which they are used (Annex G) as well as standard cartographic elements (Figure Q, reviewed in depth in [6]). As microplan development and implementation progresses, planners should consider updating and modifying their thematic maps. See Section 6.8.2.4 for further thematic mapping considerations and examples.

Figure S – Standard cartographic element to make thematic maps usable. (Extracted from [6])



SECTION 6.4

Hardware and software to geo-enable a microplan

Programme Designer	GIS Technical Staff
	

This section provides broad guidance on the hardware and software needed to geo-enable a microplan. For detailed hardware and software considerations and technical specifications, see Annex H. Decisions on acquiring specific hardware and software will depend on the applications being implemented and will be based on resources and context. Annex H should be used as a reference during the assessment step covered in Section 6.6.1.

Hardware

- GNSS-enabled devices:** These devices are used to collect geographic coordinates in the field (if needed).
- Laptop or desktop computer:** Computers should be powerful enough to run selected GIS software programs. The choice between laptop or desktop depends on use and context. When opting for a laptop, it may be helpful to have an external keyboard, mouse and screen.
- Monitor (large-size or dual screen):** While not mandatory, a large-size monitor (above 21 inches/50 centimetres) or dual monitor setup can improve efficiency and map visibility for teams.
- Printer or plotter:** Small printers are useful across all applications, while large printers or plotters are particularly beneficial for producing large thematic maps. In addition to purchasing printers, consider renting a printer or printing maps at a print shop.
- External hard drive:** Hard drives safely back up GIS data files and store large-size files not accessible through the Internet.
- Online workspace:** An online workspace, such as Google Drive or Dropbox, is useful when working collaboratively, especially in the absence of an internal private network.
- Internet access:** A stable broadband Internet connection is required to access online workspaces, geo-registries and online resources, as well as to display and share collected data and thematic maps such as web maps⁹.

Software

- Desktop GIS software programs:** While a variety of desktop GIS software programs exist, QGIS (open source) and ArcMap or ArcGIS Pro (proprietary) are the most commonly used. Software choice should be driven by functionality and by the technical and financial context.
- Online GIS programs:** Online GIS programs such as ArcGIS Online (proprietary) or GeoNode (open source) can provide much of the same core functionality as desktop GIS programmes, but are usually not as fast and offer fewer extra features.
- GIS extensions and external tools:** Some processes may require the use of GIS extensions, which are additional functions or tools.
- Online mapping tools:** These mapping tools are different from online GIS programs, have limited analytical capabilities, and are primarily used to generate and share online thematic maps.
- Geo-registry:** An IT solution that allows storing, managing, validating, updating and sharing the master list and associated geospatial data for a specific geographic object.

9. <https://www.reach-initiative.org/>
<https://data.grid3.org/>

- **Spreadsheet software:** Spreadsheets manage data and information in tabular form and can generate tables and graphs to support different data products.
- **Field data collection app:** These apps help collect data during field visits, such as geographic coordinates or population statistics.

See Annex H for detailed hardware and software technical specifications.

SECTION 6.5

Technical expertise and skills requirements

Programme Designer	GIS Technical Staff
	

Geo-enabling the microplan and operationalizing geospatial technologies and their subsequent data products requires technical expertise and skills. Identifying which level of expertise and skills are needed is important at this stage in the process.

More specifically, at least one individual presenting the following overarching expertise will be needed independently from the applications of geospatial data and technologies being implemented:

- supervise the implementation of the geographic component of the microplan
- advanced use of the hardware and software specific to each application (Table 11 in Annex H)
- develop guidelines and standard operating procedures (SOPs)
- train people.

Some more specific and advanced expertise may also be needed depending on the country's context. This might, for example, be the case when there is a need to develop or contextualize spatial analysis protocols or models.

The technical staff to support the in-country work should themselves have, or have the capacity to learn the following technical skills, depending on the application of geospatial data and technologies they are meant to support in the geo-enabling process:

- use of the hardware and software specific to each application (Table 11 in Annex H)
- manage data across the geospatial data management cycle [33]
- collect data in the field (e.g. geographic coordinates)
- conduct spatial analysis
- apply spatial models
- create thematic maps.

In addition to the above, those meant to use the resulting maps should have the necessary skills to understand and interpret their content.

The anticipated level for each of these skills by application for both the central and subnational level is reported in Table 5. This table can be used as a reference to identify the skills that are currently available in the country, and then take actions aimed at filling the gaps identified.

Table 5 – Expected skill level needed to operationalize geospatial data and technologies covered by handbook at central and subnational (district) levels.

		Georeferenced master lists	Geographic accessibility, service location and route optimization models	Population estimates and spatial distribution	Thematic maps
Use of hardware and software specific to each application	National	High	High	High	High
	District	Low to moderate	Low	Low	Moderate
Manage data across the geospatial data management cycle	National	High	High	High	High
	District	High	High	High	High
Collect data in the field	National	High	Low	Moderate	Not applicable
	District	High	High	High	High
Extract geospatial data from basemaps	National	High	Low	Not applicable	Not applicable
	District	Moderate	Not applicable	Not applicable	Not applicable
Conduct spatial analysis and/or apply spatial models	National	Not applicable	High	High	Not applicable
	District	Not applicable	Low	Low	Not applicable
Generate information products (maps, tables, graphs)	Central	Not applicable	High	High	High
	District	Not applicable	Low	Low	Moderate
Understand and interpret the content of thematic maps	Central	Not applicable	Not applicable	Not applicable	High
	District	Not applicable	Not applicable	Not applicable	High

Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.6.1 Assessing level of geo-enablement across the supporting environment



SECTION 6.6

Assessing the geo-enablement level of a microplanning process

Programme Designer	GIS Technical Staff
	

It is important to gain a clear understanding of a country's progress towards fully realizing the nine elements of the geo-enabling framework (Figure B) as part of its microplanning process. Thoroughly assessing a country's geo-enablement level highlights gaps and opportunities across the first three stages of the framework, including in data, hardware, software and technical capacities needed to operationalize the applications covered by this handbook



MEL:

Thinking ahead: measurement, evaluation and learning

This assessment provides a baseline measurement of institutionalisation that can guide evaluation of, and investment in the sustainability of the geo-enablement process post-project (see Section 6.9.1).

6.6.1 Assessing level of geo-enablement across the supporting environment

Programme Designer	GIS Technical Staff
	

The first part of the assessment focuses on the elements of stage 1 (vision, strategy and plan, governance structure, policy, resources for sustainability) and stage 2 (specifications, standards and protocols, technical capacity and appropriate geospatial technologies) of the geo-enabling environment (Figure B). This initial part of the assessment also involves collecting preliminary information to be used during the second part, covered in the next section. Refer to Annex H when conducting portions of the assessment related to hardware and software specifications.

The assessment should cover the programme developing the microplan as well as other health programmes that may also use geospatial data and technologies, such as communicable diseases, immunization, or emergency management. It is recommended to begin the assessment with the health information system (HIS) before focusing on individual programmes, as this provides a broad overview of the ministry of health first.

The process and instrument for conducting this part of the assessment is documented in reference materials [5] and [18]. Review the following resources from these documents and consider for use in conducting the assessment:

- the benchmark expected to be reached for each of the elements in the framework (Annex 1 in [5] complemented by Table 5 in this handbook when related to technical capacity)
- a quick HIS geo-enabling assessment form to assess HIS capacity at the ministry level (Appendix E and Annex 2 in [18])
- a list of additional, complementary information and documents to be collected beyond the assessment (Appendix F in [18])
- an example assessment form that can be adapted to other programmes (Appendix G in [18]).

Depending on resources, the assessment can either be conducted via a survey (online or on paper), one-on-one interviews, or a workshop involving representatives from concerned programmes and key external partners (e.g. national mapping agency and/or statistical agency). An advantage of conducting a workshop is that participants can collectively validate information during the meeting.

It is important to note that some national governments may have established, or are working to establish, a national spatial data infrastructure (NSDI). In some cases the NSDI is developed in alignment with the United Nations' integrated geospatial information framework (IGIF) [10]. Both the NSDI and IGIF aim to develop, integrate, strengthen and maximize geospatial information management and related resources. The infrastructure and the framework can provide important information about the country's current situation for the assessment, especially regarding resources and data outside of the health sector.

The assessment should identify potential gaps across the seven elements of the supporting environment, which form the foundation of the HIS geo-enabling framework. Teams can then design activities to fill these gaps as part of the geo-enablement of the microplanning process. Refer to Annex 5 in reference document [5] and Appendix H in reference document [18] for guidance on the types of activities that could be implemented in this regard.



MEL:

Thinking ahead: monitoring, evaluation and learning

Including monitoring, evaluation and learning (MEL) advisors and other key staff in assessment discussions helps ensure that resulting objectives and outcomes can feed directly into the MEL framework. Inappropriate framing of either can result in unclear project directions, unmeasurable progress indicators, or other problems for MEL and project administration. See Section 6.7.7 for more information.



6.6.2 Assessing availability, quality and accessibility of data and information

Programme Designer	GIS Technical Staff
	

Developing a sound workplan involves assessing the availability, quality and accessibility of data and information needed to geo-enable a microplan. This includes identifying and documenting data gaps and determining how to fill them. In many cases, even if data do not meet all quality standards they can still add value for microplanning. It is therefore important to understand a dataset's specific shortcomings so that portions of the data that are adequately accurate can be used.

Data Needs

The content of the products identified in Section 6.3 will define data and information needs.

Table 6 provides the master list and primary geospatial data required to operationalize the other three applications covered by this handbook and to generate the products defined in Section 6.3 (adapted from [34]). Table 6 also indicates the typical governmental entity mandated to curate each of these lists and data.¹⁰ Note that the table represents minimum requirements and that some microplanning interventions may require additional data.

Table 6 – Core master lists and geospatial data needed for geo-enabled microplanning (adapted from [33])

Geographic feature	Master list	Geospatial data	Governmental source
Service delivery points	District	District	Ministry of health
Health areas and catchment areas	✗	✗	Ministry of health
Administrative units (down to lowest level)	✗	✗	Ministry of interior, national statistical agency, national mapping agency
Human settlements (e.g. cities, villages)	✗	✗	Ministry of interior, national statistical agency, national mapping agency
Points of interest (e.g. schools, market places, landmarks)	✗	✗	National mapping agency
Supply points (e.g. vaccine depots)	✗	✗	Ministry of health
Transportation network	Not necessary	✗	Ministry of public works, ministry of transportation
Hydrographic network	Not necessary	✗	Ministry of environment/agriculture
Population distribution (vector or raster)	Not applicable	✗	National statistical agency
Digital elevation model	Not applicable	✗	National mapping agency
Land cover/land use	Not applicable	✗	National mapping agency, ministry of environment/agriculture

Official lists are typically found within these government sources. However, it is important to consider open-source data in microplanning efforts if government data sources are not up-to-date, if a desired dataset is unavailable, or if an agency that collects these data is not willing to provide it.

In addition to the above, statistical data, programmatic information and other non-spatial input parameters are needed to conduct analysis, apply models and include data in thematic maps. Table 7 shows types of non-spatial data that are commonly used.

10. The name and exact mandate of the concerned governmental entity will vary from one country to another

Table 7 – Examples of statistical data, programmatic information and other non-spatial input data.

Data type	Description	Use	Governmental source
Population estimates and related statistics	Population estimates/spread, age, sex, employment, income, education, etc., disaggregated to lowest level possible	Population estimation and spatial distribution Contextual information on thematic maps	National statistical agency
Service delivery point information and statistics	Services offered, capacity, type, presence of cold storage, accessibility to electricity and/or clean water	Geographic accessibility Contextual information on thematic maps	Ministry of health
Previous campaign data	Coverage data from previous campaigns (e.g. indoor residual spraying, insecticide treated net distribution)	Determine campaign prioritization	Ministry of health
Programmatic data	Outbreak data (e.g. malaria or measles outbreaks)	Determine campaign prioritization	Ministry of health
Budgeted resources	Available resources for the health intervention (e.g. supplies, financial)	Determine resource allocation	Ministry of health
Security concern	Type of security concern	Determine campaign feasibility	Ministry of health, Ministry of interior
Travel scenario	Transportation mode, speed of travel	Input parameters for geographic accessibility, service location and route optimization modelling	Ministry of public works, ministry of transportation, ministry of health
Campaign target	Not necessary	Input parameters for geographic accessibility modelling	Ministry of health

Finally, basemaps are needed to provide background detail to orient the location of the area in thematic maps and, in the case of satellite images, to assess the quality of geospatial data by serving as ground reference.

Data compilation

Once all needs are identified, the compilation of available data, information and input parameters can take place. Available sources can live in large databases in the cloud, hard drives, DVDs, tabular databases, or in electronic or printed versions of documents or maps. Each format presents its own challenges, and additional technical work might have to be performed on the data (e.g. digitizing) before using it in the assessment and to support the microplanning process.

The review of available sources should collect as much contextual information as possible about each source, ideally captured in associated metadata. This contextual information should help answer the following questions [34]:

- What is the data about? This information is generally captured in the source's title and description or abstract.
- Who created the data? Different parties might be involved in creating, updating and sharing a dataset.
- When was the data created/collected/last updated and what is its temporal validity? See the data consideration sub-sections in 6.6 for more details.
- How was the data created? The process used to create a dataset can provide valuable information regarding its intended purpose, quality and methodological limitations.
- What are the data specifications (e.g. geographic coordinate system/projection system, scale, accuracy)? This is critical information when using geospatial data, especially when combining it with other datasets for a specific application.

- Are there any access, use or redistribution restrictions or limitations attached to the data? Just because a dataset is available online does not necessarily mean that it can be used and/or redistributed. At a minimum, many datasets require acknowledgement of the author. Other restrictions or limitations might be documented in different parts of the metadata (access constraints, use constraints or the disclaimer). Data accessibility in this case should be evaluated against the intended use case and microplan implementation, to ensure that information can be easily accessed and shared between necessary groups and implementers.
- Who can I contact if I have questions about the data? It can be helpful to have a direct contact at the organization providing the data to resolve any issues.



Note:

Note that while priority should be given by default to official and hence “legitimate” data, data generated by non-governmental entities, multilateral institutions or open data initiatives may be more appropriate than, or complementary to official datasets, as long as these datasets are trusted by the programme implementing the microplan. See the considerations at the end of this section for more on this topic.

Collaboration with peers possessing datasets of unique value or additional resources can help fill data gaps in certain cases. For example, many private sector companies are increasingly sharing anonymized datasets created from user traffic with governments, nonprofits and development actors on a case-by-case basis.¹¹ However this type of collaboration can be time consuming and may not be successful. If an outside actor has a reliably high-quality dataset and a demonstrated interest in sharing, it may be worth pursuing such a collaboration. Otherwise, be careful about investing too much time or hope in what could be an uncertain outcome.

In some cases, useful data can be purchased from specialized spatial data providers. This should be approached with caution, as purchased data can be costly and may come with restrictive licenses preventing further distribution of the data and/or derivative products (maps and other datasets). Pay close attention to data origination to ensure they come from a reputable provider. To examine data quality before purchasing, it is recommended to ask to view a PDF version or sample of the data first. It may also be necessary to wait until the budget for geo-enablement has been approved (Section 6.7.6) before purchasing data.

Annex D of reference [18] provides a non-exhaustive list of resources for core spatial data-related information to which the following can be added:

- the 2021 GRID3 Core Spatial Data for Sub-Saharan Africa¹²
- the Second Administrative Level Boundaries¹³ dataset of authoritative, curated administrative units of UN Member States (including historic changes)
- geoBoundaries¹⁴
- POPGRID data collaborative¹⁵ pointing to population, settlements and infrastructure datasets.

11. Examples include Facebook’s Data for Good initiative, Google’s COVID-19 Community Mobility Reports, and the Development Data Partnership coordinated by several multilateral institutions

12. GRID3 Core Spatial Data for Sub-Saharan Africa

13. www.unsalb.org

14. <https://www.geoboundaries.org/>

15. <https://www.popgrid.org/ciesin>

Evaluating data

Once all available sources are compiled and organized, the next step is to assess their quality. This includes considering methodologies used in collecting the data in order to understand the intended purpose of the dataset and its limitations, as well as to identify gaps.

Assessing the quality of data sources is critical because final products built from low-quality data will misdirect resources in microplanning. For example, if inaccurate data are used to model the spatial distribution of a target population, the resulting data products will be inaccurate as well and may lead the microplanning team to make ineffective decisions on resource allocation. Data managers will therefore need to decide which data sources best balance accuracy with time and resources.

An assessment should cover the six dimensions of data quality shown in Table 8 [15].

Table 8 – Data quality dimensions

Data quality dimension	Definition
Completeness	State of having all the necessary or appropriate parts (no data gaps)
Uniqueness	Quality of being the only one of its kind (no duplicates)
Timeliness	Degree to which the data represent reality from the required point in time (the data is not too old)
Validity	Conformity to the syntax of its definition (format, type, range)
Accuracy	Degree to which data correctly describes the “real world” feature or event being described (geographic coordinates aligning to the correct location, statistics or information corresponding to reality)
Consistency	Absence of apparent contradictions (spatial and temporal alignment between data and information sources)
Purpose	The dataset meets the needs and intentions of the microplanning process (e.g. input data are recent and appropriate, with no missed or underrepresented populations)

The following subsections cover how to evaluate these six dimensions for the master lists, statistical data and geospatial data.

The result of this assessment should be combined with other information collected during the compilation process (data source, access, use and redistribution constraints) to identify which of the compiled sources are:

- suitable and ready to support the microplanning process
- worth the effort to correct or enhance during project implementation.

Input parameters such as travel scenarios or campaign targets should be developed separately from this assessment by using participatory consultations with concerned stakeholders. Travel scenarios should be consistent with the final land cover/land use and road classifications in corresponding geospatial datasets.

Programme Designer	GIS Technical Staff
Continue to 6.6.2.3 Assessing geospatial data	Continue to next section



6.6.2.1 Assessing master lists

Programme Designer	GIS Technical Staff
	

Ideally, a master list would exist for all geographic features relevant to public health in general and the microplanning intervention in particular. Unfortunately, this is typically not the case. In some situations, several different lists may exist for the same geographic feature and may be maintained by different government agencies. In this case, each list should be assessed separately for quality across the six dimensions referenced in Table 8. The lists should then be cleaned and merged before identifying outstanding gaps to address during project implementation. This exercise should ideally be based on the data elements captured in the final data dictionary defined for each master list (Table 3).

Once all available and accessible lists are compiled, the quality assessment process can begin. Step 4 of reference [8] outlines the process and questions that this assessment should answer in the context of developing a national master list for community health workers. This process can easily be adapted to other use cases beyond community health workers.



6.6.2.2 Assessing Statistical data

Programme Designer	GIS Technical Staff
	

Statistical data can exist as both geolocated and non-geolocated information that has been collected and aggregated or inferred and exposed through analysis of varying sources. Population data for example can consist of census information that has been enhanced with population estimation modelling and socio-economic modelling outputs to generate a coded categorization for geographic regions. These regions can be associated with the data nominally, perhaps by a label designating the correlated administrative area, or more directly by the inclusion of coordinates.

While assessing the accuracy and timeliness of the statistical data in general is beyond the scope of this handbook, assessment of the statistical data for completeness, uniqueness and consistency remains relevant in the geo-enabled microplanning context.

Population estimates and related statistics

Population statistics are particularly relevant to geo-enabling microplans and can often be readily integrated into master lists and paired with geospatial data to inform planning decisions. Due to their importance in microplanning, population statistics have been utilized below as an example of the process for evaluating the six quality assessment dimensions of statistical data.

Primary challenges of population data assessment, and questions to ask during data assessment:

1. Completeness

- ⦿ Are there recent census, survey, Civil Registration and Vital Statistics (CRVS) or health facility headcount¹⁶ datasets that were reliably collected?
- ⦿ Is full country coverage available?
 - ▶ If so, the data can be used for a top-down modelling approach.
- ⦿ If full country coverage is not available, are there census, survey, CRVS or health facility headcount datasets available that have reliable estimates?
 - ▶ Incomplete or facility-specific datasets can still be utilized with a bottom-up modelling approach to fill population data gaps.

2. Uniqueness

If multiple data sources present different values for the same statistics, the planners conducting the assessment must evaluate data provenance and quality as it pertains to the other five quality dimensions. To avoid duplication and potential conflicting information, planners should identify the more accurate resource or determine if a strategic combination of statistical data is necessary.

3. Timeliness

Timeliness includes ascertaining when the last date of collection of the dataset took place, and if it is recent enough to produce a reliable population estimate or needs to be updated. If recent census data based on a complete enumeration of the country are available, these are often the best choice for population estimates and denominators¹⁷. National census data are ideally collected every ten years, but these are often outdated due to significant changes in population distributions over the course of a decade or more.

There are different ways to estimate population when the census data available are outdated. National Statistics Offices produce “projected” population estimates, which are estimates that fill the gaps between census years. However, not all these estimates are suitable for microplanning as they may lack the required resolution or may not account for impacting factors. Careful review of temporally projected data should take place to ensure they meet the standards required by all data quality dimensions.

4. Validity

Assessing validity involves determining if the statistical population data source contains the information it is intended to in a logical format. In addition, teams need to evaluate if the statistical data is available in a usable spatial format, or can it be easily converted into such.

Other questions include:

- ⦿ Are the features and their attributes properly associated?
- ⦿ Are there broken relationships within the data source or missing identifiers?

16. Health facilities may choose to use their own headcounts, which are typically tied to a catchment area. It is important to ensure that the catchment area that the facility has delineated is the same as the catchment area in the map, which could be modelled. If the catchment area in the map is not the same as the facility's, the facility headcount will not accurately represent the population in the map's catchment area, meaning that a different population dataset may have to be used.

17. The population denominator is the total target population that would be used to model estimates across the region of interest.

5. Accuracy

To assess accuracy, determine if the statistical data are representative of known “real world” information. Other questions to ask include the following:

- ⦿ Does the population data align with trusted sources of truth? For example, a modelled population estimation that represents recent population data should be compared to historical census, recent CRVS or another trusted data source to ensure the projection is reasonable.
- ⦿ Are the data collection methods reliable/trusted by stakeholders? An understanding of data provenance is beneficial to ensure data collection processes and quality assurance meet the necessary standards to generate reliable and useful population statistics.

6. Consistency

Teams should assess if the information contained within the statistical data agrees with itself. This includes asking if the statistical data are free of contradictions or information that could conflict with integrated data sources. For example, projected population data often do not account for migratory and displaced populations, and there are often discrepancies between the original administrative boundaries generated with the census, and the new projected numbers. If these projected statistical data were combined with more recent geospatial administrative boundary data, the population distribution would be misrepresented, potentially leading to misallocation of resources.

7. Purpose

To evaluate purpose, consider if population data is at a high enough resolution to be considered useful for the microplanning exercise. Population data can be collected or aggregated to an extent that excludes information required for successful deployment of the microplan. This aggregated statistical data may be useless when combined with geospatial data and master lists, as it provides no unique information that can be used to differentiate and categorize the data. For example, the population and demographic statistics for a country-level study would not be used to deploy a localized microplan within the country, since the demographic and population data could be significantly different within a settlement or village than the country averages.

In addition, ensure that statistical population data resolution aligns with the fidelity of the microplan so that the target populations are reached and no groups are excluded. This includes determining if the dataset is representative of the entire target population. Just as the statistical data can be aggregated beyond usefulness geographically, statistical data can over-generalize population and demographic information regardless of scale, leading to incorrect assumptions about the populace. Biases in data collection, or variances in demographic participation in studies can influence statistical data, skewing the resultant information.

Assessment of statistical population data can lead to valuable information such as the insights captured in the following table.

Table 9 - Common population data sources: their advantages and disadvantages (adapted from [35]).

Dataset	Advantages	Disadvantages
National census	<ul style="list-style-type: none"> Can be reliable and fully representative of the population 	<ul style="list-style-type: none"> While census data are ideally collected every 10 years, they are often not completed that frequently
Household Survey (HHS) - Demographic health surveys (DHS), Multiple Cluster Indicator Surveys (MCIS)	<ul style="list-style-type: none"> HHS and DHS provide direct estimates of indicators needed They include measures of uncertainty, and are highly representative of the target population. 	<ul style="list-style-type: none"> Often collected every 5 years, and not necessarily synchronised with the reporting requirements of long-term international targets and national health interventions plans Not necessarily representative at geographic administrative unit levels used for microplanning.
Civil Registration and vital statistics (CRVS) data	<ul style="list-style-type: none"> Include details on important health indicators needed for microplanning 	<ul style="list-style-type: none"> Often unavailable or of poor quality
Projected population estimates (from census or survey data)	<ul style="list-style-type: none"> More temporally accurate population estimates Can account for fertility and mortality rates to have a more accurate estimate Higher resolution estimates when generated using top-down or bottom-up approaches 	<ul style="list-style-type: none"> When generated by the national statistics office, they may only be estimated at the highest subnational administrative level (coarse resolution) Can introduce temporal discrepancies between the date of administrative boundary updates and the year the data are projected.

For more information regarding the considerations on population data for microplanning, see 6.8.2.2.

If the available statistical data are determined through the assessment to be incomplete or outdated, additional data collection for the microplanning area of interest may be considered if time and budget allow.

6.6.2.3 Assessing geospatial data

Programme Designer	GIS Technical Staff
	

While geospatial data can take many forms, they can generally be defined as any piece of information that can be associated with a geographic location or area. Often, satellite imagery and sensor data are used to generate new vector geospatial data that can then be attributed with information related to that geographic location and stored in a geo-registry. The quality of these derived data can be heavily impacted by the scale of feature extraction and the quality of the source satellite imagery.

Geographic features in a GIS – referred to as geographic objects or geo-objects – are represented in either raster or vector data formats.

Vector data

The vector data format is used to represent geographic features that have discrete start/end points or finite geographic extent on the Earth's surface. Vector data are not restricted by pixel resolution and can be modified and adapted to any scale. Vector features consist of a series of geolocated coordinates that can be displayed in collections as lines or polygons, or singularly as point features.

Figure T – Types of geographic vector features.



Examples of geographic features captured in vector format are:

- health facilities as points
- catchment areas as polygons
- road datasets as lines.

Raster data

The raster data format is used to represent geographic features that are continuous on the Earth's surface, meaning that there is a value for every geographic position within the extent of the data bounds. Raster data is digitally structured as a series of equal-area pixels, or cells. Most often, raster data are collected via remote sensing¹⁸, but may also include secondary GIS data products that summarize vector data or a series of various data inputs into equal-area cells.

Examples of geographic features captured in raster format are:

- satellite, aerial or drone-derived imagery
- remotely-sensed products (e.g. digital elevation model, precipitation models)
- spatial distribution of a population.

Assessing the quality of available geospatial raster and vector data across the six dimensions is best done using benchmarks captured in the data specifications, as well as remote sensing imagery and master lists as sources of truth (Table 10).

18. Remote sensing is defined as collecting and interpreting information about the environment and the surface of the Earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the Earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote sensing methods include aerial photography, radar and satellite imaging. See Glossary in Section 5.

Table 10 – Instrument (data specifications, ground reference) being used to assess geospatial data quality across its 6 dimensions.

Data quality dimension	Data specifications	Ground reference	
		Satellite imagery	Master lists
Completeness		✓	✓
Uniqueness			✓
Timeliness	✓	✓	✓
Validity	✓		✓
Accuracy	✓	✓	
Consistency	✓	✓	✓

Please refer to [15] for a detailed account of the measures and information associated with each of the data quality dimensions, and considerations for selecting appropriate satellite imagery for the assessment. Annex E provides questions that should be answered across the six dimensions of data quality during the assessment, and this for both vector and raster format geospatial datasets.

Through the field of Earth observation, the planet is continually being observed and imaged by government and commercial satellites (e.g. WorldView, Landsat, IKONOS). The following criteria should be considered when deciding on the most appropriate satellite imagery:

- Spatial Resolution - What is the amount of detail needed in the imagery for it to be useful? This is measured by the size of one pixel on the ground. High-resolution imagery (30cm - 5m/pixels) captures small details in high quality (e.g. individual structures like homes and vehicles) but often comes at a high price point. Lower resolution imagery (10 - 60m/pixels) only captures larger ground features (e.g. rivers, urban boundaries, agricultural fields) but is often free/open source.
- Temporal Resolution - How recent does the imagery need to be for it to be relevant to the use case? Pay attention to the collection date and consider if the image is outdated and no longer represents the geography in an accurate way. For example, if you are using satellite data found in the open domain, such as Google Earth backdrops available in QGIS, note that different images have different timestamps. Images that cover the same catchment area may have been taken at different times.
- Cloud cover and other obstructions - How clear does the imagery need to be for it to be useful? Aspects of the imagery could include cloud cover, smoke, or haze that may obscure ground features. Depending on the use case, these obstructions can be worked with or, in some cases, render specific imagery useless.

Recently, medium resolution (10 - 30m/pixel) satellite data have become increasingly cheap, or even open source and freely available. Depending on the specific use however, this imagery may not be useful.

The quality and currency of the imagery selected can often correlate directly to the usefulness of derived vector geospatial data. Low quality sources can lead to data aggregation issues and inaccurate representations of spatial information related to ground references. Alternatively, high quality sources of imagery can be used to validate the accuracy of existing vector datasets to ensure utility and applicability to the targeted use case.

Figure U illustrates the importance of the data specifications and ground references in assessments by overlaying two sets of administrative unit boundaries on a satellite image used as a ground reference (See [15] for further reference):

- for work at a scale of 1:250 000 (~130 metres positional accuracy) both sets of boundaries would be suitable
- for work at a scale of 1:50 000 (~26 metres positional accuracy) only the first dataset (Figure T.a) would be suitable.

Figure U - Illustration of the suitability of two administrative unit boundaries datasets based on the scale of work defined in the data specifications¹⁹.

A



The vector data (road) aligns with the road in the satellite image below.

B



19. Maxar Open Data Program imagery over Dhaka, Bangladesh Provided with CC BY-NC 4.0 licence.

In the above example, the vector data may have been mapped to a different scale or imagery layer and do not align perfectly with the road in the satellite image. However, in most cases the data can still be used.



Note:

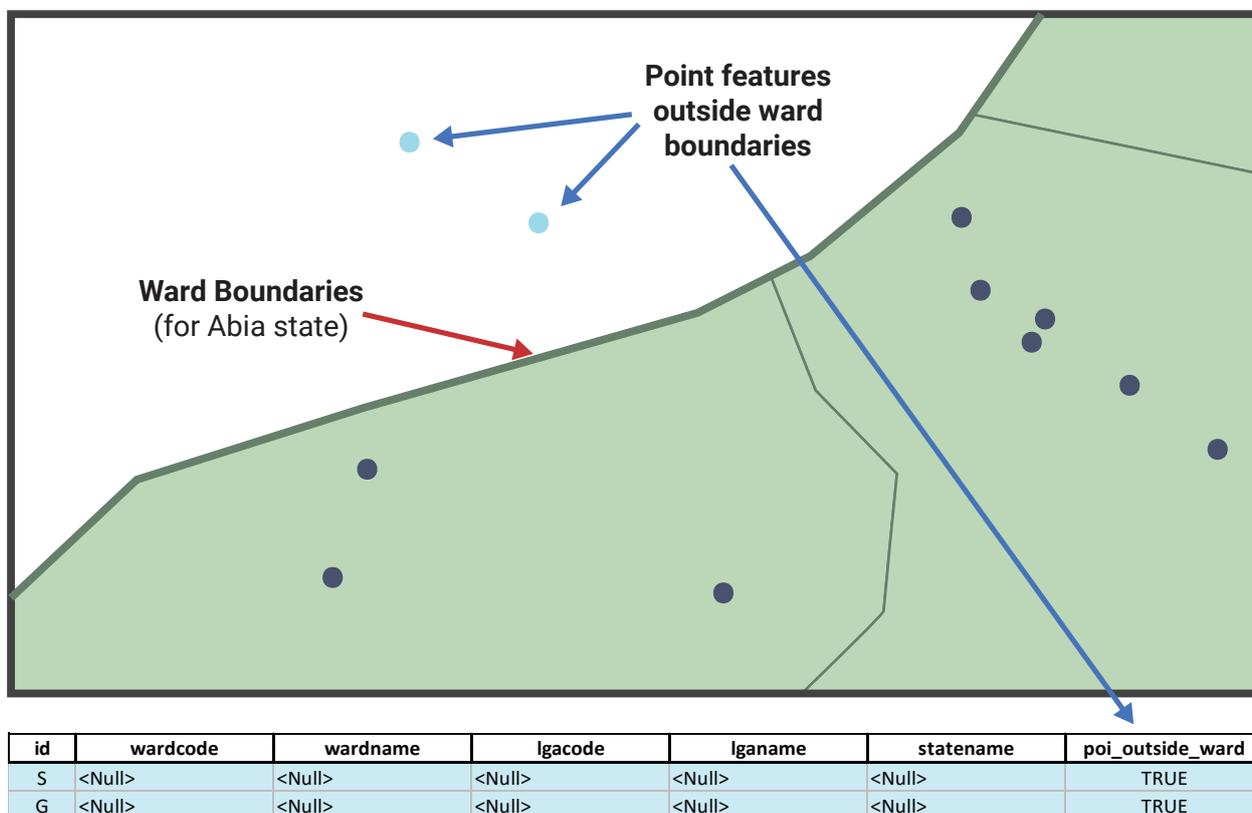
Note that the possibility to use master lists during this assessment will itself depend on their assessed availability and quality.

The final data specifications, choice of satellite images, and references to all master lists should ideally be captured in guidelines used by the ministry of health. See reference [36] for an illustrative example of guidelines developed for the Ministry of Health and Sports of Myanmar.

Once these guidelines are ready, different sources of geospatial data can be assessed as per Annex 1 of reference [34].

Boundary datasets should be used cautiously when assessing the positional accuracy of point data – very often boundaries are either incorrect or insufficiently accurate, due to the scale at which they have been generated for example, to compare with geographic coordinates collected via a GNSS-enabled device. Figure V illustrates this situation by showing two points located close to, but outside of the ward in which they are supposed to reside, but this could be linked to an issue with the level of accuracy of the ward boundary and not an issue with the geographic coordinates of the two points in question, especially if an appropriate SOP has been followed during data collection.

Figure V – Potential confusion resulting from a difference in accuracy between a boundary and a point dataset.



