# Digital Works for Urban Resilience

SUPPORTING AFRICAN YOUTH

# RAPID PILOT PHASE

## FINAL REPORT

GFDRR
Global Facility for Disaster Reduction and Recovery

WORLD BANK GROUP

Design: Miki Fernandez, ULTRA Designs, Inc.

Front cover photos: left–Resilience Academy - Morogoro; center–screenshot of OpenStreetMap RapiD tool; right–Spatial Collective.
Back cover: Spatial Collective.

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# ACRONYMS

| | |
|---|---|
| **AI** | Artificial Intelligence |
| **DLR** | German Aerospace Agency |
| **FCV** | Fragility, conflict, and violence |
| **HOT** | Humanitarian OpenStreetMap Team |
| **JOSM** | Java OpenStreetMap Editor |
| **ML** | Machine Learning |
| **OSM** | OpenStreetMap |
| **POI** | Point of Interest |
| **RA** | Resilience Academy |
| **UN ECA** | United Nations Economic Commission for Africa |
| **UX** | User Experience |
| **WB** | The World Bank |
| **WSF** | World Settlement Footprint |
| **ZMI** | Zanzibar Mapping Initiative |

# BACKGROUND

**As urban populations continue to grow, managing growth in a way that fosters cities' resilience to natural hazards and climate change requires detailed, up-to-date geographic data of the urban environment.**

Understanding and addressing this challenge requires innovative, open, and dynamic data collection processes that support management of urban growth, disaster risk and emergency response. Successful activities are contingent on local capacity to develop accurate, up-to-date information that can support real-time decision making, affect long-term policy and planning, and develop tools to translate data into meaningful action. The heightened impact of global public health emergencies such as the COVID-19 pandemic underscore the need to build local skills to create the required digital information while providing learning and livelihood opportunities.

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*How we build and how we manage our resources defines how our cities will develop in the future.*


## Urbanization is changing Africa's Risk Profile

**Africa is urbanizing faster than any other continent.**[1] Over 470 million people currently live in Africa's urban areas, and that number is projected to reach 1.2 billion by 2050[2,3]. Population growth and demographic shifts on the continent are two of the most significant structural changes taking place in the 21st century. Based on the latest demographic projections, Africa will soon dwarf Europe's population, and account for 41% of the working-age population worldwide.

**The patterns of urban expansion are increasing vulnerability.** The geospatial characteristics of African cities are different from comparable cities on other continents. Much urban development in Africa is in the form of expansion and leapfrog development rather than infill. This leads to the development of fragmented and disconnected cities which are unable to benefit from the economies of scale[4]. Uncontrolled urban growth also leads to the proliferation of informal settlements and difficulties in enforcing urban master plans.

**The disaster risk profile of countries in sub-Saharan Africa has changed.** Expected losses and economic shocks are shifting from predominantly rural risks—with drought and food security challenges—to predominantly urban, with floods, cyclones, and earthquakes. Many of these risks build up in informal settlements located in hazardous areas. The poor are especially vulnerable as they often live in hazardous areas, suffer higher losses, and are less resilient to loss. Unplanned urbanization can also lead to environmental degradation and the expansion into hazardous land. The pattern observed across much of Africa's urbanization of land intensive urbanization—leading to urban sprawl.

**The build-up of disaster risk is largely unseen and therefore unmanaged.** A key challenge in risk reduction is the timely collection of actionable risk data. There is still little reliable information regarding how quickly cities are growing, where they are growing, and how they are growing. These

1 Global Facility for Disaster Response and Recovery (GFDRR), January 2016. Urban Resilience: Challenges and Opportunities for African Cities.
2 World Bank Group, 2017, Africa's Cities: Opening Doors to the World
3 GFDRR 2016
4 Lall, S.V., Henderson, J.V. and Venables, A.J., 2017. *Africa's cities: Opening doors to the world.* The World Bank.

data include information on socio-economic activity such as the concentration of people, housing and facilities. UN ECA estimates that in Africa only 2.9% of the continent is mapped at local scales, in contrast to over 87% of Europe. This deficit is particularly challenging for evaluating risk in the fast-growing, largely unplanned, and unsurveyed towns and cities[5].

## To increase Urban Resilience we need to see a Paradigm Shift in the production of data and information through the use of disruptive technologies and development of local skills

**Cities in Africa can harness new low-cost digital tools to help bridge the data gap.** Digital technologies offer the promise of low costs for scale and dissemination. The current geospatial revolution is driving ever more sources of data for lower costs and simpler deployment models. Daily satellite monitoring services can provide routine and high frequency change detection. Improved imaging sensors and lower cost drones enable high quality aerial surveys. Local data collection via mobile phones or in-situ stations has achieved survey grade quality for consumer grade prices.

**Artificial Intelligence (AI) can also help accelerate change detection services; but this technique requires local validation.** Recent advances in automatic image processing workflows for geospatial data generation are providing groundbreaking results[6,7]. However, these algorithms require a very large number of training samples; samples that should be representative of the communities being mapped. Using low cost digital tools, African youth can contribute to obtain and classify locally representative samples with which to train these algorithms.

**Community participation and feedback is key to mapping informal and unplanned areas.** Many features pertinent to urban service delivery and urban risk profiles—such as status of waste management, status of water provision, health and education services, condition of drainage networks, frequency of river flooding, stability of slopes and embankments—are a challenge for city government to monitor but well-known to ward level leaders and communities. Participatory mapping methodologies such as Ramani Huria[8] (the Open Map) have shown how community knowledge can be digitized and maintained using free online tools such as OpenStreetMap. Involving community members also supports their understanding of both the value of their assets, and local risks, underlining the importance of having these features mapped for their protection, and for the development of more effective disaster risk management solutions. Improvements in both the accuracy of handheld tools (often consumer mobile phones) as well as quality control methods have demonstrated increasing quality of datasets collected in comparison with traditional engineering consultancies—and at much lower costs.

**Producing and updating information needed for governments and communities to improve urban resilience requires building local skills and service providers, and provides an opportunity for income generation.** Working with trained locals for data collection (and attribute identification) has the potential to rapidly and efficiently produce vast amounts of information needed for disaster and climate risk management, as well as infrastructure and service provision decision making. A holistic approach is needed to organize the demand for input data and information with the supply of information production services, and appropriate quality assurance. It provides an opportunity to build digital skills and create income-generating opportunities for different skill levels in both the private and public sectors. These opportunities range from simple microtasks that can be done at scale (i.e. identification of features in pictures, collection of points of interests with mobile phone) and can provide supplemental income, to more sophisticated tasks such as data quality control, spatial analyses of services, and risk assessments, which develop professional skills required for more sustainable job opportunities.

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5 Hamed Alemohammad, 2020. Regional Training Data are Essential for Building Accurate Machine Learning Models. Medium
6 Maxar, 2020. Building Footprints: Precision, GIS-ready polygons for expedited analysis
7 Deepglobe, 2018. Deepglobe Satellite Challenge
8 Ramani Huria is the world's largest community mapping exercise, in Dar es Salaam, Tanzania, focussed on urban flood risks. http://ramanihuria.org/

## COVID-19 heightened the needs for data and jobs in poor urban areas

**COVID-19 is threatening cities and communities across the globe in an unprecedented way, impacting not only public health but also the economy and social fabric with significant job losses and impacts on livelihoods.** While COVID-19 might not be as fatal as previous epidemics such as SARS, Ebola, and MERS, its transmission rate is much higher, which poses a greater challenge to dense urban areas in the world, especially those with poor infrastructure and service delivery systems. Besides its impact on public health, the COVID-19 epidemic is generating multifaceted, and likely prolonged economic impacts, ranging from disrupted global supply chains to bankrupted small businesses, with significant job losses and impacts on livelihoods of people everywhere, and especially informal sector workers and those with irregular earnings and unstable jobs that have fewer safety nets to weather the crisis.

**Setting up effective emergency response and recovery actions to the COVID-19 crisis requires up to date digital data on health infrastructure, urban density, sanitation and solid waste management services amongst other urban services.** It is shown that countries with well-functioning Data Infrastructure (e.g. Singapore and South Korea) perform better in infection controls. Innovative tools can effectively support cities to identify hotspots of disease transmission in cities. Available geospatial tools using technologies such as satellite remote sensing, drones, and artificial intelligence, can help assess overall accessibility to urban health services, infrastructure and amenities, and the location of hospitals and clinics vis-à-vis specific vulnerable groups. Areas of heightened risk for disease transmission due to the intersection of population density and the (absence) of infrastructure and services can also be assessed across cities for which data exists to predict areas of potential rapid spread of contagion. Applying such strategies in data-poor cities calls for greater investments in geospatial data and analytics and smart urban governance systems.

**Innovative geospatial data collection and gig economy workflows can be used to provide earning opportunities despite the mobility restrictions put in place to stop the spread of COVID-19.** Complex data collection processes can be broken down into small tasks that can be conducted remotely using smart phones or computers, or, in the field with mobiles. Such tasks include simple image classification tasks, filling in complex forms for field data collection, or data conflation tasks. For each completed task, participants get small earnings through mobile payments, while acquiring digital and soft skills along the way. This approach is known as microtasking and can be used to create a variety of digital data, for instance the inspection of sampled satellite imagery to identify built-up areas, or tagging specific types of infrastructure or features in street-view pictures. The increased adoption of microtasking has also been driven by the huge demand for data inputs from the machine learning industry (for instance for self driving cars) as it can be utilized to perform large scale training and validation of machine learning algorithms[9].

[9] Financial Time: AI's new workforce: the data-labelling industry spreads globally

> The COVID-19 pandemic highlights the need to **utilize low-cost disruptive technology** to create the information required to manage and recover from the crisis, while simultaneously **providing skills development and earning opportunities**.

# DIGITAL WORKS PROGRAM FOR AFRICAN URBAN YOUTH

## OBJECTIVES

Building on the success of the Resilience Academy[10] and Open Cities[11] programs, the objective of this pilot study is to explore the feasibility of establishing a Digital Works for Urban Resilience Program, targeting local populations who have been impacted by COVID-19 restrictions. Program activities will:

1. create high quality geographic data (of the built environment and critical infrastructure) that will be used to inform future urban planning, disaster risk reduction, and emergency response efforts
2. create a social safety net in the form of short term income-generating activities for Africa's vulnerable youth, and
3. possibly, for a subset of the youth who prove to be digitally savvy, lead to medium-term employment by providing learning opportunities on valuable digital skills and geospatial technology.

The activities presented here have started to explore the following dimensions:

1. Can task based digital microwork be a viable source of supplemental income for unemployed youth?
2. Can both entry level (low skilled) workers, and university educated persons participate alike? Though advantageous, previous technical experience is not required, and participation in digital tasking could be a viable first step in developing more advanced digital skills, that when linked to micro-credentialing could lead to future work prospects.
3. Does a microtasking approach to the generation of basic mapping data offer scaling and efficiency opportunities when compared to the traditional hiring model of geospatial firms; one that relies on teams of professionally trained staff?
4. Can this approach generate data of sufficient quality to inform urban development investment planning and policy making?
5. Is the volume of tasks available from the public sector (and potentially private sector) sufficient to create a viable supply of tasks for workers? To what level?
6. What are the mechanics and costs of engaging local populations through microtasking through existing commercial platforms as well as custom open-source ones? Particularly in terms of targeting and hiring, mobile payment, skill evaluation, and quality control?

To quickly start investigating those questions, several rapid pilot projects were carried out to develop, test, and adapt data creation workflows that could feasibly generate safe and/or remote employment opportunities for African youth and contribute information on urban development in African cities. The Program compared established commercial platforms with customized open source platforms and the feasibility and practicality of different engagement mechanisms for a variety of tasks.



[10] https://www.worldbank.org/en/news/video/2019/10/30/resilience-academy-education-for-improved-urban-resilience
[11] https://opencitiesproject.org/

## PILOT COMPONENTS

Each pilot featured 3 components: (A) Digital Tasking; (B) Engagement Management (for outreach, quality control and payment); and (C) Skill Development.

### A. Digital Tasking

**Following microtasking approaches, the Digital Works Program for African Youth is collaborating closely with World Bank task teams to identify data that can be arranged in digital tasks that respond to operational needs and inform resilient urban development.** For instance, by remotely identifying the geographic extents and characteristics of built-up areas, and using multiple rounds of tasking to monitor urban development and services over time. Field-based workers can identify specific Points of Interest (POIs) in informal settlements, such as essential services, markets, and green spaces. Digital tasks can also support disaster risk assessment by obtaining data on hazards, exposure, and vulnerability. For example, infrastructural features can be collected for exposure mapping and flood risk management, drainage features can be mapped to support flood models, and street-view images can be analyzed to document damage in post-disaster analyses and hazard mapping. Note that for all applications, the microtasks can either directly provide the data needed or can be used to create or validate artificial intelligence algorithms that are developed to provide the data needed. **Each "Digital Task" contains a bundle of activities designed to fill a sector-specific data gap**, and many are modeled after tested and proven data collection methodologies from across the tech for development space.

**FIGURE 1** Microtasking, micro-learning, and mobile payment workflows


**One of the most significant impacts of the COVID-19 pandemic is the loss of employment.** This is particularly true for informal sector workers and those with irregular earnings and unstable jobs. The mobility restrictions in place during the pandemic response period precludes traditional recruitment and training opportunities, therefore the use of mobile based digital platforms to perform simple digital-tasks-for-cash is a novel way to employ new recruits in the digital mapping workflow. Within this model, tasks can range from low skill options (such as simple feature recognition from images or photographs), to high skilled options (such as mapping geographic features from satellite or drone imagery) - to suit the prior experience, training, and digital resources of the recruits. Typical remote and field based task types are outlined below:

**Remote tasks** can be performed anywhere, therefore this workflow is more suited to the current mobility restricted stage of the COVID-19 response.

1. Low Skill (mobile app based work):
   a. Classification of street view image/photograph (street-sign, street light, shop)
   b. Classification/validation of satellite/drone images (building footprint, road, forest)
2. High Skill (Desktop computer based work)
   a. Outlining features such as public infrastructure and their condition on street view images using mapping tools
   b. Outlining geographic features from satellite/drone images using mapping tools for image segmentation (roads, buildings etc)
   c. Validation/Consolidation/Quality


Analysis and Quality Control of existing mapped data or AI generated tools. With R&D on specific workflows, it can be made accessible to any skill.

d. Data analysis using the generated datasets to provide insights to practitioners and decision makers

**Field based Tasks** are only appropriate where local public health guidelines permit, and where socially distanced field work can be conducted safely.

1. Low Skill (mobile app based work, only in-app training required):
   a. Collect simple information about a location (e.g. pictures, building name, function, state, operating hours, etc)
   b. Collect new street view imagery data
2. High Skill (some training/prior experience required, either face-to-face, or webinar):
   a. Collect detailed information about geographic features that require specific knowledge (e.g. building condition, construction materials, drainage features etc.)

