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Anarchic occupation: Before and after study of the habitability of the Makasi cell in the town of Butembo in North Kivu/DR Congo

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Abstract
The urban fabric of the Makasi Cell, in the city of Butembo (North Kivu/DRC), is in a very advanced state of degradation. This comparative study before and after habitability sheds light on the direct impacts of housing occupation. To do this, GPS (Global Positioning System) coordinates and those related to the physical condition of buildings and roads were used. The GIS and remote sensing methods were chosen to highlight the slope class dedicated to the constructible zone and that related to the degradation of the fabric. The ground truth required field inspection before, during, and after rain scenes. It emerged that 40.07% of the surface area was in the 0–2% slope range. This low slope of the non-building zone exposes the Makasi Cell to the risk of flooding where it is considered a thalweg. After a rainy scene, the waters of the neighboring cells take the route into the Makasi Cell, the majority of which stagnates due to the configuration. On the other hand, after habitability, it results in 51.22% of buildings being in poor condition or in critical condition, almost collapsed by the floods. There are 1,458 linear meters of traffic lanes which are in a very advanced state of disrepair.

INTRODUCTION

The anarchic occupation of urban spaces, also known as informal occupation, has emerged as a response to environmental and housing challenges in contexts of precariousness, rapid population growth, lack of land use studies and lack of adequate public infrastructure that are exacerbated by rapid and often uncontrolled unregulated urbanization. and not planned by public authorities cities in developing countries (Maachou, et al., 2018; Samari & Yonkeu, 2016). These countries have remained less urbanized since the 1950s, but are now experiencing rapid urbanization leading to irreversible changes in land use (Mardiansjah, 2013). Added to this is the disorganization of the city and urban disorder that affect the population (Allogho-Nkoghe, 2013; Tohozin et al., 2014; Vahtrapuu, 2013) .

According to projections and studies on the proportion of the population in urban areas at the global level, half of the population residing in urban areas will have to reach 60% by 2030 (Vahtrapuu, 2013) and 68% by 2050 (UN-Habitat, 2012a ; Puca, 2014 ; Moles and Varnai, 2018 ; Dorling, 2021). Indeed, this strong demographic pressure of recent years accompanied by a lack of appropriate study before and after occupation of the land, a lack of planning and the absence of structures for the production of social housing, leads the population to an anarchic occupation of certain sites unsuitable for construction, not suitable for housing called "no man's land zones or Non-building zones " which are found in the slope range of 0-2%. This becomes problematic when this spatial expansion is neither regulated nor guided by an appropriate urbanization policy.

This phenome non of absence and insufficiency of studies before and after land occupation is responsible for the slumization of many sites by the spontaneity of degraded or precarious neighborhoods (Cosse, 2016 ; Oura, 2012 ; Thiaw et al., 2021 ; Memel, 2020). It is linked to a lack of rigorous land planning policy by the public authorities (Tohozin et al., 2014). As is the case for other districts and cells, the Makasi Cell, in the Commercial Center district, in the city of Butembo, has not been miraculously spared. It is now facing the same challenges linked to the context of global changes (society and climate), including the lack of prior planning, flooding which causes building subsidence, precarious housing, notorious insalubrity, the filling of certain avenues, the illicit fragmentation of plots, the impassability of avenues, streets and dead ends exacerbated by floods, which are of concern to the Makasian population.

These roads are currently occupied by informal activities, transformed into the unregulated informal market locally called "Makasi Market" which operates every Wednesday and Saturday in a deplorable condition where foodstuffs are spread on the ground on mixed waste from flood mud, hindering the fluidity of movement of pedestrians and two-wheelers within the Makasi Cell and amplifying the hygienic condition and anarchy (UN-Habitat, 2012b) . Anarchism in this urban fabric seems to be "legalized" by the public authorities who deploy less effort to resolve it and initiate urban development projects or even lobby donors who work in planning in order to carry out urban analyses and diagnoses of this natural disaster. However, the public authorities should quickly intervene for critical and precarious habitats which undermine urban road and building systems (Bottiglione, 2014 ; René-Bazin, 2018) in order to combat urban sprawl and plan preventive measures to combat flooding (Russias, 2017).

These floods not only destroy the physical environment of the Makasi Cell but also cause significant material damage (Mulambu-F, 2001), with a sometimes brutal awakening of the occupants during the rainy season. These urban pathologies locally generate impoverishment of the Makasi population, while compromising any endogenous development initiative (Sahani, 2012), thus increasing the vulnerability of the local population (Samari & Yonkeu, 2016) and giving rise to a new mode of land occupation leading to a rampant fragmentation of urban land and leading to a proliferation of informal housing (Lupiki & Makinga, 2020). Today, the Makasi Cell requires certain interventions through urban renewal operations in order to improve the housing and living conditions of the Makasian population. (Michel, 2019). This is why the urban planning operation to be carried out in this article gives importance to studies carried out upstream and downstream, that is to say before and after habitability of the site in order to take into account the natural appearance of the land and the allocation of facilities during development and enhance pre-existing urban fabrics while improving the quality of life of the urban population (Manirakiza, 2015).

