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Ramani Huria

The Atlas of Flood Resilience in Dar es Salaam



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FOREWORDS

I do a lot of work in Tandale to see it develop in a good way, a planned way. As the head of the ward, the main thing I do to make sure that Tandale is planned is to collaborate with the Department of Planning, to see how we can develop Tandale with a structure. Tandale is currently an unplanned settlement and the hygiene situation is not good – so we need to set a new plan for the new Tandale; we want to see drainage, we want to see new infrastructure in the ward.

For planning, we need a lot of things – but firstly, we need maps. Until this project, Tandale hasn't had a map. People build whatever they want, wherever they want – often in areas that experience flooding. Ever since this project began, I have seen flashes of the new Tandale. Now we have a map and a map is something to start with. We can identify different areas to restructure and improve. It is a roadmap for us to set up new plans, to organize ourselves while involving the community. And the community can have a sense of ownership over our new plan for development.

These maps have already helped me to request funding from the Municipal Director to improve on drainage systems in the areas most affected by flooding. Beyond flooding, the maps have also helped us improve the ward's health and sanitation – allowing us to identify areas where there has been an outbreak of cholera, directing us to the locations of patients. Since we don't have a water system in Tandale, cholera outbreaks are associated with well water. With these maps, we can collaborate with DAWASCO to establish pipes and develop a public water system. There are also many social issues that they can address – like identifying areas where we can put schools. In Tandale, we don't have a secondary school. These maps can help us direct us in placing a secondary school.

The basic thing is that we want to improve the living standards of the people of this ward because the area seems to be getting worse. Tandale is a forgotten place. There are no roads, no feeder roads, no planning for households, so the best thing to do is to properly plan the settlement of Tandale and to do what we can to improve the living standards for those inhabiting this area. And let's not end here, because this is just the beginning. We can start with Tandale, but we need to see the whole municipality of Kinondoni. This is the time to change things, and the way to change is to accept this and start.

OSILIGI LOSSAI

Executive Officer, Tandale Ward

As head of Urban Planning for Kinondoni Municipal Council – I know how much we need up-to-date maps. Up-to-date maps are valuable tools because, through them, we can identify different opportunities and challenges within the area and the community. Before this project, our base maps were over 20 years old. Since then, a lot of development has happened – and working with those basemaps, we waste more time while even more development is taking place. Most importantly, outdated maps have made it very difficult to educate the people of our city on planning.

With this project, with community mapping, we grow with the community step by step – they see their role, we talk to them, we identify the problem together with them and it becomes easier for them to understand. The map is a simplified way of providing open data, where everybody can see and learn. It's an easier way of communication, especially to the people at community level who come from varying levels of education. The maps can help us to improve accessibility and, through accessibility, other services will come automatically. For instance, improving the water supply will improve solid waste management also improving the overall health condition of the area.

With this map, I feel empowered that now if I want to work in our city, I'm working with the already existing situation, and an up to date map. This data is authoritative. This is the best map made of this area, and it belongs to the community. In order to succeed in a community you have to work with the community, they have to understand you and appreciate you. This is what will take them there.

Going forward, if we can have maps like this for the whole of Kinondoni, we'll be maybe 20 steps ahead.

JULIANA LETARA

Head of Department of Urban Planning, Kinondoni Municipal Council

MUSSA NATTY

Senior Technical Advisor, Dar es Salaam Regional Commissioner's Office

The Tanzania Commission for Science and Technology is the main government advisor on science, technology, and innovation, so the Ramani Huria project is very important to us. It demonstrates the value of science, technology, and innovation in solving community problems.

Firstly, Ramani Huria has contributed to the open government initiative and open data, making all collected data available in the public domain. This means that the data can be used by all people to develop their areas and establish necessary socioeconomic programs. We can already see this in its ability to highlight areas of focus for projects in sanitation, health, education, and infrastructure, and there is great potential for this to stimulate job creation on many fronts.

It is clear to me that demand is rapidly increasing for the services that Ramani Huria has provided. Zanzibar is the best evidence of this - with the request for mapping coming directly from the government. We now also have a request from the Ministry of Works, Transport, and Communication to assist in the mapping of the Kilimanjaro International Airport and a request from the Regional Commissioner of Songwe who is keen to map the area of Tunduma. Within the land sector, the value of these services are being noted by the Land Tenure Program.

These requests keep coming in - and the spillover effect is enormous. With this being the first time that state of the art technology like drones have been used in Tanzania - we were quite anxious about how people were going to react. But it has been so well-received, and the presence of this technology has triggered the creation of a large group who have interest in using it in other sectors to provide many different services to our people.

I think what is the most important is that we have demonstrated proof of concept for how these things can be done. The demand is there, the question is how can we scale up and how can we integrate these aspects in our normal routine activities. The approach has been very successful - and COSTECH is very keen to use this approach in different parts of the country. We must now share our lessons with other local authorities so that it can take off in a rapid way.

HASSAN MSHINDA

Director General, Tanzania Commission for Science and Technology (COSTECH)

Using OpenStreetMap to enable community mapping in Dar es Salaam has its roots in a 2011 pilot project in the Tandale ward, known as “Ramani Tandale”. The project demonstrated that a few dedicated individuals – both students and Tandale community members – could generate and manage data about their community well beyond what was previously available to any “expert” inside or outside of Tanzania. It was unclear at the time what the future would bring. With Africa being the fastest urbanizing continent on earth, and Dar es Salaam its fastest growing city, new and innovative approaches would be needed for urban planning and disaster management data to keep pace.

The kick-off of the Dar Ramani Huria project took place in early 2015. Dar Ramani Huria is groundbreaking in many ways. It expands on the Tandale pilot to not only include over 200 students and community, but truly rely upon their skills to carry out the mapping process. The project has moved from mapping one ward to comprehensively mapping 29 wards and covering an area home to an estimated 3.5 million people. It has incorporated Unmanned Aerial Vehicles (UAVs) and a street-view mapping bajaj to increase mapping precision. In summary, it is the largest and most complex urban mapping project in East Africa while being driven almost entirely by students and community members serving as HOT staff and volunteers. Each team member’s desire to put the city or neighborhood they call home “on the map” was multi-faceted. One important, yet little-publicized motivating factor was that several HOT team members are disaster survivors themselves, having been severely affected by flooding in their family homes. Working to map their city was a powerful way to make the invisible visible and contribute real data for government-led urban planning and disaster management. Dar Ramani Huria not only generated near real-time, comprehensive and detailed flood data and maps. It also transformed residents from victims of disaster to survivors having the capacity and ability to advocate for and affect positive social change.

Moving forward, an incredible wealth of data now exists on some of the previously least-mapped areas in the country. This data has incredible potential to be used not only for improved urban planning and disaster risk reduction, but also to contribute to achieving the Sustainable Development Goals. Each day, Dar Ramani Huria team members are working to update OpenStreetMap with water, sanitation, and hygiene related map features and add data for more sectors, such as bicycle routes and other sustainable transportation. HOT congratulates the Ramani Huria team on the work to date and looks forward to the many potential uses of the map data in improving life in Dar es Salaam.

TYLER RADFORD, PAUL UITHOL AND INNOCENT MAHOLI
The Humanitarian OpenStreetMap Team

The American, Danish and Tanzanian Red Cross Societies and Red Cross Red Crescent Climate Centre have collaborated with the Ramani Huria project through Zuia Mafuriko, Swahili for “Stop Flooding”. Our aim with Zuia Mafuriko has been to support the building of flood preparedness and response planning in Dar es Salaam, understanding how the flood impacts in detail and how municipalities and communities fail to act based on forecasted warnings. From here we can utilize better the available weather forecast information and effectively contribute to preparedness action planning.

Working closely with municipal councils and communities, networks of community volunteers (Community Disaster Preparedness and Response Teams) have been established. The volunteers are capacitated to equip the communities with knowledge that builds public awareness of the risks of flooding and assist in response if it should happen. Community members and stakeholder consultations identified flood preparedness actions that have developed Standard Operating Procedures (SOPs) for Forecast Based Financing in flood prone communities, while identifying safe/evacuation areas. The SOPs stipulates specific flood preparedness actions to be taken in response to specific weather forecast.

We have established connections and collaborations amongst resilience stakeholders, and connecting between communities and stakeholders such as Tanzania Meteorological Agency (TMA), Tanzania Meteorological Agency and Dar es Salaam Multi Agency Response Team (DARMAET), Prime Minister’s Office – Disaster Management Department, Scouts, Fire and Rescue Forces and Police Forces resulting in improved information flow, quicker response and improved coordination of disasters

From this foundation of information and response teams, local and city government with community leaders can identify actions that mitigate impact of flooding whether this be through the supplying of pumps or through outreach that empowers and educates on flood resilience.

NYAMBIRI KIMACHA
Tanzanian Red Cross Society

JULIE ARRIGHI
American Red Cross

The participatory approach of Ramani Huria across the flood prone communities of Dar es Salaam has collected important and scarce data on the infrastructure, schools and other facilities exposed to a risk of flooding. Additionally, it has pioneered techniques and methods for creating flood inundation extents from the historical knowledge of the communities affected.

By pairing local wisdom with scientific knowledge, Ramani Huria has created different risk scenarios, particularly those related to flooding, that allow for a thorough and accurate assessment - enabling communities, disaster managers, and planners to produce realistic measures for a range of natural events.

To strengthen its impact, Ramani Huria collaborated with the Red Cross on their Zuia Mafuriko “Stop Flooding” project. This trained first responders and educators how to use the maps to make positive changes in their community - by identifying and cleaning drains, establishing new solid waste collection points, and educating communities on the need for flood resilience.

Ultimately, this project is driving resilience to natural hazards in communities across Dar es Salaam by connecting community members and local knowledge to professionals at local universities and city administration.

MARK ILIFFE AND EDWARD ANDERSON
The World Bank

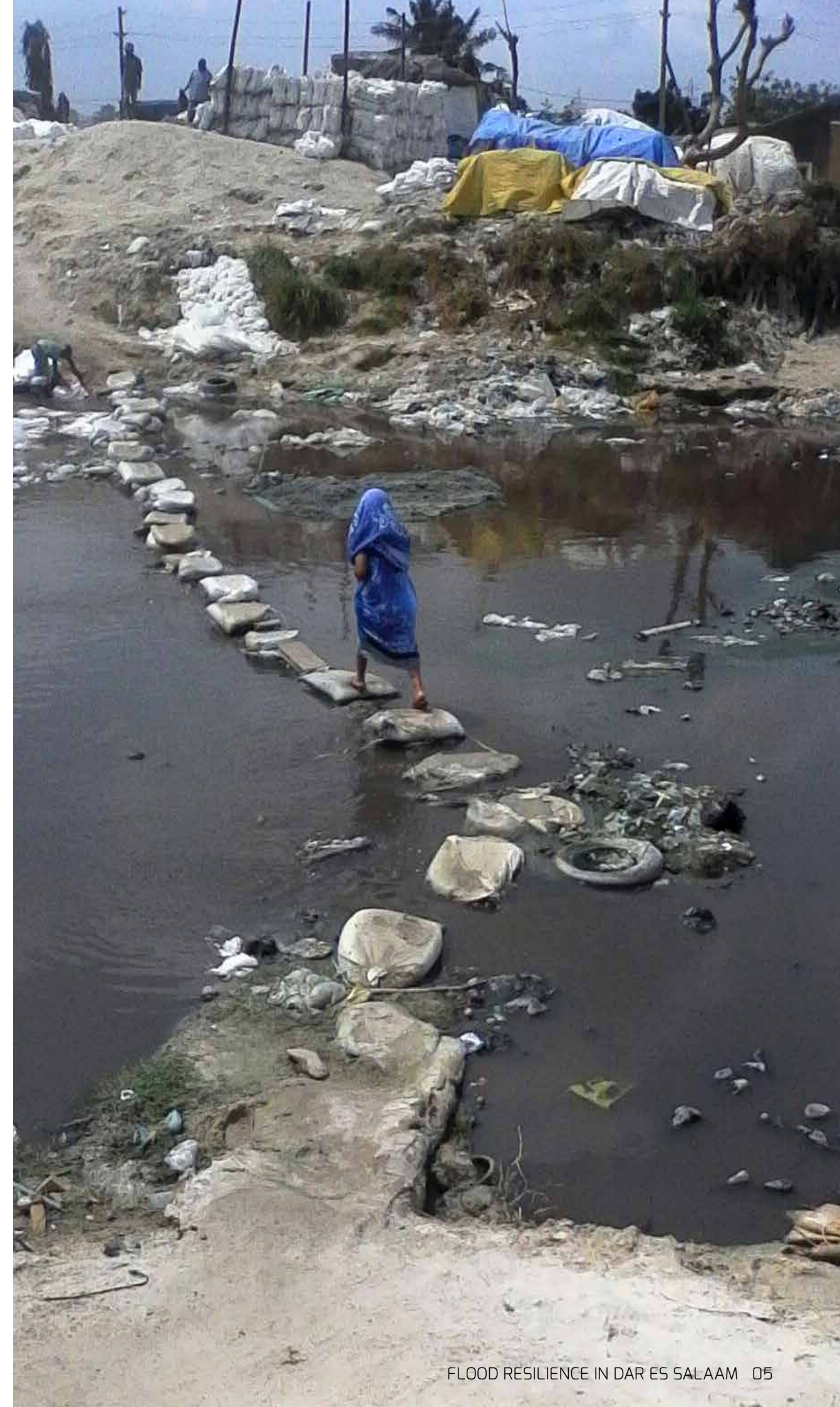
INTRODUCTION

Dar Ramani Huria (Swahili for “Dar Open Map”), is a community-based mapping project in Dar es Salaam, Tanzania that builds flood resilience in communities across Dar. This project has trained teams of local university students and community members from throughout Dar es Salaam to create highly detailed local area maps of the most flood-prone areas of the city.

Every year during the rainy season, Dar is prone to suffering from devastating floods that wipe out roads and take out houses, resulting in a risk to life and infrastructure alike. By collaborating with communities to map residential areas, roads, streams, floodplains, and other relevant features, Ramani Huria is stimulating greater awareness and engagement in disaster prevention.

The maps have been combined with InaSAFE, a free software that enables users to run realistic natural disaster scenarios for better planning and response. As an added benefit, these maps will be publicly available online, available for download on the project website, and also in printed form to the local governing bodies of each ward¹.

Dar Ramani Huria is supported by the World Bank, the World Bank’s Global Facility for Disaster Reduction and Recovery and the Red Cross. The project website, showing current mapping progress and updates on the blog, is at <http://www.ramanihuria.org>.



¹ A general map: <http://www.openstreetmap.org/#map=15/-6.8105/39.2533>.
A drainage map: https://api.mapbox.com/v4/hot.683fcd43/page.html?access_token=pk.eyJ1IjoiY29iaG90IiwiaW5SI6IiBtUmNiR1kifQ.dCS1Eu9DIRNZGktc24IwtA#14/-6.8015/39.2403

PROJECT PARTNERS AND SPONSORS

Ramani Huria is supported by a broad consortium of both international and Tanzanian supporters, including:

ARDHI UNIVERSITY

Ardhi University (formerly University College of Lands and Architectural Studies) is a public university in Dar es Salaam, Tanzania. It was established 28 March 2007, though it has been offering training for more than 60 years in different status. It provides education in Architecture and Design, Construction Economics and Management, Environmental Sciences and Technology, Geospatial Science and Technology, Urban and Regional Planning, Real Estates Studies, Housing and Information Systems Management.

DAR ES SALAAM CITY COUNCIL

Dar es Salaam City Council governs Tanzania's economic capital. According to the 2012 National Tanzania Census, Dar es Salaam was home to 4,364,541 inhabitants at that time, growing at a rate of 5.6% per year in the period from 2002 to 2012.

ILALA MUNICIPAL COUNCIL

The Ilala Municipal Council heads Ilala district, one of three districts in Dar es Salaam. The 2012 National Tanzania Census states the population for Ilala as 1,220,611 (doubling from the 2002 census). The area is 273 km². Ilala contains the area commonly referred to as 'downtown' with Kivukoni, Kisutu and Kariakoo, where much of the commerce, trade, banking, and government offices are located, but also extends further west to flood prone wards Ilala and Mchikichini and wards further west like Kinyerezi.

KINONDONI MUNICIPAL COUNCIL

The Kinondoni Municipal Council heads Kinondoni district, the northernmost of three municipalities in Dar es Salaam. The 2012 Tanzania National Census reports

the population of Kinondoni to be 1,775,049. The area of Kinondoni is 531 km². Kinondoni contains a number the wards hardest hit by flooding, like Magomeni, Mzimuni and Tandale, but also Ubungo (home to UDSM and Ardhi University) and wards on the coast such as Msasani and Kawe.

TEMEKE MUNICIPAL COUNCIL

The Temeke Municipal Council heads Temeke district, the southernmost of three districts in Dar es Salaam with flood prone wards like Keko, Sandali and Temeke, but also extends south and east, like Kigamboni ward. The 2012 Tanzania National Census reports the population of Temeke District as 1,368,881. The area of Temeke is 787 km².

TANZANIA OPEN DATA INITIATIVE (TODI)

The Tanzania Open Data Initiative (TODI) promotes open data and open governance by helping and sensitizing policy makers in the Government of Tanzania to the importance of digitizing high value datasets, and supplying these as open data sets to citizens, businesses and government agencies.

BUNI HUB

Buni is a technology Hub which foster innovation and technology entrepreneurship through capacity building, mentoring programs and community empowerment. Founded in 2011, Buni Innovation Hub focus is to discover, nurture and mentor youths with innovative technological solutions to problems facing Tanzania.

TANZANIA COMMISSION OF SCIENCE AND TECHNOLOGY (COSTECH)

COSTECH is a parastatal organization with the responsibility of coordinating and promoting research and technology development activities in the country. It is the



chief advisor to the Government on all matters pertaining to science and technology and their application to the socio-economic development of the country.

TANZANIA RED CROSS SOCIETY (TRCS)

The Tanzania Red Cross Society (TRCS) is a voluntary and independent humanitarian organization that joined the worldwide network of Red Cross and Red Crescent Societies in 1963. TRCS aims to mobilize resources through the power of humanity towards improving the situation of the most vulnerable in Tanzania. The Zuia Mafuriko project aims to improve flood resilience in Dar es Salaam, utilizing data collected together with Ramani Huria.

WORLD BANK

The World Bank is an international financial institution that provides loans to developing countries for capital programs. It comprises two institutions: the International Bank for Reconstruction and Development (IBRD), and the International Development Association (IDA).

THE DEPARTMENT FOR INTERNATIONAL DEVELOPMENT

The Department for International Development leads the UK’s work to end extreme poverty, building a safer, healthier, more prosperous world. Through Ramani Huria, DfID has provided UK AID funding for open data, open government and climate resilience.

GFDRR

The World Bank’s Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change.

AMERICAN RED CROSS

The American Red Cross (ARC) is a humanitarian organization that provides emergency assistance, disaster relief and education. In addition to domestic disaster relief, the American Red Cross assists in international relief and development programs, such as Ramani Huria and the TRCS’ Zuia Mafuriko project

DANISH RED CROSS

The Danish Red Cross was founded in 1876. The Danish RC operates in the fields of humanitarian assistance, relief work and education, either alone or in co-operation with state bodies or other organisations. The Danish RC and the government also co-operate in the area of asylum seekers and international humanitarian aid and rehabilitation.

HUMANITARIAN OPENSTREETMAP TEAM (HOT)

The Humanitarian OpenStreetMap Team (HOT) applies the principles of open source and open data sharing for humanitarian response and economic development. Free, up-to-date maps are a critical resource when relief organizations are responding to disasters or political crises. HOT creates and provides those maps.

UNIVERSITY OF DAR ES SALAAM (UDSM)

The University of Dar es salaam is the oldest and biggest public university in Tanzania. It is situated on the western side of the city of Dar es salaam. It was established on 1st July 1970. Prior to that, the university college, Dar es Salaam had started on 1st July 1961 as an affiliate college of the University of London.

PROJECT SUMMARY

The Ramani Huria project officially kicked off with a workshop at the Tanzanian Commission for Science and Technology (popularly known by its abbreviation “COSTECH”) on March 26th and 27th 2015. Over the following year, Ramani Huria has gone through several phases:

- › Trial phase (3 wards; Ndugumbi, Tandale, Mchikichini)
- › Scale up (14 wards, and an additional 8 downtown)
- › Scale down (4 wards)
- › Drainage mapping and reviewing (36 wards)
- › Continued participatory mapping (in the 21 community mapped wards)

At the start of the project, about 15 students from Ardhi University (on the Urban Planning program) were recruited as interns to trial and refine the community mapping approach to the conditions and circumstances in Dar es Salaam. The first ward to be mapped was Ndugumbi, followed by Tandale and Mchikichini. Gradually, the students were given more responsibility, until several were placed in charge of mapping subwards in Mchikichini in June.

During the scale up phase, starting on July 6th with a workshop at Nkrumah Hall at University of Dar es Salaam (commonly known as UDSM), over 150 students from Ardhi University and UDSM were involved in the project. The best of the original Ardhi students were promoted to supervise mapping in these wards, and were also in charge of training these 150 students. Volunteers from the Tanzania Red Cross Society helped out in a number of wards as community members. Over the course of July and August, 14 wards were mapped with the full community process, with up to six wards being mapped in parallel, and an additional 8 wards in downtown Dar es Salaam were mapped alongside the Africa Open Data Conference in early September.

After the scale up period, which ended on October 9th with the closing community forums in Manzese, Mzimuni, Kigogo, and Vingunguti, Ramani Huria entered a calmer phase, with a focus on data quality and expanding coverage of the drainage system outside of the centre of Dar es Salaam. The number of mappers was reduced to 20, plus 2 supervisors. Of these, 10 are graduates from Ardhi University and 12 are graduates from the University of Dar es Salaam. Selecting the best 20 mappers out of 60 reduced the average time to completion of mapping a ward

from three weeks to only two weeks. A total number of 4 wards have been mapped since then (Ubungo, Tabata, Ilala and Temeke), bringing the number of wards mapped using the community process up to 21. An additional 8 wards in the downtown areas of Dar es Salaam were fully ground surveyed, meaning we’ve fully mapped 29 wards now. Our mappers have been asked to participate in a number of other tasks during this period (all with a geospatial component), benefitting their overall experience, knowledge and improving their ability to successfully execute future geospatial assignments.

To expand the area available for hydrological analysis, the drainage and water systems were mapped in a further 36 peripheral wards, bringing the total number of wards for which the available maps have been improved significantly up to a total of 65.

To put the scale of the mapping operation in perspective, the Dar es Salaam area on OpenStreetMap contained 1254 km of waterways as of May 2016 (compared to 173 km at the start of 2015), 3396 km of roads (compared to 1720 km at the start of the year), and the amount of school buildings has increased from 3 to over 1700. In the same timeframe, the size of the OpenStreetMap dataset for Tanzania (in ‘pbf’ format) has grown from 11 MB to 45 MB, quadrupling in size. The waterways mapped include:

- › 5917 ‘drain’ sections, at a total length of 790 km
- › 779 ‘ditch’ sections, at a total length of 94 km
- › 448 ‘river’, ‘stream’ or ‘canal’ sections, at a total length of 339 km.

According to the 2012 census data, the area we’ve fully mapped (including all buildings) so far is home to around 1.17 million people. As Dar es Salaam is the fastest growing city in Africa¹, more people will be living in these wards now; 1.34 million people when using the growth rate estimated in the African Development Bank report (5% per year). Including the wards where drainage and water systems has been mapped, this amount rises to 3.05 million people (in 2012 census figures), and 3.51 million people when including estimated growth since then.

¹ According to figures from the African Development Bank

MAPPING APPROACH AND PROCESSES

From March 2015 until February 2016, 65 wards of Dar es Salaam were mapped using several different (but complementary) methodologies, tools, and technologies. Of these 65, 21 wards were mapped using a community-driven process, with community members, supported by university students and technical staff, leading the mapping in the field. A further 8 wards in the downtown area were fully field mapped by teams composed of university students, and in an additional 36 wards, the drainage networks were mapped¹.

COMMUNITY MAPPING

The 21 most flood prone wards of Dar es Salaam were mapped using a community mapping process. These were identified in collaboration between municipal councils and the Red Cross. Then, communities and technical experts came together collect data in these wards, digitize it, and use GIS tools to assess flood risk. In a community mapping approach, community members not only contribute their local knowledge on map features (buildings, street names, administrative boundaries, flood prone areas), but also work to communicate and raise awareness within their communities about actions that could be taken to improve resilience to flooding. Facilitating community members in mapping their own ward increases their understanding and knowledge about their own environment; empowering them to better understand the issues, potential solutions, and how to communicate these most effectively to (local) authorities.

In order to be able to build on this data, it is important to create a positive feedback loop by promoting its usage, thereby producing demand for more data and affirming the influence communities have by collecting this data and communicating about their issues to begin with. To accomplish this, Ramani Huria is cooperating with local authorities and other potential users of the data at different (higher) levels of government, and providing hands-on workshops teaching how to import, process, and analyse the generated OpenStreetMap data.

In order to use the data most effectively, and to be able to collaborate on datasets across agency boundaries, it is important to promote open data as well. All OpenStreetMap data is available under the Open Database License

(ODbL), and all the produced content by Ramani Huria (maps, data and other media) has been released under a Creative Commons license. Please see <https://github.com/hotosm/RamaniHuria> for more details.

In the wards where we have presented the community mapping process, the following steps were taken:

1. Obtain permission to map from the municipality, confirmed in a letter;
2. Discuss the purpose, scope and objectives of mapping with the ward officer. Logistics regarding workspace also need to be arranged. Identify key community members to approach for the workshops, the community mapping, and possibly other activities. Community members can be approached through ward officer contacts, existing volunteer networks, and/or the Tanzanian Red Cross Society;
3. Identify technical team members and a team leader that will be mapping in the ward. This team (in our case, mostly students from local academic institutions, Ardhi University and UDSM) provide continuity in terms of applied mapping skills and procedures, and can train and guide community members and officials;
4. Organize an opening community forum, establishing the collaboration with the community, understanding the challenges faced by the community, finalising the ultimate goal of mapping that ward and why;
5. Support mapping training for community members, to raise awareness of concepts and workflow;
6. Execute mapping activities:
 - a. Preparation (ward level)
 - b. Mapping
 - Preparation (daily survey level)
 - Data collection according to the data model²
 - Digitization
 - Data review (daily survey level)
 - c. Data review (ward level; may loop back to b. Mapping as spot checks are done and data is corrected)
 - d. Map production

¹ This has been supported by imagery taken by Unmanned Aerial Vehicles (UAVs) and street view imagery captured from a bajaj throughout the mapped area.

² <https://github.com/hotosm/RamaniHuria/raw/master/data%20model/Data%20Model%20and%20Tagging.pdf>

7. Organize a closing community forum, presenting the printed map to the wider community, soliciting feedback, and discussing uses of the map and potential issues that can be addressed by using it;
8. Revisit the ward to help with questions and other issues, and to discuss with community leaders how the maps can be improved. The mapping phase combines a number of tools and technologies, like the use of field papers, GPS devices, and mobile phones for data collection, JOSM³ (the Java OpenStreetMap editor) for digitization (adding surveyed data with data already present in OpenStreetMap), QGIS⁴ for data analysis and map production, and InaSAFE⁵ for risk analysis.

To spread awareness of the project and the collected data and increase sustainability of the OpenStreetMap community in Tanzania, numerous community and skill building activities were deployed. This includes organizing mapping events at BUNI Hub, as well as collaborating with the Tanzanian Red Cross Society and its sister project, “Zuia Mafuriko” (Flood Resilience), which is developing disaster preparedness and response plans.

In addition to this ward level focus, Ramani Huria has been working with the wider Tanzanian innovation community. This has been through numerous MapTime events that work with innovation hub members on mapping their hometown. Ramani Huria has also provided experience in other domains, such as transport, for our mappers by participating in events and activities like mapping dala dala routes and helping to import Tanzanian roads data from the Medical Stores Department. The team’s community service has been further expanded through assisting in the General Cleanliness Day (#HapaUsafiTu), participating in the GIS Day at UDSM and in UWABA cycling events, and providing workshops and lectures at local universities.

USE OF UAVS TO CAPTURE HIGH RESOLUTION IMAGERY

Ramani Huria uses SenseFly eBee drones⁶ to support its engagement in Dar es Salaam, made available for the project by COSTECH. These drones (also referred to as UAVs, Unmanned Aerial Vehicles) work to acquire very high resolution imagery (between 3-5 centimeters per pixel, depending on flight altitude) of the most dense

³ <https://josm.openstreetmap.de/>

⁴ <http://qgis.org/en/site/>

⁵ <http://inasafe.org/>

⁶ <https://www.sensefly.com/drones/ebee.html>



(and flood prone) areas of Dar es Salaam. The high resolution of the imagery is especially helpful in the unplanned settlements, where it is often hard to distinguish where one building ends and another begins when using traditional aerial imagery. To complement the UAV imagery in areas that were not covered, such as around the airport and downtown, HOT worked with the MapGive⁷ initiative from the U.S. Department of State to acquire recent satellite imagery.

PARTICIPATORY FLOOD PRONE INUNDATION EXTENT IDENTIFICATION

Generally, flooding in Dar es Salaam manifests itself through flash flooding along the path of a river, during which water levels rise rapidly, or through more

⁷ <http://mapgive.state.gov/>, <https://blogs.state.gov/stories/2014/03/07/openstreetmap-diplomacy-mapgive-and-presidential-innovation-fellow>



prolonged flooding downstream from these areas. To capture this information, Ramani Huria uses a participatory approach involving community members. During opening community forums, community members discuss which areas can flood within their wards. Through this, a picture is established of where the most affected areas are within a given ward. Following this, community members and students use a GPS and sketches to collect information in the field. This maps critical infrastructure, drainage, and all other data contained in this atlas.

In an effort to further refine and enhance the identification of flood prone areas, a separate process was used in each ward as part of the mapping process with the community to determine the extents of historical flooding and to collect the subward boundaries. During the full mapping of the wards, ward and subward boundaries were drawn and digitized into OSM with the help of ward and subward officials. The same approach was employed for flood prone areas with the Ramani Huria mapping teams.

To increase the accuracy of the gathered information on flood prone areas, a second phase of mapping with the wider community was made in cooperation with community members, ward officers, and other local officials. Using the newly

created maps as a base layer, tracing paper and pencils further refined the inundation extent, displayed on the inundation maps that are in this atlas. As a community process, it is not just one voice that is heard, but many, and this is an important factor as a first step to empowering communities.

This process pulls out the community perception of flood risk, using a targeted methodology to obtain uniform results across different wards. The flood inundation extents in this atlas are based on community input from the extents of annual flooding in combination with their recollection of the extents of flooding in 2011 (which saw the worst flooding in recent history)⁸.

From discussions with the community mappers during the participatory mapping process, experience shows that the identified and mapped flood prone areas experience a range of between 0.5 and 5 meters level of flooding. Some buildings along rivers, like the Msimbazi river, were affected by floods of 2 meters and above. Buildings further away (50 meters from the river streams) and along drains are less affected, experiencing flooding of up to 1 meter. When it rains, 0.5 - 1 meter level floods may rapidly occur (within 1 hour), depending on the amount of precipitation.

Furthermore, the discussions revealed that the communities know and experience the risks of living within and along flood prone areas, but opt to remain due to financial constraints, commute time, and/or proximity to family and friends.

The data collected from the participatory mapping sessions (following the process as outlined above) has been digitized into OpenStreetMap, and has been used as the basis for the "Potential Inundation" maps found in this Atlas.

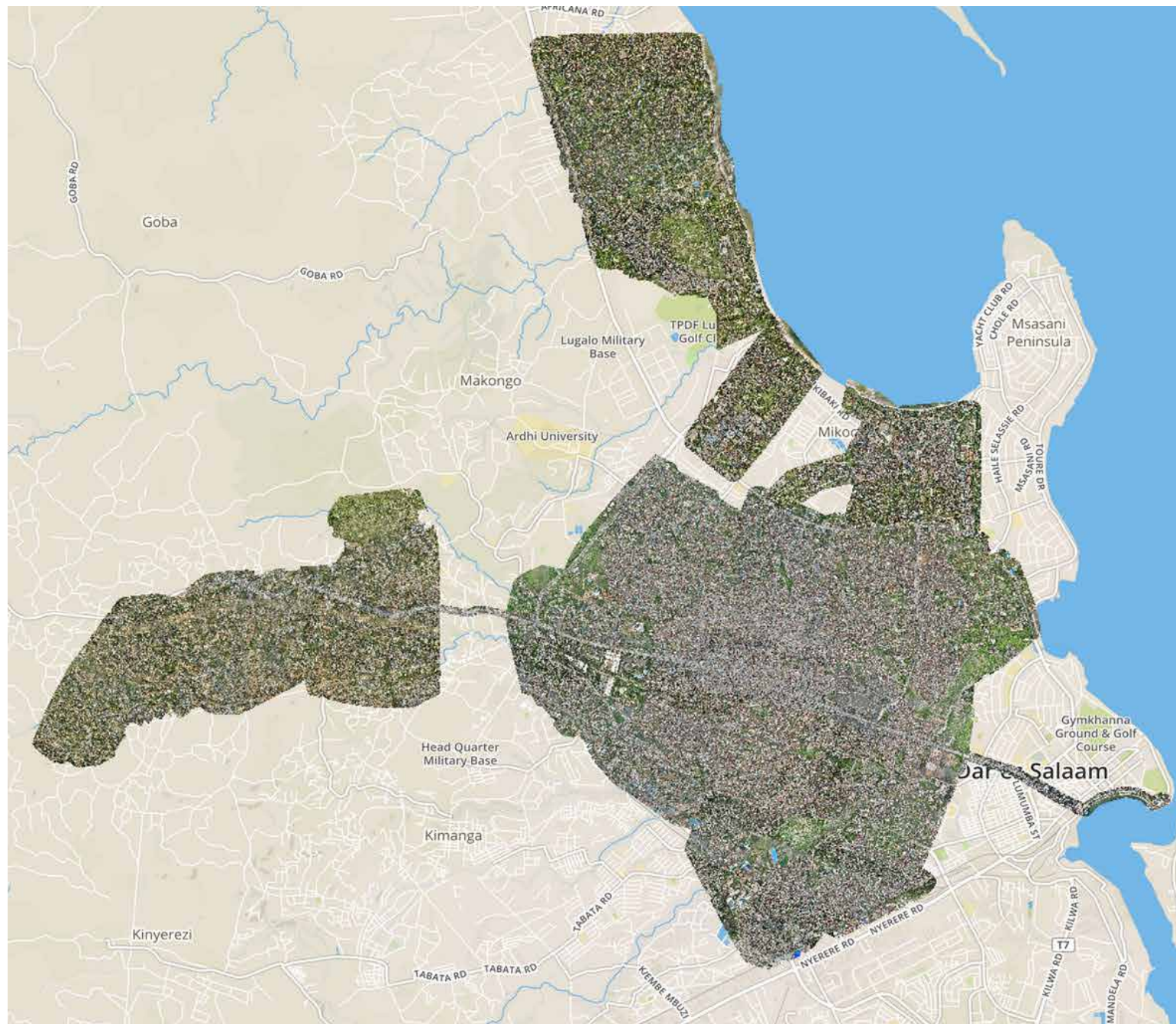
DRAINAGE MAPPING

In order to improve the understanding of the water network of Dar es Salaam, and increase the potential for hydrological and flow analysis in the future, coverage of the drainage network has been expanded to encompass the wards surrounding the areas where we performed community mapping. Features collected as part of this include the length and depth of drain, construction type, and whether it was covered or open.

Precipitation in these areas accumulates and drains through Dar es Salaam to the Indian Ocean, making this part of the same catchment area and integral to include in hydrological analysis. The drainage mapping has extended coverage to an additional 36 wards, which act as catchments and tributaries draining into the rivers and streams that cut through the informal settlements in the heart of Dar es Salaam.

A team of sixteen mappers was dedicated to this task, mapping a ward in groups

⁸ More information on this process can be found at <http://ramanihuria.org/participatory-mapping-historical-flood-inundation-extents/>

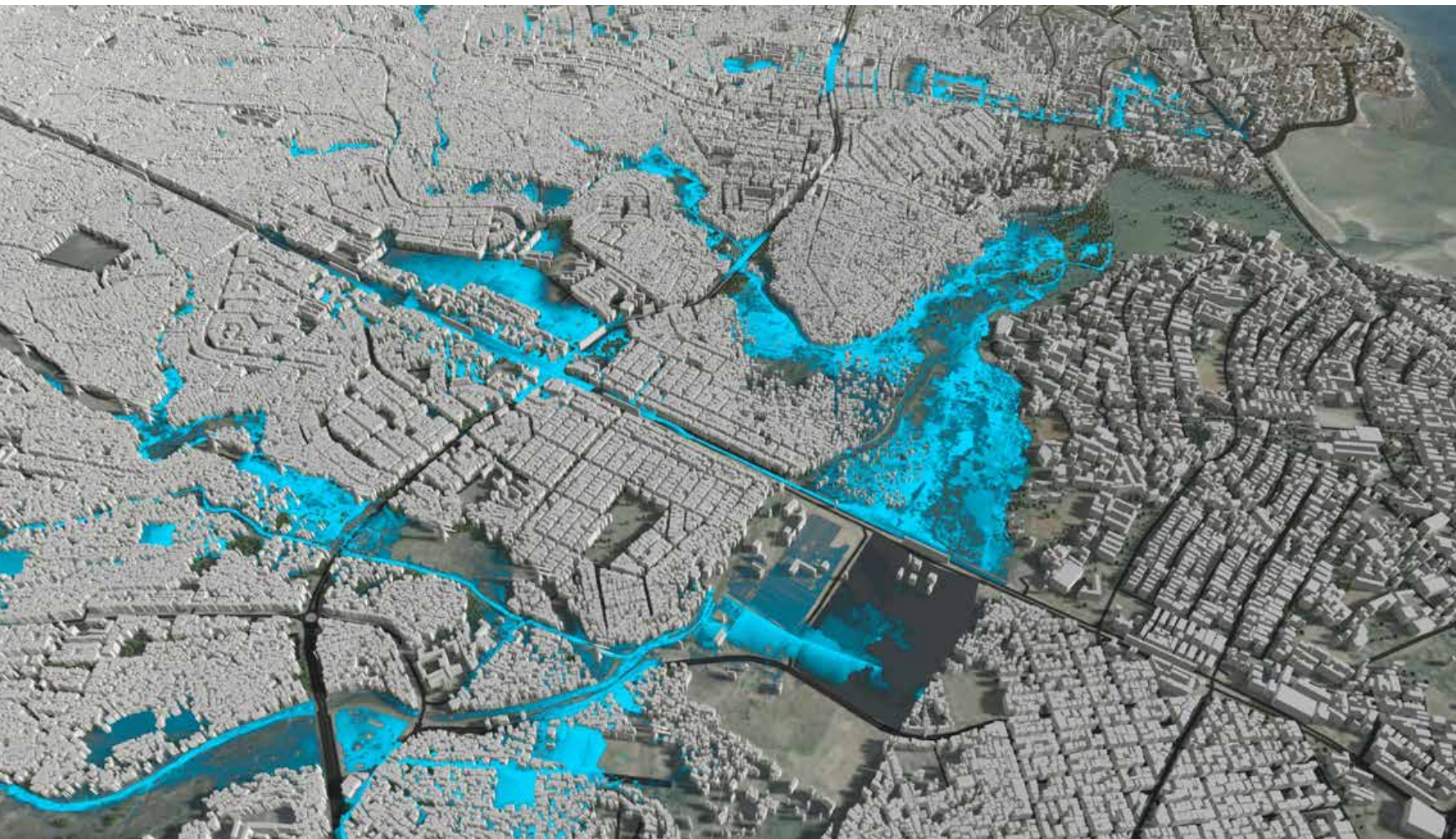


of four (which meant we were able to map four wards in parallel). Fully mapping the drainage and water systems of a single ward takes around three days on average, consisting of two days of data collection and one day of verification and digitization work. This should enable more thorough analysis of the complete water system for Dar es Salaam.

TOWARDS DATA DRIVEN INUNDATION MODELS

The versatility of UAVs allows them to be used to create more complex datasets, such as Digital Terrain Models (DTM) and point clouds. A DTM is a representation of heights and a point cloud is effectively a 3D model of an area. These datasets are especially useful when exploring the creation of hydrologic inundation models as they allow for the modelling of a city. With them, flood modelling experts can run scenarios that demonstrate what happens if a certain amount of rainfall occurs, a river bursts its banks, or infrastructure is constructed - like a drain.

The typical plethora of terrain data generated from point clouds can be used to establish simple to very complex flood inundation models, each meant for a very different purpose. Simple methods include GIS terrain contouring methods, which can be used to highlight the elevation relative to the nearest drain. Such methods do not take into account rainfall events, drainage impediments, drainage conditions, or other features that relate rainfall to runoff. They can, however, be used to infer which areas are likely to flood under a given water level in the nearest stream and are therefore very useful to provide warning perimeters at a community level. To study the genesis of rainfall events - how they may flow through a ward, what drainage impediments may occur, and what event specific flooding may occur - a hydrodynamic model is required. Such models can be employed for instance to assess flood impacts of specific rainfall events, flood risk due to the governing climate, and impact forecasting if used in combination with meteorological simulation models and a forecasting shell.



Ramani Huria together with partners Deltares and the City of Cleveland⁹ established a first of its kind seamless flood inundation map from UAVs based upon the Height-Above-Nearest-Drainage principle. This is a GIS terrain contouring method that first establishes the height of each point in a given study area with respect to the nearest point in the drainage network, and then estimates levels of inundation in the area, given a depth within the drainage network. The 3D visual of the Msimbazi Catchment demonstrates the value of OpenStreetMap data, making possible a direct overlay with exposed households. This map is a first step in the process of building flood inundation models from the many datasets collected by Ramani Huria. In the next steps, specific conveying and blocking elements should be included in a much more comprehensive and dynamic flood model that simulates genesis of flooding within the drainage network and its surroundings.

STREET VIEW MAPPING

For the wards that have been community mapped in In Dar es Salaam, the process is very resource intensive (and as a result, also time consuming) due to the high density and large amount of features being surveyed. With a relatively large mapping team based in the ward, surveying a complete ward typically takes

several weeks. This works very well for densely built up urban environments, but gets more difficult when larger distances need to be covered, with sparser features to be mapped (like suburban or rural areas). Take for example the Msasani peninsula in Dar es Salaam; this is a richer area, home to ambassadors' residences, expats and embassies. The plots of land here are much larger, with compounds surrounded by gardens and walls. In these types of areas, taking a different approach to the surveying can lead to similar quality results, while taking less time and effort to collect. One such approach involves taking street view imagery from a moving vehicle using dedicated cameras, and using this imagery as an additional source of data when mapping an area remotely (which separates the task of collecting data from digitizing it, negating the need to be physically present in the area that is being mapped).

To make the collected imagery easily accessible to remote mappers, the imagery is uploaded to Mapillary¹⁰. This imagery can also be accessed from JOSM using a plugin. To obtain this imagery, several types of equipment have been used in Dar es Salaam: Garmin action cameras, regular mobile phones attached to a motorbike, and also a sophisticated Trimble MX7 device.

HOT's contacts at Trimble have allowed us to test a prototype Trimble MX7 Mobile Imaging System¹¹. This device can be mounted on top of a vehicle, making it easy to quickly and accurately collect georeferenced road and site infrastructure data. The MX7 captures a 30mp, 360o panoramic image of the environment that is fully calibrated and georeferenced. The system is controlled from inside a vehicle with a wireless tablet. In Tanzania, the bajaj (the local name for a tuk-tuk) is a common mode of transportation that can pass through traffic much faster than a full-size car, making it an ideal platform for the MX7 camera. However, these vehicles don't have a roof structure that is capable of carrying weight (the MX7 with roof rack weighs around 30kg). To this end, a roof structure was welded on, carrying the weight down to the floor plate. Using Trimble software, the collected data can be used for object positioning, measurement, data layer creation, 3D models and analysis of georeferenced imagery. The open data that is generated this way can be used to derive data for the current flood resilience purposes, but is subsequently also available for other disaster risk management purposes. So far, Ramani Huria has uploaded 20681 images, and mapped over 500 kilometers of road, according to the Mapillary statistics at <https://www.mapillary.com/profile/ramanihuria>

⁹ With special thanks to Hessel Winsemius (Deltares) and Steve Mather (City of Cleveland)

¹⁰ <https://www.mapillary.com/map/im/Cv3p42g3ISCFd79x9-CLnw/map>

¹¹ <http://infogeospatial.trimble.com/TrimbleMX7.html>



Trimble

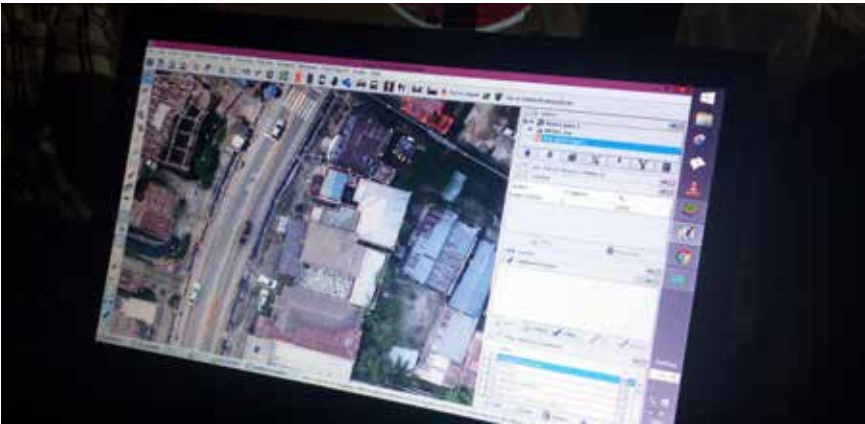
www.opens...

DAR
RAMANI
HURIA

Humanitarian
OpenStreetMap
Team

ATLAS

FIELD MAPPING TOOLS AND ACTIVITIES



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BUGURUNI

MAPPING PERIOD

August 17–September 10 2016

SURFACE AREA

3.49 km²

FLOOD PRONE AREA

0.69 km² (20%)

POPULATION (2012 CENSUS)

70,585

TOTAL NUMBER OF BUILDINGS

12,315

AT RISK OF FLOODING

Buildings at risk of flooding 2,937,
of which 10 are school and hospital
buildings.



Description and Recommendations

Buguruni's northern boundary is formed by the Msimbazi river valley, which separates Buguruni from Tabata and Kigogo. Within this ward, Maruzuku, Kisiwani and Mivinjeni subwards are most affected by flooding. Maruzuku and Kisiwani are primarily industrial areas and Mivinjeni is primarily residential.

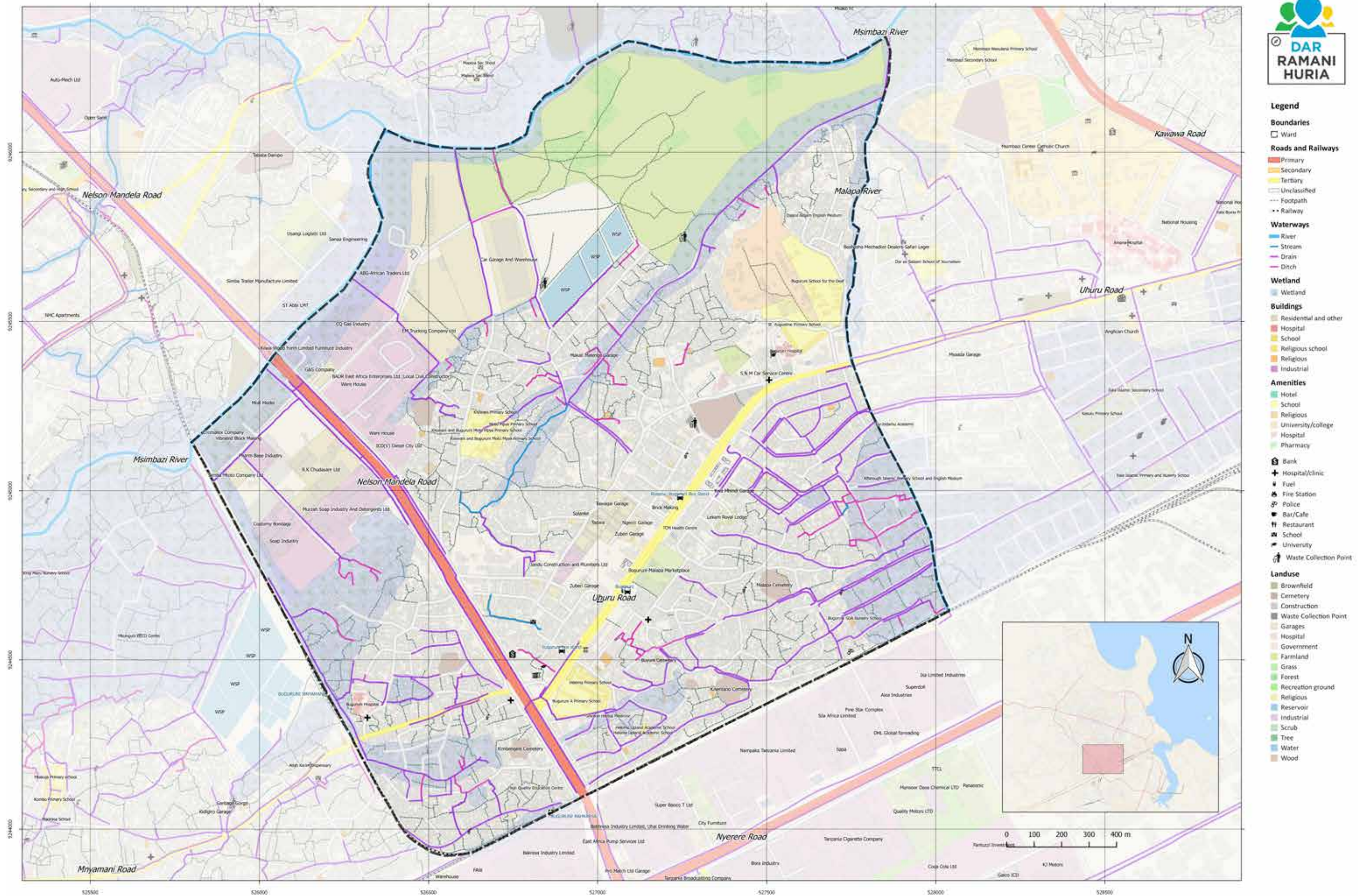
In Mivinjeni, the land most affected by flooding from the Msimbazi is mainly used for agriculture as local farmers grow vegetables and other crops. In addition to the Msimbazi river valley, a man made drain that cuts across Mivinjeni also causes floods during rainy season, affecting the surrounding residential buildings as the drain gets clogged with waste materials (mostly plastic bags) when it rains.