As part of the research and design element of this program, the team went through a comprehensive effort to inventory the sectors (urban monitoring, disaster risk management, transport, solid waste management, health, ecosystem monitoring, emergency response etc.) and the type of data within each sector where the approach can be applied. The workflow to collect these datasets can be effectively broken in a series of microtasks through a number of technical steps:

**Identify how the data needs can be broken down into microtasks.** The overall operational data need should be broken into remote tasks or field based tasks, and skill level. For example, if the data need is to obtain an updated exposure map, the microtasks may consist of delineating building footprints in satellite imagery for a city block. Initial examples of sectors, tasks, framework for task description are provided in Appendix 2.

**Choose a suitable platform / tool to manage the microtasks** based on the type of task (remote vs field based and low skill vs high skill) required. One can select an existing commercial platform or tool or opt for a custom app development. Some examples of existing commercial platforms are: Google Task Mate, Native.io, CloudFactory, Premise, Digital Divide Data, SamaSource, Avala, and Amazon Mechanical Turk. The platforms differ regarding the countries they operate in, how workers are paid, the use of laptops or mobile phones to conduct the work, the geographic region or socio-economic characteristics of the workers, the processes to perform quality control, etc. Most platforms are set-up with a number of standard tasks such as identifying objects in imagery, answering questionnaires, or collecting GPS locations in the field. These standard tasks require certain forms of data input and provide standardized outputs.

Some operational data needs may not fit into these standard tasks and will require back-end customizations or even the development of a custom application to define the microtasking. Such customizations give more freedom in the design of the microtask but require more time and financial resources. More comparisons between commercial and custom platforms are discussed in the section on pilot outcomes and learnings below.

**Define the data quality control mechanism.** Microtasking workflows generally request multiple users to conduct the same task and/or to have a quality control step which can also be a microtask. Redundancy provides a measure of data quality control. Some workflows ask one worker to perform a microtask and then asks other workers to **validate the first worker's submission**. Other platforms ask multiple workers to perform a single microtask and then use the **consistency between the answers** as a measure of data quality. Tasks are generally repeated by 3 to 10 workers where higher repetition provides a higher confidence of data quality, but also increases data collection costs. Task redundancy and consistency should be checked throughout the data collection process as they provide immediate feedback on possible issues with the workflow or with workers and help flag difficult tasks or unclear instructions.

Completing these steps results in the technical set-up of the data workflow and microtasking platform. The next components of the work program consist of defining an engagement manager and facilitating skill development.

## B. Engagement Management for outreaching, ensuring quality and payment

To deploy the activities, the program worked with firms to serve as engagement managers. These firms have extensive in-country experience and serve as an interface between the workers and the technical partner. Their main tasks were to: **recruit workers, manage payments, conduct training, monitor and ensure quality of the data output, and provide feedback on the experiences of the workers.**

**FIGURE 2** Role of Engagement Managers


Worker recruitment and outreach was first conducted by mobilizing existing networks. The World Bank has working relationships with organizations and projects including: the Open Cities Africa network, OSM Africa Network, Slum Dwellers International, Existing African Data Science Network, Existing Jokko Labs network/ Digital Africa, Humanitarian OpenStreetMap Team, and Youthmappers. The engagement partner then helped in the selection of workers and ensured that any accessibility concerns (access to computers, smart phones, data bundles) were resolved. All pilots strived for an equal balance between male and female workers. The engagement partner may also target specific demographic groups such as students, home-makers, unemployed, and residents of disadvantaged areas. High-skill tasks could include digital or geo-spatial skills as a selection criterion.

**The engagement manager also advised the technical partner on appropriate compensation rates for the digital tasks.** Most payment schemes were based on a combination of the number of tasks completed, and having these tasks successfully pass a data quality mechanism;while other payment schemes were based solely on fixed hourly rates,or, the number of tasks completed (not both). Typically, the technical partner would provide metrics on worker activity and performance quality, while the payment was conducted by the engagement managers. Microtasking platforms that allow for direct payments to workers through mobile payment platforms12 are ideal, but mobile payment systems and related rules are still highly dependent on the country context and Africa lacks a single dependable micro-payment system, although FinTech innovations are progressing rapidly. The plausibility of mobile money options was therefore investigated on a case-by-case basis.

**Once a pilot project was started, both the technical partners and engagement managers were involved in training the workers.** The engagement managers then continued to manage the workers to ensure output quality and fraud mitigation. The engagement manager provided troubleshooting support on smaller issues and served as an interface between workers and the technical partners. At the end of the pilot, the engagement manager solicited and consolidated workers' feedback on the pilot, skills learned, and platform satisfaction through questionnaires.

Note that in some cases, an engagement manager was not hired separately; the technical partner performed the outreach and recruitment through their platform. More differences between pilots using local engagement managers and commercial platforms with integrated engagement management are discussed below in the section on pilot outcomes.

## C. Skill Development

The skill development component focused primarily on the development of **basic digital skills** (app installation, clicking, swiping, data entry, messaging and communication, taking digital pictures) and introductory **geospatial skills** (imagery interpretation, feature identification, GPS, geolocalisation), but also a sensitization to **broader concepts** such as urban planning, solid waste management, and flooding as well as development of **soft skills** such as time management.

Skill development in the pilot phase was facilitated online (primarily) by the respective engagement managers.

**Basic Skill Development:** Tutorials embedded in the platforms covered the technical aspects of app navigation and operation. Workers learned how to conduct the task; which answers were acceptable, and which were not, as well as clarifying why. Several of the microtasking platforms were quite similar and therefore the digital skills

[12] https://qz.com/africa/1721818/africa-mobile-money-industry-is-entering-its-next-stage-of-growth/

gained from one platform were somewhat transferable to other platforms. Examples of tasks that develop basic geospatial skills are:

- Tagging built up areas in satellite imagery: workers were shown a fragment of satellite imagery and asked to determine whether the area was built-up or not. Training covered navigation of the app itself (clicking, swiping and task progression), and introduction to basic imagery interpretation with regard to what constituted a "built-up" area. This training was delivered through in-app videos.

- Identifying building height in street view images: workers were required to identify the highest building in a street-level image, noting the number of floors. Training began with a webinar covering the project objective and the use for the data collected, while the application itself contained a tutorial on app navigation, and an active WhatsApp group which enabled workers to ask questions and receive feedback.

**High level Skill Development:** High-skill tasks required more advanced training. For example, one might need to learn skills in usage of desktop geospatial software. For these tasks, online classes and webinars were conducted and there was more interaction between the engagement managers and the workers. As a result, the worker gained more advanced digital skills which are more transferable to other geospatial platforms. Examples of high level skill development include:

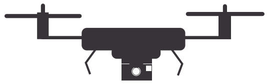
- Mapping tree canopies in satellite imagery: participating students and their technical advisors were trained in a face-to-face virtual session by Azavea staff on identification and digitization of tree canopy from satellite imagery within GroundWork, Azavea's geospatial annotation application. This was followed up with weekly calls to address technical issues and labelling edge cases. Training materials were shared, and examples of best practices in labelling, and new and unique edge cases were added periodically.

- Conflating OSM data: For Part 1, participating mappers were trained on the Java OpenStreetMap Editor (JOSM) (an advanced desktop mapping software); the HOT tasking manager, and for communication, training and project coordination: Zoom, Whatsapp and Google Suite. For Part 2, mappers participated in a Training module entitled: "Using Map With AI for building conflation". This module introduced the participants to the Map With AI tool which leverages Artificial Intelligence to simplify data conflation processes.

In the long-term, the Digital Works Program for African Youth aims to make use of micro-credentialing systems where the participant will follow short modules and take a short test to demonstrate proficiency in the subject matter covered. A micro-credential, or badge will be awarded for the successful completion of each module. Series of badges can be grouped to create micro-certifications. These badges can be posted to social media and platforms that focus on professional networking and career development, such as LinkedIn.

*Once a pilot project was started, both the technical and engagement partners were involved in training the workers. The engagement partners then continued to manage the workers by monitoring metrics on the quality of data inputs and worker activity to ensure the outputs were provided and mitigate fraud.*

# PILOT ACTIVITIES



*This first phase of the Digital Works for Urban Resilience Program consisted of seven individual rapid pilot activities (see table below for an overview), designed to develop, test and adapt data creation workflows that could feasibly generate safe and/or remote based employment opportunities for targeted African youth.*

Each pilot was based on a specific Bank Operational data need, had a technical partner to define tasks, workflow and toolchains, and an engagement manager to manage the hiring, payment, and quality control of the work. Each pilot considered different types of tasks (both low and high skilled remote tasks, and one field task), tools and platforms (large established microtasking platform, custom tools adapted to the workflow, and traditional work center), and targeted participants (students, WB project beneficiaries). In each pilot, monitoring of output quality, mobile money payment options, and other aspects of potential workflow scaling were explored. For most pilots, payments were handled by the engagement manager hired to work with each technical partner to: populate tasks, perform outreach, hire participants, monitor the output and handle payments. Two exceptions were Task Mate by Google (beta) and Native who as established microtasking platforms had access to their own workforces. Individual daily rates for cash-for-work recipients depended on local markets, complexity of the tasks, and average time to complete a tasks, and adequate remuneration was determined together with the local engagement manager in each case[13]. More details on each of the pilots is provided in Appendix 2.

**TABLE 1** **Overview of the seven pilot activities of the first phase of the Digital Works for Urban Resilience Program.**

| No. | Name | Technical Partner | Engagement Manager | Skill Level | Task Location/ Device | Data Product Coverage | Workers Located |
|---|---|---|---|---|---|---|---|
| 1. | BUILT UP AREA TAGGING | Task Mate by Google (beta) | – | Low | Remote/Mobile Device | Global | Kenya (multiple cities) |
| 2. | GEOLOCATING SLUM URBAN SERVICES | Native | – | Low | Field/Mobile Device | Nairobi, Kenya | Nairobi, Kenya |
| 3. | STREETVIEW PREDICTION VERIFICATION, AND STREETVIEW IMAGE VALIDATION | Spatial Collective Mapillary | Spatial Collective | Low to Medium | Remote/Desktop Computer | Zanzibar, Tanzania | Zanzibar, Tanzania and Nairobi Kenya |
| 4. | BUILDING HEIGHT VALIDATION | MindEarth | Resilience Academy and Studio 19 | Low | Remote/Mobile Device | Global | Dar es Salaam, Tanzania |
| 5. | CLASSIFYING AERIAL IMAGERY TO IDENTIFY SOLID WASTE | MapSwipe | HOT | Low | Remote/Mobile Device | Bamako, Mali | Bamako, Mali |
| 6. | REMOTE CANOPY DETECTION | Azavea/ CloudFactory | Resilience Academy/ OpenMap Development Tanzania | Medium to High | Remote/Desktop Computer | Freetown, Sierra Leone, and Dar es Salaam, Tanzania) | Dar es Salaam, Tanzania |
| 7. | ZANZIBAR BUILDING CONFLATION TO INTEGRATE IN OPENSTREETMAP DATABASE | Spatial Collective Facebook ESRI | Spatial Collective | Medium to High | Remote/Desktop Computer | Zanzibar, Tanzania | Zanzibar, Tanzania |

[13] For instance; for Tanzanian student interns the stipend is between $5 and $10 per day per student for a maximum of 2 hours work, or, between $25,000 and $50,000 USD for 100 students for 10 weeks. For full-time employees working on AI labelling, it is roughly $500 per month per employee.

The pilots served Bank operational data needs by validating global datasets generated by artificial intelligence and by collecting new data through local communities. Pilots 1 and 4 served to validate global datasets on urbanization dynamics which were produced through artificial intelligence and earth observation methods by the German Aerospace Agency (DLR). The microtasking pilots enabled the validation of hundreds of thousands of data points. This scope and depth of validation by local youth is unprecedented and provides crucial information regarding the validity of the artificial intelligence algorithm and utility of the datasets to African Cities and Bank Operations. Similarly, Pilot 7 used the workers to validate and possibly correct buildings identified by artificial intelligence algorithms before uploading the results to OpenStreetMap. The data collected through Pilots 4, 5, and 7 served to provide training data to develop new artificial intelligence algorithms. Pilots 1, 2, 3 and 5 are examples of micro tasks that involved local communities to provide information on local assets that can be used directly for urban planning, disaster risk management, and emergency response. In summary, the pilots responded to the World Bank and its client data demands by providing information on local community assets and exposure and/or by responding to the high data requirements for the creation and validation of artificial intelligence algorithms.

## PILOT METRICS: A QUICK SNAPSHOT

The project outcomes were overwhelmingly positive in terms of data collected, methods tested, and workers engaged. An overview of key metrics, and a summary of key findings are outlined below in terms of Training and Skills, Benefits, Challenges, and Lessons Learned. It is important to note that the total cost includes all overhead cost, mobile payment fees, software development costs, etc.

There was some variation in the time required to complete the pilots. The preparation could be as fast as 1-2 weeks after hiring the firms if using an existing platform and/or workers are already available. This phase could take as long as 1-2 months for pilots requiring specific platform modifications or targeted recruiting. After recruitment, workers needed to complete a training (1 day-1 week) after which the data collection could start. The time required to complete the data collection depended on the number of workers and number of tasks to be completed.

Organizations implementing the pilots were requested to complete a digital worker engagement survey. This provided an overview of the worker demographics, available digital tools and internet, satisfaction with the training and salary, and the impact of the pilot on their skills and future employment opportunities (see Appendix 1, section F for a complete list of survey questions). Over all the pilots, 45% of the workforce were women. Workers came from various backgrounds with some pilots focusing on hiring ongoing students from the university, others recent graduates without a job, and others from the general population with no prior knowledge of the tools. Their age ranged from 18 to early 50's with the bulk being between 20 and 35. All pilots target workers in Africa and in most cases workers were from the same cities or neighborhoods represented in the data.

**PEOPLE HIRED**
**1,333**

**WORKERS PAYMENTS**
**$66,813**

**NUMBER OF TASKS**
**2,850,395**

**OVERALL COST**
**$275K**

## PILOT 1: BUILT UP AREA TAGGING WITH TASK MATE BY GOOGLE (BETA)

The aim of this pilot was to validate the World Settlement Footprint 2019 (WSF-2019), a large geospatial dataset generated with AI by the German Aerospace Center (DLR) which identifies built-up areas in 2019 at a global scale. The pilot was conducted with an early stage product of Task Mate (beta) as part of their own pilot stage. Task Mate is a microtasking platform under development at Google which offers registered users a range of tasks to perform both remote and field tasks in return for mobile money payments. In this case, digital workers were asked to identify specific land cover types and/or buildings from image samples to help with a broad classification of built or settled space in Kenya.