If properly documented, the standard operating procedure (SOP) or method used to generate the geospatial data can also provide information about its quality. A few things to look at in particular in such documentation include: (see Section 6.4.1 and reference [14] for more details):

- Geographic coordinates collected using a GNSS-enabled device:** While this is a reliable source of spatial data for geographic objects represented by a point, it too can have errors and be inconsistent. This is for example the case when different models of devices have been used, or if the GNSS receivers have not been tested to identify if some of them were defective. Inconsistencies can also occur if the coordinates have been collected by several independent field teams, integrated into team-specific spreadsheets, and then later manually integrated into a combined dataset. Coordinates located in a “near” location (e.g. the far side of a river or parking lot due to lack of access) may be a problem depending on data specifications for accuracy.
- Geospatial data extracted manually from satellite imagery:** These data can have very low completeness or accuracy depending on imagery’s own horizontal accuracy, cloud coverage and/or resolution relative to the size of the target geographic object. Geographic coordinates might be associated with the wrong building if manual extraction is conducted without the presence of someone knowledgeable of the area.
- Geospatial data extracted from satellite imagery using machine learning:** As for manual extraction, the result of this kind of method depends on the satellite imagery being used (horizontal accuracy, resolution, cloud coverage). It is also important to have information on quality assurance and quality control for such data products. This may require some reading of methodology notes and/or background knowledge on the correct interpretation of the quality metrics.
- Digitizing from paper maps:** While digitizing tables are not often used nowadays, it can sometimes happen that the only way to generate geospatial data is by scanning a hand-drawn or previously printed map and digitizing its content using a GIS software. The quality of the resulting data will depend not only on the scale of the original paper map and the quality of the scan, but also on the quality of its georeferencing and orthorectification (the process of converting images into a form suitable for maps by removing sensor, satellite/aircraft motion, and terrain-related geometric distortions from raw imagery).
- Crowdsourcing:** Crowdsourced data input by volunteers into platforms like OpenStreetMap can be of excellent or poor quality, potentially within the same dataset. If this method has been used outside of these platforms, then very good guidance and quality control measures must have been taken to ensure consistent and high quality. Nevertheless, do not hesitate to consider crowdsourced data – it is frequently an excellent backup – but do expect to devote additional attention to quality assessment and control on such datasets, as they rarely are perfect for the area of interest.

Programme Designer	GIS Technical Staff
Continue to 6.7 Developing the work plan	Continue to next section

6.6.2.4 General data considerations

Programme Designer	GIS Technical Staff
	

Temporal accuracy

Temporal accuracy (data age) can significantly impact the utility of geospatial information for a microplanning initiative. Out-of-date information can lead to ineffective resource allocations and exclude critical populations. As such, evaluating temporal accuracy is one of the first steps in assessing a potential source of geospatial data. The following questions should be asked when evaluating a dataset’s temporal accuracy:

- ⦿ **What is the appropriate tolerance for temporal accuracy?** Prior to the temporal evaluation of data, it is critical to identify the data currency that best balances error avoidance within the microplan with pragmatism and data availability. This will likely vary depending on the data type and application. For example, vaccination sites may require data that is less than a year old, while population statistics may be acceptable within a two-to-five-year window. Note that because geospatial data takes time to produce it is rarely perfectly temporally accurate.
- ⦿ **When was the data originally produced?** While the data may have been updated or enriched since the original production date, this question provides the age of the oldest features that may still exist in the dataset. A clear answer will give insight into potential data anomalies and temporal gaps.
- ⦿ **When was the data last updated/enriched and to what extent?** Understanding any enrichment and maintenance that may have taken place since the original creation of the data will provide a more comprehensive picture of data value. Note that updates may only have been performed on specific regions of interest or a particular set of features or data elements, implying spatial and/or temporal inconsistencies in resulting analyses.
- ⦿ **How does the age of the data impact its serviceability?** While old data is often not useful, there are cases in which age is not problematic. For example, if a database containing administrative boundaries exists, and local/government knowledge states that these boundaries have remained static for the last 10 years, the data source is most likely still appropriate for use. Old data can also be used analytically to track changes over time when paired with newer sources. Data should not be discarded based only on age. It should be evaluated against the use case to see whether it can add value.

Official data versus Open datasets

Analysts and planners undertaking geo-enabled microplans must decide whether and when to use official or open spatial data sources. Official data sources will always provide the bedrock data of most spatial analyses, but growing investment has led to a sharp rise in the quantity and quality of openly available spatial data.

Official data sources carry several powerful advantages. First and foremost, they are the fundamental sources of truth for government-established entities like administrative boundaries, master lists of facilities, and population registries. Moreover, they may present information difficult or impossible to collect without government resources, such as links to highly granular demographic information collected during a census. Data endorsed by a government is inherently legitimate in the eyes of government (and most other) partners, and plans based on alternative datasets may not be as easily accepted.

Set against these advantages are several potential drawbacks. Official data may be low quality where lack of resources, low capacity, or access constraints inhibit data collection. In some cases there may be multiple “official” datasets for the same type of feature from competing government departments. This requires the identification of which of these entities has the official curation mandate over this dataset and therefore is appropriate to use.

In cases where governments cannot freely share data, access permissions may pose a formidable obstacle to effective use. Official channels for granting permissions, through a data sharing agreement for example, may be poorly or not at all documented, even between government departments, and in practice may require patient relationship building. Even when usage permissions are granted they rarely permit further sharing or access to future iterations of datasets, complicating outside collaboration and the replicability and sustainability of the work.

Open datasets offer distinctive tradeoffs with official data sources. Most notably, they usually can be accessed instantly online, and for free²⁰. This not only speeds up the project’s setup but also enhances its sustainability, as continued access and shareability are predictable. Open datasets are also frequently built to the latest standards in data formats, access methods, and analysis capabilities. As global datasets, their data models and methodologies are often well known and sophisticated tools, templates, and techniques for their analysis may be publicly available. For instance, tools for optimizing routes over OpenStreetMap road networks are available in most GIS desktop software packages, and many spatial analysts are familiar with how to assess the quality of a given country’s WorldPop datasets.

20. For open population data sources, please consult the GRID3 Data Hub and WorldPop:
<https://data.grid3.org/>
<https://www.worldpop.org/>

Open datasets also offer unique opportunities to improve the data and create sustainable public goods in the process.²¹ Because the resulting data is open, this creates sustainable leave-behinds for future microplanning exercises, other development actors, and the local private sector to leverage.

Open data is not without its weaknesses. Data may be of low quality, either in terms of attribute completeness, spatial accuracy, or consistency between locations. Such data problems may not be immediately obvious to non-specialists, particularly for data created via machine learning “black boxes”, raising the potential for uncomfortable surprises during fieldwork. Additional validation effort may therefore be necessary to assure collaborators of open datasets’ fitness for purpose.

In practice, the choice to work with official or open data is rarely binary, and the best path is usually some combination of both. Open data often usefully complements official data, filling gaps in quality or simply offering useful validation. However, analysts should be aware of a few tricky issues that can emerge.

First, datasets may clash in ways that require manual alignment. Contrasting building footprints or land cover data may require manual rectification, and road and river topology from different sources may not connect, complicating routing. Attributes present in one dataset may not be present in another, may be from a different time period, or may have been collected in a materially different way (differently phrased survey questions for example). Some open data sources like OpenStreetMap require that data products derived from their data are equivalently open access and almost all require public attribution. Last but not least, any data that is either coming from a non-government source or generated by combining government with non-government data will have to be trusted and endorsed by the programme developing and implementing the microplan.



Summary:

When choosing which datasets, the following should be considered:

- **Does government endorsed geospatial data exist?** If yes, which department is it with? Different datasets may be located in different ministries and departments.
- **Is the government data accessible?** Governments may or may not share their data between ministries. Data sharing agreements may need to be established. This needs to be planned well in advance.
- **Does the central level allow the use of non-government endorsed data in microplanning?** Facility headcounts may be allowed even if they are not inline with official population data from the statistics office.
- **What is the quality of government data available?** Depending on when a census happened in the country, population data may be inaccurate, or if new administrative units were created there may not be an updated boundary dataset available.
- **If government data are not available or accessible:** Global datasets can be used for microplanning.

For a list of open population data sources consult GRID3, WorldPop, OpenStreetmap, and Facebook road data²².

21. The popular OpenStreetMap platform even has a structured program, the Missing Maps program, for marshalling digital volunteers to improve mapping data in support of developmental and humanitarian goals

22. <https://data.grid3.org/>
<https://www.worldpop.org/>
<https://www.geoboundaries.org/>
<https://github.com/facebookmicrosites/Open-Mapping-At-Facebook/wiki/Available-Countries>
<https://download.geofabrik.de/>

Data privacy

Data privacy refers to the principle that individuals possess the right not to have personal details collected about them exposed without good cause and informed consent. Appropriately balancing microplanning necessities with individuals' and groups' data privacy during geo-enabled microplanning exercises requires foresight and deliberate action. Most importantly, individuals' personal data should never be exposed in any way that could result in harm to them or others. Particularly sensitive health data might include disease, immunization status, disability, ethnicity, religion, age, relationships to others, or home and work location; anything an individual might reasonably not want exposed to the wider world. Relevant principles of data privacy include data minimization (only requesting necessary data), storage limitation (discarding data when it is no longer needed), purpose limitation (using data only for its intended purposes), and limiting transfers of and access to sensitive datasets. Readers interested in a more complete account of data privacy standards and best practices in the context of public health should refer to WHO's recent policy note on this subject [37].

Under prominent data protection standards like the European Union's General Data Protection Regulation, public health interventions such as microplanning generally justify some level of data privacy flexibility given their public benefits. However, justified usage of personal data does not imply usage without constraints: planners still must adopt responsible data privacy policies and adjust their workflows, datasets, and visual products accordingly to minimize the chances of data leakage or accidental harm to beneficiaries. This is particularly important given the ease of redistributing and repurposing visual information products like maps.

First, those in charge of developing the microplan should review the local legal data protection framework to be aware of any binding constraints on data usage and exceptions for public health interventions, if any. Based on this review, they should design data management and visualization practices that will comply with local legal frameworks and global data privacy standards. Common such practices are reviewed below; to avoid mishaps, a formal data privacy review step should be included for all data preparation and visualization steps (e.g. map production) in the microplanning process.

Anonymization, pseudonymization, aggregation, and access control are the most common data privacy management techniques for GIS data used in public health interventions. Anonymization refers to removing any identifying information from individuals' data records in such a way that they can never be "re-identified" by name, location, or otherwise. In cases where a valid need for re-identification exists, pseudonymization substitutes an ID code for individuals or communities in most records; when re-identification is necessary, reference can be made to a separate key linking each ID to an individual or community's necessary identifying information. In cases where individual data is sensitive but community or administrative data is not, aggregating sensitive data points per administrative unit, health facility catchment, community, or other reference point can protect data privacy while providing necessary information. Regardless of the data management practices used, planners should seriously consider establishing an explicit "need to know" policy for some or all datasets and ID keys, defining permissions for data access by position, and if possible reflecting these permissions in local IT systems via passwords and shared folder permissions. If using mobile data collection systems during fieldwork, ensure data is aggregated on secure servers, and tightly control permissions to access these servers.

Special care must be taken to safeguard data privacy within the GIS data products resulting from most geo-enabled microplanning. Where possible, microplanners should avoid showing private information like disease incidence or vaccination status at the level of individuals or households on maps. In some cases, even aggregate information like case rates per community can unfairly stigmatize populations. It can also reveal individuals' private health data if said individuals' health status is uncommon and they are part of a minority group – for example, if there are only two individuals of ethnic group X in location L and one has disease D, it will be very easy to deduce who has it, even if individuals are pseudonymized. A good standard for such cases is to aggregate data with fewer than 5 or 10 records.

If it is impossible to accomplish microplanning goals without displaying sensitive data, consider representing individuals with pseudonymous IDs and either reserving the keys for office staff, or distributing them on separate sheets to complicate re-identification. Potentially stigmatizing aggregate data may be represented within appropriately sized coloured raster grids (e.g. X% case rate per grid cell) instead of at the level of administrative units, communities, or clinic catchments. In extreme cases, ensure accountability for sensitive visual products during fieldwork by watermarking maps with the responsible field team members' names and instituting a check-in, check-out system at the beginning and end of each day. This helps ensure sensitive information does not leak via accidental loss or intentional redistribution.



6.6.2.5 Documenting the data and information assessment

Programme Designer	GIS Technical Staff
	

Gaps in data and information identified at the end of the assessment should be precisely documented to support workplan development (Section 6.7) and implementation (Section 6.8). The microplanning team may choose to record assessment results in a document or spreadsheet format. The team should address gaps and inaccuracies found in all spatial and non-spatial data that will be used during the microplanning process²³. This includes:

1. Assessing availability and accessibility of data or information (e.g. are data missing or incomplete?)
2. Describing current quality gaps across the six dimensions of data quality (Table 10), for data and information that are available
3. Describing approaches that may be used to fill identified gaps.

Working with imperfect data can be an opportunity to improve the data using local knowledge during the microplanning process. This can be accomplished through creative and participatory approaches that are convenient for field teams, such as drawing revisions on a paper map and then sending photos via mobile phone to GIS technicians to update digital files (see field data collection below).

For details on implementing selected approaches in this section, see Section 6.8.1.

Table 11 – Possible approaches to fill data or information gaps.

	Manual extraction/correction			Interactive or automatic extraction	Field data collection	Expert consultation
	Participatory mapping	Crowd mapping	Single operator			
Geospatial data (vector)						
Geospatial data (vector)	✓	✓	✓	✓	✓	
Lines	✓	✓	✓	✓		
Polygons	✓	✓	✓	✓		
Other						
Data						
Data elements (list)					✓	✓
Statistical data					✓	✓
Input parameters (e.g. travel scenario)						✓
Reference material	[38],[39]	Crowd mapping	14	14	12	

23. The types of data would include the master list and geospatial data (Table 6) and statistical data, programmatic information and non-spatial input parameters (Table 7) needed to support geo-enablement.

More specifically:

- **Participatory mapping:** Process through which local individuals knowledgeable about the geographic location or extent of specific types of geographic objects work together to capture this information on paper maps or digitally using basemaps (typically remotely sensed imagery), and often using a GIS software or online app as ground reference. This approach does not require advanced GIS skills if the exercise takes place in person and is supervised by GIS experts. Participatory mapping can also help reduce data collection costs, increase local engagement and build local technical capacity for data collection, contributing to long-term sustainability [18]. Participatory mapping has been successfully used in various microplanning processes (see reference 39 for an example). Figure W is an example of a participatory mapping product that was created by various stakeholders in Myanmar working together to delineate health areas for immunization microplanning.

Figure W – Midwives and township-level staff drawing the extent of Expanded Programme on Immunization communities as part of a participatory mapping exercise. (Courtesy: Steeve Ebener)



- ◎ **Crowdmapping:** Involves a group of people, generally volunteers, working to extract geographic features (e.g. buildings, roads, rivers) visible on remotely sensed imagery by using a web-based application. This approach is particularly useful when there is a need to extract a high number of features in a limited amount of time. It is generally implemented as part of mapathons, grouping individuals by skill level depending on the type of features to be extracted or corrected. Mapathons may be organized over a number of hours or days. For example, a mapathon organized to support a microplanning project in Myanmar brought together 72 volunteers who located 157 400 buildings over 15 days. Midwives and district officials then used these points as reference when drawing the extent of communities and health areas as part of the participatory mapping exercise mentioned in the previous bullet point.
- ◎ **Single operator:** Refers to the use of a GIS software/app by an advanced GIS user to extract or correct features, possibly using basemaps as ground reference. This approach may be necessary when there is a need to clean topological errors (e.g. overlaps, slivers) in a GIS layer, which could have resulted from a participatory mapping exercise.
- ◎ **Field data collection:** Refers to data collectors using a portable device (laptop, tablet, smartphone) and an app to collect geographic coordinates and/or information in the field. This can be accomplished directly on site (e.g. in front of a health facility to collect its geographic coordinates) or in collaboration with local staff knowledgeable about an area's geography or information (e.g. village population counts). Refer to [12] for more details on options for collecting geographic coordinates in the field, including standard operating procedures and data collection forms.
- ◎ **Expert consultation:** Bringing selected stakeholders to fill data and/or information gaps that are not related to extracting or correcting the geographic location or extent of geographic features on a map. For example, this approach could be used to improve the quality of a master list or to build consensus on the input parameters to be used in spatial analysis or models (e.g. travel scenarios, mode of transportation, speed of travel).

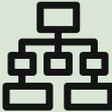
The following should be considered when deciding on approaches to fill data and information gaps:

- ◎ Make sure to involve the government entity having the curation mandate over the data or information in question. This will not only facilitate the validation of the data but also potentially feed the new or improved data into their own data life cycle. This might also strengthen the technical capacity of these entities, and therefore contribute to long-term sustainability as well as strengthen collaboration and coordination with the health sector.
- ◎ Find the right balance between scalability and accuracy, especially in the context of a pilot project, as the same approach would have to be applied during the scale-up.
- ◎ Covering the complete gap might require a combination of approaches. For example, the features extracted through a participatory mapping exercise might need to be cleaned by a single operator in order to reach the expected quality level.
- ◎ Ensure that the approach includes data quality control during implementation, potentially with a validation step at the end.
- ◎ Depending on the quality of available imagery to be used as ground reference, there might be a need to purchase new imagery or, depending on the area to be covered, to collect it through other means, such as a drone.
- ◎ When developing GIS maps, involve health care workers who will deliver services in the field from the beginning. This will allow them to better understand how to use maps, especially if working on campaigns in communities with which they are not familiar.
- ◎ The choice of approaches to fill data gaps might require adjusting the list of hardware and software (Section 6.4) as well as technical expertise and skills (Section 6.5). Efforts to fill data gaps may also require quality control through visiting random sections of the area of interest.



SECTION 6.7

Developing the work plan

Programme Designer	GIS Technical Staff
	

Geo-enabling a microplan entails managing additional strategic, technical, logistical and cost elements within the overall microplanning process. This section assumes familiarity with the general microplanning process. These additional elements required for geo-enabling should either be incorporated in the overall microplanning workplan or, if this is not possible due to a difference in timeline for example, these elements should be part of a separate geo-enabling workplan. In both cases, and as illustrated in the following box, it is critical for this exercise to be as inclusive and comprehensive as possible.



Example of polio and measles interventions in Nigeria:

To resolve challenges in microplanning, Nigeria's polio vaccination programme created GIS-based thematic maps containing data collected in the field. This data included the location of health facilities, markets, schools, mosques/churches, transit and water points, and population estimates based on imagery-extracted settlements and buildings.

The quality of the collected data resulted in better products (e.g. more accurate maps) which contributed to better microplanning outcomes (e.g. improved accountability, more accurate coverage estimates, elimination of chronically missed settlements). The newly collected high-quality data also highlighted challenges that could be addressed through a more inclusive and comprehensive workplan, as described below.

- Because the work was conducted by a local non-governmental organization (NGO) with minimal government involvement, government officials were initially reluctant to accept the new maps and population estimates and use them in microplanning.
- There was little technical capacity at the local level to understand and use GIS data, and local teams believed they knew their own area and did not need maps to plan or to guide them.
- Infrastructure that may be important to implementing a programme, such as line electricity, WiFi and cellular networks, were often only available in larger towns and cities.
- There was a general reluctance to accept lower target population estimations, as this usually resulted in budget reductions in other areas (e.g. number of teams and supervisors, transport money, trainings, etc.).
- Most countries do not have specific data governance policies covering spatial data, which could lead some governments to limit or ban use and sharing of such data if brought to their attention.

Further details on this use case can be found in Annex B4.

It is also critical for the success of any microplan to ensure that its objectives, expected outcomes and target populations are well defined.

Ideally, these are already well known at the time of identifying the applications of geospatial data and technologies that could support the microplanning process. It is important to check if the objectives or expected outcomes have evolved before developing the microplan's geographic component. If this is the case, these changes might impact the geographic dimension of the microplan and/or the purpose, audience and format of the final products, and therefore require adjustments to the geo-enablement workplan.

The following subsections provide key considerations, recommendations and examples of good practices for items in the workplan to geo-enable a microplanning process.

Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.7.3 Technical expertise and skills

6.7.1 Governance

Programme Designer	GIS Technical Staff
	

Developing a geo-enabled microplan is a comprehensive process that relies on input from multiple stakeholders (e.g. health programme implementing the microplan, donors, communities, etc.) and is usually organized by a governing body, which provides coordination and builds consensus across the microplanning process. Geo-enabling a microplan may require engaging additional technical expertise to support key stakeholders with decision-making, and call for building additional partnerships with organizations outside of the public health institutions that typically lead microplanning processes.

Technical experts typically oversee the geo-enabling component of the microplanning process. These experts would ideally be involved in the process from the beginning, or as soon as discussions regarding geo-enablement have started.

Additional partners that could also be engaged include organizations that have a mandate to curate relevant data, or that have technical capacity to help support geo-enablement for the microplan. These potential partners include the following organizations:

- **Department within a ministry of health:** these may include departments that currently use microplanning to support their campaigns, as well as departments that manage master lists or geospatial data and technologies within a ministry of health.
- **National mapping agency, national spatial data infrastructure committee or national geospatial information authority:** these agencies typically have technical capacity and knowledge of geospatial data, especially data related to settlements and population.
- **Central statistics agency or similar body:** these agencies may have census data critical to determining target population counts.
- **Academic institution:** university programmes focused on land tenure or geographic studies may have geographic data relevant to the microplanning process.
- **Non-governmental organization (NGO):** these organizations can serve as valuable partners by supporting a ministry of health to implement a geo-enabled microplanned intervention.
- **International donor organizations:** these include multilateral organizations such as WHO and UNICEF, that have strong convening and advocacy power and may have active initiatives to support microplanning projects.

The microplanning governing body has the opportunity to expand the application of geospatial data and technologies across different types of interventions beyond its initial programme. For example, if microplans are established for a polio vaccination campaign, the resulting geospatial data and information products could be used in the microplanning process for an immunization or malaria prevention programme. Having a diverse governing body will help prevent siloed data streams and ensure that different microplanning processes benefit from one another.

It is important to consider financial compensation for staff of government agencies who may not otherwise have the capacity to be involved in a microplanning governing body. For guidance on building budgets for a geo-enabled microplanning process, see Section 6.7.6. and Annex D. See Annex C2 for example terms of reference for a governing body.

6.7.2 Implementation: pilots and scaling

Programme Designer	GIS Technical Staff
	

When defining the implementation scale of the microplanning process, it is important to distinguish between elements of the geo-enabling framework (Figure B) that should be implemented at the national level from those that will be implemented at different levels depending on the assessment conducted in Section 6.6.

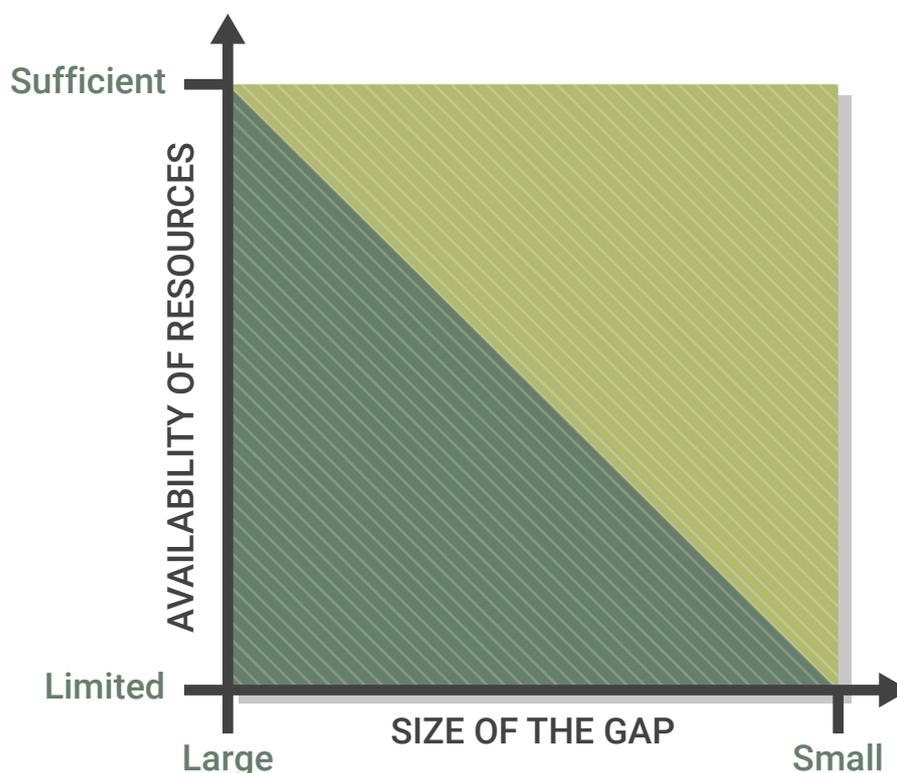
Elements covered at a national scale include the supporting environment of the framework (stage 1 and 2 in Figure B): vision, strategy and plan; governance structure; policy; resources for sustainability; specification, standards and protocols. For the remaining elements of stage 2 (technical capacity, appropriate geospatial technologies) as well as the applications of geospatial data and technologies (stage 3 and stage 4 in Figure B), the scale at which they can be implemented depends on the size of the gap and on the resources necessary to fill it.

For these elements, the following process should determine the appropriate level of implementation:

1. Define the level at which potential data gaps in existing lists and geospatial and statistical data could be addressed based on the results of the assessment conducted in Section 6.6.2
2. Use the result from step 1 to determine the level at which each application of geospatial data and technologies could be implemented based on the data needed to operationalize them. If the gap for any of this data cannot be filled at the national level, then the corresponding application should be implemented as part of a pilot as well.
3. For applications that could be implemented at the national scale after step 2, assess if the potential gap in technical capacity and/or technology can be addressed. If not, then the application should be implemented as part of a pilot.
4. Review any existing microplanning processes in the country that are operational at scale to learn from their successes and challenges.
5. If the governance of the national health programme is not highly centralized, consider if the same geo-enablement approach will apply between the country's regions or provinces. For example, the geography of the microplan might vary substantially from region to region.

There are no strict rules for determining the exact threshold between the need to first conduct a pilot project or to implement directly on a national scale. However, Figure X can be used as a guide.

Figure X – Implementation level based on the size of the data gap and the availability of resources to fill it (extracted from [5]).



It is possible that microplanning teams will determine that some applications can be implemented at the national level (e.g. establishing the master list of health facilities), while others should be part of a pilot project due to limited data or technical capacity needed to operationalize them (e.g. creating geographic accessibility models). The geographic extent of the area over which a pilot is implemented will also depend on the gaps and availability of resources, but will generally correspond to the extent of one or more first- or second-level administrative units (e.g. province, district).

Programme Designer	GIS Technical Staff
Continue to 6.7.5 Activities, responsibilities and timeline	Continue to next section

6.7.3 Technical skills: needs and capacity building

Programme Designer	GIS Technical Staff
	

Identifying needed skills and gaps

Geo-enabling and implementing a microplan requires expertise and skills at various levels of the health system (e.g. logistics, social and behaviour change, and monitoring, evaluation and learning (MEL)). While outside technical expertise may be needed to operationalize the geo-enabled aspects of microplanning (see Section 6.5 for requirements) it is also important to identify internally available technical capacity and gaps (see assessment in Section 6.6.1).

Whenever possible, capacity gaps should be filled by qualified local personnel or by domestic institutions, such as the ministry of health or a university. Microplanning projects often contract academic institutions for support, as they can provide needed expertise for spatial analysis and modelling tasks. When it is difficult to find national staff who have needed technical expertise, it may be necessary to search for international personnel, particularly for high-level roles related to geo-enablement. In these cases, it is important to arrange for international personnel to work with national staff to transfer knowledge and help build sustainable in-country capacity.

Training considerations

Ensuring the use of geo-enabled microplans will depend on the added value that they bring to users. This means that users of maps and other data outputs need to know how to use the products developed in order to assess and appreciate their value.

Subnational level:

- Map comprehension
- Data quality and use comprehension
- Understanding how to link the geo-enabled products to the respective microplanning templates that are submitted to the higher levels (typically in Excel)
- For admin level 2 managers (i.e. district officers overseeing the process): advanced map and data understanding and comprehension, ability to guide data updates if applicable, the ability to access DHIS2 to assist in prioritization.

National Level:

- Map and geodata comprehension for financial planning
- Using geoproducts for prioritization
- Understanding data gaps and needs, and the benefits of accurate data
- Data use for decision-making
- Leadership skills to encourage and embed data use in government processes.

Training needs will depend on staff familiarity with microplanning and geospatial data and technologies. It is likely that more training days will be required at the beginning of the process, and that training can be gradually reduced as technical capacity is built. Depending on the context (e.g. country size, implementation scale), national- and subnational-level personnel may be trained together, or national-level staff be trained first and then serve as trainers for subnational staff.

Involving local universities in developing training materials and conducting training sessions can help build technical capacity, not only for the programme currently leading the geo-enabled microplanning process, but for future microplanning efforts as well.

Ultimately, having technical staff with both GIS and data management skills are critical to generating quality and useful products from geo-enablement. Technical experts with high GIS skill levels but low proficiency in data management may be able to generate maps and other data products, but their quality may be insufficient to support decision-making.



MEL:

Monitoring, evaluation and learning A helpful metric in an MEL framework might include the number of individuals trained on the management and use of geospatial data and technologies in microplanning. If stakeholders notice a gap between the number of individuals trained and percent uptake of geospatial data and technologies in the corresponding service delivery, this could be an opportunity to review if the training content or delivery method needs to be adjusted.

6.7.4 Hardware and software

Programme Designer	GIS Technical Staff
	

Teams should identify the mix of hardware and software needed for the workplan based on which of the four applications the intervention will support.

Table 16 in Annex H outlines the types of hardware and software needed to geo-enable a microplan. Section 6.6.1 discusses how to assess the hardware and software available to a programme implementing the microplan and across a ministry of health.

Please refer to the Digital Square Public Goods Catalogue for a list of relevant GIS applications that have been vetted for digital maturity based licence, open source, flexibility and adaptability.²⁴ Linking with these applications would allow the ministry of health to have better confidence on the cost/benefit and licensing of the software. The choice of hardware and software will impact timelines and budgets. It is important to invest in appropriate hardware and software to ensure not only the generation of quality products but also long-term sustainability. Refer to Section 6.4 for more details and guidance.

Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.7.7.2 Data needs in MEL



6.7.5 Activities, responsibilities and timeline

Programme Designer	GIS Technical Staff
	

The detailed list of activities to be considered for implementation, and therefore inclusion in the work plan, are functions of the applications of geospatial data and technologies that have been selected (Section 6.3), the result of the assessment (Section 6.6) and the considerations reported in Sections 6.3.

These activities are meant to cover the following areas of work and to be implemented in the order presented below (Note that activities 1 and 2 could be conducted in parallel):

1. Hire and train staff.
2. Purchase and install hardware and software.
3. Address input data availability and quality issues.
4. Generate data products, including validation.
5. Integrate and use geo-enabled products in the microplanning process.
6. Document the overall process and communicate the results.
7. Scale up and/or sustain what has been implemented.

24. <https://digitalsquare.org/>

The individuals responsible for the above activities will vary based on country context. It is important that the timeline associated with the geo-enablement aligns as much as possible to the overall microplanning timeline. This helps ensure that the geo-enablement generates information products in time to be useful for the microplan's development and implementation.

Planners may still have to find the appropriate balance between geo-enablement and overall microplanning timelines, as determined by factors such as health service delivery schedules, seasonality of disease incidence, resource constraints and other limitations (e.g. seasonal weather conditions, population movement, security threats). The timeframe for interventions can shape the quality of preparable data, information products and operational plans. For instance, additional human resources may be needed to compensate for higher-than-anticipated planning error, if short timeframes do not allow for advanced population distribution modelling or fieldwork to collect missing master list data. If this is not possible, it might take several rounds for the microplanning process to fully benefit from the geo-enablement.

The following activities may take more time than generally anticipated when developing the timeline (expanded from [17]):

- Engaging with other governmental entities and partners
- Gathering existing data, obtaining authorization to use and share it, as well as making it usable for selected application of geospatial data and technologies
- Procuring hardware and software, especially in some countries (it is recommended to start this process as soon as possible)
- Translating materials into local languages (e.g. standard operating procedures, training materials) and validating translation containing complex technical concepts and terms
- Training technical staff to manage and use geospatial data and technologies
- Collecting field data (can be impacted by weather and unexpected insecurities)
- Validating results from applications and integrating them into the microplanning process
- Aligning programmes to the annual microplanning cycle (e.g. the routine immunization microplanning process is often performed at a specific time of the year)
- Securing local political support and awareness, and mobilizing in-country actors
- Embedding the geo-enabled products into the microplanning templates used
- Scaling data use and map comprehension trainings to local levels
- Establishing systems that can accommodate data updates from local levels, as errors will likely be found while using data and require updating.

Internal communications - cascading information and training

It is critical to share information about the geo-enabling process within and among government agencies involved in the microplanning process. This internal communication can include training local or state officials on how to use products generated through the geo-enablement (e.g. maps, tables, etc.) or sharing information about the value of the geo-enabling process itself. Project managers overseeing the geo-enabling process will face one of two scenarios when considering internal communications and cascading of information:

1. **The same government agency that is leading the geo-enabling process is also directly implementing the resulting microplanned intervention.** In this case, project managers should develop a plan that focuses on sharing about the geo-enabling process within their departments or agencies, ensuring that the process and its intended products are explained at an appropriate level to relevant staff. Examples of this scenario include a national-level agency creating malaria stratification maps, and also developing microplans to distribute bed nets and resources based on those maps (Annex B2). This scenario can also take place at the local level, for example, a city health department generating thematic maps and route optimizations to guide its own routine immunization microplanning (Annex B3). In either of these cases, it is still important to communicate an overview of geo-enablement to local health officials and facility staff so that they gain a base understanding of how the process adds value to microplanning.

2. **The government agency leading the geo-enabling process is different from the agency that will ultimately use the products to create microplans and implement interventions.** This is often the case when the geo-enabling process is conducted at the national level and the products (e.g. maps, tables, etc.) are distributed to state or local officials for their use in microplanning. In these situations, it is critical for project managers to create a plan for cascading information from the national level to state- and local-level officials. This cascading of information may include explaining the value of the geo-enabled products, as well as extensive capacity building on how to use products in microplanning interventions. National-level officials should also consider establishing accountability mechanisms to track the use of geo-enabled products at subnational levels.

It is important that cascaded communications and capacity building are scheduled to align with the delivery of geo-enabled products to local officials. This can help ensure that local officials are able use the products by the time they begin developing microplans. Failure to plan for cascading information and capacity building can result in local officials not using geo-enabled products in their microplanning because they did not know how to, or did not understand the value of these products. See Annexes B1, B4, and B5 for use case examples on how officials in Nigeria cascaded information and training about their geo-enabled products across government agencies and levels for a variety of microplanned interventions.

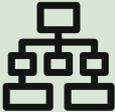
Sustainability and re-use of geo-enabled products

Internal communication and information sharing is also critical to ensuring that data products (e.g. maps, tables) generated for a particular geo-enabled microplanning process are used in planning future related interventions. For this reason, it is beneficial to share widely about a geo-enabling process within and among health agencies at the national and subnational level. This increases the likelihood that other officials may adapt data products from one geo-enabled microplanning process for use in another. This sharing of information among health officials at various levels can be important to improving the efficiency of different microplanning efforts. It can also support the sustainability of geo-enabled products as they are reused and updated by different project teams. For example, settlement maps originally created for polio vaccination microplanning in Nigeria (Annex B4) were later adapted by officials to microplan for measles vaccination campaigns (Annex B5).

For additional activities, responsibilities and timeline considerations, see reference [17].



6.7.6 Budget

Programme Designer	GIS Technical Staff
	

Developing the budget to implement geo-enabling activities according to the agreed upon timeline (Section 6.7.5) is a critical component of workplan development. Budgets should be as detailed as possible and cover all the areas of work reported in Section 6.7.5. This will help avoid resource shortages during the geo-enablement process. This exercise should result in a budget spreadsheet that shows anticipated cost by activity, category (e.g. personnel, travel, hardware, field data collection) and events (e.g. workshops, training). Line items should include information on the approximate timeline for spending to align with the activity implementation timeline.