For Mnyamani subward, the central part is most affected by flooding as this area is at a lower elevation compared to its surroundings. Consequently, water drains into the space in the area; when it rains intensely, these drains overflow.

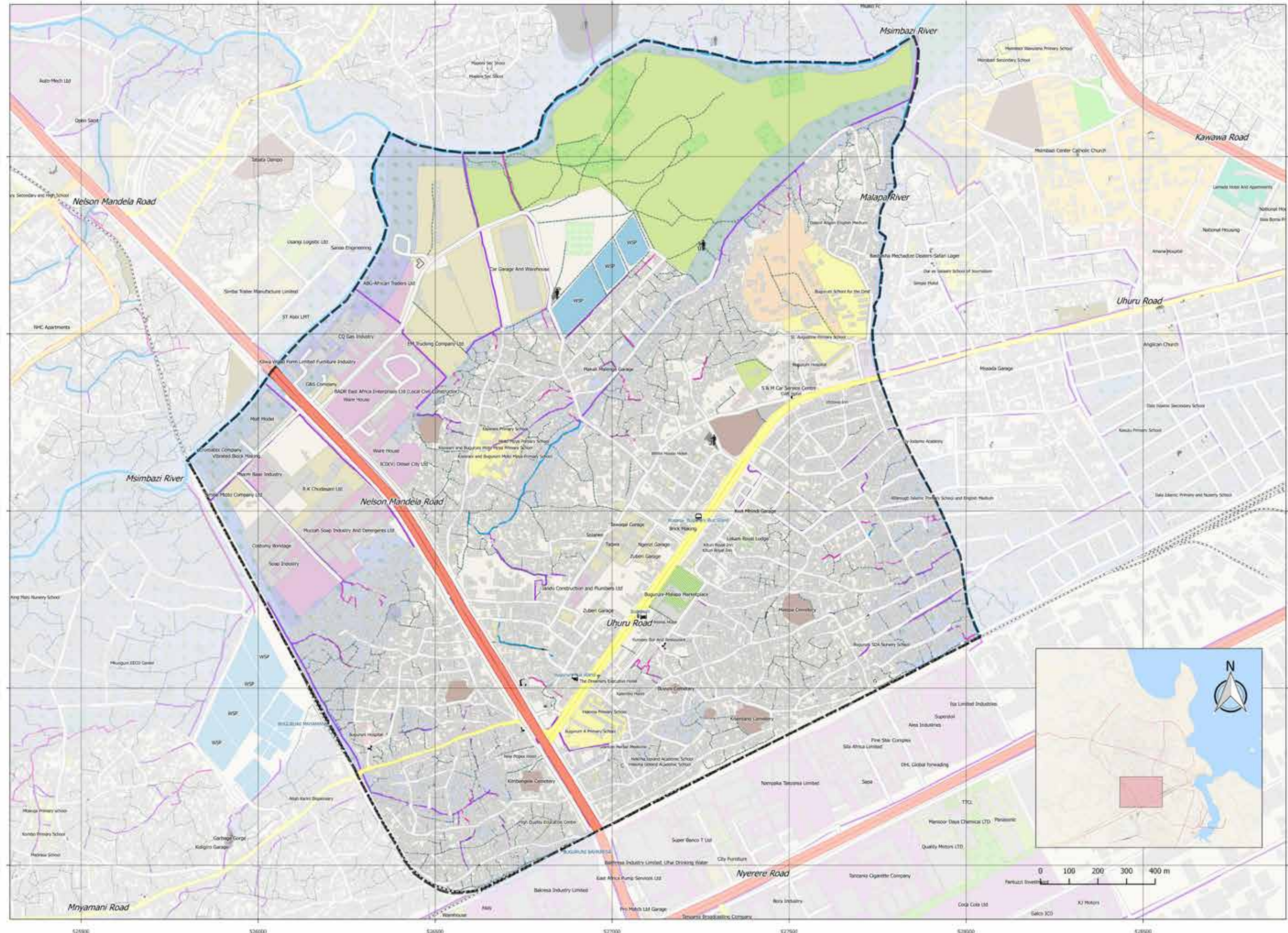
In Madenge and Malapa subwards, there is a large and well-built drain from Ilala ward that passes through. Though the drain is large and well built, at periods of high intensity rainfall its capacity to contain and drain water that comes from Madenge and Malapa (in Buguruni) and Mafuriko (in Ilala) is challenged, hence dispersing water into neighbouring sections of both Buguruni and Ilala.

Exploring how the existing drainage capacity of Buguruni could be improved could alleviate the accumulation of water in this basin, while keeping water contained within the drainage network.

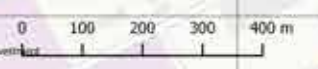
BUGURUNI DRAINAGE MAP



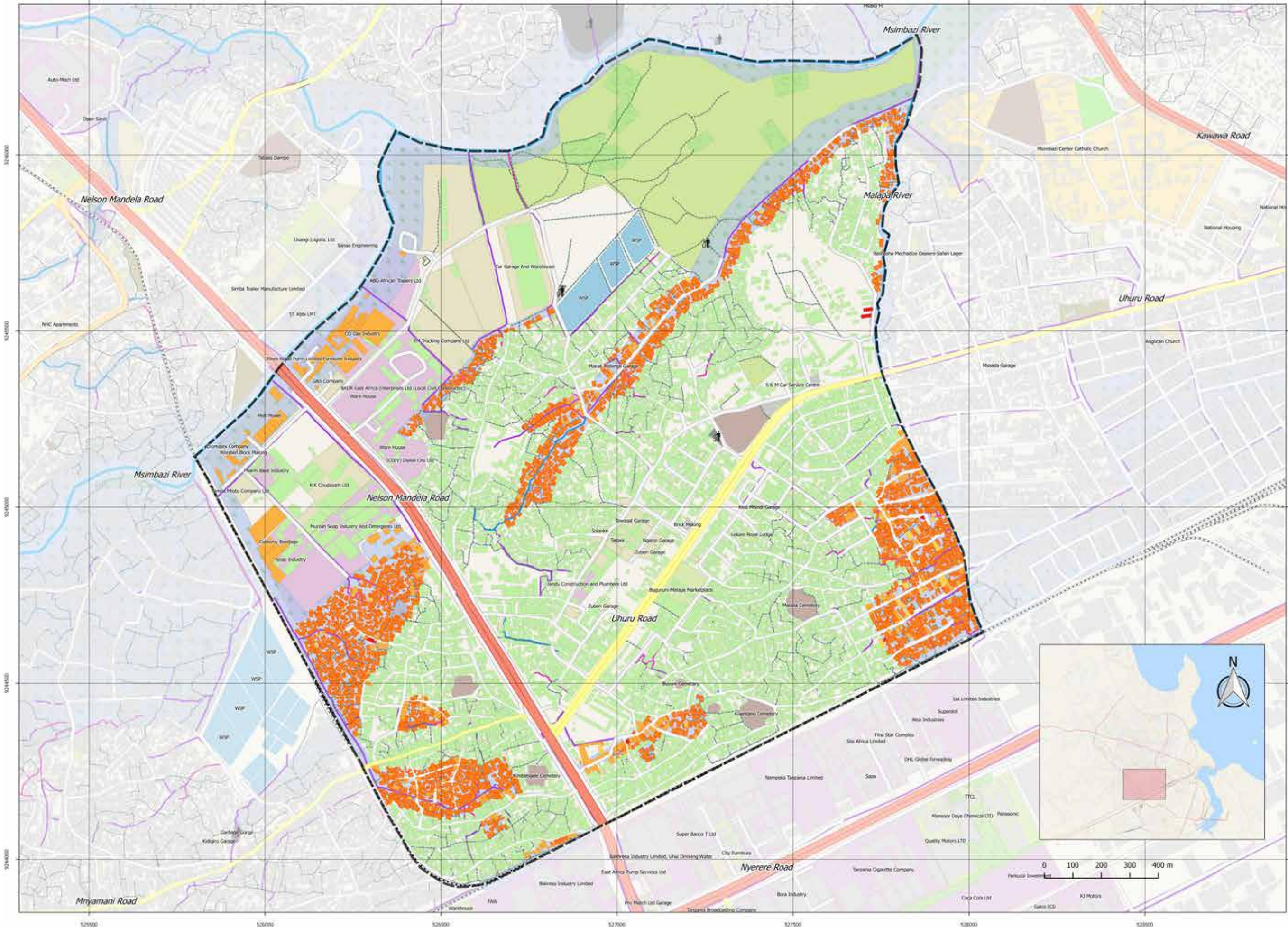
BUGURUNI GENERAL MAP



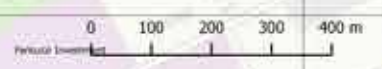
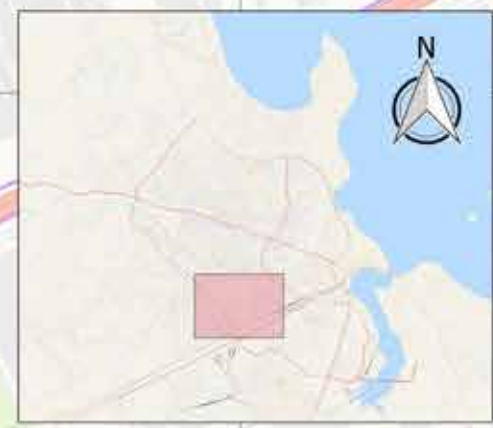
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



BUGURUNI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [12315]**
 - Not inundated [9387]
 - Inundated, school or hospital [9]
 - Inundated, residential [2545]
 - Inundated, commercial [323]
 - Inundated, other [51]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



ILALA

MAPPING PERIOD

November 12th until November 27th 2015

SURFACE AREA

2.02 km²

FLOOD PRONE AREA

0.91 km² (45%)

POPULATION (2012 CENSUS)

31,083

TOTAL NUMBER OF BUILDINGS

4,544

AT RISK OF FLOODING

Buildings at risk of flooding 2,513, of which 38 are school or hospital buildings



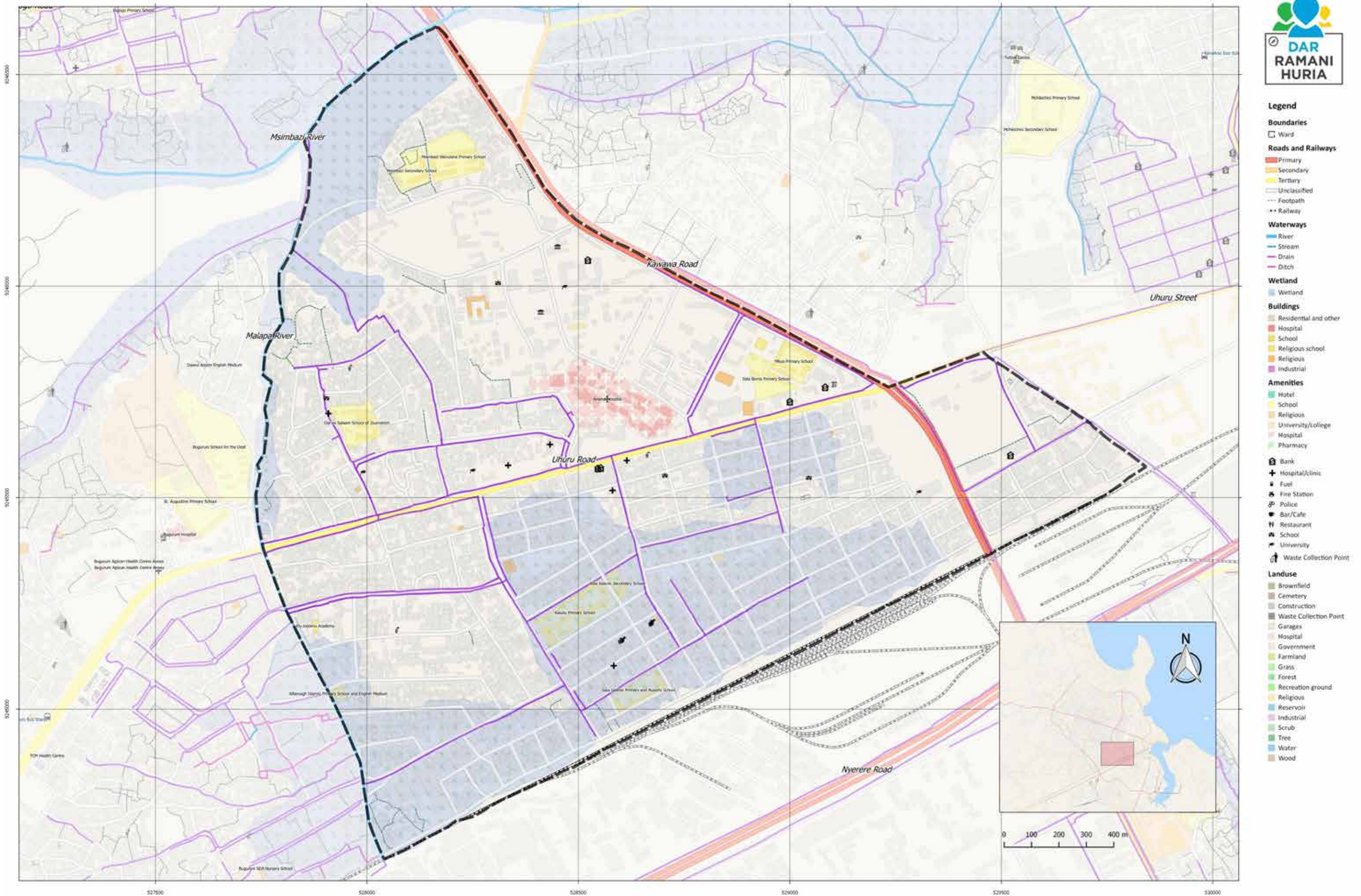
Description and Recommendations

Much of the terrain of Ilala ward is flat. Although it is largely planned and surveyed, it is under-served by a drainage network when compared to surrounding wards. The existing drainage channels are commonly blocked, leading to the overflow and pooling of water, instead of directing water away from the residential settlements.

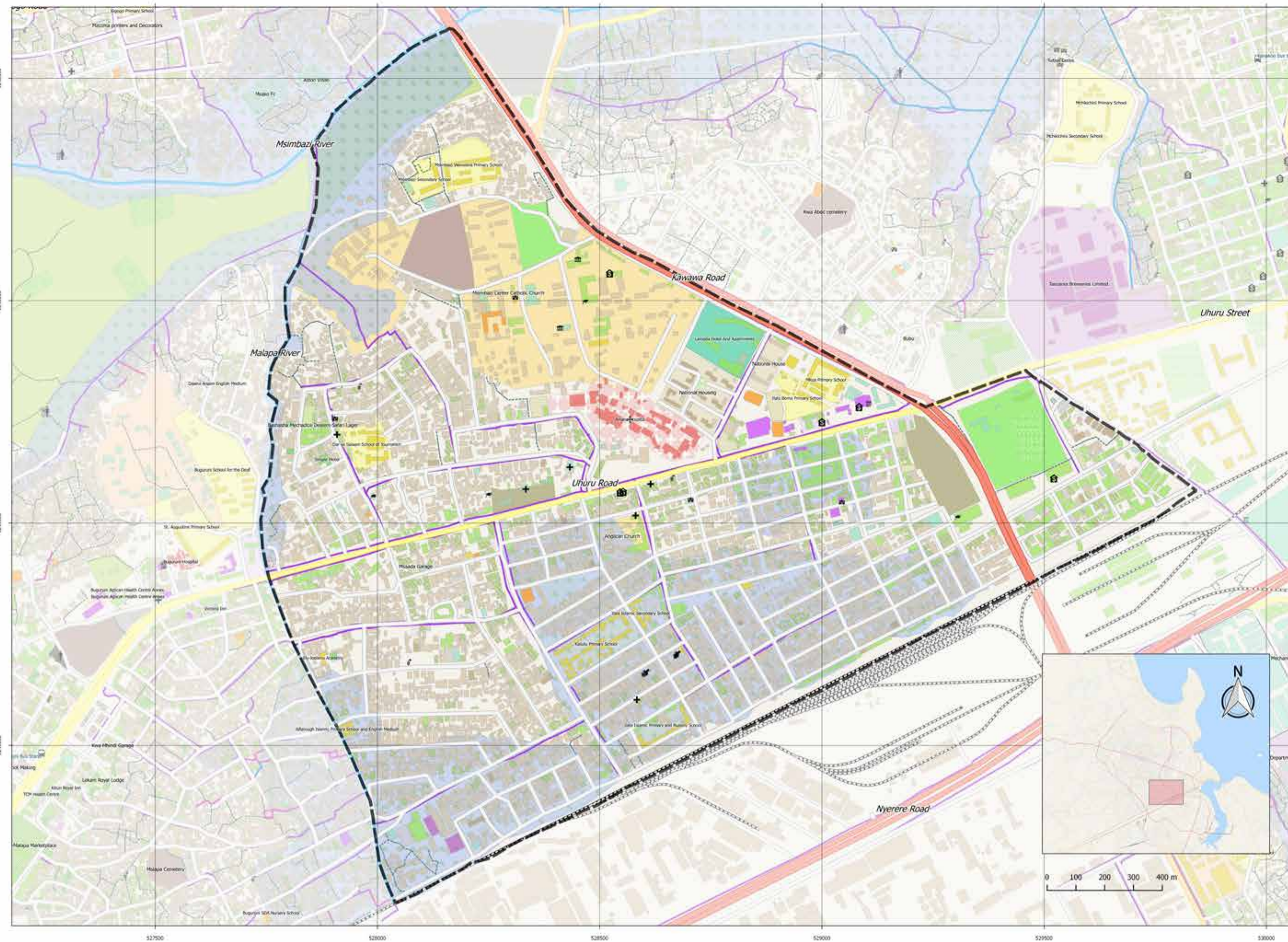
Additionally, there is no connection between a main water body, such as the Msimbazi river, with one major drainage point - the large drain in the Mafuriko subward on the boundary between Ilala and Buguruni.

It is recommended to regularly clean the existing drainage systems and look towards expanding the drainage infrastructure to connect to a major drainage point to increase drainage capacity.

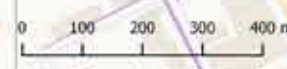
ILALA DRAINAGE MAP



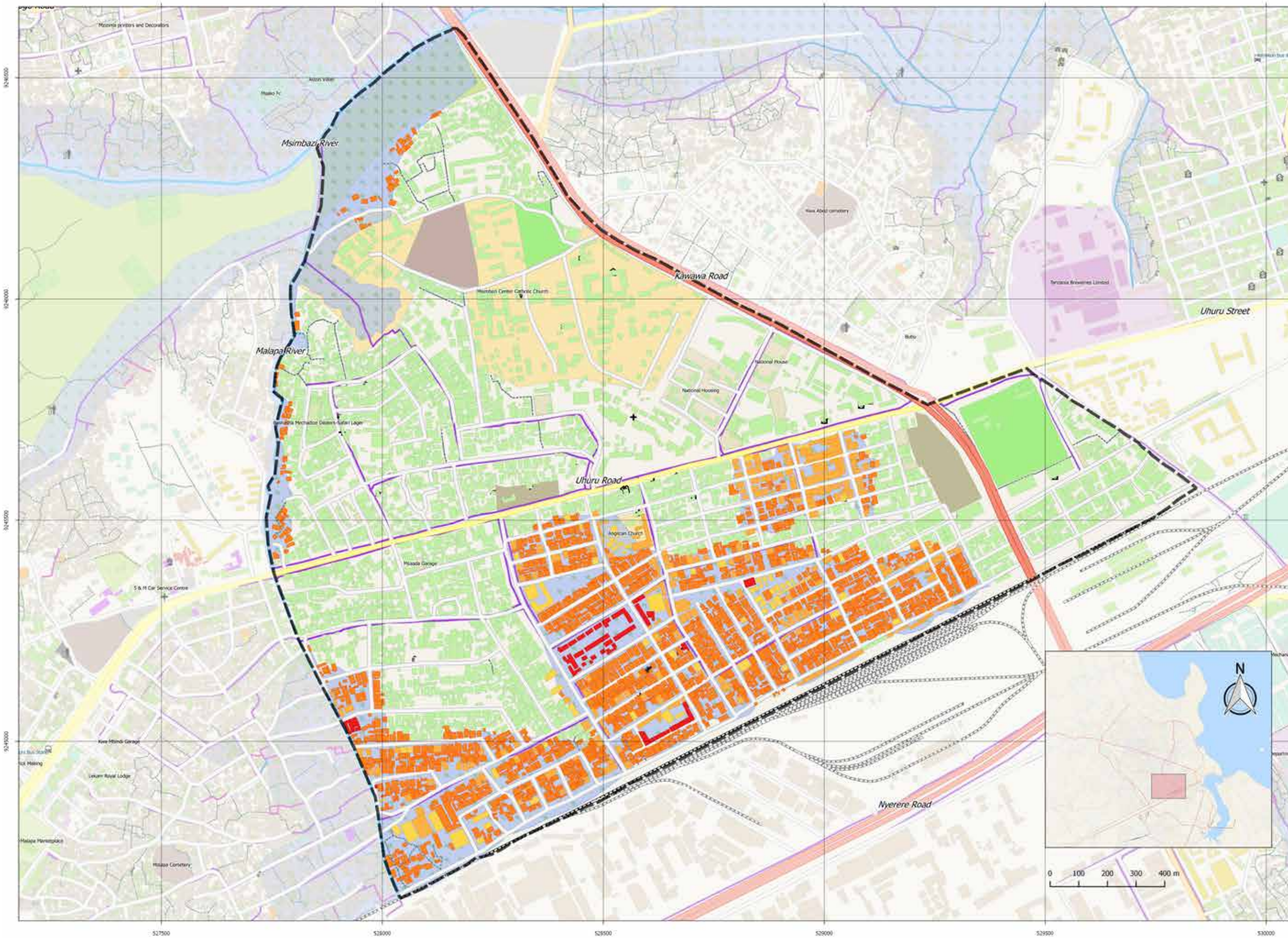
ILALA GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



ILALA POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [4544]**
 - Not Inundated (2803)
 - Inundated, school or hospital (38)
 - Inundated, residential (1400)
 - Inundated, commercial (233)
 - Inundated, other (79)
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MCHIKICHINI

MAPPING PERIOD

June 15th until July 1st 2015

SURFACE AREA

1.71 km²

FLOOD PRONE AREA

0.84 km² (49%)

POPULATION (2012 CENSUS)

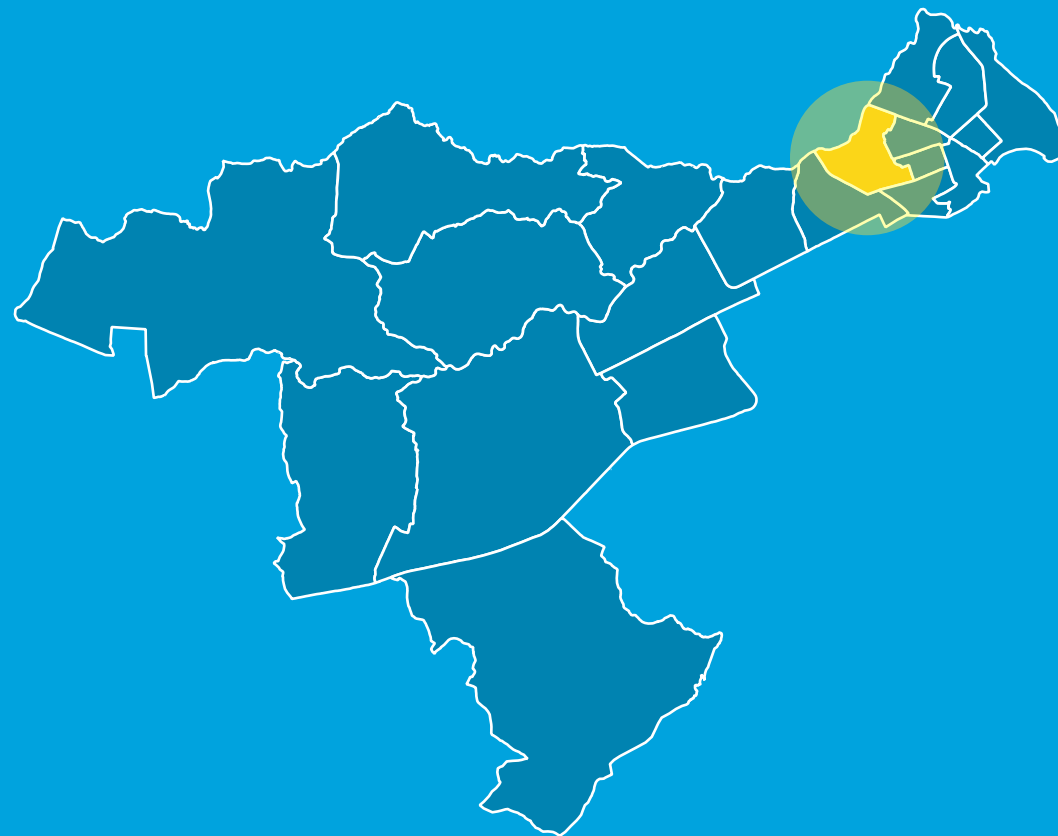
25,510

TOTAL NUMBER OF BUILDINGS

3,551

AT RISK OF FLOODING

Buildings at risk of flooding 1,374, of which 8 are school or hospital buildings.



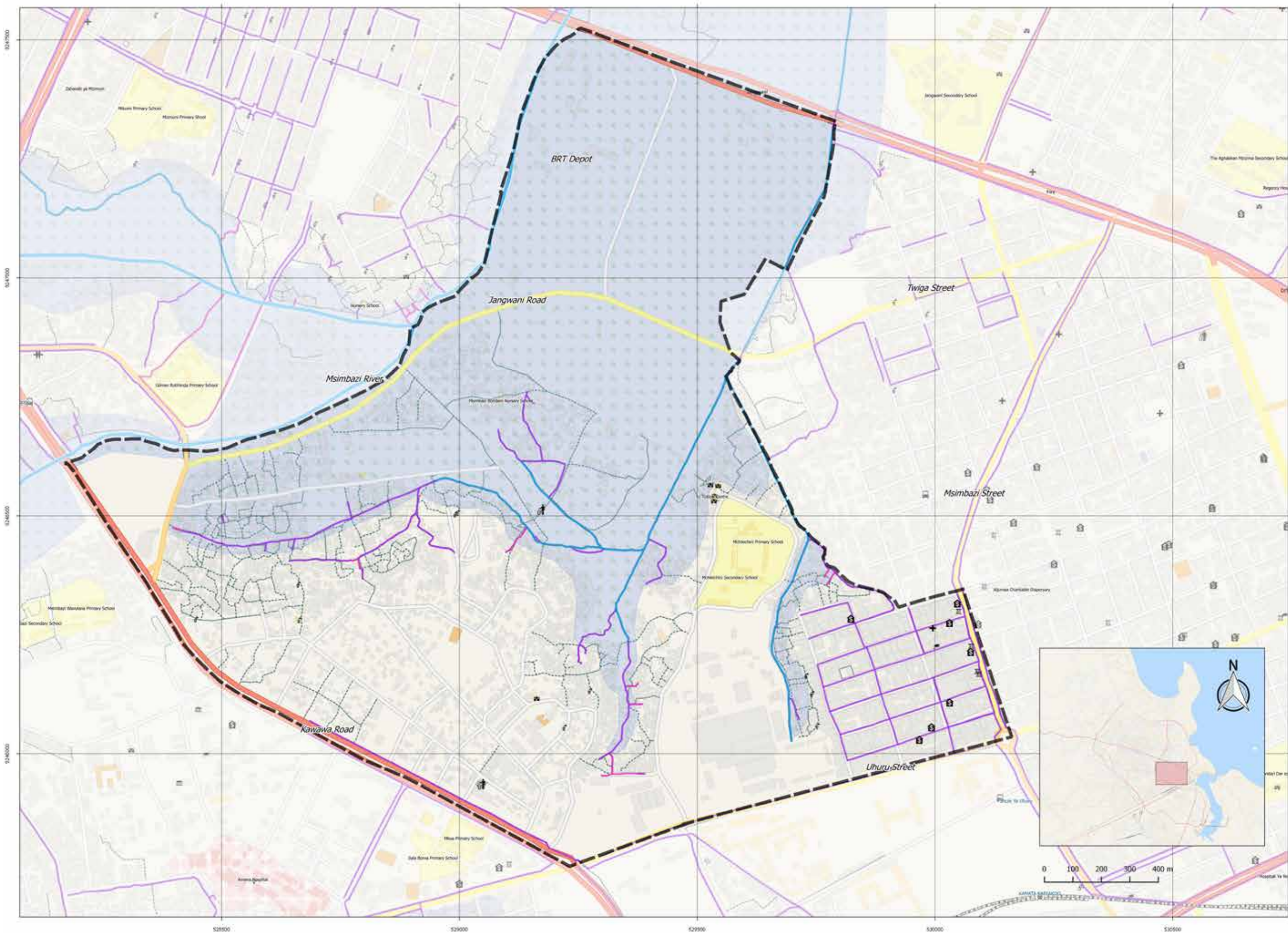
Description and Recommendations

The presence of the Msimbazi river valley makes Mchikichini exceptionally prone to flooding. Of its three subwards (Misheni Kota, Ilala Kota and Msimbazi Bondeni), Msimbazi Bondeni is the most flood prone, due to its low elevation raising the risk of flooding across the subwards' infrastructure.

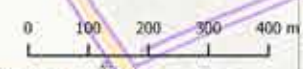
Compared to Msimbazi Bondeni, Misheni Kota and Ilala Kota are comparatively less affected as they are located on higher grounds, safeguarding them from the consequences of heavy rainfall, which flow towards the Jangwani fields through Msimbazi Bondeni.

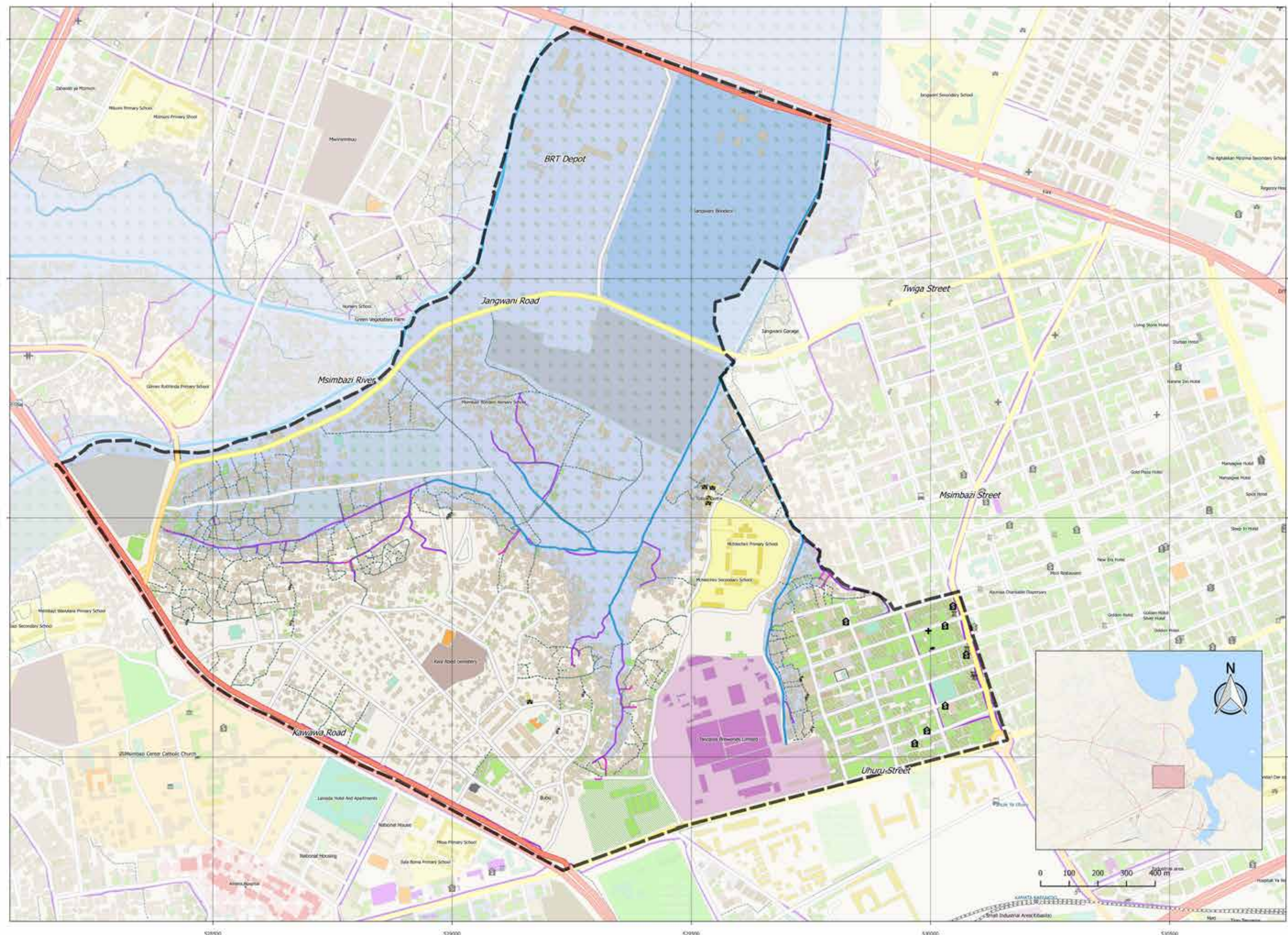
Establishing drainage ditches could potentially ameliorate this situation of overflowing water, lessening the impact and risk of flooding on ward residents.

MCHIKICHINI DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

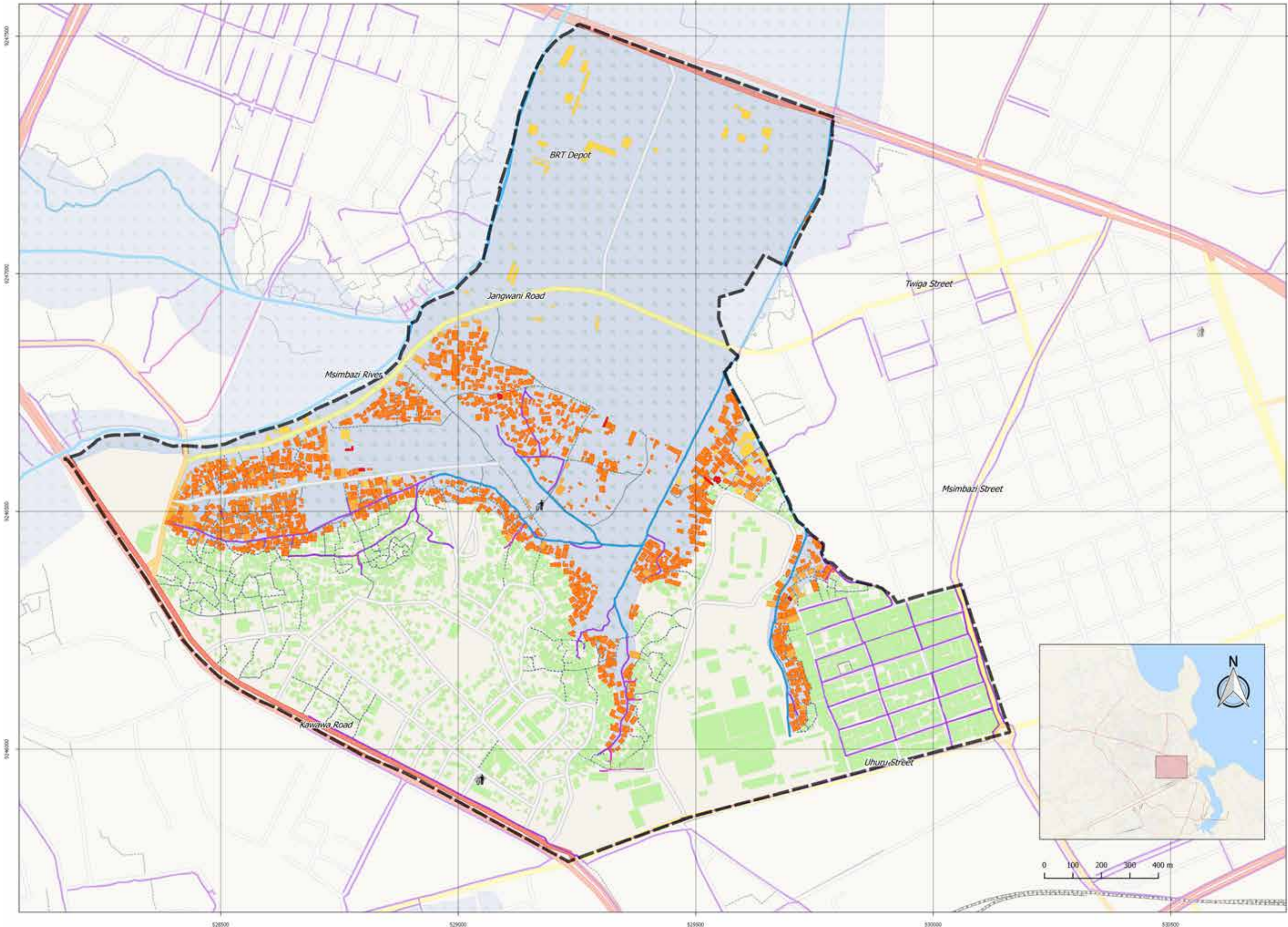




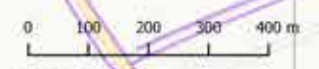
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



MCHIKICHINI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [3551]**
 - Not inundated [2177]
 - Inundated, school or hospital [8]
 - Inundated, residential [1197]
 - Inundated, commercial [100]
 - Inundated, other [70]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



TABATA

MAPPING PERIOD

October 7th until November 6th 2015

SURFACE AREA

4.49 km²

FLOOD PRONE AREA

0.82 km² (18%)

POPULATION (2012 CENSUS)

74,742

TOTAL NUMBER OF BUILDINGS

11,485

AT RISK OF FLOODING

Buildings at risk of flooding 2,324, of which 2 are school or hospital buildings.



Description and Recommendations

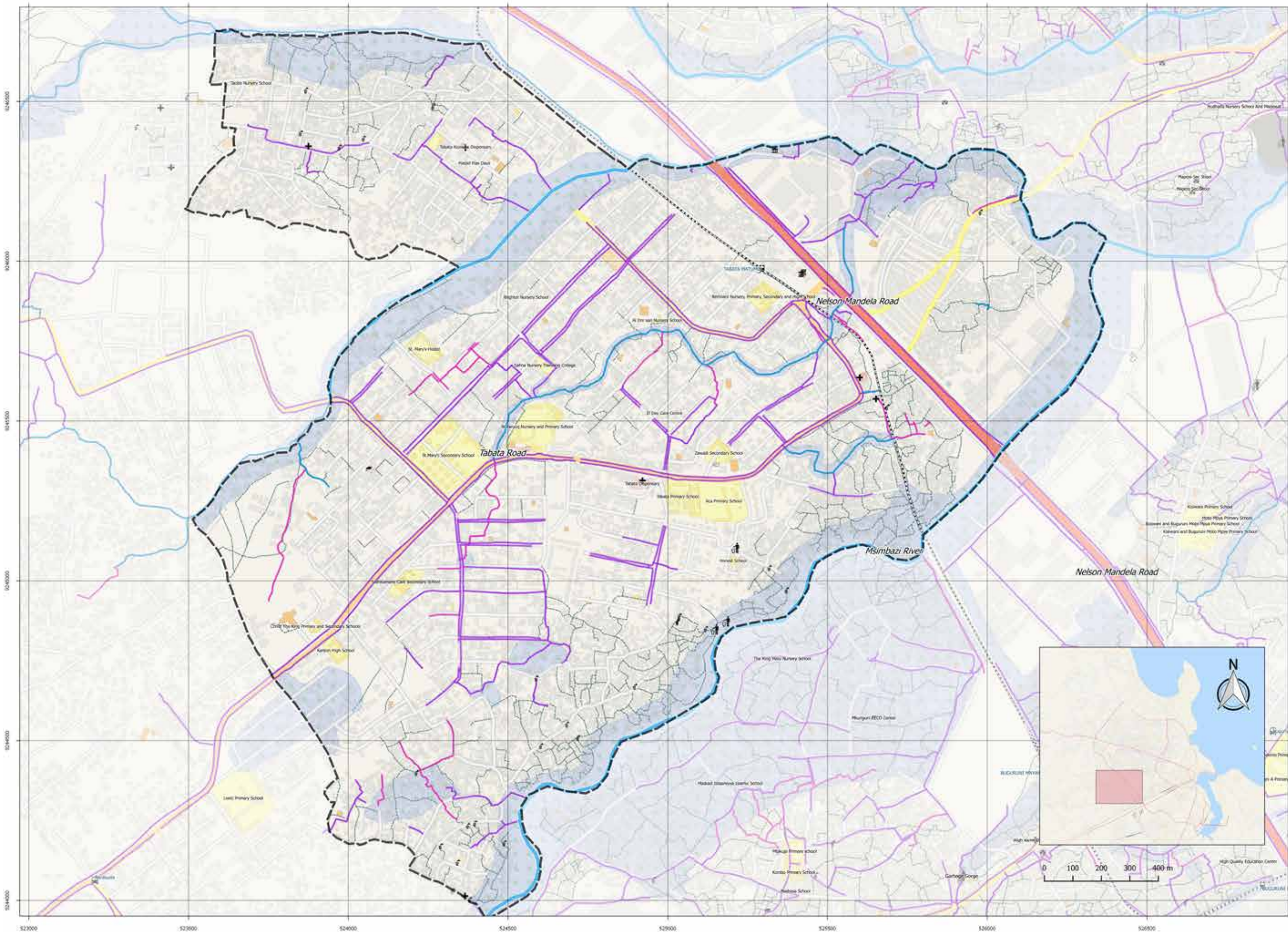
With the Msimbazi river valley located to the south of Tabata, parts of the ward, especially Msimbazi Magharibi, Msimbazi Mama, Mtambani, Matumbi and Mandela subwards, are affected by flooding.

Most residential buildings along and within the valley are vulnerable to the point that some have been abandoned by their owners. The river over time has expanded in width, placing buildings and infrastructure along its valley at risk. This has exacerbated by local residents engaging in economic activities within the river valley, such as urban agriculture and sand mining for construction purposes.

Kisiwani subward in northern Tabata is also impacted by flooding. Two shallow river streams that run along the boundaries of the subward contribute to flooding of residential buildings when extreme weather events occur, raising the risk of damage Tabata and Tenge subwards.

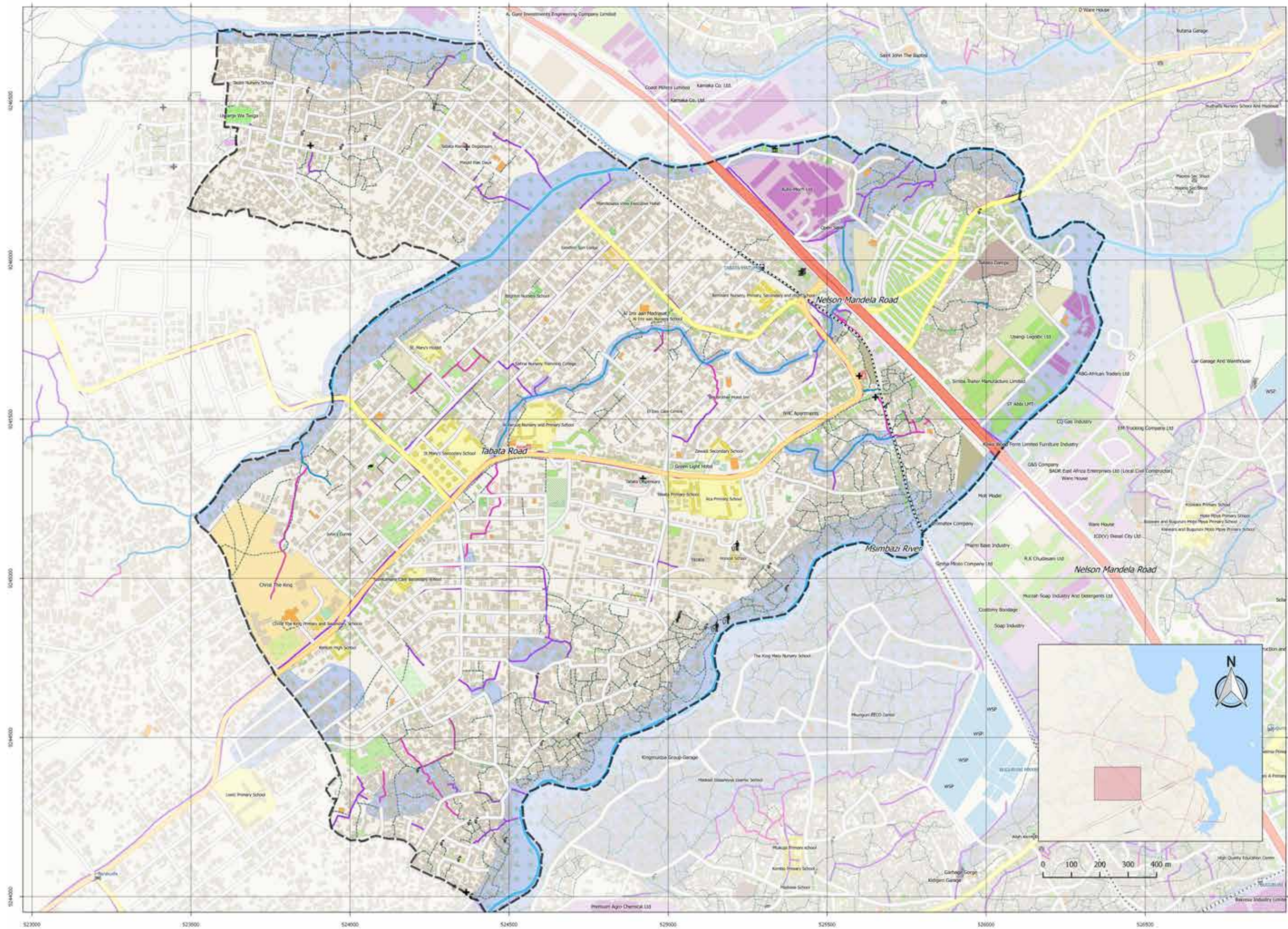
Expanding capacity of these streams would potentially allow for a reduction of flood risk.

TABATA DRAINAGE MAP



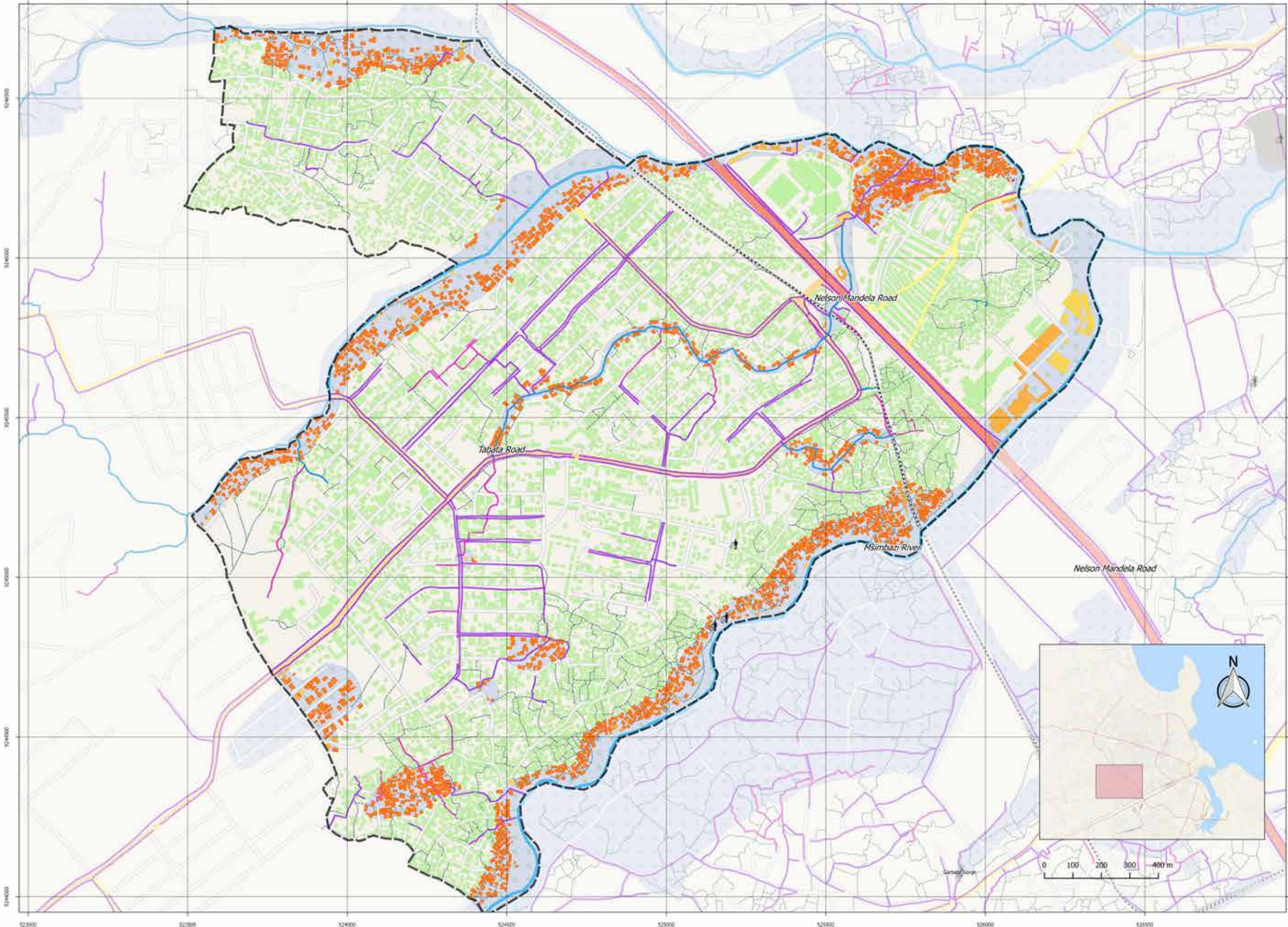
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

TABATA GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

TABATA POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Buildings_Inundation [11485]**
 - Not inundated [9162]
 - Inundated, school or hospital [1]
 - Inundated, residential [2140]
 - Inundated, commercial [124]
 - Inundated, other [58]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



VINGUNGUTI

MAPPING PERIOD

September 11th until October 9th 2015

SURFACE AREA

4.48 km²

FLOOD PRONE AREA

1.22 km² (27%)

POPULATION (2012 CENSUS)

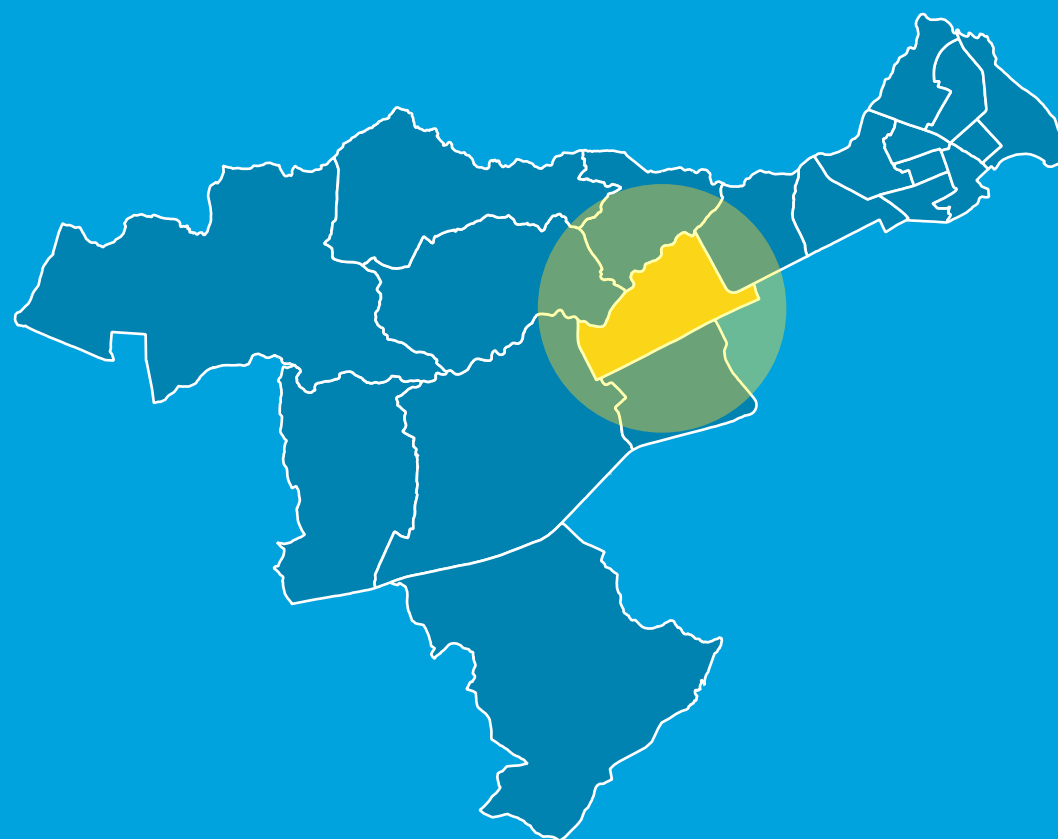
106,946

TOTAL NUMBER OF BUILDINGS

15,080

AT RISK OF FLOODING

Buildings at risk of flooding 5,321, of which 26 are school or hospital buildings.