This urban project intervenes in development actions by requalifying the existing fabric and enhancing urban dynamics and activities of sociability and urban economy (Dahmani et al., 2015). These studies take into account the geomorphological configuration of the urban space before any subdivision operation (Samari & Yonkeu, 2016) and after habitability in order to avoid generating illegal development on the urban fabric. It will bring a change particularly to the physical state of the building and the roads and in general of an urban fabric to sleep to a new adapted development (Luis & Moncayo, 2016) or even to the change of functions. They would also rename the urban fabric according to planning standards (Ndock, 2020), and bring order to the way the city is rebuilt on top of itself (Bottiglione, 2014).

The figures below show the condition of the structures in the Makasi Cell in the city of Butembo.

Figure 1. **Overview of food sales on waste with poor condition, without display at Makasi market.**

Source: Authors' photograph, field survey, 2024

Figure 2. Overview of the subsidence of the buildings which are in a very advanced state of disrepair.

Source: Authors' photograph, field survey, 2024

Figure 3. Overview of waste and flooding in the places often occupied by the Makasi market after a rain.

Source: Authors' photograph, field survey, 2024.

Figure 4. Overview of the state of the Butembo Health Zone office and the flooding of the squares occupied by the Makasi market.
Source: Authors' photograph, field survey, 2024

This research aims to analyze the topographic configuration and slope classes of the Makasi Cell to identify constructible and flood-prone non-building zones before occupation, while also assessing the physical condition of buildings and roads after habitability, particularly the impacts of flooding on urban degradation. Additionally, the research maps land use and spatial distribution of various activities, identifies watersheds and water flow patterns contributing to flooding, and proposes urban renewal strategies for restructuring and rehabilitation to improve living conditions and prevent future flood risks. The findings are expected to contribute theoretically to urban planning literature on anarchic occupation in developing countries and the relationship between geomorphology and habitability, while practically serving as a reference for policymakers and planners in Butembo, providing diagnostic data for prioritizing rehabilitation interventions, assisting donors in identifying urgent needs, raising community awareness about flood risks, and promoting participatory and sustainable urban planning that enhances quality of life, reduces vulnerability, and fosters social inclusion.

RESEARCH METHODS

Study environment

This study was carried out in the Makasi Cell in the Centre-Commercial district. The latter is one of the districts that hosts the commercial activities of the city of Butembo. Butembo is the second city in the North Kivu Province after Goma, in the east of the Democratic Republic of Congo. It is located at 0° 7'47.29" North latitude and 29°17'27.85" East longitude. The Makasi Cell is located in the Centre-Commercial district, precisely in the Kimemi commune, bounded to the north by Lubero Avenue. It is located to the south by Boulevard Monseigneur Emmanuel Kataliko. To the East, it is bounded by Rue President of Republic or National Road Number 2 then by the Vungi district. To the west, it is bounded by Rue Paluku Denis, formerly Rue d'ambiance or by the Lumumba district. It is diagonally south with the Biondi district. The Makasi Cell enjoys an equatorial climate tempered by the mountains whose proximity determines two rainy seasons (March-April-May and August-September-October-November) corresponding to the passage of the sun at its zenith and two relatively dry seasons corresponding to the months of June and July and the months of January and February (Sahani, 2012) . The figure below shows the location of the study area.

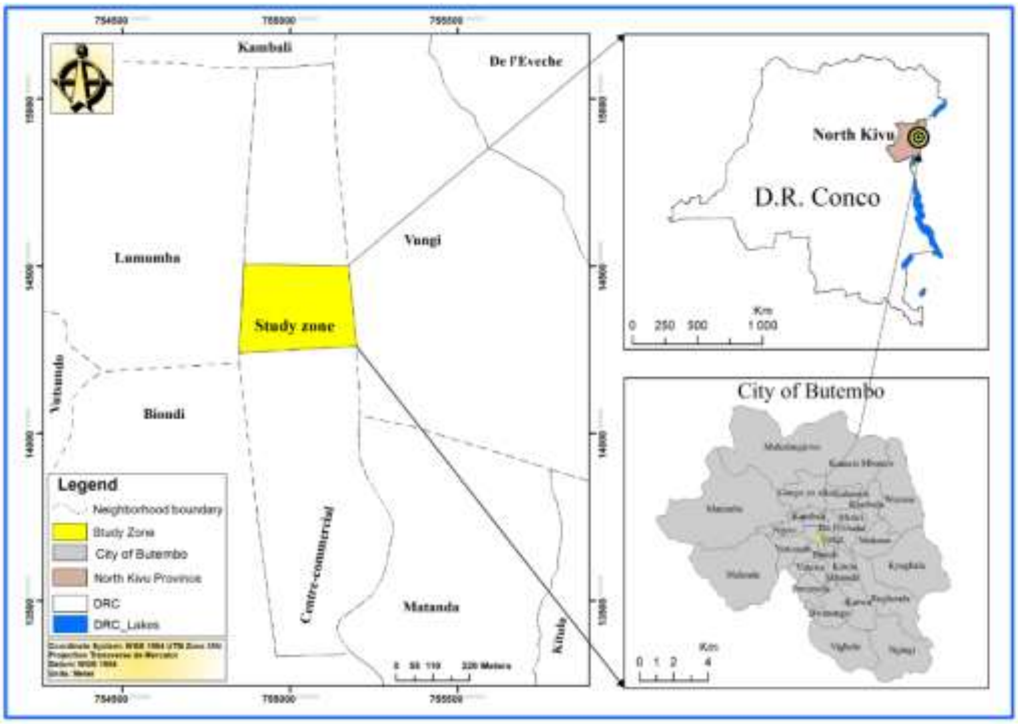


Figure 5. The location of the study area.