**NUMBER OF TASKS**
161,865

**TASK TYPE**
Remote work, low skilled

**GEOGRAPHY**
Kenya

**PEOPLE HIRED**
722
(412 female, 366 male)

**PLATFORM TYPE**
Commercial

**OPERATIONAL USE CASE**
Urban planning

**WORKER PAYMENTS**
$1,618

**WORKERS**
Students, homemakers, unemployed youth and retirees

**TOTAL COST**
$ [covered by Google]

**FIGURE 3** Screenshots from the Task Mate by Google (beta) app, illustrating task progression.

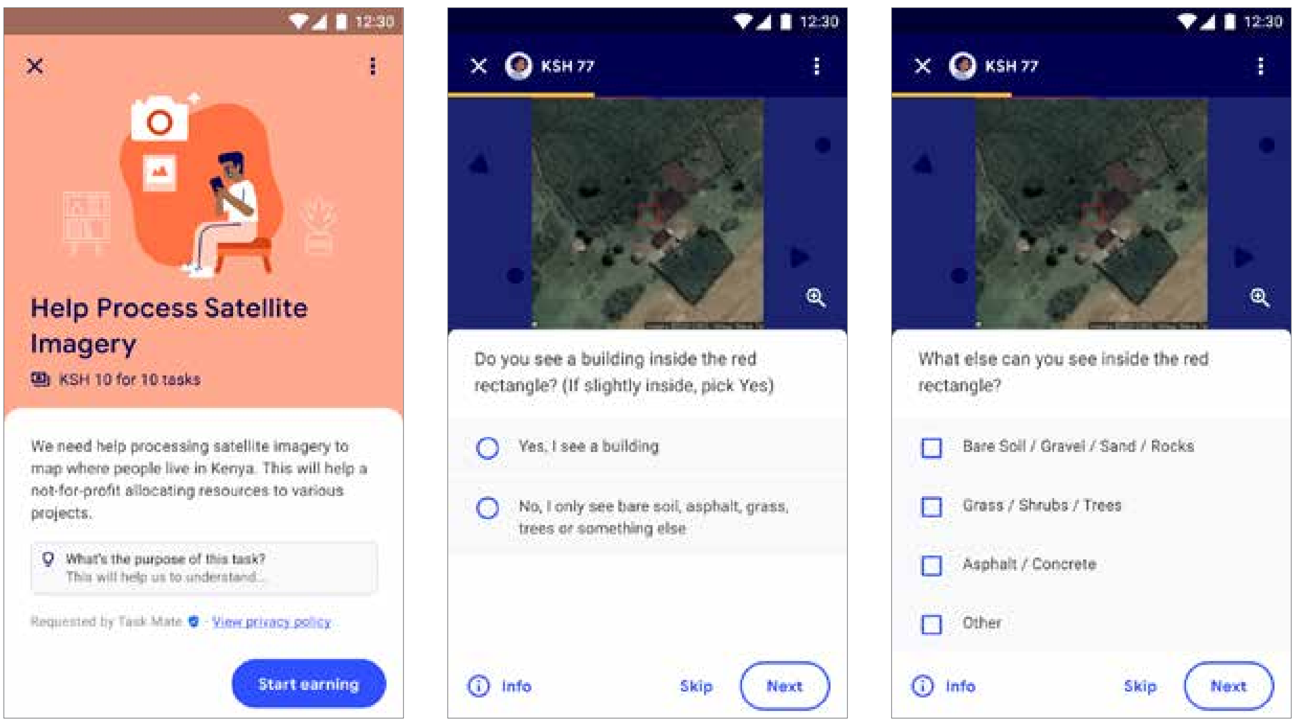
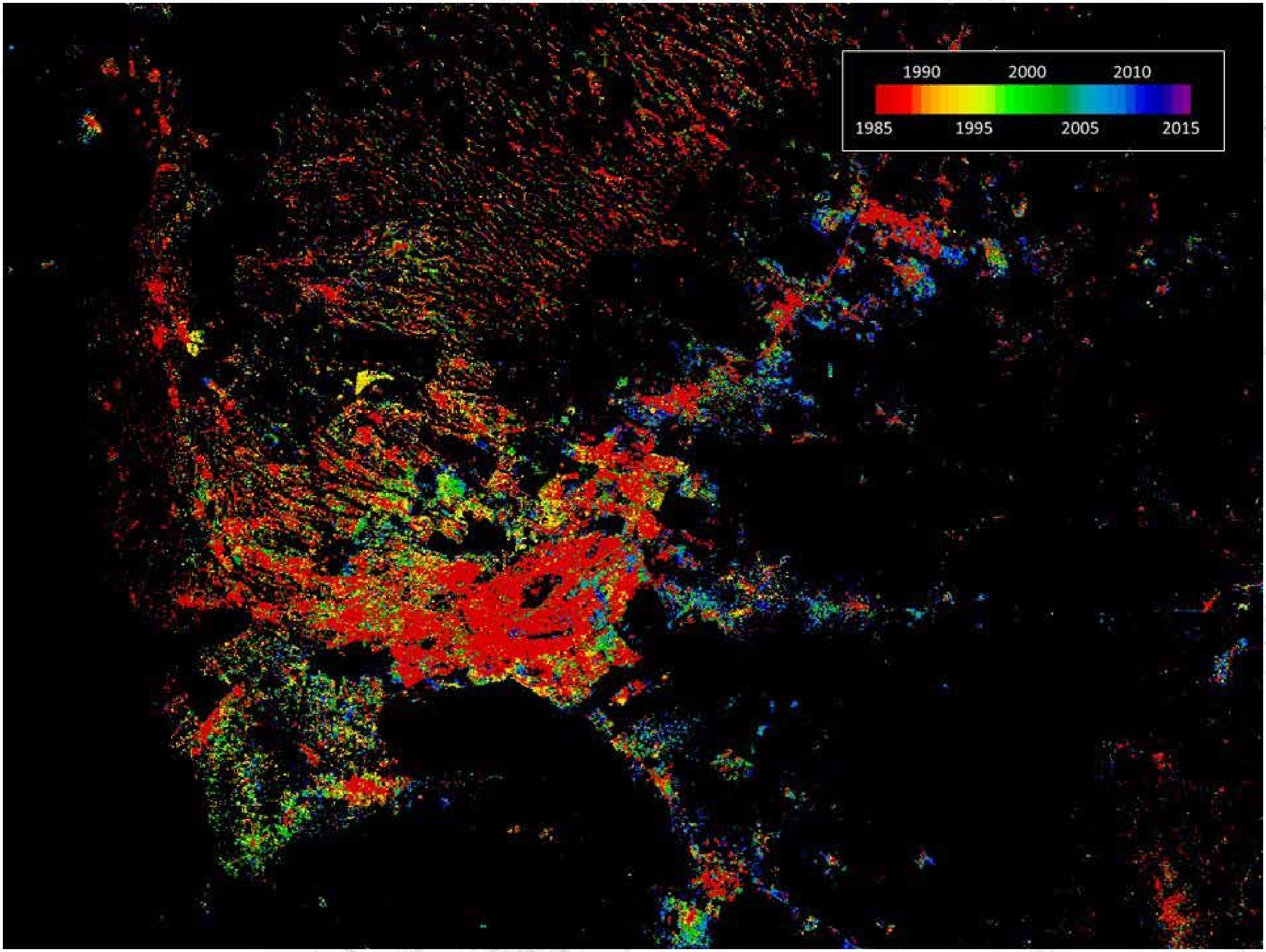


**FIGURE 4** The WSF-Evolution dataset for Nairobi where the color indicates the year in which that area was first urbanized. The accuracy of this dataset was validated through Pilot 1.



## PILOT 2: GEOLOCATING INFORMAL SETTLEMENT INFRASTRUCTURE WITH NATIVE

The main objective of this pilot was to develop and test a simple microtasking workflow to **collect data on urban services in informal settlements to better understand the location of potential COVID-19 hotspots as well as inform recovery**. The refined field data collection workflow could be scaled to other data collection themes, such as solid waste identification, green spaces, etc. This specific assignment was carried out in 8 neighborhoods across 4 cities in Kenya. Data collectors were hired through social media advertisements targeted geographically with the goal to have local residents participate. After receiving virtual training, local data collectors received push notifications of work opportunities, then travelled to designated areas to find and locate infrastructures and services. For each point of interest, depending on the type of services, they had to take a picture and enter specific characteristics relevant to the modelisation of COVID-19 hotspots and COVID-19 related services.


© NATIVE

**NUMBER OF TASKS**
**3,205**

**TASK TYPE**
**Field, low skilled**

**GEOGRAPHY**
**Kenya**

**PEOPLE HIRED**
**161**
**(38 female, 123 male)**

**PLATFORM TYPE**
**Commercial**

**OPERATIONAL USE CASE**
**Urban Services planning**

**WORKER PAYMENTS**
**$11,500**

**WORKERS**
**Youth targeted geographically**

**TOTAL COST**
**$ 50,000**

**FIGURE 5** The worker first selected a task, then find the relevant infrastructure to geolocate and characterize them.

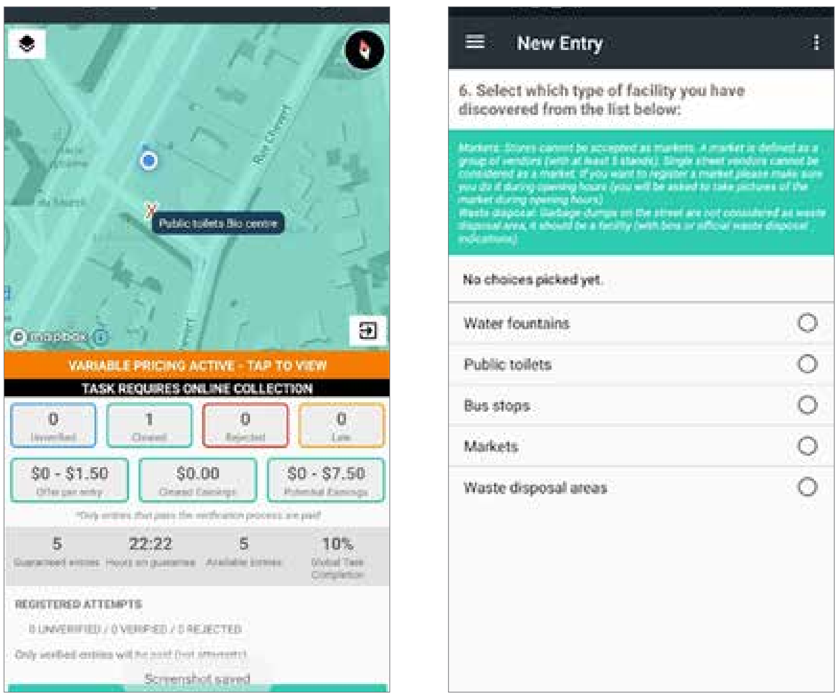
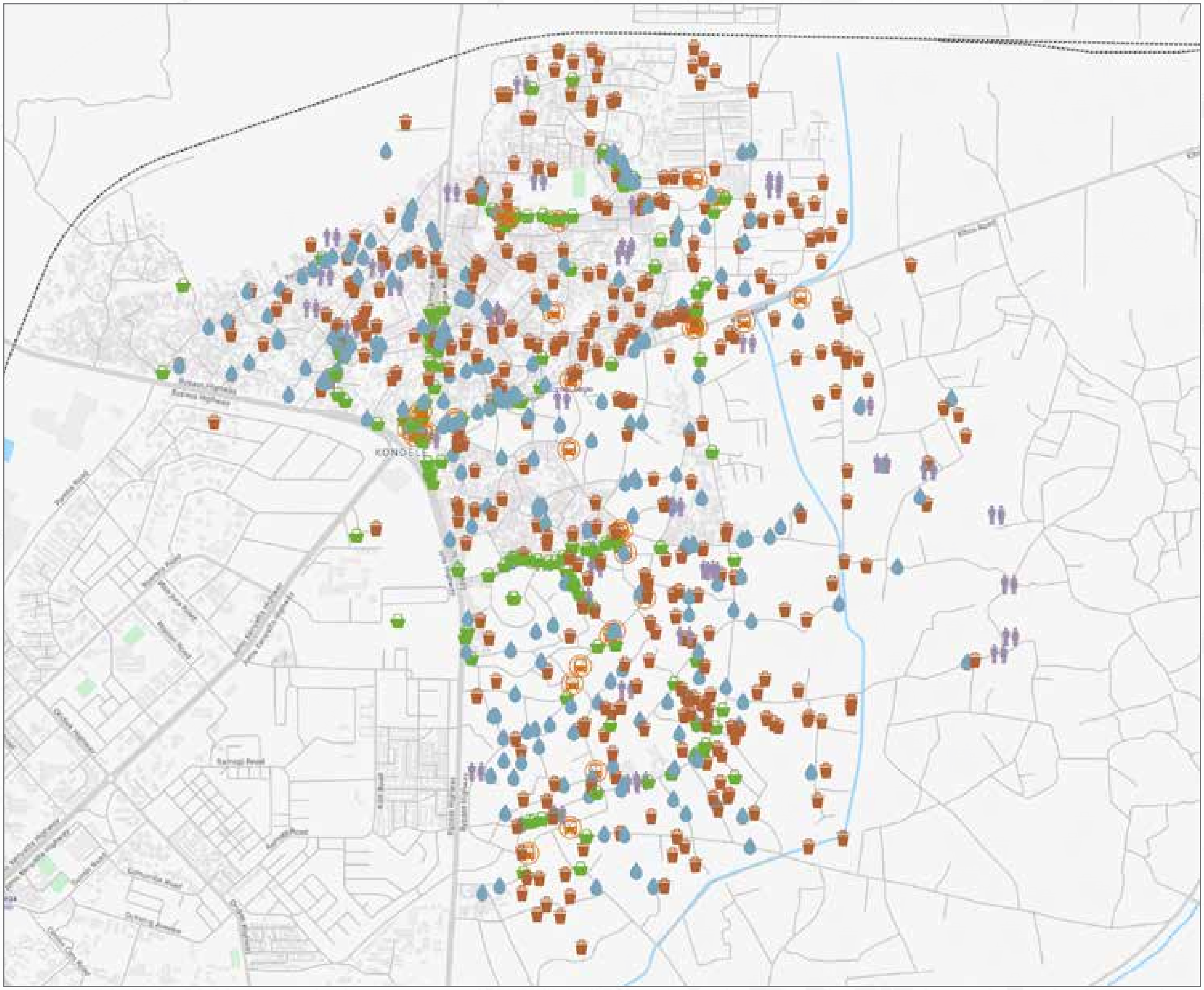


**FIGURE 6** **A map showing points of interest in the Manyatta slum (Kisumu, Kenya) which was generated from the data collected in Pilot 2.**




**Points of interest**

- Bus stops
- Markets
- Public toilets
- Waste disposal areas
- Water fountains

## PILOT 3: OBJECT DETECTION FROM STREET-LEVEL IMAGERY SPATIAL COLLECTIVE AND MAPILLARY

The goal of this pilot was to develop and test a simple microtasking workflow and associated tools for validating and mapping features automatically extracted from street view imagery. For this pilot, youth from informal settlements in Nairobi and unemployed recent graduates from Zanzibar developed a **comprehensive urban asset inventory from street-level imagery** including: manholes, trash cans, crosswalks, street lights, CCTV cameras, traffic lights, and store signages. Workers initially remotely verified Artificial Intelligence predictions over a large part of the island using their mobile phone; then in another more complex task they could add the predicted features to OpenStreetMap.