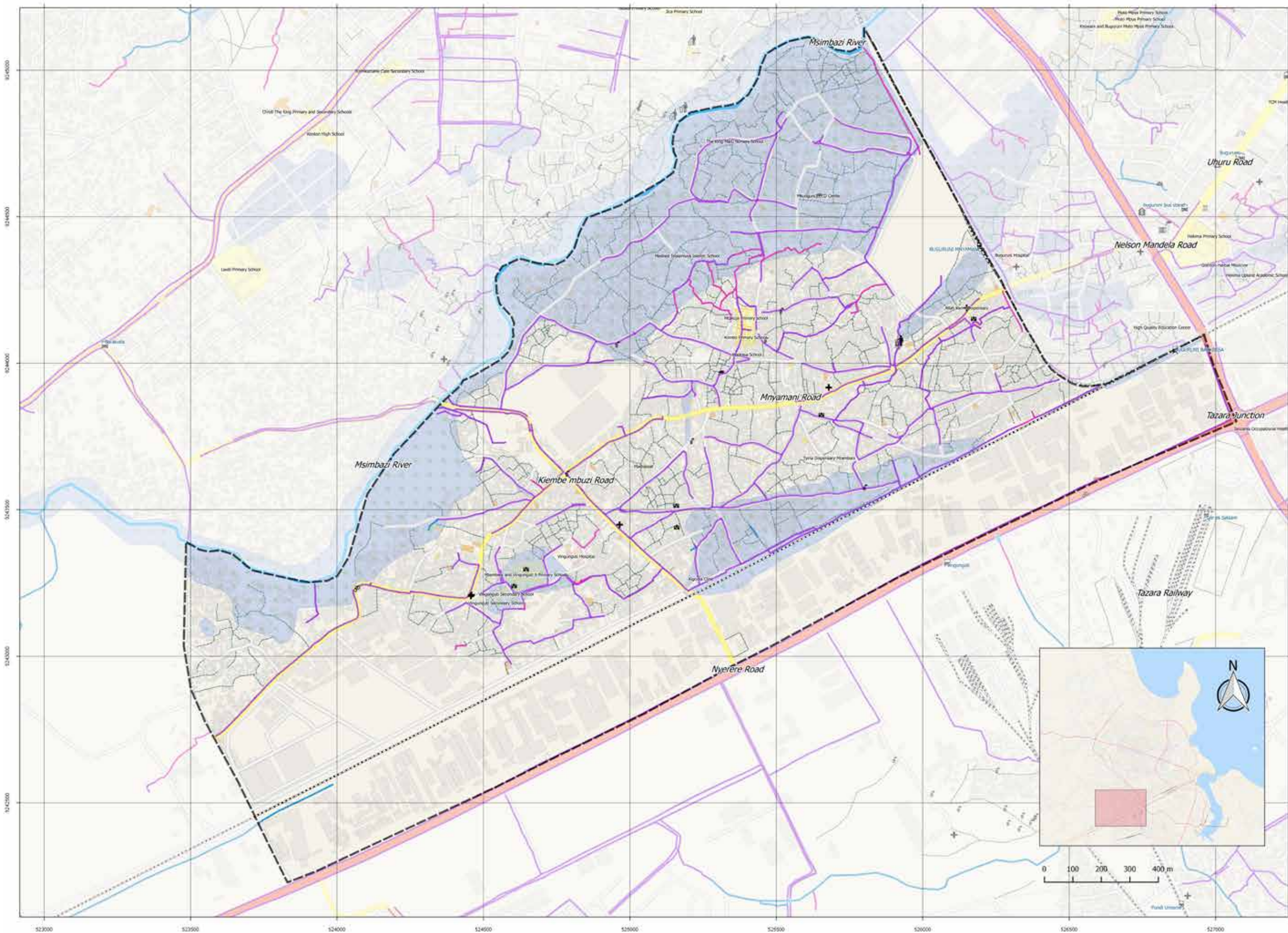


Description and Recommendations

The northern boundary of Vingunguti is formed by the Msimbazi river valley. Most residential buildings along the river valley are affected by flooding, while Majengo, Kombo and Mji Mpya subwards are particularly vulnerable. The reasons are much the same as for Tabata: human economic activities has led to an increase of river width, reducing the river valley's holding-capacity of water. To prevent damage, local residents of Vingunguti have engaged in initiatives to clean the river valley.

In addition to the areas affected by the Msimbazi river, buildings located around the railway line that passes through Mtakuja, Mtambani and Faru subwards are often exposed to flooding. This is mainly due to the drainage channel constructed along the line that does not connect to a main drainage channel, causing it to overflow into residential properties and businesses. Connecting this channel could be a first step in mitigating Vingunguti flood risk.

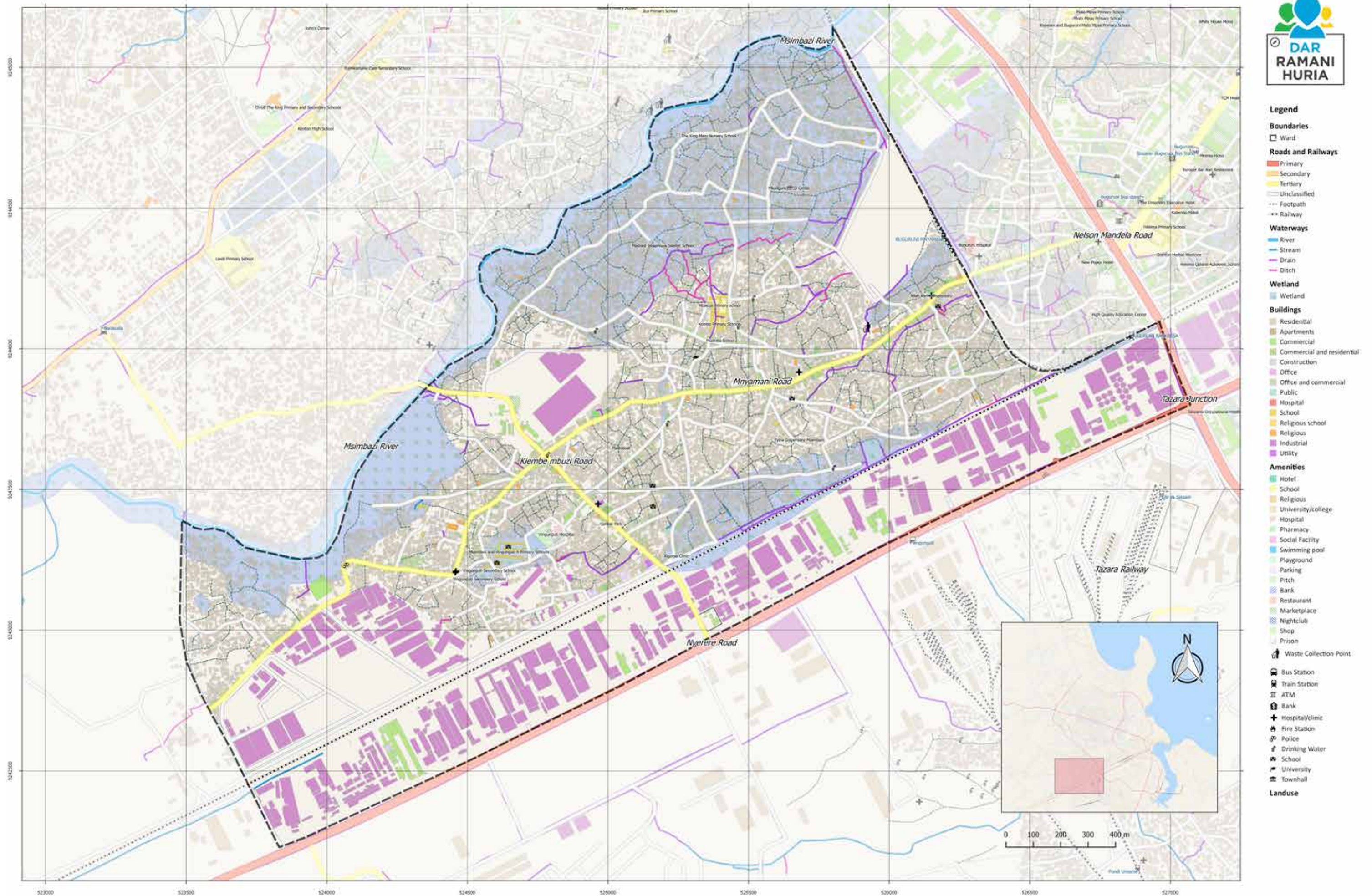
VINGUNGUTI DRAINAGE MAP



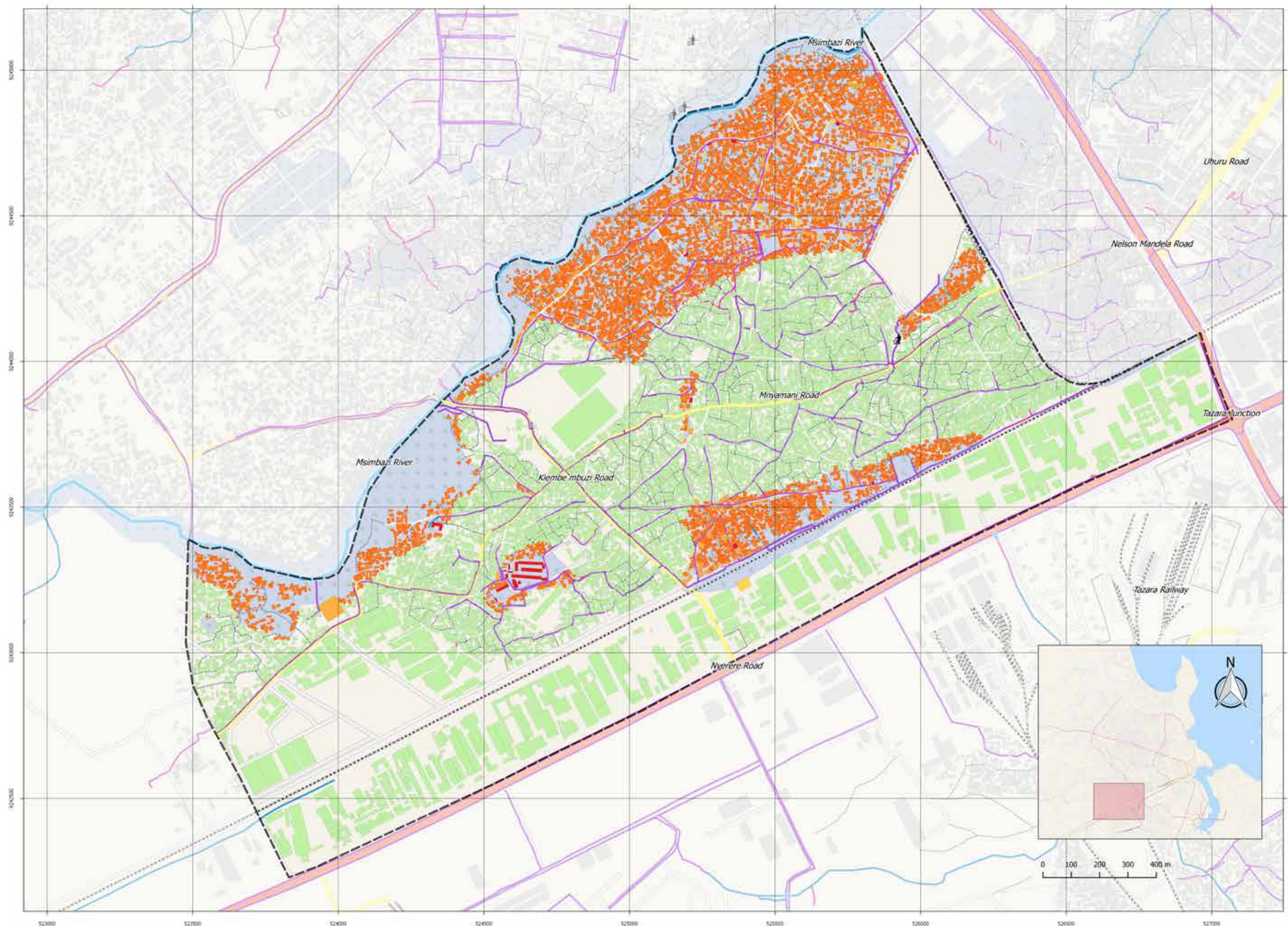
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**



VINGUNGUTI GENERAL MAP



VINGUNGUTI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [15080]**
 - Not Inundated [9785]
 - Inundated, school or hospital [26]
 - Inundated, residential [4911]
 - Inundated, commercial [308]
 - Inundated, other [52]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



HANANASIF

MAPPING PERIOD
August 17th until September 10th 2015

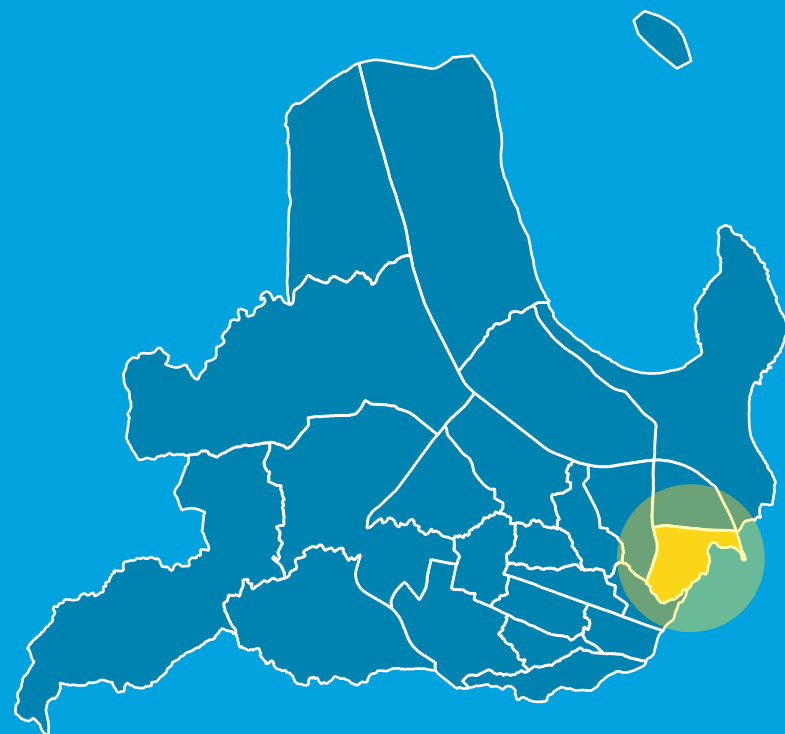
SURFACE AREA
1.85 km²

FLOOD PRONE AREA
0.57 km² (31%)

POPULATION (2012 CENSUS)
37,115

TOTAL NUMBER OF BUILDINGS
6,528

AT RISK OF FLOODING
Buildings at risk of flooding 1,272, of which 1 is a school building.



Description and Recommendations

Hananasif's southwestern boundary is formed by the river Ng'ombe and its southern and southeastern parts bordering on the Msimbazi river. Accordingly, the neighbouring Kawawa and Hananasif subwards are most impacted by high intensity rainfall when the river Ng'ombe overflows, before it connects to the Msimbazi river.

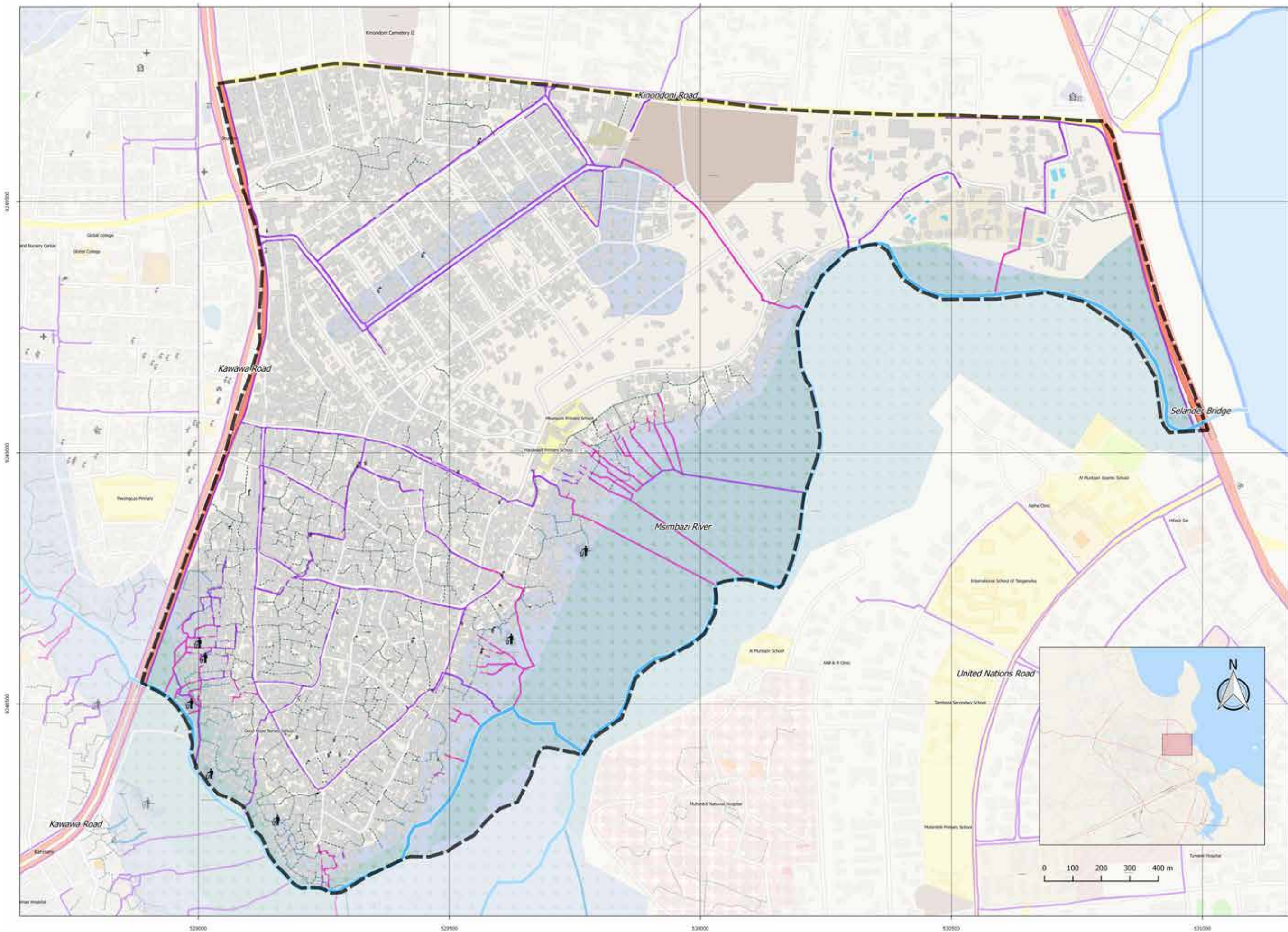
A drainage channel that passes through Hananasif from Tandale, Makumbusho, Ndugumbi, Magomeni and Mwananyamala wards further exacerbates flood risk.

Both the Mkunguni A and Mkunguni B subwards are adjacent to the Msimbazi river valley and the Indian Ocean. Upstream, water has drained through Vingunguti, Tabata, Kigogo, Buguruni, Mchikichini, and many other wards in the basin on its way through to Selander Bridge and into the Indian Ocean.

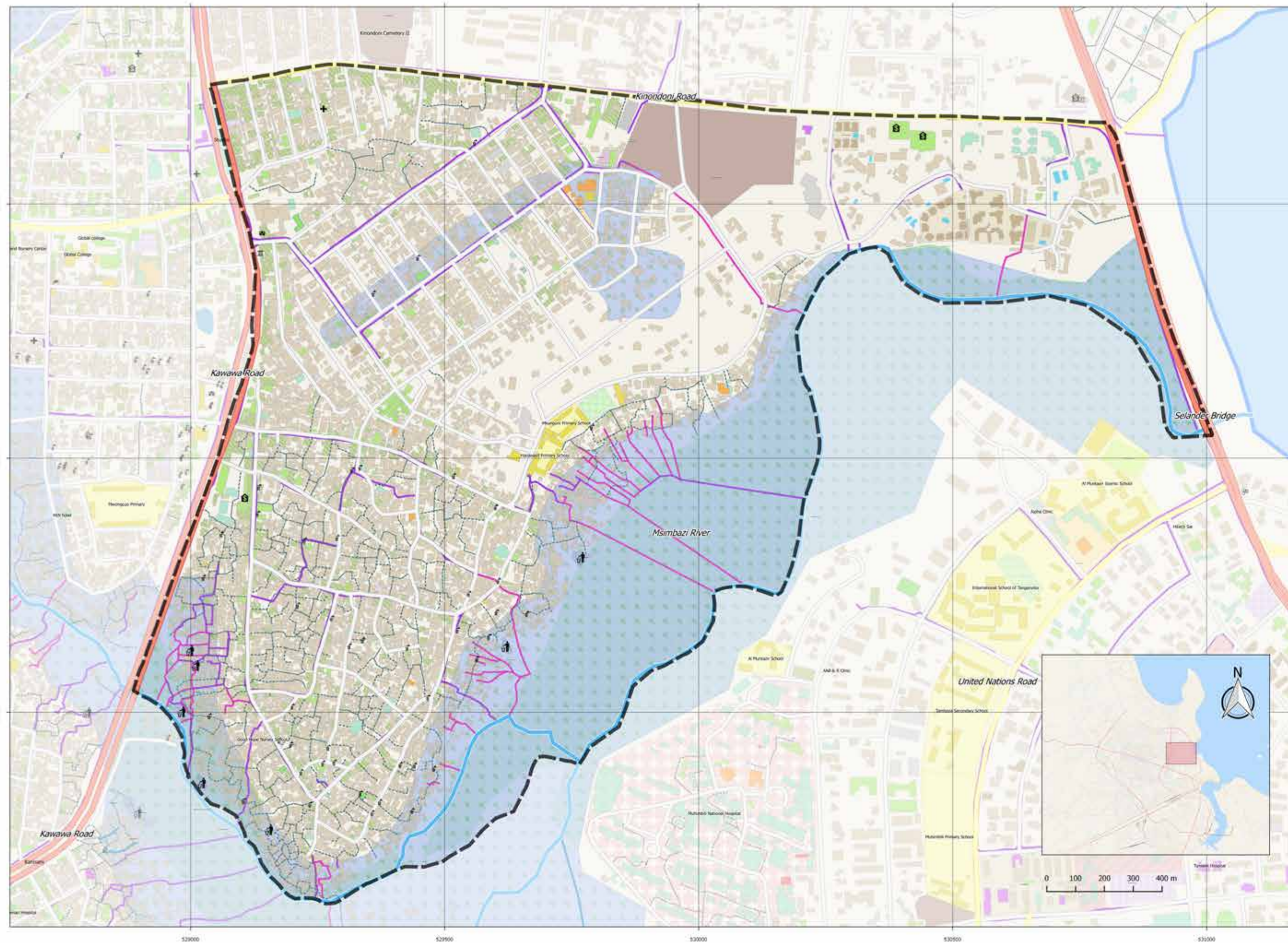
The low elevation and proximity of Mkunguni A and Mkunguni B to the Msimbazi river valley, and the amount of water draining from upstream, increases the flood risk in these areas. The issue of solid waste carried downstream amplifies this risk as waste materials get caught in the mangrove forest at the mouth of the river.

Efforts to clean this forest could help to mitigate this; however, improving solid waste collection across all municipalities in Dar es Salaam and educating residents to use these services would allow for improved drainage across the basin into the ocean, negate the need for cleaning, and reduce the impact of flooding on the residents of Hananasif.

HANANASIF DRAINAGE MAP

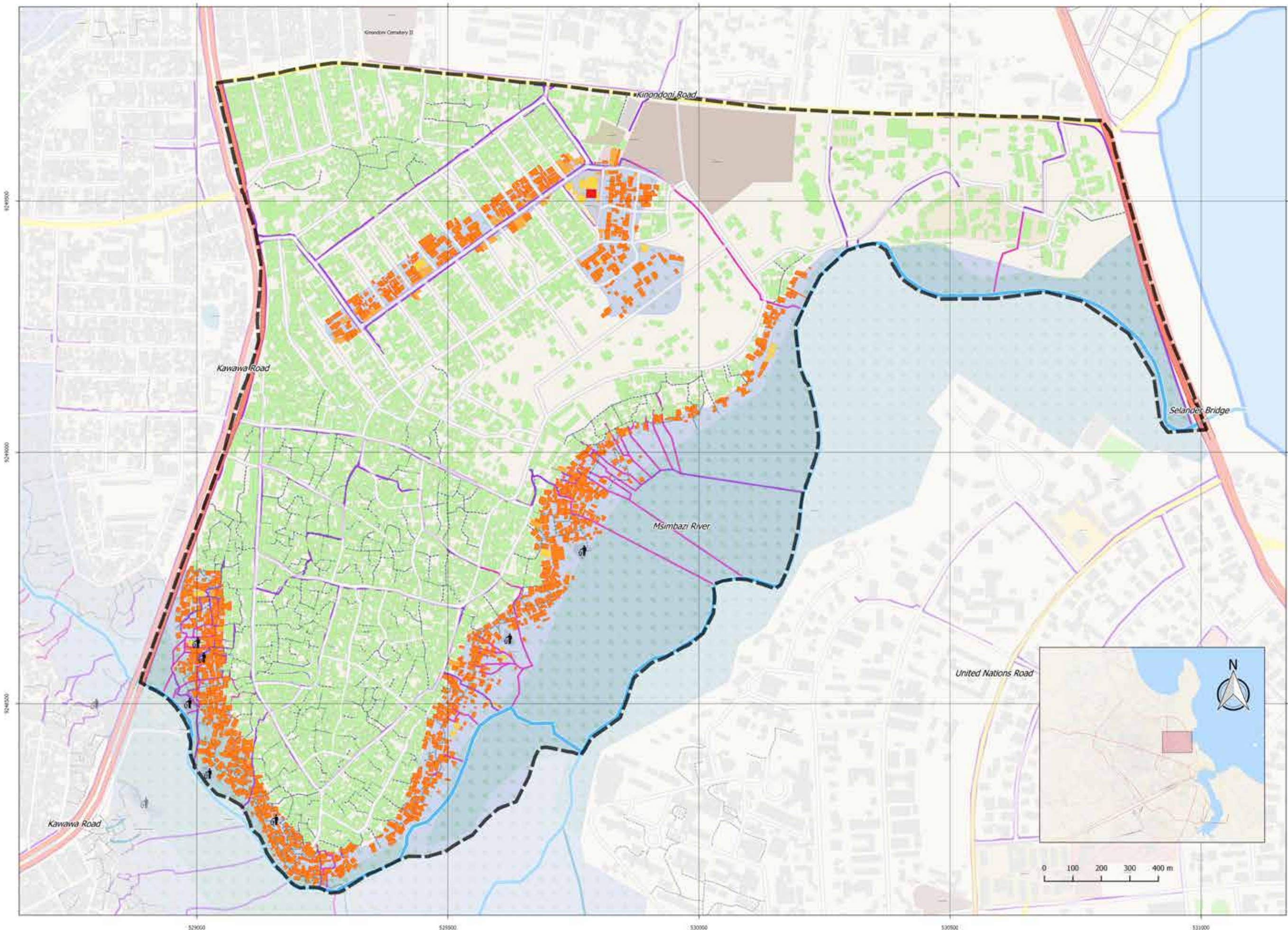


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

HANANASIF POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [6528]**
 - Not Inundated [5257]
 - Inundated, school or hospital [1]
 - Inundated, residential [1191]
 - Inundated, commercial [51]
 - Inundated, other [28]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point

KIGOGO

MAPPING PERIOD

September 11th until October 9th 2015

SURFACE AREA

1.91 km²

FLOOD PRONE AREA

0.92 km² (48%)

POPULATION (2012 CENSUS)

57,613

TOTAL NUMBER OF BUILDINGS

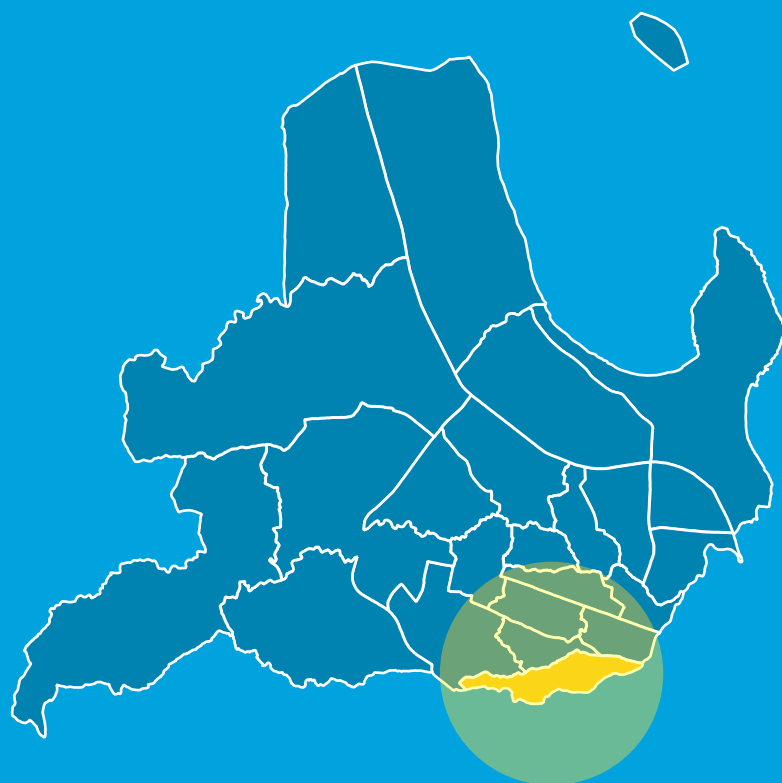
8,869

SCHOOL AND HOSPITAL BUILDINGS

4 school buildings/ hospital building

AT RISK OF FLOODING

Buildings at risk of flooding 4,450, of which 4 are school or hospital buildings.

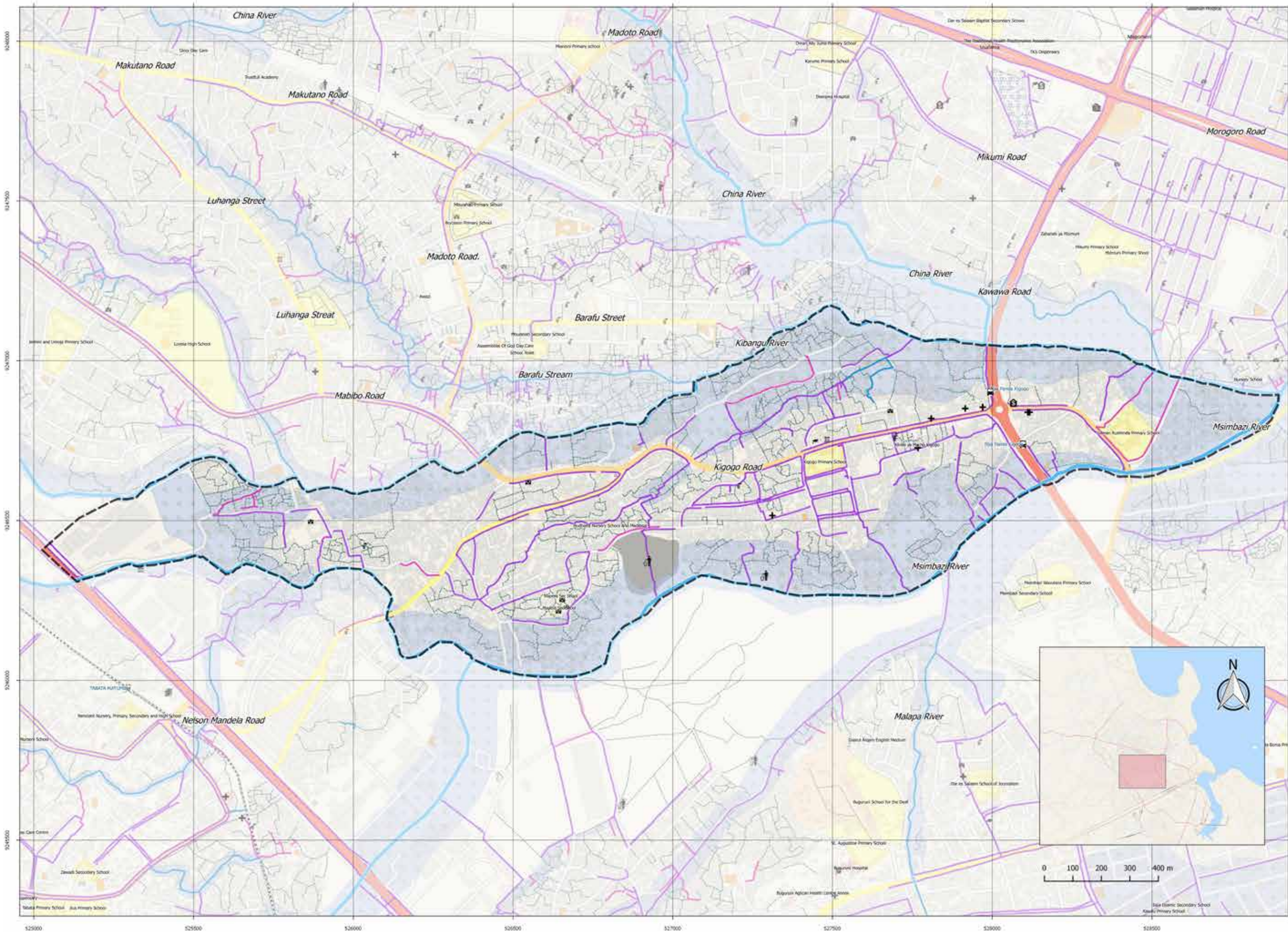


Description and Recommendations

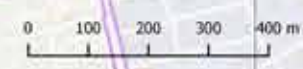
Kigogo is surrounded by river valleys on both sides. Historically, Kigogo was not terribly affected by floods, but flood prone areas are currently expanding due to higher urban density and an increase in population.

Residents are developing settlements alongside the river valleys without adding solid waste collection points. This has led to the dumping of solid waste into waterways, subsequently blocking the river. A lack of drainage channels to transport water away from the settlement also contributes to Kigogo's flood risk during the rainy seasons, demonstrating the need to expand the current drainage infrastructure.

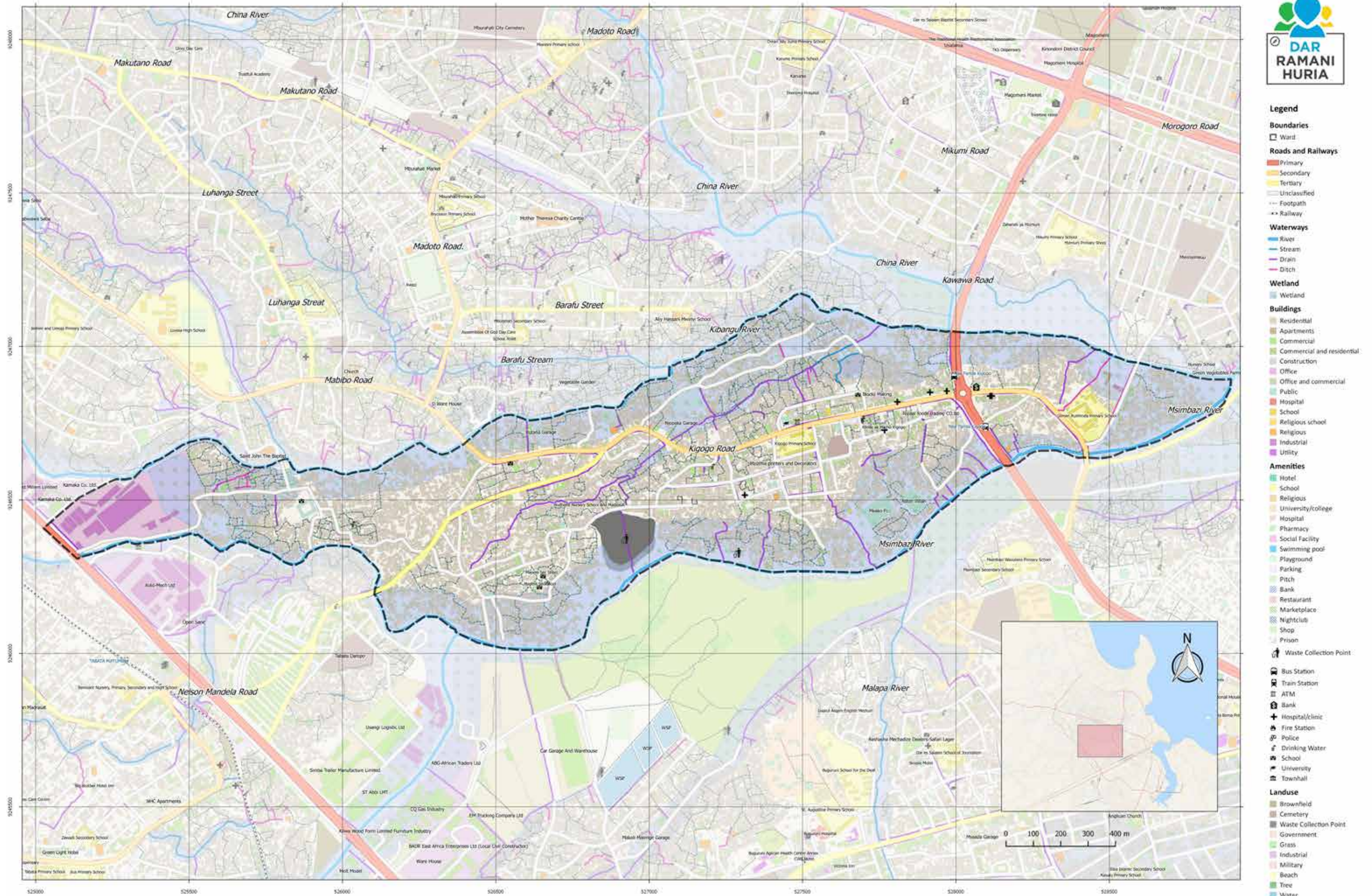
KIGOGO DRAINAGE MAP



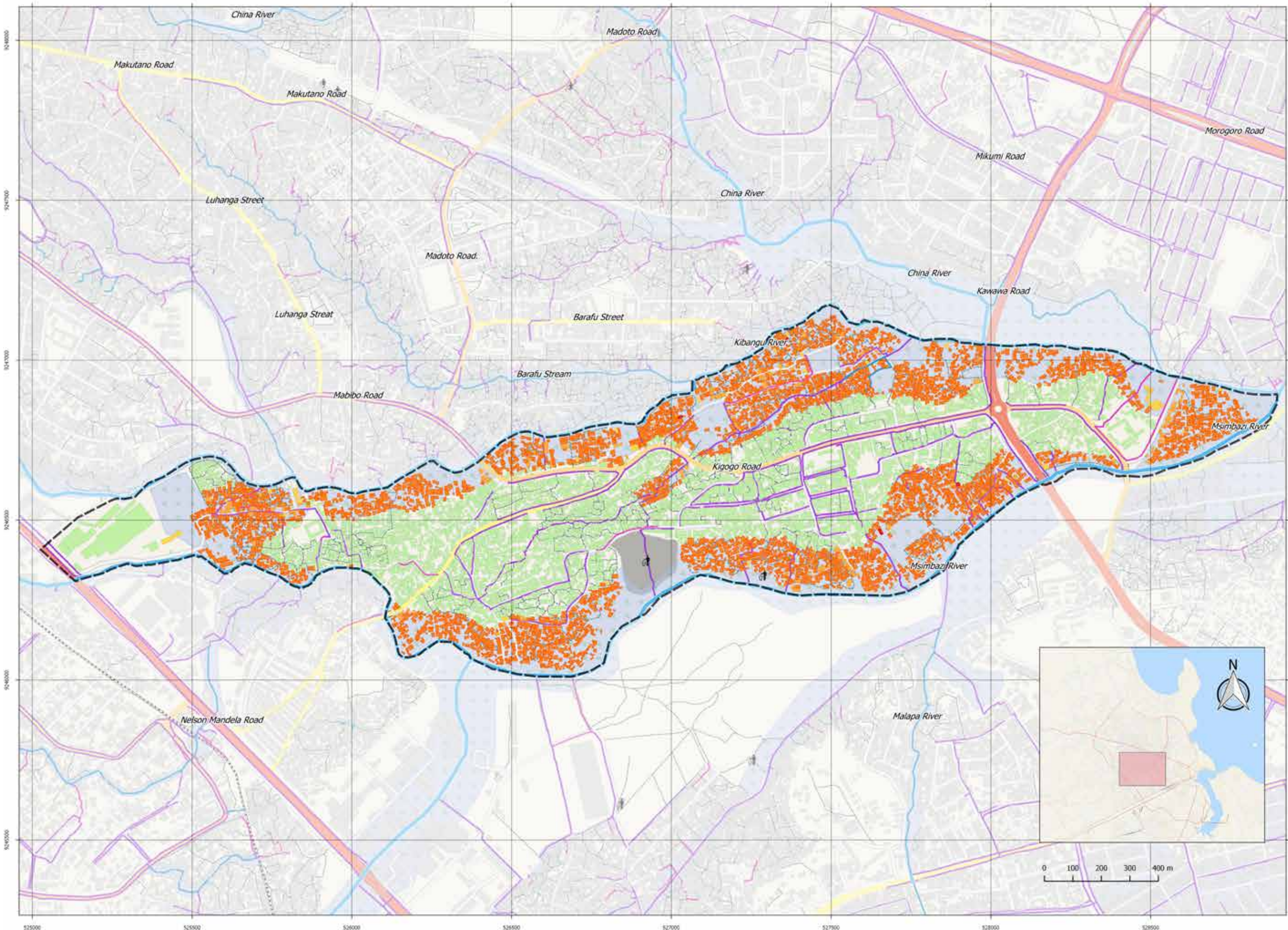
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



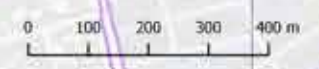
KIGOGO GENERAL MAP



KIGOGO POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [8869]**
 - Not Inundated [4419]
 - Inundated, school or hospital [4]
 - Inundated, residential [4195]
 - Inundated, commercial [191]
 - Inundated, other [62]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MAGOMENI

MAPPING PERIOD

August 17th until September 10th 2015

SURFACE AREA

1.11 km²

FLOOD PRONE AREA

0.50 km² (45%)

POPULATION (2012 CENSUS)

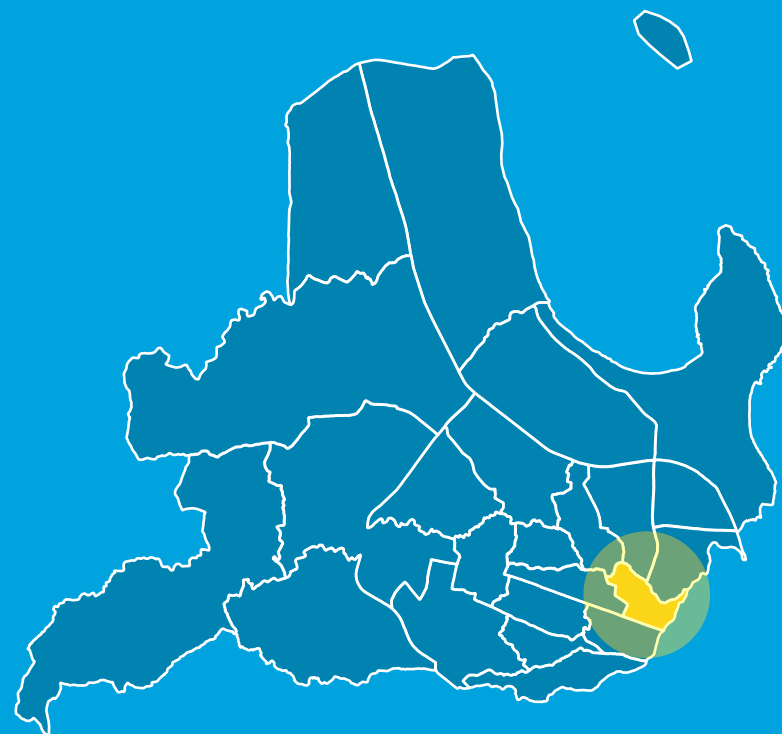
24,400

TOTAL NUMBER OF BUILDINGS

4,273

AT RISK OF FLOODING

Buildings at risk of flooding 1,744, of which none are school or hospital buildings.



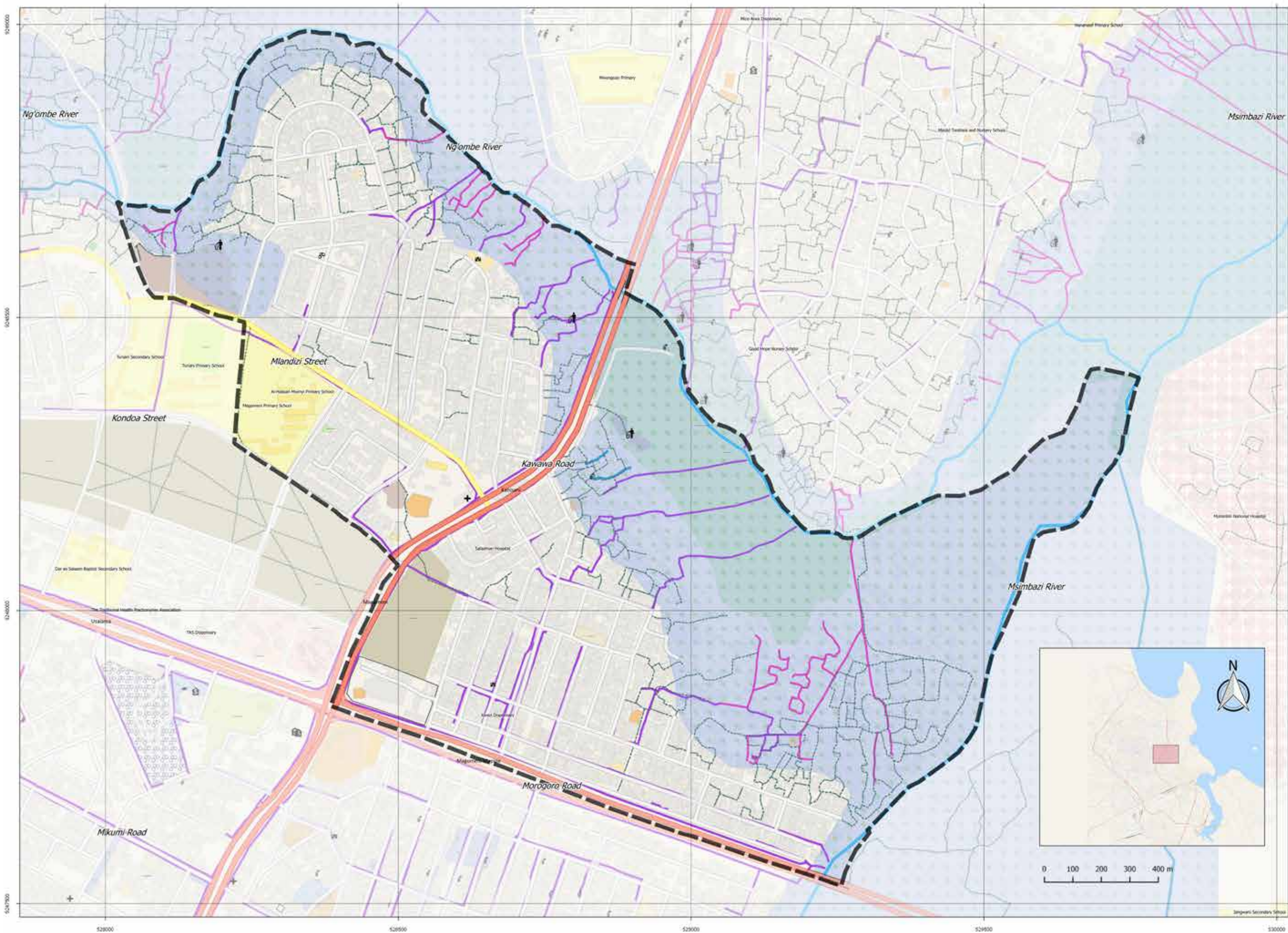
Description and Recommendations

Magomeni is at risk of flooding, with the most at risk areas surrounding the river Ng'ombe and the Msimbazi river. The Suna subward is most at risk due to it being intersected by these two rivers in its northern and eastern areas.