Source: Authors' elaboration from GPS coordinates (Garmin GPS Map 64x) and satellite images (SAS Planet Nightly 191006 GIS) using ArcGIS 10.8.2 and QGIS 3.20 software, 2024.

Methods Materials

To facilitate the data collection for this article, certain equipment was used. A Garmin GPS (Global Positioning System) sensor (GPS Map 64x) was used to collect geographic coordinates. These geographic coordinates had the WGS84 (World Geodetic System) Datum and were expressed in decimal degrees. These were transformed into UTM (Transverse Mercator Projection) using Convers 3 software. These Mercator Projected coordinates were first used with Surfer 13 software to model the study area in Three dimensions (3D). A digital terrain model (DTM) was created from these terrain coordinates and another was downloaded from the Alaska website. Satellite images were downloaded from SAS Planet Nightly 191006 GIS. These images were plotted in the ArcGis 10.8.2 and QGIS 3.20 software environments. The images were printed on A2 (59.4 cm x 42 cm) boards (Bristol) of buildings and roads to facilitate analysis, identification and recording of the state of the habitat using a pen. Word processing and some statistical analyses were carried out respectively using Microsoft Office Word and Excel version 2019 software.

Data collection

The methodological approach used in this article consisted initially of an observation stage. The GPS geographic coordinates were taken while respecting the natural appearance of the terrain. These coordinates in decimal degrees were then transformed into UTM (Transverse Mercator Projection). The Excel format of the transformed coordinates was transformed into Grid with Surfer 13 before producing a Three dimensions (3D) topographic map. A Digital Terrain Model (DTM) was created and another with a precision of 12.5m was downloaded from the website (https://asf.alaska.edu) to produce the two dimensions (2D) topographic map and a slope map, taking an area beyond the study site limit to assess whether the study area is actually in which slope class. On the other hand, the water flow map was produced from grid on Surfer and exported to Esri format Shapefile to ArcMap. A satellite image with a resolution of 1.19 m by pixel was downloaded from SAS Planet Nightly 191006 GIS and then plotted in the ArcGIS and QGIS software environments as a base for the maps in order to facilitate the digitization of plot boundaries, blocks, and certain recent buildings, roads, and flooded areas, in order to calculate their areas and lengths. The other shapefiles of the buildings were downloaded from the OpenStreetMap website (https://extract.bbbike.org). The ratings of the state of degradation of buildings and roads were initially based on empiricism. The latter consists of direct observation through personal experience with in-depth intellectual background in urban planning and development in a similar discipline. In practice, we were more inspired by the criteria for evaluating the physical state of buildings proposed by the National Housing Agency (Borgquist, 2010) . From these criteria, we based ourselves on three very important parts of a house including the current state of the foundation (part on which the wall rests and which transmits the load of the building to the ground), the structure (consisting of the wall, the floor, the staircase, the ramp, the guardrail) and the roof. The latter concerned the assessment of the state of the roof and accessories such as sheets, tiles and gutters (Uzimati et al., 2022). As a result, maps have been developed that allow for precise immersion and analysis of the sites.

The figure below shows the analysis status land and some places under the influence of the flood.

RESULTS AND DISCUSSION

The site analysis map

Figure 6. Analysis map of the Makasi Cell.

Source: Authors' elaboration from field survey data (GPS coordinates) and satellite images (SAS Planet Nightly 191006 GIS), 2024

In this figure 6, some flooded areas have been circled and illustrated by photos taken in the rain at the occurrence of the market places of Makasi, the streets, the yard of the Central Office of the Butembo Health Zone.

The 2D (Two dimensional) Topographic Map.

The figures below show the configuration of the study site or the natural appearance of the terrain.

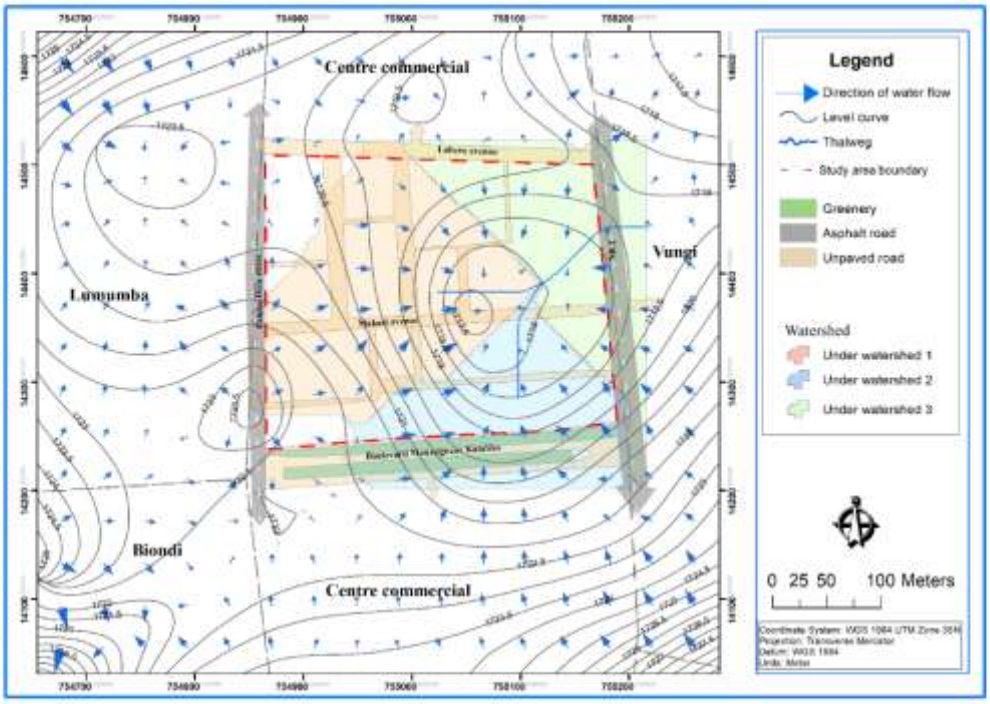


Figure 7. The 2D topographic map

Source: Authors' elaboration from GPS coordinates using ArcGIS 10.8.2 and QGIS 3.20 software, 2024