**NUMBER OF TASKS**
**703,000**

**TASK TYPE**
**Remote work, low and medium skilled**

**GEOGRAPHY**
**Zanzibar, Tanzania and Kenya**

**PEOPLE HIRED**
**85**
**(39 female, 46 male)**

**PLATFORM TYPE**
**Open Source, customized**

**OPERATIONAL USE CASE**
**Urban planning, transport connectivity**

**WORKER PAYMENTS**
**$9,500**
**(across 2 pilots)**

**WORKERS**
**Unemployed youth**

**TOTAL COST**
**$50,000**
**(across 2 pilots)**

**FIGURE 7** On the left an example of AI validation performed by the participants on their mobile phones; on the right, the tools using the validated prediction to enter them in the OpenStreetMap database.

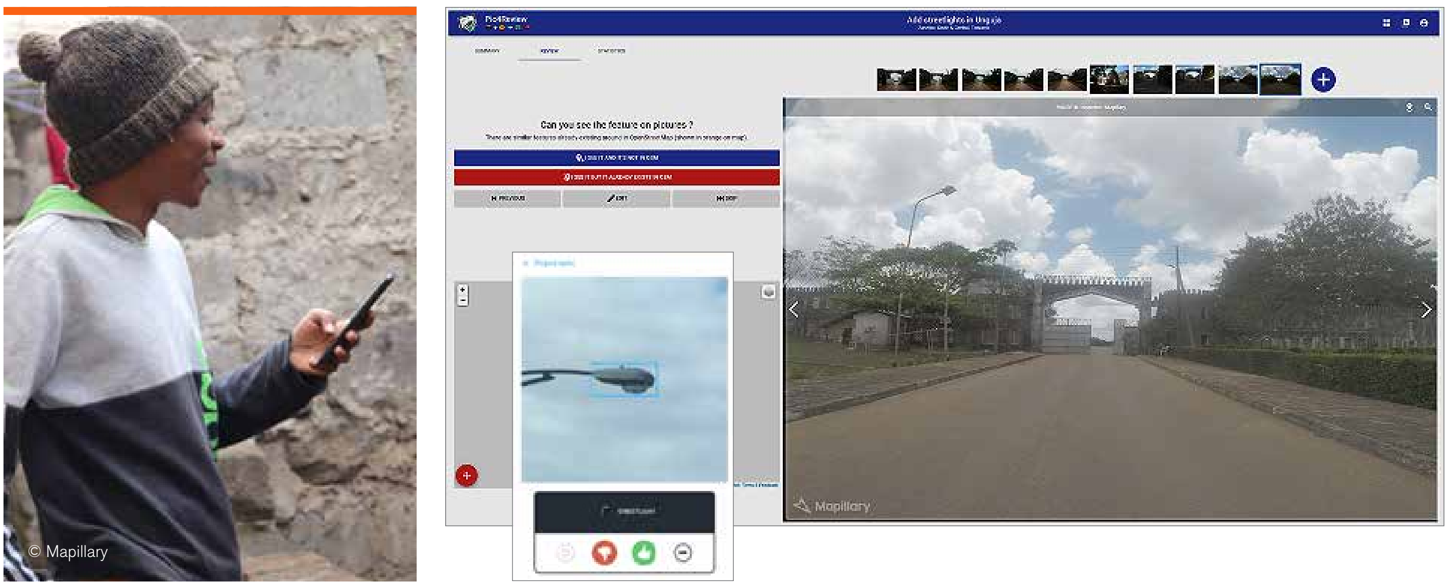
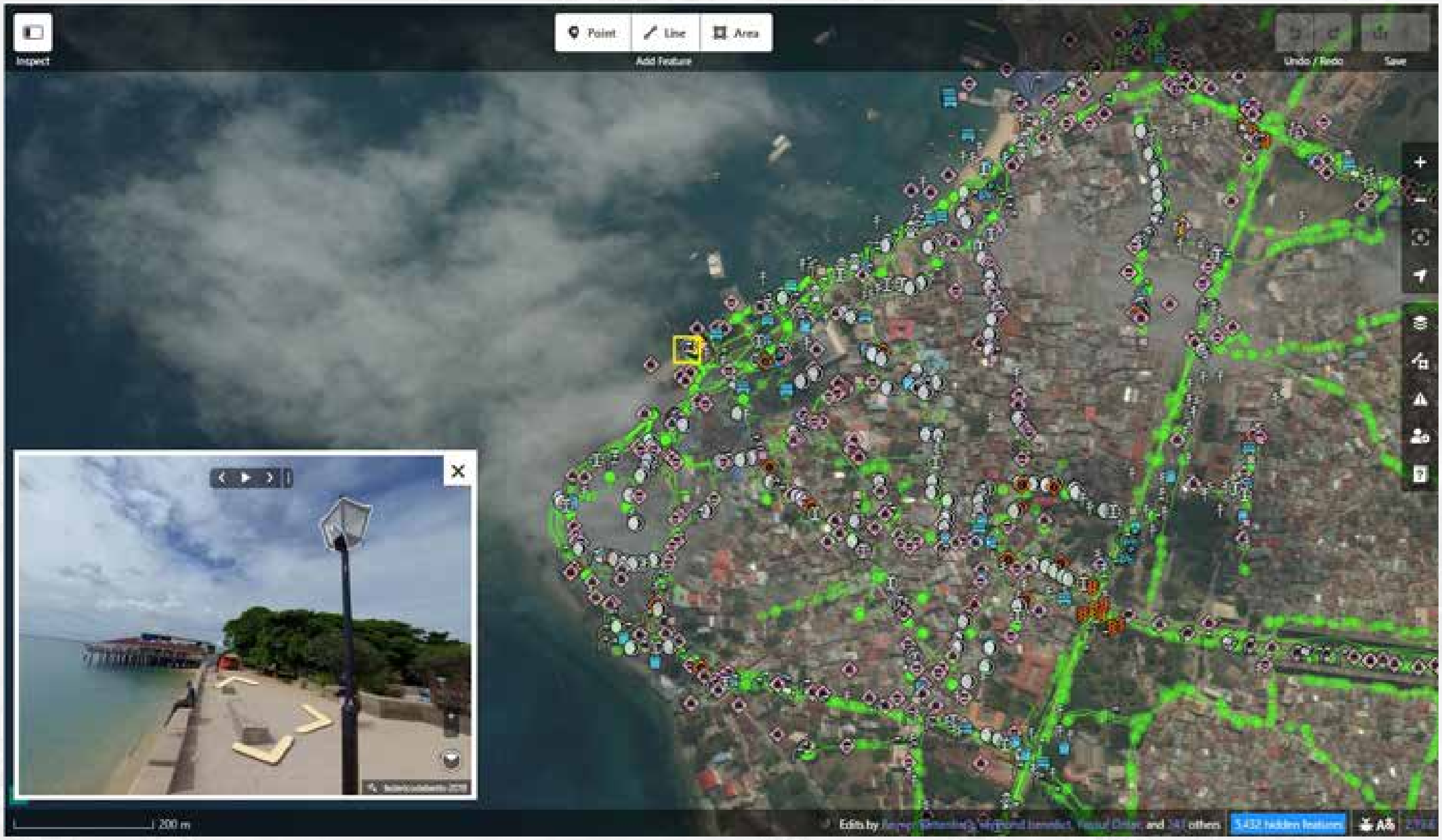
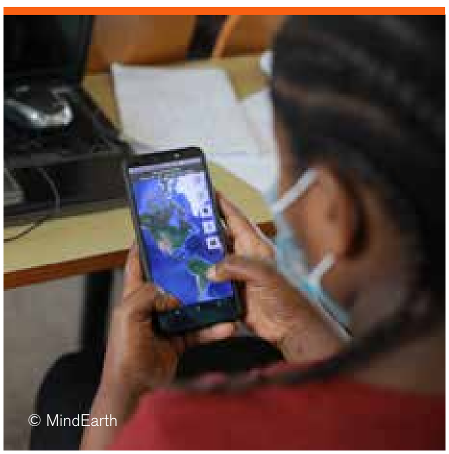


**FIGURE 8** **An overview of features mapped during Pilot 3. Green areas represent locations where street-level imagery was available and the icons show different features that were mapped. The inset image shows an example of a lamp post identified in a street-level image.**



## PILOT 4: BUILDING HEIGHT VALIDATION WITH MINDEARTH

The main objective of this pilot was to develop and test a simple microtasking workflow and associated tools to perform a rigorous validation of the World Settlement Footprint 3D (WSF-3D) by the German Space Agency (DLR) . WSF-3D is a global dataset which provides the estimated average built-up height of buildings at a spatial grid of 12m. Student workers from the Resilience Academy were shown streetview images and asked to click on the location of the highest building in the image, and to report the number of floors. This pilot was very successful. More than 159 000 points were labelled over the course of 18 days. The students were only allowed to work a maximum of two hours per day on workdays and a payment scheme was designed based on the total number of tasks completed, time spent on the labelling, and correctness of the results




**NUMBER OF TASKS**
159,490

**TASK TYPE**
Field, low skilled

**GEOGRAPHY**
Tanzania

**PEOPLE HIRED**
120
(54 female, 66 male)

**PLATFORM TYPE**
Open Source, customized

**OPERATIONAL USE CASE**
Urban planning

**WORKER PAYMENTS**
$18,666
(across 2 pilots)

**WORKERS**
Students

**TOTAL COST**
$58,865

**FIGURE 9** A visual overview of the MindEarth workflow, the worker selects the tallest building in the image (left), if this is not possible they should explain why (middle), and if it is possible then the worker identifies how many floors this tallest building has (right).

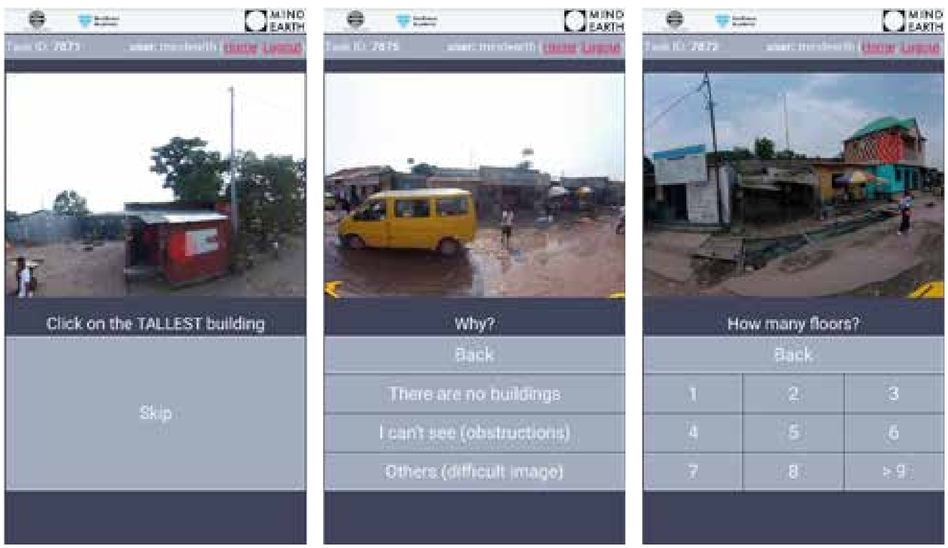
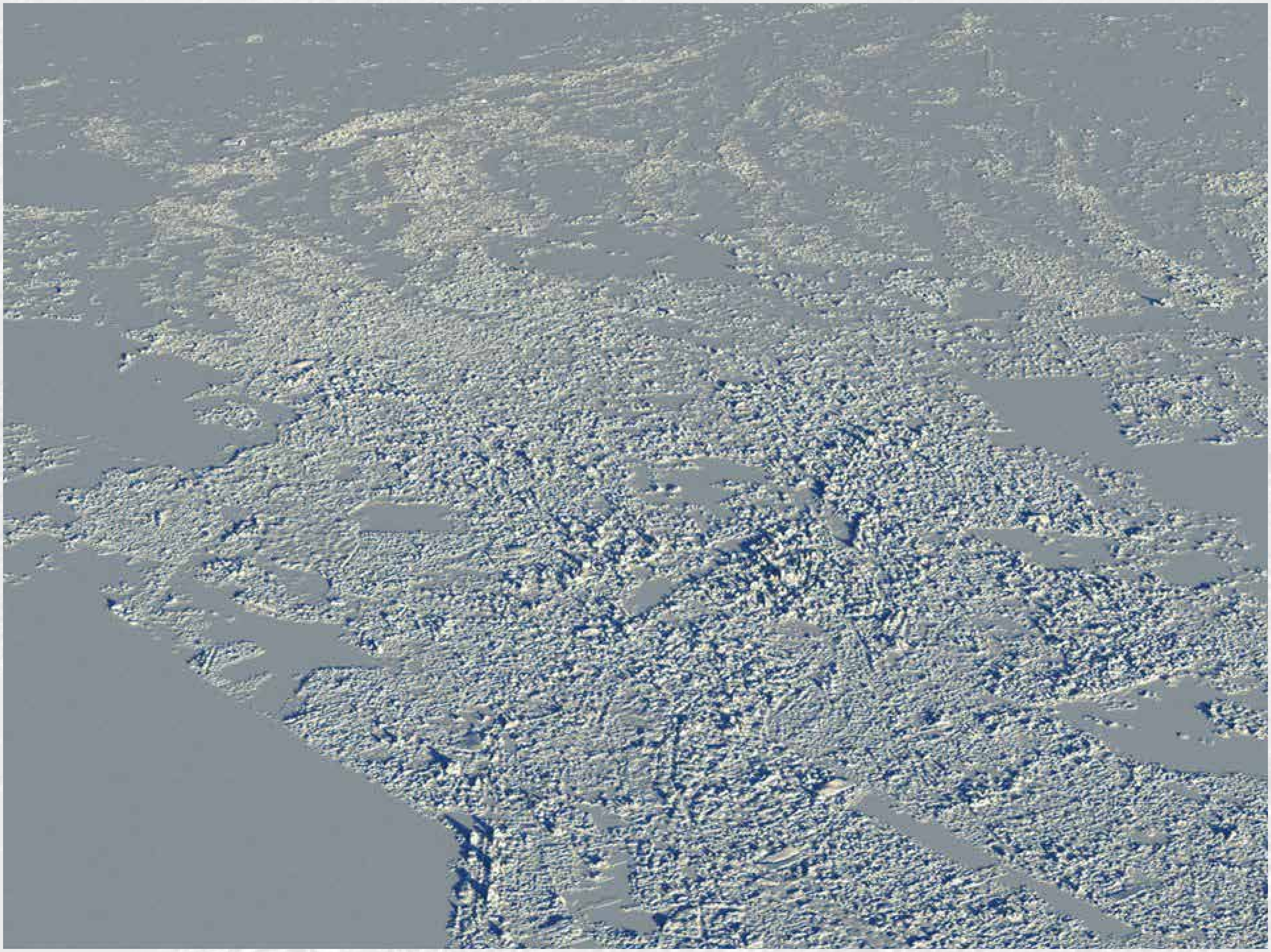


**FIGURE 10** An example of the WSF-3D dataset for Nairobi, which shows the estimated building height of African cities. The accuracy of this dataset has been validated through Pilot 4.