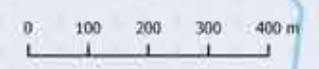
Insufficient drain capacity, unprotected river banks, and unplanned construction along the river valley are the main contributory factors of flooding in these areas. This challenge is further amplified by the large amount of solid waste deposited here from upstream parts of Dar es Salaam.

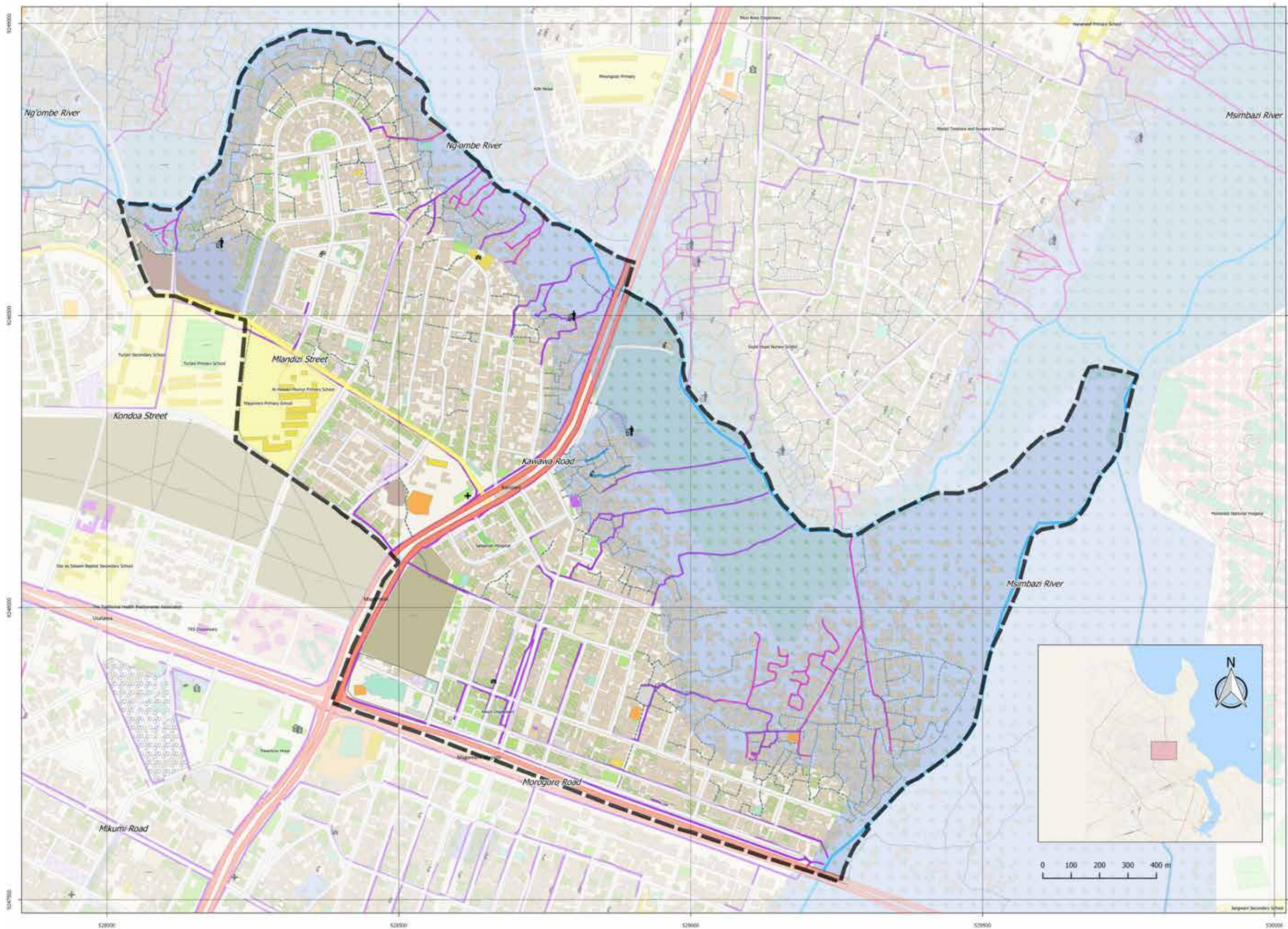
Improving solid waste collection and increasing depth of drainage channels could help to mitigate the flood risk and improve the quality of life for people living in this ward.

MAGOMENI DRAINAGE MAP

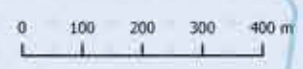


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Landuse**
 - Wetland
 - Landuse**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Landuse**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Landuse**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

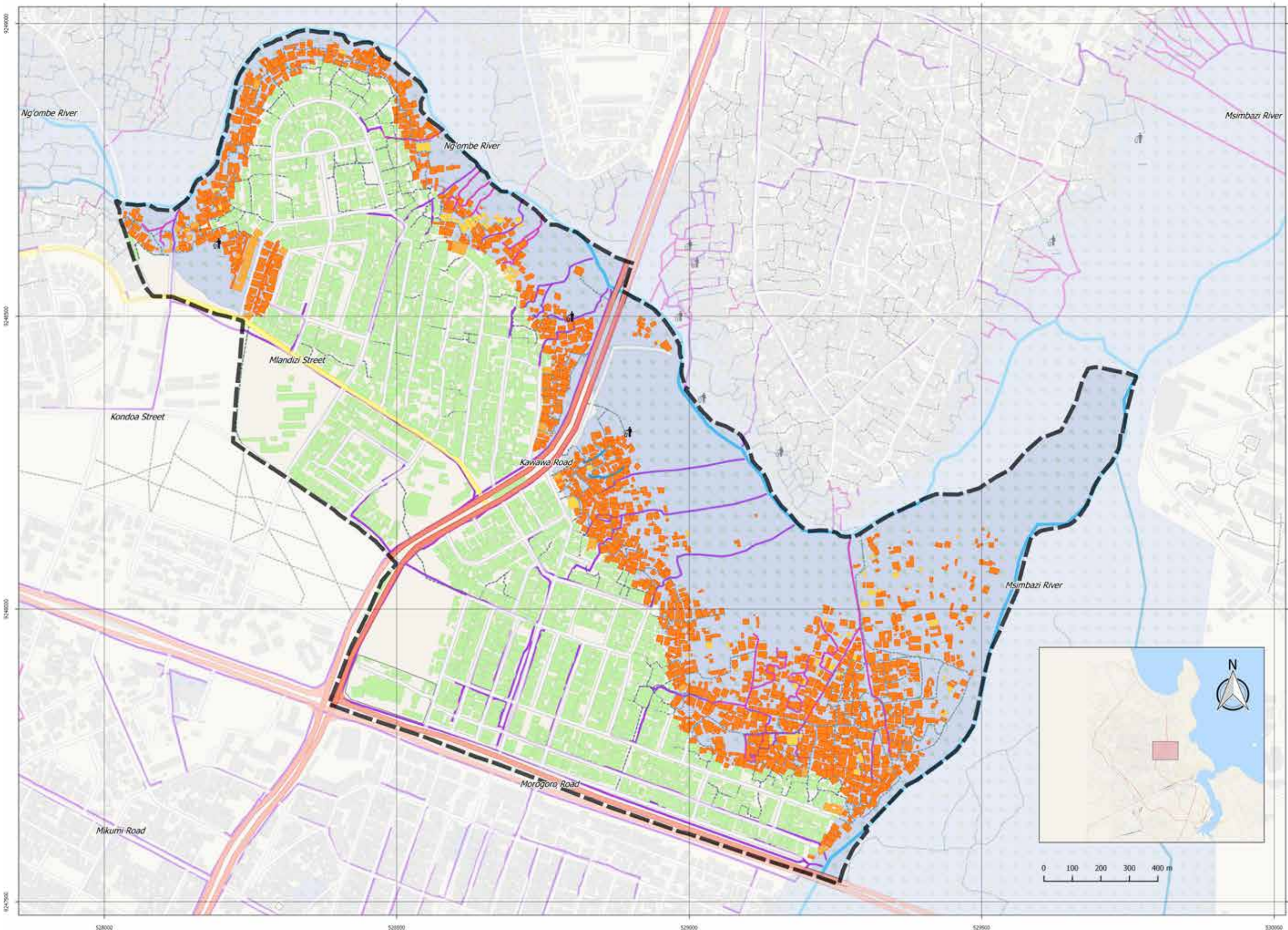




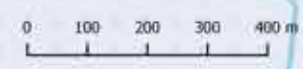
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Landuse**
 - Wetland
 - Landuse**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Landuse**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Landuse**
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



MAGOMENI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [4273]**
 - Not inundated [2503]
 - Inundated, school or hospital [0]
 - Inundated, residential [1644]
 - Inundated, commercial [33]
 - Inundated, other [95]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MAKUMBUSHO

MAPPING PERIOD

July 13th until August 11th 2015

SURFACE AREA

1.76 km²

FLOOD PRONE AREA

0.61 km² (35%)

POPULATION (2012 CENSUS)

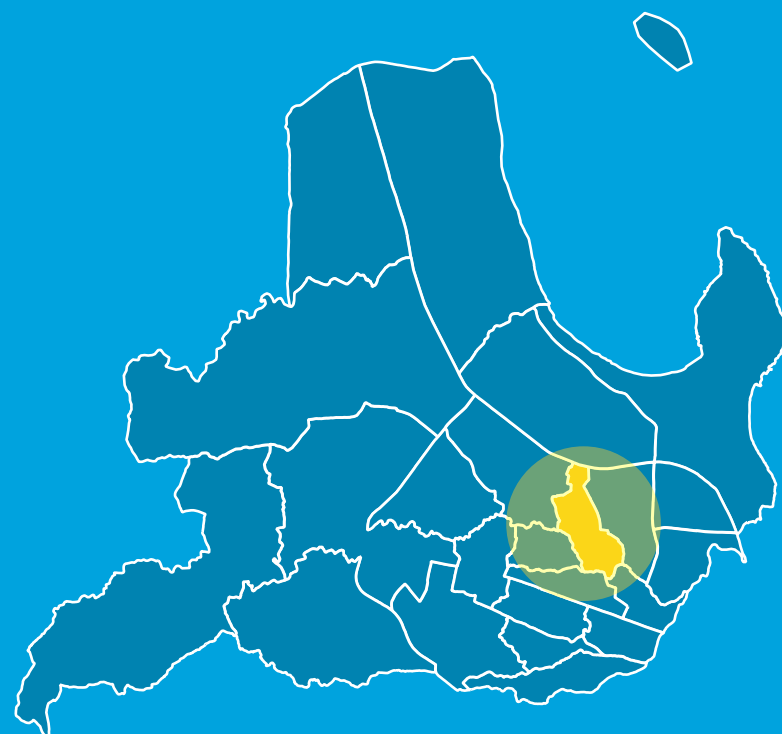
68,093

TOTAL NUMBER OF BUILDINGS

7,848

AT RISK OF FLOODING

Buildings at risk of flooding 3,053, of which 19 are school or hospital buildings.



Description and Recommendations

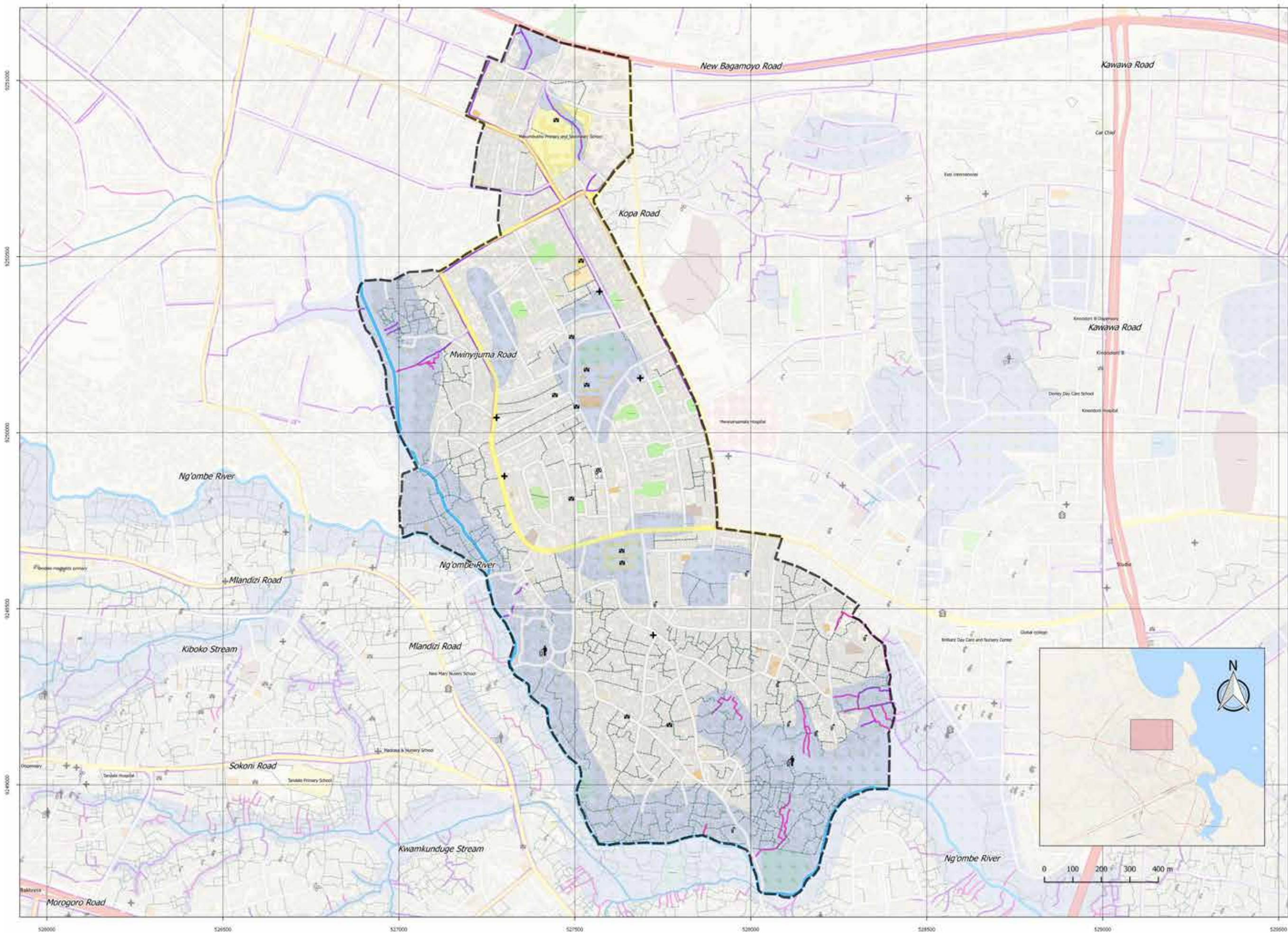
With two rivers forming its western and southern boundaries, Makumbusho is highly prone to flooding. This is further exacerbated by a shallow stream in the western part of the ward that flows through Kijitonyama to the Ng'ombe river in the south.

During instances of high rainfall, Mbuyuni subward is most affected by this stream overflowing, causing damage to residents and infrastructure along its banks. This impact on residents and infrastructure also occurs along the Ng'ombe river, which passes through the Sindano, Kisiwani and Mchangani subwards.

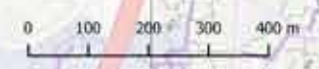
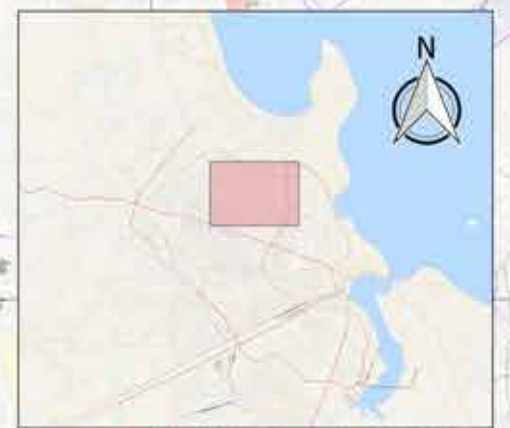
A central part of the ward around Kisiwani Primary School is also affected by flooding. Insufficient roadside drainage and broken water pipes within this area lead to an accumulation of rainwater without any means of flowing out.

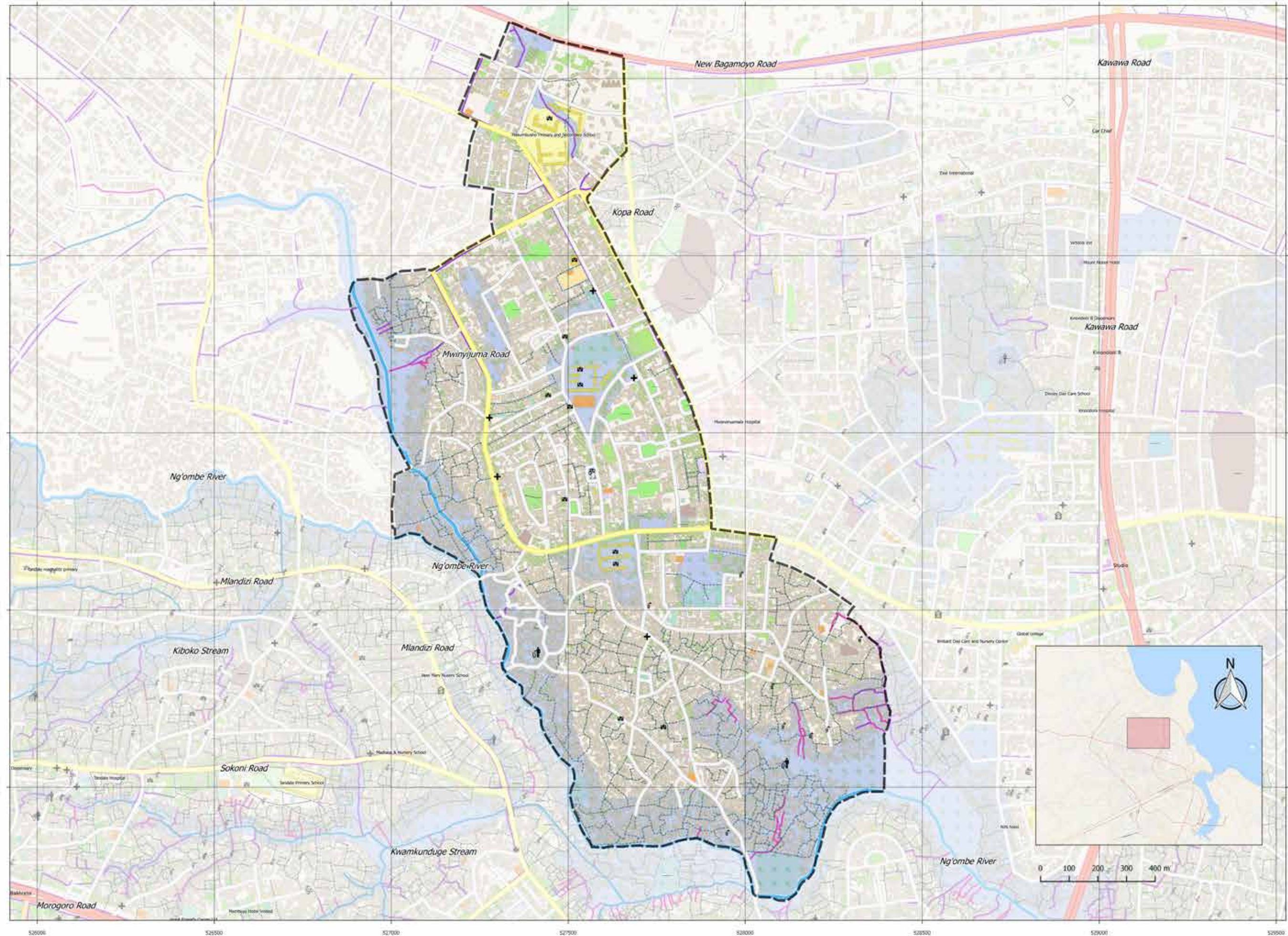
The connection of the existing drainage network together, augmented by new construction could begin to alleviate this impact on Makumbusho ward.

MAKUMBUSHO DRAINAGE MAP

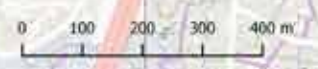
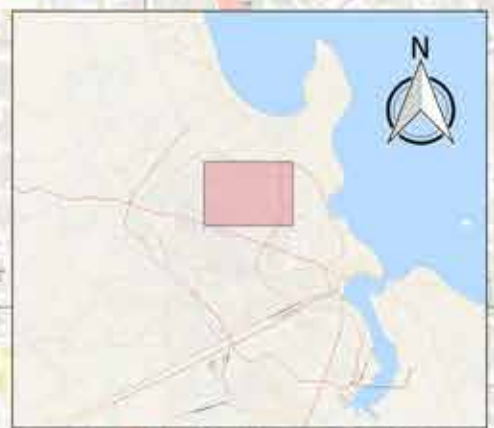


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

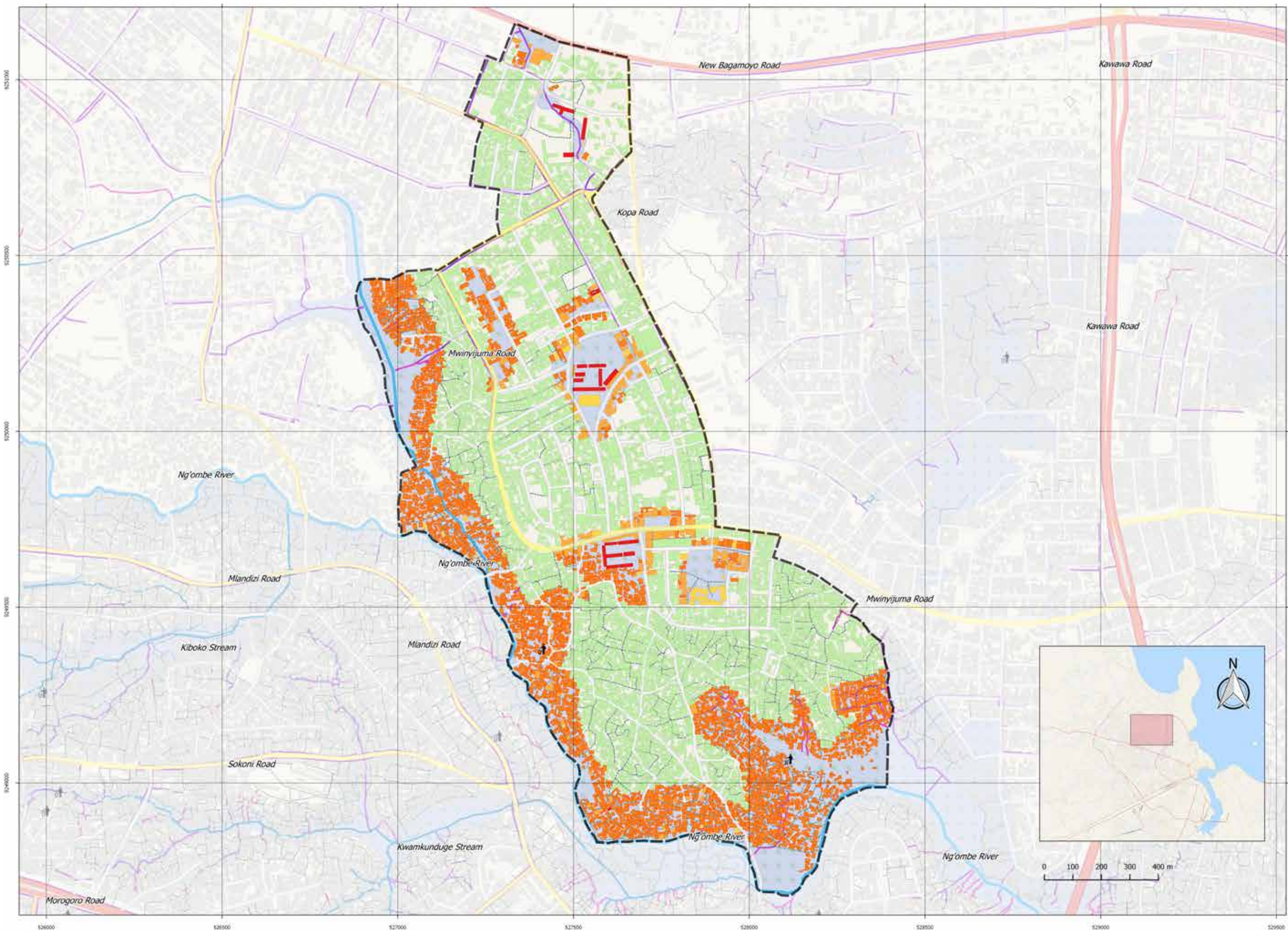




- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



MAKUMBUSHO POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation (7848)**
 - Not Inundated (4814)
 - Inundated, school or hospital (19)
 - Inundated, residential (2783)
 - Inundated, commercial (182)
 - Inundated, other (50)
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point

MSASANI

MAPPING PERIOD

July 13th until August 11th 2015

SURFACE AREA

11.59 km²

FLOOD PRONE AREA

1.07 km² (9%)

POPULATION (2012 CENSUS)

48,920

TOTAL NUMBER OF BUILDINGS

8,020

AT RISK OF FLOODING

Buildings at risk of flooding 2,578, of which 27 are school or hospital buildings.



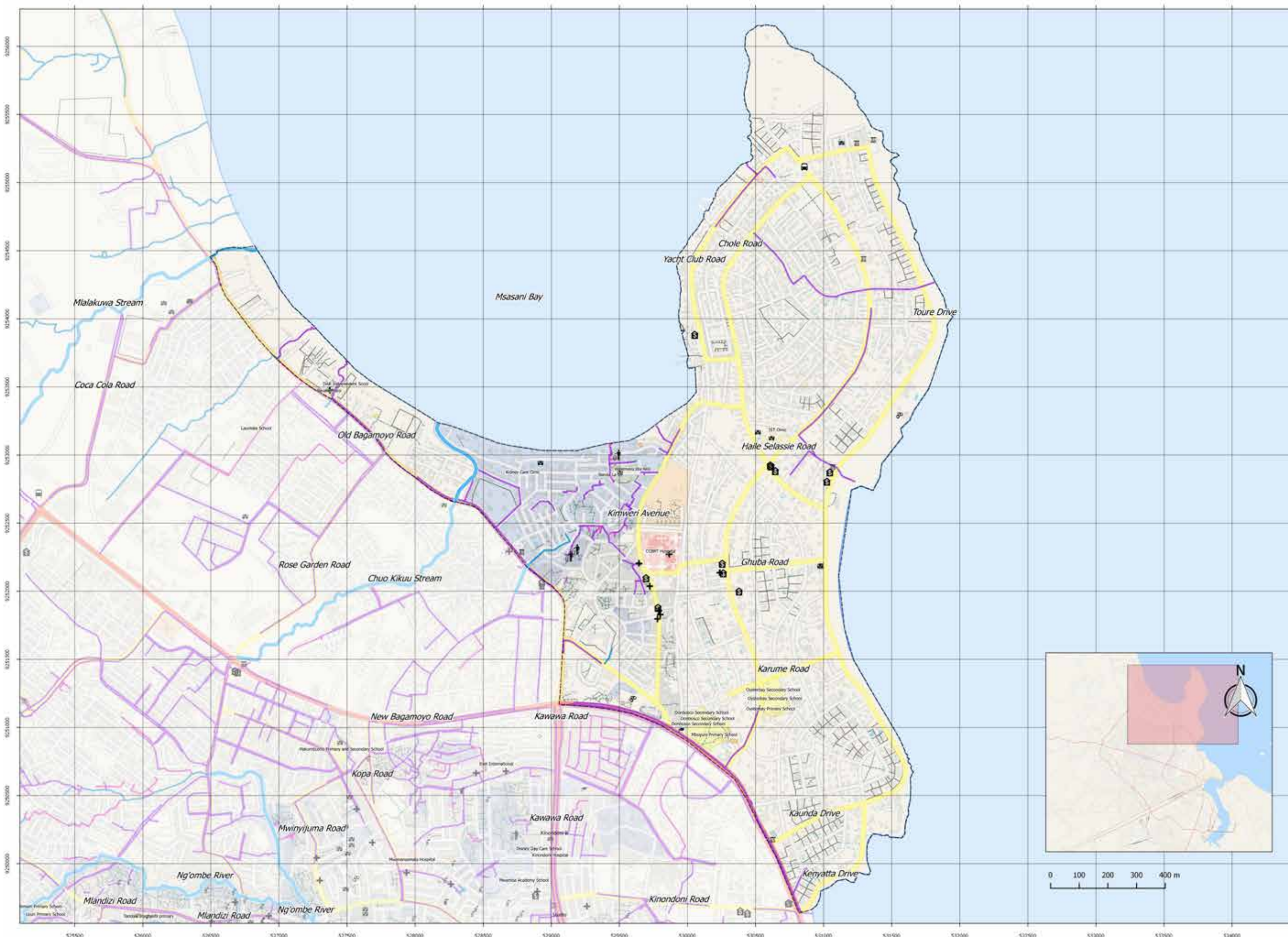
Description and Recommendations

A large portion of Msasani is composed of upmarket housing, which is on slightly higher ground and thus largely unaffected by flooding. However, much of the western Bonde la Mpunga subward is at risk during heavy rainfall. The name “Bonde la Mpunga” implicates this as well, as it translates to “valley for rice cultivation”.

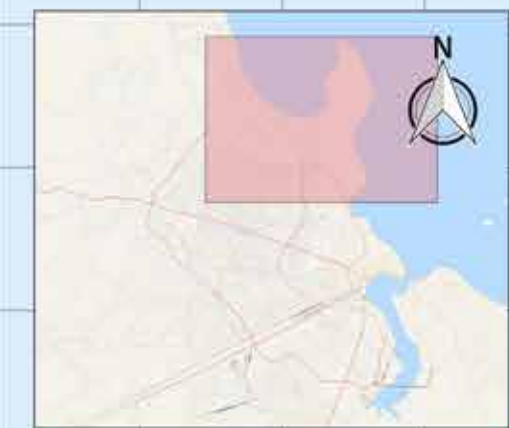
The combination of construction along drains and spread of solid waste in drains and streams challenges the water network to sufficiently drain the volumes of water from the Msasani when severe climatic events occur.

Expanding the drainage system within this area, improving the solid waste management, and cleaning the drains on a regular basis, will move towards reducing the impact of flood risk in Msasani.

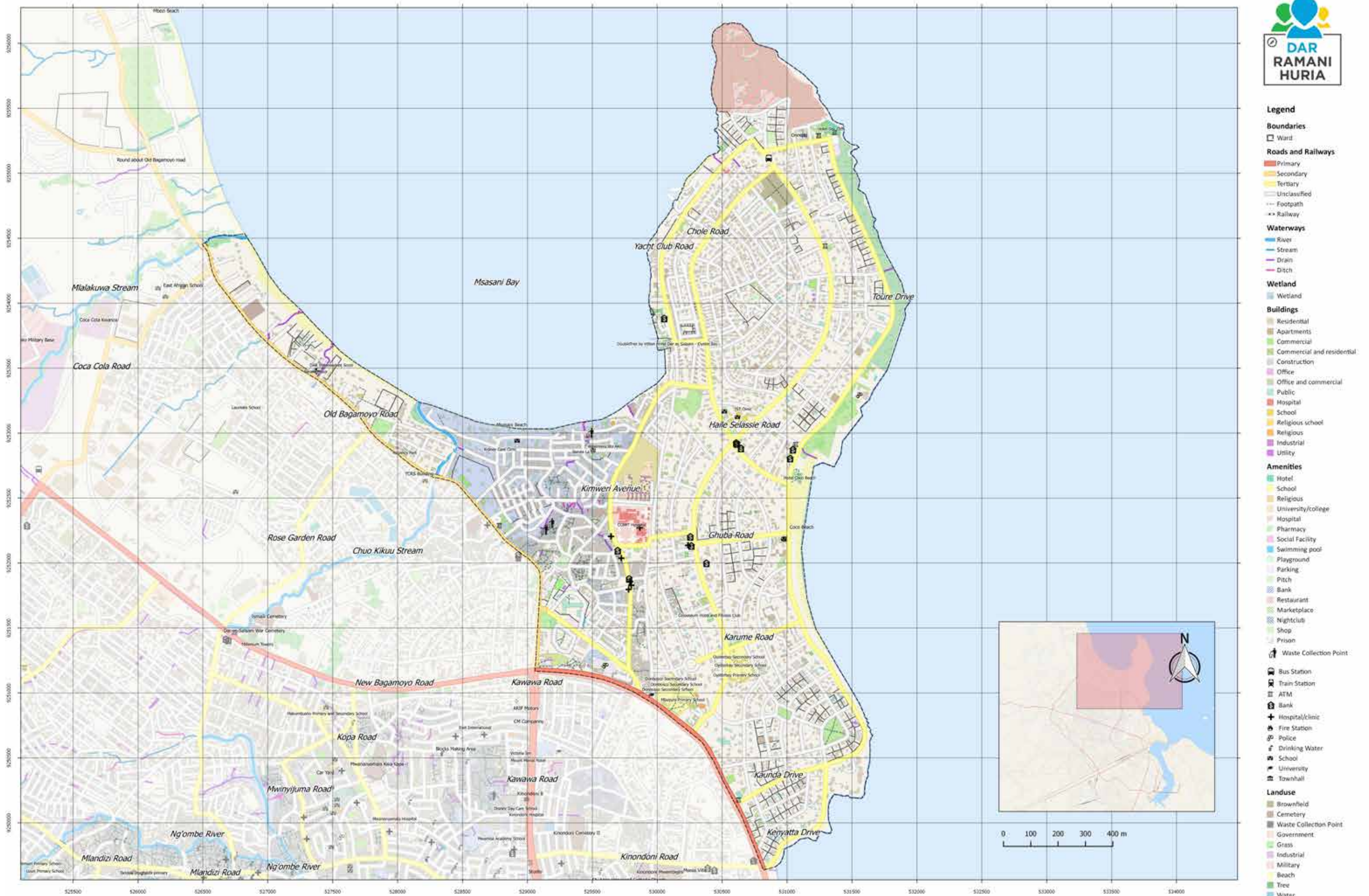
MSASANI DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Icons**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



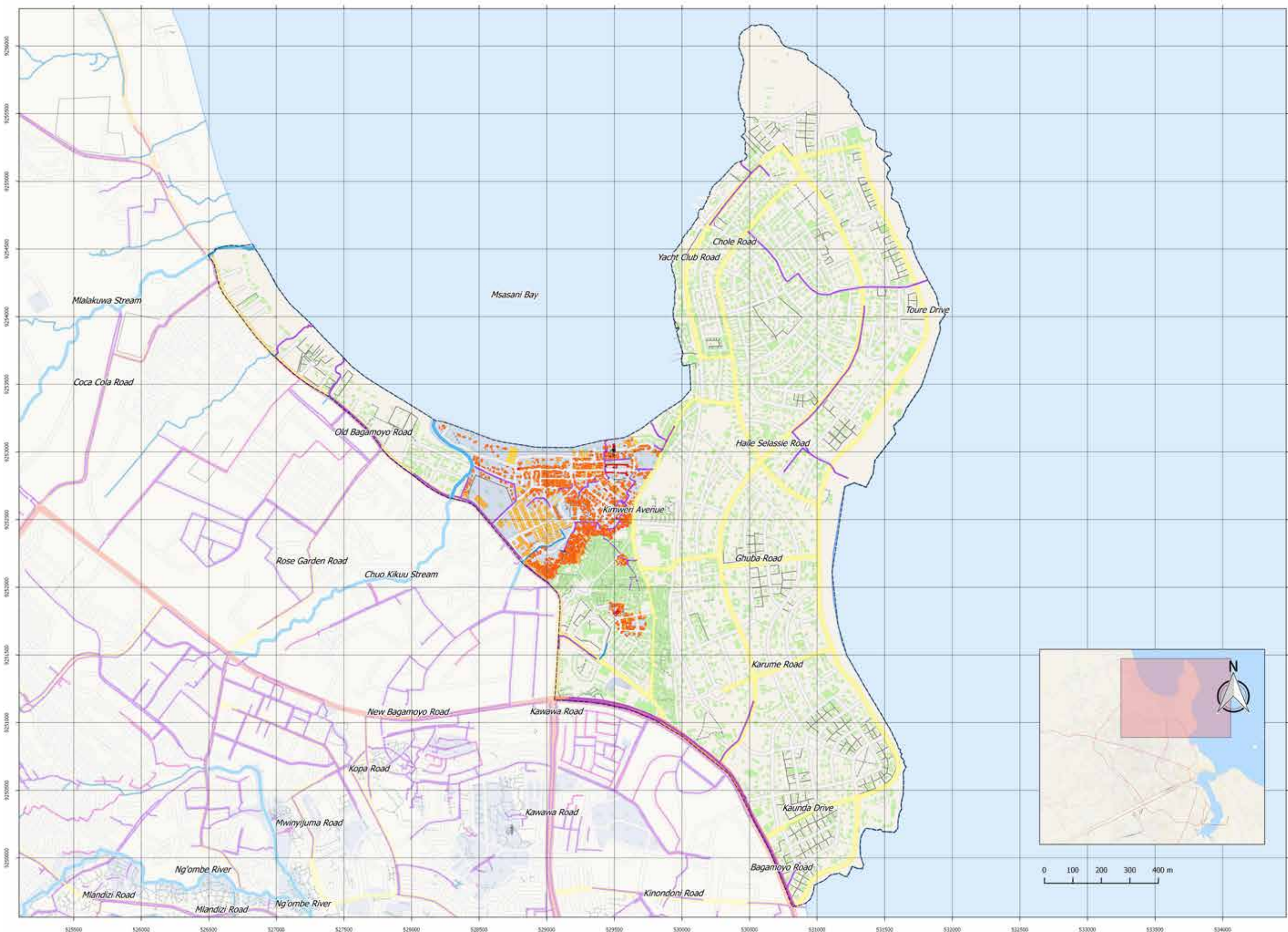
MSASANI GENERAL MAP



MSASANI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [8029]**
 - Not inundated [6201]
 - Inundated, school or hospital [27]
 - Inundated, residential [1587]
 - Inundated, commercial [149]
 - Inundated, other [248]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MWANANYAMALA

MAPPING PERIOD

August 17th until September 10th 2015

SURFACE AREA

2.52 km²

FLOOD PRONE AREA

0.57 km² (23%)

POPULATION (2012 CENSUS)

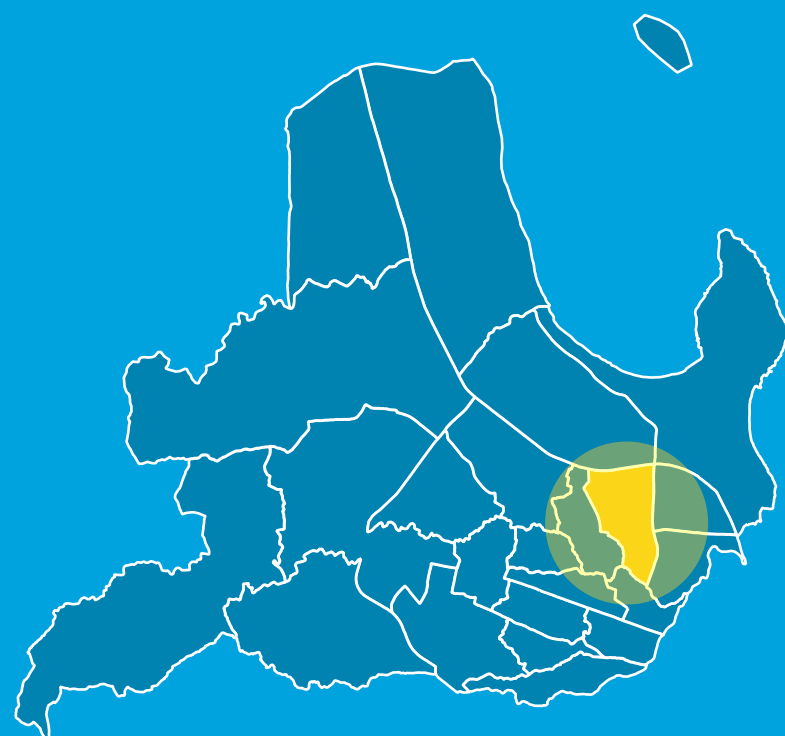
50,560

TOTAL NUMBER OF BUILDINGS

9,914

AT RISK OF FLOODING

Buildings at risk of flooding 2,863, of which 21 are school or hospital buildings.

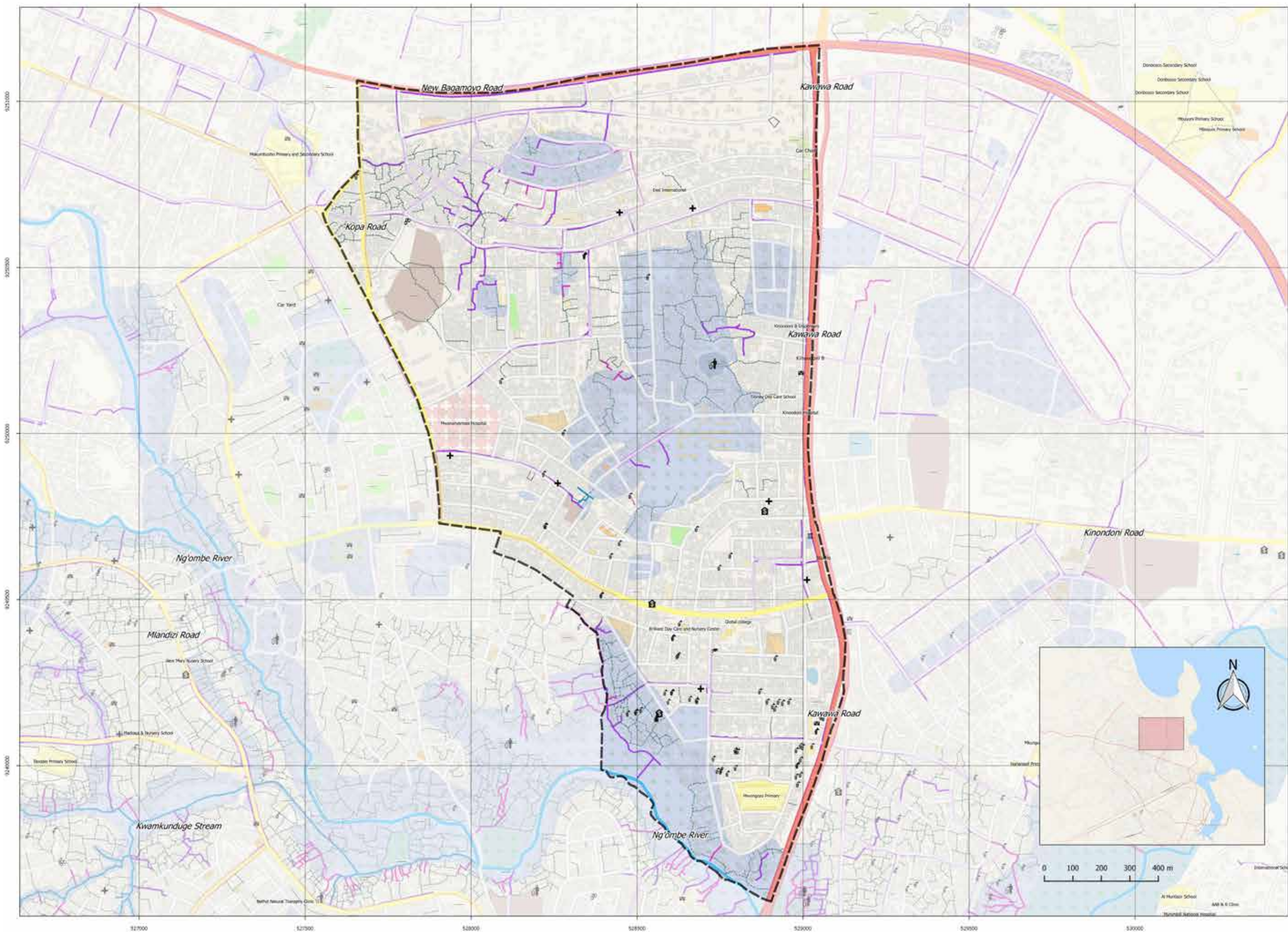


Description and Recommendations

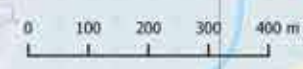
Much of Mwananyamala is a low lying and flood prone area. As a result of this, many buildings here, most of which are residential, are at risk of being inundated under high rainfall. An absence of drainage channels also allows the pooled water to become stagnated. This poses a flood and a health risk to the residents of Mwananyamala. In the southern area of Mwananyamala, the river Ng'ombe can overflow into the Mwinjuma subward.

Investigating how new drainage could alleviate and direct the flow of water would be a good step to improve the situation for residents of Mwananyamala.