Our study area has an almost rectangular shape, with a slope in the middle of the terrain according to its morphology. According to the natural terrain shape, the waters flow towards the middle of the terrain. The thalweg lines are characterized here by the concavity of the contour lines, which is oriented towards the lower elevations, while the concavity of the contour lines of the ridge lines is oriented towards the higher elevations. This latter concavity allows the waters to be separated. The site has a minimum and maximum altitude of 1717 and 1724 meters respectively, with a mean of 1720.42 meters and a median of 1720 meters. The variance is 0.27 while the standard deviation in turn is 0.515. According to the natural configuration of the Makasi Cell, it can be seen in Figure 7 that the waters that accumulate in the said cell are not only those of the Makasi cell but also some come from the Commercial Center district, the Biondi district and the Lumumba district. These waters once arrived in Makasi and find that the old pipes are completely blocked by the anarchic construction. As a result, these waters seek better to stagnate due to lack of pipes, but also the configuration of the land and also the humidity of the soil.

Topographic map (Makasi Cell watershed)

This plan below delimits the Makasi cell.

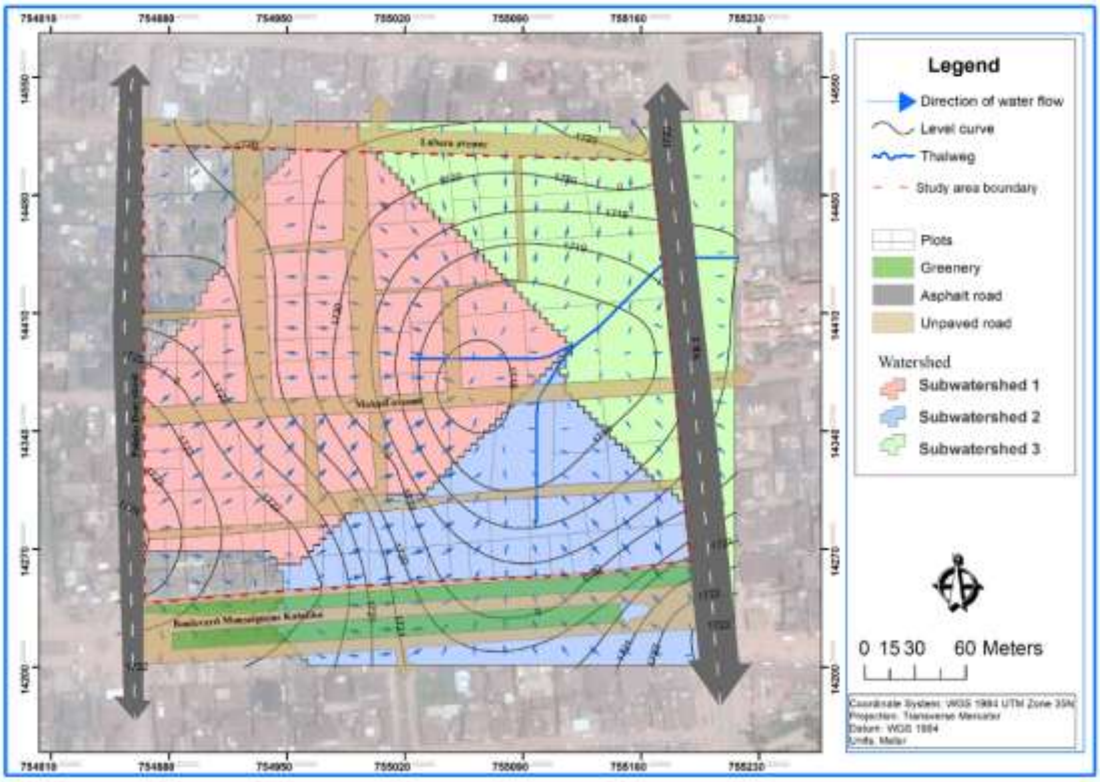
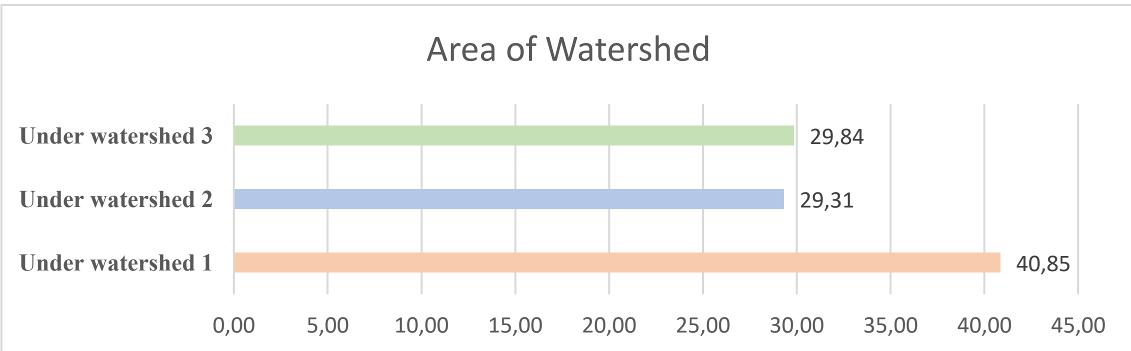