## PILOT 5: IDENTIFYING SOLID WASTE FROM IMAGERY WITH MAPSWIPE

MapSwipe is an open-source mobile app that empowers individuals to complete task based work that supports humanitarian and development work worldwide. The app has been designed specifically to handle satellite imagery and contribute to geospatial projects such as OpenStreetMap. In Bamako, solid waste is a large issue and information on where solid waste hotspots are is critical for future planning. As part of the Bamako Pilot Project, the MapSwipe team built on the existing app to enable youth within Bamako to swipe through satellite imagery, **identifying areas where solid waste sites are located**. Swipers would identify image cells where solid waste was visible, by tapping on the app. Each image was checked by 5 swipers for agreement. The pilot program (i) generated a high resolution map identifying all the solid waste points in Bamako, allowing future field mapping teams to travel to sites for further data collection; (ii) trained local mappers in Bamako on how to use MapSwipe and raised awareness on the solid waste challenges within their community; and (iii) created a cash for work opportunity for individuals whose livelihoods are affected by COVID-19, creating a safe, low-barrier entry for completing task-based work without needing to travel.

**NUMBER OF TASKS**
**1,331,154**

**TASK TYPE**
**Remote work, low skilled**

**GEOGRAPHY**
**Mali**

**PEOPLE HIRED**
**119**
**(53 female, 66 male)**

**PLATFORM TYPE**
**Open Source, customized**

**OPERATIONAL USE CASE**
**Solid waste management**

**WORKER PAYMENTS**
**$6,805**

**WORKERS**
**Students and unemployed youth**

**TOTAL COST**
**$68,343**

**FIGURE 11** Snapshots of the MapSwipe workflow. A tutorial explains to the worker what they should look for (left and middle) and a sample task (right).

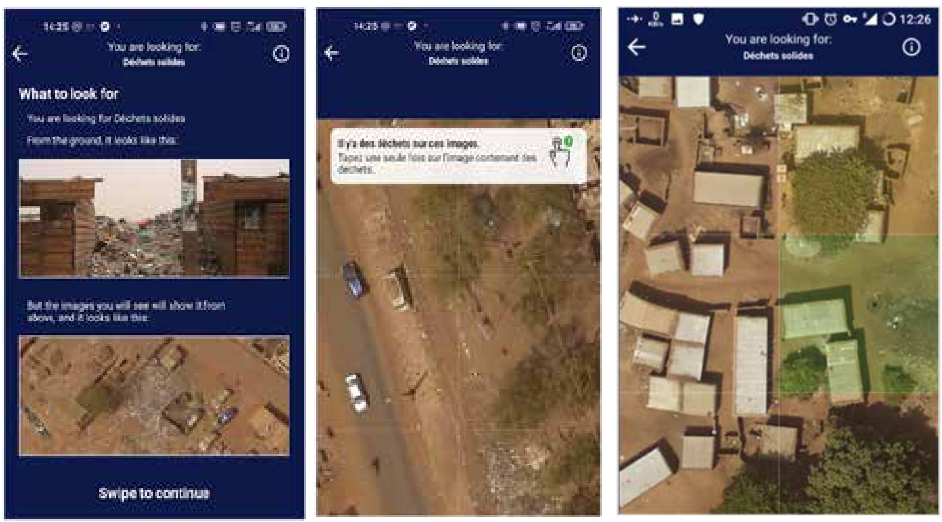
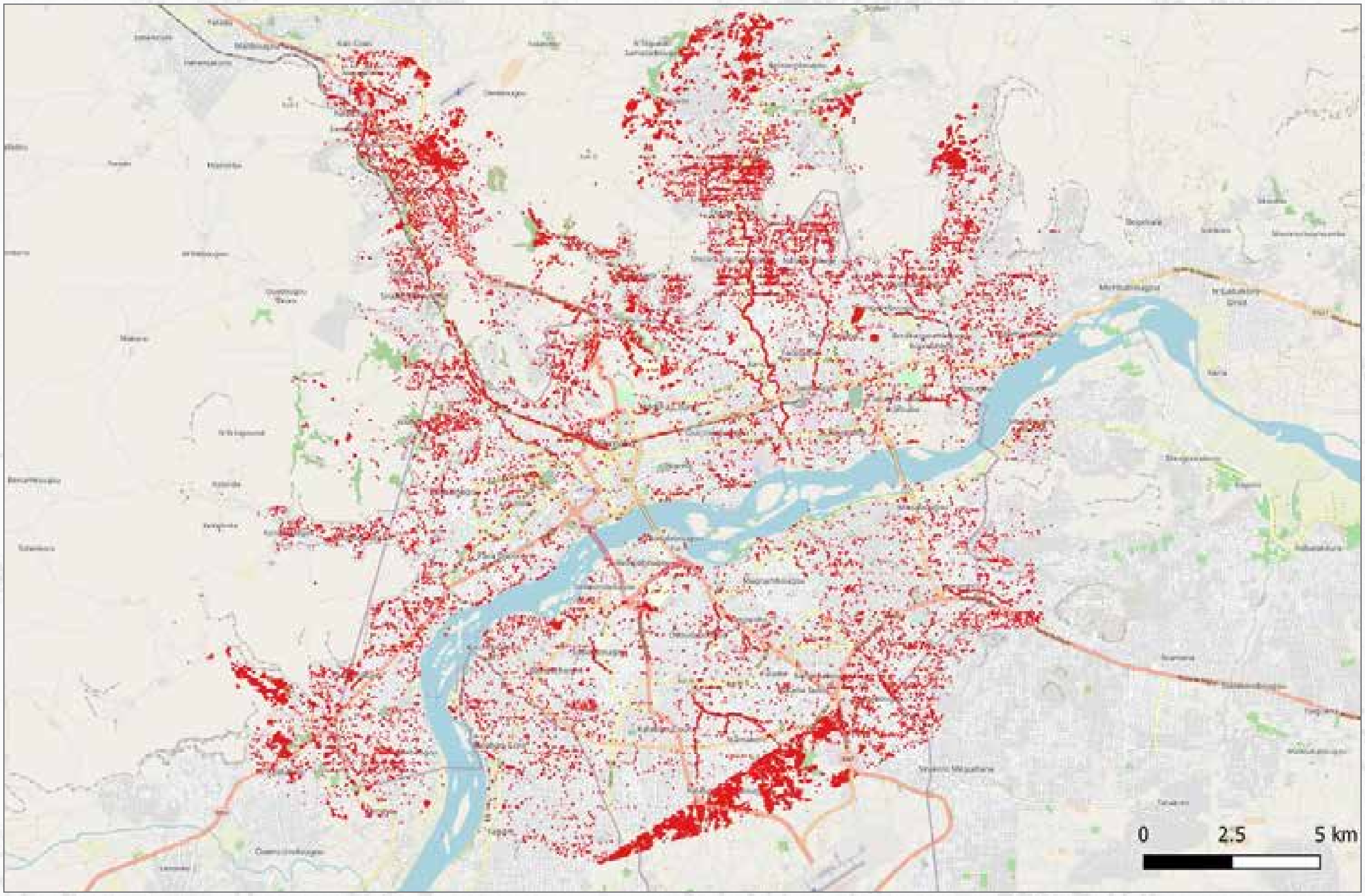


**FIGURE 12** A map showing the solid waste accumulation points in Bamako identified through Pilot 5.



## PILOT 6: REMOTE CANOPY MAPPING WITH AZAVEA

The city of Freetown wishes to establish regular monitoring of green spaces to ensure the sustainability, and adequate maintenance of their extensive urban tree planting campaign. In order to track and quantify Freetown's greening efforts, a workflow that incorporates baseline assessment, and regularly updated change detection is required. Using high-resolution imagery, local mappers used Azavea's Groundwork platform to **identify, digitize and label representative samples of existing urban canopy cover**. This data was used to train a ML algorithm, to classify historic imagery, and establish a "greening" baseline.

**NUMBER OF TASKS**
**4,681**

**TASK TYPE**
**Remote and field, moderate skilled**

**GEOGRAPHY**
**Tanzania**

**PEOPLE HIRED**
**50**
**(25 female, 25 male)**

**PLATFORM TYPE**
**Open Source, customized**

**OPERATIONAL USE CASE**
**Green cities planning and monitoring**

**WORKER PAYMENTS**
**$18,724**

**WORKERS**
**Students**

**TOTAL COST**
**$66,724**

**FIGURE 13** Azavea's Groundwork tool, in validation mode.

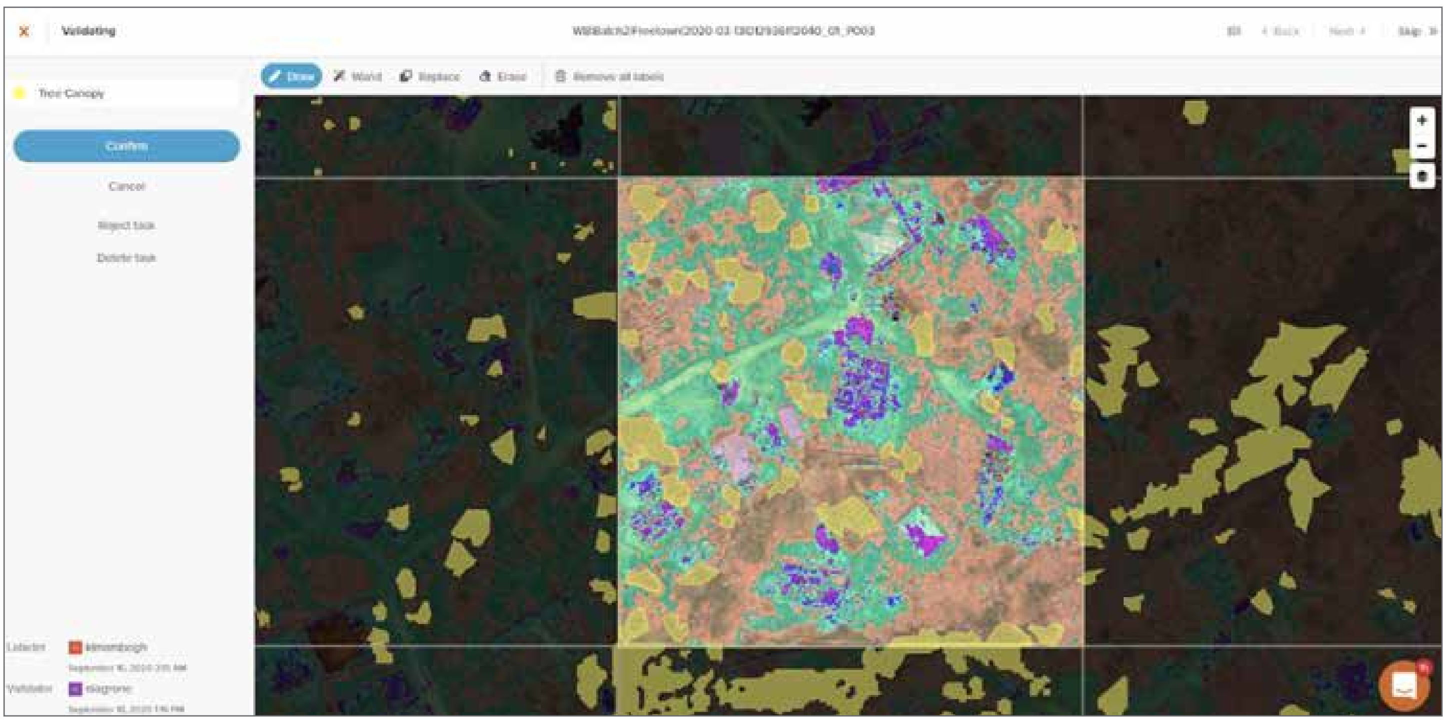
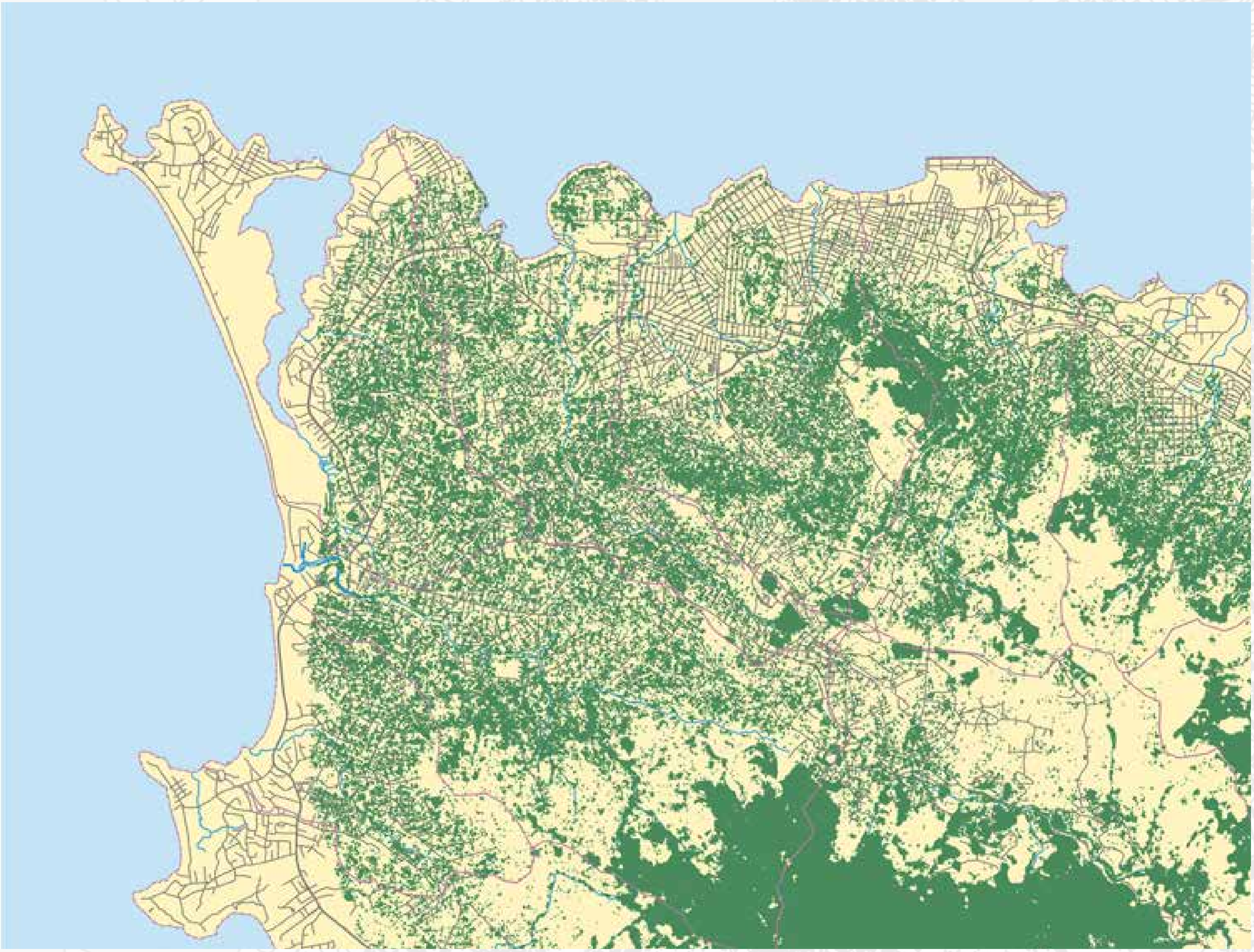


**FIGURE 14** **A sample of the AI-generated canopy output for Freetown, Sierra Leone.**



## PILOT 7: BUILDING CONFLATION SPATIAL COLLECTIVE - FACEBOOK - ESRI

The aim of the project was to do a large scale data conflation and integration project, importing all of Zanzibar's building footprints in OpenStreetMap. Experienced mappers, recent graduates from the Zanzibar Resilience Academy but unemployed, **tested a new data conflation workflow using tools and methods under development by Facebook**. Facebook is using artificial intelligence to predict map features on high-resolution satellite imagery and then using the Map With AI workflow to integrate these predictions in OpenStreetMap. This workflow cuts down on tracing time, and directs mappers to where data is missing.