Consider the following when developing this budget:

- Some costs will have to be covered before reaching the development of the workplan. These costs are usually related to consultants' working time and potential travel to support:
 - ▶ buy-in and initial kick-off of the microplanning geo-enablement process
 - ▶ determining microplanning challenges and whether they can be addressed through geo-enablement
 - ▶ assessing current geo-enablement level of the microplanning process
 - ▶ developing standard operating procedures and other guiding documents.

- ⦿ Additional budget items related to launching the geo-enabling process include upfront costs such as purchasing hardware and software, training staff and field data collection. Other items will have recurring costs that should be considered to ensure long-term sustainability. These recurring costs can include data maintenance and update, software licensing and updating, hardware maintenance/replacement, data plan, power and printing.
- ⦿ Data extraction or creation to fill data gaps, such as field work, is typically the most expensive item in a geo-enabled microplan. Other elements for fieldwork will depend on data collection methods and could include:
 - ▶ vehicle rentals and petrol
 - ▶ insurance for staff and vehicles
 - ▶ staff per diem (food stipend, travel and lodging)
 - ▶ staff working time for training, workshops, and supervision (government and consultants)
 - ▶ data collection devices
 - ▶ software licence costs
 - ▶ monitoring
 - ▶ data quality control, validation and integrations.
- ⦿ Depending on funding resources, there may not be sufficient scope to collect the necessary data to generate quality products. If this is the case, it might not be possible to generate some products defined earlier in the process (Section 6.3). The impact on geo-enablement would then have to be evaluated.
- ⦿ In some cases, purchasing proprietary data such as satellite imagery or population statistics might be the most cost-effective option. When this is the case it is important to remember that the cost generally increases with the volume and/or the data type (e.g. resolution of satellite imagery).
- ⦿ Enough flexibility should be included in the budget to account for possible changes in the content and format of the products at the time of generating them.
- ⦿ Investing in quality training and capacity strengthening for all relevant local personnel to be involved in geo-enablement is key to ensuring long-term sustainability. It is also important to generate quality and relevant products through geo-enablement. The same applies to a lesser extent to purchasing and maintaining hardware and software.
- ⦿ Printing may be costly and/or require specialized large sized printers. In some cases it might also be worthwhile to print maps on laminated paper to facilitate annotations (see Section 6.8.2.4 for more details)
- ⦿ Financial resources will also be needed to sustain what has been established by institutionalizing the supporting environment (Section 6.9.1) as well as maintaining and updating the data and products that have been generated (Section 6.9.2). If the geo-enablement is only beginning, this cost might be difficult to estimate until the first set of products has been generated. See Section 6.9 for details on considerations on budgeting for long-term sustainability of geo-enablement activities.

Regarding the elevated cost of field data collection, microplanning teams should consider the relevant cost/benefit of utilizing local health staff for field data collection (generally lower budget) versus hiring a technical organization.

Table 12 – Utilizing local health staff versus hiring technical partners.

Pros	Cons
Generally lower cost	Poor training with potential for poorer or inconsistent quality of data might require repeated data collection campaigns, offsetting the cost advantage
Better long-term sustainability by building local capacity	Health staff manpower diverted from their routine duties, need to fit microplanning exercise into programmatic schedules

Consider the cost of refresher trainings for personnel at central and subnational levels involved in field data collection, data management and updating. In addition, consider the GIS skills that might be required to enhance spatial data through digitization. These typically include:

- verifying and completing road network shape files
- quality checking low-level administrative boundaries for topological accuracy
- name tagging of satellite-derived settlement layers (this will require interaction consultation with district-level personnel).

Additional key considerations can be found in [17] as well as in Appendix I of [18]. While these have been developed for strengthening immunization programmes through the use of geospatial data and technologies, they remain applicable to other programmes.

The following can be considered if there is a need to reduce implementation cost, (e.g. when the budget available for the geo-enablement is tight and/or it is not possible to obtain additional external resources):

- Leverage as much as possible existing material, especially for standard operating procedures and training materials.
- Explore options for open-source and free software (grants, non-profit licences), but do not compromise functionality for cost. These software are the tools that create the critical data products that geo-enable a microplan, and are worthwhile investments in the programme's success. See Section 6.4 for details on types of software, and their pros and cons.
- Explore the possibility to use freely accessible data, including satellite imagery to be used as basemaps.
- If multiple devices are needed (e.g. GNSS-enabled tablets for field workers or supervisors) consider buying in bulk for a discounted price.
- If access to the Internet is needed while in the field, consider buying the service in bulk unless logistically challenging (some countries restrict the ability to do so without permission).
- Consider alternative approaches for data collection that may still be able to fill gaps (e.g. use satellite imagery and local knowledge to locate health facilities or settlements, instead of sending teams into the field with GNSS-enabled devices).
- Consider conducting a pilot instead of a national-level implementation for some of the initially planned activities.



6.7.7 Monitoring, evaluation and learning

Programme Designer	GIS Technical Staff
	

The challenges to microplanning identified in Section 6.1 become the basis for all subsequent geo-enablement plans and activities. Establishing a monitoring, evaluation and learning (MEL) framework during the planning phase ensures that:

- metrics of success and change pathways are clearly articulated
- mechanisms are put in place to track performance
- course correction is initiated when activities are off track
- impact of the geo-enablement microplan can be universally measured.

6.7.7.1: Key steps in MEL framework design

Programme Designer	GIS Technical Staff
	

Step 1: Identify outcomes of interest

Effective MEL planning requires a clear understanding of the purpose (primary) and subsequent benefits (secondary) of the geo-enabled microplan. Stakeholders must first identify the primary outcome of interest, or the highest-level purpose of the geo-enabled microplan. Next, consider any secondary outcomes of interest (subsequent benefits). See Figure D for a sample theory of change, including outcomes of interest, from [17]. See outcome examples from the geo-enabled microplanning use case in Annex B3 highlighted below.



Outcomes of interest in practice: Routine immunization use case example

Health officials in the city of Patna, India used a geo-enabled process to microplan routine immunization outreach (Annex B3). The outcomes of this process are listed below, along with examples of how these might be defined as outcomes of interest during MEL framework design.

- Children who received the full suite of recommended vaccines by one year of birth increased from 43.8% in 2007-2008 to 69.8% by 2015-2016
 - ▶ **Primary outcome of interest: increased number of children immunized**
- A more than two-fold increase in vaccines administered through public health care services (reaching 72% by 2015–2016), as opposed to private clinics, which improved vaccine safety and efficacy
 - ▶ **Secondary outcome of interest: improved vaccine safety and efficacy**
- Reduced delivery time for vaccines and supplies to sites, and reduced travel time for 45 nurses who had been seconded as field vaccinators
 - ▶ **Secondary outcome of interest: improved efficiency of immunization services**
- Improved vaccination reach and supply through optimized delivery routes, reducing the number of missed population pockets
 - ▶ **Secondary outcome of interest could be:**
 - ▶ improved vaccine reach and supply
 - ▶ increased equity in vaccine coverage

Step 2: Define use as intended

To measure performance, it is important to set the criteria and key performance indicators (KPIs) for the effective use of the geo-enabled microplan. This requires defining “use as intended,” which clearly states how the products of geo-enablement (e.g. maps, tables) are to be used by each relevant stakeholder in microplanning.



Use as intended in practice: Routine immunization use case example

In the case of Patna, India (Annex B3) use as intended was achieved when stakeholders used the maps to:

- Determine a large number of additional vaccination sites that would be easily accessible to the general public. Selected sites had to allow for timely access to vaccines and provide the ability to reach underserved populations.
- Demarcate well-defined catchment areas for each vaccine storage depot to ensure efficient planning, reduce overlap of service areas and avoid service gaps.
- Determine efficient vaccine delivery routes, as one vehicle was often deployed to deliver vaccines to multiple sites.



Use as intended in practice: COVAX use case example

Nigeria used geo-enabled microplanning to plan for COVAX COVID vaccination campaigns (Annex B1). While national-level officials produced GIS maps as part of the process, the maps were distributed to local officials for their use in developing actual microplans to be implemented. Following the intervention, local officials were interviewed about how they used the GIS maps. Interviewees stated that they used maps to:

- ensure that no settlements were missed during microplanning
- estimate target population
- improve the delineation of health facility catchment areas
- determine the distance from health facilities to settlements.

The above bullet points are examples of how to define use as intended in an MEL framework. The method used to obtain this information (interviewing officials who used the maps) serves as an example of how to monitor use as intended throughout the microplanning cycle.

Step 3: Establish KPIs to measure use as intended

KPIs will need to be established to assess if products of the geo-enabling process are in fact being utilized according to the defined use as intended. There are two types of KPIs (process and impact), and two means to monitor KPIs (quantitatively and qualitatively):

- **Process KPIs** measure how the teams developing the microplan for an intervention use the geo-enablement products (e.g. maps, tables, graphs). KPIs may focus on the percentage of officials who used maps or tables, as well as how officials used them to address specific challenges or to answer questions. It may be possible to measure KPIs before an intervention is completely implemented.
- **Impact KPIs** measure end results after implementing an invention that used a geo-enabled microplanning process. Impact KPIs for health interventions typically measure changes in outcomes for patients or improvements in efficiency for health care staff or resources. When setting impact KPIs, it can be helpful to consider impact KPIs that were used previously by similar interventions in order to set matching indicators that can provide point-in-time comparisons.

- Quantitative indicators can be measured through data sources such as vaccination coverage and equity surveys at the start of, and throughout an intervention's implementation. Quantitative indicators may also be measured retroactively, by linking process KPIs with impact KPIs. This could include examining if use of geo-enabled products by local programme managers correlates to increased vaccination rates in their assigned campaign area.
- Qualitative indicators are important to include in the MEL plan as they reveal how microplans are being developed and used, highlighting key perceived benefits and challenges for users of geo-enabled products (e.g. maps, tables). Qualitative insights are particularly useful for identifying critical pivots needed to ensure that products are used. These adjustments could include increasing capacity building, changing training methods or developing communication strategies for map delivery and expectation for use.



KPIs in practice: COVAX use case example

The following are sample KPIs to measure the use as intended for the COVAX use case (Annex B1).

Process KPI: Number and/or percent of programme managers (disaggregated by gender, age and disability status) who can use a geo-enabled microplan to:

- ensure that no settlements are missed during microplanning
- estimate target population
- define health facility catchment areas
- determine the distance from health facilities to settlements.

Impact KPIs: Percent or number of target population (disaggregated by gender, age and disability status) who are fully vaccinated against COVID-19 when compared to campaigns that did not use a geo-enabled microplan.

For **qualitative indicators**, the MEL team interviewed local health officials in eight states to assess how they used GIS maps in developing their microplans. Respondents who did not use the maps indicated that this was due to a lack of training and technical capacity on using the maps. Others reported that the maps arrived too late to be used in planning or had not arrived at all.

Step 4: Create and implement the MEL framework

For MEL to be effective, it is important to articulate the process's starting point, its end goals or targets, and steps needed to reach those goals/targets in a concise MEL framework (see Theory of Change Figure D in Section 5.2.1).



Note:

Note that the MEL framework will be revised several times over the course of the project when:

- assessment results change resource and capacity expectations
- data reviews identify unachievable outcomes
- the workplan clarifies activities, their dependencies and available resources
- monitoring data suggests adjustments to the project plan.

Expect to revisit this framework several times during the planning process and mid-project.

In addition to having a MEL plan, it is important to identify key learning questions, which contribute to the evidence base as well as to the greater adoption and use of geo-enabled microplanning. Key learning questions may include the following:

- ⦿ What are the perceived benefits of geo-enabled microplans among map users?
- ⦿ What are the perceived challenges of geo-enabled microplans among map users?
- ⦿ What differences in adoption of geo-enabled microplan map use exist across gender, age and/or ability status?



Equity learning questions

A key benefit of using geospatial data and technology to develop microplans is the ability to increase equitable access to services by prioritizing vulnerable and often-overlooked populations. It is beneficial to consider these populations in the MEL plan, as they will impact the design and implementation of the geo-enabled microplan. Below are equity-based key learning questions to consider, and potentially measure, during the geo-enablement process:

- ⦿ To what extent are individuals represented across age, gender and disability status in decision-making roles during the geo-enabled microplan design process?
- ⦿ To what extent are individuals represented across age, gender and disability status, in geo-enabled map training participants?
- ⦿ Is the gender of a health worker related to geo-enabled product uptake, given social and cultural contexts?
- ⦿ Is available data informing the microplanning process being disaggregated by gender, age and disability status?
- ⦿ Are target service locations in the microplanning process equally accessible to individuals across age, gender and disability status?
- ⦿ Are services optimized by geo-enabled microplans equally accessible to individuals across age, gender and disability status?

6.7.7.2 Data needs in MEL

Programme Designer	GIS Technical Staff
	

The KPIs specified in the MEL framework may be directly or indirectly filled by the spatial data gathered throughout the geo-enabling process. For example, this could include using population estimates to calculate target populations reached. This may require additional investment in data improvements if the needed data is of sufficient quality for programming, but not for KPIs.

Available data in practice: Routine immunization use case example

In the routine immunization use case example (Annex B3), officials in the city of Patna, India had recently completed multiple house-to-house polio vaccination rounds. As a result, updated location data for children between the ages 0–60 months was readily available to use for routine immunization microplanning. This data was readily available to compile and layer on GIS maps, and thus was realistic for use in monitoring.

Collecting data in practice: Malaria stratification use case example

Cambodia's National Malaria Center (CNM) set out to create GIS maps to geo-enable the microplanning of its malaria outreach programme (Annex B2). The Center determined that the maps would need to have:

- updated village lists
- correct and consistent village names
- updated village population counts
- accurate village GPS coordinates

CNM conducted the following activities to collect these data:

- To improve village lists for malaria endemic areas, the team collected baseline data on village names, locations and population from the Ministry of Interior.
- To verify village coordinates, names and population counts, the team conducted participatory mapping exercises at health facilities using satellite imagery in Google Maps, and leveraging health workers' extensive knowledge of local communities and catchment areas.
- Village names were confirmed through consensus during workshops conducted primarily at health centres.
- When sufficient information could not be gathered from health facility visits, CNM then dispatched a team of local health workers and international staff to record point-level data for villages, but not for boundaries, as official boundaries were often unclear on the ground and not generally relevant to local communities.
- Because the Center managed the entire process, it was able to ensure that all data collectors in the field used the same updated list of villages and administrative areas. Using a consistent village list for reporting cases and interventions was critical, as village lists had previously changed from year to year.

Having accurate village data was critical to both creating the geo-enabled products, and to adequately monitoring reach of the malaria intervention.

There may be a need to collect primary data to adequately measure KPIs before or during the course of the project. This could include recording the number of staff at each health post to calculate per-health facility outputs as a ratio of staff resources.

It is important to consider this assessment of institutional capacity and data availability when developing the MEL framework to ensure that evaluation activities are adequate, realistic and relevant to the geo-enabling process and its desired impacts. Project staff should revise the MEL framework and any linked log frame documents based on these capacity findings so they remain useful and practical tools.

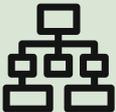
If certain outputs or outcomes are dependent on data that is unavailable: those outputs and/or outcomes should be eliminated from the MEL framework.

If these data must be collected: data collection activities should be incorporated into the framework. Alternatively, if the specified KPIs cannot be adequately monitored with the assessed capacity or resources, they should be revised to something achievable.

Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.7.8 Data and products sharing policy



6.7.7.3 MEL activities and deliverables

Programme Designer	GIS Technical Staff
	

A sample breakdown of MEL activities and deliverables by project period and responsible staff follows in Table 13. The table should be interpreted as an outline to adapt to the specific workplan context and needs. No two projects' frameworks will look exactly alike.

Table 13 – Sample breakdown of MEL activities by project period and responsible staff.

Phase	Activity/Deliverable	Person(s) responsible
Project start	Baseline data collection (survey)	MEL staff
	Logframe (if using)	MEL staff with project managers
	Decide any leading indicators to use	MEL staff with project managers
	Identify triggers for action mid-project	MEL staff with project managers
	Identify key learning questions	MEL staff with project managers
Throughout project	Routine data collection	Project staff
	Periodic monitoring surveys	MEL staff
	Routine semi-structured interviews with subsets of users and/or staff	MEL staff with project staff
	Regular evaluations – process to impact KPIs	MEL staff with project managers
End of project	Final collation of monitoring data	MEL staff
	Evaluation survey	MEL staff
	Analysis of all data	MEL staff with project managers



6.7.7.4 Revisiting the MEL framework

Programme Designer	GIS Technical Staff

Microplanning teams should revisit the MEL framework in light of the workplan developed (see Section 6.7). The clearer picture of budgets, resources and timelines provided in the workplan should prompt the expansion, elimination or reconfiguration of activities and outputs, and possible reconsideration of outcomes.

The workplan should also provide clarity about the manner and timing of MEL data collection and analysis. This could include:

- When to administer the baseline survey
- What data can be collected during the course of normal activities
- By what date monitoring analysis would be needed to adjust plans successfully
- Who will be responsible for each part of the framework.

Once revisiting the MEL framework is completed, insert any new activities, corresponding staff, resources and timelines into the workplan. Planners should look for efficiencies wherever possible, both to save resources and ensure MEL is a part of, not incidental to, the project.

For instance, MEL consultations should be incorporated into existing workshops, data for KPIs should be collected during the course of normal activities when possible, and analysis should be timed to arrive right before key decision points.

6.7.8 Data and products sharing policy

Programme Designer	GIS Technical Staff
	

Because geospatial data and products used to develop the microplan will also be used in monitoring and evaluating the outcomes of the resulting intervention, it is important to consider key aspects of this source data. The following can impact the ability to publicly share or distribute products or results from the geo-enabling process:

- Licensing, proprietary and open-source (introduced below and detailed in Annex F)
- Data privacy and protection (introduced below and detailed in Section 6.6.2.4)

Data privacy

Data privacy refers to the principle that individuals possess the right not to have personal details collected about them exposed without good cause and informed consent. Appropriately balancing microplanning necessities with individuals' and groups' data privacy during geo-enabled microplanning exercises requires foresight and deliberate action. Most importantly, individuals' personal data should never be exposed in any way that could result in harm to them or others. Particularly sensitive health data might include disease, immunization status, disability, ethnicity, religion, age, relationships to others, or home and work location. This could be summarized as anything an individual might reasonably not want exposed to the wider world. Relevant principles of data privacy include data minimization (only requesting necessary data), storage limitation (discarding data when it is no longer needed), purpose limitation (using data only for its intended purposes) and limiting transfers of and access to sensitive datasets.

Data privacy is addressed in more detail in Section 6.6.2.4 of this handbook. For a more complete account of data privacy standards and best practices in the context of public health, refer to the WHO policy note on this subject [37].

It is important to consider these aspects of input data at each step of the microplanning process, as they may impact decisions made along the way.

Licensing

Data licensing can be an intimidating aspect of geospatial data utilization, creation and distribution. Uncertainty regarding licence interpretation can lead to omission of useful data and missed opportunities to share valuable information. To fully realize the potential of data resources, it is critical to develop familiarity with common geospatial data licences.

Sources for geospatial data vary widely. Data can be furnished by government entities, purchased from third-party suppliers, generated in-house or pulled from open-source repositories online. With each data source, consider restrictions that could impact the usability of data and its products.

Some data sources, such as satellite imagery, may allow derivative products (e.g. building footprints, catchment areas, administrative boundaries) to be created using the imagery and distributed to users and analysts. However, some licence agreements restrict sharing the original imagery. Other sources may allow for flexible utilization but require specific citations in the metadata to support data lineage tracking.

Regardless of the source, licensing agreements and permitted use documents should be thoroughly reviewed prior to using a geospatial data source. Restrictions should be evaluated against the intended use case, to ensure that no conflicts will arise during the data lifecycle that could impact the serviceability of final data.

For more details on the elements of a geospatial information licence agreement, see Annex F.



Example of the Open Data Commons Open Database Licence

The verbose legal language required to address potential loopholes and prevent misuse make it difficult to identify the applicable restrictions and limitations in a licence agreement. Fortunately, many licence publishers provide a summary of the important points covered in the licence.

Consider, for example, the summary provided by the Open Knowledge Foundation for the Open Data Commons Open Database Licence:

Users are free to:

- ⦿ share (copy, distribute and use the database)
- ⦿ create (produce works from the database)
- ⦿ adapt (modify, transform and build upon the database).

As long as users:

- ⦿ Attribute: Attribute any public use of the database, or works produced from the database, in the manner specified in the licence. For any use or redistribution of the database, or works produced from it, one must make clear to others the licence of the database and keep intact any notices on the original database.
- ⦿ Share-Alike: If there are any adapted versions of this database, or works produced from an adapted database, users must also offer that adapted database under the licence.
- ⦿ Keep open: To redistribute the database, or an adapted version of it, users may use technological measures that restrict the work, such as Digital Rights Management (DRM), as long as a version without such measures is also redistributed

These summaries are extremely useful for quickly identifying restrictions. However, if the desired data use is not clearly addressed in the summary, the full licence should be reviewed to prevent any violations.²⁵

25. Learn more at <https://opendatacommons.org/licenses/odbl/summary/>

Open data licences

Open data licences generally allow for flexible use of data, and the licence elements outlined above may not be restrictive compared to commercial licences. Open licences often intend to promote knowledge sharing and easy access to information for public benefit. Therefore, licences are constructed in a way to remove barriers to dissemination. However, open data sources should be cited in attribution for initial data products, and in copied and derivative data whenever possible. Source attribution is often required for open data products, but even when it is not required it should be maintained if possible. Maintaining the source attribution is a way to credit the publisher for their efforts in generating the data, and their generosity in making it publicly available.

Examples of Common Open Geospatial Data licences:

- Open Data Commons Attribution Licence²⁶
- Open Data Commons Open Database Licence²⁷
- Creative Commons Attribution²⁸
- Creative Commons Attribution-ShareAlike²⁹
- GNU Free Documentation Licence³⁰

SECTION 6.8

Implementing the work plan - full scale or pilot

Programme Designer	GIS Technical Staff
	

The following subsections provide additional guidance on key actions to be taken at each step of implementation, as per the list and order of work areas reported in Section 6.7.5. Guidance on hiring and training of staff is covered in Section 6.7.3, and guidance on hardware and software is provided in Section 6.7.4.

Technical work done as part of this implementation should be documented as precisely as possible in standard operating procedures (SOPs) or protocols, so that a technician with the appropriate skills could reproduce the process and results. This documentation may be needed for auditing purposes. In the case of a pilot programme, SOPs and protocols will be important to ensuring the same methods and processes are applied when an intervention is scaled. Lessons learned and good practices observed during the implementation should also be documented.

Programme Designer	GIS Technical Staff
Continue to 6.8.3 Integrate and use the products in the microplanning process	Continue to next section

26. <http://opendatacommons.org/licenses/by/1.0/>

27. <http://opendatacommons.org/licenses/odbl/1.0/>

28. <https://creativecommons.org/licenses/by/4.0/>

29. <https://creativecommons.org/licenses/by-sa/4.0/>

30. <http://www.gnu.org/licenses/fdl-1.3.en.html>

6.8.1 Address input data availability and quality issues

Programme Designer	GIS Technical Staff
	

This section builds upon the assessment conducted in Section 6.6.2 and the work planning and budgeting conducted in Section 6.7.6

Before implementing a geo-enabled microplan, the team should have identified availability and quality gaps in the data needed to operationalize the four key applications of spatial data and technologies, and chosen approaches to fill those gaps (Section 6.6.2). For example, if the assessment determined that missing data would have to be purchased, the team should have allocated resources in the budget to obtain and assess that data (Section 6.7.6).

Take the following steps to ensure that the highest quality data or information is collected and produced:

1. Develop clear and easy to understand standard operating procedures (SOPs) detailing each step of the process for operators (see examples in [12]). Conducting a test run of the SOP with people who are not familiar with it could help to validate the procedures, especially for approaches that have never been implemented before.
2. Define monitoring, quality control and/or validation measures that can be implemented on site or remotely, depending on the approach.
3. Select operators or field data collectors with the appropriate technical skills.
4. For field data collection, check that mobile devices are functioning properly.
5. Develop training materials adapted to participants.
6. Make sure participants understand and adhere to the SOP by conducting practical exercises during training.
7. Provide operators and data collectors with printed copies of SOPs, as well as contact details of support staff, in case they encounter technical problems during field data collection.
8. Implement monitoring and quality control measures as soon as implementation starts and throughout the entire process, making sure to address potential quality issues as soon as possible.
9. If possible, conduct a validation exercise involving representatives from the programme implementing the microplan. While the exercise's main objective is to build trust in the quality of the data that has been collected, it may also help identify issues to address before using data, (e.g. data entry errors, location data error, inconsistencies with other geospatial datasets).

It is possible that additional issues or improvements in SOPs will be identified during training or data collection. When this occurs, assess the possible negative or positive impact on the quality of data to be collected, and balance these impacts against the need for data collectors to be retrained if such changes were made to SOPs.

It is also critical to consider the political processes required to update these data. For example, if settlements and/or health facilities are attributed to another boundary than originally stated in the data product, this will have political implications. A clear process is needed for handling such cases, otherwise data products will have limited use. The same applies to settlements or health facilities that are being added to or removed from administrative areas. For example, in the case of settlements derived from satellite imagery, some settlements may have been missed due to extraction errors or imagery issues. If settlements are to be added, this may require a new SOP.

Last but not least, some data gaps might still remain at the end of the secondary data collection exercise. Because data needs to be updated regularly, there will never be a perfect dataset and there will be data gaps. Data gaps can be tolerated, especially when the data is being used in thematic maps and local level officers have the ability to pinpoint gaps and fill them for their planning process.

Depending on the size of such a gap, it might be necessary to consider redoing some analysis, and/or the creation of data products to be based on the dataset in question. Were the analysis still to be conducted and/or the product generated, the gap in question and its impact should be clearly documented in the metadata, report or on the product itself (e.g. in the case of thematic maps).

6.8.2 Operationalizing the four applications and generating products

Programme Designer	GIS Technical Staff
	

The operationalization of the applications covered by this handbook can start once data availability and quality issues have been sufficiently addressed to generate the products defined in Section 6.3.

Operationalizing the applications is often done in the following order, due to the interdependencies that exist between the applications and to avoid implementation in silos. However, in some cases, especially for emergencies or time-constrained cases, a thematic map can be produced using globally available data sets that would be superior to the hand-drawn maps otherwise used. These maps can be produced at an earlier step of microplanning and can involve local leaders to identify and fill gaps. The applications' interdependencies can be understood as follows:

1. Finalize georeferenced master lists, as the content of these lists, together with the associated geospatial data, are key to operationalizing the other applications.
2. Generate spatial distribution and estimates for the target population next, as this data and information are needed to conduct geographic accessibility analysis and route optimization analysis.
3. Conduct geographic accessibility, service location and route optimization modelling, using geometry stored or associated with master lists and population distributions as key input datasets.
4. Generate thematic maps based on results from the other three applications. As noted above, cases may exist in which producing a thematic map earlier in the process, using global datasets, is still preferable to relying on inaccurate hand-drawn maps.

After generating products, answer the following questions for each of them.

- ⦿ Do the products help address the challenges of the microplanning process (Section 6.1)?
- ⦿ Do they meet the purpose, content and format that have been defined, and are they presented in such a way that they can be understood by the intended users (Section 6.3)?
- ⦿ Are there any limitations and/or gaps that could affect intake or decision-making (e.g. data gaps that have a bigger impact than anticipated after the secondary data exercise (Section 6.8.1); low level of trust in conclusions made from the product)?
- ⦿ Were the products accessible early enough to effectively contribute to the microplanning process?
- ⦿ If using a microplanning template, do the products accurately reflect the template requirements?

Answering these questions could be part of a product evaluation and validation workshop, facilitated by those who generated the products, and that brings together representatives from different stakeholder groups meant to use the products in planning or implementing the intervention (Section 6.3). During this workshop, participants should first be instructed how to read and interpret the content of the different products, and understand their relation to the overall microplanning process.

The following subsections provide additional considerations on operationalizing the applications covered in this handbook, and generating quality data and information products.

6.8.2.1 Georeferenced master lists

Programme Designer	GIS Technical Staff
	

Implementation

Microplanning teams should first integrate the information collected under Section 6.8.1 in the corresponding master lists, if not already done after the data collection exercise. This includes integrating geographic coordinates for object types represented by a point (e.g. health facility, vaccination post, village, etc.).

Next complete a quality check of each master list, following the same process applied during the initial assessment (Section 6.6.2.1). When defining the content of each list, ensure that the specifications associated with each data element in the data dictionary are consistent with the classification tables established for the concerned data elements (e.g. health facility type and ownership in the master list of health facilities) (Section 6.3).

After completing the quality check, take the following steps for each master list:

- Adjust the label associated with each data element to match the one decided upon at the time of defining the content of each master list (Section 6.3).
- If it does not already exist, define and implement a unique coding scheme to identify each geographic object in the list (see rules in [8,10,11]). If multiple coding schemes are already used in a country, store each of them as a different data element (e.g. columns), giving priority to the official coding scheme.
- If needed, adjust the detailed data dictionary. For example, this may be required to include new data elements identified during the process; to modify the specifications for data elements; or to create the summary data dictionary and include it in the master list file.
- If needed, and when applicable, adjust the classification tables and include them in the file containing the master list.
- Create the metadata associated with each list, and include it in the file containing the master list.

If the master list requires the geographic extension of each geographic object to be stored in a separate geospatial dataset (e.g. administrative units, health areas), consider the following:

- Ensure the structure and content of the master list matches those of the geospatial dataset attribute table (e.g. order of data elements, labels).
- Create the metadata for the geospatial dataset and, when possible, capture it either directly in the geospatial dataset file or in a separate file associated with it. In this metadata, make reference to the master list in order for the user to have access to the complete data dictionary and classification table.

Considerations

Once the above is completed, determine how key microplanning decision-makers and others in charge of creating products from the geo-enablement process will have access to the master lists (including the summary data dictionary, metadata and classification tables) and associated geospatial data.

If this is the first time that these lists and datasets are being generated to support the microplanning process, they could be shared through a temporary common repository (e.g. Google Drive, Dropbox). Avoid sharing individual lists and datasets on request, by email for example, as it could result in different stakeholders using different versions of the same master lists or geospatial datasets, if adjustments are made during a microplan's implementation.

Refer to Section 6.9.2 in case a maintenance and/or updating mechanism is already in place, or could be established as part of the current phase of the geo-enablement process

6.8.2.2 Population estimates and spatial distribution

Programme Designer	GIS Technical Staff
	

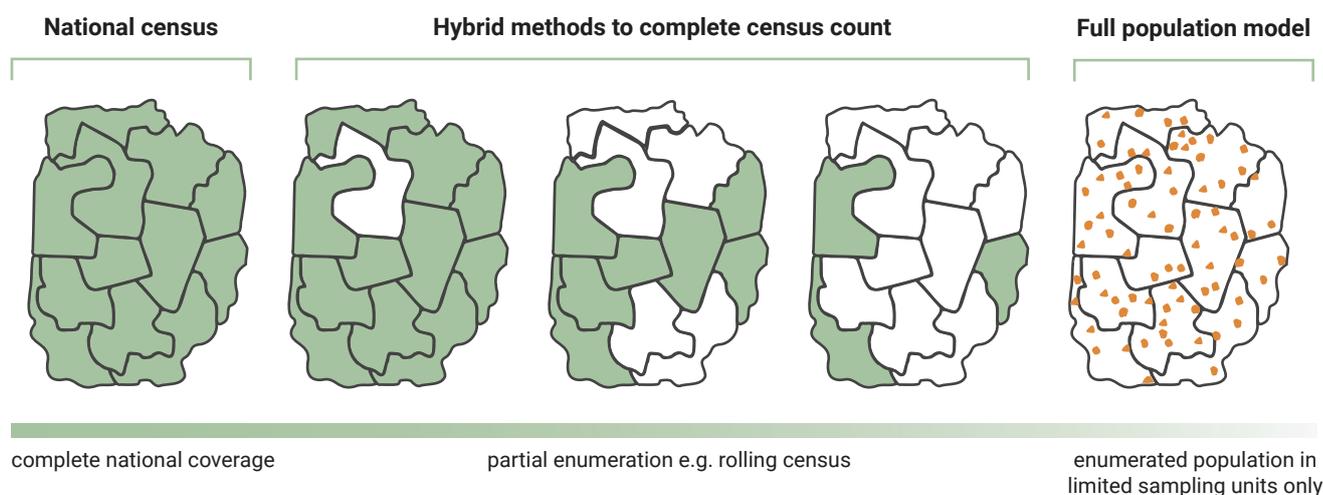
Implementation

The first step in utilizing population estimates for microplanning is to assess the type of population data available from the national statistics office, ministry of health or other government agencies that manage and collect population data. This assessment should include the seven dimensions of data quality reviewed in 6.6.2, as well as a review of factors specific to population data, which are covered below.

“Traditional” population data collected from censuses are the ideal source of data for population denominators, as they usually cover the entire population. However, they are infrequent and therefore become quickly outdated, and administrative boundaries may change over time. Other traditional population data can be obtained from surveys and Civil Registration and Vital Statistics (CRVS) systems.

While the full assessment of population data is out of the scope of this handbook, this section discusses important considerations for population data assessment.

Figure Y – Illustrative diagram of the types of population data sources and possible modelling approaches to estimate population. (Source: UNFPA, WorldPop) [43]



Begin by taking inventory of “traditional” and “official” population data for potential integration into the microplan.

1. Review available census data.

If recent census data based on a complete enumeration of the country are available, these are often the best choice for population estimates and denominators. National census data are ideally collected every ten years, but these are often outdated due to significant changes in population distributions over time.

2. Review other “traditional” or “official” population data sources such as representative household surveys, a CRVS, or health facility headcount data.

There are two common types of household surveys: demographic health surveys (DHS) and Multiple Cluster Indicator Surveys (MCIS). These surveys provide direct estimates of indicators needed, include measures of uncertainty, and are representative of the target population. Disadvantages posed by these data are that they are often collected every five years, and can therefore become easily outdated. They may not necessarily

be synchronized with the reporting requirements of long-term international targets and national health interventions plans and, like projected population estimates, they are often aggregated to high geographic administrative unit levels (i.e. coarse resolution) [35].

A well-functioning CRVS registers all births and deaths, issues birth and death certificates, and compiles and disseminates vital statistics, including cause of death information. It may also record marriages and divorces. A CRVS uses inputs into and exits from a population register to provide governments with critical information on their population by age, sex and location, on which to develop policies and plan services. While CRVS data are ideal, they are often unavailable, incomplete or of poor quality in most countries.

Health facilities may have their own headcounts that they use for microplanning. Comparing these data to other existing data, and presenting and discussing the differences and reasons for these differences at the local levels, can lead to enhanced geodata uptake, trust, use and data improvements. GIS officers can create thematic maps and charts comparing the differences and present them to local stakeholders, who can determine which population data source is most representative of the target population.

3. Estimate population or utilize previously generated estimates where census data is outdated or missing coverage.

National statistics offices produce “projected” population estimates, which are estimates that fill the gaps between census years. These projections can vary in complexity and resolution, from a linear growth rate to a rate that accounts for fertility, mortality and other factors.