Figure 8. Topographic plan

Source: Authors' elaboration from Digital Terrain Model (DTM) downloaded from Alaska Satellite Facility (https://asf.alaska.edu) and processed with ArcGIS 10.8.2, 2024



A watershed of the Makasi cell has been delineated. It is subdivided into three sub-watersheds with a total area of 10.09 hectares or 100860.86 square meters. Among these three sub-watersheds, the one that occupies the largest part or area of the study area is sub-watershed 1 with an area of 4.119972 hectares or 40.85 percent followed by the third sub-watershed with a superfine of 3.009788 hectares or 29.84 percent and in order to the second sub-watershed with an area of 2.956326 hectares or 29.31 percent. All these three sub-watersheds drain their rainwater via Makasi Avenue by the main road (President of the Republic Road)

Slope map

Topographic slope is the tangent of the inclination between two points on a piece of land, therefore of its angle with respect to the horizontal . It is therefore the ratio between the difference in altitude between the two points and the horizontal, cartographic distance between these two points (Charles et al., 1869)

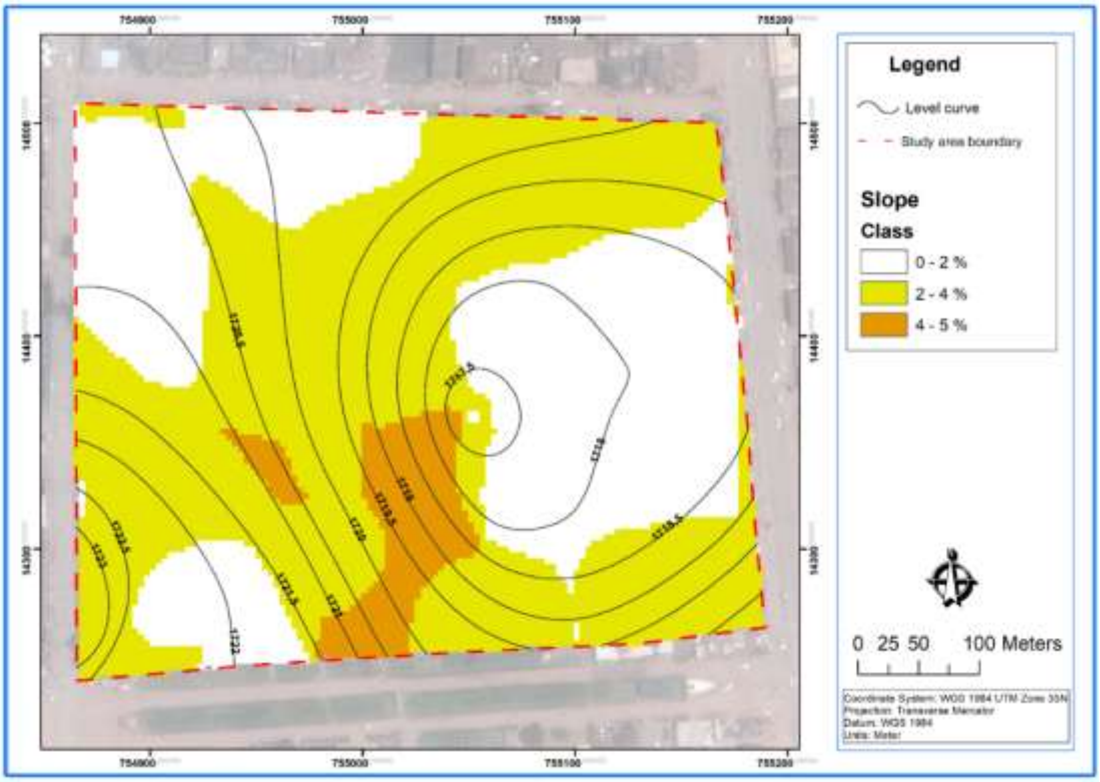


Figure 9. Slope map

Source: Authors' elaboration from Digital Terrain Model (DTM) using ArcGIS 10.8.2 and Surfer 13 software, 2024

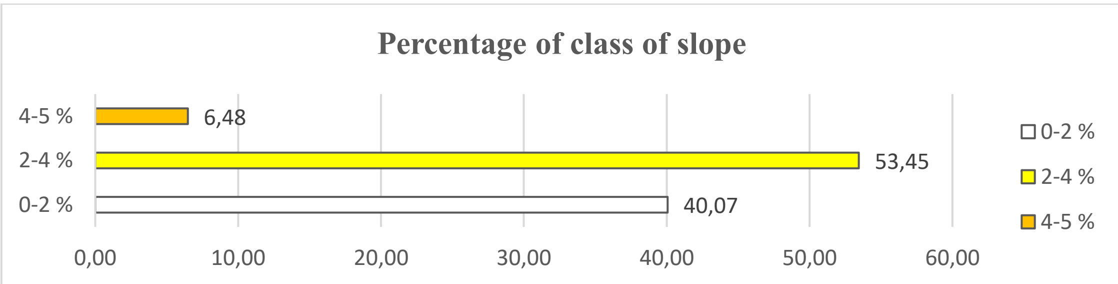


Figure 9 shows the slope map of the Makasi cell. We can still observe from a general point of view, a predominance of slope class of 2-4% which represents 53.45%. While 40.07% of the surface is occupied by a slope class that varies between 0-2%. This last slope class is the one normally not buildable also called a non-building zone. And finally, we have a slope class that is between 4-8%. It represents 6.48% of the total surface area of the study site. These results attract the attention of researchers in the field of urban planning in order to each time take into account.