**NUMBER OF TASKS**
490,000

**TASK TYPE**
Remote work, high skilled

**GEOGRAPHY**
Zanzibar, Tanzania

**PEOPLE HIRED**
20
(12 female, 8 male)

**PLATFORM TYPE**
Open Source, customized

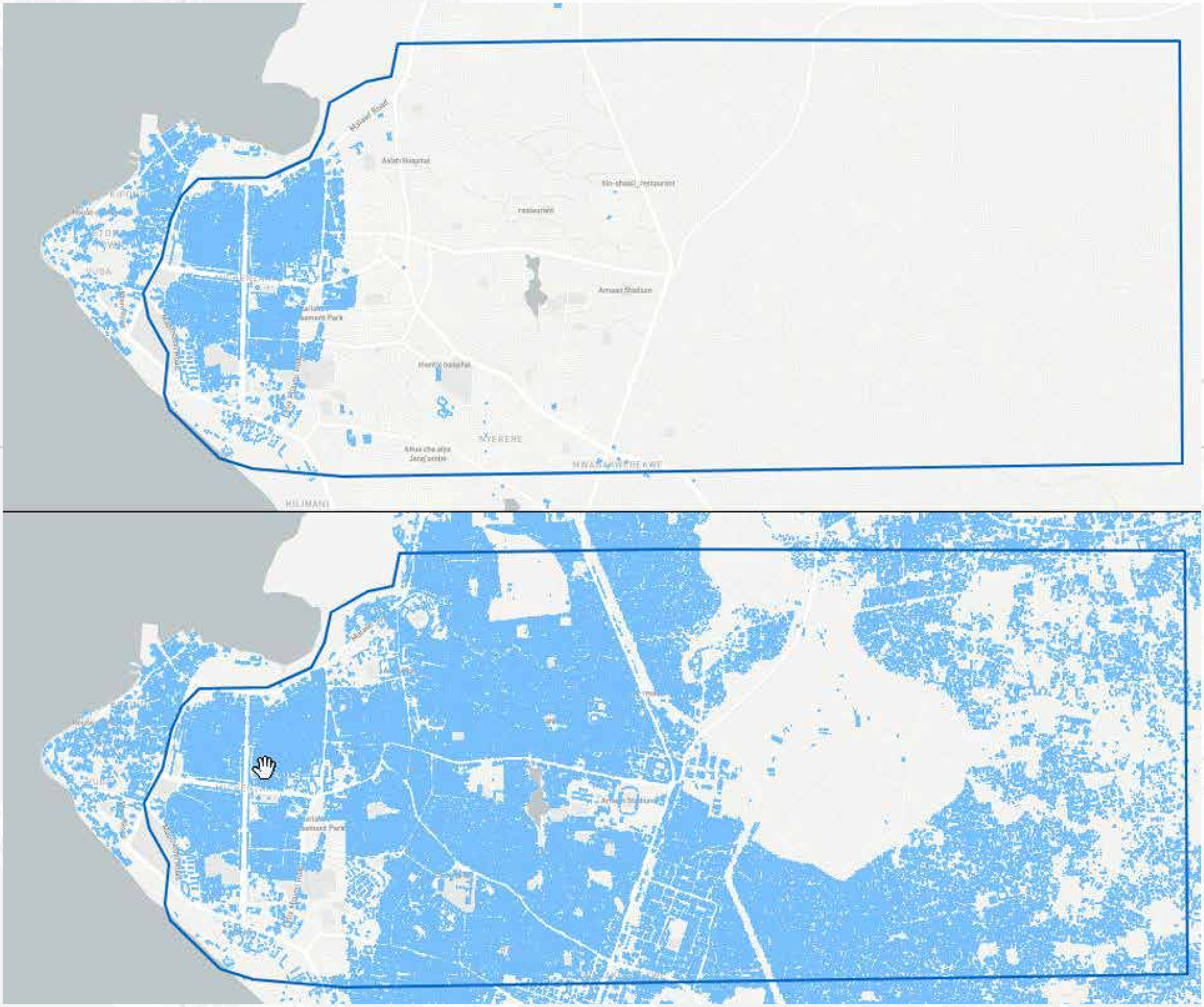
**OPERATIONAL USE CASE**
Urban planning

**WORKER PAYMENTS**
$9,500
(across 2 pilots)

**WORKERS**
Students

**TOTAL COST**
$50,000
(across 2 pilots)

**FIGURE 15** **An example of OpenStreetMap in Zanzibar before (above) and after (below) the building conflation completed during Pilot 7.**



# PILOT OUTCOMES

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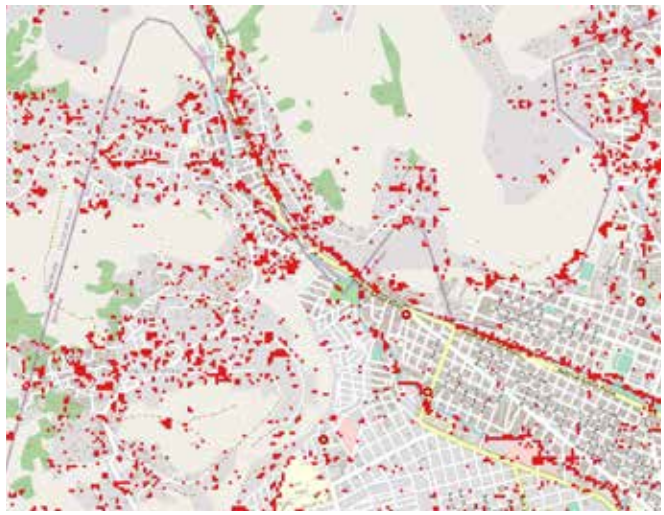
## DATA OVERVIEW

The pilots served Bank operational data needs by providing evidence to inform investments and policy decisions, validating global and local datasets generated by artificial intelligence applied to satellite and street imagery and by collecting and generating local data in the field. Pilots 2, 5, and 6 are examples of micro tasks that **involve local youth to provide information on local assets**; used for urban planning or disaster risk management.

Pilot 2, operating in Nairobi Kenya, tasked local participants to collect neighbourhood level data directly in the field, on congregation hotspots and urban services during the COVID-19 crisis. This information has many potential uses, such as: urban service maps for investment prioritization, and human mobility maps for disaster risk management planning. Beyond the data, the process itself is relevant in many different data collection scenarios, such as business, public health or health care infrastructure surveys. This approach favors a large distributed team of data collectors, tasked with purposely simple data collection requests, so that the relevant information can be collected quickly, and efficiently. Once engaged, these local field mappers can be redeployed for future data collection initiatives. Pilot 5 focused on establishing a map of solid waste in Bamako, Mali. This map is enabling the operational team working with the government of Mali to design solid waste management investments to better understand the area of Bamako occupied by solid waste, the volume of solid waste to be cleaned, places where the current system may underperformed, potential location for transfer points, and to compare cleanliness of different neighbourhoods. This information will be complemented by further data collection on collection routes and operators to inform upcoming solid waste management investments in the Bamako Urban Resilience project. Operationally, this entirely remote approach to data collection is incredibly useful in contexts where conditions in the field are not conducive to in-person data collection (such as issues of security in FCV settings, or in pandemic related lockdown). With imagery of sufficient quality, it's possible to detect a wide range of features, such as buildings (and other construction), roads, paths, drains, waste disposal and also, to monitor changes in both urban and environmental infrastructure over time.

**FIGURE 16** **Informal solid waste visible in aerial imagery over Bamako (left) and the solid waste maps generated through Pilot 5 (right).**



In addition to community mapping initiatives, World Bank Operations are increasingly **using artificial intelligence or machine learning** to generate baseline data and maps. These algorithms require large amounts of data to train the algorithms and validate the results. Collecting this data requires a lot of manual work and often knowledge of the field, but the teams and firms generating this information are generally far from the field. During Pilot 6, remote canopy mapping with Azavea, two customized AI algorithms were developed to detect urban canopy for Dar es Salaam, Tanzania and Freetown, Sierra Leone. These algorithms were applied to current imagery to establish a canopy cover baseline, and will be re-ran periodically to monitor canopy changes over time. Baseline measurements are an important component in the operational context, allowing us to check periodic change against that baseline, allowing us to further determine whether interventions such as wide scale planting efforts have been successful in the longer term. In the case of Freetown, combined with individual tree locations, it is helping the Mayor's team to monitor their progress against their Freetown TreeTown tree planting campaign objectives.

Pilots 1 and 4 served to validate global datasets on urbanization dynamics which were produced through artificial intelligence and earth observation methods by DLR. The microtasking pilots enabled the validation of hundreds of thousands of data points. This scope and depth of validation by local youth is unprecedented and provides crucial information regarding the validity of the artificial intelligence algorithm and utility of the datasets to African Cities and Bank Operations. For example, these datasets have already been used for Urbanization Reviews, monitoring populations and IDPs, calculating global flood exposure and estimating the growth of human population into high-risk zones, as well as calculating market access and the Economic Potential Index.

Pilot 3 workers cross-checked or validated the automatic categorization of urban infrastructure assets from street-level images. Operationally, this type of activity supports more efficient and expedited data collection for urban planning and urban maintenance initiatives, such as constructing a comprehensive inventory of transportation network infrastructure (traffic lights, traffic signage) or public works infrastructure (manholes, street lights, fire hydrants). This information will be used in the Zanzibar urban development project that looks at revitalizing some of the secondary tourist cities. Pilot 7 engaged workers to validate and correct (where applicable) buildings identified by artificial intelligence algorithms, before uploading the results to OpenStreetMap. This data is now used by the Commission for Land in Zanzibar to support urban planning, land management, and its own source revenue system. The data collected through Pilots 4, 5, and 7 was also used as training data to develop new artificial intelligence algorithms that can be reused in other cities and similar contexts.

In summary, the pilots responded to the World Bank and its client data demands by providing information on local community assets and exposure and/or by responding to the high data requirements for the creation and validation of artificial intelligence algorithms.

## TRAINING AND SKILLS DEVELOPMENT OVERVIEW

**Multimodal training approaches:** Training modes across all pilots ranged from in-app, or other asynchronous means of training, to live webinars and in limited cases, (socially distanced) in-person training and monitoring. Participant feedback indicated a higher level of satisfaction in terms of training and skills development when a local engagement manager was involved, though satisfaction with the level and content of training was still relatively high across all pilots. The accessibility and flexibility of in-app training content was deemed critical to participation for some workers.

**Training content and focus:** Most implementers focused on application and platform-specific training only, while others provided a mixture of platform-specific, and contextual training. In cases where training content was focused on platform-specific content, most implementers indicated a willingness to expand on these offerings in the future. For example, optional (in-app) training videos could expose workers to contextual topics related to the broader work, such as: solid waste management, urban growth and flooding; introductory geospatial analysis and general digital literacy; or, broader soft skills such as time, and money management, and communication. In many of the post-worker satisfaction surveys, the participants indicated that they valued the skills training almost as much as the income.

*"I will be making contact with agencies that work in solid waste management to find out more about what they are doing"*
–Worker from Pilot 5: MapSwipe

**Feedback:** Responsive feedback, using a systematic and accessible approach was also highly valued by workers. WhatsApp, especially the use of groups, was rated highly amongst workers as a suitable feedback platform. This feedback mechanism enabled a two-way dialogue. Task managers could contact unresponsive workers or workers providing low-quality data. At the same time, workers themselves were able to contact task managers with technical questions about the platform or which answers were expected for specific tasks.

**Skills Hierarchy and Task Assignment:** Several implementers expressed a desire to implement some type of a skills hierarchy in future implementations. This approach would allow workers to get access to more difficult tasks (and potentially better paying tasks) after passing tests, or demonstrating repeated proficiency on easier tasks. This could improve quality, and lead to advanced skill development.

*"App should match tasks with skills so that low accuracy taskers can earn money and also don't interfere on tasks that they don't know"*

–Worker from Pilot 1: Task Mate

| PILOT | Platform Specific Training | Live Class or Webinar | Contextual Training | Feedback/ Troubleshooting | Peer-to-peer Feedback/ Troubleshooting |
|---|---|---|---|---|---|
| **1. Task Mate by Google (beta)** | Y | N | N | Y | N |
| **2. Native** | Y | N | N | Y | N |
| **3. Spatial Collective Mapillary** | Y | N | N | Y | Y (incl WhatsApp group) |
| **4. MindEarth** | Y | Y | Y | Y | Y (WhatsApp group) |
| **5. MapSwipe** | Y | N | N | Y | Y (incl WhatsApp group) |
| **6. Azavea** | Y | Y | N[14] | Y (escalate to team lead) | Y |
| **7. Spatial Collective Facebook ESRI** | Y | Y | N[15] | Y | Y (incl WhatsApp group) |

## MAIN BENEFITS

**Worker Satisfaction: workers across each pilot study were polled regarding their level of satisfaction with the engagement. Implementers found that fair remuneration, flexible working hours, and achievable work targets are key in attracting workers.** Most workers indicated that the opportunity to earn supplemental income was the key motivating factor for joining the pilot in the first place, though skills attainment was a very close second. While the flexibility of remote training and work was appreciated during COVID-19, participants of the MindEarth project (Pilot 4) indicated that the close relationship between workers and the engagement managers and technical partners created a sense of community which fostered skill development, ensured that task quality and productivity remained high, and was conducive for a fair working environment. This sentiment was echoed for the participants of Pilot 6 with Azavea. Workers recruited to Task Mate by Google (beta) (Pilot 1) also reported a desire to work more collaboratively, rather than the current individual focus of the work.