Projected population numbers are most often generated at the subnational administrative level, and are not at the resolution needed for microplanning activities. These data often do not account for migratory and displaced populations, and often include discrepancies between original administrative boundaries generated with the census and newly projected numbers.

Next, take inventory of geospatial modelling-derived population data. When census, survey, CRVS or projected population estimates are available but out-of-date, low-resolution, or incomplete, high-resolution (fine detail) population estimates can provide an alternate source of reliable denominators, with distribution by operational units for programme planning and monitoring. The outputs of both are produced in raster (i.e. grid) format, and can often be obtained for free online and in ready-to-use file formats for GIS programmes. While these models are out of the scope of this handbook, it is important to understand their origin when assessing which population dataset to use for microplanning activities.

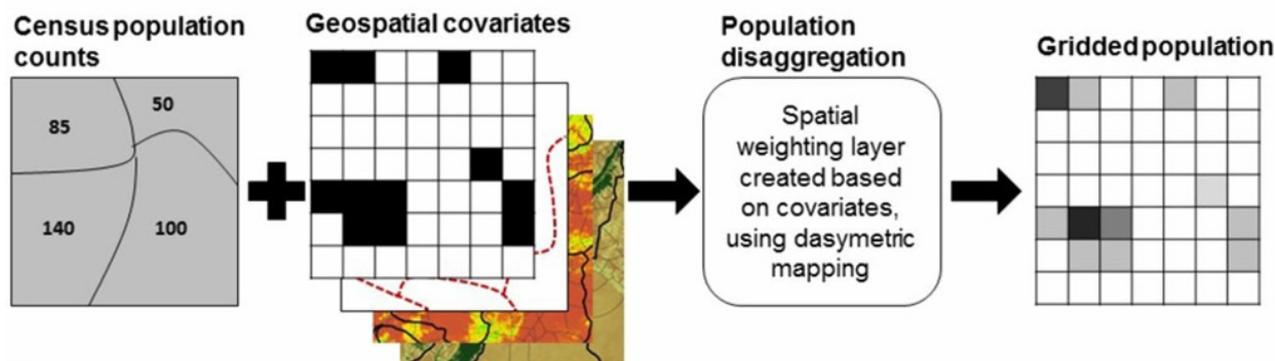
Geospatial model-derived population estimates are generated using statistical modelling techniques, geospatial covariates, and traditional (census or survey) population data when they are available.

Top-down estimation: When the chosen census or survey population dataset has complete spatial coverage of a country for the year of collection, a top-down estimation approach can be used to generate population estimates. This model uses dasymetric-modelling approaches to disaggregate the census data to a higher resolution (i.e. grids).

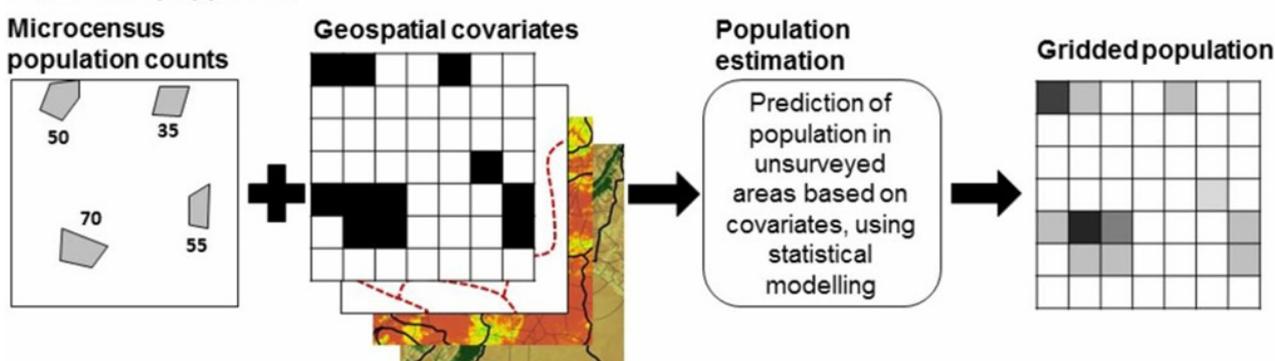
Bottom-up estimation: If a given “traditional” population dataset does not have complete national coverage, a bottom-up modelling approach can be used. This methodology is more recent and relies on geospatial data such as land cover, building footprints, roads and other geospatial features as covariates for Bayesian statistical models. This approach can also be used when no population data are available [35].

Figure Z – Schematic of (A) top-down and (B) bottom-up mapping approaches. Populations are assumed to be restricted to areas containing residential buildings; population density within these areas is predicted based on ancillary datasets such as road networks, temperature, or green vegetation. (Source: N.A. Wardrop, et al. [31])

A Topdown approach



B Bottom-up approach



When assessing these approaches for microplanning purposes, it is important to consider what caveats exist with the original geospatial data and population estimates used. It is also worth assessing the population modelling methodology's ability to filter out potentially problematic (inappropriate or oversimplified) methods and datasets. See [31,35,43] for more on these approaches. If the available population data are incomplete or outdated, additional data collection should be considered if time and budget allow. If no population data are available to support statistical modelling, CRVS data, existing population estimates and rapid modelling tools can be used to generate population estimates.

As population estimation methods are based on incomplete knowledge of the true population, one of the two following scenarios will likely occur when defining the content and format of the final product.

1. One of the available national, regional or global population distribution grids identified during data assessment (Section 6.6.2) meets the needs of the microplanning challenges (Section 6.1). In this case, products matching the purpose, content and format for the target audiences can be generated either directly through graphs or tables, or by creating thematic maps (Section 6.3.4 and 6.8.2.4).
2. None of the available population distribution grids meet microplanning needs. In this case, a population estimate grid will need to be created first, using the data that has been compiled (Section 6.6.2) along with data from a secondary source (Section 6.8.1), in order to develop products needed to support the rest of the microplanning process.

It is important to note that in the second scenario, the input data and methodology can vary widely and can produce different outputs. These outputs should be iteratively reviewed against the seven dimensions of data quality outlined in 6.6.2, to ensure quality and utility persist throughout integration.

See reference [32] for further details on these statistical modelling techniques.

Considerations

1. In some cases, it may be difficult for non-GIS experts to fully understand modelled data or the process used to create it, potentially causing stakeholders to doubt its accuracy and to be unwilling to use the data. Uptake and trust of modelled data can be improved by including relevant stakeholders in the modelling process, for example having them suggest weights, advise on model inputs or suggest travel time metrics.
2. There are inherent uncertainties and biases in population estimation methodologies, even when the input data is up-to-date and as complete as possible. Populations are not static, as they migrate, grow and even shrink over time in non-uniform ways. These uncertainties must be well understood on a case-by-case basis. Not only do they impact the population estimates and microplan effectiveness, but the uncertainties may also hinder stakeholder confidence and acceptance of the data. For example, if populations in certain parts of the country are known to be nomadic or highly mobile (perhaps on a seasonal basis), this may increase error rates in unpredictable ways, and lead to disproportionate miscounting of remote, nomadic and/or marginalised populations [17]. Many of these datasets are available in gridded (raster) format, and are freely available for download, along with guidance on intrinsic uncertainties and recommendations for use. For the reasons mentioned above, population estimation methodologies are often needed to fill in missing population data gaps.
3. Census, survey data, and population projections are often generated at the enumeration area boundary or sample cluster level. These boundaries can change over time, and may also vary depending on the government ministry or entity creating the data. The team should make sure to have the latest official administrative boundaries, enumeration area boundaries, and other relevant data from the appropriate government ministry to ensure comparability with original population estimates.

Population modelling needs boundaries that match observations. For example, if the census data were produced in 2019 but administrative boundaries were modified in 2021, then the 2019 boundaries should be used for population modelling. However, 2021 boundaries could then be used to aggregate the results up to the current administrative areas.

4. Land classification: Satellite imagery may be used to classify land use into categories, such as residential or agricultural. These classifications can be measured and used to identify where population may have changed since the source population data were collected. It is especially useful for capturing urbanisation, historically underrepresented populations and rural areas.
5. Building footprints: Building footprint vector data can often be obtained for target regions. These footprints may have been manually digitized, or generated from satellite imagery using machine learning models. Building footprints can then be used to constrain results to settled areas, and thus to accurately estimate the number of households. When available, footprints can also be used to validate census data and land classification and, if the footprint quality is high, to generate more accurate population estimates.

6.8.2.3 Geographic accessibility, service location and route optimization models

Programme Designer	GIS Technical Staff
	

Implementation

While modelling methodologies and software vary widely, there are a few key input data used for most geographic accessibility models, which could include the following:

- A transportation network for the area of interest
- Hydrographic network and other potential barriers to movement (flooded areas, low security areas)

- Spatial distribution of the population in point vector or raster format
- Boundaries of the areas for which population coverage would be estimated (administrative or health units)
- A travel scenario, or defining average driving speeds over different classes of roads and/or land cover, depending on the considered mode of transportation
- Point locations for the places to and/or from which physical accessibility is being estimated, or routes are being calculated. This may include health facilities, cold storage locations, or settlement locations.

Once these data are available, take the following steps to create a geographic accessibility model:

1. Clean and harmonize input data, particularly if it comes from multiple sources.
2. Integrate data into either a vector network or a raster “friction surface” over which travel times can be calculated.
3. Calculate access times from origins to destinations over this network or surface.
4. Prepare visuals, charts or key figures from the resulting GIS data, to help communicate findings.
5. If needed, prepare linked analysis products, such as service delivery route optimizations or service location optimizations.
6. Socialize and validate results with stakeholders, and repeat the modelling process if results are not validated, inputting new data and/or adjusting parameters until realistic travel times are obtained.

The above represents a high-level summary of a complex and sometimes highly technical process. Examining this process in depth is beyond the scope of this handbook and is covered in detail elsewhere. Readers with lower resources and/or technical backgrounds should also consider making use of semi-automated tools such as AccessMod³¹, to prepare accessibility models with less resource and time commitments.

Considerations

Teams weighing whether and how to implement accessibility models within their geo-enabled microplans should take into account several key considerations. First and foremost, like population estimation and spatial distribution, geographic accessibility and service location optimization modelling can be time-consuming and resource-intensive. Creating a highly accurate, customized and locally appropriate model may take weeks or months, including time waiting for data access.

Additionally, the best custom accessibility and route optimization models emerge from a combination of expert knowledge about local travel conditions, and high-quality, recently produced spatial data inputs. If such inputs are unavailable, as is common, a degree of error is unavoidable in the models. Defining and communicating the minimum acceptable level of error at the outset of a project can help to manage expectations.

Beyond the above potential issues with data input quality, resourcing and timeframes, service location models may also encounter difficulties and delays if their conclusions are not accepted by local partners. Local partners may be reluctant or unwilling to relocate fixed services that have been sub-optimally allocated for specific reasons, policy-related or otherwise, prompting awkward and time-consuming negotiations. This underlines the value of regular consultations with partners, starting early in the geo-enablement process to avoid such surprises near the end.

Be aware that geographic accessibility models return results for the “average” traveller in a population. Even if sufficient data can be gathered to make model results as realistic as possible for the target population, they will always tend to produce results corresponding to the best case scenario (people going to the nearest service delivery point, equal opportunity to travel, and/or quality of service, etc.). These results are therefore much more informative if they can be complemented by data and information describing the real behaviour of people in the field (e.g. results from patient and/or household surveys).

It is also important to be aware of the advantages and disadvantages of different distance, travel time, and catchment extent modelling methods. This information is reported in Table 14, and

See reference [32] for further details on these statistical modelling techniques.

31. <https://www.accessmod.org/>

Table 14 - Primary methods used to model distances, travel times and catchment area geographic extents around service delivery points

Method	Measurement type between two locations (A and B)	Resulting catchment area	Advantages	Disadvantages
Euclidean distance	Straight line distance from A to B	Areas defined by a buffer of a given radius around service delivery points	<ul style="list-style-type: none"> ◉ Easiest method to operationalize, requires less data, computing power and skills 	<ul style="list-style-type: none"> ◉ Only applicable to travel on foot ◉ Not practical, does not account for impacts of natural barriers, topography, etc.
Isochrone	Time from A to B along network N (no off network travel allowed)	Areas defined by connecting locations from which it takes the same time to travel along a network (e.g. transportation network)	<ul style="list-style-type: none"> ◉ Easier to operationalize than the travel time-based method ◉ Provides more realistic results than Euclidean distance, especially when travel is primarily along a transportation network 	<ul style="list-style-type: none"> ◉ Primarily applicable when a population travels using the transportation network ◉ Does not provide realistic results in areas with limited or no transportation network (over or underestimated travel time in these areas) ◉ Requires more data and skills
Cost-distance	Time from A to B using the fastest available means of transport, on- or off-network	Areas defined by the sum of all locations (on or off transportation network) from which it takes the same time to travel	<ul style="list-style-type: none"> ◉ Offers most realistic results, provides real values for locations, allows for combining different travel scenarios (walking, motorized vehicle, etc.) and accounts for natural barriers 	<ul style="list-style-type: none"> ◉ Most complex and resource intensive method, requires more input data, computing power and skills

Population can also be used to define the geographic extent of the modelled catchment area (see Section 6.2). In this case, either population is used as the limiting factor to define the size of the buffer around each service delivery point (Euclidean method); or used in combination with travel time to define the geographic extent of the catchment area (cost-distance method).



6.8.2.4 Thematic maps

Programme Designer	GIS Technical Staff
	

Implementation

As thematic mapping generates the most visible product when geo-enabling the microplanning process, special attention should be placed on creating these maps.

Generating thematic maps can be accomplished in many ways, depending on the context of the microplan. The following process is a general outline for creating thematic maps. Special considerations for this process, including generating GIS data for inclusion in a microplanning template (e.g. REDREC), can be found in the Considerations section below. Reference [6] contains more details on each step:

1. Import data into the GIS software
2. Select the appropriate mode of representation
3. Fix the symbology
4. Add labels to the map
5. Choose the map orientation (or map template)
6. Fix other elements of the layout to make the map usable
7. Save the final map in the appropriate format.

Considerations

In addition to the above process, there are other important considerations for generating thematic maps.

If using a microplanning template (e.g. the Reach Every District Reach Every Child (REDREC) template), it is important to address the requirements when creating GIS data, to make sure the maps and data are relevant and useful. For example, a vaccination microplan may target children under five years of age who are 5km or more away from a health facility. A microplanning template may require that all settlements that are over 5km away from a health facility are symbolized (colour coded) a specific way in a thematic map, or catchment areas are generated in specific time increments.

Aside from template-specific considerations, the following items should be considered independently from the format in which the maps created using the GIS software are being shared:

- ⦿ Ensure that all the standard cartographic elements necessary to make the thematic map usable are included (Figure Q).
- ⦿ Prioritize “easy comprehension” over “beautiful design”, as simpler maps are often more likely to be understood and used by their intended audience.
- ⦿ If hand-drawn maps have been in previous microplanning efforts for similar interventions, include as many features as possible from these hand-drawn maps when creating GIS maps, in order to facilitate uptake and understanding.
- ⦿ Name the type of geographic objects in the map legend in the same manner as they are referred to in the corresponding master list.
- ⦿ Ensure map colours do not consist of both green and red, as colour-blind persons will not be able to distinguish the difference.
- ⦿ Not all elements need to or should be added to maps. Charts and tables with information, such as population totals or breakdowns, can be useful alongside a map.

The following should be considered when using printed versions of thematic maps.

- Map appearance: When choosing label sizes, consider that not all map users may have good eyesight or have access to glasses.
- Map size and printing: Ensure that the map is either zoomed sufficiently on the area of interest, or large enough to effectively convey and display necessary information. Map dimensions will depend on the size of the operational area needed to support microplanning. If maps in smaller sizes are required, such as A4 or A3, optimize map colours for black and white printing in case colour printers are not accessible locally.
- Map use and replicability: In case the geospatial data or information on the map is incomplete, consider printing maps on laminated paper and providing stickers or erasable markers, so that users can make additions and suggest corrections to the map directly.

When shared in electronic format (e.g. pdf or jpg), users can zoom in and out of specific areas on a thematic map. This enables more detailed data to be observed in comparison to paper maps, and can allow users to identify accuracy issues in datasets.

In addition, thematic maps shared as web maps may be set to allow users to zoom in and out, or to select which datasets should appear on the map. Users may also be able to dynamically query information attached to each geographic object on the map, or the value stored in each cell of a raster layer. However, these increased capabilities bring with them the need to ensure the quality of the geospatial data used, and of the information that can be queried through it:

- Establish a feedback or coordination system to ensure that data that are updated or changed on the map are also updated or changed in the central geo-registry or original dataset.
- Conduct map user interviews to assess 1) if the maps were used in the field, 2) how they were used, and 3) ways in which the maps can be improved for future use.

Figure AA – A map generated to support geo-enabled COVAX microplanning efforts in Nigeria. (Source: GRID3)



Programme Designer	GIS Technical Staff
Continue to next section	Continue to 6.9 Scale up and/or sustain what has been implemented



6.8.3 Integrating products in the microplanning process

Programme Designer	GIS Technical Staff
	

The products and associated information considered suitable for use in the current and/or future round(s) of the microplanning process (Section 6.8.2) still need to be properly integrated into it. While the purpose, audience, content and format of such products and associated information have been described earlier (Section 6.3) the considerations described here are aimed at ensuring that they are effectively linked with the relevant operational steps of the microplanning process so that the intended users can effectively use them for action and decision-making.

The primary products and associated information to be integrated include:

- The result of the conceptual data model exercise (e.g. definition and classification tables for the types of geographic objects used as the smaller implementation units in the microplanning template).
- Master list for types of geographic objects core to the microplanning process.
- Tables and graphs presenting statistics and information resulting from population measurement and spatial distribution (e.g. target population distribution by subnational unit or health area) or geographic accessibility analysis (e.g. percentage of the target population with access).
- Thematic maps presenting the geographic location or extent of various geographic objects stored in the master list and/or the geospatial data that has been generated (e.g. population and travel time distribution).

The actions required to ensure integration of the products and associated information in the microplanning process can be broadly summarized as follows. These are detailed in the remainder of the section with more specific examples:

- Alignment between the list of geographic objects, their definitions and hierarchies defined during the geo-enabling process, and the equivalent information contained in other information products utilized by microplanning users, such as microplanning forms.
- Inclusion of additional tasks arising from the geo-enablement in the official microplanning SOPs and guidance distributed by the relevant authority overseeing the microplanning process.
- Delivery of the maps, charts and tables produced by the geo-enabling process to the right user at the appropriate stage of the microplanning process and with adequate training.

The result of the conceptual data model exercise, especially the part aimed at identifying and defining the geographic objects key to the microplan (Section 6.2), might require adjusting or improving the forms and associated microplanning material. This kind of adjustment or improvement should be implemented in the planning phase of the microplanning process.

In Myanmar, this exercise allowed improvement of the classification used to define the different types of EPI communities to be covered during routine immunization and ensure that none of them were missed. Table 15 presents the classification that resulted from this exercise, and Table 16 the classification of population presence status associated with it.



Table 15 – EPI community classification (Myanmar)[44].

Type of EPI community	Definition	Population presence status options
Ward	4th level administrative divisions encountered in urban areas and officially recognized by the GAD	long term
Village	Long term settlement officially classified as village by the GAD	long term
Army	Settlement managed by the Ministry of Defense	short term, long term, seasonal
Camp	Settlement typically settled for displaced population (refugees or internally displaced population for example)	short term, long term
Workers settlement	Settlement setup by workers to live close to their place of work (plantation, factory, building site, mining site...)	short term, long term, seasonal
Other settlement	Any other inhabited place not covered by the other definitions, including displaced and migrant populations	short term, long term, seasonal

Table 16 – Population presence status classification (Myanmar).

Population presence status	Definition
Short term	Settlement setup for a period shorter than 1 year
Long term	Settlement setup for a period longer than 1 year
Seasonal	Settlement setup temporarily over the same period every year

Coming up with such a classification required adjustment of some of the content of the microplanning form (e.g. change of header label, additional column) as well as the SOP used by field staff to fill the form.

In Mozambique, the process to understand the geographic dimension behind routine microplanning identified that two of the geographic objects used for planning and monitoring in the microplanning form (*povoado* and community) were subject to interpretation in the field, partly because their definition had not been officially standardized by any government agency. To avoid missing part of the population during routine immunization, it was suggested to the EPI programme to consider developing and managing the microplan at the concentration point³² level.

Available georeferenced master lists of quality should be used by all the involved stakeholders at all stages of the microplanning process (Table A), not only because they provide the planning denominator (e.g. number of available health facilities, vaccination points or warehouses), but also ensure data interoperability across sources through the unique identifier (unique ID) set for all the geographic objects considered in the microplan, as well as the generation of thematic maps and other products geographically consistent across sources.

In order to operationalize the above, the same version of the master list needs to be accessible to all stakeholders involved in the development, implementation and monitoring of the microplan. This could be challenging depending on accessibility to the Internet, especially in the field, and require different approaches including the printing of the master lists. Given the importance of the unique ID for data interoperability, it is typically required that the unique ID be integrated into the relevant microplanning forms to ensure unequivocal cross-referencing between geo-enabling products and other information products (for example the microplanning forms). This should be accompanied by specific guidance and provision in the relevant SOPs for the proper recording and utilization of the unique ID.

32. equivalent of a vaccination point

Each master list should be accompanied by its respective data dictionary and associated classification table, as well as metadata (see Section 6.3.1), to ensure their proper understanding and use.

How to access and use the master lists should be documented and included in the microplanning material distributed to stakeholders. Please refer to Section 6.9.2 for more detail on reporting and treatment of issues identified with the master lists during their use.

Tables and graphs presenting statistics and information resulting from population measurement and spatial distribution, as well as geographic accessibility analysis, will themselves be used during the planning and re-evaluation phases of the microplanning process (Table A). This means that the analysis generating these products should be conducted as early as possible to allow for their use during the planning process.

The resulting tables and information should ideally be accompanied by a data dictionary and, when needed, a description of the method that has been used to obtain them, either as part of their metadata or a separate document, depending on the level of detail necessary to ensure their proper understanding and use.

Thematic maps are intended to support the whole microplanning process and are suitable for integration at different stages and at different levels. Their applicability can result in more users than the products generated through the three other applications, and therefore require more comprehensive/diverse material to allow for their proper understanding and use. The geo-enablement may generate a large number of products (tables, graphs, maps) making it difficult for them to be absorbed by the staff meant to use them. In this case, integrating these products together either in a static form (e.g. tables and graphs integrated in .pdf format maps) or dynamic (e.g. dashboard) should be considered.

There will always be a need to facilitate the introduction of new products in the microplanning process. This will require:

1. The development of a guide on how to read, understand and use the product.
2. Training the staff using these products on the basis of the guides developed under point 1 (Section 6.7.3).
3. Adjusting the microplanning material to describe where and how the new products should be used and for what purpose.

Once new products considered suitable for integration in the microplanning process are identified, training material has been developed and the microplanning material has been adjusted, it needs to be decided if the timing is right for such integration.

Reasons for the timing not being appropriate include but are not limited to:

- ⦿ The emergency situation (e.g. disease outbreak) which might not allow enough time for quality products to be generated and/or introduced sufficiently to be understood and used correctly in the field.
- ⦿ The implementation of the microplan is already too far advanced to change the process on a large scale without risking a negative impact on its outcomes.
- ⦿ The change management required by the integration is more significant than initially anticipated, e.g. requiring more advocacy to take place.

When this is the case, the integration may be implemented at a lower scale than initially planned, in areas where the microplanning process has not yet started, or postponed and implemented during the next microplanning cycle.

If the integration is postponed, it can be useful to capture feedback, comments and suggestions on the new products from the staff who will use them, not only to improve them, but also to facilitate their introduction during the next microplanning cycle. This could take place as part of a survey or interviews conducted at the different levels of the microplan implementation (Section 6.8.4).



6.8.4 Documenting processes, lessons learned and impact

Programme Designer	GIS Technical Staff
	

Documenting processes and lessons learned during the geo-enablement of the microplan is a crucial step towards either scaling it up, if implementation has only taken place as a pilot until now, and/or institutionalizing it. (Section 6.9.1)

In view of the length of the geo-enabling process, it may be preferable to develop the following set of documents:

1. Overall process that led to the development of the geo-enabling workplan (Section 6.7), starting from identification of the microplanning challenges to be addressed through the geo-enablement (Section 6.1).
2. Details of technical processes followed including challenges and lessons learned when addressing data availability and quality issues (Section 6.8.1); identification of the geographic dimension of the programme and definition of the conceptual data model (section 6.2); and generating the products resulting from the operationalization of the four applications of geospatial data and technologies covered by the present handbook (Section 6.8.2). If data specifications and/or standards have been defined as part of the geo-enablement these should be documented at the same time.
3. Processes, feedback, challenges and lessons learned during the integration and use of the products in the microplanning process (Section 6.8.3).

This documentation is not only useful from a reporting and auditing perspective, but could also serve as reference material to be used by other countries during the implementation of their own microplan. It also plays an important role when scaling up or sustaining the geo-enablement of the microplanning process (Section 6.9.1) and should, as such, be as comprehensive as possible. In order for this to be possible, the documentation process should take place in parallel to the implementation of the geo-enablement and not at the end of it; be the responsibility of staff directly involved in the implementation of the processes; and, when applicable, include recommendations for the scaling up and/or sustainability of the geo-enabled microplan.

Evaluation reports capturing key lessons from monitoring, evaluation and learning, key lessons learned, stories, and suggestions regarding the next actions are highly valued by outside audiences, especially those who invested in the programme (donors and partners). They also need regular reporting to evaluate the success of their investments. Consider establishing a system of regular health check-ins with stakeholders who are not involved in the day-to-day activities as a key function of sustaining a programme.

The technical processes that have been followed to address data input issues as well as generate products should be captured in such a way that they can be reproduced and reach the same results if they are implemented by someone other than the technician who implemented them in the first place.

The feedback, challenges and lessons learned being documented should ideally cover, but not be limited to:

- Difference in budget and timeline compared to what has been defined in the workplan.
- Adequacy of technical capacity, and workload of personnel involved to operationalize the chosen applications.
- Gaps in the standards, protocols and guidelines that have been used.
- Insufficient or inadequate technology being used during data management, including data collection, and/or the generation of the products.
- Issues in data availability, quality and accessibility that could not be resolved.
- Difficulties by the intended users in reading, understanding, trusting and/or using the products that have been generated despite the documentation provided.

- Inadequacy of the products that have been generated.
- Insufficient support (hotline) during the use of the products.
- Adequacy of channels or avenues of communication and coordination between the personnel involved in various stages of the geo-enablement.

Documenting difficulties in reading, understanding, trusting and/or using the products that have been generated could take place in the form of a survey, or interviews aimed at those who were meant to use them across the microplanning process and levels. This exercise could also help understand if and how the products have been used.

The above should be complemented by the measurement of the key performance indicators (KPIs) defined in the MEL framework (Section 6.7.7) before, during and after geo-enablement of the microplan.

In addition, these indicators should provide a measure, quantitative or qualitative, of the impact that the geo-enablement had on the challenges identified at the beginning of the process. These measurements are particularly important when it comes to justifying the investment made through the geo-enablement, and to request additional funding for scaling up and/or long term sustainability (Section 6.9). Moreover, the design of the KPIs should be done so as to allow probing contextual causes of the challenges encountered which might not be technical or procedural in nature. These could be, for example, motivational or socio-economic factors associated with the sustainable utilization of new technological devices, or adherence to the process by frontline health workers or district planners. Such information will be crucial for devising adequate strategies for scaling up of the intervention.

6.8.5 Sharing products beyond the microplan

Programme Designer	GIS Technical Staff
	

The sharing of products among the stakeholders directly involved in the implementation and monitoring of the microplan should be secured as part of the development and implementation of the workplan (Section 6.7.8).

There may also be value in sharing products generated through the geo-enablement, as well as disseminating the details of the geo-enablement process, beyond the specific public health programme that originated the investment. This could be the case when looking for additional external sources of funding; leveraging the outcomes of the geo-enablement to support geo-enabling other public health programmes; building on the geo-enablement of a specific programme to advocate for a wider geo-enabling of the Health System; or informing the public about the geo-enablement and its positive impact on the population's health.

In addition, other government agencies or some institutions (e.g. research entities) might be interested in accessing some of the data generated or improved during the geo-enablement for purposes other than microplanning (e.g. georeferenced master lists, population distribution, travel time distribution grids).

In both cases, it is important to define the general terms and conditions through which the data and products in question can be shared taking into account the policy, and therefore potential restrictions, associated with the original data that have been used to generate them (Section 6.6.2.4). Privacy and sensitivity issues should also be considered when defining such terms and conditions.

6.9 Scaling and sustaining geo-enabled microplans

Programme Designer	GIS Technical Staff
	

This section covers:

1. Storage, maintenance, improvement and updating of the data and products generated during the geo-enablement.
2. Scaling up the geo-enablement process if it has been a pilot project.
3. Long-term sustainability of the geo-enabled component of the microplan when applicable (e.g. routine immunization).

These considerations can assist the microplanning team and programme managers to develop an understandable investment strategy for scaling up and sustainability, taking into account documented processes, challenges, feedback and lessons learned (Section 6.8.4).

6.9.1 Storing, maintaining and updating data and products

Adequate consideration for the storage and maintenance of the core data of the geo-enabled microplan should be part of the development and implementation of the workplan (Section 6.6.2). In this section, additional considerations to ensure scaling and sustainability of the use of the data are discussed.

It is important to ensure the proper storage and maintenance of the data generated or improved during the operationalization of the four applications covered by the handbook, regardless of the scale at which the geo-enablement took place, because:

- They provide a picture of the situation at the time of implementing the microplan.
- They could be re-used for future microplanning needs (e.g. routine immunization or subsequent public health campaigns).
- They could be re-used to support other interventions, possibly outside the public health sector (e.g. education or nutrition programmes).
- If re-used for future interventions they might need updating, which will be facilitated by proper storage and maintenance systems.

As an example, in Vanuatu in 2019 as part of an accessibility analysis to health care services conducted by the Ministry of Health³³, the improvement of the master list of health facilities and their geographic coordinates, as well as the work done on other geospatial data, directly supported the rapid impact assessment and the response to tropical cyclone Harold in April 2020.

Other sources of data or information of importance to the operationalization of the four applications covered in this handbook may also be generated or collected during field activities beyond the microplanning process. If these are good quality (see Section 6.6.2), such data should be considered for integration in the existing datasets used for the generation of microplanning products. These could be, for example, the availability of a higher resolution digital elevation model (DEM), a more recent land cover layer, or a large health facility level survey conducted for planning purposes.

In addition, the geography of the microplan evolves over time. New health facilities, vaccination and/or distribution points will open, others will close, the population will grow or move, and new roads will be built, health areas will be modified – all of this impacts microplanning.

33. https://healthgeolab.net/KNOW_REP/Acc_Analysis_VUT_050224_FINAL.pdf

This calls for the data to be:

- ⦿ properly stored in a backed-up repository agreed upon by the microplanning team (not someone's personal computer)
- ⦿ maintained (curated, improved)
- ⦿ regularly updated
- ⦿ documented based on a metadata profile defined on the basis of existing standards (e.g. ISO, FGDC, DCMI [13]).

Efforts should be made to ensure that the data in question remain openly accessible to allow for their largest use possible, and as such contribute to data interoperability. In addition, if data sourced during the geo-enablement of the microplan are already adequately stored and maintained in a dedicated repository (e.g. a settlements master list maintained by the national statistics office), the geo-enablement programme should not create a duplicate storage solution, but rather agree on provisions for leveraging the existing repository.

All the above should ideally take place under the umbrella of a cross-sectoral coordination and collaboration mechanism such as the National Spatial Data Infrastructure (NSDI) when in place [18].

The products generated as part of the microplanning process, such as the results of an accessibility analysis or a thematic map, should be stored in an organized way, ideally in the same backed-up repository as the one containing the data, together with associated key files (e.g. GIS projects used to create thematic maps) and metadata, enabling people to easily find, use and edit them as needed.

The details of the process used to generate or improve any given product, including the model(s) that have been implemented, should be well documented in order to allow for their understanding as well as their potential re-use and/or improvement (Section 6.8.4). This documentation should be easily accessible and referred to in the metadata of the given products.

Any significant change in the data used to generate these products, as well as errors or need for adjustment identified during the use of the current version of these products, should ideally trigger their update.

The timing for implementing changes in the data and/or products will depend on the availability of the technicians who have the responsibility and necessary skills for the management of the data and/or the generation of the products.

The appropriate timing for replacing the old version of the products with the new ones should be decided on a case-by-case basis. For example:

- ⦿ If the changes are not significant enough to have an impact on planning, implementation or monitoring of the microplan, they can wait until after the implementation of the current microplan.
- ⦿ If the changes are significant and could have an impact on microplanning, the possibility to proceed with replacement will depend on difficulties in sharing the updated/improved data and/or products (e.g. low internet connectivity), as well as the confusion that such a change might introduce especially if the previous version has already been used.

The next sections provide some additional storage, maintenance and update considerations specific to each of the four applications of geospatial data and technologies covered by the handbook.



6.9.1.1 Georeferenced master lists

Programme Designer	GIS Technical Staff
	

Quality georeferenced master lists are not only core to the geo-enablement of the microplanning process, but also of any other health intervention.

As such, it is important that the master lists generated or improved as part of the geo-enabling process for the types of geographic objects core to microplanning are stored, maintained (curated, improved), and regularly updated in a way that ensures their quality over time as well as provides easy access for use, not only in the context of the microplanning process but also beyond.

Although it is common for countries to utilize less than optimal IT solutions for such tasks (e.g. excel spreadsheet or other software solutions not adequately designed), the above tasks can be facilitated and optimized through the use of different registries, geo-registries or in a common geo-registry providing the necessary functionalities to store, manage, curate, regularly update and share the different master lists, as well as the associated hierarchies and geospatial data, as they evolve through time.

It is important to highlight that most, if not all, of the types of geographic objects core to microplanning will not be under the curation mandate of the health programme implementing the microplan. The government entities having such a mandate within the ministry of health (e.g. department of planning for the health facility master list) or outside it (e.g. ministry of interior or the national mapping agency for administrative units or villages) should therefore be the ones to handle the above-mentioned lists, hierarchies and geospatial data in separate registries, geo-registries or in a common geo-registry.

These same government entities should be the ones in charge of operationalizing a mechanism for regular updating the lists and associated geospatial data. Such mechanisms may typically include:

1. Regular censuses for the specific geographic objects, at national level or for specific areas: these can provide complete data of standard quality, but are very costly and time consuming.
2. Specific update reporting protocols within government agencies responsible for specific master lists, to be triggered when an update is required for specific records: these can significantly optimize the updating process and reduce costs, but will require efficient organizational coordination to be effective.
3. Inclusion of geospatial data collection protocols alongside availability of GNSS-enabled digital devices for health programmes involving field activities, such as primary health care programmes: These have the advantage of limited cost (if GNSS-enabled devices are already available), but will require adequate training to ensure quality of the data collected.
4. Public crowdsourcing platforms or dashboards: These platforms are very useful especially in areas where data are missing and to engage the public, but data quality and consistency can be difficult to ensure and assess.