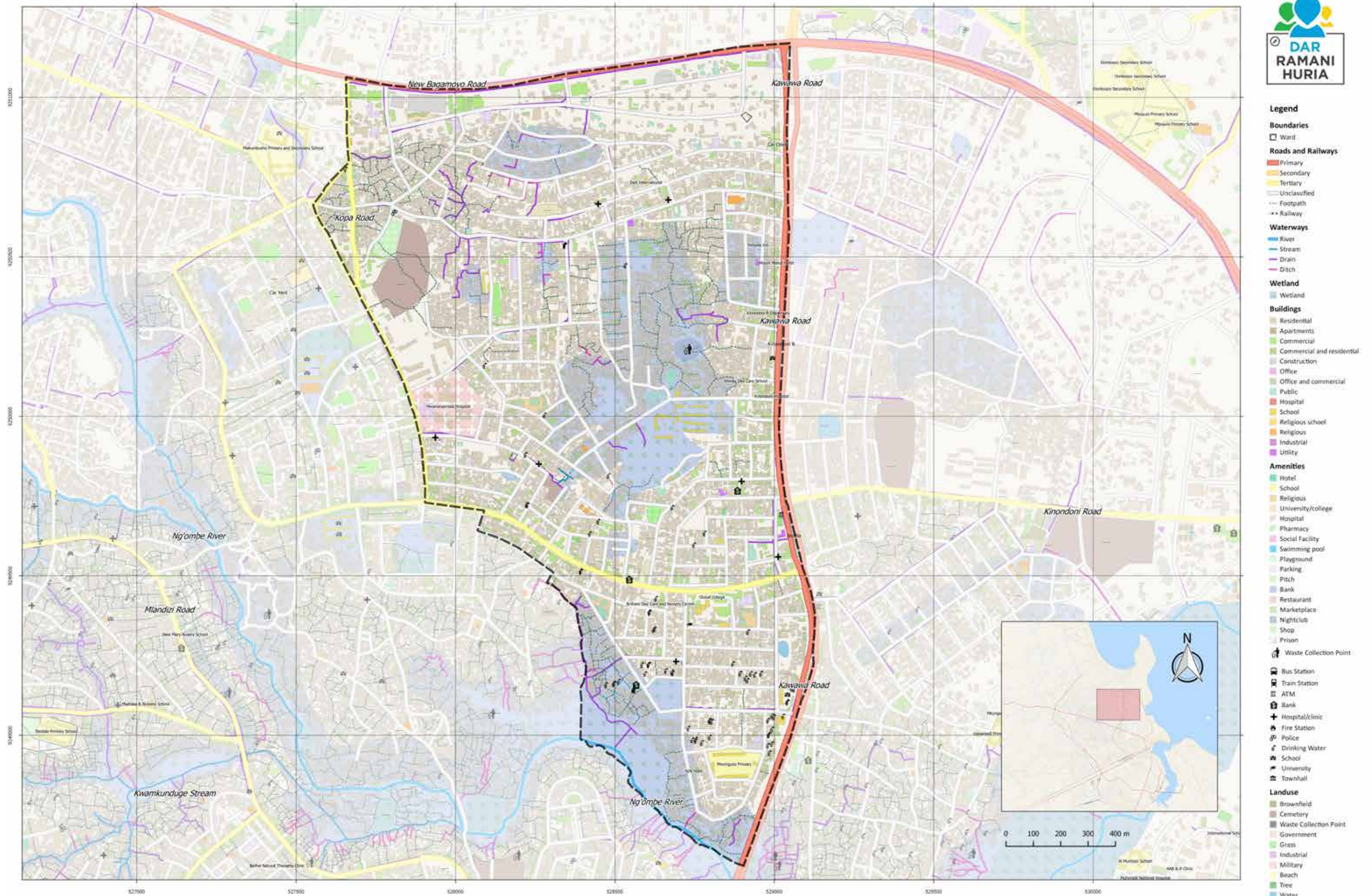
MWANANYAMALA DRAINAGE MAP



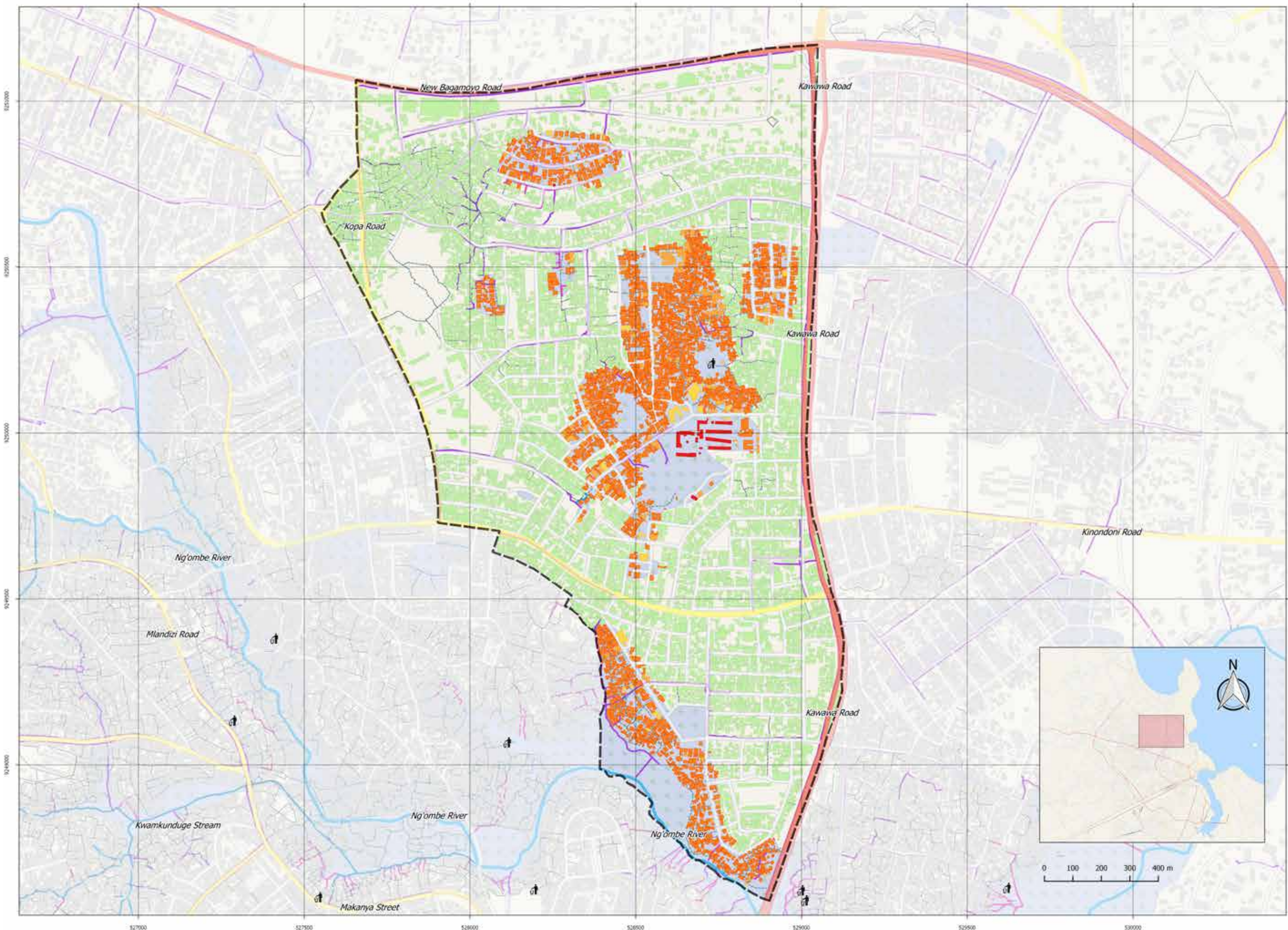
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



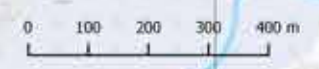
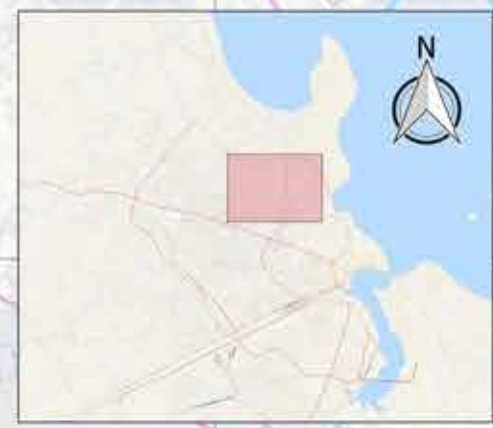
MWANANYAMALA GENERAL MAP



MWANANYAMALA POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [9922]**
 - Not inundated (7066)
 - Inundated, school or hospital (21)
 - Inundated, residential (2589)
 - Inundated, commercial (200)
 - Inundated, other (46)
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MZIMUNI

MAPPING PERIOD

September 11th until October 9th 2015

SURFACE AREA

1.28 km²

FLOOD PRONE AREA

0.35 km² (27%)

POPULATION (2012 CENSUS)

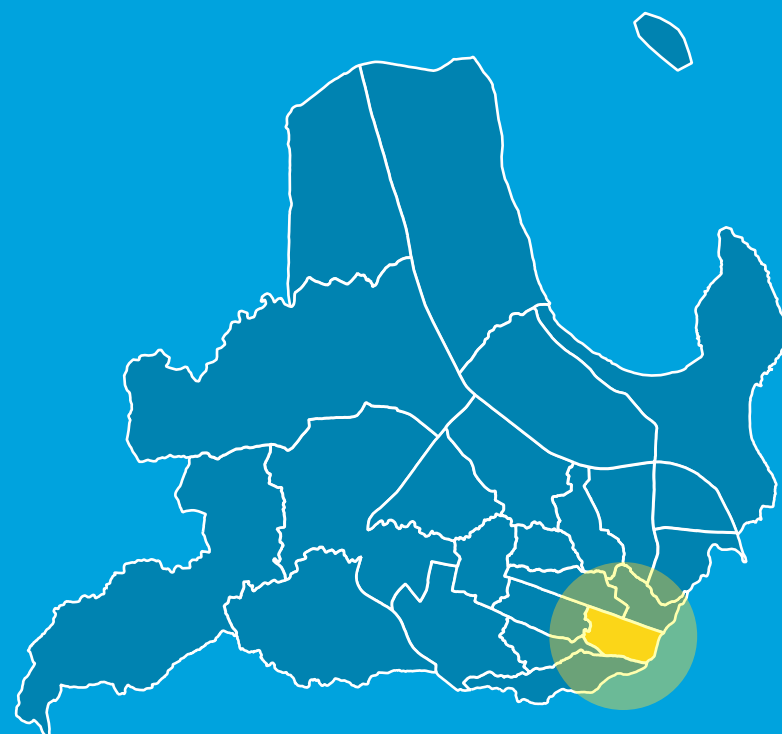
21,486

TOTAL NUMBER OF BUILDINGS

4,021

AT RISK OF FLOODING

Buildings at risk of flooding 959, of which 1 is a school building.

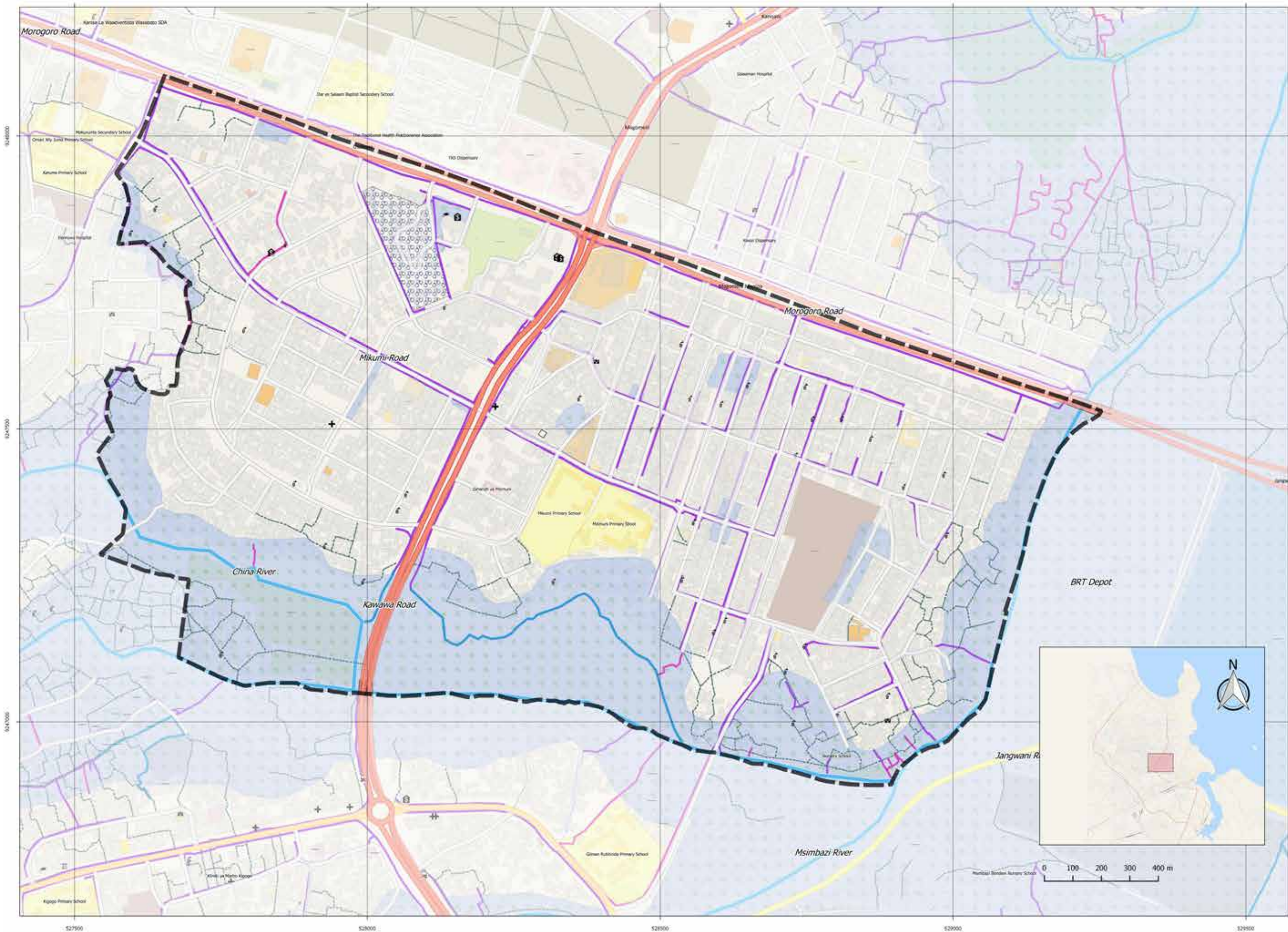


Description and Recommendations

Intersected by both the China and the Kibangu rivers in the south of Mzimuni ward and bordered by Jangwani Fields and Msimbazi river in the east, the Mtambani and Mwinyimkuu subwards of Mzimuni are prone to being inundated during heavy rainfall.

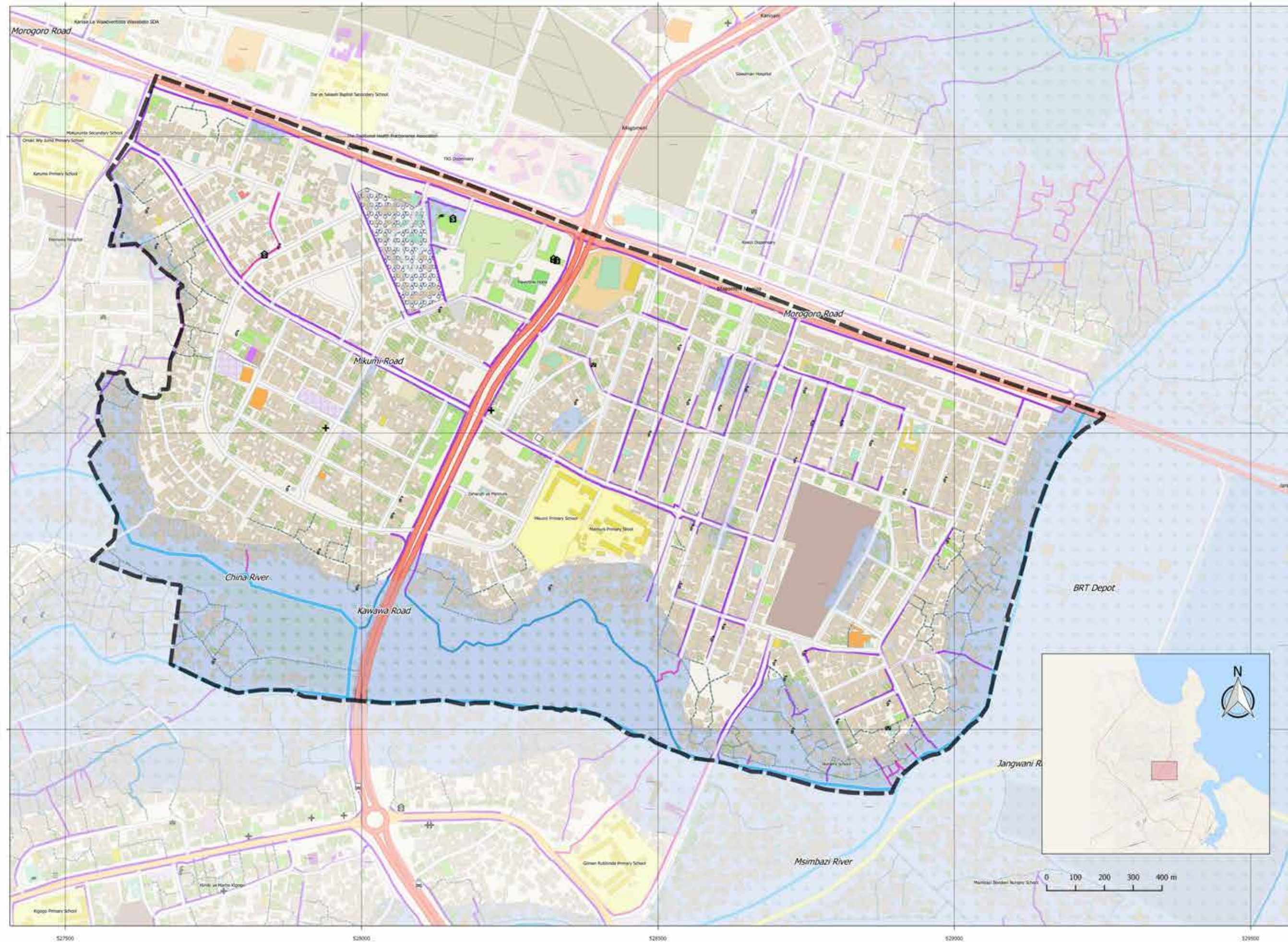
In response to this situation, deepening the surrounding rivers and enhancing capacity for planning by ward and community leaders could begin to ease the pressures of urbanisation within Mzimuni.

MZIMUNI DRAINAGE MAP



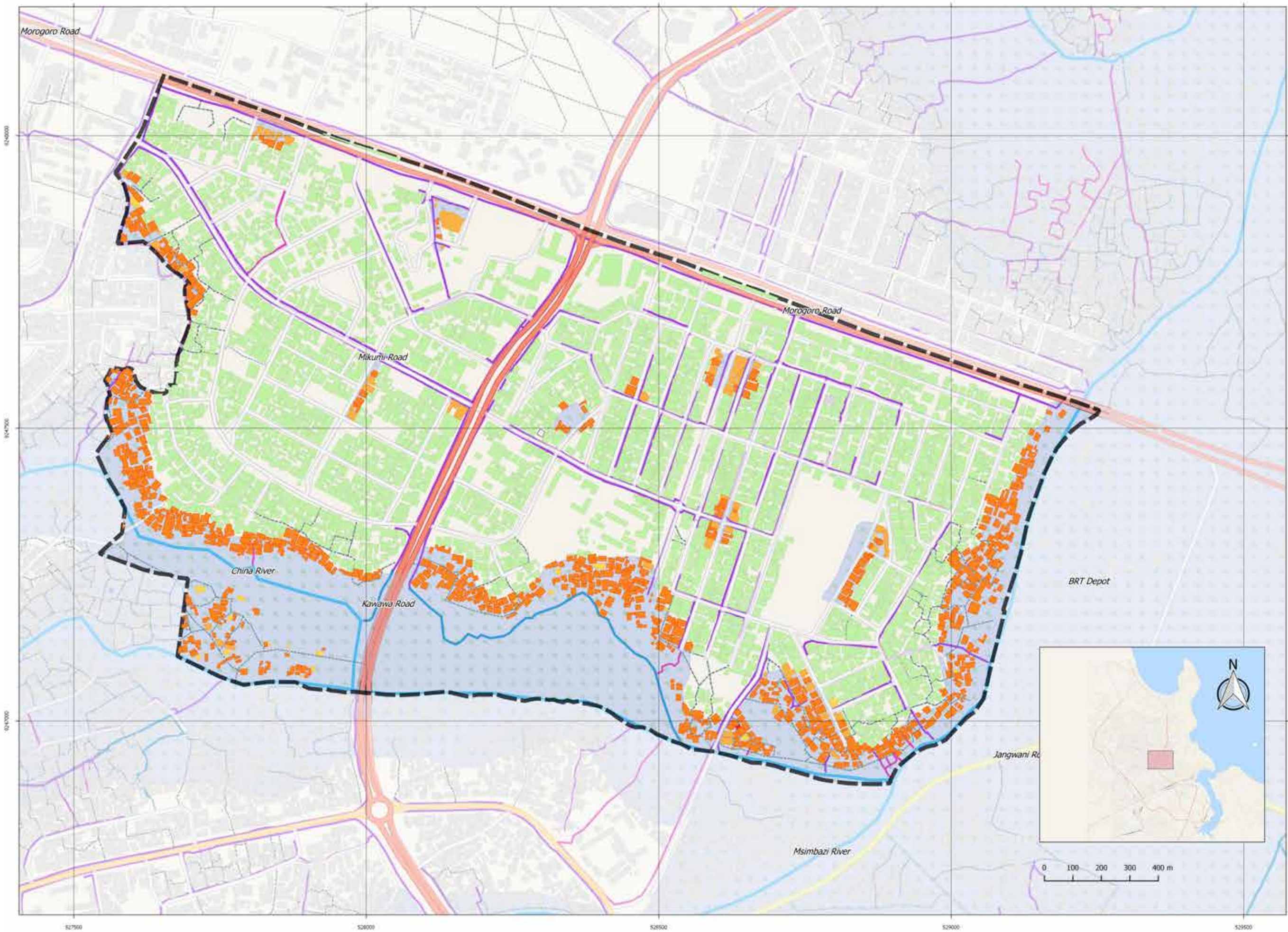
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Landuse**
 - Wetland
 - Landuse**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Landuse**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Landuse**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



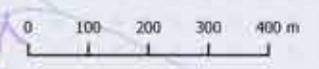


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Landuse**
 - Wetland
 - Landuse**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Landuse**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

MZIMUNI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [4021]**
 - Not Inundated (3096)
 - Inundated, school or hospital (1)
 - Inundated, residential (937)
 - Inundated, commercial (63)
 - Inundated, other (24)
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



NDUGUMBI

MAPPING PERIOD

March 29th until April 28th 2015

SURFACE AREA

1.34 km²

FLOOD PRONE AREA

0.18 km² (13%)

POPULATION (2012 CENSUS)

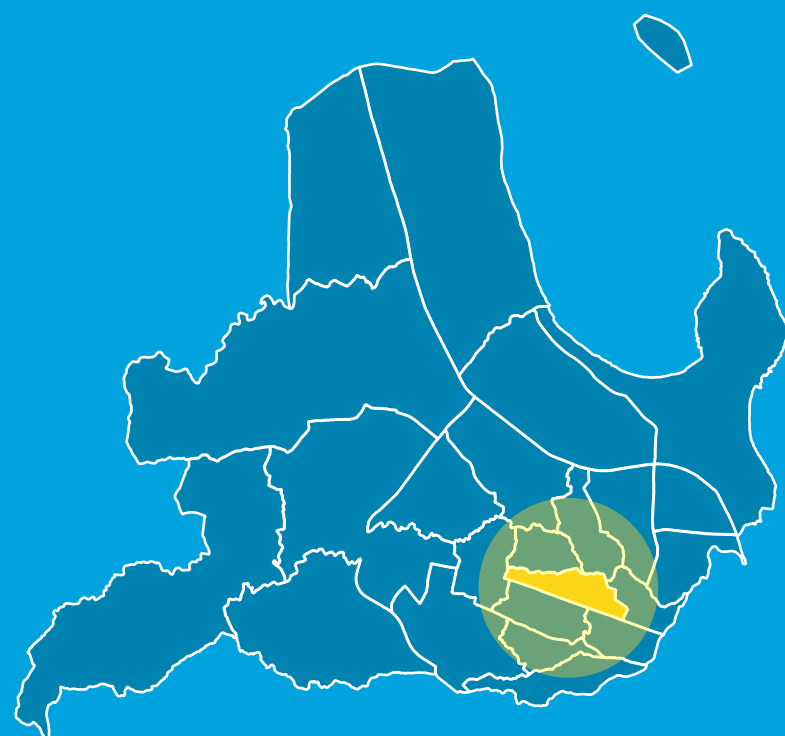
36,841

TOTAL NUMBER OF BUILDINGS

5,242

AT RISK OF FLOODING

Buildings at risk of flooding
1,137, of which none are school
or hospital buildings.



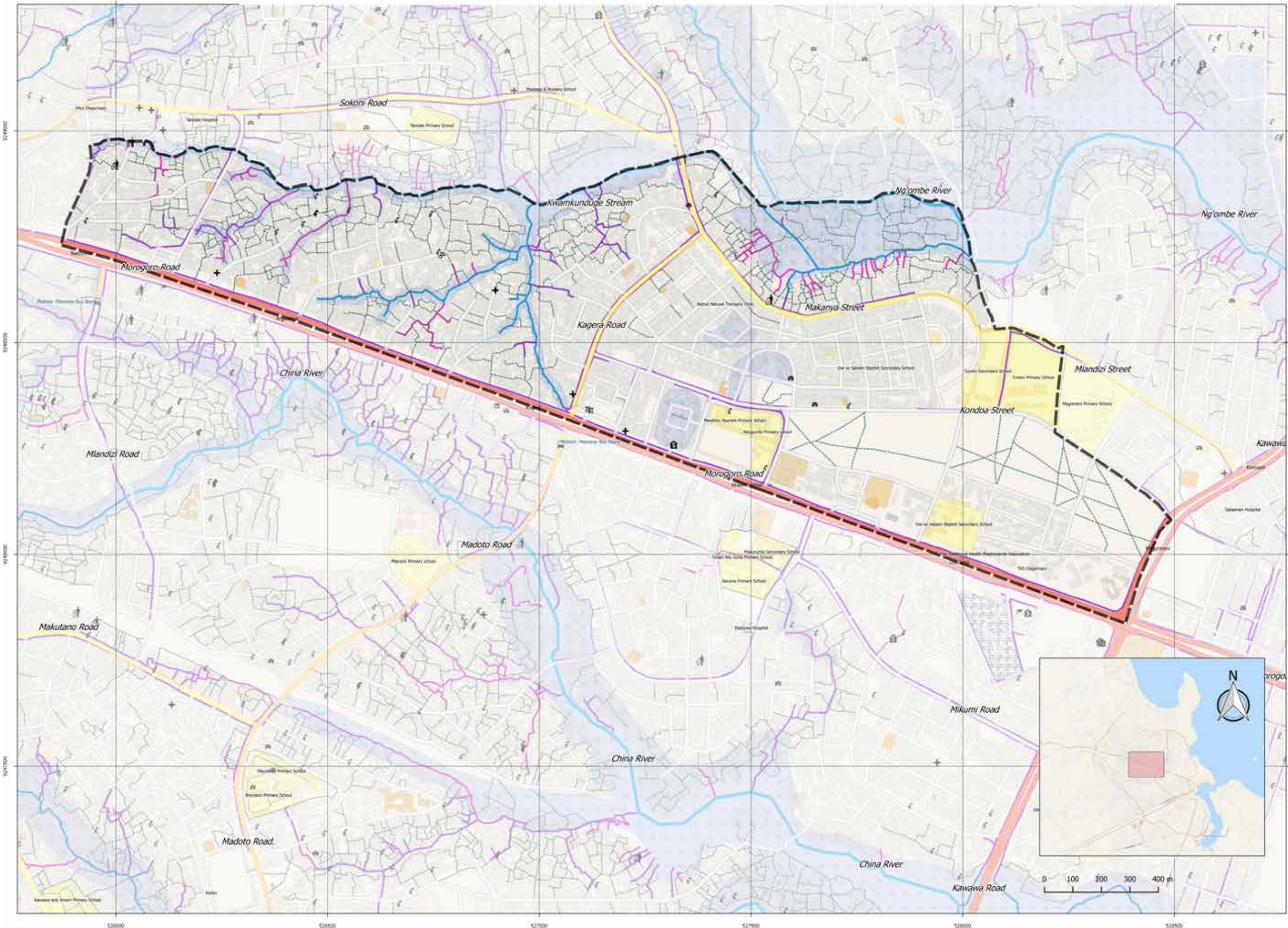
Description and Recommendations

Ndugumbi's southern border is formed by Morogoro Road, alongside which large drains have been constructed to support the new Bus Rapid Transit system. More roadside drains are present in the western parts of the ward, but these are not to the capacity as those near Morogoro Road and can overflow during heavy rains.

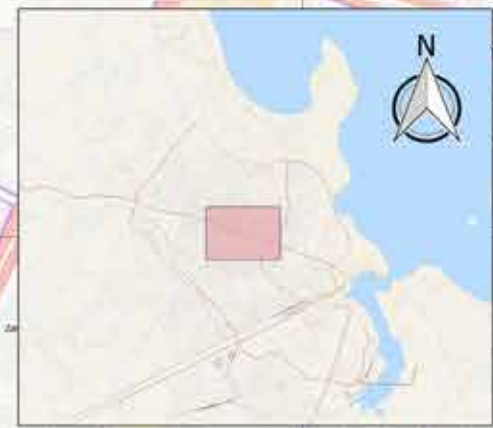
In the north of Ndugumbi, the Ng'ombe river separates the ward from Tandale. The river catchment can affect the Vigaeni, Mikoroshini and Makanya subwards, these border Tandale.

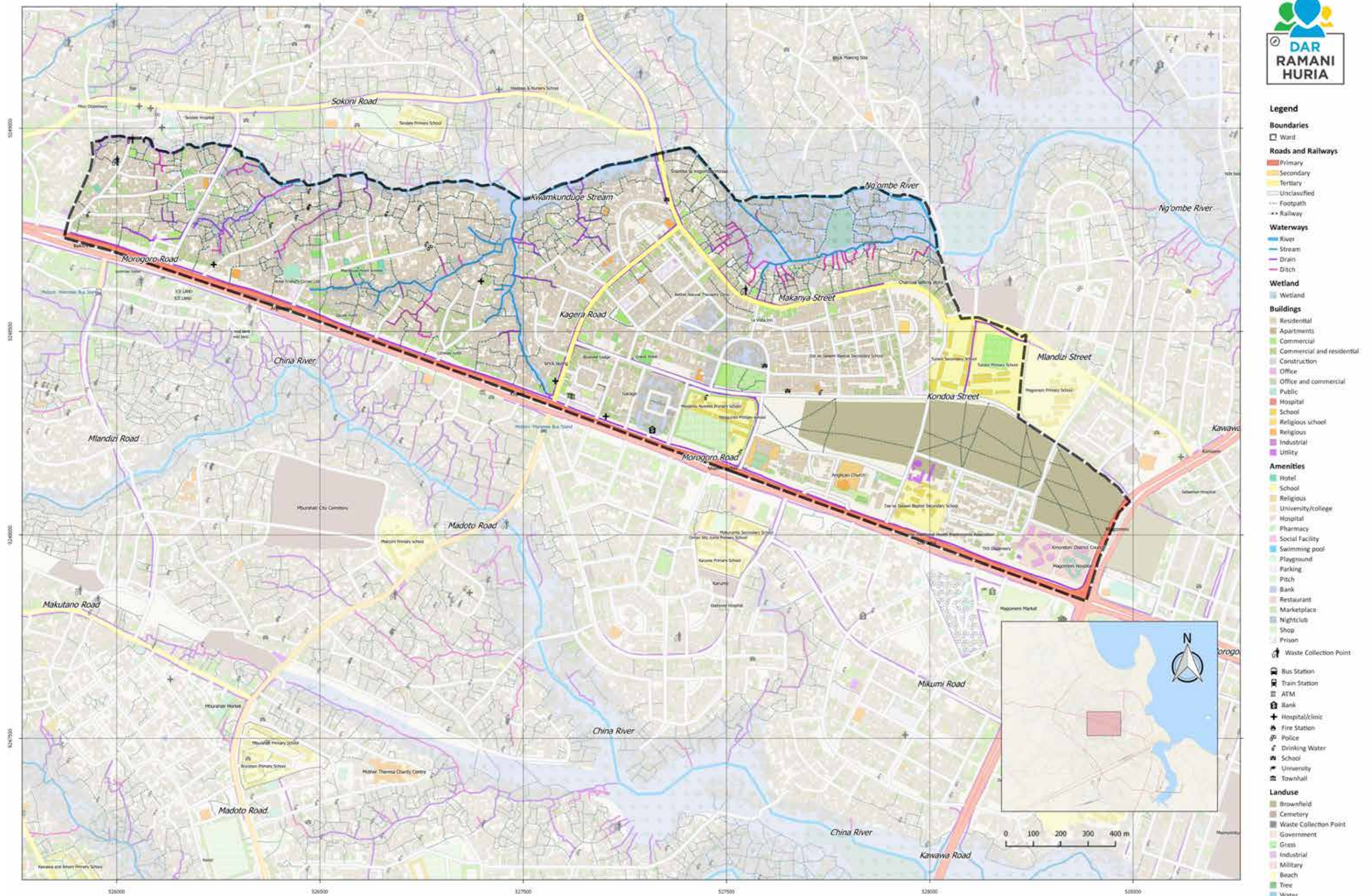
Exploring how the Ng'ombe River basin could alleviate the pressure of flooding in Ndugumbi and adjoining wards.

NDUGUMBI DRAINAGE MAP

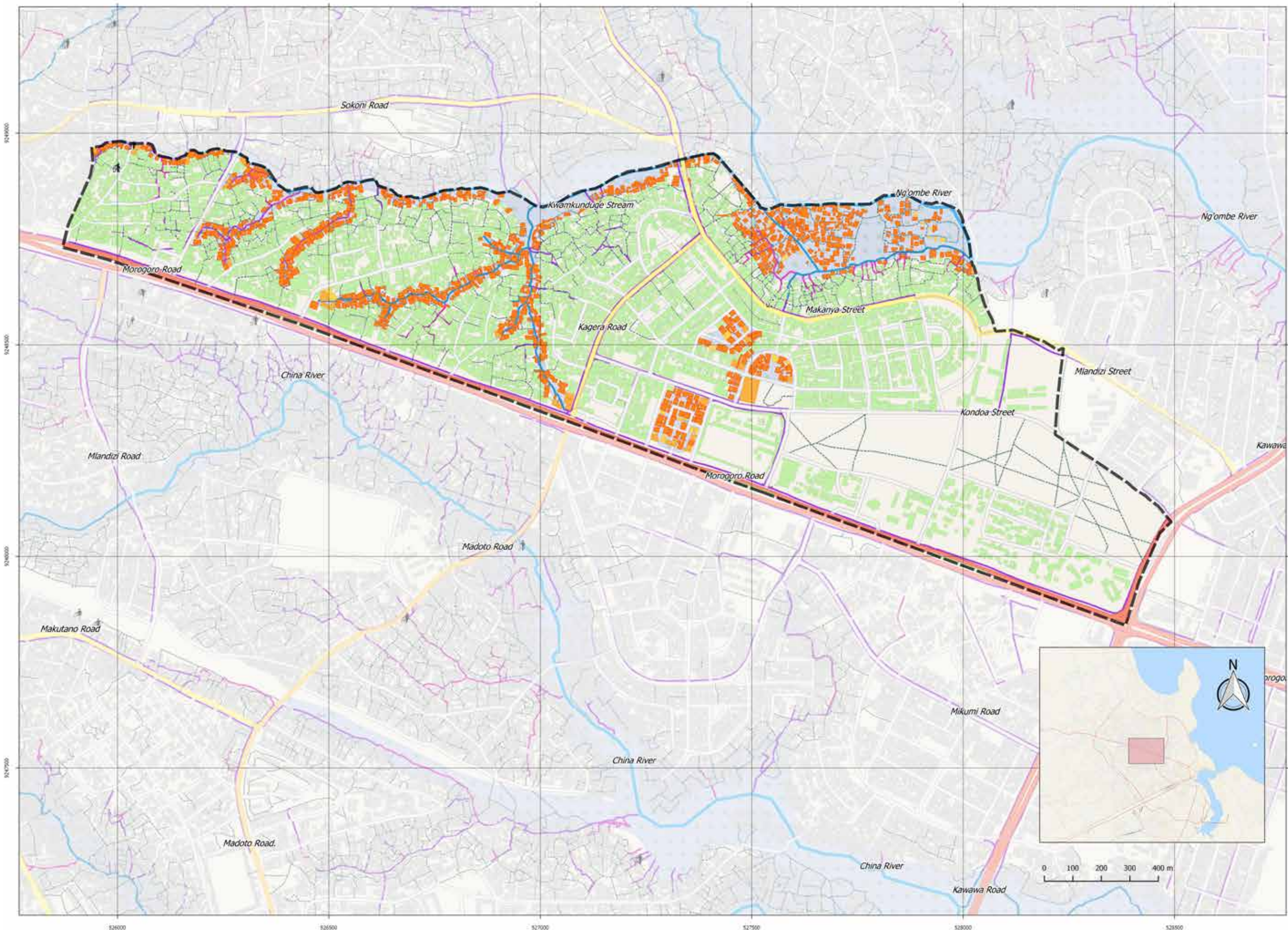


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

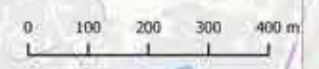




NDUGUMBI POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [5242]**
 - Not Inundated (4105)
 - Inundated, school or hospital (0)
 - Inundated, residential (1059)
 - Inundated, commercial (49)
 - Inundated, other (31)
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



TANDALE

MAPPING PERIOD

April 29th until May 29th 2015

SURFACE AREA

1.17 km²

FLOOD PRONE AREA

0.35 km² (30%)

POPULATION (2012 CENSUS)

54,781

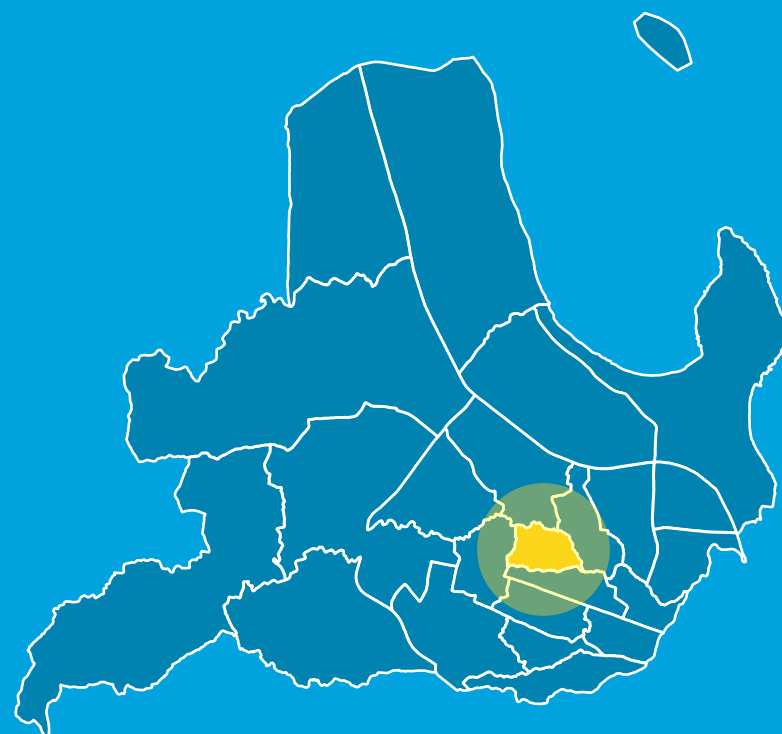
TOTAL NUMBER OF BUILDINGS

9,504

AT RISK OF FLOODING

Buildings at risk of flooding

1,948, of which 12 are school or hospital buildings.



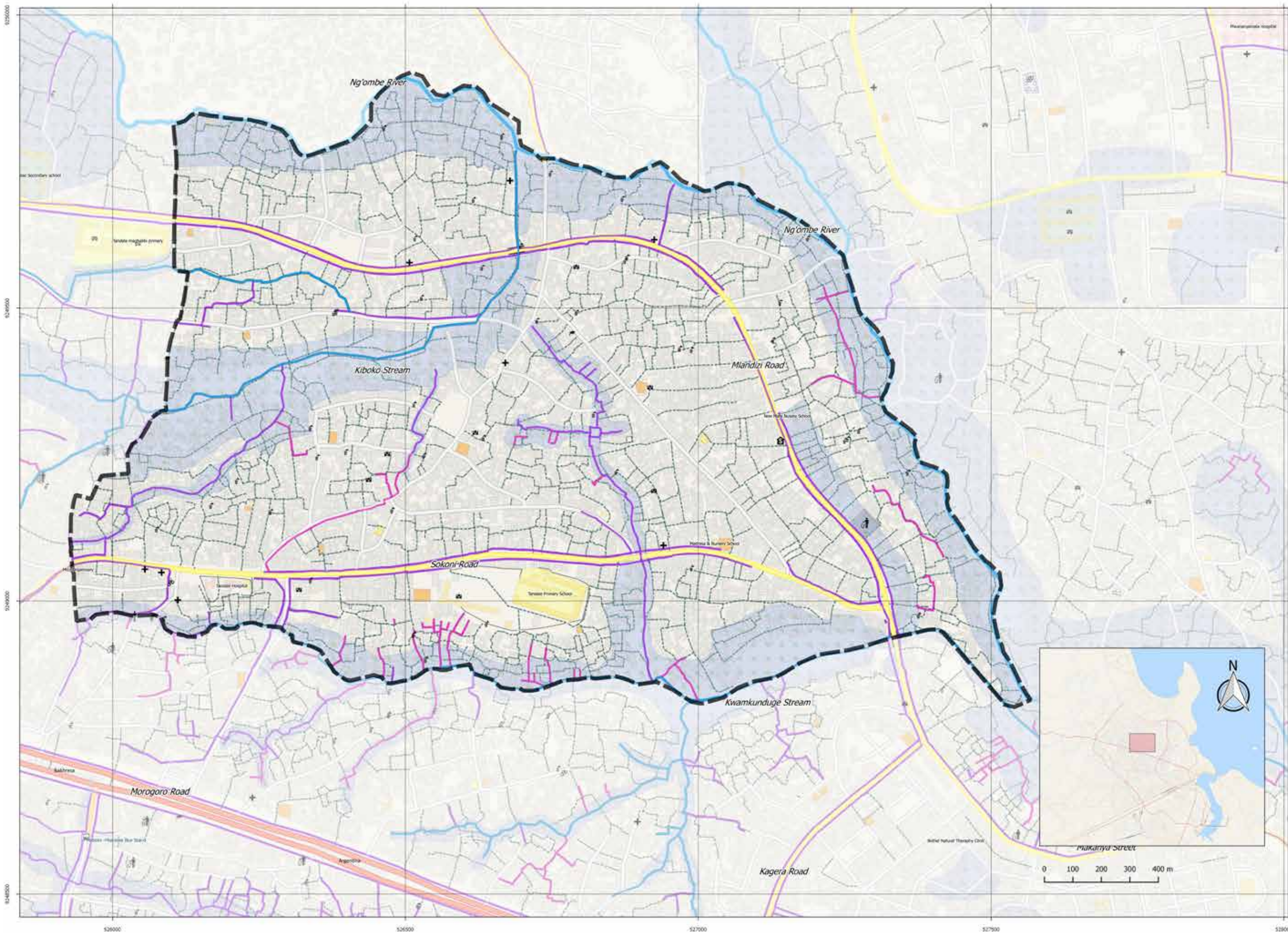
Description and Recommendations

In the north, Tandale is bordered by the Ng'ombe river, which forms its boundaries with Kijitonyama and Magomeni wards. This part of the ward (comprising largely of Mharitan, Mkunduge and Mtogole subwards) can be inundated during heavy rainfall. The low-lying grounds along the river Ng'ombe are most prone to flooding.

Pakacha subward of western Tandale is mainly affected by a stream called Kiboko, which drains the area to join the Ngo'mbe river.

In the southern part of the ward, there is a stream that flows from Pakacha to Sokoni and Tumbo subwards to join the river Ng'ombe. The stream is man made and has been reinforced by packed waste materials along its walls to increase its depth. The height of these materials has been breached in exceptional climatic events, reducing accessibility in Tandale. This can have a significant effect on Tandale Market which is one of the main agricultural trading points for Dar es Salaam. There have been many successful initiatives by local residents to clean the stream; however, these efforts have been challenged by the pace of urbanisation and the severity of the changing climate.

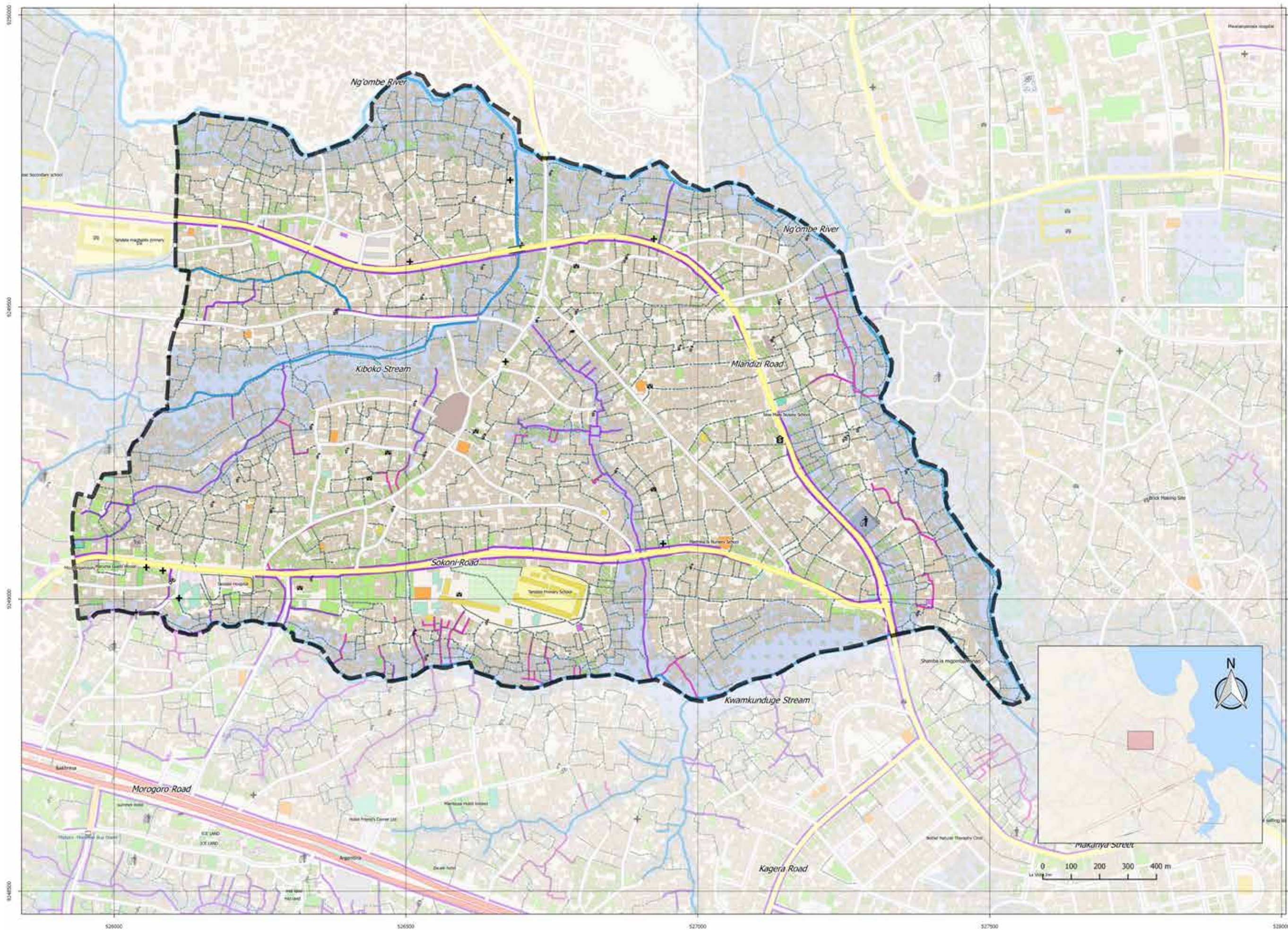
TANDALE DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



TANDALE GENERAL MAP

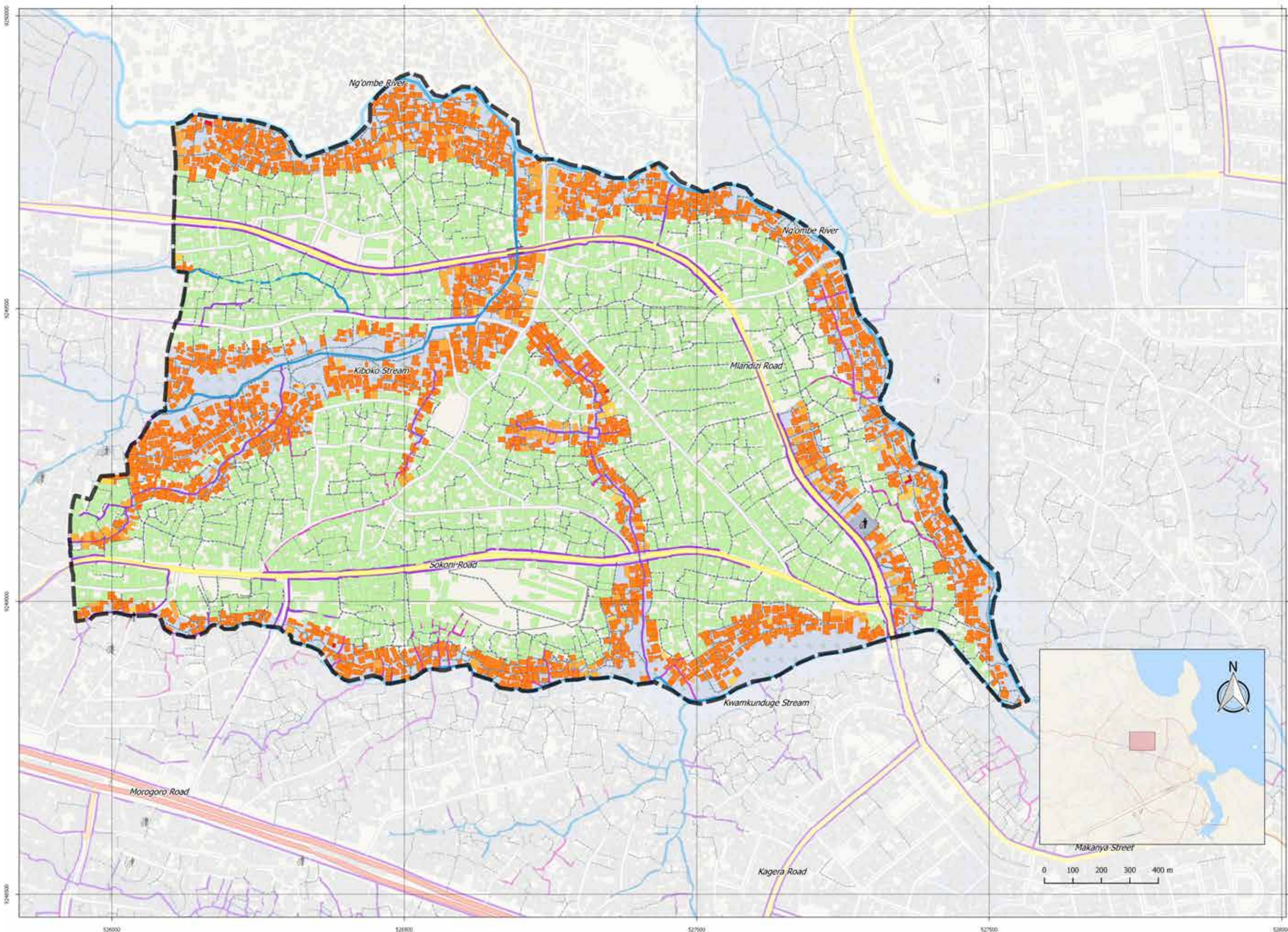


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

TANDALE POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [6833]**
 - Not Inundated [4532]
 - Inundated, school or hospital [4]
 - Inundated, residential [2077]
 - Inundated, commercial [155]
 - Inundated, other [65]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



KEKO

MAPPING PERIOD

July 20th until August 12th 2015

SURFACE AREA

1.48 km²

FLOOD PRONE AREA

0.25 km² (17%)

POPULATION (2012 CENSUS)

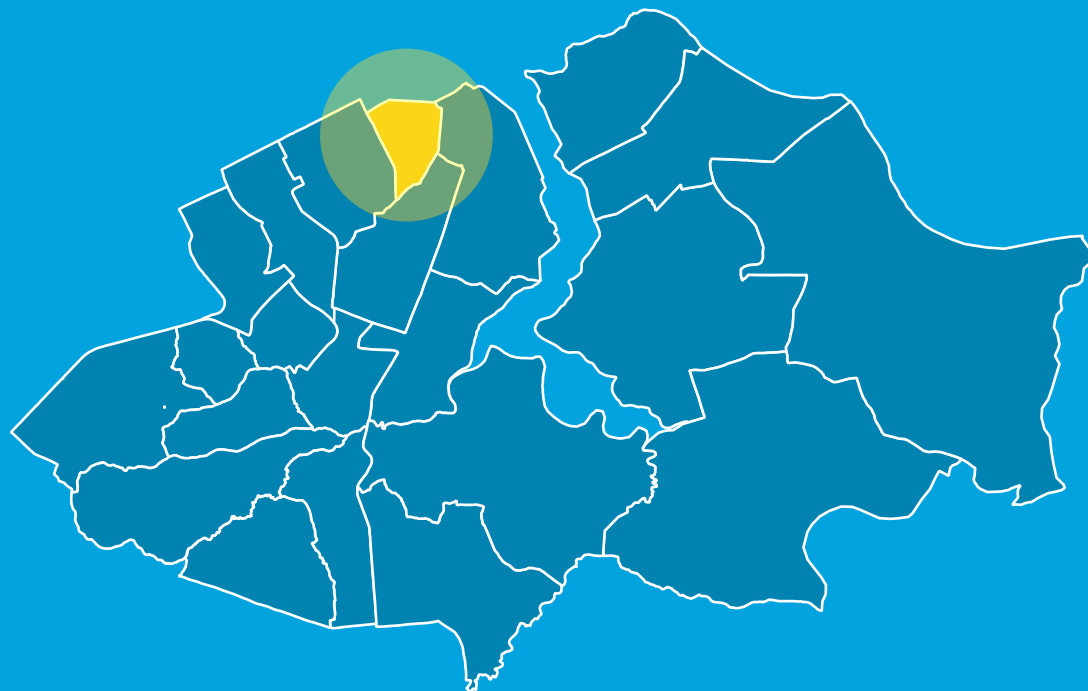
35,163

TOTAL NUMBER OF BUILDINGS

4,575

AT RISK OF FLOODING

Buildings at risk of flooding 961,
of which none are school or hospital
buildings.