Terrain profile map (Makasi Cell)

Two field sections were made to assess the level of surface water flow in the Makasi cell.

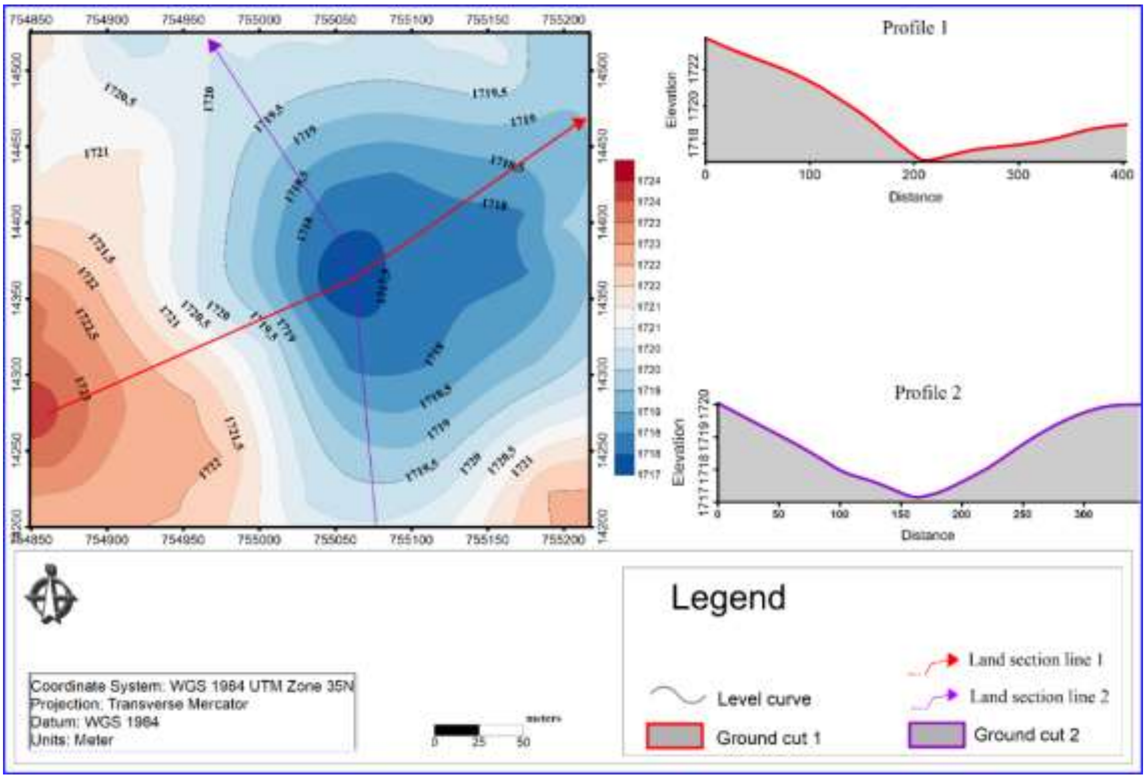


Figure 10. Terrain profile

Source: Authors' elaboration from field survey data (GPS coordinates) using ArcGIS 10.8.2 software, 2024

From these two significant sections, the low level of the ground where rainwater stagnates emerges at their intersection. The first profile starts at an altitude of 1723 meters and goes through 1718 meters in altitude before this rainwater flows into the gutter of National Road number 2. The second profile, on the other hand, starts at 1721 meters in altitude, passing through 1717 meters up to 1721 meters in altitude. These profiles clearly show the areas of flooding.