In the context of (3) above, the integration of the information and data collected for specific geographic objects during the geo-enablement of the microplan (e.g. geographic coordinates of health facilities or villages that were previously not available in the master lists) are amongst the possible mechanisms.

The updates that are being implemented in the master lists and associated geospatial data should be reflected in their metadata, and eventually data dictionary and classification tables.



6.9.1.2 Population estimates and spatial distribution

Programme Designer	GIS Technical Staff
	

The population estimates and spatial distribution used, or generated, as part of the geo-enabled microplan are meant to be updated as the target population grows or otherwise changes over time, for example due to internal migration, displacement or seasonal movements. Moreover, when new sources of population data are made available through household surveys; censuses or other data collection activities, including demographic and health surveys (DHS); multiple indicator cluster surveys (MICS); or headcount exercises (for example conducted as part of a routine microplanning process); these will provide the opportunity to update the population estimates.

Microplanning teams and the partners who generated the population estimates and spatial distribution for the current microplan, as well as the agencies collecting data for the above-mentioned surveys, censuses or other demographic data, should coordinate the efforts aimed at updating the population estimates and spatial distribution to be used during the next cycle of the microplanning process.

Such coordination is amongst the activities that would be facilitated by the governance structure established as part of the geo-enabling process (section 6.7.1). This coordination could for example lead to [17]:

- ◉ Identifying new data sources (e.g. household survey and ancillary data, DHS) that can be used to update or enhance the population estimates, and ensuring that such data are shared and accessible in a format conducive to being used for population estimates (for example, ensuring that quality geospatial coordinates of survey clusters are collected and made available).
- ◉ Consulting on quality assurance criteria, and quality assessment and monitoring procedures, including for the identification of data sources that would be suitable for integration in the next edition of estimates and spatial distribution, or the choice of the model being used to generate these products.
- ◉ Harmonizing sampling design for future data collection exercises. For example, the coordination could lead to aligning the geographic extent of the smallest microplanning unit (e.g. EPI community) with those used for census purposes (e.g. enumeration areas), to facilitate the use of census data during microplanning.

All population raw data, estimates and resulting spatial distribution should ideally be stored, maintained and documented in a geo-enabled data warehouse, managed by the government entity having the curation mandate over population data (e.g. national statistical agency).

To ensure the proper contextualisation of population figures both geographically and temporally, (for example so that population spatial distribution can be adequately spatially overlaid with other data to inform health programmes, or that population figures can be extracted from the spatial products for specific geographic areas of interest), this data warehouse should be in sync with the registries, or common geo-registry, hosting the master lists, associated hierarchies and geospatial data for the geographic objects to which the population figures are attached.



6.9.1.3 Geographic accessibility, service location and route optimization models

Programme Designer	GIS Technical Staff
	

Geographic accessibility will evolve through time. The spatial distribution of the population will change (Section 6.9.2.2), new services will be established, others will close or potentially be relocated, new roads and bridges will be built, etc. All of this, as well as other factors, will have an impact on the results obtained when using spatial modelling to define the optimal location of services, or to define the optimal route for the delivery of services or commodities.

The quality of the data used to conduct this kind of analysis might also improve, including the content of georeferenced master lists for the relevant services (e.g. health facilities, vaccination points, warehouses) (Section 6.9.1.1), the spatial distribution of the population (Section 6.9.1.2), or other geospatial data such as transportation and hydrographic network or land cover.

The above calls for the same considerations as those mentioned for population estimates and distribution (Section 6.9.2.2) when it comes to the need for collaboration and coordination among the partners involved in the generation, storage, maintenance and regular update of the data that are needed to conduct these analyses.

The models and processes being used to measure geographic accessibility or optimize the location of services or routes should also be regularly reviewed to identify if the results they generate remain pertinent to support microplanning, or if other models should be used instead (e.g. using a travel time-based model instead of a distance-based one).



6.9.1.4 Thematic maps

Programme Designer	GIS Technical Staff
	

The electronic form of the thematic maps created and used during the microplan should be organized and stored in the backed-up repository agreed upon by the microplanning team.

The following should ideally be stored in the repository for each thematic map so that any operator, including the one who created the map in the first place, can easily maintain and update the maps:

- On the map itself:
 - ▶ The name of the GIS file used by the GIS analyst to generate the map. This information will allow the operator to easily find the file in question and can appear in very small caps in a corner of the map [6]
- Associated to the map:
 - ▶ The geospatial and statistical data included on the map with its metadata
 - ▶ Any SOP or methodological notes followed to create the map.

If online maps have been created, the necessary information to access their editable form should be documented and also stored in the repository.

Thematic maps are the products that will need to be updated and/or adjusted the most frequently among those generated to support a geo-enabled microplan. They will be updated to reflect the evolution of the microplanning geography through time, or adjusted as new sources of quality primary or secondary data are available. Moreover, updates might be required to accommodate feedback, as well as requests for modification and improvements to the layout and content of the thematic maps received from those using them.

Managing requests for modification or improvement requires feedback and request mechanisms to be defined, documented (e.g. SOP) and operationalized. Such a mechanism could for example be initiated at the moment of distributing the maps to those meant to use them. Not only would this ensure that the maps are being understood, but also create a sense of ownership among stakeholders by capturing their local knowledge on the map. Depending on the resources available, stickers or other materials can be added to maps to indicate feedback or request for changes. A photograph of the map resulting from this exercise could then be sent to the appropriate person based on the defined SOP.

Independently from the mechanism that has been established, the feedback and requests received should be treated according to their nature. More specifically:

- Requests related to information captured in one of the **georeferenced master lists** should be channelled through the updating mechanism associated to these lists. This type of request includes, for example, new geographic coordinates collected in the field; identification of health facilities missing on the map and therefore in the master list, or that are not operational anymore. When it is not possible go through these channels because of the situation (e.g. response to an outbreak), or because they are not in place, a note of the modification applied on the map should be taken and passed through the channel in question as soon as possible, for the benefit of all users.
- Feedback or requests related to the usability of the **thematic maps** (e.g. change of colours in the legend, or errors noticed outside of the map content itself e.g. typo in the title of the map) could be directly communicated to the technician in charge of updating the map in question, once the change has been approved for implementation.
- Feedback or requests related to the products on **population spatial distribution** or the results of the **accessibility analysis** might be more difficult to implement due to the complexity of the models and processes used to generate them. The pertinence and possibility to implement them should be assessed by the microplanning team, in consultation with the partner organizations that contributed to the creation of the products, in view of the effort that these might represent.



6.9.2 Scaling up the geo-enablement of the microplanning process

Programme Designer	GIS Technical Staff
	

If the geo-enablement has taken place under the form of a pilot covering only part of the country for some or all of its components, as decided at the time of developing the workplan (Section 6.7.2), and it has been successful, the possibility to scale it up should be considered.

Such scaling up should take place on the basis of a new workplan that will build on the results of the initial assessment (Section 6.6), and will be developed using the same guidance and considerations as those described in this handbook for workplan development (Section 6.7) and its implementation (Section 6.8)

At this stage care should be taken that any new knowledge arising from the pilot project (as documented in Section 6.8.4) is integrated into the new workplan, and that the technical capacities that have been established or strengthened during that same pilot are leveraged.

However, depending on the geographic extent of the pilot project, the size of the country and/or the resources at disposal, the scaling up might either take place in phases or all at once to reach national coverage.

6.9.3 Institutionalizing what has been established

Programme Designer	GIS Technical Staff
	

Once a microplan needing to be repeated on a regular basis has been geo-enabled (e.g. for the delivery of routine immunization services), there is a need to ensure the long-term sustainability of the process by institutionalizing it. In addition, the geo-enablement of each microplan represents an opportunity to provide technical and political momentum for further geo-enabling the overall health information system.

Institutionalization at both the microplanning and health system levels should be viewed holistically in the context of the first two stages in the geo-enabling framework pyramid (Figure B), namely:

- Stage 1 (institutional framework): vision, strategy and plan, governance structure, policy and resources for sustainability
- Stage 2 (standardization and technical capacity): specification, standards and protocols, technical capacity.

The first step towards the development of an institutionalization plan is to assess the level of geo-enablement across these different components, using the same approach as the one implemented at the beginning of the geo-enablement of the microplanning process (Section 6.6.1)

This will not only identify the gaps that remain, but also monitor progress made towards addressing them at each iteration of the microplanning process.

Monitoring successes and being able to regularly evaluate progress over time is important to ensure that capabilities are managed and improved, as well as avoid wasting effort on the wrong focal areas, and to stay ahead of the next financial need. This will allow the programme to do continuous advocacy and fundraising where needed and, as such, ensure the continuity of the geo-enablement from one microplanning cycle to the next.

The definition of the vision, strategy and plan; the establishment of the governance structure; the development and endorsement of policies; the identification or development of specifications, standards and protocols; and, to the largest extent possible, the strengthening and maintenance of technical capacity, as well as the leveraging of resources pertaining to the management and use of geospatial data and technologies, should be institutionalized at the health system level as well as being aligned with the NSDI efforts. This will not only be more cost-effective, but also facilitate coordination, collaboration, data quality and interoperability among all partners.

The programme that has geo-enabled its microplan may need to institutionalize the investments made in some specific technological solutions and technical capacities. Considerations in this regard are detailed in the following two sections.

6.9.3.1 Long-term investments in technology

Programme Designer	GIS Technical Staff
	

When considering long-term technology investments, it is recommended that the programme staff focus on the cost of establishing and sustaining in the relevant agencies involved in the microplanning the technical capabilities required to respond to the identified programmatic use cases and needs analysis.

When it comes to investment in technology required for geo-enabling the microplan, the following considerations will be relevant to an ecosystem of hardware and software assets (section 6.4) (Annex H):

- All technology investments have two parts: the initial outlay (the money spent to purchase and set up the system), and the cost of ownership over the life of an asset (one to three years of all expected costs to maintain the system and resolve failed parts/software issues).
- An investment strategy should include costs associated with the total anticipated years of maintenance when planning a project. This helps organizations to understand the “total cost of ownership” over the life of the assets, and to better make value comparisons across options. It is common to use a simple multiplier like 20% of the initial outlay as the estimated year-on-year maintenance costs, given how hard that can be to predict in reality (US\$100 000 for initial project cost would mean \$20 000 for maintenance budget each year for the life of the asset). Project investments in sustaining geo-enablement may qualify as tax-exempt, or have other financial benefits for the organization, including deducting amortization/depreciation expenses, which can help reduce the total cost of ownership. Where appropriate, be aware of the organization’s financial and accounting environment, to take advantage of additional value where possible.
- Technology investment is often a combination of locally owned and maintained infrastructure combined with one or many technical services provided by third parties. When conducting investment analysis for geospatial capabilities, consider several “build versus buy” options in infrastructure/applications, as building and owning technology can require additional staff and capacity building. In some cases, building technology may be worth the investment given the implications of how the technology will be used in practice. However, staff should be clear about the core technical skills they should maintain for the programme to achieve outcomes and impact, versus the overall set of skills and capabilities needed to run and update the technical systems that support microplanning analysis (section 6.7.4).

- Invest in a Configuration Management Database (CMDB) and a supporting process to document asset information needed to maintain systems. This information should include information such as: the system ID; current operating system installed; expected life of the asset; licenses; users and access rights; systems to which assets connect; and last security patch and date. A CMDB is vital in technology decision-making because it allows users to determine relationships among processes, people, applications and technology infrastructure, and to help manage changes made over time to the systems to resolve problems faster and reduce errors, among other benefits. The database can take various forms, ranging from a simple spreadsheet to an advanced network identification tool that can automatically document assets and their state.

6.9.3.2 Evaluating and improving processes

Programme Designer	GIS Technical Staff
	

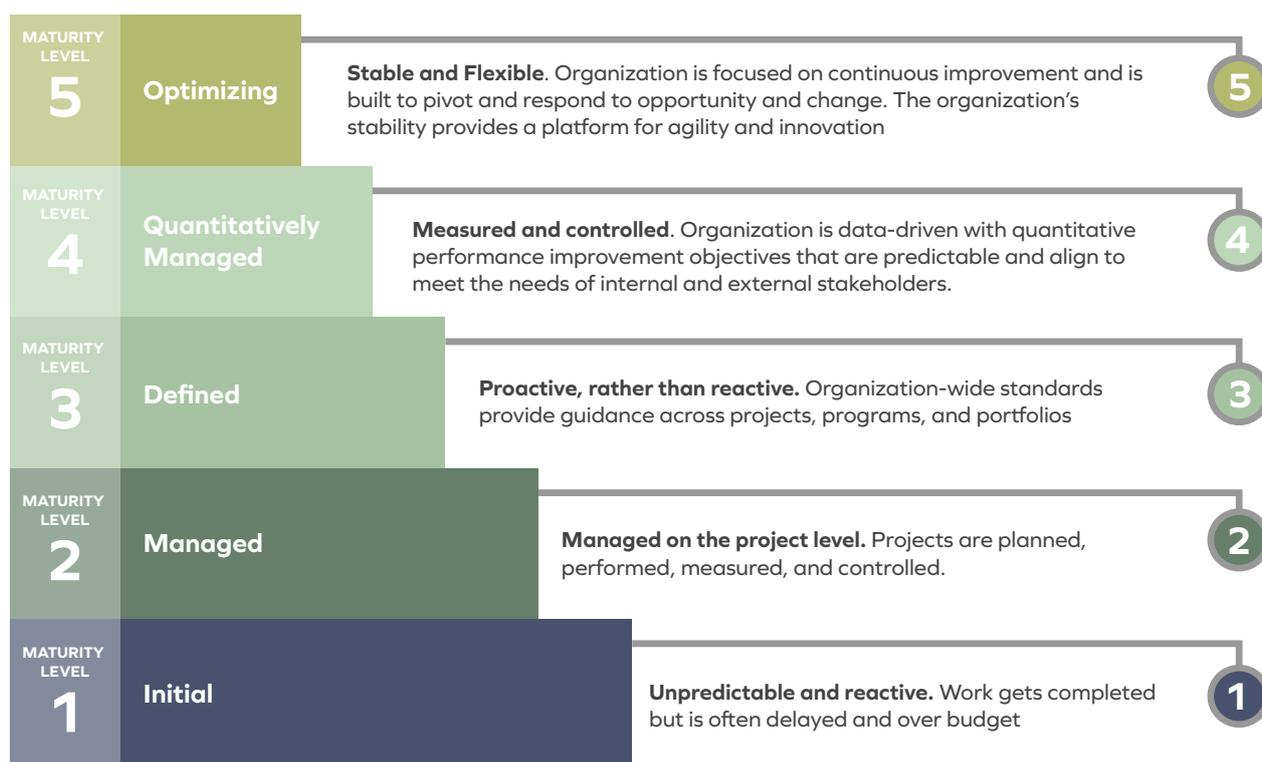
Successful data production and technology management processes for geo-enabled microplanning involve concepts of workflow design, evaluation of production efficiency, and quality control and distribution.

A geo-enabled microplanning programme should consider broad goals (see section 5.1 and Figure B, and section 6.6) for baselining the current state of process maturity, setting targets for the desired future state, and then evaluating progress over time. With a baseline measurement of the programme's current capabilities, a team can begin to identify the additional or advanced skills, technologies or processes needed to meet goals. Questions to help shape these goals could include:

- Does a standardized, documented process for data production exist, and are the inputs and outputs connecting the process with other processes or decision making activities clear and valid? Are these being continuously reviewed and improved?
- Is the technology implementation fit for the strategic goals or intervention needs as defined?
- Does a staff culture exist that values process adherence and, by extension, create a more predictable working environment? Do staff build continuous improvement activities into their processes?
- Do standardized, documented processes for data governance and change management exist in the overall system? Are those processes regularly used, reviewed and improved?

The above are example questions that support goal setting for processes. The goal of this exercise is to develop measures that represent the maturity steps along the way to the ultimate goal or highest level of process maturity desired by the programme team. Considering many programmes can take years to build up, the ability to target and achieve smaller targets over time will be crucial to sustainability. Teams should build a scorecard that will help make success measures visible to all audiences involved, and steer teams towards the most immediate areas of focus. The team should use a simple set of language to define the maturity framework and goals, such as the one employed by the Capability Maturity Model Integration (CMMI) standards model for multiple industries in Figure AB.

Figure AB – CMMI Standard Model.



Suggested readings on continuous improvement models include the following:

- Toyota “Gemba” and “Kaizen” practices:** “Going to Gemba” means administrators and leaders spend time going to where the work is actually conducted to learn from staff and frontline workers. By asking questions and exploring beyond assumptions, Toyota’s leaders applied a philosophy of continuous improvement and learning (Kaizen) to find incremental improvements to production, resulting in the working conditions of staff vastly improving³⁴. In the context of geospatial technology and its application, we are looking for feedback from producers of data and users of data as they interact and make decisions with it. Programme leaders should allocate regular time to check in with staff in different roles to ask for their input and feedback, identify priority areas for improvement, and then set in motion activity to address concerns as evidenced by interviewees. Allow staff and user input to guide improvement thinking and interpretation rather than only relying on old assumptions and previous history. The key to using this model is to ask questions to get to the root causes of process impediments even when they may not be obvious issues at first.
- CMMI maturity evaluation:** This model represents a simple method of describing maturation goals and, if evaluated by an outside consultancy, can help an organization understand its maturity relative to others³⁵. For example, a maturity Level 1 definition might say a programme is not using a regular source for its georeferenced master list. A maturity level 2 definition might incrementally improve that to say a georeferenced master list has been created but is not regularly maintained unless a project or new funding allow for it. Maturity level 3 would be proactive updating and management across the organization with sustainable funding. It should be noted that a level 4 or level 5 maturity may not be necessary for a programme’s needs, but if used will rely heavily on cyclical measurement and evaluation strategies, or a more detailed analysis of what influences programme success beyond just process existence and regular updating. In the georeferenced master list example, a maturity level 4 might define data completeness, conformity and time series regularity as focal maturation points.
- ITIL Service Management Framework:** As an owner of technology and technical capabilities, a programme needs to organize itself to maintain an ever-growing set of processes and responsibilities. The ITIL framework is a set of publications laying out standards for technology management that consider the cyclical nature of the work and the need for integration amongst processes³⁶.

34. Toyota Production System - what it all means - Toyota UK Magazine

35. Capability Maturity Model Integration (CMMI), background notes - Azure Boards | Microsoft Docs

36. <https://www.axelos.com/>
<https://www.ibm.com/>

6.9.3.3 Long-term investments in staff and capacity building

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All main applications of geospatial data and technologies for geo-enabled microplanning, and particularly population estimates and distribution as well as geographic accessibility, service location and route optimization modelling require advanced technical skills in the management and use of geospatial data and technologies (Table AR).

While the products generated through the operationalization of these two applications will be useful across all public health programmes, it can often be that the programme conducting the microplan is the first one using them.

When this is the case, the programme in question should look at institutionalizing sufficient technical capacity to serve a scaled deployment of the solution, as well as establishing a cyclical investment strategy to refresh and build the capacity of new staff working on geo-enabling microplans.

Anticipating staffing growth and turnover is a serious consideration in being able to maintain control of the processes that the programme has built up. Consider developing a plan that covers staffing and training needs for at least the next 6-12 months and, where possible, set plans for longer timelines that align with your overall goals. If for example you are planning routine immunization programmes that will continue year over year, you may want to project several years of financial outlay needed to support several interventions in sequence.

The Integrated Geospatial Information Framework (IGIF) for example promotes consideration of four elements of capacity strengthening within an organization:

1. **Awareness-raising forums and programmes** – advocating and promoting principles, values and benefits of geospatial data (could include lobbying and media campaigns).
2. **Formal education** – providing a foundation of concepts and theory (only a small proportion of GIS and technical staff, such as a technical team leads, may need such training). Consider working with local universities to add GIS to their curricula or programmes, with specific coursework on using geodata for public health and microplanning.
3. **Professional workplace training** – continuing professional development, including short courses on developments within the sector that can integrate with staff members' ongoing work responsibilities. This area of focus can benefit greatly from an organization's investment in continuous documentation of process and best practices.
4. **Entrepreneurship** – creating an environment that pushes the boundaries by examining existing procedures and seeking to innovate and improve.

Consider establishing goals for staff using these categories to frame the areas of focus. These individual goals can, and should, directly support programme and organizational goals established in previous sections of this guidance document.





Future iterations



Future iterations

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The purpose of the Geo-Enabled Microplanning Handbook is to serve as a communal resource and a living document. To these ends, we welcome your feedback on how future iterations of the handbook can be made more relevant and useful to your needs and to those of your colleagues. We also look forward to leveraging this handbook to foster a robust community of practitioners of, and advocates for, geo-enabled microplanning. We encourage you to share and discuss this handbook with your colleagues, and we welcome your comments and questions at gissupport@who.int.

The WHO-UNICEF COVAX GIS Working Group will follow countries and partners as they utilize this Handbook and integrate its guidance into their microplanning capacity development programmes. This feedback and learning will be used to update and improve this document. To stay aware of enhancements, including translations to other languages and an eLearning companion course, please refer to <https://www.covid19giswg.net/>





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SECTION 8.0

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Annexes

Table of contents

Annex A: Glossary of terms -----	144
Annex B: Use case examples of geo-enabled microplans-----	149
B1: COVAX use case example -----	149
B2: Malaria stratification use case example -----	155
B3: Routine immunization/expanded programme on immunization use case example -----	160
B4: Polio supplemental immunization activities use case example -----	167
B5: Emergency outbreaks: measles vaccination use case example -----	171
Annex C: Terms of reference-----	175
Annex C1: Generic terms of reference for technical expert overseeing geo-enablement -----	175
Annex C2: Example terms of reference for technical working group on the management and use of geospatial data and technologies in the health sector -----	178
Annex D: Template budget spreadsheet -----	180
Annex E: Questions for assessing geospatial data -----	181
Annex F: Elements of a geospatial information licence agreement -----	182
Annex G: Uses of thematic maps in microplanning-----	186
Annex H: Hardware and software technical specifications -----	189
Annex I: Data dictionary guidance -----	197

Annex A: Glossary of terms

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The present glossary covers specific terms used in the handbook. Please consult the following glossaries for GIS-related terms not covered here:

- Wiki.gis.com GIS dictionary: http://wiki.gis.com/wiki/index.php/GIS_Glossary
- Esri Support GIS Dictionary: <https://support.esri.com/en/other-resources/gis-dictionary>

Term	Definition
Administrative unit	Delineated geographical areas within a particular sovereign state or territory created for the purpose of administration
Basemap	Basemaps serve as a reference map on which one can overlay data layers and visualize geographic information e.g. Google Street Map, Open Street Map, Google Satellite
Catchment area	A geographical area delineated around an institution or business, such as a health facility, from where the population utilizes its services
Common Geo-registry	IT solution that allows the simultaneous hosting, management, regular update and sharing of master lists as well as associated hierarchies and geospatial data for the geographic objects core to development in general and public health in particular.
Conceptual data model	A data model that represents an abstract view of the real world, a conceptual model represents the human understanding of a system
Data	Raw, unorganized facts and statistics collected for reference or analysis
Data dictionary	A collection of names, definitions and attributes about data elements that are being used or captured in a database or information system
Data element	Fundamental data structure in a data processing system, any unit of data defined for processing is a data element. For example: Full name, type, address, etc. are each separate data elements. A data element is defined by its size (in characters) and type (alphanumeric, numeric only, true/false, date, etc.).
Data management	All the disciplines related to managing data as a valuable resource
Data product	A product that facilitates an end goal through the use of data. For example: a dataset with calculated distance across the terrain from each household to the nearest health facility is a data product.
Geo-enable	To apply geospatial capabilities to a business process in order to establish the authoritative spatial location of business data and enable contextual spatial analysis
Geographic coordinates	A measurement of a location on the Earth's surface expressed in degrees of latitude and longitude.
Geographic data	Information describing the location and attributes of things, including their shapes and representation. Geographic data is the composite of spatial data and attribute data.
Geographic feature	Naturally and artificially-created features on the Earth. Natural geographical features consist of landforms and ecosystems. Natural geographical features include terrain types and physical factors of the environment. Artificial geographical features include human settlements or other engineered forms.
Geographic information	Spatial and/or geographic data organized and presented to create some value and to answer questions

Geo-registry	An IT solution that allows storing, managing, validating, updating and sharing of the master list and associated geospatial data for a specific geographic object.
GIS data product	Any product generated by a GIS, often printed and online maps, but also can include charts, graphs and reports. These include hardcopy or electronic maps with locations, basemaps and possibly added value layers (e.g. geographic accessibility), as well as digital tools such as interactive GIS content to support decision making.
Geographic object	Computer representation of a geographic feature (e.g. point, line, polygon)
Geography	The study of the physical features of the Earth and its atmosphere, and of human activity as it affects and is affected by these elements, including the distribution of populations, resources, land use and industries
Geometry	The measures and properties of points, lines and surfaces. In a GIS, geometry is used to represent the spatial component of geographic features.
Georeferencing	Process of assigning locations to geographical objects within a geographic frame of reference
Geospatial data	Also referred to as spatial data, information about the locations and shapes of geographic features and the relationships between them. Usually stored as coordinates and topology.
Geospatial technologies	Refers to equipment used in visualization, measurement and analysis of Earth's features, typically involving global Navigation Satellite System, geographical information systems and remote sensing
Global Navigation Satellite System (GNSS)	A satellite navigation system with global coverage
Global Positioning System (GPS)	Satellite-based radionavigation system owned by the United States Government and operated by the United States Space Force
Health area	Area around a health facility defined for the purpose of cataloguing, budgeting and managing health resources
Health facility	Infrastructure where health care is provided. Depending on the microplanning use case, this might be limited to fixed infrastructures or also include mobile ones.
Health information system (HIS)	A system that integrates data collection, processing, reporting and use of the information necessary for improving health service effectiveness and efficiency through better management at all levels of health services
Hierarchy	Arrangement of items (objects, names, values, categories, etc.) in which the items are represented as being “above”, “below”, or “at the same level as” one another. For example, region level is above state level which is above community level.
Information	Data processed, organized, structured or presented in a given context so as to make it useful
Information product	A product that has been derived from one or more sources of information to meet a specific purpose. For example, a thematic map combines multiple sources and additional information.
Isochrone	A line on a map or diagram connecting places from which it takes the same time to travel
Macroplanning	The process of setting strategy, policies, measures and instruments for implementation and budgeting with a multi-year and national-level scope
Master list	Unique, authoritative, complete, up-to-date and uniquely coded list of all the active (and previously active) records for a given type of geographic feature/object (e.g. health facilities, administrative divisions, villages) officially curated by the mandated agency
Metadata	Information that describes the content, quality, condition, origin and other characteristics of data or other pieces of information.
Microplanning	The process of creating detailed, delivery-level operational plans for reaching target populations with short-term interventions with a level of granularity typically below district level and down to the individual or community level

National Spatial Data Infrastructure (NSDI)	Data infrastructure implementing a framework of geographic data, metadata, users and tools that are interactively connected in order to use spatial data in an efficient and flexible way
Online GIS Programme	An online and increasingly cloud-based GIS solution. Can be used to make maps, analyse data, and to share and collaborate in an online setting.
Point of interest (POI)	A specific point location that may be useful or interesting to an individual, entity or project. In the microplanning context, POIs may be non-core features that include schools, markets and places of worship.
Polygon	A shape feature in a GIS or on a map with three or more points connected by lines
Population denominator	In the context of population estimation in microplanning, the population denominator is the total target population that is used when modelling the spatial distribution of a population
Population estimation	The use of statistical models, remote sensing datasets and sampled census information to create spatially accurate and precise estimates of population density and distribution
Product	An internal or external deliverable or set of deliverables that contributes to a use case
Registry	An IT solution that allows storing, managing, validating, updating and sharing of the master list for a specific geographic object. It is the “container” for the master list.
Remote sensing	Collecting and interpreting information about the environment and the surface of the Earth from a distance, primarily by sensing radiation that is naturally emitted or reflected by the Earth's surface or from the atmosphere, or by sensing signals transmitted from a device and reflected back to it. Examples of remote-sensing methods include aerial photography, radar and satellite imaging.
Satellite navigation system (Satnav)	A system that uses satellites to provide autonomous geo-spatial positioning
Spatial data	See geospatial data
Service delivery point	Location at which the population receives a service
Standard	A required or agreed level of quality or attainment
Standard Operating Procedure (SOP)	A set of step-by-step instructions compiled by an organization to help workers carry out routine operations
Thematic layer	A spatial representation of analysed geospatial data consisting of the same type of elements (e.g. health facilities, roads, districts)
Thematic map	A map that combines geospatial data and attribute data (e.g. information, statistics) to convey information about topics or themes in visual form
Unique identifier	Data element in a relational database that is unique for each record



Annex B: Use case examples of geo-enabled microplans

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B1: COVAX use case example

Figure AC - Evaluation of a map generated for COVAX geo-enabled microplanning by health officials in Nigeria. (Source: GRID3)



Background

Like many countries on the African continent, Nigeria was hit hard by the second wave of the COVID-19 pandemic at the start of 2021. In March of 2021, Nigeria received the first 4 million AstraZeneca vaccines from the COVID-19 Vaccines Global Access or (COVAX) initiative. The government prioritized vaccinations for populations deemed to be most at risk: frontline health workers, persons over 50 years old, and persons with comorbidities. The National Primary Health Care Development Agency (NPHCDA) was responsible for leading the microplanning process to identify locations where vaccines were most needed across Nigeria's 36 states and Federal Capital Territory, and population of more than 200 million. This vaccination microplan would be critical in helping state and local health officials to determine vaccination supply-chain requirements such as the number of vaccination teams needed, transportation, personal protective equipment and other supplies. However, officials lacked updated population data and maps for local government areas (LGA) and wards to identify where priority populations were concentrated. The NPHCDA turned to geo-enabled microplanning to help identify where target populations were concentrated.

Objective

While planners of the vaccination campaign could assume that most health care workers were located at health facilities, persons with co-morbidities and those over 50 years old could be spread unevenly across LGAs and wards. Thus, a major goal for the geo-enabled microplanning process was to identify wards with higher concentrations of older persons and persons with high comorbidity risks in order to prioritize these areas for vaccination. In addition, officials needed maps that placed every settlement within a catchment area and ensured that all settlements were assigned to a vaccination site.

The maps would also need to show which settlements could be reached within 2, 5, and 10kms of designated vaccination sites (primarily health facilities in the campaign's initial phases and expanded to other sites later). This proximity information was critical in assigning teams to cover settlements. Populations living within 2km could walk or travel to a health facility for vaccination, while populations beyond 5km would be assigned field teams to travel and set up temporary vaccination sites. Reaching populations more than 10km from a health facility would require additional planning and resources, and possibly involve house-to-house vaccination.

It was also important that the maps include settlement names and gridded population estimates, as well as the locations of other health care facilities, infrastructure, and points of interest such as schools, prisons and internally displaced persons' camps.

Stakeholders and Personnel

In developing and implementing its geo-enabled COVID-19 vaccine microplan, the NPHCDA partnered with Nigeria's National Space Research and Development Agency (NASRDA) to access high-resolution satellite imagery. In addition, the NPHCDA requested GRID3's support in using and analysing geospatial data to help determine target population groups and vaccination sites, as well as to help with end-to-end microplanning. GRID3 produced and printed maps for the 774 Local Government Areas in Nigeria. The maps display the locations of vaccination sites, healthcare facilities and infrastructure (such as schools, prisons, and internally displaced persons' camp survey points), settlement names, as well as gridded population estimates. These maps also include tables summarising total population per ward, total population for those 50 years or older, as well as comorbidity risk per ward. Under GRID3, Fraym provided technical support with comorbidity risk.

The US Centers for Disease Control provided technical support along with the Clinton Health Access Initiative, the African Field Epidemiology Network, and Sydani. The NPHCDA collaborated extensively with State Primary Health Care Development Agencies in implementing the geo-enabled microplan.

Process and Methods

1. First, the team gathered available datasets and created models for data they did not yet have. The NPHCDA provided local data on health facilities designated as vaccination sites, which GRID3 used to create base maps for the entire country. The base maps leveraged previous polio vaccination work that used field data collection to add points of interest and new settlements. Settlement polygons had previously been generated based on building footprint layers from Ecopia, which uses an artificial intelligence programme to automatically trace structures on satellite images and turn them into more usable vector layers.

GRID3 then turned to computational modelling to fill in the gaps on critical demographic data. GRID3 generated a statistical model for populations and age groups that combined information on building density in settlements along with known population data from microcensus samples from selected states. The result was a model that could estimate population by age at a 100x100m grid. This allowed the team to create a gridded population layer for persons 50 years of age and older.

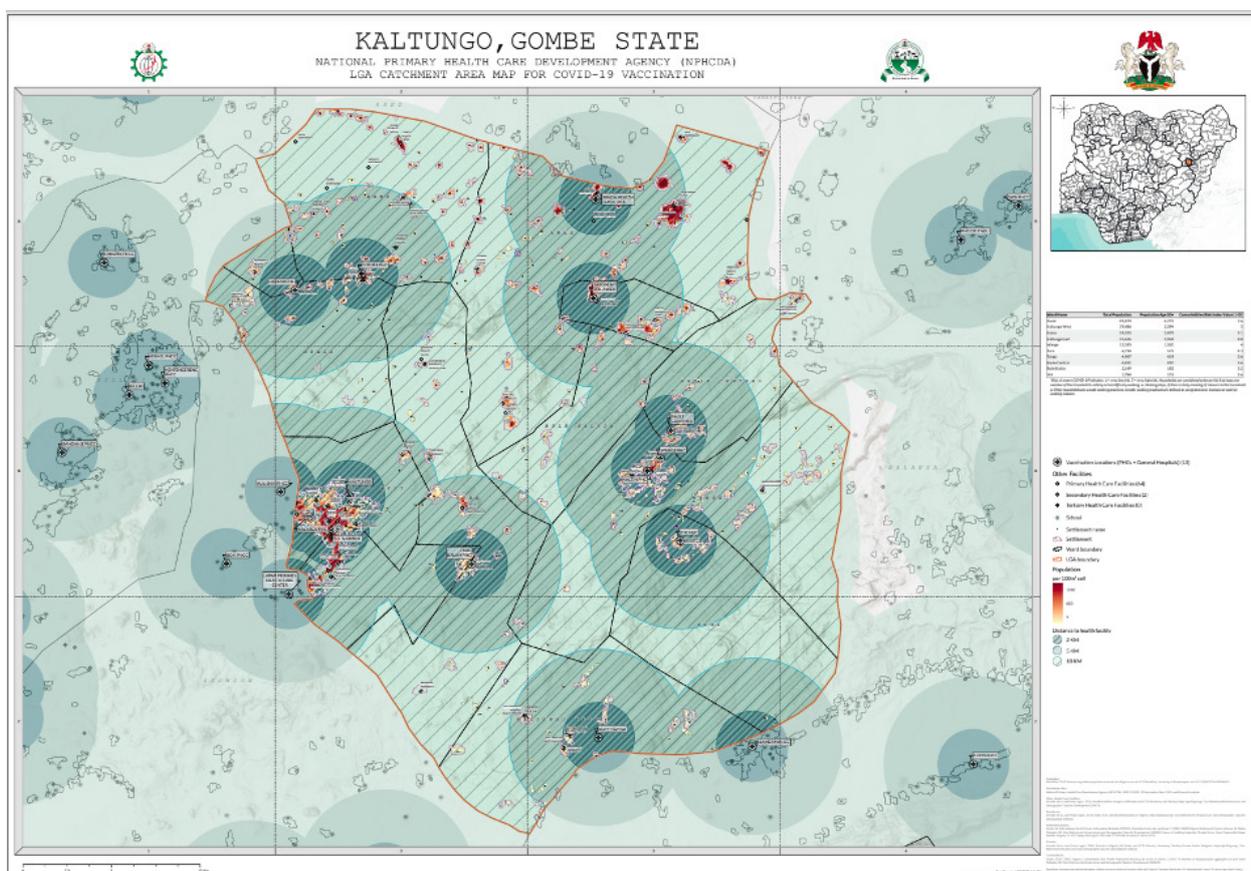
Fraym created a modelled comorbidity risk layer using data from Nigeria's 2018 National Demographic and Health Survey, which sampled populations throughout the country to capture indicators of respiratory and general health. Factors that were deemed to make households at-risk of comorbidities included having a member with difficulty walking, daily smoking of tobacco, or indoor cooking with coal or other biomass. Fraym used this survey data from the state level to create a model that could predict the comorbidity risk score at the ward and LGA levels.