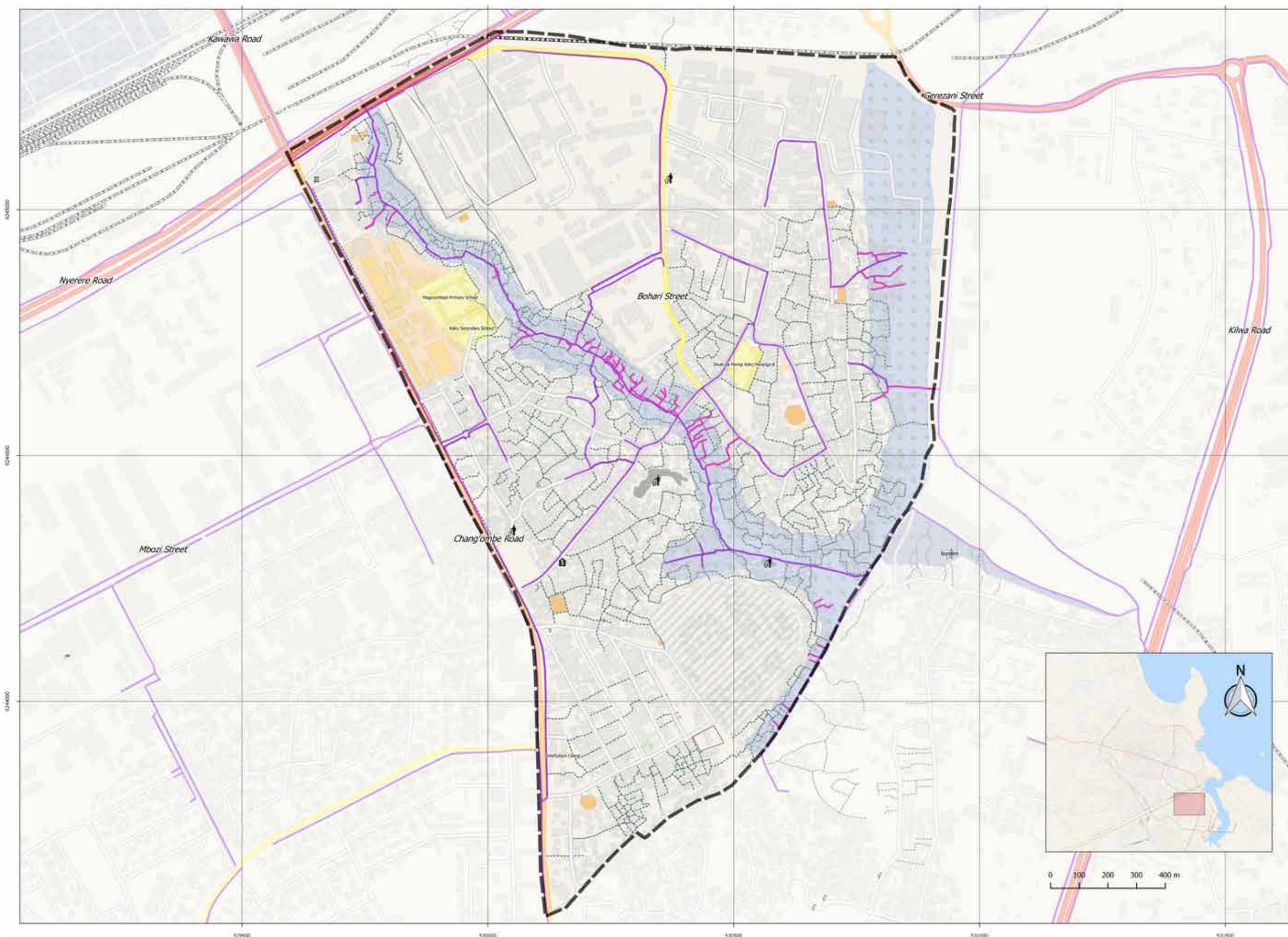


Description and Recommendations

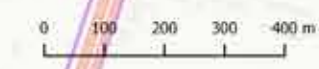
The stream that drains and cuts across Keko from Nyerere Road in the north to Miburani ward in the south causes is prone to overflowing during heavy rains, affecting residents that live along it. The risk of the stream overflowing is further increased due to the dumping of solid waste into its waters.

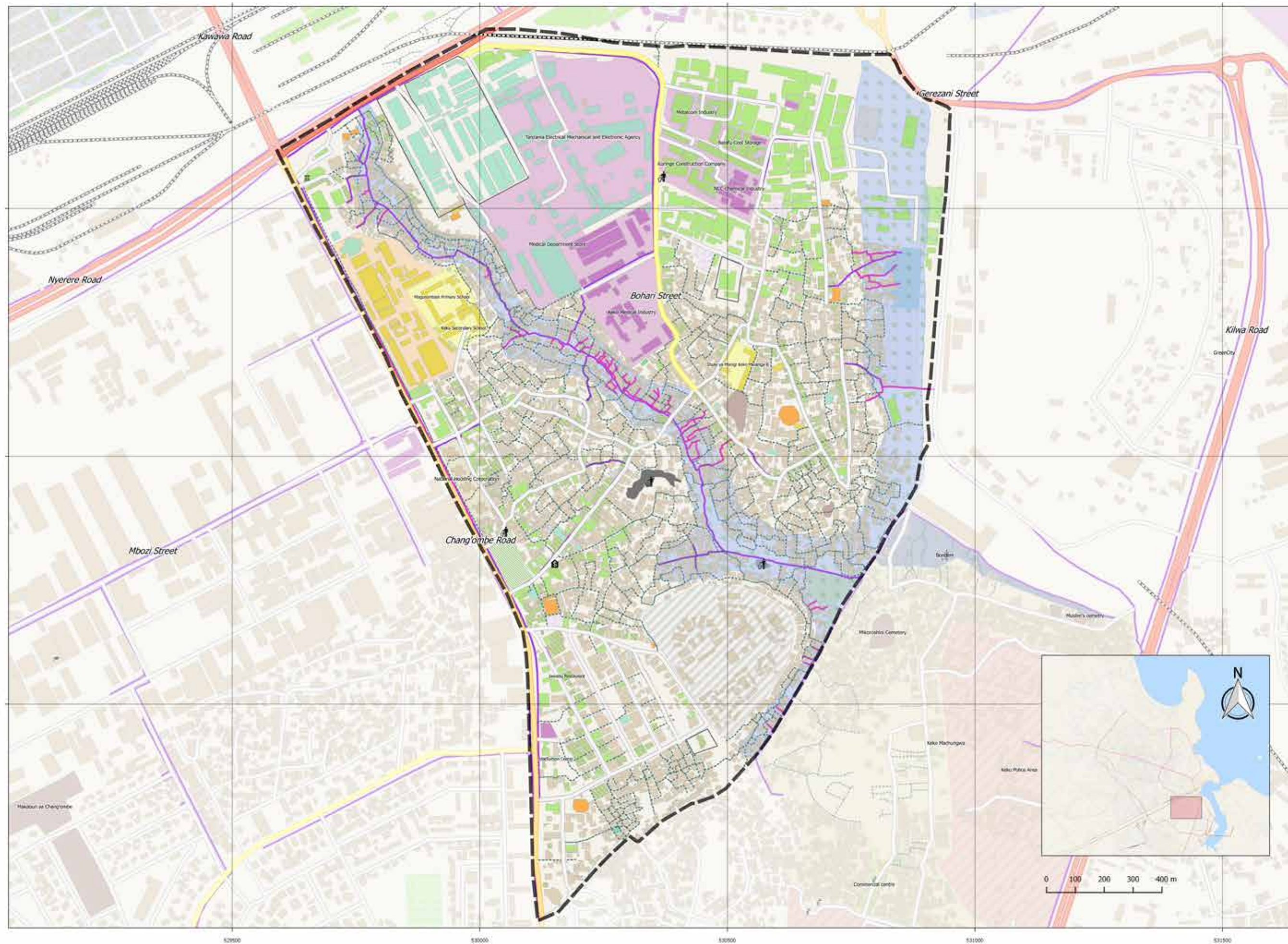
The same applies to the stream and flood prone area in the eastern part of the ward adjacent to Kurasini ward. According to community members, floods in Keko have minimal impact in terms of loss of life, but they do often fear the destruction of property. They believe that if waste materials were removed from the stream and its depth increased, damages could be effectively minimized.

KEKO DRAINAGE MAP



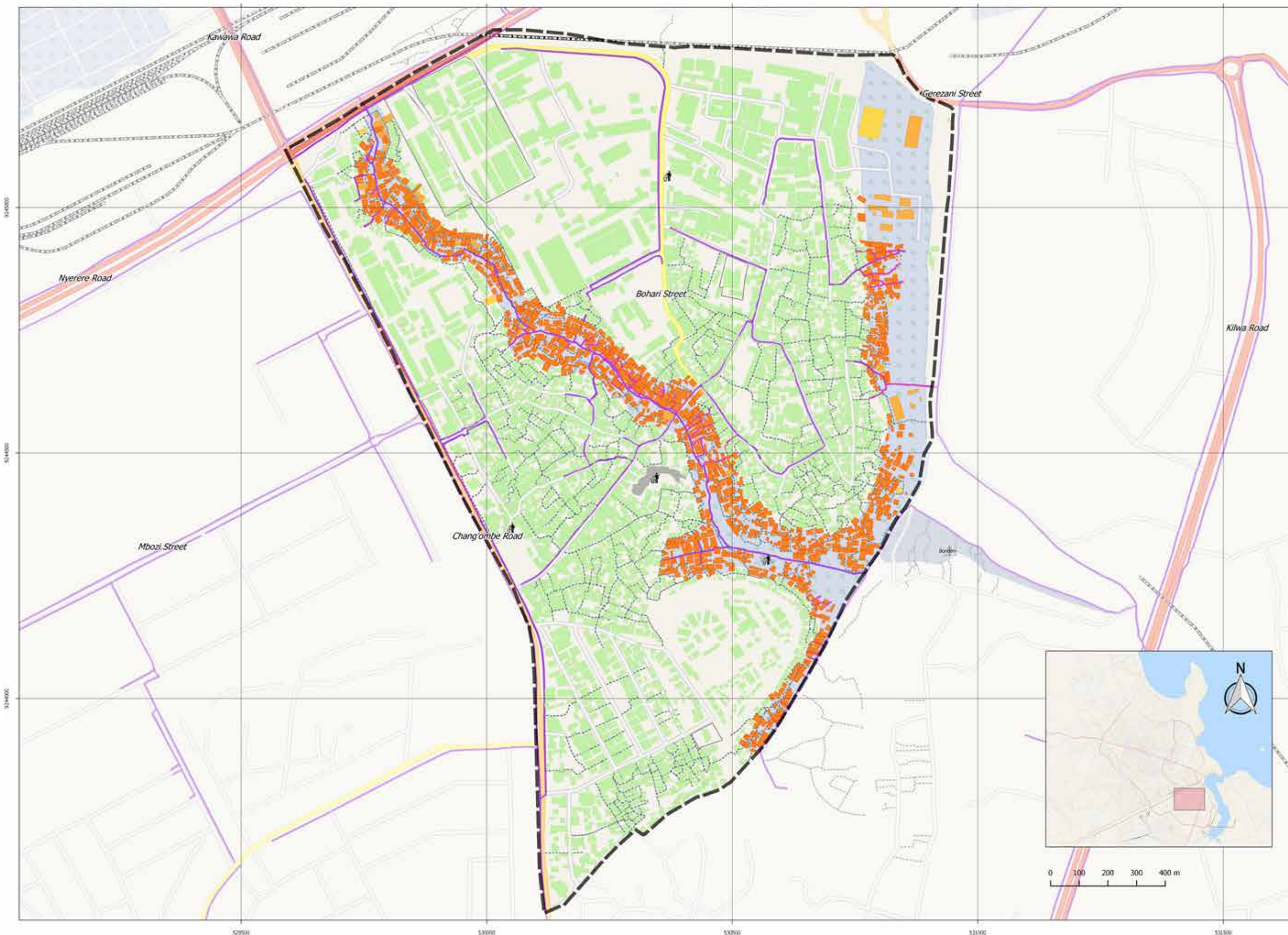
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



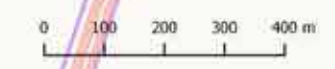
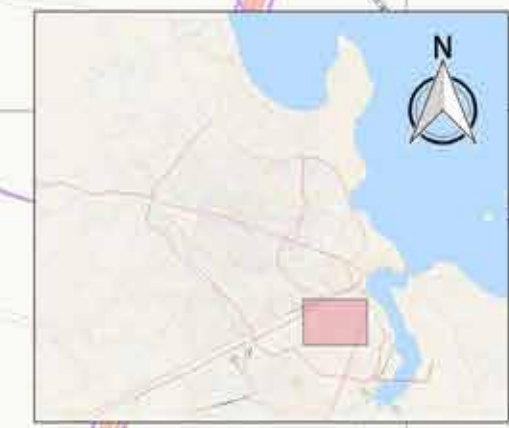


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

KEKO POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Buildings_inundation [4575]**
 - Not Inundated [3383]
 - Inundated, school or hospital [0]
 - Inundated, residential [1136]
 - Inundated, commercial [44]
 - Inundated, other [10]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



TEMEKE

MAPPING PERIOD

November 13th until November 27th 2015

SURFACE AREA

2.97 km²

FLOOD PRONE AREA

0.12 km² (4%)

POPULATION (2012 CENSUS)

26,047

TOTAL NUMBER OF BUILDINGS

4,246

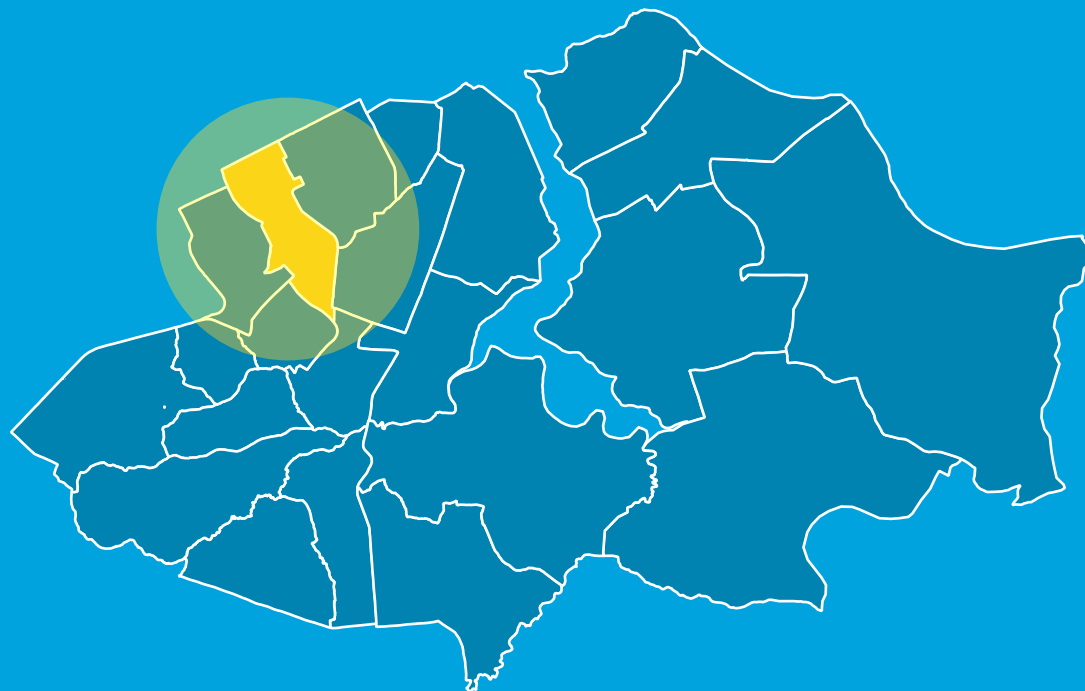
AT RISK OF FLOODING

Buildings at risk of flooding 323, of which 2 are school buildings.

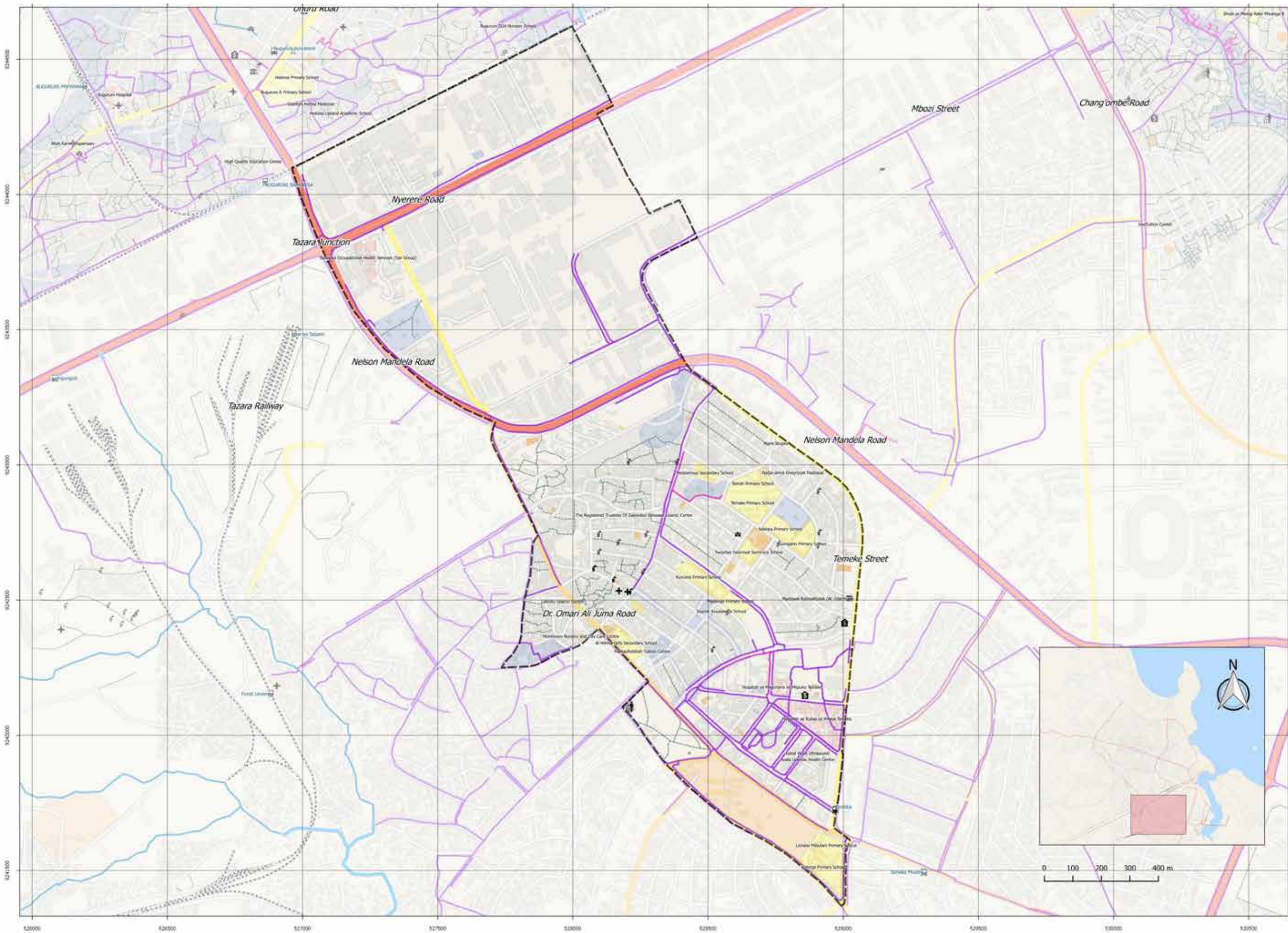
Description and Recommendations

With three quarters of the ward area having been planned, drains throughout the ward are mostly structured and connected. This makes Temeke more resilient when compared to other wards, with community leaders expressing a desire for their ward to exemplify potential infrastructural improvements across the city.

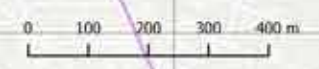
The addition of drains in certain areas would further enhance the resilience of Temeke to flooding.



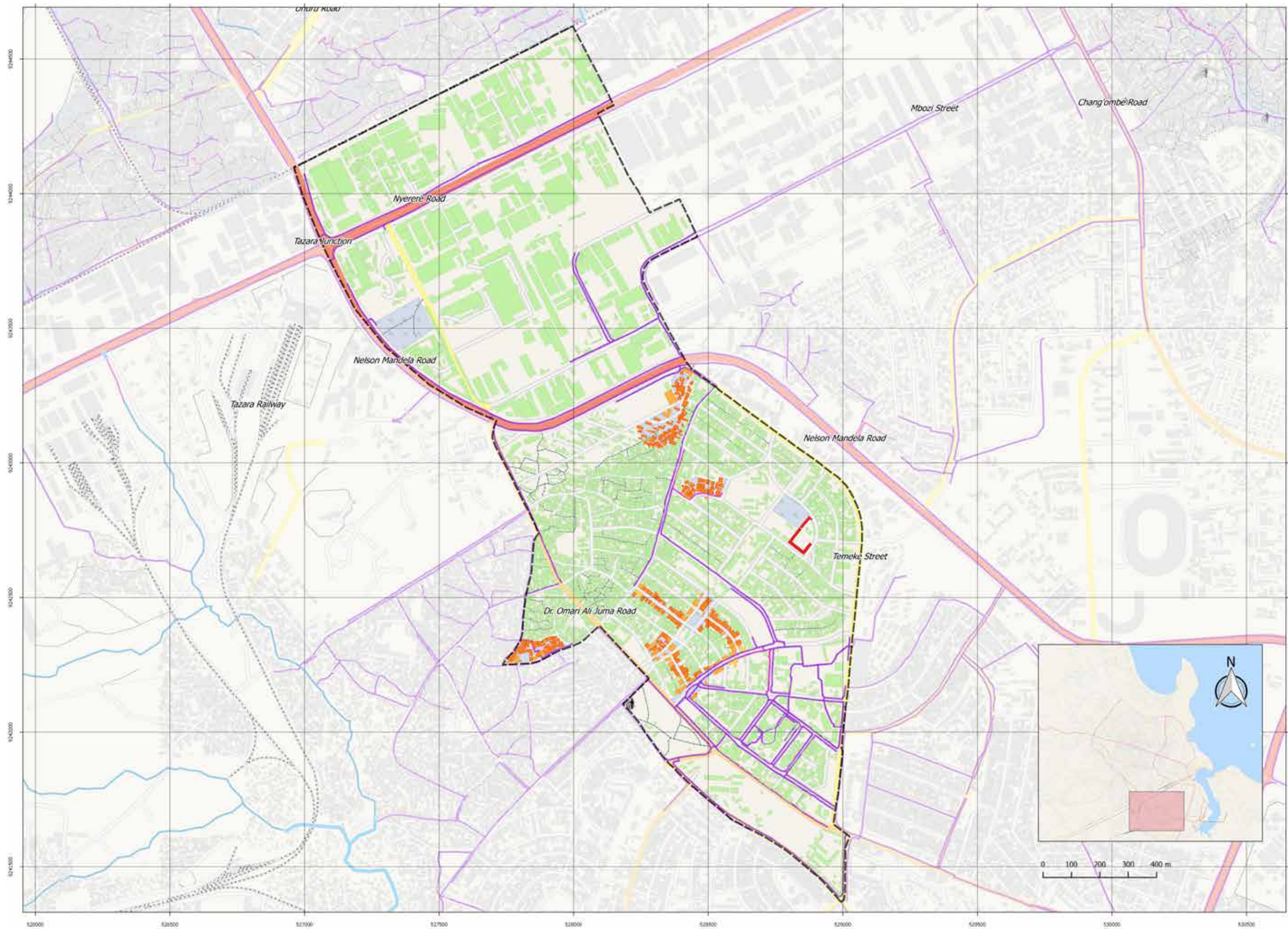
TEMEKE DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



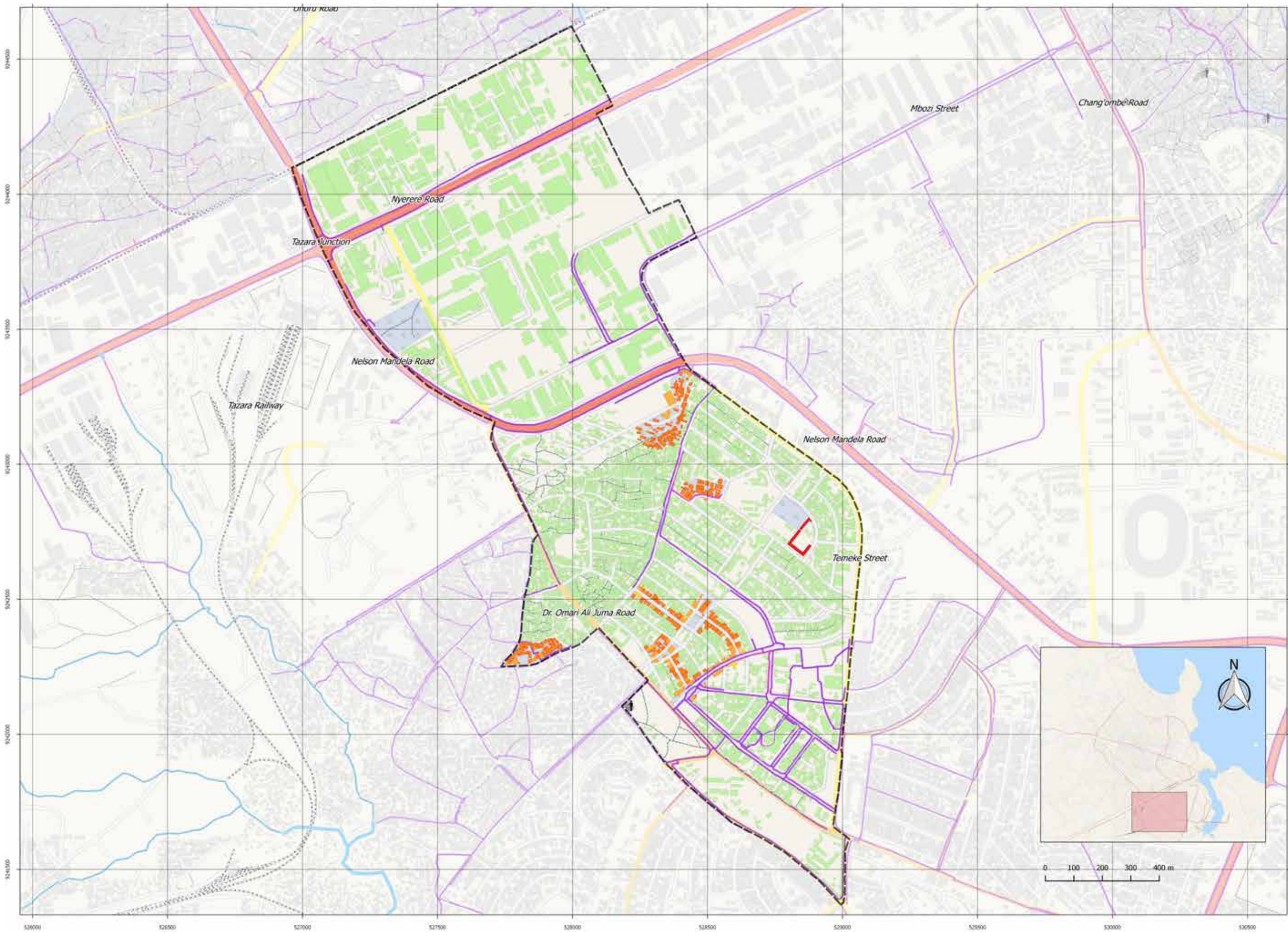
TEMEKE GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water



TEMEKE POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation (4245)**
 - Not Inundated [3925]
 - Inundated, school or hospital [2]
 - Inundated, residential [250]
 - Inundated, commercial [65]
 - Inundated, other [3]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point

MBURAHATI

MAPPING PERIOD

July 14th until August 11th 2015

SURFACE AREA

1.13 km²

FLOOD PRONE AREA

0.38 km² (33%)

POPULATION (2012 CENSUS)

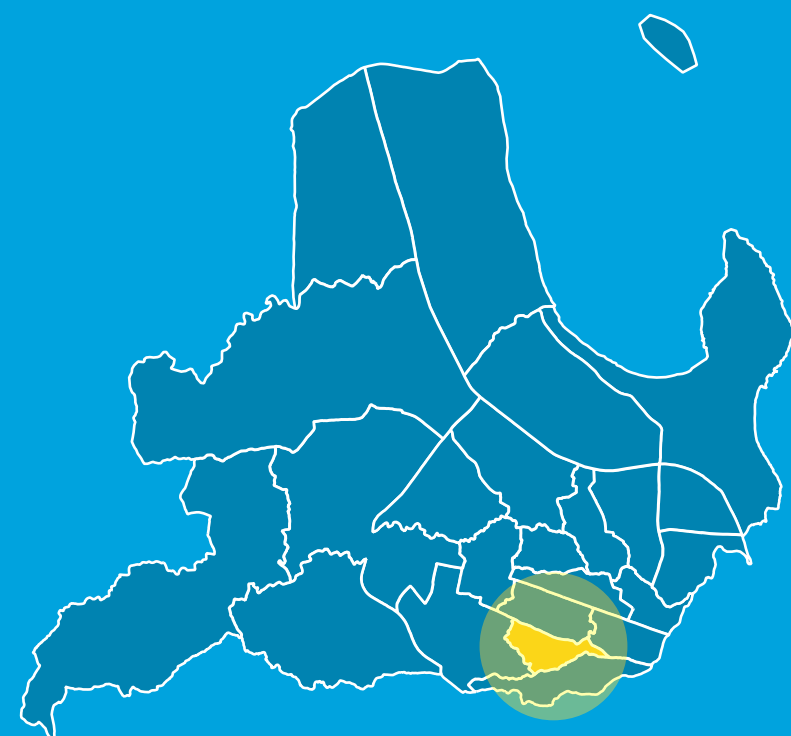
34,123

TOTAL NUMBER OF BUILDINGS

5,753

AT RISK OF FLOODING

Buildings at risk of flooding 1,997, of which 1 is a school building.



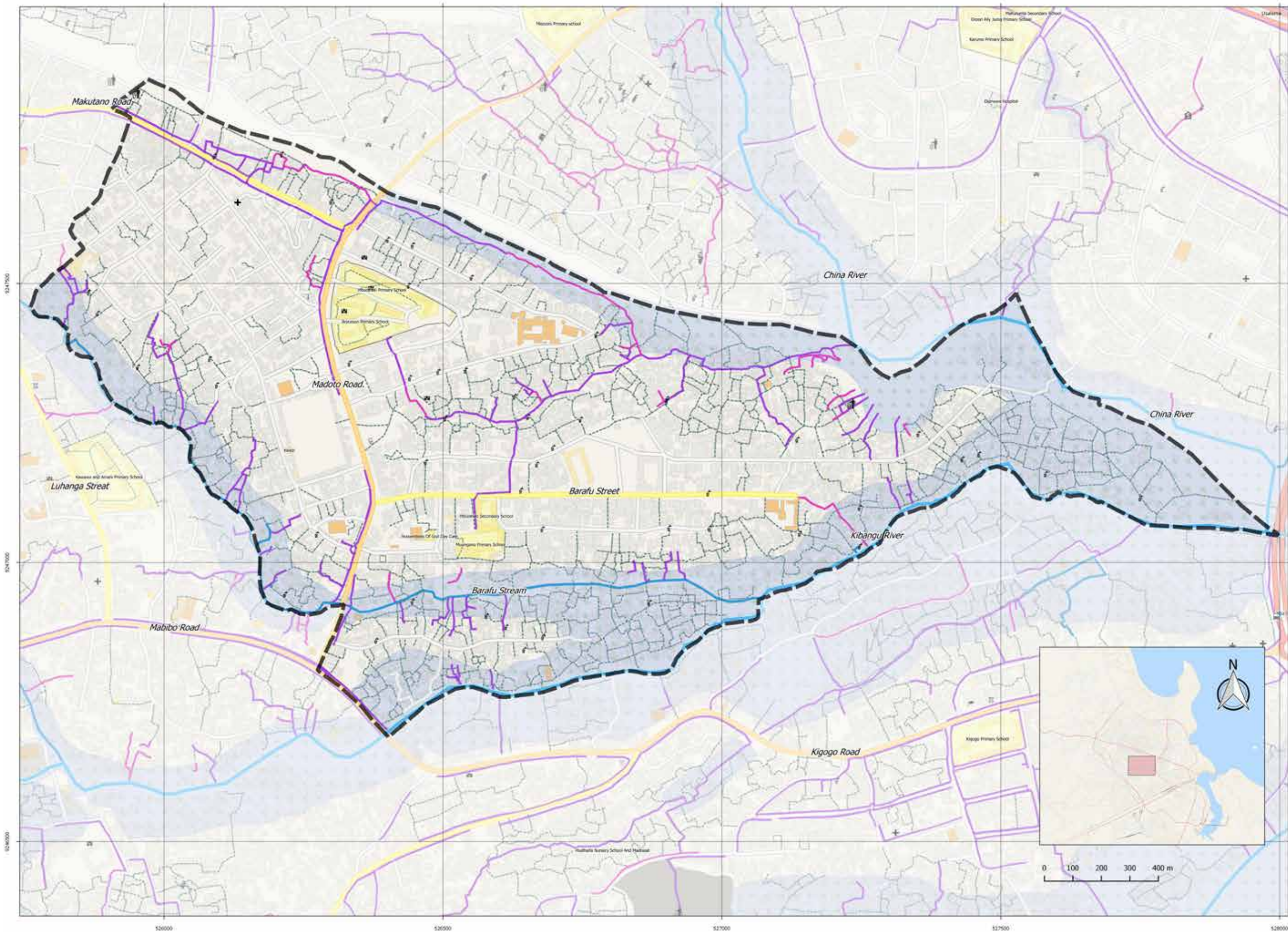
Description and Recommendations

In the southwestern part of the ward, the river stream that forms Mburahati's ward boundary and cuts across the ward to join Kibangu river can burst its banks under high rainfall . This can affect residents along its path.

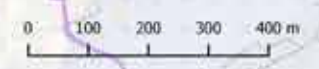
Additionally, the Kibangu river in the south, which drains from Mabibo ward and moves towards Kawawa road, combined with the China river in the north-eastern part of the ward, together pose a flood risk to the residents and infrastructure around these areas. Many settlements have been developed along these rivers, leaving residents vulnerable to the consequences of flooding during heavy rains.

In response to this situation, the deepening the rivers and supporting enhanced planning capacity for ward and community leaders could begin to ease the pressure of population growth in the ward.

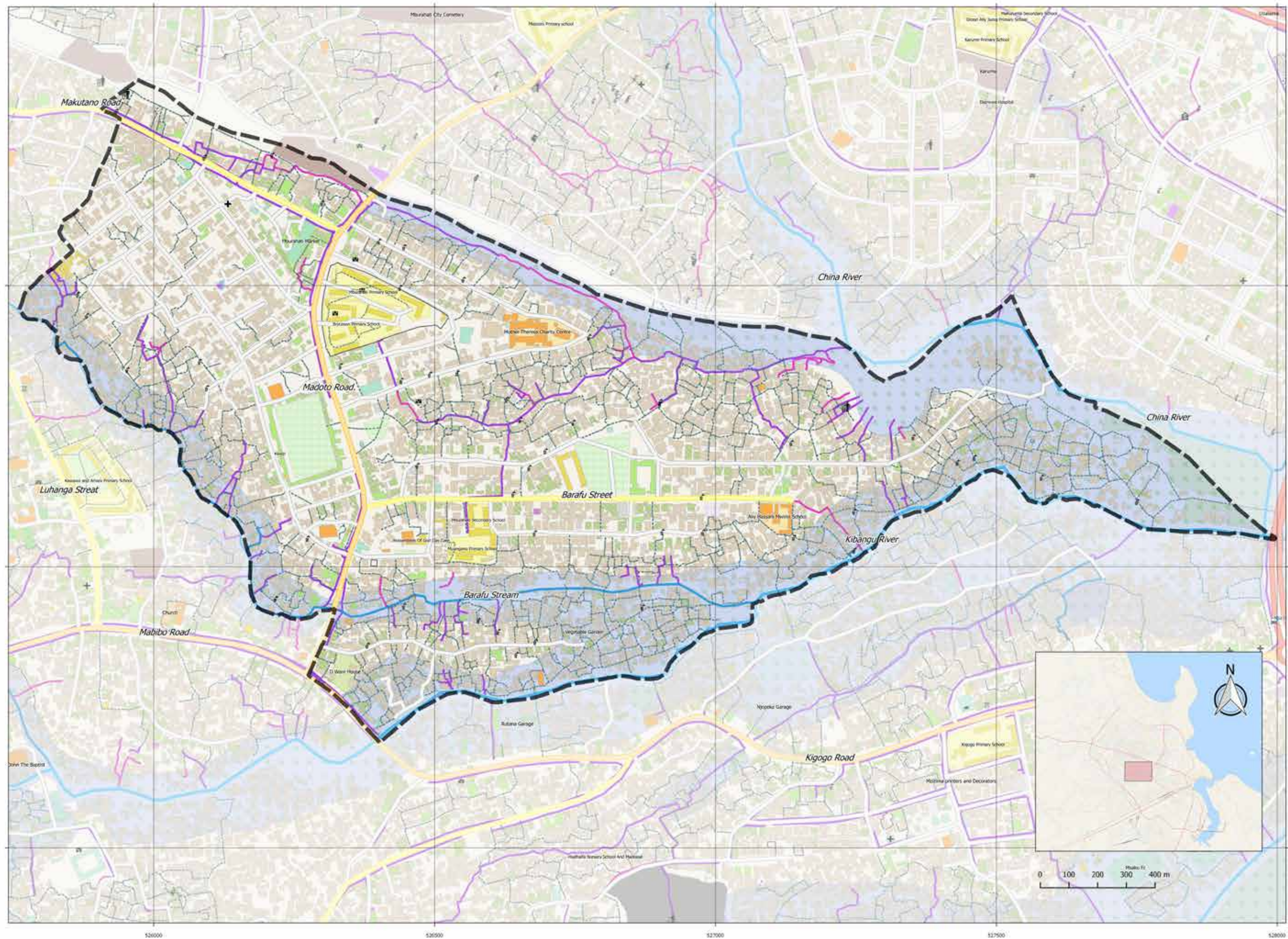
MBURAHATI DRAINAGE MAP



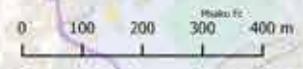
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



MBURAHATI GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

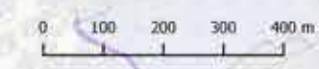
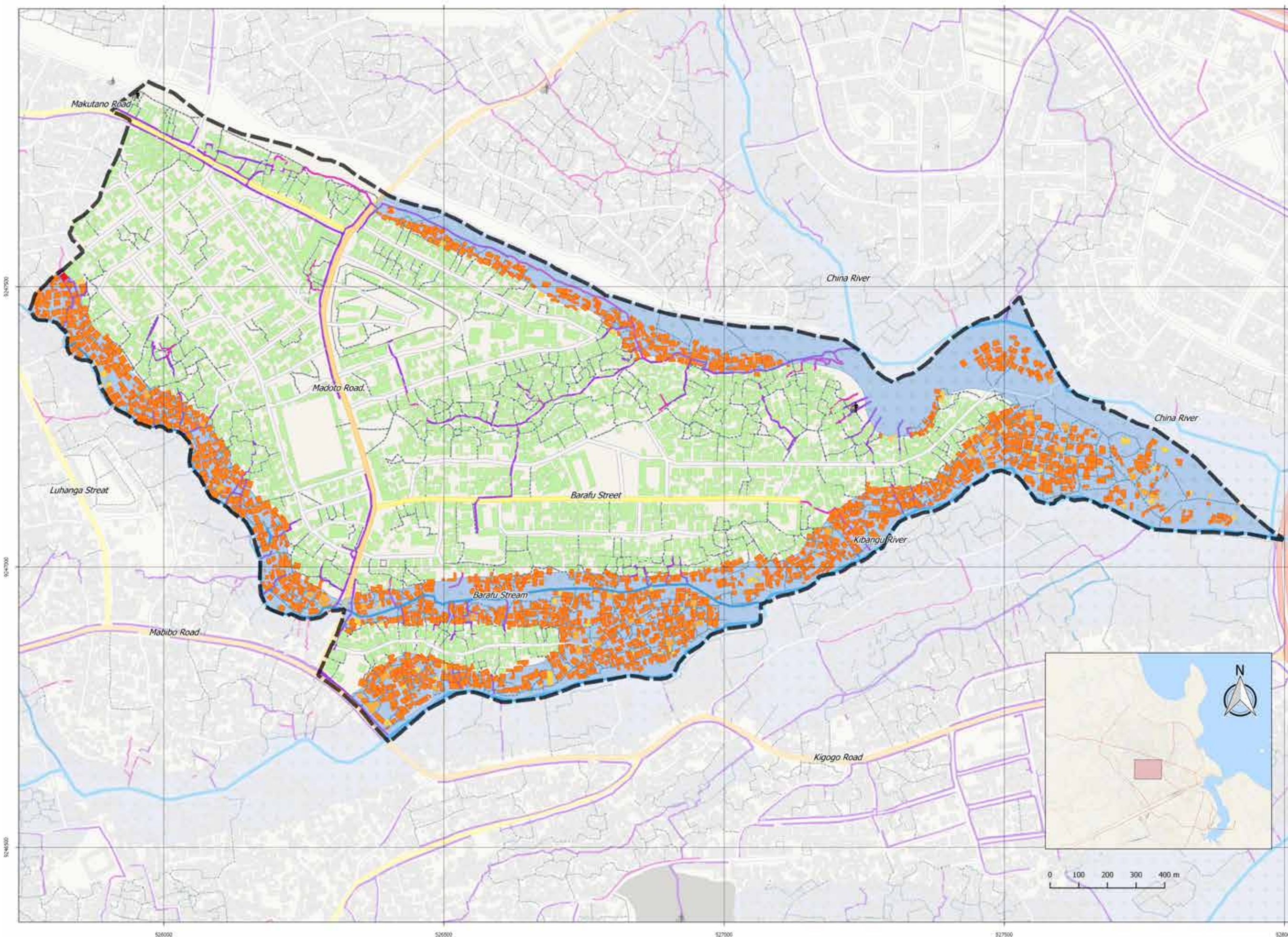


MBURAHATI POTENTIAL INUNDATION MAP



Legend

- Boundaries**
- Ward
- Building Inundation [5753]**
- Not Inundated [3757]
- Inundated, school or hospital [1]
- Inundated, residential [1862]
- Inundated, commercial [54]
- Inundated, other [80]
- Roads and Railways**
- Primary
- Secondary
- Tertiary
- Unclassified
- Footpath
- ⊠ Railway
- Waterways**
- River
- Stream
- Drain
- Ditch
- Features**
- Wetland
- ♣ Waste Collection Point



MABIBO

MAPPING PERIOD

July 14th until August 12th 2015

SURFACE AREA

3.93 km²

FLOOD PRONE AREA

0.51 km² (13%)

POPULATION (2012 CENSUS)

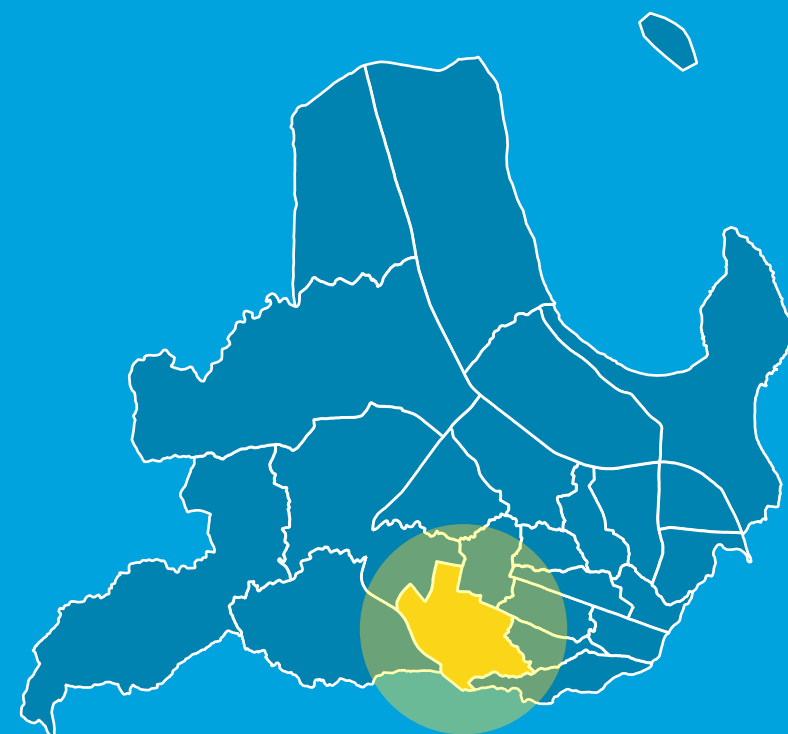
85,735

TOTAL NUMBER OF BUILDINGS

16,349

AT RISK OF FLOODING

Buildings at risk of flooding 1,519, of which 2 are school or hospital buildings.

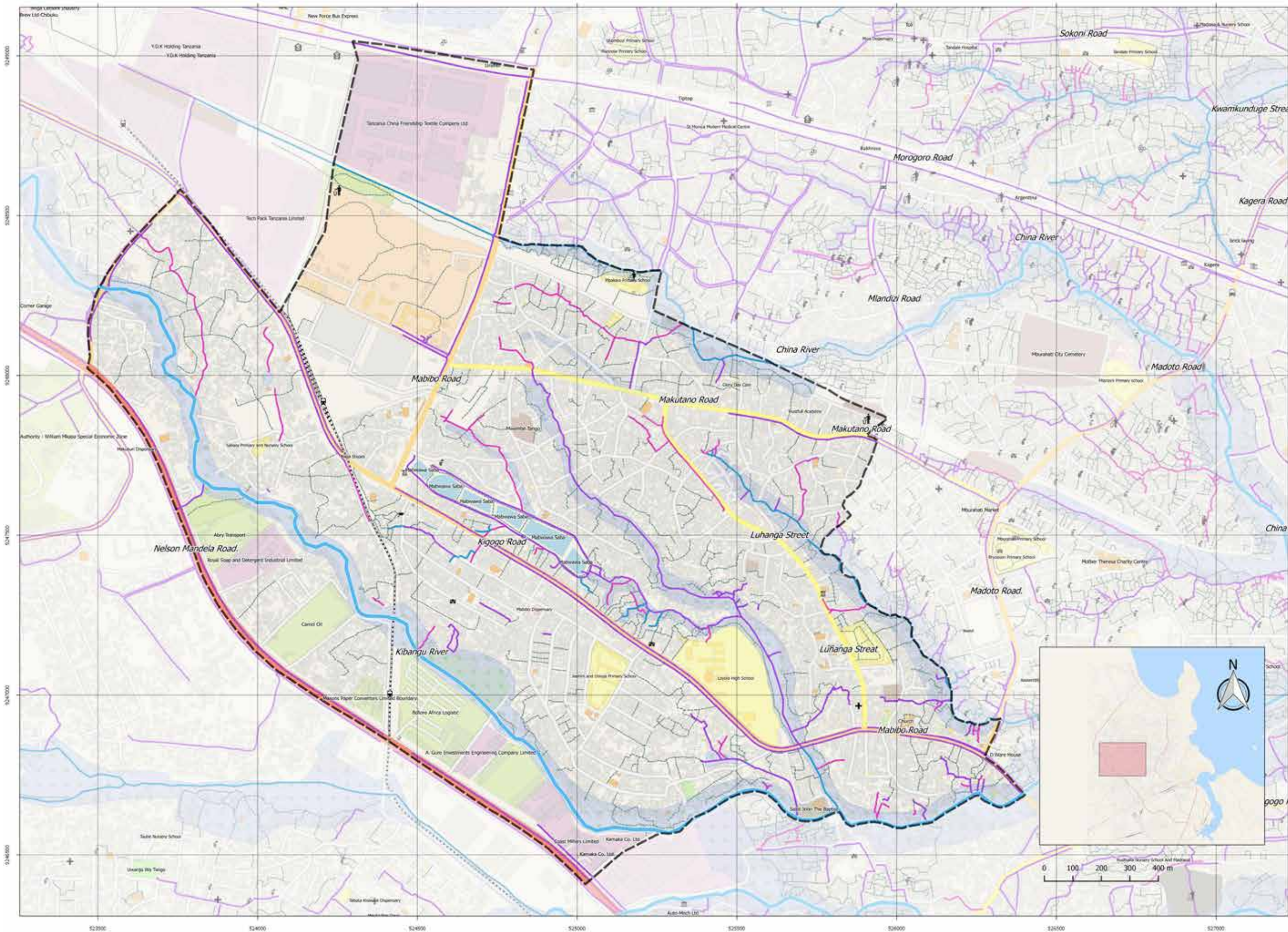


Description and Recommendations

In Mabibo, parts of the Mabibo Relini and Mabibo Farasi subwards (adjacent to Tabata) are affected by the Kibangu river. The Kibangu river runs through the western and southern parts of the ward, between Ubungo and Mburahati wards. During high rainfall the river overflows, leading to a risk of flooding affecting residents in its proximity.

In Jitegemee and Azimio subwards, two drains intersect downstream. These drains are shallow and contain waste material. To mitigate this situation, residents of these subwards have constructed levees from waste material on the drainage walls. While this has increased the drainage depth, the health and hygiene concerns that remain suggest that the construction of a deeper drain would be a more sustainable solution for improving the drainage capacity.