3D Topographic Map

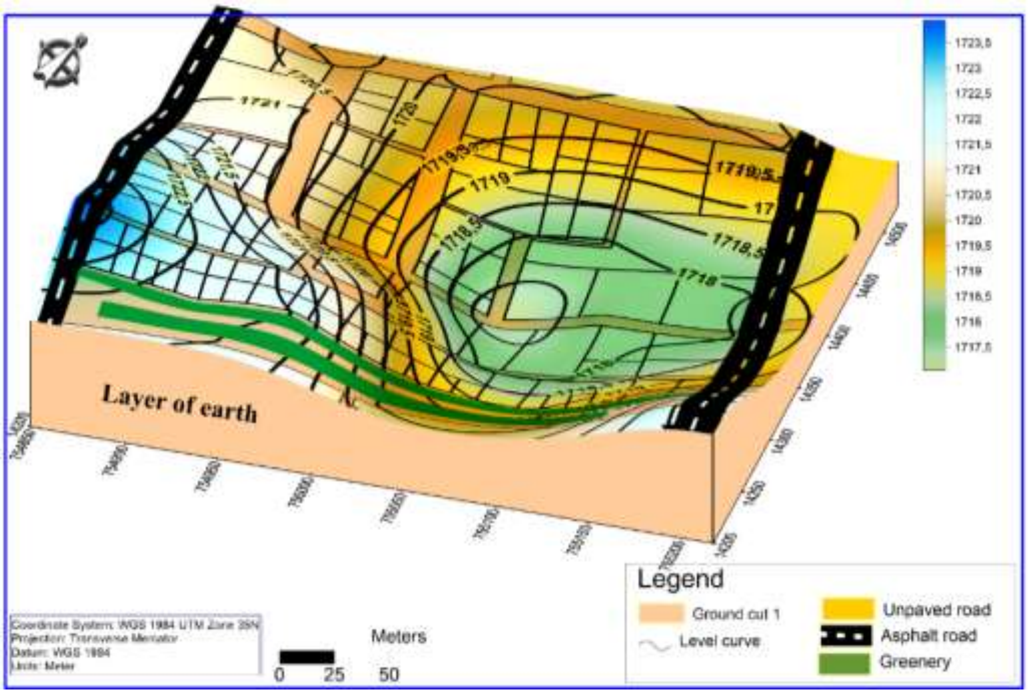


Figure 11. 3D topographic map

Source: Authors' elaboration from field survey data (GPS coordinates) using Surfer 13 software, 2024

This figure above shows the digital terrain morphology of this study site. It clearly shows the areas occupied by the accumulation of rainwater. These are also considered non-building zones or non-man's land zones. These areas are not favorable for construction.

Land use plan of the Makasi Cell.

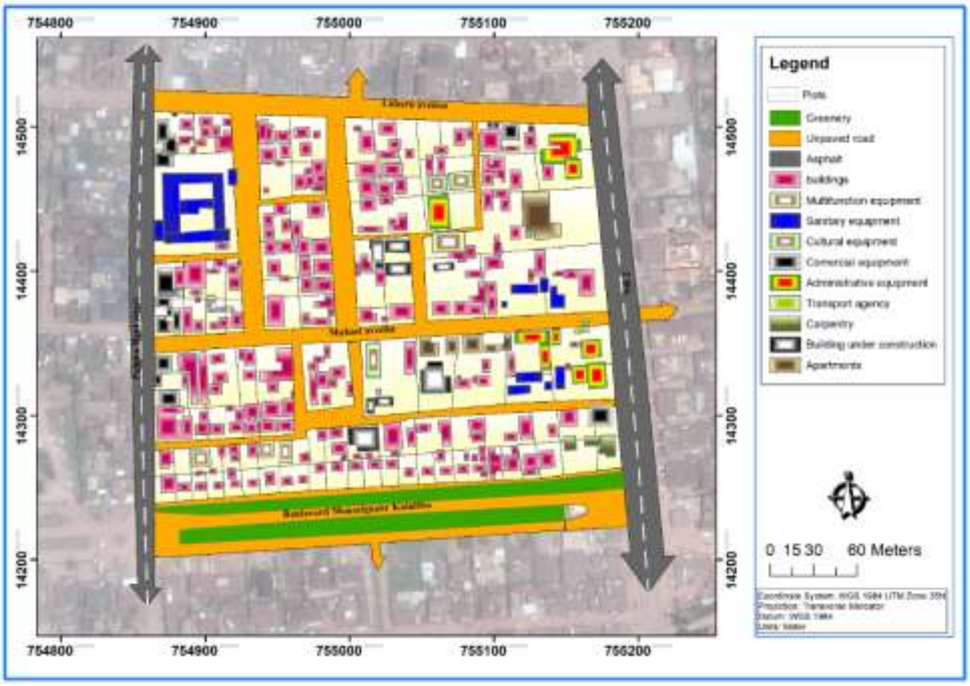


Figure 12. Land use map

Source: Authors' elaboration from field survey data (GPS coordinates), satellite images (SAS Planet Nightly 191006 GIS), and OpenStreetMap data (https://extract.bbbike.org) using ArcGIS 10.8.2 and QGIS 3.20 software, 2024

Table 1: Surface balance of land use

Designation	Area in square meters	Area in %
Transport agency	56.8	0.28
Carpentry	287.57	1.42
Under construction	1336.69	6.62
Apartments	1168.46	5.78
Equipment multifunction	710.47	3.52
Equipment sanitary facilities	2255.14	11.16
Equipment cultural	87.98	0.44
Equipment commercials	1563.85	7.74
Equipment administrative	1128.26	5.59
Housing	11606.14	57.45
Total	**20201.37**	**100**

Source: Result of the occupation from the ground

From Figure 12 and Table 1 above, the majority of the activity in the study area is occupied by housing, 11 606.14 square meters, or 57.45% of the total area. Sanitary facilities also occupy a significant space, 2 255.14 square meters, or 11.16% of the area. Among these sanitary facilities, we find the Lumière hospital center, followed by the Makasi hospital center and finally the health center bearing the name of the same cell. Another important activity is that of commerce. Commercial activities occupy 1 563.85 square meters, or 7.74% of the total area. This is justified by the fact that our study area is located among the cells of downtown Butembo.