2. Next, GRID3 worked to adjudicate overlapping jurisdictions and resolve unclear boundaries. Because ward boundaries had not been validated by a government authority, community members sometimes felt that their boundaries were not accurately represented. In addition, some settlements overlapped between wards, leaving teams to decide how to assign settlements to a vaccination site. Health officials addressed these issues by engaging community leaders to develop solutions and assign vaccination sites.

3. To generate the maps, GRID3 combined the different data layers and overlaid them on the updated and adjudicated settlement maps. Buffers of 2, 5, and 10km areas were set around selected vaccination sites to guide the vaccination strategy per settlement. The resulting maps showed population per ward, population for residents 50 years or older, and ward comorbidity risk score, along with approximate distance from the nearest vaccination site.
4. The NASRDA printed the GIS maps of LGAs on A0-size paper and delivered them to the National Polio Emergency Operations Centre of the NPHCDA, which distributed maps to the state ministries of health. The NPHCDA also requested ward-level maps printed on A1-size paper, allowing local health workers to view high-resolution population estimates and settlements where vaccination sites would be established in order to develop ward-level microplans.
5. Local and state health officials used these maps to develop effective vaccination microplans by identifying areas where target populations were concentrated and determining how to optimally distribute resources. Teams also used the maps during implementation of the microplans.
6. To increase demand for COVID vaccines, the NPHCDA deployed a Service delivery, Communication, Accountability, Logistics, EMID, Supervisory (SCALES) strategy and established mass vaccination sites (MVS) to deliver vaccines directly to the target population. GRID3 supported this initiative by identifying optimized vaccination sites targeting densely populated areas at the ward level, which were then used as MVS.

The entire process took approximately three months from kick-off meetings to the creation and distribution of the maps and the development of new microplans. This expedited timeline was facilitated by all partners being dedicated to working in emergency response mode throughout the process.

Figure AD - Example of a map showing total 50+ population, and comorbidity per ward, LGA and ward boundaries, settlements with total population, facilities and buffers at 2km/5km/10km. (Source: GRID3)



Outcomes

The NPHCDA and its partners met their goal of developing and distributing detailed GIS maps to all of Nigeria's 774 LGAs. In March 2021, efforts began to fully vaccinate target populations across the country. Following the vaccination campaign launch, GRID3 interviewed map users in eight states to determine the maps' value and understand how they were used. Despite limited knowledge on GIS maps in some areas, 67% of officials interviewed reported that they had used the maps in their planning process. However, the usage rate may have been higher in other states not interviewed.

Officials interviewed by GRID3 used the GIS maps to:

- ensure that no settlements were missed during microplanning
- estimate target population
- improve the delineation of health facility catchment areas
- determine the distance from health facilities to settlements.

The GIS maps enabled local officials to better allocate immunization funding and resources and to establish new vaccination sites where they were needed most.

Respondents who did not use the maps indicated that this was due to a lack of training and technical capacity on using the maps. Others reported that the maps arrived too late to be used in planning or had not arrived at all.

Programme Sustainability and Key Takeaways

Following the initial vaccination campaign launch, GRID3 provided the NPHCDA with an online dashboard for state and local officials. The dashboard uses geospatial and demographic data (such as population density and existing infrastructure) to suggest the placement of new COVID-19 vaccination sites. In addition, the NPHCDA plans to continue updating and using GIS maps for other interventions beyond COVID-19 vaccinations.

Figure AE – Prince Clem Ikanade Agba, Minister of State, Budget and National Planning, Federal Republic of Nigeria reviews a map generated for COVAX geo-enabled microplanning efforts in Nigeria before it is distributed to local government areas across the country. (Source: GRID3)



Key Learnings

- ⦿ It is important for government stakeholders to understand what data is needed to produce maps that will help them identify target populations. Officials should be aware of this data's source and if it is of acceptable quality for use in microplanning.
- ⦿ Although some local health care officials may be able to use GIS maps with little or no training, local-level capacity building is critical to ensuring that maps are used to their full potential in microplanning. Such capacity building could include linking data on the maps with other databases such as DHIS2, instructions on identifying map features, and linking maps to analyses and reports.
- ⦿ A manual and/or standard operating procedures should be provided along with GIS maps.
- ⦿ Extra time and funds should be allocated for map distribution and teams should discuss best options to distribute maps. For example, sending maps along with vaccine doses may ensure delivery to proper personnel, while sending them via courier may be quicker and provide more planning time.
- ⦿ It is important to establish accountability for map delivery to ensure they are received on time by the correct personnel. Establishing a GIS focal point at the national or state level could assist with this.
- ⦿ National-level guidance is key to integrating geospatial data and maps into immunization processes at the local level.
- ⦿ Recognizable landmarks, such as roads and key buildings, should be identified on maps to assist with logistics planning.
- ⦿ To make maps more accessible to all stakeholders wherever they are located, consider increasing the number of maps printed per area or developing a mobile-accessible version of maps. If producing web maps, consider load times for users with low-bandwidth connections. Digital image files or 'soft copies' may also be distributed directly to field teams to use on mobile devices or laptops.
- ⦿ Consider printing smaller-scale maps at A1, A2, A3 sizes for field teams, as these sizes can be easier to print and less expensive. These size maps also tend to be more widely distributed and used during implementation. However, printing at smaller scale may cause loss of relevant detail. One solution is to break an A0-size map into smaller A4-size portions to be printed and taped together, allowing local-level offices to re-produce large-scale maps.



Additional Reading

GRID3 data as a building block for COVAX interventions: spotlight on Nigeria microplanning” GRID3, May 18, 2021. <https://grid3.org/news/grid3data-covax-interventions-nigeria>

Supporting COVID-19 vaccination interventions: spotlight on Nigeria” GRID3, August 11, 2021 <https://www.youtube.com/watch?v=FVyaBPGIWdM>

B2: Malaria stratification use case example

Background

As part of Cambodia's aim to eliminate malaria by 2025, the country had found success in using village malaria workers (VMWs) to diagnose and treat patients in rural areas, along with increasing access to long-lasting insecticide-treated bednets (LLIN). More recently, these interventions have been supplemented by strategies to target high-risk groups, such as forest goers, with mobile malaria workers (MMWs). However, the spread of parasites resistant to artemisinin and later artemisinin combination therapy anti-malarial drugs has threatened to roll back progress made against the disease. Much of the transmission occurs in and around forests where the main mosquito vectors breed, with cases becoming increasingly concentrated among forest goers and mobile and migrant populations, despite overall case numbers falling in recent years.

Cambodia's National Center for Parasitology, Entomology and Malaria Control (CNM) received additional funding from the Global Fund to Fight AIDS, Tuberculosis and Malaria to respond to the emergence of artemisinin-resistant malaria. To make the most efficient use of these funds, CNM aimed to allocate resources, such as targeting of LLINs, VMWs, and MMW, guided by malaria stratification down to the village level. This stratification would use malaria incidence, proximity to forests, and distance from health facilities to identify the most at-risk populations.

However, officials did not have all the data required to calculate and visualize this information. Cambodia's Malaria Information System (MIS), which provided village-level data on malaria incidence and real-time case tracking, lacked accurate and up-to-date demographic and geographic data, including village names, population counts and administrative unit hierarchies, as well as GPS locations of villages and health facilities. In 2016, it was estimated that around one third of villages in the national master list from the 2009 census had missing or unusable GPS coordinates. In addition, approximately 1 in 10 villages were not recorded on maps, as many new villages had been established since the last census. The next census was set for 2019, with no plan to collect GPS coordinates or demographic data for villages in the meantime. Additional challenges included varying definitions of villages and sub-villages among stakeholders, as well as multiple different names being used for the same communities. Population estimates for villages were either missing or out of date. Furthermore, while GIS forest cover layers existed for Cambodia, they were out of date and did not match the country's actual forested areas.

Although CNM was able to obtain some data from government agencies and other sources, these information gaps and inaccuracies constrained the Center's ability to use the MIS data to plan its malaria activities down to the village level.

Objective

CNM set out to create GIS maps to geo-enable the microplanning of its malaria outreach programme. The Center determined that the maps would need to have:

- Updated village and health facility lists
- Correct and consistent village and health facility names
- Updated village population counts
- Accurate village and health facility GPS coordinates
- Accurate forest coverage map data.

Once CNM had gathered this data in the MIS, it could combine the different layers to calculate village-level malaria incidence and the distance of villages from health facilities and forests to generate stratification scores.

Stakeholders and Personnel

The Global Fund to Fight AIDS, Tuberculosis and Malaria has been a key partner in supporting CNM to increase access to LLINs, along with providing early malaria diagnosis and treatment. The Mahidol Oxford Tropical Medicine Research Unit (MORU) provided technical assistance in geo-enabling CNM's microplanning, including facilitating a partnership with the European Space Agency.

CNM also coordinated with local health officials, health facility staff and communities to confirm village names and populations, as well as conducting participatory mapping exercises.

Process and Methods

In 2016, CNM, with support from MORU, began work on the geo-enabled microplanning process, taking the following steps.

- To improve village and health facility master lists for malaria endemic areas, the team began by collecting baseline data on health facilities from the Ministry of Health and on village names, locations, and population from the Ministry of Interior.
- Due to resource and time constraints, with the urgency of approaching malaria elimination goals, a mixed-methods approach was adopted for verifying and correcting health facility and village coordinates, as well as village names and population counts. The team visited health facilities to conduct participatory mapping exercises using satellite imagery in Google Maps (OpenStreetMap was not sufficiently accurate or complete for Cambodia) and leveraging health workers' extensive knowledge of local communities and catchment areas. Village names were confirmed through consensus during workshops conducted primarily at health centres.

- When sufficient information could not be gathered from health facility visits, CNM dispatched a team of local health workers and international staff to record information in the field. Field teams collected point-level data for villages and health facilities, but not for boundaries, as official boundaries were often unclear on the ground and not generally relevant to local communities. Because the Center managed the entire process, it was able to ensure that all data collectors in the field used the same updated list of villages and administrative areas. Using a consistent village list for reporting cases and interventions was critical, as village lists had previously changed from year to year.
- MORU worked with the European Space Agency to provide CNM with newly acquired satellite imagery and an updated forest cover map for Cambodia. The forest layer was generated by using an automated model that matched different satellite spectral images to vegetation types. The model was informed by field teams validating sample areas to report the type of plants or trees present. This process was conducted over several weeks at multiple sites and helped determine which spectral forms were actually forest and which may have been tall grass or another type of vegetation.
- This updated village and forest cover data allowed MORU and CNM to create maps that accurately showed all villages and health facilities in malaria endemic areas and highlighted those within close proximity to forests. This data was used to calculate the distances from villages to forests and health facilities as well as malaria incidence per population. Beginning in 2020, CNM used this data to generate stratification scores for villages.
- The information enabled the development of a robust methodology for determining which villages were most in need of interventions. CNM based its microplans for malaria outreach on the stratification scores and GIS maps, and continues to update maps and planning annually.

Outcomes

Following CNM's use of geo-enabled stratification for microplanning, reported malaria cases:

- decreased by 79% and 69% for *P. falciparum* and *P. vivax* respectively from 2019 to 2020
- decreased by 71% and 69% for *P. falciparum* and *P. vivax* respectively from 2020 to 2021.

In addition, the real-time case reporting combined with village and health facility lists, and updated location and population data, helped CNM to quickly identify subsequent outbreaks and data quality issues. This also allowed the Center to better monitor and evaluate the performance of VMWs and health facilities.

Programme Sustainability and Universal Takeaways

This geo-enabled data stratification method is now incorporated into Cambodia's MIS and can be easily updated annually. While health care institutions in many countries face similar issues related to a lack of up-to-date, complete and sufficiently detailed geospatial and demographic data, these gaps and challenges can be overcome through collaborative approaches with local, national and international partners. With the help of MORU to start the process, CNM is now independently updating and managing its geo-enabled microplanning.

Key Learnings

1. Data quality is key to a successful geo-enabled health intervention. Substantial resources may be wasted without accurate and up-to-date information on which to base decision-making. It is also essential to verify data quality prior to use.
2. Having sufficiently detailed data is critical for developing efficient intervention plans, with targeting at finer geographical scales required to ensure that resources are used where they are needed most.
3. From the beginning of the geo-enabled microplanning process, it is important for key project stakeholders to have an understanding of the quality, type and granularity of data needed and how it can be obtained.
4. Collecting and correcting geospatial data does not need to be cost- or time-prohibitive. The process can be made feasible and affordable by taking a targeted approach and by utilizing a combination of methods. These could include fieldwork as well as data sharing from others across the health care system, government institutions, or international organizations, such as space agencies.



Additional Reading

Siv, S., Roca-Feltrer, A., Vinjamuri, S. B., Bouth, D. M., Lek, D., Rashid, M. A., By, N. P., Popovici, J., Huy, R., & Menard, D. (2016). Plasmodium vivax Malaria in Cambodia, The American Society of Tropical Medicine and Hygiene, 95(6_Suppl), 97-107. Retrieved Feb 8, 2022, from https://www.ajtmh.org/view/journals/tpmd/95/6_Suppl/article-p97.xml



B3: Routine immunization/expanded programme on immunization use case example

Background

Rapid urbanisation often outpaces the ability of public health services to provide sufficient routine immunization services in growing cities and emerging urban areas. This was the case in the city of Patna in India's Bihar state, which had a population of 2 million and an annual cohort of 50 000 newborn children. Unfortunately, these infants were grossly underserved by routine immunization services, especially among poor and marginalised populations. According to 2005-2006 surveys, only 32.8% of children in Bihar state had received all basic vaccinations by their first birthday.

Primary reasons for poor vaccination rates in Patna included:

1. Limited number of vaccination sites (31), with an average site serving a population of 6 700 and expected to vaccinate 1 600 new infants each year.
2. Lack of clearly defined coverage areas, vaccine storage depots and vaccination sites, leading to many unserved areas.
3. Insufficient human resources for vaccination, including trained vaccinators and local mobilizers.
4. Poorly-organized system for vaccine distribution from storage depots to vaccination sites.

To address these challenges, Patna set out to create a more effective vaccination system to reach more unvaccinated children by using geo-enabled microplanning.

Objective

Public health experts set out to leverage GPS data, satellite imagery, and GIS software, in conjunction with population and human resources data, to identify optimal vaccine storage depots and vaccination sites and to plan more efficient vaccine distribution systems.

Officials aimed to accomplish the following through the geo-enabled microplanning approach:

1. Update city maps, as existing maps lacked sufficient detail in recently developed areas.
2. Determine a large number of additional vaccination sites that would be easily accessible to the general public. Selected sites had to allow for timely access to vaccines and provide the ability to reach underserved populations.
3. Demarcate well-defined catchment areas for each vaccine storage depot to ensure efficient planning, reduce overlap of service areas and avoid service gaps.
4. Determine efficient vaccine delivery routes, as one vehicle was often deployed to deliver vaccines to multiple sites.
5. Address human resource challenges, as there was a lack of vaccinator nurses, community mobilizers and supervisors to cover these growing urban areas.

Stakeholders and Personnel

The Patna Department of Health collaborated with the local Remote Sensing Application Centre at the Department of Science and Technology, to develop a hub-and-spoke model of vaccination for urban areas. Key stakeholders included the District Immunization Officer and the Urban Nodal Immunization Officer, supported by UNICEF and WHO officials. The US Centers for Disease Control (CDC) provided funds to UNICEF's Bihar field office for activity planning and supported data analytics and layering of ground information on GIS maps.

Process and Methods

The intervention was tested in the catchment area of a public hospital, which also served as a vaccine storage depot. This helped fine-tune the process for determining new sites, which was later expanded to other areas. The Patna Public Health Department's geo-enabled microplanning process is outlined below.

1. Officials identified nine hospitals of the Patna urban areas as outreach and vaccination hubs based on their location and vaccine storage facilities. Using satellite images, team members collaborated to demarcate the boundaries of each hospital's catchment area. Hospital superintendents were given responsibility for all microplanning vaccination activities in their respective areas.

- Field scouts with hand-held GPS instruments and satellite images collected the GPS coordinates of candidate vaccination sites. These potential sites included charitable hospitals and clinics, primary public schools, community centres, homes of local elected representatives and Anganwadi centres (government sponsored child care facilities). Based on this information, officials identified Anganwadi centres as suitable once-a-month vaccination sites. The decision was based on their number, the availability of basic facilities and staff, and their distribution across the city, in particular their proximity to underserved populations.

Figure AF – Hospital catchment areas for the nine hospitals of the Patna urban area. (Source: Narottam Pradhan)

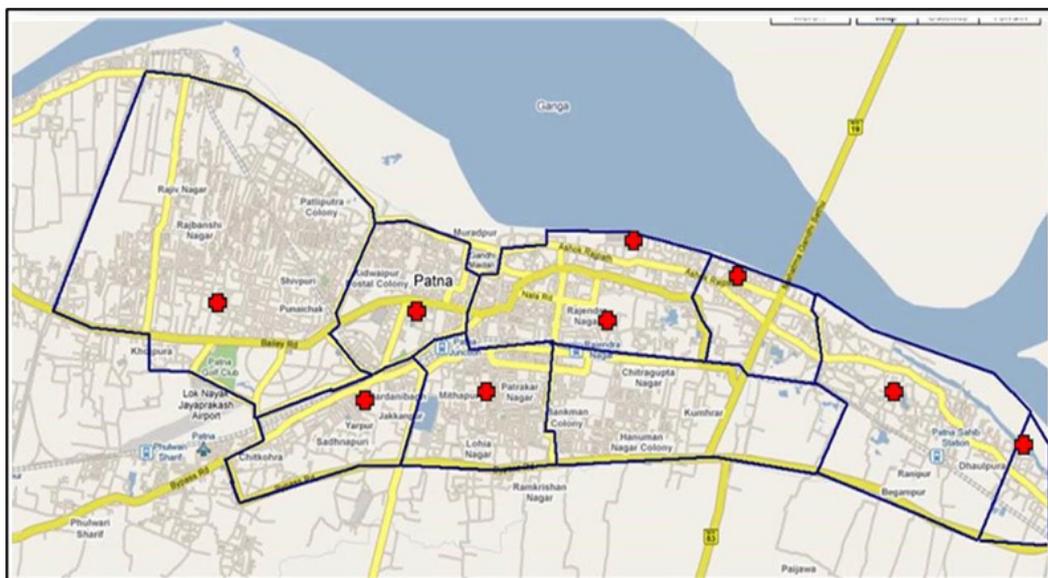
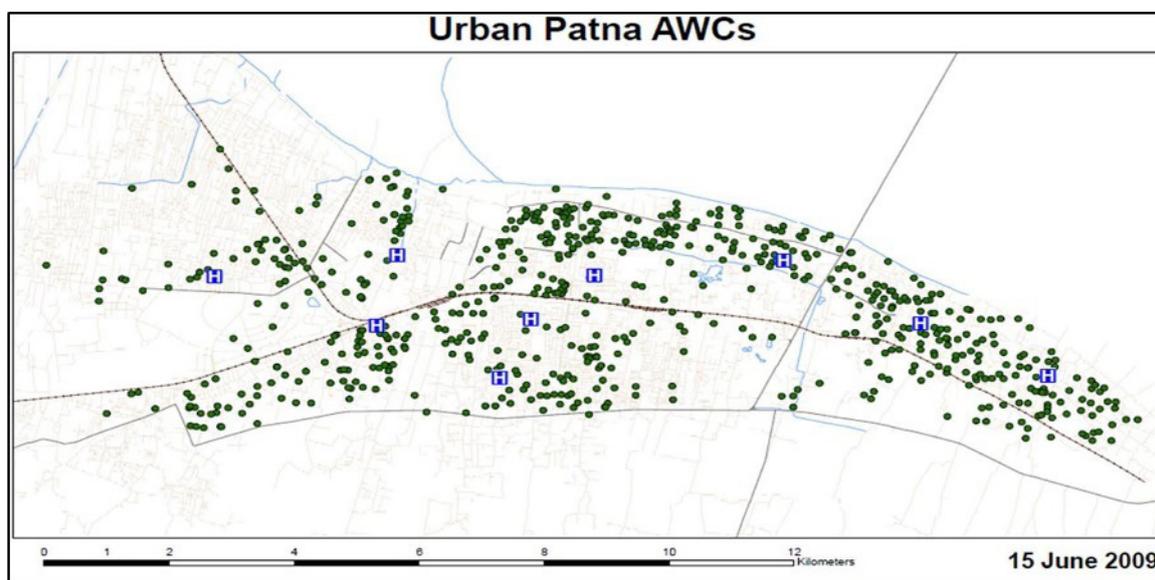
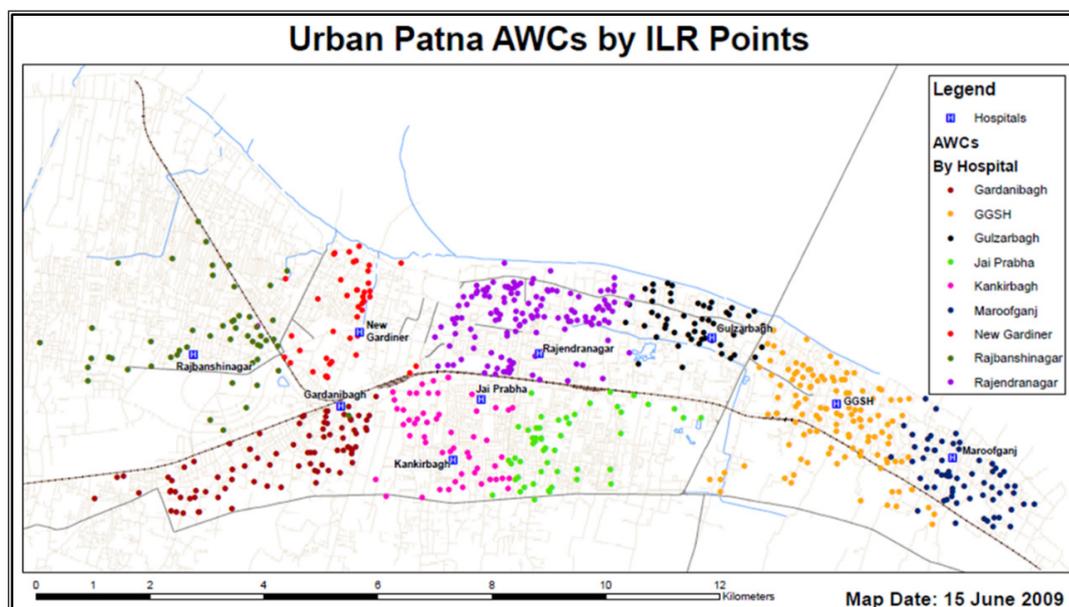


Figure AG – Map showing Urban Patna Anganwadi centres. (Source: Narottam Pradhan)



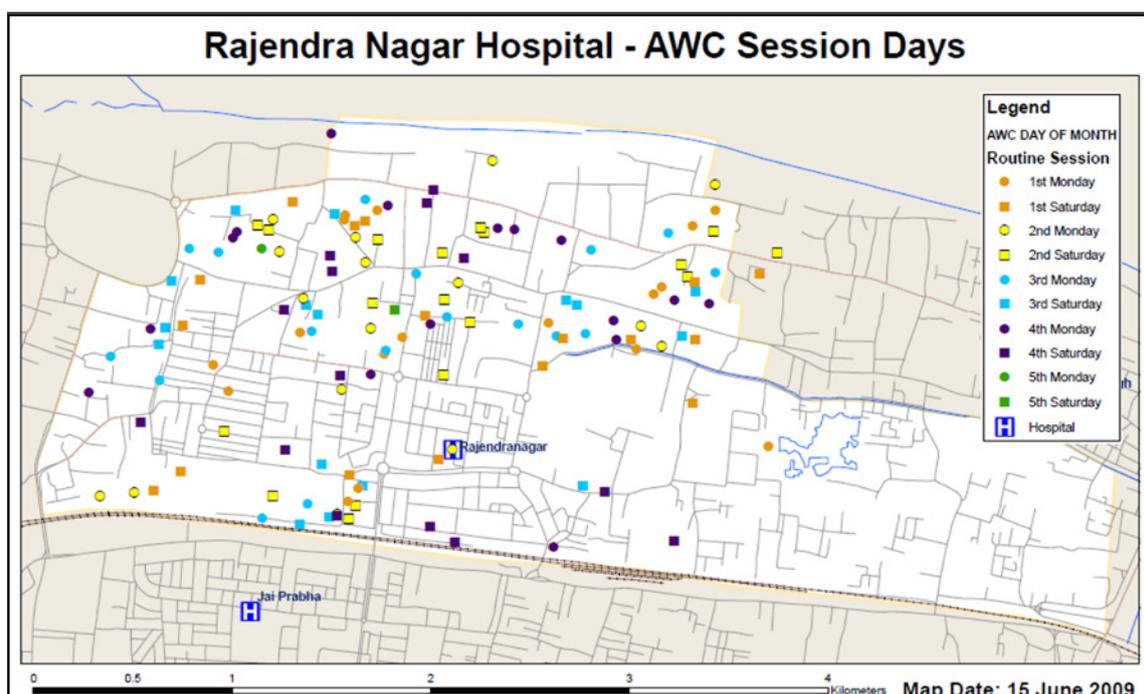
3. Since Patna had multiple house-to-house polio vaccination rounds that year, updated location data for children between the ages 0-60 months was readily available. This data was compiled and layered on GIS maps. The team created a proximity-population index to determine the accessibility of vaccination sites to the target population. Vaccination centres were added in areas with low access, which were primarily suburban areas with emerging urbanization. From the initial 30 vaccination sites, this exercise helped officials identify more than 700 additional sites across the city.

Figure AH – Map showing Urban Patna AWCs by ILR points. (Source: Narottam Pradhan)



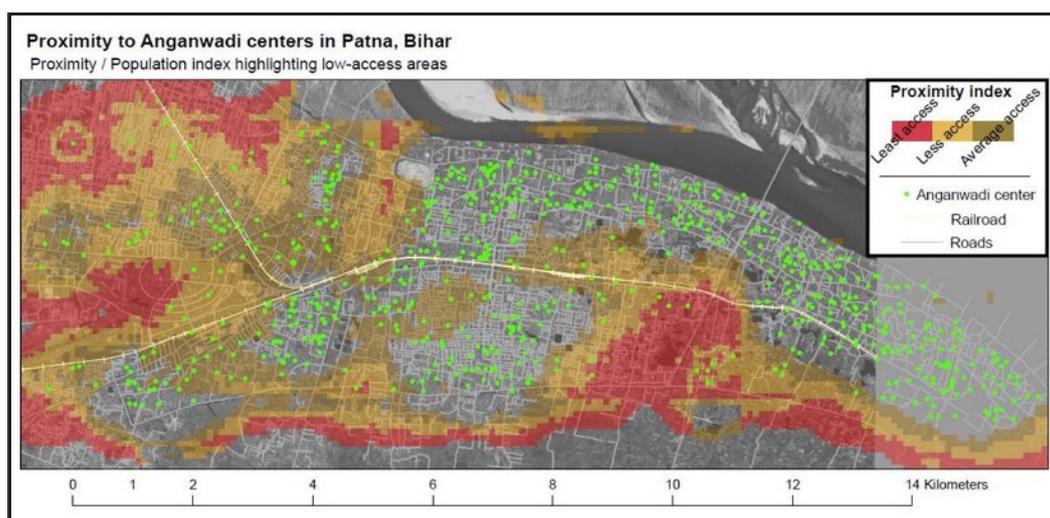
4. The team next addressed the challenge of insufficient vaccinator nurses. Patna's urban areas had a limited number of nurses, who carried additional responsibilities at their hospitals. Subsequently, nurses had to be seconded from surrounding rural areas. Field scouts collected the GPS locations of 45 rural nurses' residences and collaborated with them to determine vaccination sites they could support within an hour's travel to their homes.

Figure AI – Map showing AWC Session Days for Rajendra Nagar Hospital. (Source: Narottam Pradhan)



- Finally, the team hired bicycle and motorcycle couriers to deliver supplies to vaccination sites. Couriers were given printed maps of their catchment area along with directions for their routes each day (smart phones were not widely available at the time of the intervention). As each courier delivered to multiple sites during the day, the team used geolocation data for vaccine depots and vaccination sites, along with local knowledge, to optimize delivery routes. This helped ensure that the cold chain was maintained and that daily reports were received, while increasing overall efficiency.

Figure AJ – Map showing proximity to Anganwadi centres in Patna, Bihar. (Source: Narottam Pradhan)



The entire intervention planning took approximately six months. This included planning meetings; field visits by scouting teams; and interactions with hospital managers and vaccination staff. During this period, additional planning processes were conducted to identify vaccinators, couriers and mobilizers for each vaccination site. Officials also conducted an initial household-level survey of children in order to assign vaccination sites.

Outcomes

Following the geo-enabled microplanning and related interventions, public health officials in Patna saw substantial improvement in the reach of routine immunization services and completion of the immunization schedule for children.

Key outcomes from the geo-enabled process in Patna included:

- Children who received the full suite of recommended vaccines by one year of age increased from 43.8% in 2007-2008 to 69.8% by 2015-2016.
- A more than two-fold increase in vaccines administered through public health care services (reaching 72% by 2015-2016), as opposed to private clinics, which improved vaccine safety and efficacy.
- Reduced delivery time for vaccines and supplies to sites, and reduced travel time for 45 nurses who had been seconded as field vaccinators.
- Improved vaccination reach and supply through optimized delivery routes, reducing the number of missed population pockets.

Programme Sustainability and Universal Takeaways

Patna's geo-enabled vaccination microplanning systems, developed in 2009, have now been used for more than a decade. With the increasing urban population, health officials have added more vaccination sites, including several model immunization centres with state-of-the-art design and infrastructure. The interventions from this geo-enabled microplanning approach have been replicated in other cities and rural areas of Bihar as well.

Key Learnings

- In addition to the appropriate use of GIS tools and accurate local data sets, other major factors involved in a successful geo-enabled intervention include: a clear vision for all stakeholders, strong will among key decision makers, committed leadership and sustained efforts, as well as the support of local and national-level partners.

2. Demonstrating that the model was workable and useful in a small geographical area helped in advocating for more resources to scale the approach.
3. The convergence between multiple government departments and partners improved the collective expertise and resources available. In particular, efforts to forge linkages between the government's remote sensing and health departments were critical to success. Donor partner support was valuable in launching the initial phase of the work.
4. Geo-enabled tools were particularly useful in minimizing gaps in vaccination services by defining the catchment areas of vaccination sites. This also helped in assigning health facility staff to be accountable for outreach in areas.
5. The combination of population data and geospatial analysis helped rationalize the placement and distribution of vaccination sites. In this case, house-to-house data from polio vaccination campaigns were the best available data to use in planning.
6. Geo-enabled tools combined with local knowledge helped optimize routes for vaccine and supply delivery. This can include optimizing routes so that a single courier can serve multiple sites. These tools can also allow for routes to be determined on a real-time basis to avoid congested traffic.
7. In areas with limited human resources for health or vaccination services, geo-enabled planning helped link place-of-service with place-of-residence, reducing workers' travel times. Assigning staff to more than one site per day if needed can optimize limited human resources.



Additional Reading

Reference document [26]



B4: Polio supplemental immunization activities use case example

Scenario/Background

By the end of 2010, Nigeria seemed poised to eliminate polio from the country, with only 21 recorded cases in the year. However, spikes in case numbers over the next two years signalled that the disease was rebounding rather than receding. Health officials were puzzled by the rise in wild poliovirus cases, as vaccination coverage was above 90% for children under the age of five, the threshold required to eliminate the disease.

Nigeria's National Primary Health Care Development Agency (NPHCDA) identified a possible reason for the polio resurgence when officials noticed that the number and location of settlements on the hand-drawn maps at a ward headquarters did not match the actual settlements they had observed while driving through the area. Because microplanning for polio vaccination campaigns in northern Nigeria relied on these hand-drawn maps, any inaccurate or incomplete information could result in vaccinators missing entire settlements or sending too many vaccines to areas that did not need them. These unvaccinated communities were likely providing ample opportunity for the wild poliovirus to reproduce and spread.

Following several mapping assessments in northern states, officials found that most hand-drawn maps used for vaccination planning proved to be faulty. The hand-drawn maps showed numerous settlements that were incorrectly located or named, and some maps were missing entire settlements. These shortcomings resulted in inefficient and unbalanced work plans for vaccination teams and caused an inaccurate assessment of vaccination campaign coverage, since officials relied on the maps' information to select monitoring sites. To develop accurate maps and data to guide its polio campaign, the NPHCDA worked with partners to create a geo-enabled microplan.

Objective

In December 2011, the NPHCDA began work to replace the outdated hand-drawn maps by creating GIS-based maps for 11 northern states, which accounted for more than 75% of new polio infections in 2010-2012. The goal was to create accurate, coordinate-based maps for each state to improve microplanning and support tracking of vaccination teams and efficient vaccine distribution. This would be critical to enhancing coverage, supervision, accountability and avoiding vaccine wastage.

Stakeholders and Personnel

In planning and executing the geo-enabled microplanning process, the NPHCDA collaborated with Global Polio Eradication Initiative (GPEI) partners as well as with local health staff and community leaders across northern Nigeria, to collect and validate data on communities and train staff in GIS tools. Public Health Services and Solutions, Novel-T and eHealth Africa provided technical and field support for the initiative. In addition, the US Centers for Disease Control and Prevention, Esri, Oak Ridge National Laboratory and WorldPop/ Flowminder supported the process by providing access to high-resolution satellite imagery, machine learning and advanced data science methods.

Process and Methods

The NPHCDA worked with technical experts and community leaders in northern Nigeria to develop and implement a comprehensive methodology for geo-enabling its microplanning for polio vaccination.