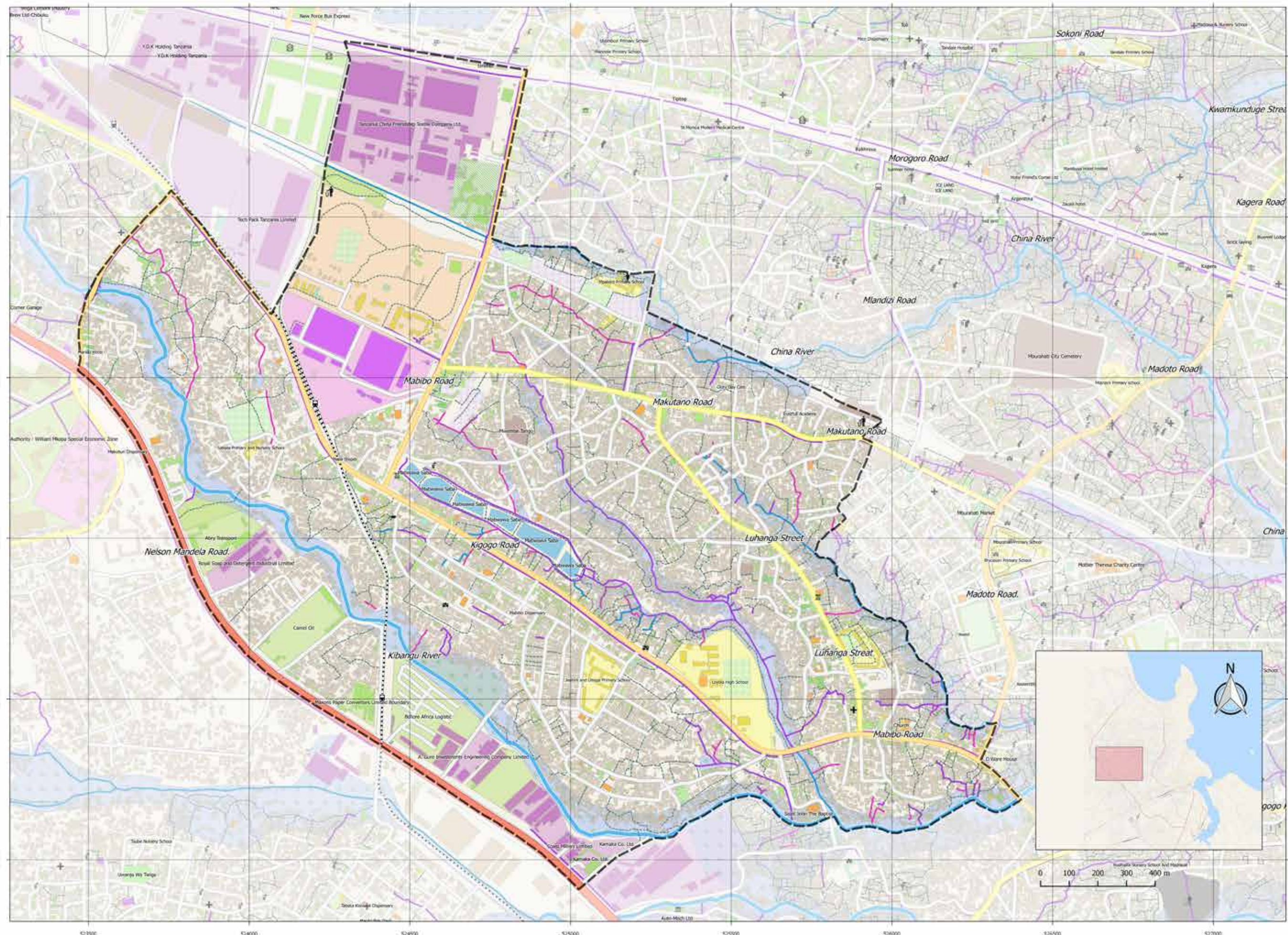
MABIBO DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Icons**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

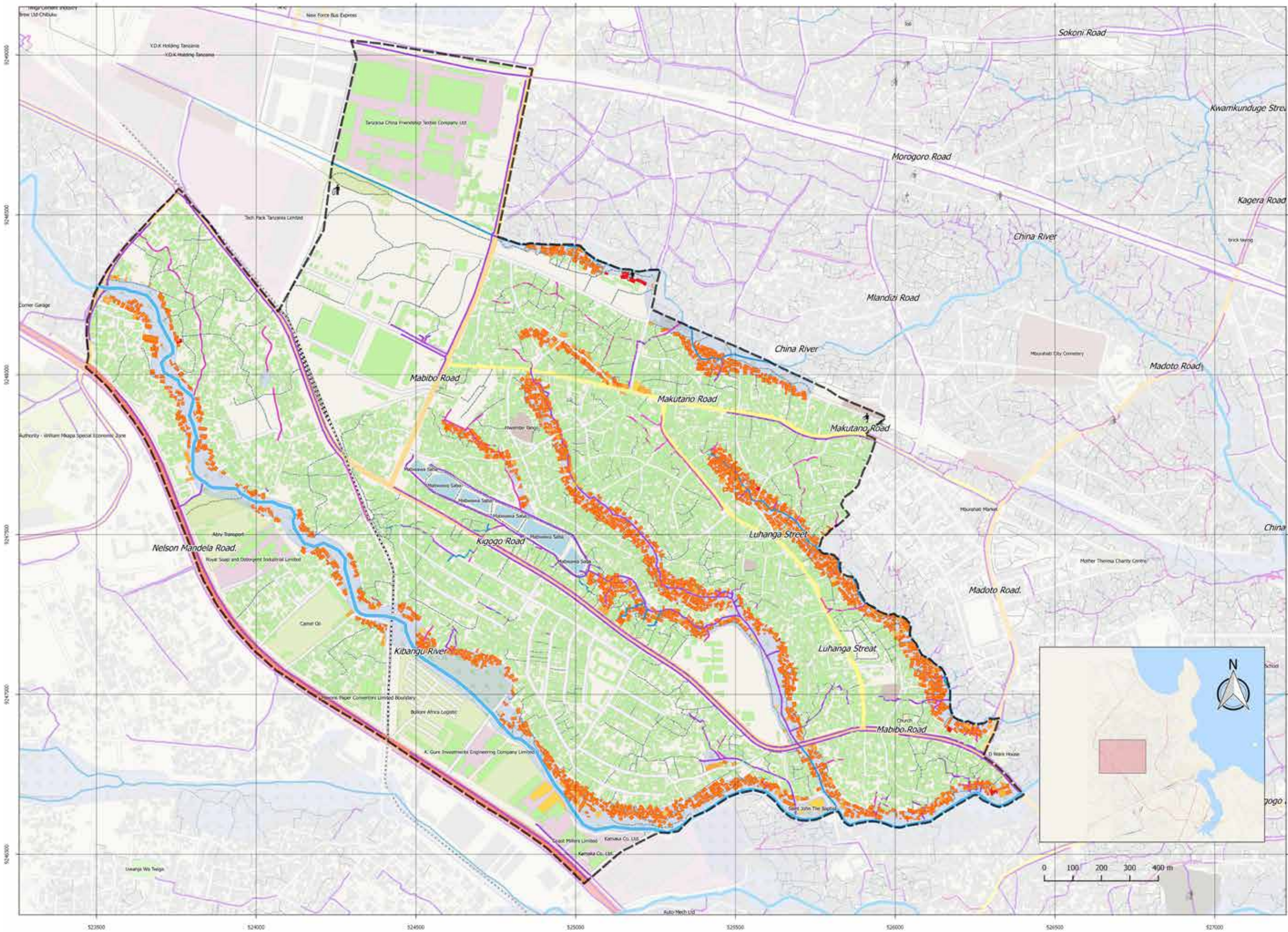


MABIBO GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

MABIBO POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [16540]**
 - Not inundated [13827]
 - Inundated, school or hospital [10]
 - Inundated, residential [2421]
 - Inundated, commercial [178]
 - Inundated, other [104]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point

MANZESE

MAPPING PERIOD

September 11th until October 9th 2015

SURFACE AREA

1.86 km²

FLOOD PRONE AREA

0.31 km² (17%)

POPULATION (2012 CENSUS)

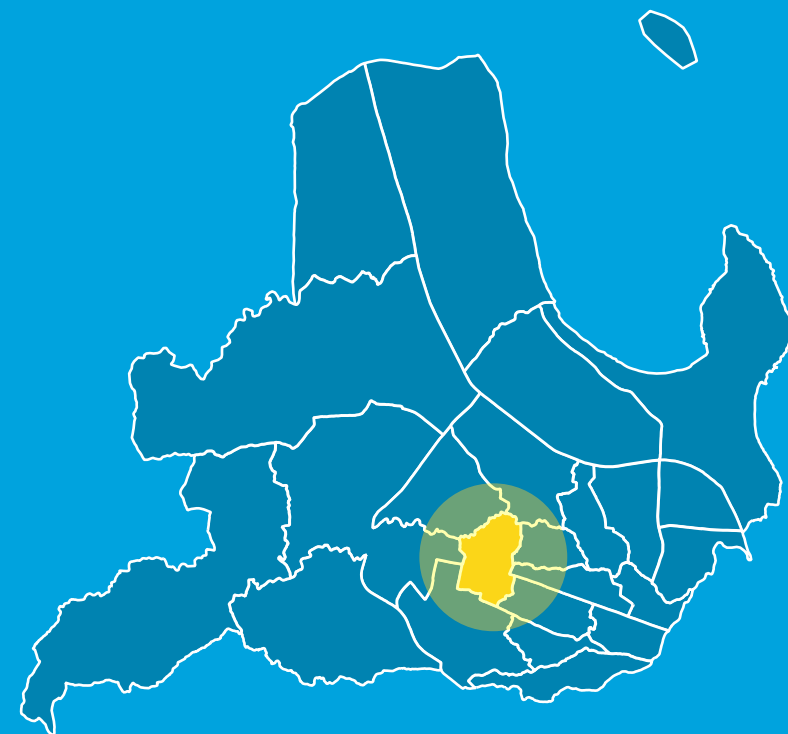
70,507

TOTAL NUMBER OF BUILDINGS

9,504

AT RISK OF FLOODING

Buildings at risk of flooding 1,948, of which 12 are school or hospital buildings.



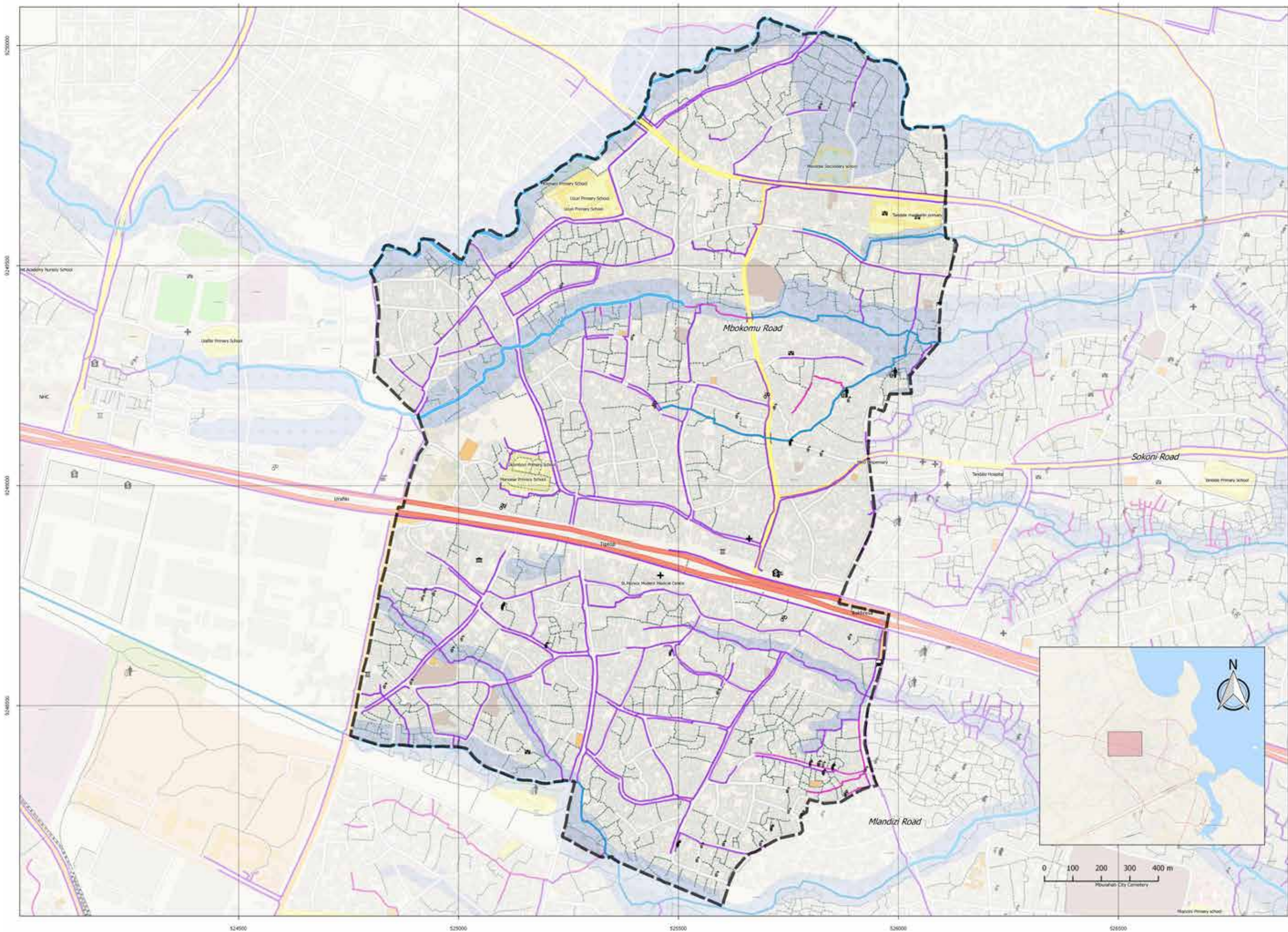
Description and Recommendations

Manzese is intersected by a large network of rivers and streams, along with the newly constructed Bus Rapid Transit system on Morogoro Road.

In the northern area of Manzese, Chai Bora subward is bordered by the Ng'ombe river, with water pooling along the river banks when intense rains occur. Mvuleni and Uzuri subwards are also affected by this phenomenon, though the additional complication of the Mbokomu stream (that later joins the Kiboko river) leaves the buildings and infrastructure along its banks even further prone to flooding.

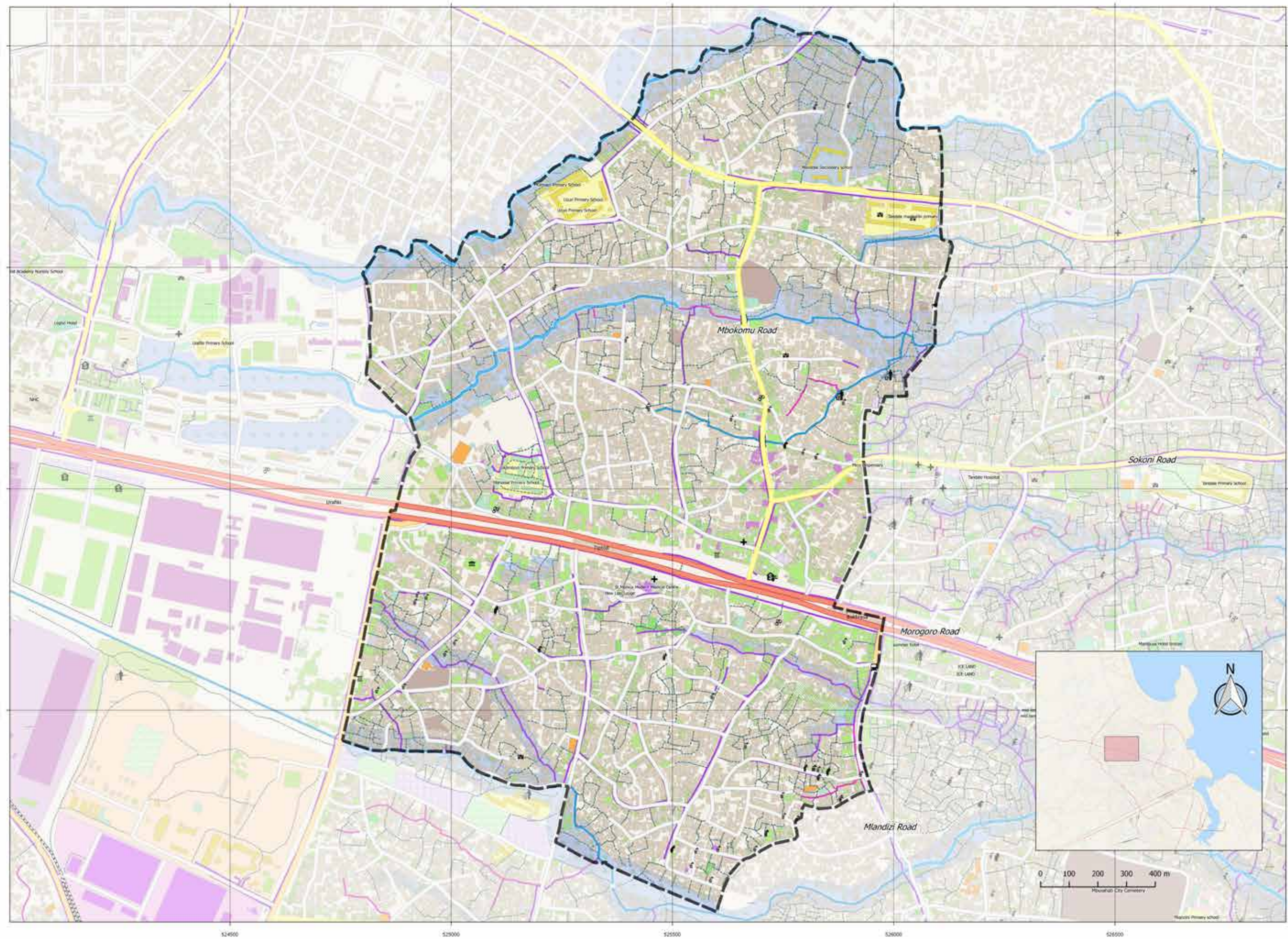
Expanding the capacity of drainage could ease the flood propensity of Manzese and improve the situation for those living within the ward.

MANZESE DRAINAGE MAP



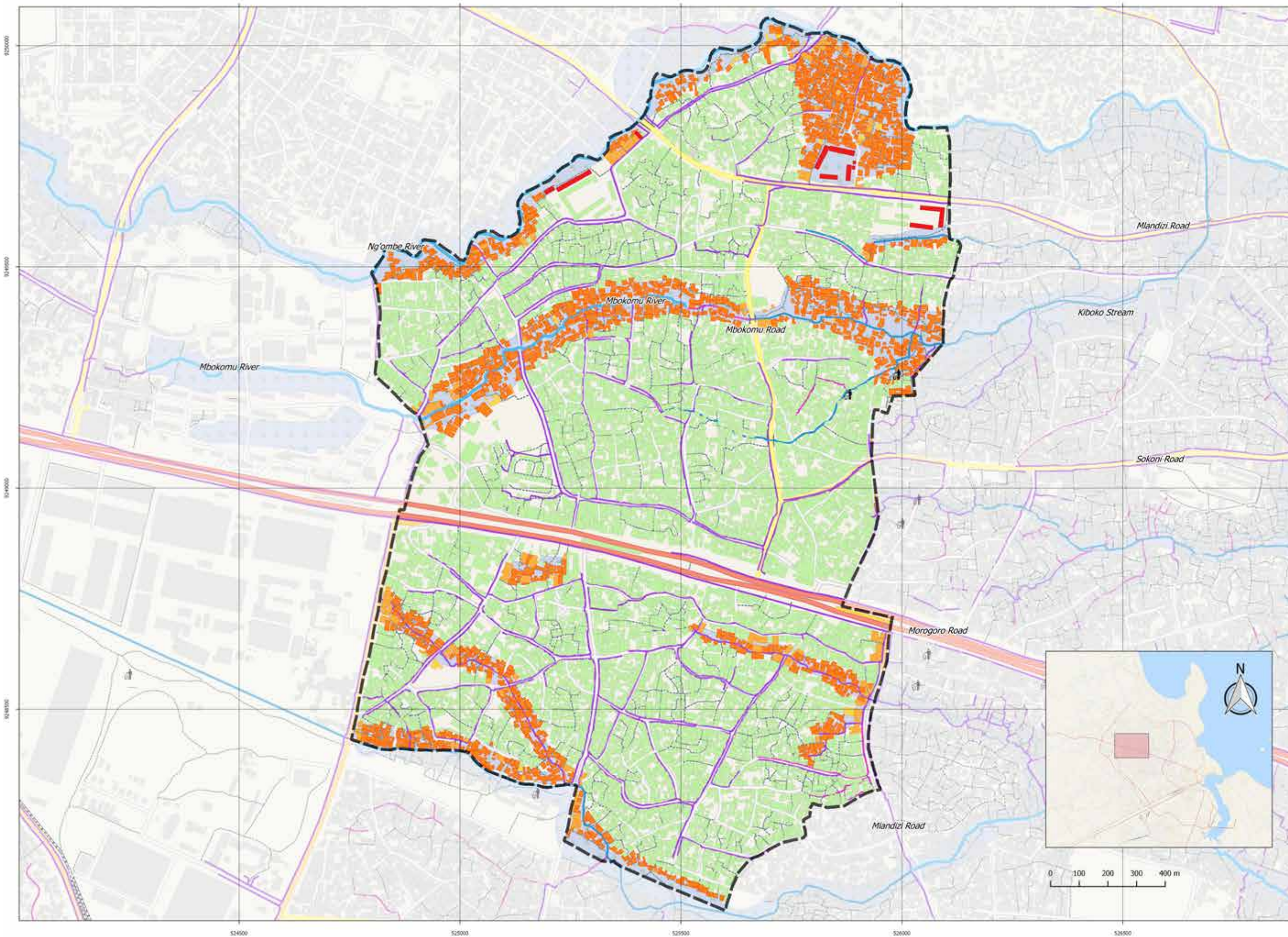
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Hospital/clinic**
 - Fuel**
 - Fire Station**
 - Police**
 - Bar/Cafe**
 - Restaurant**
 - School**
 - University**
 - Waste Collection Point**
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood





- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

MANZESE POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [9504]**
 - Not Inundated [7568]
 - Inundated, school or hospital [12]
 - Inundated, residential [1719]
 - Inundated, commercial [160]
 - Inundated, other [46]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point

UBUNGO

MAPPING PERIOD

October 8th until November 6th 2015

SURFACE AREA

10.17 km²

FLOOD PRONE AREA

0.58 km² (6%)

POPULATION (2012 CENSUS)

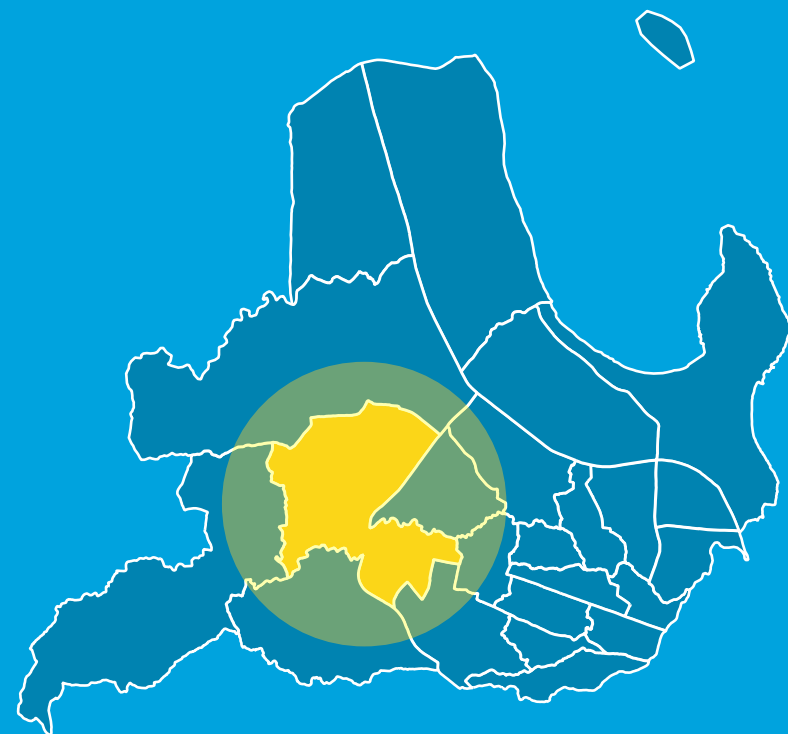
56,015

TOTAL NUMBER OF BUILDINGS

9,282

AT RISK OF FLOODING

Buildings at risk of flooding 1,102, of which 12 are school or hospital buildings.



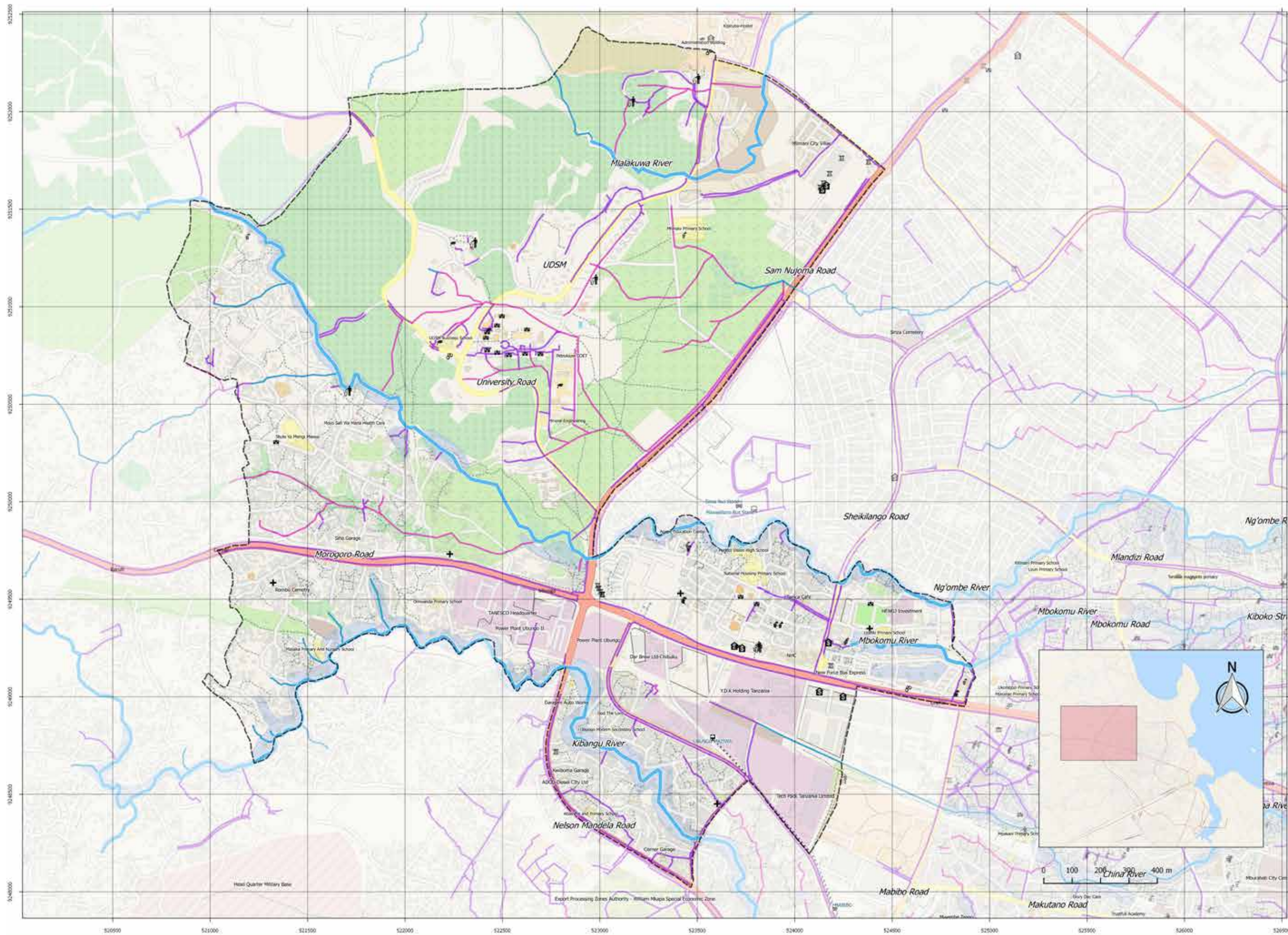
Description and Recommendations

Most of subwards in Ubungo (except for Chuo Kikuu, where the University of Dar es Salaam and Ardhi University are located) have the same challenge: a lack of drainage infrastructure.

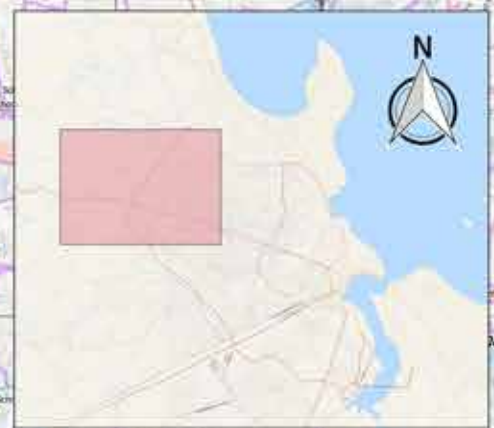
This is augmented by Ubungo's growing population, leading to an increase in demand for housing and for business areas. The growing need for space has led some residents to construct buildings on top of waterways, contributing to the blockage of storm drains and the overflowing of stormwater during heavy rains. Solid waste management is a further contributory factor, resulting in further blockage within the drainage system.

In response to this situation, enhancing capacity for planning by ward and community leaders could begin to ease the pressures of urbanisation within Ubungo if supported by regular cleaning and removal of solid waste within the drainage network.

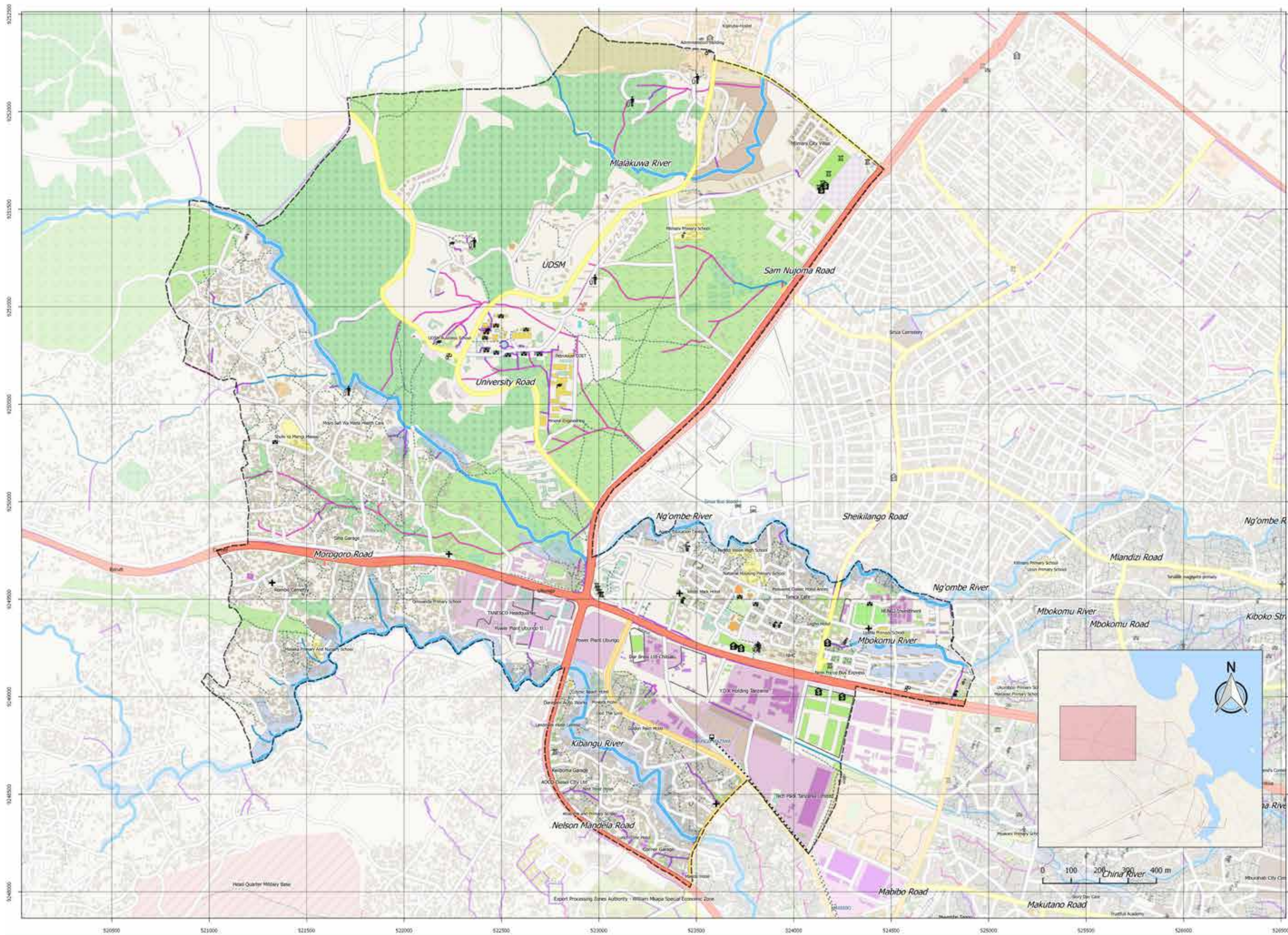
UBUNGO DRAINAGE MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Icons**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Waste Collection Point
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Waste Collection Point
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood

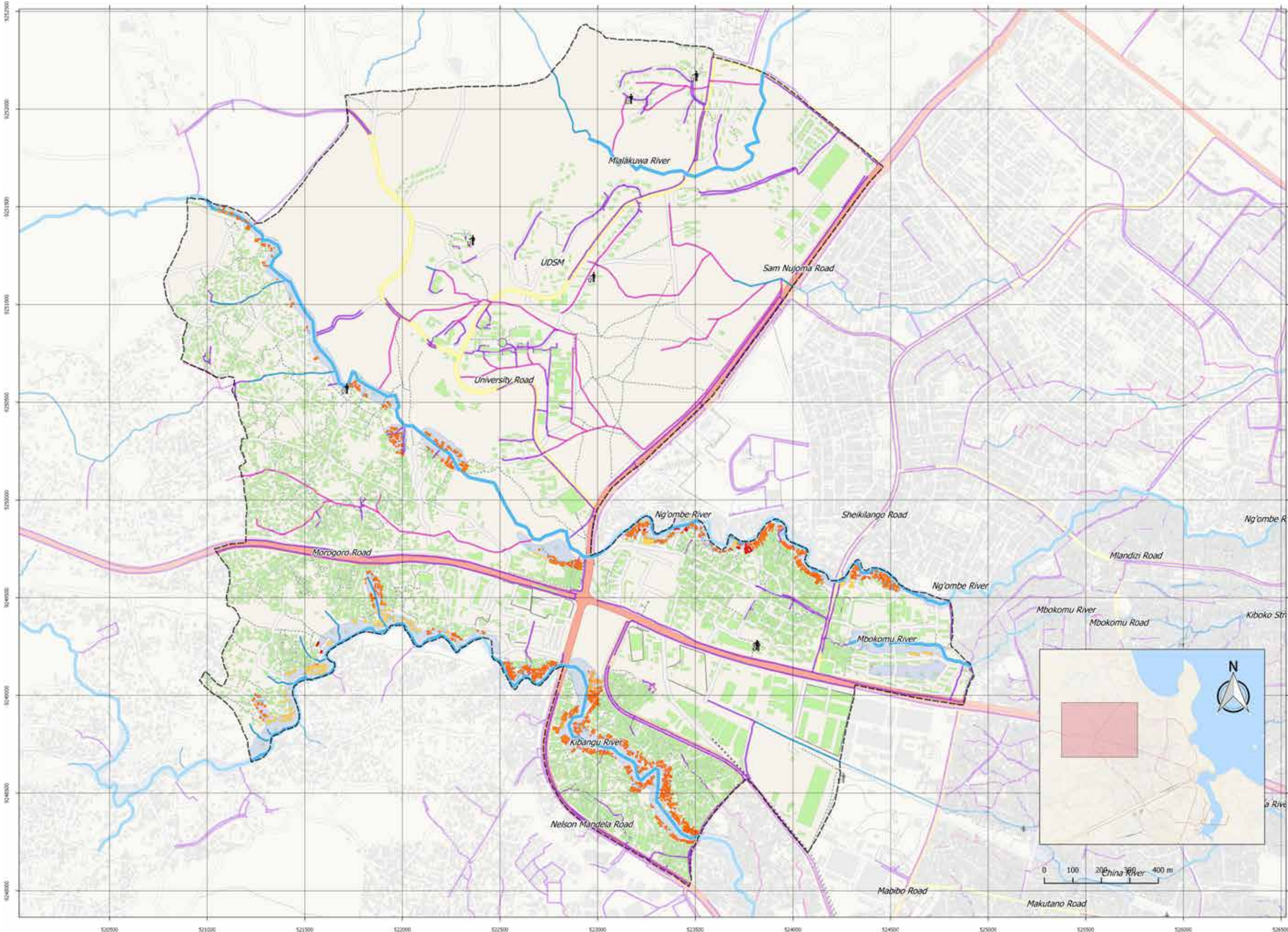


UBUNGO GENERAL MAP

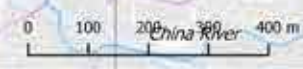
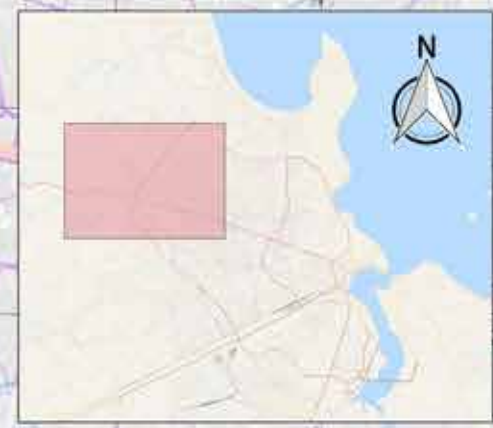


- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Waste Collection Point
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Landuse**
 - Brownfield
 - Cemetery
 - Waste Collection Point
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water

UBUNGO POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building_Inundation [9282]**
 - Not Inundated [8180]
 - Inundated, school or hospital [12]
 - Inundated, residential [904]
 - Inundated, commercial [35]
 - Inundated, other [153]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



MAKURUMLA

MAPPING PERIOD

July 13th until August 12th 2015

SURFACE AREA

1.57 km²

FLOOD PRONE AREA

0.29 km² (18%)

POPULATION (2012 CENSUS)

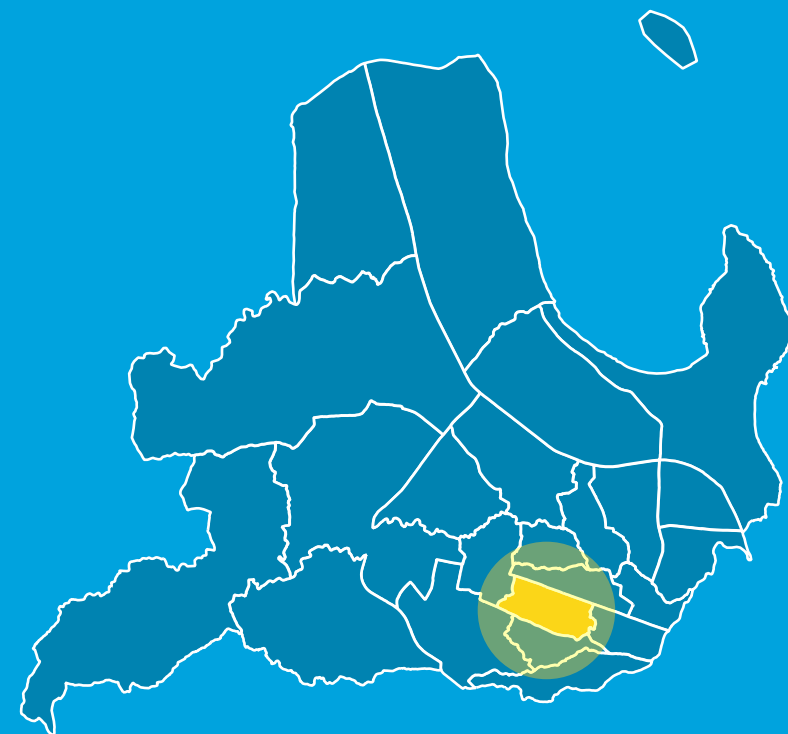
63,352

TOTAL NUMBER OF BUILDINGS

8,043

AT RISK OF FLOODING

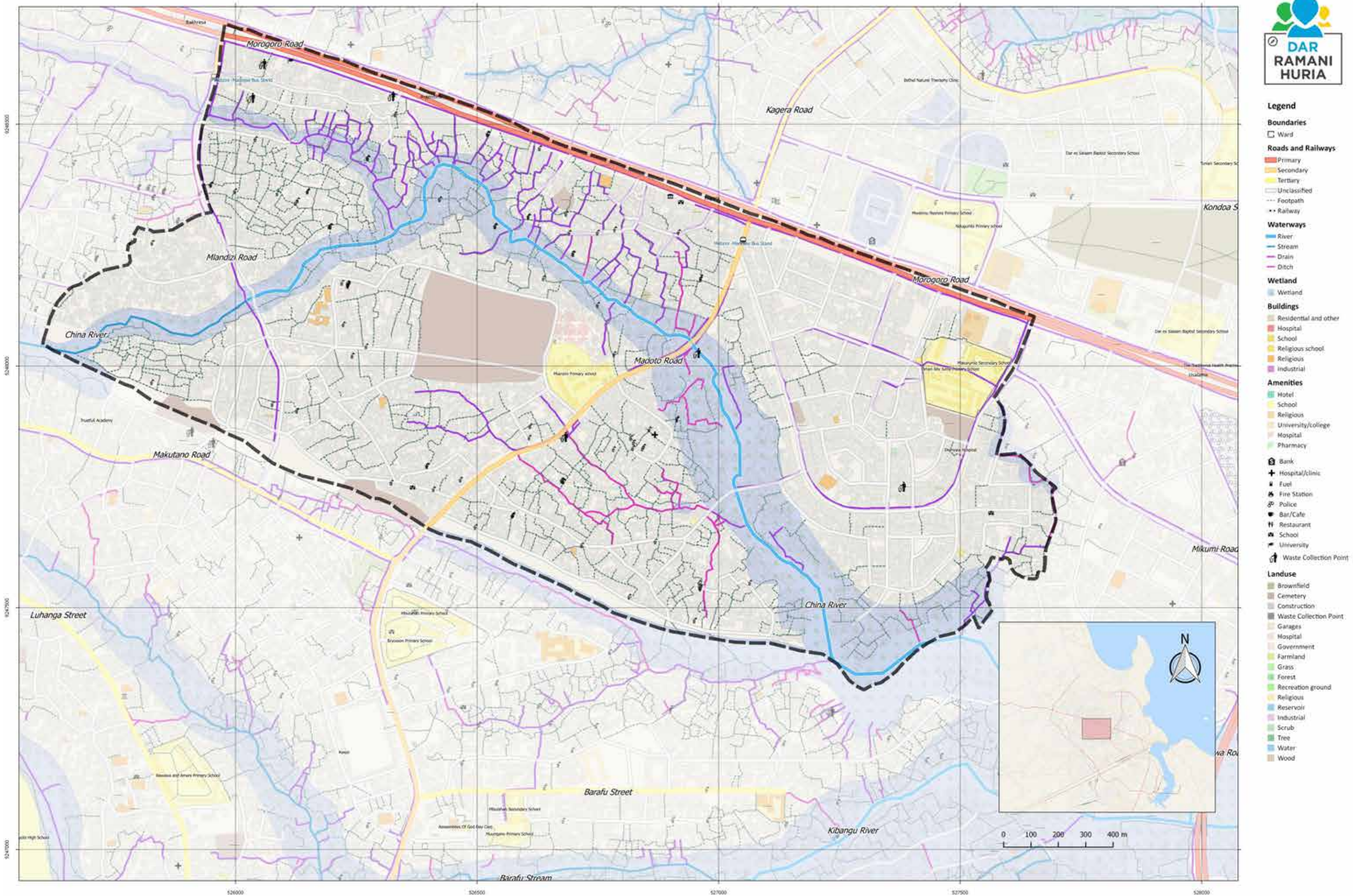
Buildings at risk of flooding 1669, of which 1 is a school building.



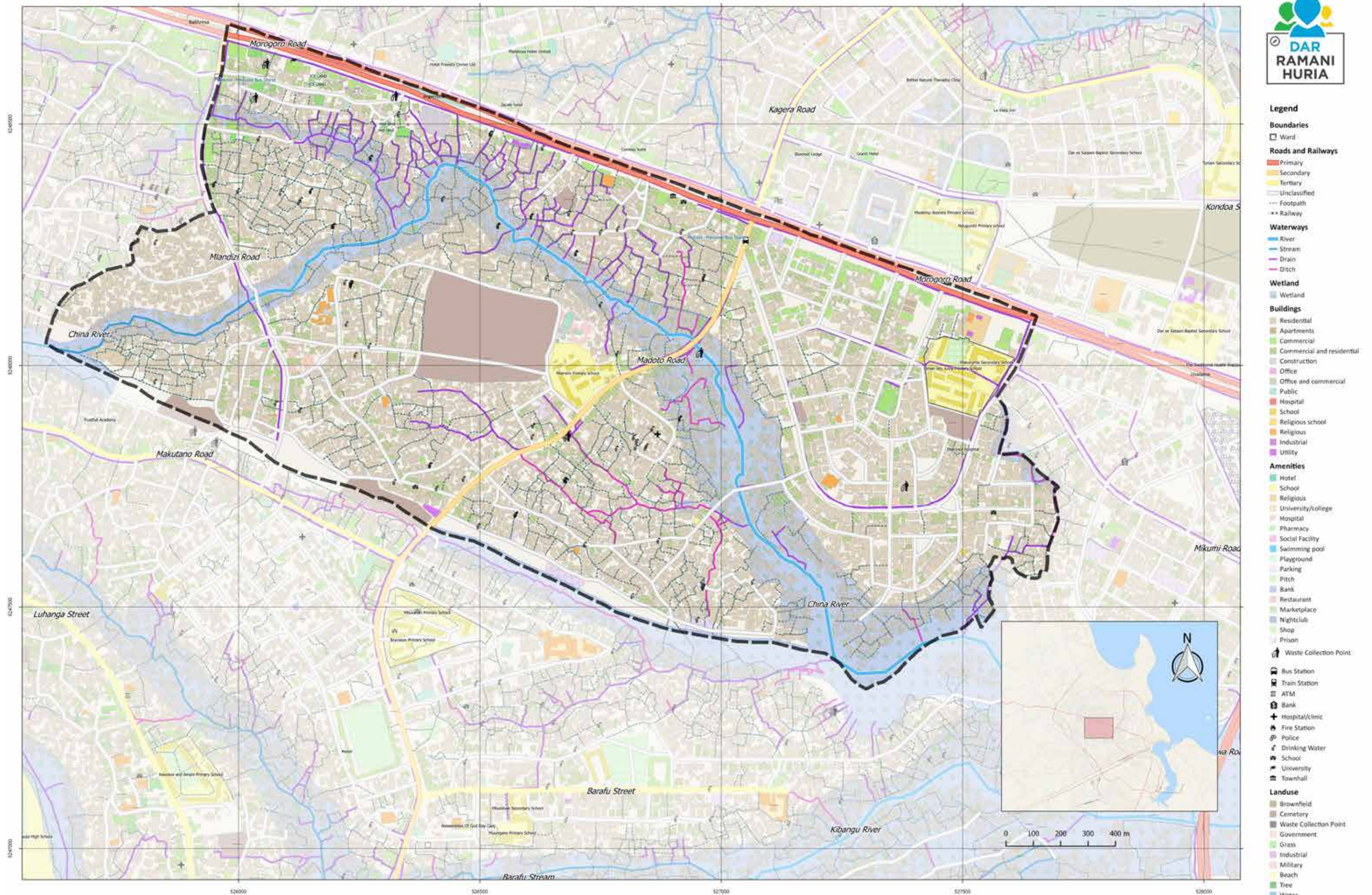
Description and Recommendations

With the China river cutting across the ward, most of the buildings along this river are in an area prone to flooding. This is especially true in Kwa Jongu, Mianzini, Sisi kwa sisi and Kimamba subwards.

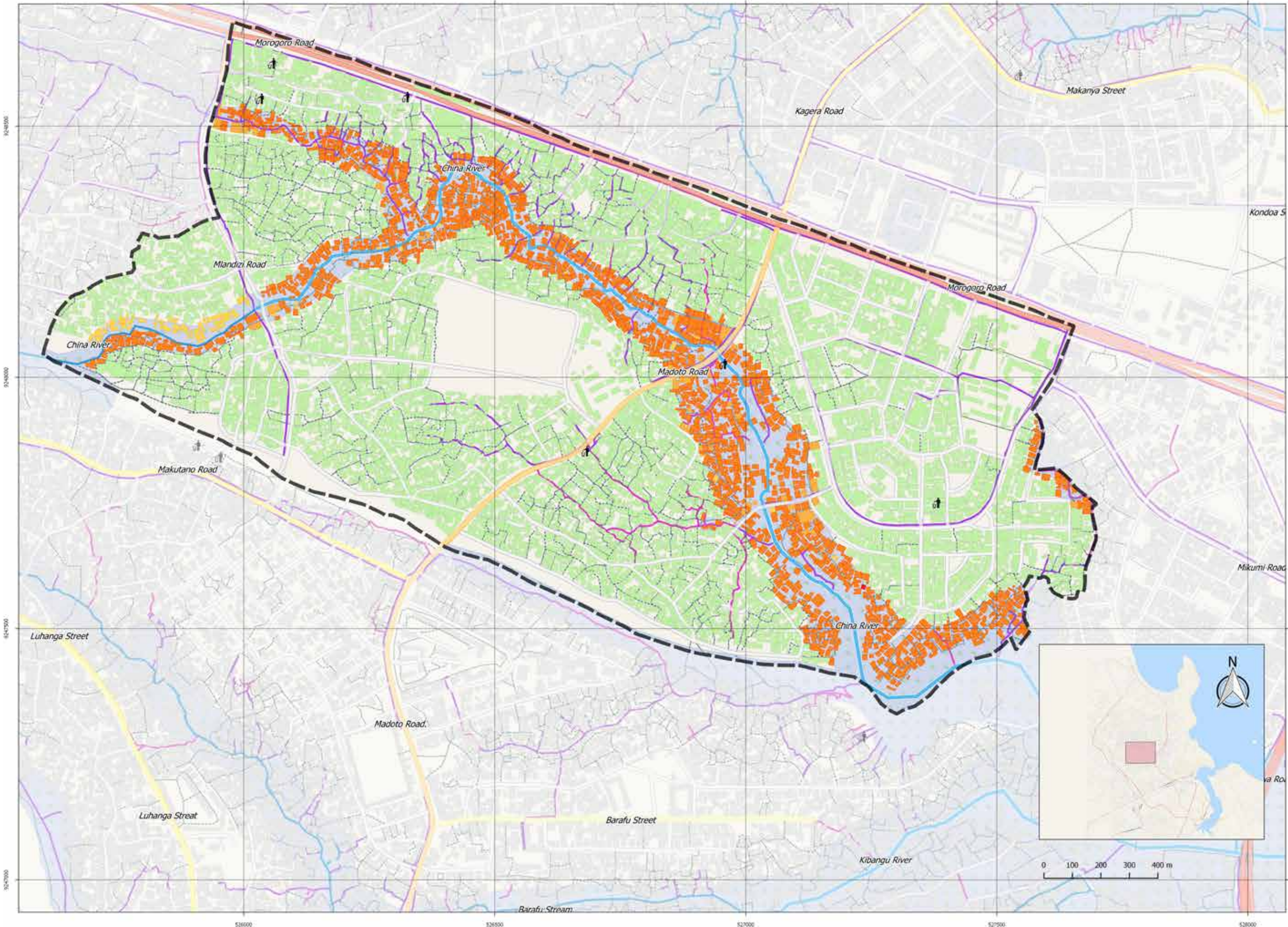
The main issue to be addressed to prevent flooding within Makurumla is the improper dumping of waste materials, causing river water blockage and the redirection of water to flow into residential areas. This could be achieved through expanding the network of waste collection points and educating the community on the need for consolidated waste collection.