*"Mapillary has been one of the interesting work that I have ever experienced in my life, working from home has been a great advantage. Considering safety, it was safe for me since there is no moving around especially in this time of pandemic that I fear the most. Time scheduled was also favorable since I had to work in my free time and earn money at the same time. It was also an easy platform to work with, hence doesn't require training to do so, at some time I will multitask with other work without feeling any impact of double work"*

–Worker from PIlot 3: Spatial Collective/Mapillary

**Income generation: one of the overwhelming benefits of these pilot projects was the supplemental income generationfor targeted youth across the pilot locations.** Across seven pilot projects, 1,333 people were hired, earning a combined total of $66,813. The average worker earned between 46 USD (Pilot 1: Task Mate) and 155 USD (Pilot 4: MindEarth) during the entire pilot. Some pilots limited the number of tasks per day per person and paid a maximum of 4.3 USD (Pilot 3: Spatial Collective/ Mapillary) or 8.6 USD per 2-hour working day (Pilots 3 and 6). Other pilots had no workload restrictions and a user could earn up to 35 USD (Pilot 5: MapSwipe) or 72 USD (Pilot 2: Native) per

[14] In this instance, most participants had a university education relevant to the overall theme of the pilot.

[15] Ibid.

day. Employment opportunities for many urban youth were affected by COVID-19 related lockdown measures, and these engagements explored innovative ways to inject money into the gig-economy, while also improving future work prospects. Some pilots targeted workers from informal settlements in Kenya (Pilot 2: Native), as well as recent graduates without employment and university students from the Resilience Academy in Tanzania, who used this activity in lieu of face-to-face work experience to complete their program requirements (Pilot 6: Azavea).

*"The wages were good in this hard times of Covid19, plus working at home was also so good."*

–Worker from Pilot 3: Spatial Collective/Mapillary

**Data Quality: Overall, the quality of data generated was reported to be of high, or sufficiently suitable quality,** which is an impressive result considering the majority of worker training was remote, and the duration of the projects was short. It demonstrates that in most cases, the complexity of the tasks were suited to the skill level of the participants; some with no prior experience, and some with prior technical skills. Google Task Mate reported that their task load was completed rapidly and of sufficient quality for this pilot, while MindEarth indicated that all participants provided statistically significant data and with 92 out of the 115 workers obtained above 80% correctness in terms of their classification submissions. Each project had strict data validation procedures in place, that ranged from three-fold redundancy in task visitation (Pilot 5: MapSwipe), to professional verification of submissions (and subsequent feedback) by full-time staff (Pilot 5: Native and Pilot 6: Azavea)

**Role of local Engagement Managers: while increasing costs, active local engagement managers and their technical support structure ensured easier targeting and hiring, high worker engagement, higher task accuracy, and worker retention.** Five of the seven pilots used a local engagement manager to recruit, train and manage the worker pool (all but Pilot 1: Task Mate by Google (beta), and Pilot 2: Native). MindEarth (Pilot 4), who worked through the Resilience Academy in Tanzania, reported that only 5 of the original 120 workers did not complete the full pilot (96% retention). In the case of both pilots implemented by Spatial Collective (Pilots 3 & 7), retention rates of 100% and 98% were reported respectively. Technical partners that worked through an academic local engagement manager felt this contributed to a greater focus on technical skill development both during the pilot and for future academic courses after the pilot (Pilot 4: MindEarth, Pilot 6: Azavea and Pilot 7: Spatial Collective/Facebook/ESRI)

**Scaling is necessary to achieve economy of scale in terms of costs and complexity: most of the pilot workflows determined that scaling would be both practical and feasible, with the application of certain lessons learned.** Commercial platforms such as Native, and Task Mate by Google (beta) were intentionally designed to scale, and already had features such as mobile money payment and multi-language systems facilitate this. Native already had an established pool of data collectors, and were therefore able to respond to the data collection request in a very timely fashion. Many of the other featured apps and workflows are grounded in academic or crowdsourced approaches. Keeping this in mind, the question of scaling had more to do with future and sustainable development funding, than any significant technical obstacle. The MapSwipe application, for example, is ideally suited to a broader portfolio of uses. Theoretically, it could be used to locate any identifiable feature from aerial imagery with minimal overhead cost (mostly targeted at training resource development for feature identification, and minimal UX modifications).

**Competitive Costs: in the case of mobile microtasking applications, it was found that apart from the additional costs for developing or modifying the application itself, the actual cost per task completed with engagement managers and local experts was competitive compared to conventional global crowd labelling platforms. Worker payments consisted of 10% - 37% of the total pilot costs.** It is important to keep in mind, however, the cost associated with sufficient internet data to complete the work. Some applications like MapSwipe used quite a large amount of data, compensation for which should be either pre-paid to workers (which can be risky in gig-like scenarios), or reflected in the task pricing. The cost-benefit of paying experienced workers over project-specific recruits will require further analysis. Some project partners like Native saw value in paying higher per task rates for highly ranked experienced data collectors. For the tree canopy labelling work (Pilot 6: Azavea), a professional labelling firm (Cloudfactory) was compared to a student team for cost and quality of outputs. The speed and accuracy of the work completed by the professional (therefore more expensive) labellers was preferable to that created by students. However, considering the steep learning curve for this particular task and the amount of time given to complete it, the student did incredibly well.

**Advancing the science: several new approaches to data collection, data**

**generation and data validation were tested throughout the course of these pilots.** Approaches favored free and open software and locally available resources. Feature detection algorithms were developed for canopy monitoring in Freetown Sierra Leone (Pilot 6: Azavea), while the Map with AI/RapiD workflow tested the interaction between AI generated roads and human validation for large scale mapping efforts (Pilot 7: Spatial Collective/ Facebook/ESRI). New data validation methods were developed for continental and global datasets (Pilot 1: Task Mate by Google (beta) and Pilot 4: MindEarth), providing in-depth quality assessments for public good datasets. Feedback and lessons learned will make a meaningful contribution to the future development of these workflows and platforms.

**Open Source Outputs: the tools and data outputs of the pilot program are being made openly available where possible.** In the case of the Tree Canopy detection algorithm produced by Azavea (Pilot 6), the model results and documentation are openly available. The model can therefore be run on any new labeled imagery (of a comparable area of interest) with relative ease.

**Remote participation: Five of the seven pilot studies allowed users to participate from anywhere, at any time, and did not require users to physically travel to locations to collect data.** Applications like Task Mate by Google (beta) (Pilot 1), MindEarth (Pilot 4), MapSwipe (Pilot 5) and Spatial Collective / Mapillary (Pilot 3) supported remote participation (and mostly mobile interface). This cuts down on transportation costs for the workers involved, while the flexible timetable allows them to schedule participation around other work or school commitments.

## CHALLENGES

**Adequate compensation: Establishing adequate costing for microtasks is still a complex and challenging undertaking because of the balance required between participants' expectations, existing budgets, the targeted audience, and the tools used.** Multiple pilots reported difficulty in calculating appropriate compensation per task. Basing compensation on volume of work alone is not adequate to reflect the time and attention many participants paid to the task at hand. A combination of productivity, time, and quality of submissions may be the fairest way to calculate compensation, though the practicality of this led many of the local engagement managers to resort to an hourly wage for work completed, with random quality control measures to ensure submissions were adequate. Most of the workers polled across all pilots reported being satisfied or somewhat satisfied with the compensation received, but also reported the lack of available tasks was frustrating in some cases.

*"The project is a good one and economically it has boosted so many people more so during the pandemic period." and "We are working in a very insecure environment but the earning is very little"*

–Workers giving conflicting views of compensation rates for Pilot 2: Native

**Data Input Challenges: feasibility of remote tasks hinges on availability of high-resolution images. In some cases, these may be available globally for free or commercially, or they may be required to be collected locally (i.e. drone and street-level imagery), and in all cases their quality is key and can be a bottleneck.** Two pilots reported issues with imagery resolution. For the canopy labeling exercise (Pilot 6: Azavea), the labellers (especially the student team) reported that it was difficult at times to distinguish between large shrubs and true tree canopy (imagery used was 50cm resolution Maxar). The labellers felt this improved with practice (but the window of opportunity was limited due to the short duration as microtasking projects were limited to 3 months for this pilot phase). Interpretation issues were significantly improved on samples of higher resolution imagery, but the cost of acquiring such imagery (sub 50cm) would render it infeasible. Image resolution was also reported as problematic in the case of the street-level imagery classification exercise for Mapillary (Pilot 3). The issue did not render the task impossible, but the worker was required to spend more time analysing the image before verifying the detection, which has implications for cost and efficiency. It was also noted that the Artificial Intelligence algorithms developed by Mapillary to detect street features (such as: fire hydrants, street lights, utility poles, traffic lights, trash cans, crosswalks, manholes and information signs) had been trained mostly on US and European street-level images and the models need to be refined to perform well in Africa. o be refined to perform well in Africa.

**Task Load/Supply: overall it was found that the supply of tasks was low and that participants were going through tasks very quickly in a matter of days.** The most recurrent feedback topic from the workers surveys was the request to get access to more tasks and more earning opportunities. Several of the pilot projects reported very high demand for tasks on behalf of the workers, which could create a sense of unease amongst workers when the amount of tasks available was limited  (Pilot 1: Task Mate by Google (beta), Pilot 2: Native and Pilot 3: Spatial Collective/Mapillary). The Mapillary pilot (Pilot 3) reported that some workers polled felt this undermined the intended flexibility of the work, as those with additional work or household commitments sometimes missed out on new task batches, depending on when they became available. When planning or scaling future projects it would be important to ensure sufficient tasks are available. One option is to implement a quota system to ensure registered participants had equal opportunities to access new work as it came online. Some pilots restricted the number of tasks per person by assigning a fixed allocation of tasks (Pilot 3: Spatial Collective/Mapillary and Pilot 5: MapSwipe) and by limiting the time that could be spent on the platform (Pilot 4: MindEarth). The potential tediousness and repetitiveness of tasks is another motivation to limit the task quota per worker. Secondly, the supply of tasks must be extended to create a viable system which provides a sufficient number of tasks to maintain worker interest. Such tasks can consist of routine data-collection efforts by the government, the World Bank, or other development agencies but should also identify local data collection needs in the private sector.

*"If I don't do the task it will disappear. Maybe there are so many of us, someone else will do it and I will miss the chance to earn money."*

–Worker from Pilot 1: Google Task Mate

**Payment systems: in-app mobile-money payments can incentivize participation, cut down on intermediary overhead but can be difficult to implement due to the variation in operators and systems.** Only two pilots (Pilot 1: Task Mate by Google (beta) and Pilot 2: Native) had in-app direct payment systems for work completed. obile payments for the remainder of the pilots could NOT be conducted directly through the application and a third party was required to provide the administrative support to send these payments. Hiring an intermediary to administer payroll adds costs to the overall project. Also, while mobile payment makes the process more seamless, the costs of each transaction can be high and even prohibitive on too small payments. While in-app payment will not be practical for all workflows used, it should be investigated further. Note that the variation in operators and mobile-money payment systems across countries should be considered when scaling up microtasking activities across regions.

**Internet Connectivity/Bandwidth: almost all pilots reported at least intermittent issues with connectivity during the course of the project but they were not blocking the completion of the project.** These issues were a combination of available bandwidth, and/or sufficient compensation to cover the costs of mobile data packages.  Long load times affected productivity for both the MindEarth (Pilot 4), and Azavea (Pilot 6) projects, as in both cases imagery for labelling/classification was stored server side. In the case of MapSwipe (Pilot 5), and Spatial Collective (Pilot 3), workers were provided with internet bundles a priori to facilitate connectivity, though some of the workers still experienced issues with connection quality.  Desktop tasks and tools that require constant and reliable internet activity, such as the RapiD editor (Pilot 7), or Groundwork (Pilot 6) can be a challenge for certain participants. Desktop solutions that work offline, like JOSM, are much more practical for this operating environment.

*"I was not able to work from home due to poor internet connection and a lack of a reliable power supply [...] Therefore, I was forced to be doing my daily tasks at my uncle's place"*

–Worker from Pilot 3: Spatial Collective/Mapillary

**App/Workflow Design: in certain cases, legacy workflow design (on pre-existing apps) proved to be an obstacle to complete data collection.** For Pilot 2: Native, the tasking interface blocked mappers from collecting a POI if it was likely to be a duplicate with an existing entry—avoiding duplication may have advantages in certain commercial use cases, but for the purposes of this pilot, the ability to cross-check entries would be an important advantage.

**General Data Protection Regulations (GDPR): the legal data privacy regulations should be considered at the start of microtasking pilots.** Should the World Bank wish to continue with these types of projects moving forward, a universal data privacy policy must be in place; it is recommended that the World Bank 'own' this data privacy policy, rather than relying on local implementation partners, as this can be time consuming and inconsistent. Deciding on the best path forward in this regard, delayed the beginning of one of the digital pilot projects.

## LESSONS LEARNED

**Feedback to Workers: the desire for performance feedback was strong from digital workers across all pilots. Going forward, new projects should not underestimate workers' desire to perform better, learn, and also contribute**

**to peer learning.** In the case of Pilot 1: Task Mate by Google (beta), workers with low accuracy scores insisted on feedback to explain how they could improve their work going forward. Pilot 5, MapSwipe encountered much more feedback traffic than initially anticipated (for a combination of technical and training issues) and would advise a more structured system of dealing with these requests going forward. For Pilot 6 (Azavea), the local implementor, the Resilience Academy, dealt with day to day troubleshooting and combined and escalated more serious issues to Azavea using an online spreadsheet. Though simple, this systematic approach worked very well and led to daily updates to the online training deck, which grew to include interesting edge cases and best practice examples.

*"The best thing was everyone from Kenya[ and Zanzibar were free to share their thoughts concerning any difficulties."*

–Worker from Pilot 3: Spatial Collective/Mapillary

*"I love customer care services, asking about challenges that we faced on the ground."*

–Worker from Pilot 2: Native

**Training/Onboarding: virtual training was generally considered sufficient by the workers, though high-skill tasks required longer or phased training. Feedback from workers during onboarding can identify edge cases where the local context may be different from the technical partner's expectations.** Virtual training was the dominant mode of instruction across the pilot cohort. Pilots 1 and 2 used online instruction exclusively, whereas Pilots 3, 4, 5 and 6 used a mixture of initial online training sessions followed by in-person mentoring and support. Training for Pilot 7, which involved more high-skilled desktop work, was conducted in person in a safe, socially distanced setting. While most pilots seemed to have a high level of satisfaction with the mode and level of training, a few key lessons were learned with regard to future efforts. In the case of Azavea (Pilot 6), a longer training window would be advised going forward (one week training, with two additional weeks of work). There is a steep learning curve for imagery interpretation, and the time band of student availability was too short to take advantage of this. Any future engagement of new labellers should allow for a longer training period. In the case of Native (Pilot 2), participants indicated better training was required (with examples) on what constitutes a particular POI. For example, many of the requested features (such as markets and bus stops) had both formal and informal examples in the neighborhood, and the validators were often unsure of the validity of the informal examples. As technical partners generally come from a different socio-cultural background than the workers, it is important that the onboarding process include clear examples of what features the microtask is looking for and provides opportunities for workers to indicate if this expectation doesn't match the local context. For future efforts, MapSwipe (Pilot 5) would recommend a phased approach for users, to allow them to graduate to more/higher levels of work based on their performance. The MapSwipe workflow calculates a user agreement score based on performance in a first trance of tasks; If within a certain range (ie: at 0.8 or above), then users can move forward to receiving additional work. All users would still be paid for the initial mapping, but only users who advance to the next stage would be paid for additional work, while users below the minimum agreement score would either be excluded, or retrained.