1. The team used high-resolution satellite imagery to manually identify potential unmarked settlements in target states that did not appear on hand-drawn maps. Based on the satellite images, map layers were created to include both new and previously recorded settlements. Settlements were categorized in increasing size of hamlets, small settlements or built-up areas based on the number and distribution of buildings present. These population estimates provided a breakdown of target age children per catchment area, helping to more accurately determine the number of vaccination teams to deploy there. While the technology was not available for the initial intervention, during later follow-on vaccination campaigns officials were able to generate spatially precise population estimates that used statistical models and machine learning algorithms, and were based on micro-census data and settlement maps. (To read a detailed example of bottom-up population modelling, review the Emergency Outbreaks: Measles Use Case).
2. Data collectors were trained on using a customized Android mobile GPS tracking app, and deployed with local guides to record the coordinates of settlements as well as ward-level health catchment areas (wards are the smallest administrative division in Nigeria). Data collectors were also tasked with confirming settlement names with village leaders. Unnamed settlements were assigned an alphanumeric code until a correct local

name could be identified. Data collectors also marked coordinates for additional points of interest beyond health facilities, such as schools, markets, and mosques/churches, as these could help make the maps more relatable to diverse stakeholders and easier to orient when used in the field. To avoid legal or property disputes, ward-level catchment areas were referred to as “ward vaccination boundaries” and the distinction was made that they were not administrative boundaries.

3. After teams mapped all settlement and catchment boundaries, technical experts overlaid the field data with high-resolution satellite imagery in order to visualize additional physical features.
4. Draft maps for microplanning were sent to the ward leaders for validation and sign-off. Once approved, GIS maps were printed on A2 and A3 size paper and sent to local officials. The maps were used to identify settlements that had not been served by prior polio vaccination campaigns, and to guide the allocation of vaccination teams to settlements based on their size categorization.
5. All GIS settlement and boundary data were housed in a versioned geodatabase, using commercial software (ArcGIS Enterprise, Esri) for easy updating and sharing.
6. The NPHCDA also used the GPS trackers to record the vaccination teams’ progress on the GIS maps. This allowed the team to identify various delivery bottlenecks and quickly address them. To help ensure that vaccination coverage was as comprehensive as possible, the NPHCDA’s polio Emergency Operations Centre implemented a web-based vaccination tracking system dashboard. The dashboard enabled local and remote stakeholders to view the tracking data and geographic coverage and help identify any missed settlements.

Orientation for this geo-enabled microplanning process was conducted through a cascaded training, beginning with the state Immunization Officers and WHO local government authority cluster consultants, who then trained the local Immunization Officers and ward focal points.

The geo-enabled microplanning process was launched in December of 2011, and within two years 11 states had been mapped.

Outcomes

In total, the NPHCDA created GIS maps for more than 2000 wards in the 11 target states that included updated locations for settlements, health facilities and other points of interest, as well as showing ward-level catchment boundaries and, later, spatially precise population estimates.

The GIS mapping and tracking of vaccination teams in northern Nigeria significantly improved microplanning and provided valuable monitoring information, leading to fewer missed children. In some cases, settlements of up to 1000 people that had gone unrecorded on hand-drawn maps received their first visits from polio vaccination teams. The enhanced maps and accurate data also resulted in more efficient campaigns, as planners were better able to allocate supplies and design vaccinator travel routes.

Ultimately, the ability to find and vaccinate these previously missed populations afforded by geo-enabled microplanning helped Nigeria reach a long-sought milestone. By 2017, outbreaks of wild poliovirus fell to zero and have stayed there, with the African Regional Certification Commission, an independent advisory body of WHO, certifying that the country eradicated the disease on 21 June 2020.

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“The fight against poliovirus in Nigeria and the final declaration of Nigeria as free of wild polio was made possible through the utilization of geospatial technology,” says Dr. Faisal Shuaib, Executive Director and Chief Executive Officer of NPHCDA. “GIS-based maps from the GRID3 Nigeria data improved the microplanning process, thereby enhancing the ability of frontline healthcare workers to accurately identify settlements and track under-five children to be immunized with polio vaccines.”

Programme Sustainability and Universal Takeaways

Since the geo-enabled microplanning programme was launched in late 2011, additional data has been collected in the remaining 25 states and the Federal Capital Territory. Nigeria’s government has taken full ownership and maintained the geo-enabled process, allowing health officials to have updated microplans for routine immunization, supplementary immunization activities and other primary health care services. In addition, the institutionalisation of the geodatabase at the National Space Research and Development Agency has been key to the sustainability of this geo-enabled intervention.

Key Learnings

- ⦿ GPS tracking of vaccination teams gives supervisors a tool to ensure that all settlements are visited.
- ⦿ Gaining community buy-in for the GIS mapping process early on helped to build trust, which allowed for accurate data collection at the local level.
- ⦿ Adding points of interest beyond health facilities can be valuable in making GIS maps understandable for various stakeholders, and provide multiple ways to orient maps when in the field.
- ⦿ Potential conflicts over authority to delineate official administrative boundaries can be avoided by labelling boundaries drawn during GIS mapping as “health” or “operational” boundaries/catchment areas, rather than political boundaries.
- ⦿ The impact of introducing new technology and building capacity in a country cannot be overstated. Thousands of Nigerian health workers and government officials have now been trained to read GIS maps and are beginning to recognize their value in other areas. These include planning for routine immunization activities, logistics support and cold chain management.

**Additional Reading**

Barau I, Zubairu M, Mwanza MN, Seaman VY. Improving polio vaccination coverage in Nigeria through the use of geographic information system technology. *J Infect Dis.* 2014 Nov 1;210 Suppl 1:S102-10. doi: 10.1093/infdis/jiu010. PMID: 25316823.

Outside the box: how Nigeria won the fight against polio. GRID3. July 31, 2020

B5: Emergency outbreaks: measles vaccination use case example

Background

Nigeria's measles vaccination coverage has been persistently poor, and the country ranks as one of the lowest for measles vaccination coverage in the world. This resulting low population immunity has allowed for increased transmission of the virus and led to measles outbreaks across the country, particularly in northern states. These outbreak emergencies were preceded by underperforming measles vaccination campaigns that had repeatedly missed households and entire settlements. Health officials at Nigeria's National Public Health Community Development Agency (NPHCDA) recognized that to prevent future outbreaks they would need to improve vaccination coverage and make it easier for target populations to get vaccinated.

In order to be effective, the vaccination planning would require accurate settlement lists with demographic data for target populations, which did not exist at the time. To address these data gaps, the NPHCDA adopted a geo-enabled microplanning approach that built on the GIS data and maps developed for the country's highly successful polio vaccination microplanning (read more in the Polio Supplemental Immunization Activity Use Case).

Although the polio microplanning data and products provided a useful start, the NPHCDA would need to complete further data collection and analysis specific to measles vaccination campaigns. For instance, the polio vaccination campaigns utilized house-to-house visits by trained community members to administer the oral vaccine, while the measles vaccination requires community members to travel to vaccination sites for injections from health care workers. In addition, unlike polio vaccines that can be administered from birth, the minimum age for a measles vaccine is nine months; meaning health officials would need up-to-date demographic age information for settlements to plan the number of vaccine doses required per area.

Having accurate population estimates for the targeted areas would also be important in allocating health care workers and resources. The figures from Nigeria's last national census in 2006 were outdated and local population reporting was often inflated for political gains and to attract additional resources. Furthermore, previous census data had shown total population growth or decline only at the state level, assuming equal change across all local government areas (LGAs). In reality, the populations of urban areas often grew faster than those of rural areas.

Objective

Health officials set out to create GIS maps for 10 states in northern Nigeria to support vaccination microplanning. The maps would need to:

- have clear boundaries and catchment areas
- show population estimates for the number of children in the target age range
- ensure that all settlements have an assigned vaccination site within walking distance (1km).

Because the measles vaccination planning leveraged data from the previous polio campaign, which focused on northern states, the NPHCDA also concentrated its geo-enabled microplanning efforts on 10 selected northern states. At the time, similar datasets (e.g. ward, catchment area maps, etc.) were not available to help geo-enable microplanning for southern states.

Identifying vaccination sites within 1km of all settlements would be critical to reducing the number of children who were not vaccinated because their parents found it too far to travel, which had been an issue in previous measles vaccination campaigns. Developing catchment areas based on vaccination sites and population estimates would be important in assigning vaccination teams. This data would also help to determine the amount of time spent at each site based on the number of children that a team can vaccinate in a day. Officials would have to ensure that enough vaccination sites were set up to reach all settlements and clarify responsibility for overlapping catchment areas.

Stakeholders and Personnel

The NPHCDA took the lead in developing the geo-enabled measles vaccination microplan, along with support from the WHO Nigeria office, and eHealth Africa and Novel-T serving as technical partners.

Local-level stakeholders included Local Immunization Officers, District Surveillance Officers, Ward Focal Persons, and Team Supervisors, who were supported by WHO and UNICEF officials at the state and district levels. Field validation of data was conducted by teams from the NPHCDA, WHO and UNICEF who were trained in using GPS-enabled tablets and GIS tools to record settlement coordinates and update data.

Process and Methods

The NPHCDA leveraged data from the geo-enabled polio vaccination microplanning process and worked with partners to develop ward-level GIS maps that meet their microplanning needs.

1. The team began by ensuring the list and location of settlements was up-to-date for each ward. New settlements that were not listed on previously used hand-drawn maps were identified using manual feature extraction, with a trained and supervised team marking settlements on recent, high-resolution satellite images. Many of the new settlements only had machine-generated names. Field teams were deployed to validate GPS coordinates for new settlements and confirm their names with local leaders. These updated settlement maps were validated with team supervisors, ward focal persons and traditional leaders.
2. The NPHCDA worked with partners to use modelling in a GIS programme to calculate population estimates for settlements based on buildings visible in high-resolution satellite imagery. The model was able to quickly provide accurate estimates for the number of children between the ages of nine months and five years old in each settlement
 The population estimation model was calibrated by comparing satellite imagery of building types and density in communities where population and demographic data was already known from recent micro-censuses. Using this representative sample, the model allowed the team to derive a realistic prediction of how many people live in a given area, and their approximate age ranges, based on the number, types, and density of buildings present in satellite images.
 This model was applied to recent satellite images of the selected northern states, producing a detailed population grid that showed estimated number of people and age demographics per 90x90 metre grid square. Using this information, each settlement was categorized as a large built-up area, medium-sized hamlet or small settlement and allocated vaccination teams accordingly.
3. The team then created an algorithm within the GIS programme to automatically calculate the number of vaccination sites needed to cover all settlements as well as optimal locations to ensure that each settlement was within 1km of a site. Potential vaccination sites included schools, markets, motor parks, health facilities and the homes of traditional leaders. The algorithm also helped to delineate final catchment areas. The proposed vaccination sites and catchment areas were synchronized with the situation on the ground and final sites were selected based on local context and input. The process assisted officials and local teams to more evenly spread the workload amongst vaccination teams.
4. GIS maps were printed on A3 paper and distributed to state, and then local health officials for use in microplanning. The final maps included information on settlement names, location of vaccination sites, catchment areas, and target population to be vaccinated. See Section 6.3.2 for an example of these maps.
5. Local officials used the GIS maps to plan materials, logistics and personnel for the vaccination outreach and to assign workloads to vaccination teams. Daily workloads for each team were estimated using settlement categorization, with the assumption of vaccinating 125 children per day in rural areas and 175 children per day in urban areas.
6. The microplans and daily implementation plans developed at the ward level were reviewed by the LGA team and by state and national health officials, who recommended any changes prior to implementation.

The entire intervention planning for the 10 northern states took approximately six months. This included planning meetings, training, field visits by scouting teams and interactions with hospital managers and vaccination staff. During this time, the team also conducted additional planning processes, such as identifying vaccinator nurses, couriers and mobilizers in each site.

While the initial manual feature extraction to identify and count buildings from satellite images took several weeks, automated feature extraction and settlement layers have since been produced for the entire African continent by Novel-T and GRID3, in collaboration with other technical partners. Having access to this data would likely expedite a similar geo-enabled microplanning process.

Outcomes

The geo-enabled microplanning process was shown to provide considerably accurate target population estimation, which had been a recurring problem in past immunization campaigns in Nigeria. This allowed officials to more confidently allocate vaccination teams and resources to where they were needed most. The geo-enabled process also ensured that all settlements were covered during the measles vaccination campaign.

Following the vaccination campaign, health officials reported an increase in coverage when comparing the 2017-2018 geo-enabled campaign to the 2015-2016 campaign. Key outcomes from the post campaign survey included the following.

- A greater percentage of northern states that used geo-enabled microplanning saw an increase in vaccination coverage when compared to the southern states that did not use the process.
- The percentage variation in estimated target population versus final target population (based on the verified microplans) averaged 19.6% for the southern states that used the walk through method and only 8.2% for northern states that utilized the geo-enabled population estimates.
- None of the states that used the ward-level GIS maps for microplanning had catchment areas with zero vaccination coverage among surveyed children. This was not the case in some states in southern Nigeria, where the geo-enabled microplanning was not used.
- In the northern states that used ward-level GIS maps, the percentage of responses that gave “vaccination post being too far” as a reason for non-vaccination of children was less than half the rate seen in southern areas, where geo-enabled microplanning was not used.

Programme Sustainability and Universal Takeaways

The geo-enabled microplanning process is being replicated to support routine immunization services in several of Nigeria's states. This state-level uptake is a strong indication that the approach can be adopted and sustained for a variety of health programmes, even those with limited resources. Following the success of the geo-enabled microplanning for measles vaccination, health officials also used a similar approach to distribute the injectable inactive polio vaccine at health camps in Kano State in northern Nigeria. This process also involved estimating target populations and assigning settlements to health camps within a one-kilometre radius.

Key Learnings

1. Building on the starting points and data of a previous geo-enabled microplanning intervention can facilitate health officials in adopting the approach for other interventions, such as routine immunization and cholera vaccination campaigns.
2. Building a sense of ownership among national-level officials by involving them in leadership roles and coordination of partners can be a key success factor.
3. Using GIS maps to demarcate catchment areas can support the even distribution of workloads among vaccination teams. Having clearly defined catchment areas also assists in allocating vaccine supplies and logistics for teams.
4. The geo-enabled microplanning process can help to identify new settlements that may not have been recorded on previous master lists or hand-drawn maps. This information is likely to be useful for officials planning other health interventions



Additional Reading

Joseph Oteri, Mohammed Idi Hussaini, Samuel Bawa, Samuel Ibizugbe, Kikelomo Lambo, Fred Moge kwu, Owen Wiwa, Vincent Seaman, Olivia Kolbe-Booyesen, Fiona Braka, Peter Nsubuga, Faisal Shuaib. Application of the Geographic Information System (GIS) in Immunization service delivery; its use in the 2017/2018 measles vaccination campaign in Nigeria. *Vaccine*, Volume 39, Supplement 3, 2021, Pages C29-C37, ISSN 0264-410X, <https://doi.org/10.1016/j.vaccine.2021.01.021>

B6: Co-deployment of Malaria interventions (IRS and ITN) in Zambia

Microplanning and delivery through geo-enabled co-deployment of malaria interventions (indoor residual spraying (IRS) and insecticide treated nets (ITN)) in Zambia.

Background

In Zambia, Akros supports the National Malaria Control Programme alongside USAID President's Malaria Initiative (PMI) VectorLink project and PATH to implement digital solutions to strengthen malaria vector control microplanning and coverage. Digital tools are used to assist the national malaria programme to address three challenges related to malaria campaigns:

(1) poor estimates of population and structures for microplanning; (2) limitations in planning and monitoring campaign coverage at village level; and (3) limited resources for digitally monitoring programmes.

For vector control campaigns, having ready access to accurate, geographically distributed population and structure counts is essential for high-quality planning, deployment and monitoring. The accuracy of these estimates has a significant impact on resource allocation and intervention coverage estimation. Having access to granular data by health facility catchment area (HFCA) or lower levels can improve the specificity of planning. In Zambia, these estimates have, historically, been derived from district level headcounts for campaign planning.

Attaining 80-85% coverage of vector control interventions at the community level is crucial for effective malaria control. Often, vector control programmes struggle to attain maximum impact because hamlets of houses or scattered houses are missed during intervention deployment. The individuals living in these unprotected houses or communities continue to act as reservoirs for malaria infection. To ensure high coverage levels, teams need to understand where populations are located, and managers need to be able to hold field teams accountable for reaching even the furthest houses. In Zambia, the need to plan and monitor vector control coverage was particularly acute during the 2021–2022 season, as the government implemented a “mosaic” approach where 50% of communities were to receive indoor residual spraying (IRS) and 60% were to be covered by insecticide treated nets (ITNs), with a 10% overlap. This mosaic approach proved difficult to implement, as it requires precise planning to ensure each community is allocated one of the two types of vector control.

As described below, both low-tech and high-tech approaches were used to support microplanning and campaign delivery at national and sub-national levels. These approaches, which included the use of the digital platform Reveal, supported development of microplanning maps to guide commodity and human resource decision-making, and contributed to field teams achieving significantly greater coverage rates of the interventions.

Objective:

To apply a combination of low-tech and high-tech approaches to assist the Zambia National Malaria Elimination Programme (NMEP) to address three challenges:

1. poor estimates of population and structures for microplanning
2. limitations in planning and monitoring campaign coverage at village level
3. limited resources for digitally monitoring programmes.

Stakeholders:

Zambia's Ministry of Health; National Malaria Elimination Programme; Akros; USAID President's Malaria Initiative VectorLink Project (Abt Associates).

Process and Methods:

Microplans created for all of Zambia.

In 2021, Akros supported the Zambia National Malaria Elimination Programme (NMEP) to microplan for its indoor residual spraying (IRS) and insecticide treated net (ITN) campaigns, using detailed maps with operational boundaries and population and structure count estimates down to the operational area level. To start, Akros staff engaged the Ministry of Health (MOH) and local health facility staff to discuss, map and verify the Health Facility Catchment Area (HFCA) boundaries for all 116 districts in Zambia over a period of 4 months. Using these boundaries, the Georeferenced Infrastructure and Demographic Data for development (GRID3) project used their gridded, satellite images to derive settlement-level and health facility-level population estimates. Akros further refined these population and structure count estimates in select districts using field-verified data captured

in previous years via the Reveal platform, a geospatial microplanning and data collection tool used during campaign and routine service delivery (see additional information below). Akros, in collaboration with GRID3, then produced detailed maps with the latest structure and population estimates at the HFCA-level for planning and deployment of the 2021 vector control campaigns. Akros provided both digital and print maps and an IRS planning template to each district, and trained the district teams to utilize the maps and estimation results in pre-IRS campaign microplanning meetings. The teams then used these tools to identify which settlements were to receive IRS and which were to receive ITNs, to ensure that all communities were accounted for under the vector control implementation.

Reveal deployment to guide and track delivery of ITNs and IRS. In specifically identified districts, including the high-malaria-burden district of Nchelenge, and the pre-elimination district of Chadiza, the Zambia NMEP elected to deploy the Reveal geospatial platform alongside IRS operations to enhance accountability for high vector control coverage in 2019 and 2020. Reveal is an open-source digital global good that includes a map-based microplanning user-interface to guide, track and collect data on intervention delivery at the household level, and monitoring dashboards for decision-making. Once a microplan is complete and approved, field teams are “tasked” within the application to navigate to target households, and deploy the campaign intervention. In this way, field teams are held accountable for operations at the household level. Mobile-based maps help to guide teams to specific areas and specific houses that have been targeted to receive an intervention. This robust mobile interface is made possible by uploaded map layers where all households have been identified before the campaign. As teams move through the field and collect data against specific structures, the colour of the structure on the map changes on the device to indicate whether the household has been sufficiently served, whether the household requires follow-up due to missing family members, or whether the residents were not home or refused services. When teams come across households that are not eligible for services, they can mark the structure as ineligible and it will be removed from the “denominator” (the count of the number of structures, used to hold teams accountable).

Reveal was used to guide and track delivery of IRS at the household level to ensure communities and structures were not missed, yielding extremely high coverage in Chadiza and Nchelenge districts. In Nchelenge, where a sub-district mosaic approach of IRS and ITNs was followed, the Reveal IRS dataset and paper-based ITN dataset were used to identify gaps in vector control deployment, and inform a ‘mop-up’ campaign to achieve an estimated 100% vector control coverage in these areas in 2020–2021. The granular, household-level data collected through Reveal in 2019 and 2020 also informed IRS operations in these areas in 2021 to support continued high coverage levels.

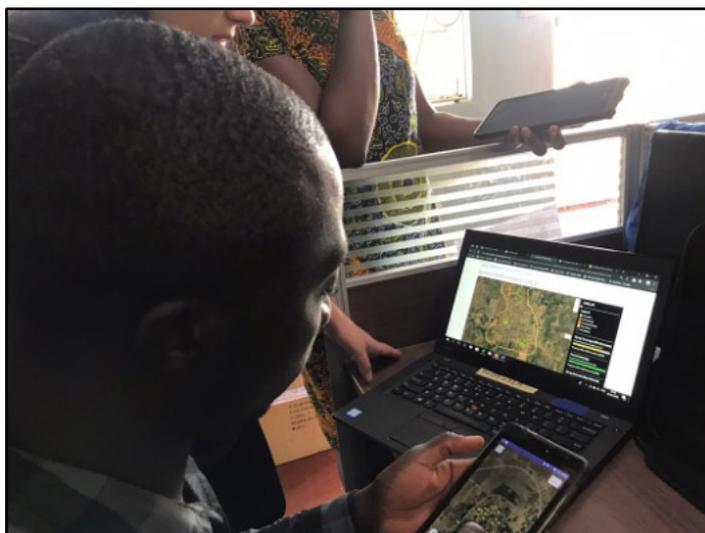
Outcomes

Microplanning maps guided commodity and human resource decision-making. The development of microplans minimized co-deployment of ITNs and IRS and maximized the population reached with ITNs and IRS across the country, mitigating the challenges of the sub-district level mosaic approach. As a result of having these maps and estimates, national-level staff are discussing indicators used to measure vector control coverage (VCC), to ensure that decision-making around planning and targeting for interventions includes the entire population and communities are not left behind; these data support planners to improve future resource allocation and deployment strategy as necessary.

Reveal microplanning and deployment contributed to significantly greater coverage rates. In districts that have deployed Reveal for pre-elimination or high-burden settings, field teams are consistently (1) finding target households; and (2) spraying those found – household visitation rates and spray coverage have increased yearly and are consistently above 90%. This is in comparison to otherwise extremely low coverage rates, for example as reported in a multi-country analysis where coverage of IRS was reported as poor across the African continent with over half of communities not reaching a 50% IRS coverage rate (compared to the global policy of 80–85% coverage for effectiveness)³⁷.

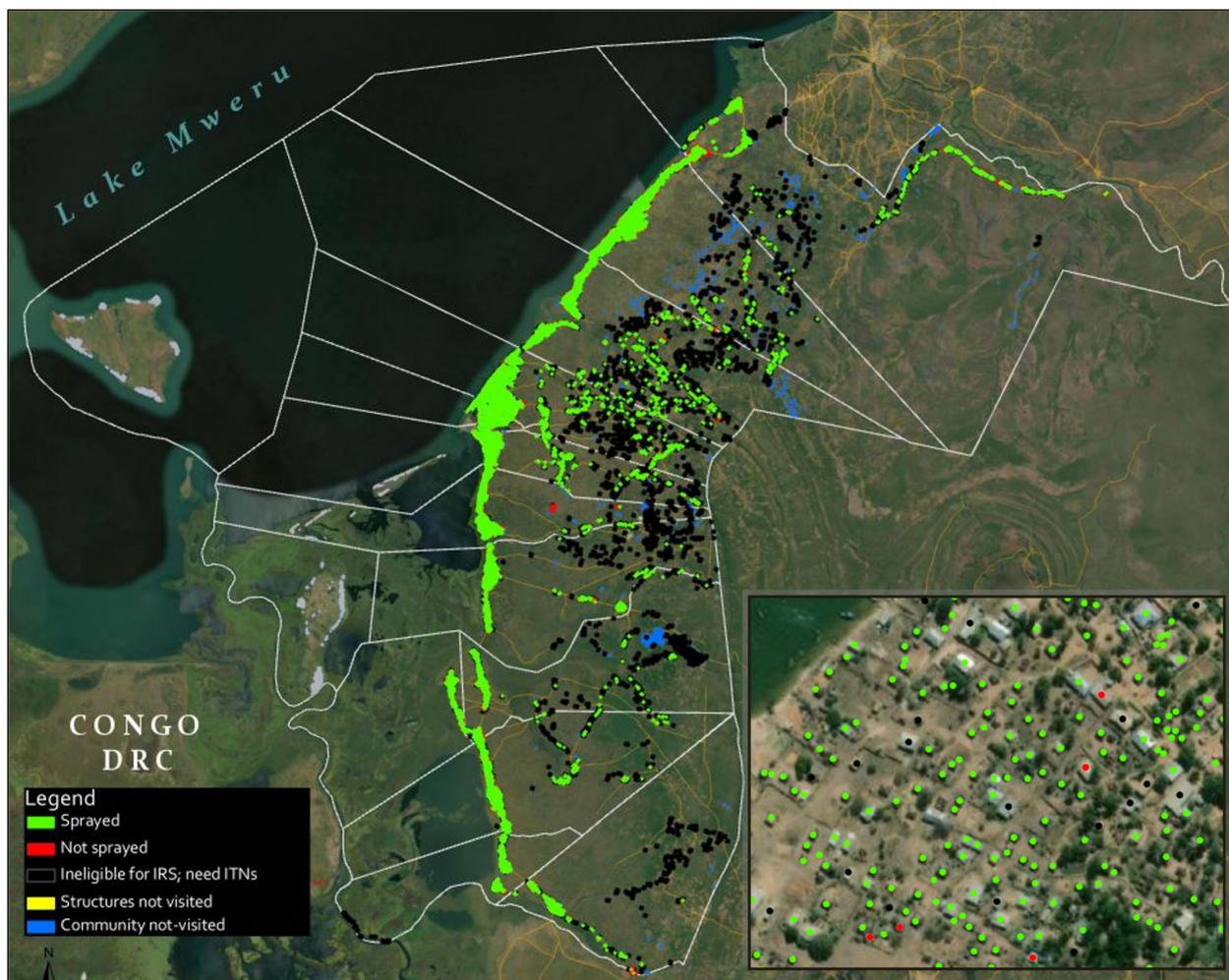
37. Larsen, D.A., Borrill, L., Patel, R. et al. Reported community-level indoor residual spray coverage from two-stage cluster surveys in sub-Saharan Africa. *Malar J* 16, 249 (2017). <https://doi.org/10.1186/s12936-017-1893-x>

Figure AK - Through Reveal, managers at central and/or local levels are able to closely monitor campaign coverage, noting areas where households have been missed, or the intervention refused. This real-time monitoring provides teams the opportunity, while they are still in the field, to navigate to missed areas and deploy the intervention to increase true coverage rates. (Source: Akros)



Granular data captured during campaigns provided insights to guide decision-making and improve impact. Following a review of the Reveal 2019 post-season coverage maps in Nchelenge, Zambia, it was discovered that many of the hard-to-reach, inland areas were not targeted and last-mile communities were being left behind. Research undertaken by Johns Hopkins University (JHU) and the International Center for Malaria Excellence (ICEMR) showed that these inland communities were important sources of transmission, given travel from inland farms to the lakeside. Resourcing was increased in Nchelenge for the 2020 season in order to reach these last-mile communities. Then, in 2020, Reveal was used to guide the delivery of these additional IRS resources resulting in significantly increased visitation coverage (from 74% to 96%) and increased spray coverage (from 83% to above 93%). Immediately following this, the IRS and ITN delivery data were merged and gaps in overall VCC coverage, primarily in hard-to-reach areas, were identified. The NMEP then distributed an additional 14 590 ITNs via a “mop-up” campaign to achieve an estimated 100% VCC coverage in these areas in 2020.

Figure AL - from Nchelenge, Zambia, show households (inset) which were sprayed (green), and those houses and communities which were not visited (yellow and blue), or ineligible (black). These houses required ITN ‘mop up’. In 2020, Reveal was used to guide the delivery of additional IRS resources resulting in significantly increased visitation coverage (from 74% in 2019 to 96% in 2020) and increased spray coverage (from 83% in 2019 to above 93% in 2020). Following the 2020 ITN mop-up campaign, all communities had achieved 100% vector control coverage. (Source: Akros)



In terms of the data and digital products produced, the shapefiles, and structure and population estimates will be uploaded to the Zambia Master Facility List developed by USAID-funded Evidence for Health project and publicly available to all Zambia stakeholders; the physical and digital maps have been shared with each district; and all jurisdictional hierarchy data (shapefiles and latest structure and population estimates), and all Reveal-collected field data from 2015–2020 are in the process of being uploaded to the USAID Development Data Library (DDL) and are available upon approved request.

Where Reveal has been implemented and continues to be implemented, we anticipate the data use culture to be self-sustaining; almost all district supervisors who used Reveal for at least one season cited the system as completely changing their ability to plan for and manage an IRS campaign.

Reveal is a digital global good that has a strong, collaborative community of practice. The satellite imagery used within Reveal is based on a free-access model with MapBox™, and Reveal is able to utilize multiple types of population data sources. Reveal supports both point-based and house-to-house campaigns, and is also available in a ‘Light touch’ format where house-to-house data collection is not required. Reveal is used across the global south and supports multiple types of campaign and routine service delivery.³⁸

38. <https://revealprecision.com/>

Key Learnings

- Geo-enabled microplanning brings the opportunity of new data sources to support planning decisions, compared to census data and/or other potentially outdated information. Updated, more robust population figures must be validated with country stakeholders to determine the best population figures for planning purposes.
- The opportunity to utilize robust, field-collected data to validate population sources cannot be understated. In this use case, Reveal data were used to validate, and improve GRID3 population datasets. This presents a significant value proposition to other global population datasets.
- Previous years field-collected data can be used and improved upon for subsequent field campaigns, building off each subsequent season.
- Microplanning is one step in the process to ensure health services are delivered to all, but cannot be considered the last step. Rather, digital tooling to ensure plans are actually deployed accurately and all target areas/houses receive the intervention is crucial. For example, in Zambia, data indicate that often field teams do not visit 41% of the targeted houses originally identified during microplanning.



Additional Reading

1. Larsen et al (2020). Leveraging risk maps of malaria vector abundance to guide control efforts reduces malaria incidence in Eastern Province, Zambia. *Nature Scientific Reports*. 10: 10307 <https://www.nature.com/articles/s41598-020-66968-w>
2. Keating, J., Yukich, J.O., Miller, J.M. et al. Retrospective evaluation of the effectiveness of indoor residual spraying with pirimiphos-methyl (Actellic) on malaria transmission in Zambia. *Malar J* 20, 173 (2021). <https://doi.org/10.1186/s12936-021-03710-5>
3. Tropical Health (Josh Yukich). Cost and cost-effectiveness of 3GIRS in sub-Saharan Africa: results of data collection and analysis in the nGenIRS project. January 2019.
4. Pinchoff, J., Larsen, D.A., Renn, S. et al. Targeting indoor residual spraying for malaria using epidemiological data: a case study of the Zambia experience. *Malar J* 15, 11 (2016).
5. Martin et al (2023). Reveal, a monitoring and evaluation tool for improved structure estimates to inform indoor residual spraying microplanning and execution: a case study in Zambia, 2016 – 2020. *Mal J* Forthcoming.
6. Larsen, D.A., Borrill, L., Patel, R. et al. Reported community-level indoor residual spraying coverage from two-stage cluster surveys in sub-Saharan Africa. *Malar J* 16, 249 (2017). <https://doi.org/10.1186/s12936-017-1893-x>

Programme Designer	GIS Technical Staff
Continue to next section	Continue to Annex E: Questions to be answered during the assessment for geospatial data



SECTION: Annex C:

Terms of reference

Annex C1: Generic terms of reference for technical expert overseeing geo-enablement

Programme Designer	GIS Technical Staff
	

Purpose

The [name of the programme] is responsible for the [description of the programme]. The [name of the programme] is using a digital microplan to support the implementation of the [name of the intervention]. Recognizing the importance of geography to ensure that the population targeted by this intervention has equitable access to the services it provides, the [name of the programme] has decided to geo-enable the digital microplan in question.

Main responsibilities

The main responsibility of the incumbent will be to support the geo-enablement of the digital microplan implemented by the [name of the programme] and used to [description of the intervention].

Description of duties

Working under the supervision of the head of the [name of the programme] and in close collaboration with all the stakeholders involved in the planning and implementation of the digital microplan, the incumbent will be in charge of providing the necessary technical support to the [name of the programme] regarding the geo-enablement of its digital microplan including:

- engagement with national and international partners regarding the geo-enablement
- assessment of the current level of geo-enablement of the microplanning process
- development of the workplan for the geo-enablement component of the microplan
- development of the necessary guidelines and SOPs, including those meant to ensure data quality
- selection, training and technical support of the local technical staff
- implementation of the workplan, including field data collection
- sustainability of what has been established.

Expected deliverables

- report presenting the result of the assessment
- workplan, including timeline and budget for the geo-enablement component of the microplan
- guidelines and SOPs to ensure the quality of the work and address the gaps identified during the assessment
- selection of the local technical staff
- training material
- report and technical summary, including lessons learned and recommendations for how to expand nationally (in the case of a pilot) and sustain what has been established.

Required qualifications

a. Education

- ⦿ University degree in data management and/or geographic information systems or a related discipline from a recognized institution, or enough professional experience to be considered as equivalent.

b. Expertise and skills

- ⦿ Advanced knowledge in the management and use of geospatial data and technologies (GIS, GNSS, RS).
- ⦿ Demonstrated abilities to supervise and train technical staff on the management and use of geospatial data and technologies across levels (central to local).
- ⦿ Ability to work in a cross-cultural environment.

c. Experience

- ⦿ At least five years' experience in supporting countries, ideally the health sector, with the management and use of geospatial technologies
- ⦿ Country-level experience in geo-enabling a public health programme and/or microplan would be seen as an advantage.
- ⦿ Strong proven experience in stakeholder engagement, including working with international agencies or multinational companies, preferably in the health, development, or humanitarian fields.
- ⦿ Experience and proficiency with capacity development, including facilitating workshops at both the national and sub-national levels.
- ⦿ Monitoring, evaluation and learning (MEL) experience desired.

d. Languages and level required

- ⦿ English: Proficient.
- ⦿ Local language: Would be seen as an advantage.

Source: *Health GeoLab Collaborative* <https://healthgeolab.net/>



Annex C2: Example terms of reference for technical working group on the management and use of geospatial data and technologies in the health sector

Programme Designer	GIS Technical Staff
	

1. Functions

The function of the Technical Working Group (TWG) is to work in partnership with all concerned stakeholders to:

- a. Support the geo-enabling of the Health Information System (HIS) by:
 1. Contributing to the development, maintenance and update of the master lists for the core geographic objects (health facilities, communities/ settlements and administrative divisions) and their associated geographies.
 2. Defining, agreeing upon and enforcing the use of guidelines, standards and protocols aiming at improving the availability, quality and accessibility of geospatial data needed by the health programmes.
 3. Coordinating data collection efforts and projects (including the harmonization of collection tools) to avoid unnecessary duplication and ensure geospatial data consistency across the health system.
 4. Coming up with the necessary policies and measures to leverage the resources needed to sustain the geo-enabling of the HIS in the long term.
- b. Assess geospatial data, technologies and services needs and gaps.
- c. Share knowledge, experiences, expertise, best practices and project information related to geospatial data management, GIS and other geospatial technologies.