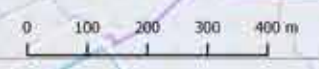
MAKURUMLA GENERAL MAP



MAKURUMLA POTENTIAL INUNDATION MAP



- Legend**
- Boundaries**
 - Ward
 - Building Inundation [8043]**
 - Not Inundated [6379]
 - Inundated, school or hospital [1]
 - Inundated, residential [1532]
 - Inundated, commercial [46]
 - Inundated, other [85]
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Features**
 - Wetland
 - Waste Collection Point



8 DOWNTOWN MAPPING WARDS

The wards within Dar es Salaam's city center include Kivukoni, Kisutu, Kariakoo, Jangwani, Gerezani, Mchafukoge, Upanga Mashariki and Upanga Magharibi. In September 2015, the Ramani Huria team ground surveyed these wards, creating detailed maps of the area. The mapping included collecting details on all buildings (building levels, building materials, use and structural information), road networks, drainage networks and other points of interest.

Within the city center, Upanga Magharibi, Jangwani, and parts of Kariakoo (which border on the Msimbazi river valley in the west) are the areas where floods occur most often. The remaining wards, Upanga Mashariki, Gerezani, Kisutu and Kivukoni, only flood when the existing ground drainage systems overflow due to heavy rainfall.

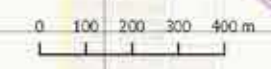
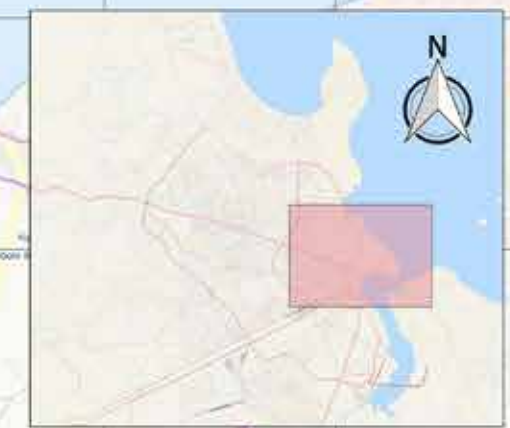
The greatest challenge for these areas is poor and old infrastructure that lacks capacity to hold large volumes of stormwater. This may already lead to flooding when it rains heavily for just a few hours. The use of data resulting from the mapping could be explored by city planners and infrastructure experts to improve the planning and maintenance of drainage infrastructure, and be implemented as input for disaster response and preparedness plans.



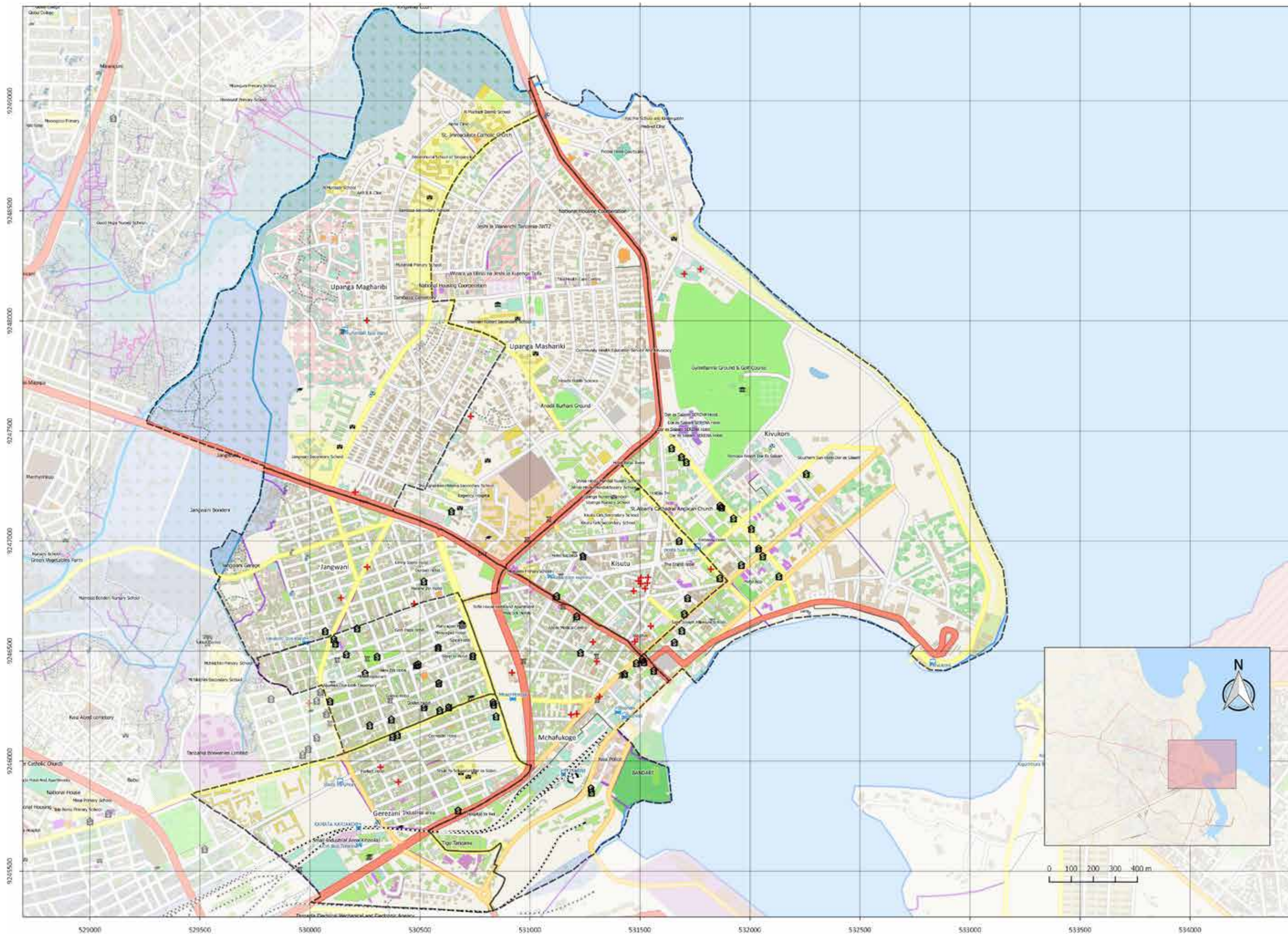
DOWNTOWN DRAINAGE MAP



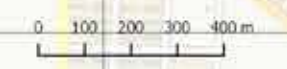
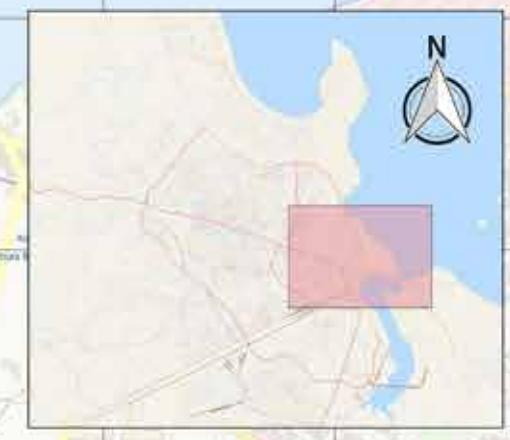
- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Wall or fence
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Culvert
 - Wetland**
 - Wetland
 - Buildings**
 - Residential and other
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Bank**
 - Bank
 - Hospital/clinic
 - Fuel
 - Fire Station
 - Police
 - Bar/Cafe
 - Restaurant
 - School
 - University
 - Landuse**
 - Brownfield
 - Cemetery
 - Construction
 - Landfill
 - Garages
 - Hospital
 - Government
 - Farmland
 - Grass
 - Forest
 - Recreation ground
 - Religious
 - Reservoir
 - Industrial
 - Scrub
 - Tree
 - Water
 - Wood



DOWNTOWN GENERAL MAP



- Legend**
- Boundaries**
 - Ward
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Culvert
 - Wetland**
 - Wetland
 - Buildings**
 - Residential
 - Apartments
 - Commercial
 - Commercial and residential
 - Construction
 - Office
 - Office and commercial
 - Public
 - Hospital
 - School
 - Religious school
 - Religious
 - Industrial
 - Utility
 - Amenities**
 - Hotel
 - School
 - Religious
 - University/college
 - Hospital
 - Pharmacy
 - Social Facility
 - Swimming pool
 - Playground
 - Parking
 - Pitch
 - Bank
 - Restaurant
 - Marketplace
 - Nightclub
 - Shop
 - Prison
 - Landuse**
 - Bus Station
 - Train Station
 - ATM
 - Bank
 - Hospital/clinic
 - Fire Station
 - Police
 - Drinking Water
 - School
 - University
 - Townhall
 - Brownfield
 - Cemetery
 - Government
 - Grass
 - Industrial
 - Military
 - Beach
 - Tree
 - Water





In order to improve the understanding of the water network of Dar es Salaam, and increase the potential for analysis, map coverage of the drainage network has been expanded to encompass the wards surrounding the areas where we performed community mapping. Precipitation in these areas accumulates and drains through Dar es Salaam to the Indian Ocean, making this part of same catchment area and integral to include in hydrological analysis. The drainage mapping has extended coverage to an additional 36 wards, which act as catchments and tributaries draining into the rivers and streams that cut through the informal settlements in the heart of Dar es Salaam. The drainage mapping was performed between December 2015 and March 2016.

The drainage map for the 36 wards of Dar es Salaam in which only drainage was mapped has been divided into five maps: the northwestern, western, southwestern, southern, and eastern areas.

36 WARDS DRAINAGE MAPPING



NORTHWESTERN AREA

THE NORTHWESTERN AREA includes **Kinondoni, Mbezi Juu, Kawe, Makongo, Sinza, Kijitonyama** and **Mikocheni**.

Kinondoni: The western, northwestern and northern parts of the ward have planned and connected drainage channels along the roads. This aids in the flow of water into larger drains along the Bagamoyo road, which subsequently flow into the Indian Ocean. The central part of the ward is an unplanned residential area which is flood prone. Because of the nature of this area and the lack of planning, there are no roads that serve the area apart from footways, which means there are no roadside drains to drain water from the area towards bigger drains.

Mbezi Juu: Generally, Mbezi Juu is not affected by floods. The river Mbezi runs through the southern part of the ward, cutting from Makongo ward across Kawe to the Indian Ocean. Most of the small rivers and streams join the river, draining these areas sufficiently. In the northern part of the ward, a river carries water from Goba ward before also cutting across Kawe and directing water to the Indian Ocean. Bagamoyo Road (along the eastern boundary) additionally has side drains that carry excess water to the river Mbezi.

Kawe: The rivers that drain Kawe come from Mbezi Juu and run towards the Indian Ocean. Most drains, streams, and rivers are connected to lead water towards the ocean. In the south, there is Mlalakuwa river; in the middle, there is Mbezi river; and in the north, there are two additional rivers. Generally, Kawe is not terribly affected by floods as the drainage system is effectively connected to the Indian Ocean.

Makongo: The drainage system in Makongo is well connected to the Mbezi river in the north and the Mlalakuwa river in the south. Most drainage channels in the centre of the ward eventually join one of these rivers that carry water out of the ward and into the Indian Ocean. This effective drainage network, combined with a comparatively high elevation, puts the ward at very low risk of heavy flooding.

Sinza: All parts of Sinza's drainage system are connected - from side drains to the rivers that cut across the ward. This makes it easy for all water to flow smoothly. In the south, the ward boundary is formed by the Ng'ombe river than drains Ubungo before cutting across Sinza towards Manzese, Tandale, and a number of other wards before finally running into the Indian Ocean. Many buildings within the ward, however, are built too close to this river, causing them to be affected when the river is high during heavy rains. In the north, the Chuo Kikuu stream drains the area next to Kijitonyama where it joins a bigger built drain towards the Indian Ocean. Most of the roadside drains are well-built and connected, directing water to either the Ng'ombe river or Chuo Kikuu stream.

Kijitonyama: Kijitonyama has well connected drainage systems throughout, from rivers to streams, drains and ditches. However, Kijitonyama is still affected by flooding due to the area being relatively flat, with most of the streets lacking side drains resulting in a lot of stagnant water after rains. This tends to lead to flooding in the streets until after the rains let up and enough time has passed for the soil to naturally absorb the water. Usually, this process takes one to two days. It is therefore recommended that more roadside drains are built in Kijitonyama to combat the flooding that occurs.

Mikocheni: Most streams and drains in Mikocheni join the Mlalakuwa river situated at the western and northern borders of the ward. The Chuo Kikuu river also cuts across the ward from Kijitonyama, offering an additional path for any excess water to flow into the Indian Ocean. These rivers effectively carry the majority of potential flood water out of the ward.

DRAINAGE MAP - NORTHWESTERN AREA



- Legend**
- Boundaries**
 - Ward
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Wetland**
 - Wetland

WESTERN AREA

THE WESTERN AREA includes **Makuburi, Kimanga, Kimara, Segerea** and **Kinyerezi**.

Makuburi: The northern boundary of the ward is formed by Kibangu river, one of the biggest rivers that cuts across several wards of the city. As some buildings are built close to the river, these buildings are affected when the river floods. The stream that borders the ward in the south also brings flooding issues, not only to Makuburi ward but also to neighboring Tabata and Kimanga wards. Most of the buildings affected here are residential. The streams, drains and ditches found in the central part of the ward drain into the main rivers. The road side drains along Mandela Road also help to drain water and direct it to Kibangu river.

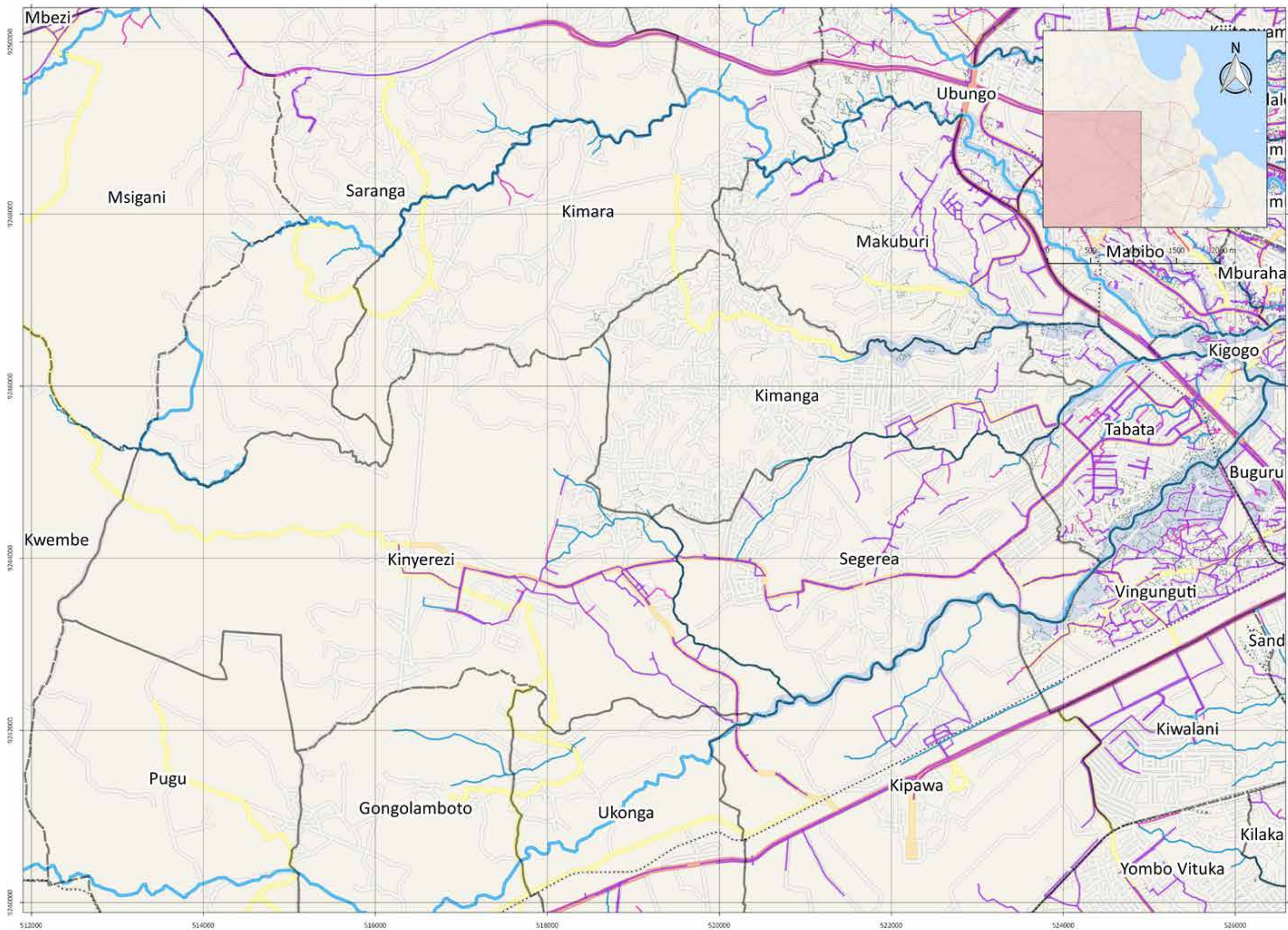
Kimanga: The streams that run along the northeastern and southeastern portions of this ward tend to flood during rainy season, affecting many residential settlements. While there are many well-connected streams and drains in the east, the west has no system in place. Fortunately, this area is quite high in elevation - deeming it less prone to flooding.

Kimara: Kibangu river forms Kimara's boundary in the north, before cutting across the ward towards Makuburi. Kimara's drainage system connects to this river, directing water out of the ward and through Ubungo. Morogoro Road, which runs through the ward, is well-equipped with roadside drains that further help to improve flood resilience within this ward. Kimara is also quite hilly in nature, allowing water to run off naturally and reducing flood risk.

Segerea: Most residential buildings within this ward are located near the Msimbazi river, putting them in danger of inundation during rainy seasons. Smaller flood prone areas also exist in the central and eastern parts of the ward. This is mainly due to a lack of outlet drains and ditches, causing water to remain stagnant, and to water that runs in from the western part of the ward that is located on higher land.

Kinyerezi: Kinyerezi is residential in nature, with most of the buildings concentrated in the central and eastern parts of the ward. The rest of the ward does have scattered residential areas, specifically in the west and north. The central and eastern parts contain streams, drains and ditches that drain water to the Msimbazi river in the southwestern area of the ward. Generally speaking, Kinyerezi is not very prone to flooding.

DRAINAGE MAP - WESTERN AREA



- Legend**
- Boundaries**
 - Ward
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Wetland**
 - Wetland

SOUTHWESTERN AREA

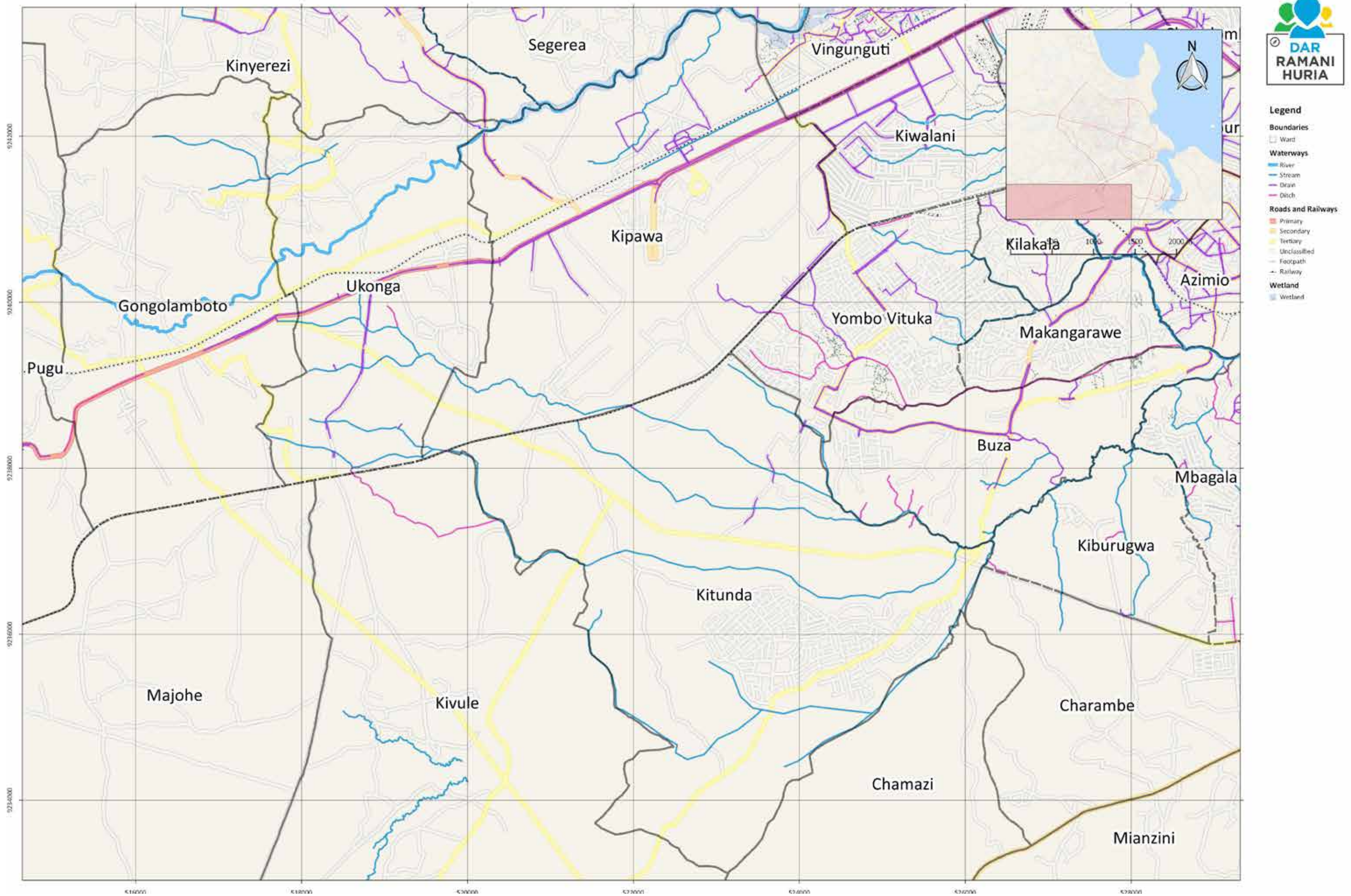
THE SOUTHWESTERN AREA includes **Kitunda, Kipawa** and **Ukonga**.

Kitunda: This ward is residential in nature, with most of the area built up for residential use except for the military area in the northern part. Kitunda consists of flat terrain and has six streams running across to drain it. During rainy seasons, water tends to flood into the residential areas. All around these streams, urban agriculture for crop cultivation has been established, supporting the residents for food and income, but also reducing the capacity of the streams to carry water.

Kipawa: Julius Nyerere International Airport is located in the central and eastern part of the ward. The rest of the ward area is mostly residential in nature, except for the buildings along the Nyerere/Pugu Road which are a mix of commercial and industrial. With the Msimbazi forming the northern boundary, residential buildings along the river are affected during the rainy days as the river floods. With the available roadside drains along Nyerere/Pugu road and other streams and ditches, the rest of the ward is less prone to flooding.

Ukonga: The southern part of Ukonga contains streams, roadside drains and ditches that drain water from the ward to Kitunda, joining other rivers towards the Indian Ocean. The Msimbazi river cuts across in the north, where urban agriculture is undertaken along the banks. Barring the buildings close to Msimbazi river in the north, Ukonga is not very prone to flooding.

DRAINAGE MAP - SOUTHWESTERN AREA



SOUTHERN AREA

THE SOUTHERN AREA includes Sandali, Chang'ombe, Mbagala, Mbagala Kuu, Miburani, Azimio, Makangarawe, Kilakala, Buza, Kiburugwa, Yombo Vituka, Kiwalani and Tandika.

Sandali: The central and southern parts of Sandali are composed of informal settlement, but do contain a well connected drainage system with streams, drains and ditches helping to drain the ward and carry water towards rivers and ultimately into the Indian Ocean. The northern part of Sandali contains two major primary roads, Nyerere/Pugu Road and Mandela Road, with roadside drains that help to move water away from the ward, making Sandali not very prone to flooding.

Chang'ombe: The central and northern areas of Chang'ombe are composed of industrial and commercial buildings, while the south is a mix of residential and commercial buildings. The drains that run alongside Nyerere and Pugu Road in the east help to drain the ward and direct stormwater to a larger drain in neighbouring Keko ward. Drains in the centre and south join with Mandela roadside drains to move water out of the ward. There are several unconnected drains with limited capacity near Serengeti Breweries Ltd. in the southern part of the ward, causing many roads to flood during rainfall.

Mbagala: The eastern boundary of Mbagala is formed by Kilwa Road, separating Mbagala from Mbagala Kuu. This road has side drains that direct water from the south towards the main river running in the north. Drains in the north and streams in the west help to move water from the central highland area to the lower-lying land in the north through which a major river runs. Buildings along this river sometimes experience flooding due to their close proximity to the water.

Mbagala Kuu: Due to its well-connected drainage system, Mbagala Kuu is not exceptionally flood prone. The southern part, however, is relatively flat - putting some residential buildings near the river at risk of inundation.

Miburani: Drains that run alongside the two major primary roads in this ward, Mandela Road and Kilwa Road, help to move stormwater towards the Indian Ocean. The rest of the drainage channels in the southern part of the ward are well-connected and join the major roadside drains.

Azimio: Although Azimio consists mostly of informal settlements, its drainage system is well distributed and connected to other larger water channels. The drainage system includes rivers in the south and roadside drains and ditches all over the ward. Buildings in the southern part can be affected during the rainy season, since a number of these are built within the river valley.

Makangarawe: Buildings along the river on Makangarawe's eastern border are affected by floods during rainy periods. Although the central part of the ward has no drainage channels, the northern and southern borders are formed by a stream and a large ditch. Most drainage systems within the ward are connected to these, managing to drain the area quite thoroughly.

Kilakala: Kilakala consists largely of informal settlements - with streams lining its eastern, southern, and western boundaries, and a drain that cuts through the ward in its entirety. The northern area is on higher ground, causing water to flow into the south and join the stream that carries water to major rivers that lead to the Indian Ocean. Kilakala is subsequently not very flood-prone.

Buza: The western part of Buza is quite densely developed with residential buildings. Fortunately, it is bordered by streams and ditches on every side, with drains running along the main road through its centre. These streams and ditches connect to neighbouring wards. The eastern part of Buza is affected by floods during rainy periods, but the area is primarily used for urban agriculture - putting very few lives at risk.

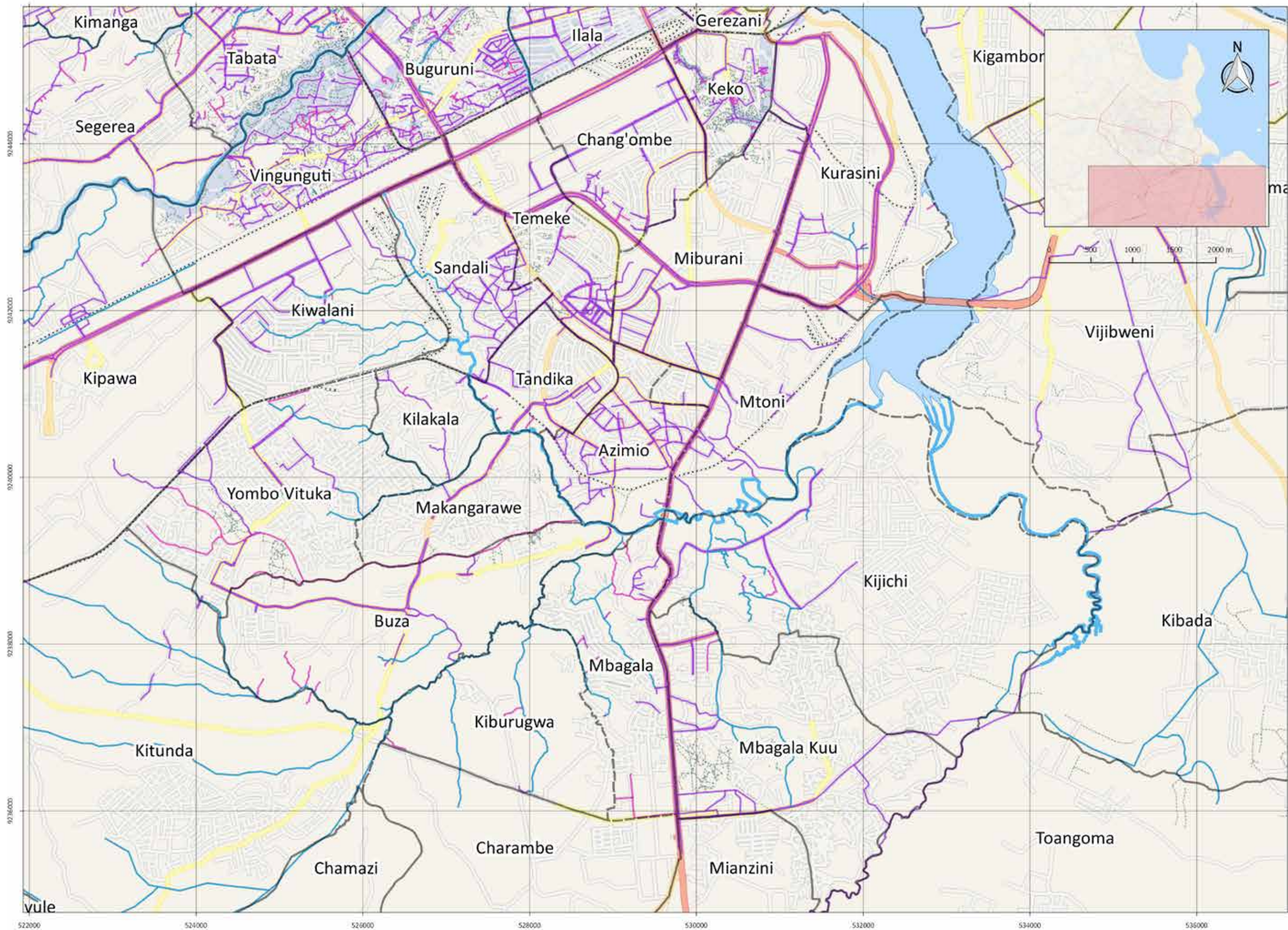
Kiburugwa: The western and eastern boundaries of this ward are formed by streams that drain water from the north and the south. The two streams cutting across the centre of the ward join the main river and also help to drain the ward. Informal settlements constructed along the river in the north are at high risk of flooding.

Yombo Vituka: About three-quarters of Yombo Vituka has been well-planned, but the area in the south is largely comprised of informal settlement. Several streams, drains, and ditches are well-distributed and connected, keeping most residents living in this ward safe from flooding

Kiwalani: The northern section of this ward is primarily commercial and industrial, while the remainder is largely residential. Drains that run alongside Nyerere and Pugu Road work quite effectively to drain the ward - linking up to an extensive channel that spans across the ward.

Tandika: The northern, central, and eastern parts of Tandika are well-planned, while the remainder is largely unplanned. The drainage system is connected ward-wide, making Tandika quite resilient to flooding.

DRAINAGE MAP - SOUTHERN AREA



- Legend**
- Boundaries**
 - Ward
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Wetland**
 - Wetland

EASTERN AREA

THE EASTERN AREA includes **Kigamboni, Tungi, Vijibweni, Mjimwema, Kibada, Kijichi, Mtoni** and **Kurasini**.

Kigamboni: The Indian Ocean forms the eastern, northern and western border of Kigamboni. Kigamboni has drains along several roads, directing stormwater to the Indian Ocean. There is a larger density of buildings in the centre of the ward, but water can run off easily making Kigamboni not very susceptible to flooding.

Tungi: Like Kigamboni, Tungi has a lot of coastline, with the Indian Ocean forming its boundaries in the west and east. Except for a few roadside drains, there are few drainage systems in Tungi, but water runs off naturally into the ocean.

Vijibweni: Vijibweni contains several scattered informal settlements. The ward's western boundary is formed by the Indian Ocean, and roadside drains and streams connect to join the Indian Ocean.

Mjimwema: Bordered by the Indian ocean in the north, Mjimwema has some scattered settlements in the northern and western parts of the ward. Large areas in the south and east are not built at all, and agriculture has prevailed here. There are flood prone areas in the eastern part of Mjimwema, but these don't do much harm as the area is not inhabited.

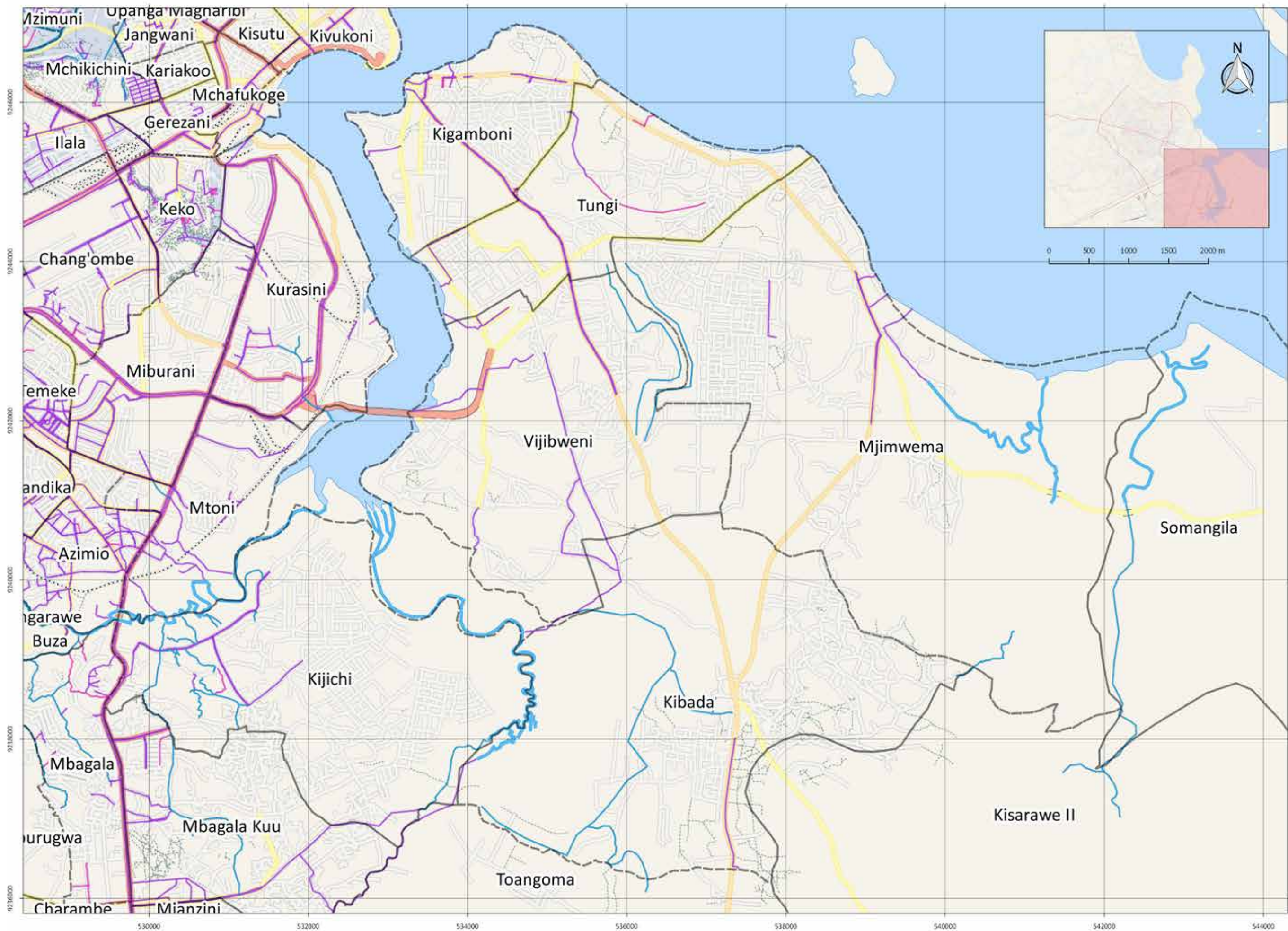
Kibada: The eastern part of Kibada contains scattered settlements, but its western part does not contain buildings at all. This is because the western area is near a river delta that enters the Indian Ocean.

Kijichi: In the north of Kijichi, there is a river delta flowing into the Indian Ocean, with its western and eastern border being formed by rivers flowing towards this delta. Most buildings are found in the centre of the ward. Drains direct water to the rivers, but the areas near the rivers are susceptible to flooding.

Mtoni: The southern and eastern borders of Mtoni are formed by a river and the Indian Ocean respectively, with most other drains and streams joining the river before it flows into the ocean. Buildings that have been constructed along the river in the south are affected by flooding in the rainy season.

Kurasini: With the Indian Ocean forming the ward's boundaries in the north and east, Kurasini has a well connected drainage system that flows into the ocean. Kurasini is also home to the Port of Dar es Salaam.

DRAINAGE MAP - EASTERN AREA



- Legend**
- Boundaries**
 - Ward
 - Waterways**
 - River
 - Stream
 - Drain
 - Ditch
 - Roads and Railways**
 - Primary
 - Secondary
 - Tertiary
 - Unclassified
 - Footpath
 - Railway
 - Wetland**
 - Wetland

0 500 1000 1500 2000 m

CONTRIBUTORS AND LICENSING

All map data is © OpenStreetMap contributors. All map coordinates in this document are given in Arc1960/UTM 37S, the standard in Tanzania. In each ward, different students and volunteers have helped us to collect the data. The map design is licensed under the Creative Commons license (<https://creativecommons.org/licenses/by-sa/4.0/>). We would like to thank our volunteers for helping us make Ramani Huria a success, and allowing us to take this step towards putting Dar es Salaam on the map.

NDUGUMBI

Ndugumbi community members: Kamal Hamis, Paulsen Angello, Pascal Charles, Lucas Geoffrey, Abdallah Juma, Rose Magembe, Musa A. Geuza, Venance Chalamila. University of Ardhi students: Ardhi University students: Tonny John, Fanuel Mtokoma, Nuru Kalulunga, Gwantwa Andrew, Cosmas Aniceth, Titus Nason, Petro Johanes, Innocent Maholi, Dorica Mugusi, Evance Calist, Jasper Ringo, Dominic Elia, Mlewa Benedict, Goodluck Malangwa, Twalib Salum.

TANDALE

Tandale community members: Farida Omari. Yusuph Makamba, Mozza Mkopi, Jamila Muhidini, Salum Kaponda, Obedi Hamisi, Salim Mtepetallah, Ashiru Issa, Nassoro Mzee, Mwanahamisi Mohamedi, Tawfiq Ahmad Bakari. Ardhi University students: Tonny John, Fanuel Mtokoma, Nuru Kalulunga, Gwantwa Andrew, Cosmas Aniceth, Titus Nason, Petro Johanes, Innocent Maholi, Dorica Mugusi, Evance Calist, Jasper Ringo, Dominic Elia, Mlewa Benedict, Goodluck Malangwa, Twalib Salum.

MCHIKICHINI

Mchikichini community members: Saleh Katumbo, Monday Anthony, Amina Mogelly, Sudi Thabiti, Kisa Mwampulo, Sultani Hassan, Zuwena Nyansasa, Almasi Chandugu, Nelson Sarafini, Ally Mansaya, Godfrey Clarence, Emilson Milanzi. Ardhi University students: Tonny John, Fanuel Mtokoma, Nuru Kalulunga, Gwantwa Andrew, Cosmas Aniceth, Titus Nason, Petro Johanes, Innocent Maholi, Dorica Mugusi, Evance Calist, Jasper Ringo, Dominic Elia, Mlewa Benedict, Goodluck Malangwa, Twalib Salum, with Kamal Hamis and Baraka Phillip.

MAKUMBUSHO

Makumbusho community members: Selemani Mohamedi, Muhsin R Giriki, Anjela S Gandhi, Mwanahamisi Salum, Siasa Sultani, Scholastika Hilary and Baraka Barton.

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MABIBO

Mabibo community members: Charles Mboya, Yusuf R. Nyumbu, Fort Amri, Sharifa Khalfan, Hassan Mbegu and Zulfa Rashid.

Ardhi University students: Benjamin Kimayani, Mtima Athanas, Muyenjwa Joseph, Mwanja Immaculate, Ngao Giveness, Ngowi Haikasia, Omari Ramadhani Salim, Ramadhani Ibrahim, Saidi Alnoor and Suleiman Septuu.

University of Dar es Salaam students: Mtaki John, Nyalusi Amour, Pongolela Joyce, Rajab Said, Shomari Malimi, Sichone Lucy, Stephano Robert, Umutoni Sarah, Umutoniwase Clementine and Zuberi Nuia.

MBURAHATI WARD

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University of Dar es Salaam students: Abubakari Hiza, Ilham Ismail, Jabir Hussein, Jackson Joseph, Elizabeth Kabage, Ramadhani Kadondoro, Bhoke Kichere, Emmanuel Kombe, Samwel Masanja, Mathew Mmelele, Menrado Mushi, Richard Ndosi, Faiza Ngendelo.

MAKURUMLA

Makurumla community members: Hanenga Said, Grace Mwaakibinga, Juma Mwanguo, Fatuma Mjanaheli, Mtumwa Ally and Praygod Mushi.

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M, Charles Frank, Chazua Iddy, Constantine Deogratus, Cyarigonza Angelique and Chrispine Tarisela.

KEKO

Keko community members: Bakari Mrosa, Florian Mbena, Pili Mikaji, Kamona Kassanda.

University of Dar es Salaam students: Gosbert Nelson, Halifa Ibrahimu, Michael Gabriel, David Gupta, Peter Harrison, Jovia Kiconco, Laizer Christopher, Daniel Gaspin, Msanga Richard, Hawa Hassani, Msoka Rosemary, Mgaza Abdallah.

Ardhi University students: Kimaro Amadeus, Gosbert Anita, Kessy Mary, Colman Fadhila, Ndauga Daudi, Hamadi Nuru, Mlagwa Diana, Msanga Richard, Christopher Christopher, Lawi Fanuel, Juma Zahara, Hamisi Salehe.

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BUGURUNI

Buguruni community members: Anifa Amir, Baraka Malima, Chiku Hamis, Fatma Salim, Felichian Lukelo, Filemoni M. Kunambi, Francis Chambo, Ismail A. Matola, Jamila Kumbilamoto, Jenifa Jacob, Johnson Vigerio, Joho Mohamedi, Justina J Mbena, Khadija Abdul, Mariam Omary, Silvanus Herman, Zaina Huseni.

Universities of Dar es Salaam and Ardhi students: Mwanja Immaculate, Ramadhani Ibrahim, Saidi Alnoor, Omari Ramadhani Salim, Muyenjwa Joseph, Ngowi Haikasia, Nyalusi, Amour, Kessy Mary, Pongolela Joyce, Sichone Lucy, Anitha Gosbert, Hamisi Salehe, Kimaro Amadeus, Harrison Peter, Fadhila Colman, Kahebo Sarah.

MWANANYAMALA

Mwananyamala community members: Aziza Omary Urembo, Fikili Abdala, Grace M.Sanga, Hadija M. Mabula, Hassan Kitambi, Mohamedi Ally Mponda, Mubarak

A. Juma, Sharifa Mtandya, Tatu Abdallah Mputo, Wales MKoma, Tatu S. Mabula. Universities of Dar es Salaam and Ardhi students: Benedict Raymond, Mustapher Asha Mohamed, Kisyombe Robinson J, Masenga Alphonse, Seme Daniel Nino, Chazua Iddy, Batenga Maryrose, Anderson Dickson, Juma Kitoi Ally, Anthony Jenester, Ngaluma Mwanaharusi, Chuwa Mary I, Gervas Godfrey, Daniel Victoria N, Christabell Alendwase, Jovia Kiconco.

MAGOMENI

Magomeni community members: Faraji A. Msuya, Fatuma Ismary, Hamady Mtakafedha, Khamisi A. Kulata, Mariam Amani Manjali, Mariam S. Hussein, Mgaya Magango, Peter Kika Kanju, Pili H. Limota, Pili Rajabu, Rehema Gumbwa, Salumu Hamisi, Selemani Matwanzi, Vincent J. Mirumbe, Yussuph A. Malidadi, Mariam B. Sulemani, Mshame S. Kwandam, Haisa Rajabu Kailah, Masoud Saleh Rashid, J. A. Maro.

Universities of Dar es Salaam and Ardhi students: Agnes Kanuti, Mapunda Erick U, Saguda Elias, Devota Mpaka, Mboya Mkundelida, Lymo Jenipher P, Mwendu Happiness, Mlambalamba Kelvin K, Matto Janet, Umutoni Sarah, Hawa Hassani, Abdallah Mgaza, Stephano Robert, Machenje James, Christopher Christopher.

HANANASIF

Hananasif community members: Abbas S. Mataka, Abdalamani Salum, Abdallah A Mwamba, Ally B. Membe, Blanka Ngowi, Devota Pango, Doris J. Manga, Fadhila J. Millinga, Fikiria L. Lwanzali, Fredrick Linga, Godfrey Chacha, Halima Kinoge, Happiness Pius, Kristina Elisha, Mahamudu Feruzi, Martha A Kibodya, Renatus S. Kazindogo, Sara R. Ndanzi, Sikitiko Mohamed, Zuhura Mgeni.

Universities of Dar es Salaam and Ardhi students: Ilham ismail, Ndosu Richard S, Faiza Ngendelo, Elizabeth Kabage, John Mohere, Kombe Emmanuel, Mushi Menrado, Sajda Mushi, Abubakari Hiza, Lucy Pagama, Sahila Rebeca W, Jonisia Ndanzi, Umulisa Aimee, Ngowoko Herbert O, Mtey Fadhili M

VINGUNGUTI

Vingunguti community members: Hamisi B Baruti, Sophia R Simba, Josephine Peter, Ramadhani Athumani, Fatuma Ramadhani, Eva Machibya, Neema Pius, Maimuna Taddey, Asha Kibwana, Ahmed Besha, Hamis S. Mtemanya, Jafar K. Ramadhan, Fadhil Ayubu, Jane Lawrent, Ashura Shabani, Agnes Robert.

Universities of Dar es Salaam and Ardhi students: Immaculate Mwanja, Alnoor

Saidi, Omari Ramadhani Salim, Joseph Muyenjwa, Mwanaharusi Ngaluma, Amour Nyalusi, Mary Kessy, Joyce Pongolela, Lucy Sichone, Anitha Gosbert, Salehe Hamisi, Kimaro Amadeus, Sarah Kahebo, Fadhila Colman.

KIGOGO

Kigogo community members: Rehema Adam Mohammed, Asma Hussein Mohammed, Selemani Athumani Said, Sharifa M. Mhumbira, Rehema M. Mgodhi, Halima Hamza Minziro, Lilian Boneventure Mtengule, Materi Andreas Doka, Meraji Awazi Simba, Suzana Masombola, Aisha Ally Safary, Raymond Tryphone Mayowera, Jema Manjori, Gasper Gasper Mponda, Mazoea Hussein Ling'omba, Zaharani Omary Maulidi, Khadija Issa Mohamed, Hafidh Hamza Salehe, Elizabeth Anthony Milanzi, Busolo Mlekwa Geoffrey.

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MANZESE

Rukia Saidi Chingeza, Zainabu Azza, Mwantumu H. Ramadhani, Mrisho Ally, Fidelis W. Mutashobya, Ratifa Ramadhani, Ramadhani Maneno, Mariam Mohamedi Kulunge, Mastidia S. Matiko, Khadija M. Mbuguni, Fatuma K. Athumani, Yuster D. Kapilima, Tatu S. Ally, Jackline Msabaha, Fadhili Omari, Isumaili Mhamedi, Anthony Nguzo, Delphinus Muganyizi, Wincelous C. Muntatina

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Mzimuni community members: Elias T. Nkini, Mamisa, Adam, Kuluthumu Ally, Fatum Maulid, Salima Buki, Rehema Pinde, Mwasanga Said, Mariam Yusuph, Maya Said, Mwajua Hamis, Mwanaharusi Kupa, Fatuma Jella, Mariam Hamis, Nuru Ramadhani, Maliselina Walter, Husna Kupa, Ashura Omar, Habiba Yusuph, Maria Mayaya, Mwanahamisi Ally.

Universities of Dar es Salaam and Ardhi students: Ilham ismail, Ndosu Richard S, Faiza Ngendelo, Elizabeth Kabage, Kombe Emmanuel, Mushi Menrado, Sajda Mushi,

Abubakari Hiza, Lucy Pagama, Sahila Rebeca W, Jonisia Ndanzi, Ngowoko Herbert O, Mtey Fadhili M, Baraka Barton.

UBUNGO

Ubungo community members: Yohana Omary, Hamisi Mnyamike, Sarah Kamanga, Tatu A. Mketu, Safina F. Ndwambo, Alinanime P. Mwalindu, Kato G. Kyaruzi, Leonard S. Mayala

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TABATA

Tabata community members: Amina Swalehe, Justine Mwangamila, Chitemwe Hussein, Thobias, Anthony Mushi, Nista Ndosu, Pili Palasugulu.

Universities of Dar es Salaam and Ardhi students: Nuru Kalulunga, Aniceth Cosmas, Tonny John, Dorica Mugusi, Baraka Phillip, Elia Dominic, Kamal Hamis, Gwantwa Andrew, Lucy Sichone, Elias Saguda, Emanuel Kombe, MaryRose Batenga.

ILALA

Ilala community members: Christina A. Msala, Upendo Kisangi, Amina Salum, Lilian Kweka, Sakina Juma, Omary Mkumbi, Msiba Sese, Asha Mambo, Mwanaidi Dazi, Ally Mshauzi .

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TEMEKE

Temeke community members: Abdallah S. Kinyogoli, Abubakari Ahmada, Ibrahim Yahaya, Neema Mremi, Norman Bilali Hayeshi, Ramadhan R. Kaniki, Said Ibrahim Mbaya and Yusuph Ahmada.

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