*"If you could improve communication especially explaining more about project before we start doing work to avoid much work being rejected because we spent our own money to buy bundles and transport"*

–Worker from Pilot 2: Native

**Recruitment: The main finding from this study is that there is a growing population of youth with digital skills willing to participate in remote digital work to earn additional income. However, most of them do not know where to look for this kind of opportunity.** Community-based organizations were used to recruit for vulnerable youth from informal settlements in Nairobi (Pilot 3: Spatial Collective/Mapillary). Retention rates in this instance were high, along with high satisfaction amongst workers, with many indicating a preference for more tasks and continued engagement. Recruitment through university engagement managers also saw high enrollment and retention rates, which was due in part to the interactivity between mentors and students, and the connection to the required work placement programs. Our commercial partners recruited workers using a mixture of local recruitment firms and social media recruitment. In the case of Native (Pilot 2) paid social media recruitment was quite expensive, and only yielded 33 out of 161 mappers (~20%). Referrals were found to be a much stronger recruitment mode.

**Worker skill level and performance: the results of the pilots suggest that even workers with limited existing digital skills can provide high-quality data. This is a promising finding as it greatly increases the number of peo-**


**ple who can benefit from digital works programmes.** An important underlying question behind the Digital Works for Urban Resilience program is whether the general population can benefit from digital works or whether only segments with specialized skills will benefit. Of course, this depends on the level of the task to be executed. High-skill tasks will require either existing skills or more extensive training than low-skill tasks. Some pilots targeted university students or members of community geospatial organizations. However, other pilots did not. In the case of Native (Pilot 2), workers were targeted based on the location within a deprived area. It should be noted that much of the initial recruitment was done through Facebook ads and the workers applying will therefore already have some kind of digital skills. Task Mate by Google (beta) (Pilot 1) specifically targeted workers belonging to the categories of gig workers, home-makers and unemployed and found that there were no significant differences in the quality of work provided by the different groups.

**Connectivity/Offline Functionality: in the user feedback surveys, several participants indicated that the ability to work offline would be a major advantage.** While offline functionality is possible for some of the apps used (such as Native, MapSwipe, and JOSM), it would not eliminate the need for users to have data bundles for data downloads, or to have connectivity that allows for the data to be uploaded back to the server. In the case of Native users, those that used the offline functionality sometimes missed out on available POI updates; therefore the tasking system would require some reconsideration (perhaps quota's or assigned POIs) to circumvent this. Apps like MapSwipe have the potential ability to work in an offline environment, but this feature is currently not configured and would take significant development costs.

## PLANNING FUTURE INITIATIVES

**Passthrough to workers: 10% to 32% of the total project cost went to worker payments in the pilot round. This could increase to an estimated 13% to 44% if the pilots are repeated.** The difference is mainly due to recruitment and development costs which may not be necessary if the same companies and workers were requested to repeat the same or a similar task. If the projects are scaled to a much higher number of tasks the proportion of total cost going to worker payments would increase even further.

**Unforeseen costs: A number of unforeseen costs , (and projected costs of scaling) were highlighted by both technical and local implementing partners due to: maintenance, taxes and legal implications.** The team at MapSwipe highlighted in particular the maintenance of software and systems in the context of open source development projects. In the case of the MapSwipe app, most of the application and backend software existed prior to the project, but regular maintenance is required to maintain functionality and enable additional development. Spatial Collective (engagement manager for Pilots 3 and 7) highlighted the tax and legal implications of any future scaled efforts. Any potential income-generating activity targeting hundreds or thousands of youth will be subject to the laws, regulations and taxes of the operating country. For example, setting up mobile payment platforms required operating licenses from the organization providing payments. Additionally, all payments to workers in Kenya and Zanzibar attract a withholding tax of up to 15% because this work is considered as income in exchange for a service. Taxes, laws, and other regulations should be considered at the start of the project.

**Timeframe: The time required to complete a microwork project depends on the preparation required to set-up the task, the training period, and the time required for workers to perform and validate the tasks. Custom microtasking platforms require more time (and financial investment) for back-end development but support custom applications.** Project start-up time is mainly influenced by recruitment (is there an existing user base and can the project use this? or does the project want to target new citizen groups who must still be recruited?) and platform development. The pilots indicated the latter could take 1-2 weeks if an existing platform is utilized but up to 1-2 months if a new platform had to be developed or major technical modifications were needed. The training period generally required one week. Established microtasking platforms often include intuitive tutorials to quickly teach a user how to use the platform, but it still takes some time to get an overview of difficult tasks and what answer workers are expected to provide. The actual time it takes all the workers to complete the tasks will depend on the task load, complexity, number of workers, and hours worked per day. Four pilots required around twenty days (Pilots 3, 4, 5, and 7) whereas one was as fast as 10 days and two required around two months (Pilots 1 and 2) to complete all tasks. In general, little post-processing was needed to transform the data generated by the microtasking platforms into the data format required by the data user.

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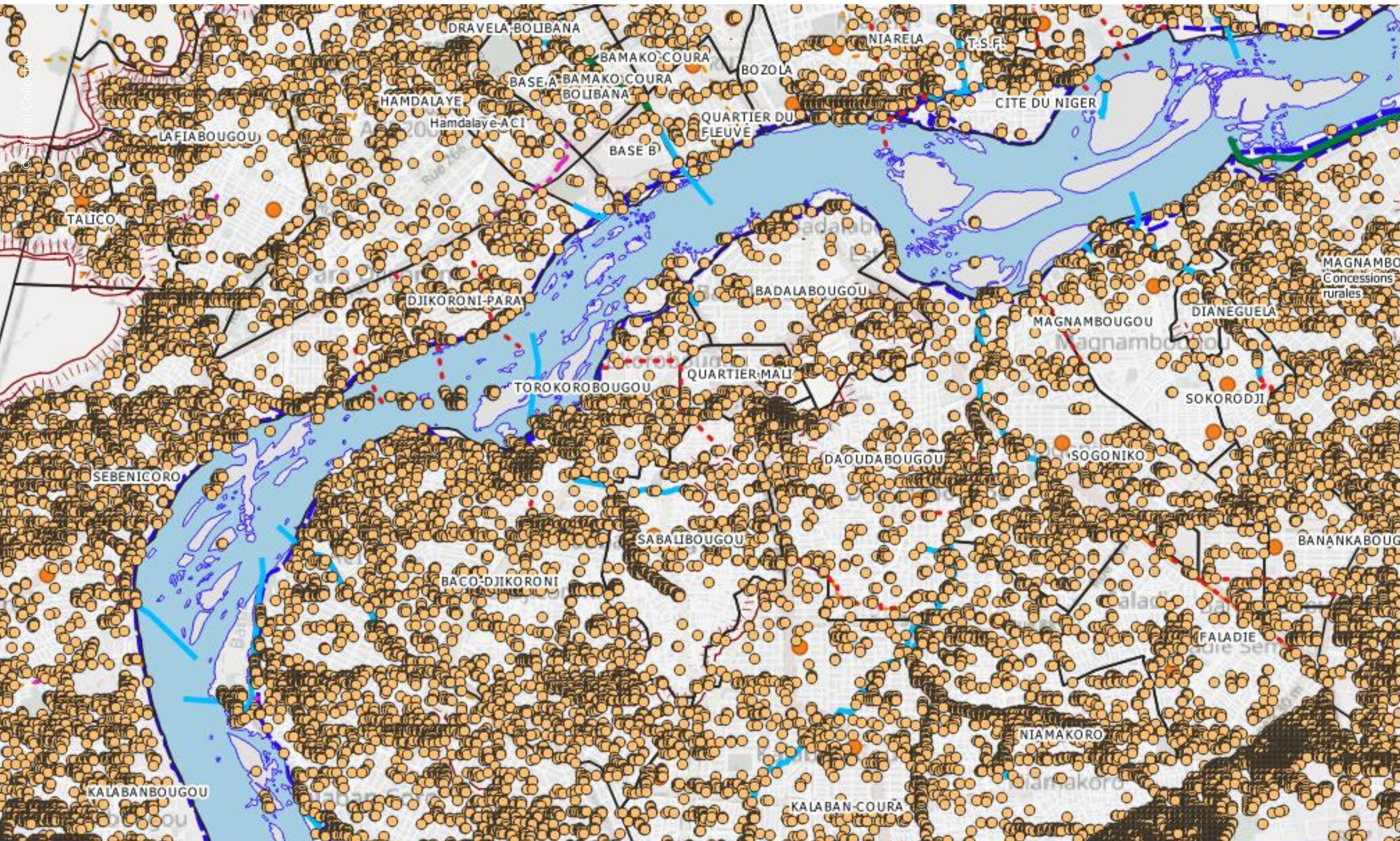
# NEXT STEPS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Hamdalaye-ACI
CITE DU NIGER
QUARTIER DU FLEUVE
LAFIABOUGOU
BASE B
TALICO
MAGNAMBO
Concessions rurales
BADALABOUGOU
DJIKORONI-PARA
DIANEGUELA
MAGNAMBOUGOU
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SOKORODJI
DAOUDABOUGOU
SOGONIKO
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SABALIBOUGOU
BANANKABOUG
BACO-DJIKORONI
FALADIE
NIAMAKORO
KALABANBOUGOU
KALABAN-COURA

Based on the Findings from Phase 1, Phase 2 will build on the microwork pilots to explore how to integrate the various platforms and approach in one integrated pilot supporting an operational project investing in informal settlement upgrading. Scale up efforts will also seek to better understand the potential of digital microwork to serve as **a public works program**, focusing on out of school youth, and whereby participants could receive more than just income but also **develop tangible skills** that will support **their professional development and serve as a bridge to more permanent employment**, for instance by providing them with tasks of gradual difficulty. Specifically, Phase 2 will explore:

1. Whether digital microwork can be a more cost-effective approach to developing urban datasets than traditional data collection efforts by local or international firms.
2. What key considerations are necessary to create digital public works schemes that support World Bank operational projects?
3. Does digital microwork result in skill building or signaling co-benefits that support vulnerable members of society to secure longer-term job opportunities?
4. How can mobile payment systems be scaled over geographical regions?
5. Does microtasking work complement traditional hiring models and workflows to collect geospatial data, and can we identify innovative ways of impacting the labour market?

Through this research the team hopes to demonstrate that digital public works programs can provide data to inform resilient urban development and an opportunity for youth to gain skills and credentials that will serve them long term. **Micro-credentials** are a form of digital certification which verifies the skills or competencies of individual learners, typically based on short online courses. They can be issued for formal and informal learning experiences, and are intended to promote skill development and knowledge acquisition to improve employment prospects for individual learners. Building on the employment opportunities created by the program, participants will have the opportunity to upskill, and receive both training and micro-credentials for more technically advanced digital work. Participants who wish to progress beyond their initial engagement can avail of a series of incremental modules that will expose them to more advanced skills in the mapping workflow. Successful completion of these training modules will lead to micro-credentials and eligibility for more detailed, higher-paying tasks. Identifying which skills are most beneficial and have the most potential for workplace advancement is a challenge, and any training and credentialing program should consider both digital skills and soft skills. The pilots showed that being part of the microtasking projects helped participating youth learn to manage time, advanced professional growth, and built confidence.

The targeting of workers was opportunistic during the pilot phase. Existing networks were leveraged to enable rapid deployment. For example, the connection with the Resilience Academy in Tanzania provided access to youth with some GIS experience. Other pilots specifically targeted residents of slum communities (Pilot 2: Native) or youth, stay-at-home mothers, and the unemployed (Pilot 1: Google Task Mate). All pilots aimed for an equal participation of men and women. Moving forward, the team would like to look at broader definitions of inclusivity and more specific targeting. Digital works are an opportunity to provide supplementary income for not only youth, but also mothers, disabled, unemployed, and other vulnerable groups.

Digital works projects also have potential for supplemental income generation in FCV settings, where people's mobility is often restricted, making traditional labor intensive public works activities (LIPW) challenging to implement. In many FCV countries, the majority of the working population participate in a "portfolio" or "basket" of income-generating activities rather than single, full-time, year-round jobs.[16] Digital works could help diversify the supplemental jobs portfolio, creating more accessible (and suitable) income opportunities for community members where safety and mobility are even more challenging (such as women, and people with disabilities). Going forward, the team is looking at working through community based organizations in FCV settings to pilot digital works style income support opportunities, and to facilitate more efficient and effective data collection to inform urban planning activities.

One of the most recurrent feedback points from the workers surveys was **the task availability and importance of having access to sufficient earning opportunities**. Additional research will be carried out to **review upcoming data needs** on Global Practice of Urban, Resilience and Land (GPURL) projects to better understand the potential for these requests to be met through microwork. Consultations will also be carried out with private sector firms to identify which skills are most in demand locally to determine whether or not such capacities can be

[16] World Bank Group (2020) Supporting Jobs in fragility, Conflict and Violence (FCV) Situations

developed through microwork. Identifying public and private sector data needs is crucial to build up a task portfolio that can provide regular tasks to workers. To better understand how this model can serve as a public works program, the team will collaborate with colleagues from the Social Protection and Jobs Global Practice to design activities and test the capabilities of this approach. The first application of this collaboration will be in supporting data collection efforts through digital microtasking on the Second Kenya Informal Settlement Improvement Project (KISIP II).

Variations in legislation, mobile operators, and mobile-money payment systems was also a restriction for scaling workflows from one country to another. Pilots using in-app mobile payments had lower intermediary overhead costs than pilots which required a third party to execute the mobile payments. Mobile and in-app payments are an important consideration for scaling up worker volumes and across regions and will be further investigated.

Consultations with local private sector firms will help the team identify the skills that will be most useful for digital microwork participants to develop, and will inform any skills building training or curriculum. This will also help **identify how the microtasking approach can complement traditional hiring models** where a geospatial firm generates basic mapping data through teams of professionally trained staff. Data quality will be assessed in comparison to traditional data collection approaches to determine whether the digital microwork could be as valuable of an approach. Should the data quality be comparable and the skills building demonstrated, this will support a pitch to World Bank operational teams to use digital microwork for their data collection needs to reap the additional benefit of supporting incoming generation and skills development among local youth and ultimately, poverty reduction and economic growth.

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