2. Structure and membership

- a. The TWG is placed under the umbrella of the Ministry of Health (MOH).
- b. The Department of Public Health shall serve as the Chair of the TWG.
- c. The roles and functions of the Chair are to:
 1. Provide leadership to the TWG.
 2. Provide the provisional agenda to all members and facilitate the meetings.
 3. Ensure TWG meetings executive summary and other associated materials are shared with the TWG members.
 4. Communicate/report on coordination and policy gaps and issues that cannot be resolved within the TWG to appropriate MOH officials for resolution.
- d. The TWG comprises focal points from:
 1. The MOH Departments/Divisions involved in the collection, management and use of geospatial data and technologies.
 2. Key partners and stakeholders from the health sector and beyond invited by the TWG Chair.

- e. The roles and functions of the focal persons are to:
1. Represent their division/agency and report on its activities during TWG meetings.
 2. Serve as contact person and subject matter expert on issues covered by the TWG.
 3. Report back to their division/agency on discussions and decisions taken during the TWG meetings.
 4. Advocate for the implementation of the agreed-upon guidelines, standards and protocol in their division/agency.

3. Method of work

- a. Technical advisory function:
1. The TWG may create task groups, sub-committees or launch projects.
 2. The task group or project reports directly to the TWG during its meetings.
 3. The results of the work conducted by the TWG together with its recommendations are presented to the Minister's Office for approval and implementation.
- b. Meetings:
1. The frequency of meetings will be determined based on the needs and progress of the TWG's activities.
 2. One week before each meeting, the Chair will ask members for items to be included in the agenda, and will share a final draft with all members at least the day before the meeting.
 3. Focal points and subject matter experts will be convened based on the items on the agenda.
 4. When appropriate, virtual meetings will be organized.
- c. Reporting:
1. An executive summary of the meeting shall be distributed to all TWG Members at least one week before the next meeting.

Annex D: Template budget spreadsheet

Programme Designer	GIS Technical Staff
	

The following link provides access to a tool for categorizing and calculating costs throughout the phases of the microplanning process: [Geospatial intervention matrix template](#).

Annex E: Questions for assessing geospatial data

Programme Designer	GIS Technical Staff
	

Quality dimension	Applicability		Questions to be answered	Method to answer the question	Resulting information/ measurement
	Vector format	Raster format			
Timeliness	X	X	What is the temporal representativity of the dataset?	Access to metadata and/or interview data source	Date or period of validity matching or not the data specifications
Completeness	X		With master list (Table AK): Does the geospatial data contain all the geographic objects contained in the master list?	Compare the content of the geospatial data with the content of the master list	% of geographic objects from the master list missing in the geospatial data
			Without master list (Table AK): Does the geospatial data contain all the features observed on the satellite images used as ground reference?	Visually assess the level of completeness using satellite imagery as ground reference	Estimated % of missing geographic objects
Uniqueness	X		With master list (Table AK): Does the geospatial data contain duplicates based on the master list?	Compare the content of the geospatial data with the content of the master list	% of identified duplicates
			Without master list (Table AK): Does the geospatial data contain duplicates that can be identified based on the content of the attribute table and/or geographic location or extent?	Visually check content of attribute table as well as location or geographic extent	% of identified duplicates
Accuracy	X		Is the scale at which the geospatial data has been created matching the one defined in the data specifications?	Access to metadata and/or interview data source, SOP used for data creation	Difference in scale between the geospatial data and the data specifications
			Are the geographic objects in the geospatial data located with the expected positional accuracy defined in the data specifications?	Visually assess the level of accuracy using satellite imagery as ground reference; access to SOP used for data collection, random check, comparison between sources,	Estimated % of geographic objects that are not located with the expected horizontal accuracy
		X	Is the resolution of the geospatial data matching the one defined in the data specifications?	Check the properties of the geospatial data	Difference in resolution between the geospatial data and the data specifications
Validity	X	X	Is the metadata for the geospatial data available?	Access to metadata and/or interview data source	Availability of metadata
			Are the geographic coordinate system and map projection known?	Access to metadata and/or interview data source	Availability of projection information
			Is the geospatial data available in a format that is compatible with the ones defined in the data specification or can it be converted accordingly?	Check the data format and/or interview data source if unknown	Compatibility of format
			Does the geospatial data cover the study area as defined in the data specifications?	Visually assess the coverage of the geospatial data using the satellite images as ground reference	% coverage of the study area



Annex F: Elements of a geospatial information licence agreement

Programme Designer	GIS Technical Staff
	

- ◉ What Geospatial Information is Being Licensed
 - ▶ A clear, complete, and accurate description of the geospatial information being licensed to prevent potential future disputes and misuse of data.
- ◉ Rights Granted to the Licensee
 - ▶ A complete description of the rights granted under the licence, otherwise known as the scope of the licence.
- ◉ Payment/Fees
 - ▶ Most commercial geospatial information licence agreements include a separate section that outlines the terms of payment for the right to licence the geospatial information. A payment generally will not be included in an “open data” licence.
- ◉ Representation and Warranties
 - ▶ Representations and warranties aid in allocating risk between the parties to a geospatial information licence:
 - ▶ Representations are statements of fact made by one party to induce the other party to enter into an agreement. A Licensor may be asked to represent that it owns the geospatial information (or that it has the right under an agreement with the owner to license the geospatial information to the Licensee for the purposes set forth in the geospatial information licence agreement)
 - ▶ A warranty is essentially a promise by the Licensor to address problems that may arise in the future, generally for a defined period of time.
- ◉ Covenants
 - ▶ Covenants are promises that one party (or both parties) make to the other to either take some action in the future or to refrain from taking certain actions. They can vary widely in a geospatial information licence agreement. A Licensee might promise not to use the geospatial information in ways that are illegal or promote violence. Alternatively, a Licensee might covenant to notify the Licensor if it learns of any errors in the geospatial information, or if it learns of a third party violating the Licensor’s intellectual property rights in the geospatial information.
- ◉ Limitations on Liability
 - ▶ A party that breaches a geospatial information licence agreement may have to pay damages to the other party. As a result, a party may seek to limit or cap its liability for such breaches. This section outlines any provisions for liability caps.
- ◉ Indemnification
 - ▶ An indemnity is a “guarantee through a contractual agreement to repay another party for loss or damage that occurs in the future”. In a geospatial information licence agreement, an obligation to indemnify will arise when one of the parties to the agreement receives a claim for damages from a third party that results from actions or inactions of the other party.
- ◉ Term/Termination
 - ▶ This section sets forth the length of the licence. It can provide that the agreement ends on a certain date, or renews automatically unless one of the other parties notifies the other of its intent to terminate the agreement.

- ⦿ Compliance with Law
 - ▶ Most licence agreements contain a clause or section whereby one or both of the parties agree to abide by applicable laws, regulations, decrees, etc. For example, a geospatial information licence agreement may have a section in which the Licensee agrees that it will only use the geospatial information in ways that comply with applicable law.
- ⦿ Data Protection/Privacy
 - ▶ If the geospatial information being licensed contains (or might contain) personally identifiable information or other sensitive information, a geospatial information licence agreement may include a section that outlines the responsibilities of both parties with respect to data protection/privacy laws. For example, a Licensee might request that the Licensor state that the geospatial information was collected in accordance with applicable law and that all necessary consents have been obtained in order for the geospatial information to be licensed by the Licensor to the Licensee. Similarly, a Licensor might require the Licensee to promise to comply with all applicable privacy/data protection laws with respect to its use of the geospatial information.
- ⦿ Taxes
 - ▶ A geospatial information licence agreement may also include a clause or section on the obligations of the respective parties to pay any taxes that may arise from the transaction. Taxes on intangible assets, such as geospatial information can vary between jurisdictions and can include sales, use, value-added and property tax. As a result, it is important for the parties to understand what, if any, taxes may apply, and which party is responsible for them.
- ⦿ Confidentiality
 - ▶ Parties to a geospatial information licence agreement often will learn details about their respective business operations and plans. A party may also learn information that the other party considers to be a trade secret or otherwise wishes to protect. Therefore, a geospatial information licence agreement will often include a section that obliges each party to take measures to protect confidential information that it has received from the other party through entering the agreement.
- ⦿ Delivery/Inspection/Acceptance
 - ▶ A Licensor can deliver geospatial information to the Licensee in several ways. For example, geospatial information can be delivered electronically, in bulk or accessed as needed through an application program interface (API). It can also be delivered physically, on a medium such as a thumb drive, or in conjunction with software. In each case, the parties should consider whether it is important to address how and when the Licensee “accepts” the geospatial information, and whether there is a certain period in which the Licensee can inspect the geospatial information and/or the medium of delivery prior to acceptance in order to determine if it conforms to what the parties agreed.
- ⦿ Updates/Modifications/Corrections
 - ▶ If the Licensor is obligated to provide the Licensee updates, modifications and/or corrections to the geospatial information being licensed (collectively “Updates”), the parties should consider how the terms of the geospatial information licence agreement apply to these Updates. For example, when and how often is the Licensor required to provide the Updates and is the Licensee required to make additional payments? Does the term of the licence remain the same or does the providing of an Update extend the term of the geospatial information licence agreement? Also, do the representations and covenants that the Licensor make with regards to the geospatial information also apply to the Updates? These issues can be included in a separate section or addressed throughout the agreement.
- ⦿ Export Compliance
 - ▶ Some countries may restrict the export of certain types of sensitive geospatial information. For example, certain countries may restrict the export of geospatial information regarding the location of natural resources. Other countries may restrict all exports to a certain country or company. The penalties for noncompliance can be quite severe. As a result, a Licensor of geospatial information should be aware if any export laws or regulations pertain to a particular type of geospatial information, or geospatial information collected from a particular platform or sensor. A Licensor also may wish to include a specific provision in which the Licensee promises not to export geospatial information in violation of applicable law.

- ⦿ Government Contracts
 - ▶ In some countries, there are unique laws associated with the government's procurement of products and services from the private sector. Some of these laws are intended to protect against government agencies overpaying for commercial products and services. These laws may not have been updated in a number of years, and therefore may not adequately address intangible assets such as geospatial information or the delivery of services and geospatial information over the internet. For example, government procurement laws may automatically grant a government agency certain rights in the geospatial information that are not standard in a commercial transaction, unless these rights are specifically waived. In such instances, if the Licensee is a government agency, a Licensor may wish to include a clause or section in which the government entity waives such rights.
 - ⦿ Force Majeure / unforeseeable circumstances
 - ▶ Many legal documents include a clause that excludes the parties from most of their obligations in the event a catastrophic event, such as a war, terrorism or natural disaster. Typically, this permitted delay in performing an obligation is only for the duration of the catastrophic event.
 - ⦿ Governing Law; Jurisdiction; Dispute Resolution
 - ▶ Many geospatial information licence agreements include a section that outlines which jurisdiction's laws govern in the event of a dispute between the parties. The jurisdiction might be a country, state or other jurisdiction with its own set of laws. In addition, the section often will include a clause that states that any dispute between the parties can only be heard by the courts of a certain jurisdiction.
 - ⦿ Assignment; Transferability
 - ▶ Often a geospatial information licence agreement includes a section that describes whether either party can assign the geospatial information licence agreement (or some or all of its rights under the geospatial information licence agreement) to a third party. This section can be important if one of the parties is a business, as it may want the ability to assign its rights to an affiliated company, or in the event another company acquires it. Some geospatial information licence agreements will not allow either party to assign the geospatial licence agreement or its rights without the consent of the other party. Other geospatial information licence agreements will allow one, or both parties, to assign, but will require the party that is assigning the agreement to continue to remain responsible to the other party for all obligations under the agreement.
 - ⦿ Survival
 - ▶ Many geospatial information licence agreements include a survival clause. This clause or section is included because from a legal standpoint it is important to make clear that some (but not all) of the provisions of a geospatial information licence agreement survive even after the agreement itself is terminated [41].
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Annex G: Uses of thematic maps in microplanning

The following table describes how thematic maps can be used to address challenges in each phase of the microplanning process. The table covers the primary purpose, minimum content and audience for thematic maps typically generated at each phase of the generic microplanning process. Reviewing this table prior to planning can assist teams in determining the data and information that they may need to collect and assess at each phase to produce thematic maps.

Phase in the generic microplanning process	Thematic map purpose	Thematic map Content		Thematic map audience
		Geospatial data	Statistical data and information	
1. Determine target population and its current service coverage	Support the identification of target population's spatial distribution, including high-risk groups and individuals	<ul style="list-style-type: none"> a. Spatial distribution of the target population b. Boundaries of administrative units c. Service delivery points d. Catchment areas e. Transportation network f. Barriers to movement (e.g. rivers) g. Difficult-to-access areas 	<ul style="list-style-type: none"> a. Recent target population statistics down to the subnational level appropriate for microplanning b. Target population by catchment area c. Percentage of uncovered target population down to the subnational level appropriate for microplanning d. Unique identifier and/or name of the service delivery point 	Planners, programme managers and major stakeholders
2. Estimate the service delivery requirements	Support the estimation of the volume of service required to cover the target population	<ul style="list-style-type: none"> a. Spatial distribution of the target population b. Boundaries of administrative units c. Service delivery points and other infrastructures (e.g. warehouse, cold chain storage, waste disposal sites, etc.) d. Catchment areas e. Transportation network 	<ul style="list-style-type: none"> a. Target population by catchment area or service delivery point delivery b. Capacity of each service delivery point and other infrastructures 	
3. Plan for commodities and equipment storage				
4. Identify and manage human resources	Provide a visual representation of the spatial distribution of existing human resources	<ul style="list-style-type: none"> a. Service delivery point b. Boundaries of administrative units c. Catchment areas d. Road network 	Number of staff by type at the service delivery point	
5. Plan service delivery	Support service delivery through implementing the microplan	<ul style="list-style-type: none"> a. Spatial distribution of the target population b. Boundaries of administrative units c. Service delivery points and other infrastructures (e.g. warehouse, cold chain storage, waste disposal sites) d. Catchment areas e. Transportation network f. Barriers to movement (e.g. rivers) g. Area at risk (security, natural hazard) 	<ul style="list-style-type: none"> a. Target population by catchment area or service delivery point delivery b. Capacity of each service delivery point and other infrastructures c. Travel time/distance between storage facility and service delivery point and/or between fixed and outreach service delivery points 	

6. Generate demand and ensure communications	Generate demand and ensure communications	<ul style="list-style-type: none"> a. Boundaries of administrative units b. Service delivery points c. Catchment area 	<ul style="list-style-type: none"> a. Target population by administrative unit or catchment area b. Disease incidence 	Communities, influencers and stakeholders
7. Support and monitor implementation	Ensure an effective microplan implementation	<ul style="list-style-type: none"> a. Boundaries of administrative units b. Location of the service delivery points c. Catchment areas d. Extent of the area of responsibility e. Road network f. Points of interest 	<ul style="list-style-type: none"> a. Target population by catchment area or service delivery point delivery b. Travel time/distance between fixed and outreach service delivery points 	Microplan implementers in the field (district/health facility teams)
		<ul style="list-style-type: none"> a. Boundaries of administrative units b. Service delivery points c. Extent of the area of responsibility 	Percentage of program implementation (coverage) by implementation unit	Planners, programme managers and major stakeholders
8. Re-evaluate the microplan	Support the re-evaluation of the microplan	<i>Use of all the maps created for phases 1 to 7</i>	Number of staff by type at the service delivery point	

Annex H: Hardware and software technical specifications

Hardware

GNSS-enabled devices: While handheld global navigation satellite system (GNSS)-enabled devices (e.g. Garmin devices) are still used in some contexts, tablets and smartphones equipped with a GNSS receiver have become the primary tools for collecting geographic coordinates in the field. GNSS devices do not require Internet connection to function. GNSS-enabled smartphones are generally cheaper and more user friendly than other GNSS handheld devices, and can be used for other purposes, such as collecting additional data and for calls or SMS messaging.

As the quality of a GNSS receiver can vary from one tablet/smartphone to another, it is important that the data collectors use the same device (brand and model). Data collectors should also check that the GNSS receiver is functioning properly by collecting a set of geographic coordinates near an easily recognisable landmark, and verifying if the coordinates match those shown on satellite imagery (e.g. in Google Maps)[12].

Ensure that the application used on the tablet/smartphone can:

- be set according to defined data specifications
- provide coordinate readings with at least five digits after the decimal point
- display the number of received satellite signals
- show the instrumental horizontal accuracy [12].

Additional considerations for GNSS-enabled devices:

- accessibility: tablets tend to be more accessible to use for individuals with visual impairment and with touch-screen registration
- cameras: it is recommended for tablets or smartphones to be equipped with a 5-megapixel camera, especially if data collection will involve barcoding or scanning of QR codes for vaccine lot numbers.

Laptop or desktop computer: The choice between the two options depends mainly on use and context. For example, a laptop may be appropriate if there is a need to move around with the computer or if frequent power outages are an issue. It is important to ensure that the selected computer meets the minimum specifications recommended for the software programmes that will be used, particularly for the GIS programmes.

Additional considerations for computer usage include the following.

- if planning to use laptops outdoors and in inclement weather, consider devices that have a bright screen or are dust- and water-proof
- desktops should allow an attached uninterruptible power supply unit, to enable continued work during power outages
- when choosing a laptop, it may be helpful to have an external keyboard, mouse and screen/monitor.

Large-size monitor or dual monitor set up: While not mandatory, the use of a large-size computer monitor (above 21 inches/53 centimetres) or dual monitor set-up can significantly improve efficiency and visibility for team discussions. Large monitors or dual monitor setups are especially helpful when working on multiple programmes in parallel, or when dealing with large datasets and master lists.

Printer or plotter: While small printers (A4/A3) are useful across all applications, large printers or plotters (A2 to A0) are beneficial when there is a need to print large-size thematic maps. Plotters create drawings using pens (output similar to that of a vector graphic), while printers print text and images (output format in the form of pixels). Colour inkjet printers are generally preferred over plotters as they are cheaper and faster. In addition to purchasing printers, consider renting a printer or printing maps at a print shop. Print shops are particularly economical in the case of plotters, which may only be needed occasionally. If bringing or purchasing printers, it is important to consider what types of ink and paper are easiest to find locally.

External hard drive: The microplanning process can generate a significant volume of computer files, which should be safeguarded in an external hard drive to protect from a computer crash or corruption. In addition, an external drive allows for easy transfer of large data files from one computer to another. When possible, consider having an additional external drive to perform a double backup. Drives should provide 1TB of storage capacity and USB 2.0 transfer rates at a minimum.

Online workspace: Having an online workspace such as Google Drive or Dropbox is useful when working collaboratively, especially in the absence of an internal private network. Note that these workspaces do not provide the same capabilities. For example, a free Google Drive is appropriate for working collaboratively on a document but does not allow files to be directly opened in a GIS program from the Drive. However, Dropbox offers both of these capabilities, but requires a paid subscription.

Internet access: A stable broadband Internet connection is key to implementing a geo-enabled microplan. In remote or emergency settings a dedicated hotspot or even smartphone-based 3G+ hotspot may suffice.

Software

Desktop GIS software programs: While a variety of desktop GIS software programs are available on the market, the most commonly used are QGIS (open-source) and ArcMap (proprietary). Software choice should be driven by functionality, and by the technical and financial context. This assessment should take into consideration the capacities of the organization leading the microplan development and those of a health information system that may be integrated. When considering programs, it is important to note the following:

- while geospatial data can easily be used in any GIS software program, the software project files used by various GIS programs are not interchangeable. For example, a QGIS .qgs project file can not be opened in ArcGIS, and QGIS cannot open an ArcGIS Pro aprx file. However, both systems are generally able to use the same data type inputs and data type outputs
- some GIS software programs, such as ArcGIS Desktop, are part of an ecosystem of geo-enabled solutions that allow data to easily pass from desktop to mobile to online mapping solutions.

Some private companies have established specific programs that allow public health institutions to access their technology free of charge over a given time period or at a highly discounted price³⁹. Depending on the context, it may be appropriate to use a combination of proprietary and open-source software (e.g. proprietary at the national level and open-source at the subnational level).



Note:

For a catalogue of relevant GIS applications that have been vetted for digital maturity-based licence, open-source, flexibility, and adaptability, please consult the Digital Square Digital Public Goods catalogue⁴⁰.

Online GIS programs: While not as fast or offering as many features as desktop GIS programs, online GIS programs such as ArcGIS Online (proprietary) or GeoNode (open-source) can provide much of the same core functionality, including editing, spatial analysis, model application and thematic map creation. Online GIS programs can also provide a convenient bridge between the desktop and mobile working environments. These online GIS programs are either deployed on the cloud or on a local server, each of them coming with a cost.

GIS extensions and external tools: Some processes may require the use of GIS extensions, which are additional functions or tools needed to operationalize the four applications covered in this handbook. These tools may not be readily available in GIS software (desktop or online) and may need customization and packaging in order to be used. Additional functionalities are often available as extensions (e.g. ArcGIS spatial analyst extension), standalone tools that run on a desktop (e.g. AccessMod)⁴¹ or as online environments (e.g. MapBox isochrone API⁴²).

Online mapping tools: Different from online GIS programs, online mapping tools often have limited analytical capabilities and are primarily used to generate and share online thematic maps. Some of these tools limit the number of geographic objects that can be displayed (e.g. Google Maps). However, others provide greater functionality, allowing elaborate thematic maps with multiple layers to be rendered (e.g. ArcGIS Online). Some online database management systems also provide advanced thematic mapping capabilities (e.g. DHIS2).

39. Esri health and human services grant program: <https://bit.ly/2PjysU1>

40. <https://digitalsquare.org/global-goods-guidebook>

41. www.accessmod.org

42. <https://docs.mapbox.com/playground/isochrone/>

Geo-registry: An IT solution that allows storing, managing, validating, updating and sharing the master list and associated geospatial data for a specific geographic object.

Common Geo-registry: A geo-registry is an IT solution that allows for the simultaneous hosting, management, updating and sharing of all master lists, geospatial data and associated hierarchies. These solutions ensures that all stakeholders in the microplanning process use and maintain the same geography over time as the microplan is updated (e.g for routine immunization). See Section 6.9.2 for more information.

Spreadsheet software: Spreadsheet software, whether proprietary (Microsoft Excel) or open-source (OpenOffice, LibreOffice), is used to manage data and information in tabular form [6] and to generate tables and graphs to support data products created throughout the microplanning process. For example, a spreadsheet can be used to manage a master list in the absence of a geo-registry.

Field data collection app: Some data collection apps can only capture geographic coordinates (e.g. GPS Essentials, open source) while others are able to collect additional information. This additional information can come in the form of an electronic questionnaire (e.g. Survey 123, proprietary), or computer-assisted personal interviewing (CAPI) tools that are able to capture geographic coordinates as well (e.g. Kobo toolbox, open-source; OpenDataKit, open-source). Ensure that the app can be set according to data specifications defined in Section 6.6.2.

The app should provide coordinate readings with at least five digits after the decimal point, and display the number of received satellite signals and instrumental horizontal accuracy when capturing geographic coordinates [12]. Finally, it is important to consider how field data will be integrated with georeferenced master lists before, during or after data collection.

	Georeferenced master lists	Population estimates and spatial distribution	Geographic accessibility, service location and route optimization models	Thematic maps
Hardware				
GNSS-enabled device (handheld device, tablet or smartphone with GNSS receiver)	To collect geographic coordinates in the field if needed	NA	NA	NA
Laptop or desktop computer	To perform the operations linked to each specific application (visualize, edit, analyse, model, generate products)			
Large size screen or dual screen setting	To perform the operations linked to each specific application more comfortably			
Small size printer	To generate small size paper copies of the generated products			
Large size printer or plotter	NA	NA	NA	To print large size maps
External hard drive	To safeguard the work done on the computer or collecting large size files that are not accessible through the internet			
Online workspace	To work collaboratively on the application when needed			
Internet connection	To access the online workspace, the geo-registry or data	To access online data or resources used to estimate and/or spatially distributed population	To access online data or resources to implement the model	To access online basemaps and/or share dynamic thematic maps online

Software				
Desktop GIS programme	To visualize and edit the geometry of the geographic objects stored in the lists	To perform the analysis or implement the model	To generate the thematic maps	To print large size maps
Online GIS programme or thematic mapping tools	NA	NA	NA	To develop and share dynamic versions of the thematic maps
GIS-based extension or stand alone tools	NA	To perform the analysis or implement the model in case not readily available in the desktop GIS software		To generate a high volume of thematic maps if the functionality is not readily available in the desktop GIS software
Geo-registry and common geo-registry	To host, maintain, regularly update and share the master lists as well as associated hierarchies and geospatial data	NA	NA	NA
Spreadsheet software	To work on the master lists outside a geo-registry (e.g. cleaning of data collected in the field before upload)	To generate tables and graphs presenting the result of the application		To prepare the business data or information to be included on the thematic map
Field data collection app	To collect data in the field including geographic coordinates to improve the quality of the master list content	To collect population related statistics in the field	To collect information allowing to calibrate the model	NA

Digital app and tool considerations

Geospatial applications/tools for microplanning are computer-based tools that allow users to store and edit data, analyse spatial information, create interactive queries and visualize maps. The following are important considerations for developing and using these apps/tools.

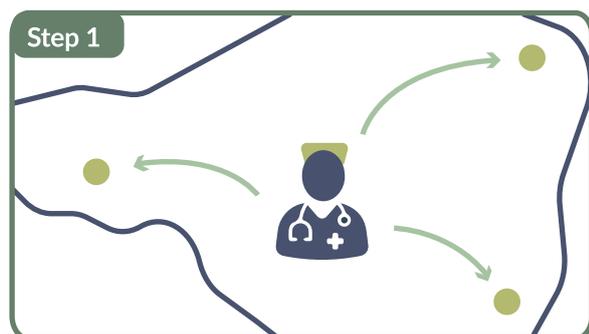
- ⦿ Development is often resource and time intensive, as apps/tools require multiple functionalities and customizations.
- ⦿ Training on the app/tool will be needed for users.
- ⦿ A deep technical understanding, as well as local knowledge gained through user/stakeholder discussions, are required to ensure the app/tool is useful on the ground.
- ⦿ Appropriate mobile devices will be needed in the field.
- ⦿ Other physical infrastructure, such as servers, may be needed if a large amount of data is to be stored on-site or locally. Cloud-based options can also be considered.
- ⦿ It is important for the app/tool to be usable online and offline.

Digital App and Tool Examples

Geospatial Tracking System

The Geospatial Tracking System, originally called the Vaccination Tracking System, proved to be an essential tool for polio vaccination teams in Nigeria. The vaccination tracking system was used to identify the location of settlements and target populations within them; track the delivery of vaccines; determine which settlements were missed; and identify areas to revisit with additional coverage efforts. Vaccination Tracking System devices, along with high-resolution geospatial data, allowed vaccinators' movements to be monitored within settlements. Digital maps on the app not only ensured that each settlement was included in vaccination plans, but also enabled significant improvements in plan efficiency. Equipped with spatially precise, accurate data, planners could better allocate vaccine supplies and better design vaccinator travel routes. As a result of its success, the tool/app is now being used for multiple types of vaccination campaigns beyond polio, and is now termed a geospatial tracking system.

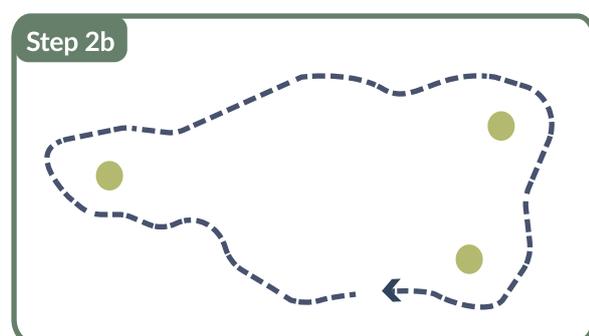
Figure AM – Geospatial Tracking System smartphone application steps. (Source: GRID3)



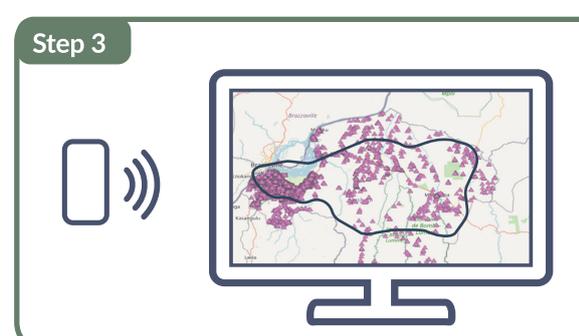
A head nurse who regularly works in a particular health area visits a health facility.



On their smartphone, the nurse records the location of the health facility.



Other relevant geospatial information (settlements, boundaries, and other POIs) can be recorded by the nurse based on their movements



This information is then compiled in the form of a digital map to provide a comprehensive picture of where health facilities, settlements, boundaries, and other POIs are.

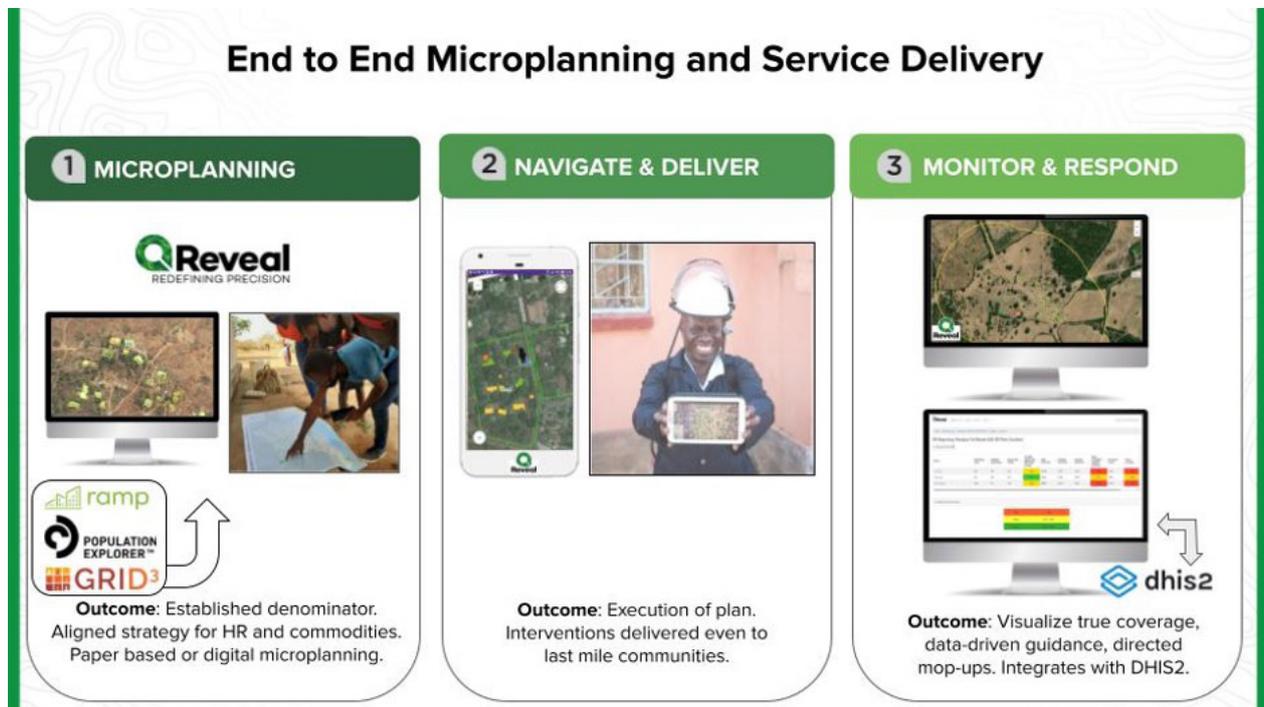
Geospatial Microplanning Toolkit

The Geospatial Microplanning Toolkit, developed by GRID3 and Novel-T in consultation with the National Primary Health Care Development Agency and GRID3 Nigeria, is a web app that enables vaccination programmes to plan and conduct microplan activities by integrating core spatial data layers in a single platform. The toolkit provides a baseline map using existing microplan data and knowledge of current vaccination programme implementation strategies. Once the baseline map is established, the toolkit enables users to manually edit and adjust boundaries and health catchment areas, and calculates the population inside each catchment automatically based on the underlying population model. It also allows for data collection and integration of missing geographic information using Open Data Kit, and seamless synchronisation into the main GRID3 Nigeria geodatabase. Furthermore, the toolkit can be utilized by multiple health facilities; and ward and local government area focal points; thereby increasing interoperability online and offline.

Reveal

Reveal is a digital global good offering end-to-end support for microplanning and delivery of health services, initially termed ‘mSpray’ when in early development alongside the Zambia Ministry of Health, National Malaria Control Program. Reveal is now used across the global south to support health campaigns and routine interventions, including microplanning and delivery of indoor residual spray (IRS), seasonal malaria chemoprophylaxis (SMC), insecticide treated nets (ITNs) as well as planning and provision of mass drug administration for neglected tropical diseases. The platform is open-source, available offline or online, and can be configured to support other campaigns and routine interventions. Through use of Reveal, health campaign coverage has improved significantly (20-30%) as teams are able to find populations and ensure health services reach them. Disease incidence has also reduced and return on investment figures are significant.

Figure AN - Reveal supports end to end microplanning and service delivery. Population data and household footprints are uploaded to the system; microplans are developed to determine commodities and human resources required for service deployment. Teams are tasked through the mobile client where they are able to navigate to target areas, visualize their location against households, and capture data against entities as the services are deployed. When in network, data are synced and visualized (on map and table) dashboards to monitor and 'mop up' missed areas as necessary. (Source: Akros)



Annex I: Data dictionary guidance

The data dictionary serves as a reference during the quality assessment of the available data lists (Section 6.6.2). The following are important steps when creating a data dictionary (modified from [8]).

- ⦿ Define the short label that will be used to differentiate each data element in the final master list and serve as the header when presented in a tabular format. This should include having the attribute table of the geospatial data contain the geographic location or extent of each geographic object.
- ⦿ Include data elements that allow the team to recreate the relationships captured in hierarchies and conceptual data models developed earlier in the process (Section 6.2). Align the values for these data elements with the content of the master lists containing this information (e.g. the unique ID and official name of the administrative unit in which a village is located). In addition, ensure that data aligns with the national spatial data infrastructure, if applicable.
- ⦿ Assess potential sensitivities associated with any data elements (e.g. name or contact information).
- ⦿ To ensure consistency, define the classification for each data element in which the values are limited to a few options (e.g. health facility type or ownership). These tables should contain the following for each option:
 - ▶ unique code
 - ▶ label (English and local language) and/or acronym
 - ▶ description (English and local language)
 - ▶ source of the definition (when applicable).
- ⦿ Use internationally recognized standards to ensure the consistency of data element values across records as well as to ensure data interoperability with other sources. These standards include:
 - ▶ character encoding: UTF8
 - ▶ dates: ISO 8601 (YYYY-MM-DD)
 - ▶ phone number: ITU-E.164 (country code (CC) and global subscriber number(GSN))
 - ▶ geographic coordinates: ISO 6709:2008 (decimal degrees (EPSG: 4326), latitude: +/- DD.DDDDD; longitude: +/- DDD.DDDDD).
- ⦿ Identify which government entity has an official curation mandate over each data element.
- ⦿ Define the metadata profile to be attached to each master list and associated geospatial data when applicable. Refer to [8, 13] for details on the minimum fields that a metadata profile should contain depending on data type.