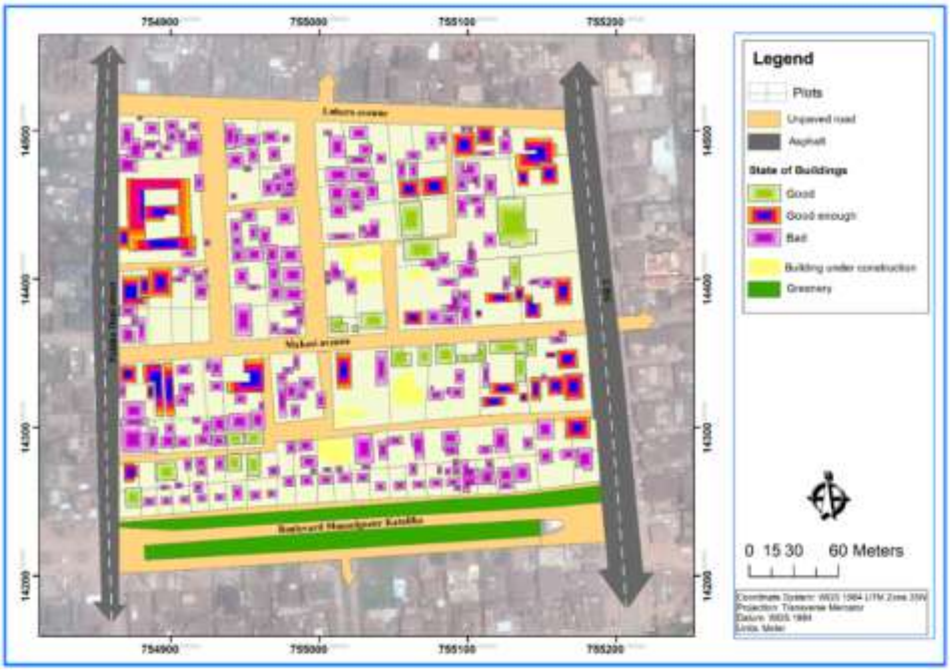


Figure 13. Physical condition map of the buildings

Source: Authors' elaboration from field survey data and visual inspection using ArcGIS 10.8.2, 2024

Table 2: Surface assessment of the physical condition of buildings

Designation	Number	Area Area in square meters	Area in %
Bad	215	10050.9	51.22
Pretty good	36	5568.51	28.38
Good	21	2667.61	13.59
under construction	9	1336.69	6.81
Total		**281**	**19623.72**

Source: result of map of state physical buildings

According to the result of the physical state of the buildings presented in Figure 13 and Table 2, the majority is in a very advanced state of disrepair, almost completely collapsed by the floods, 215 buildings or 41.28%, followed by 36 or 28.38% of the buildings that are in average or pretty good. On the other hand, only 21 buildings, or 13.59 % are in Good state and order 9 buildings under construction. This data gives us a clear idea of the budget for the restructuring and renewal of the Makasi Cell in order to allow the public authorities to seek donors working in the housing sector.

Physical condition map of roads

Figure 14. Physical condition map of the buildildings.

Source: Authors' elaboration from field survey data and visual inspection using ArcGIS 10.8.2, 2024

Table 3: Linear assessment of the physical condition of roads

No.	Designation	Number	Length in linear meters	Area in %
1	Good	2	618	20.24
2	Pretty good	3	977	32

3	Bad	10	1458	47.76
Total		**15**	**3053**	**100**

Source: field diagnostic data

By reading Table 3, a total of 15 sections emerge. These 15 sections represent approximately 3,053 linear meters, or 3.053 kilometers. In light of these results, it is possible to determine the total cost of road rehabilitation for the Makasi Cell. The figures also provide a clear idea necessary to attract investors working in the road sector who can guide administrative authorities towards better decision-making.

Discussion

The topographic configuration constructed through the two-dimensional and three-dimensional topographic map as well as the slope map made it possible to distinguish the constructible areas from those of non-building before any soil affection or occupation of the urban fabric. As a result, the slope map of the Makasi cell shows that 40.07% of the study area is occupied by the 0-2% slope class (Figure 9). The diagnosis of the state of the buildings of the Makasi Cell in the city of Butembo shows that 51.22% of the buildings are in an advanced state of disrepair (Table 2). This figure is double the value estimated by Cosse (2016) or 20% (Cosse, 2016) . It is linked to a lack of rigorous land planning policy by the public authorities (Tohozin et al., 2014).

CONCLUSION

The anarchic occupation of Cells and urban neighborhoods is a recurring phenomenon in many cities, particularly due to rapid population growth and the lack of urban planning. Our comparative study before and after habitability highlighted the direct impacts of this occupation on the habitat of this Cell. Before any activity related to habitability, these spaces are often unoccupied and almost empty and require geomorphological studies related to the configuration of the site to identify buildable areas from those non-building or no man's land. On the other hand, after occupation of an urban fabric, the public authority through organizations working in the field of housing must intervene through urban development in order to requalify and enhance pre-existing urban fabrics while improving the quality of life of the urban population. The absence of a regulatory framework favors poorly structured spontaneous housing, making access to essential public services difficult. Following development and regularization interventions, a significant transformation in habitability has been observed. Improving infrastructure, securing land tenure, and integrating residents into urban policies allow for a better quality of life and a more structured environment. However, these interventions are only effective if accompanied by inclusive and participatory planning. Thus, the regularization of cells and neighborhoods occupied in an irregular manner cannot be a mere administrative formality: it must be part of a comprehensive vision of sustainable urban development. In the future, better anticipation of urbanization dynamics and accessible housing solutions could limit these phenomena and ensure more resilient and inclusive cities.

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