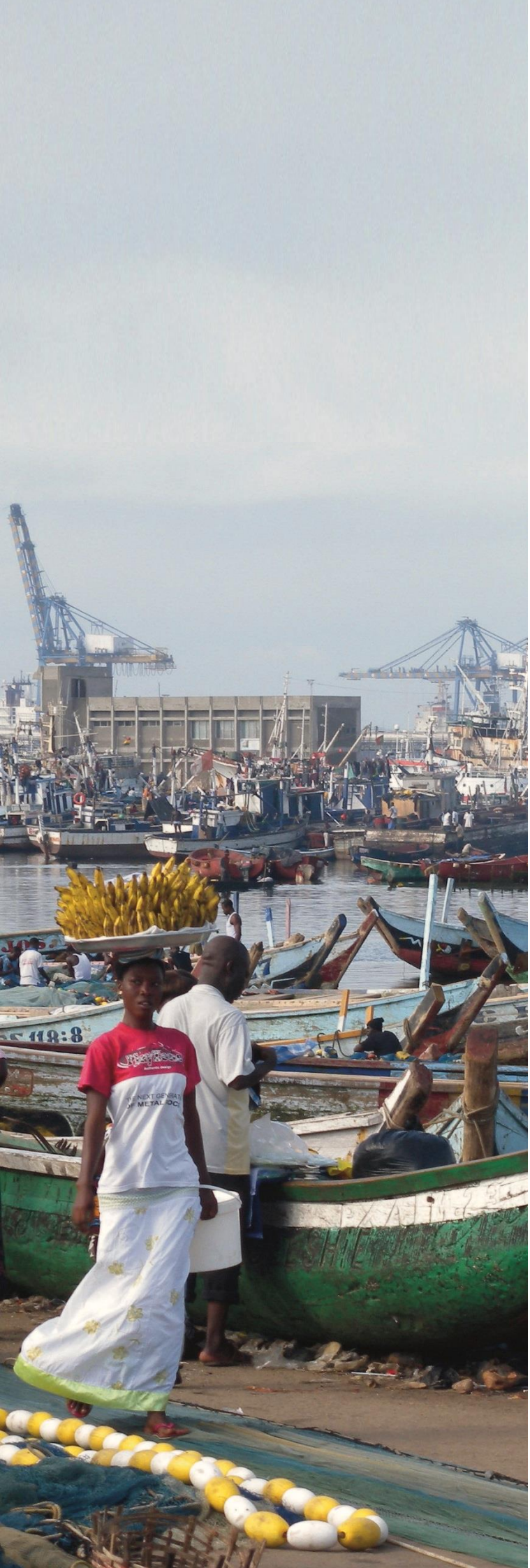


Universität Trier

Christel Weable

Analysis of two streets in the Densu Delta using Mapping Keys

A Research Project

WaterPower Working Paper Volume No. 18

WATERPOWER

WaterPower Working Paper Series

WaterPower Working Paper Series
ISSN (Print) 2510-0521
ISSN (Online) 2510-2222
Governance and Sustainability Lab
Faculty VI - Regional and Environmental Sciences
University of Trier

Suggested Citation: Weable, Christel (2019): Analysis of two streets in the Densu Delta using Mapping Keys - A Research Project. WaterPower Working Paper, No. 18. Governance and Sustainability Lab. Trier.

Authors' addresses

Christel Weable
C.Weable@t-online.de

Analysis of two streets in the Densu Delta using Mapping Keys

Christel Weable

By 2030, urban areas are projected to house 60% of people globally and one in every three people will live in cities with at least half a million inhabitants [25].

United Nations, 2016

1 Introduction

Urbanization is a global driver and cities are rapidly growing in both size and number [24, 25]. "In 2016, an estimated 54.5% of the world's population lived in urban settlements" [25]. In the past 20 years Ghana experienced expeditious urbanization, with a higher urbanization then the global average and it even surmounted the West African average [22]. Ghana's coastal capital city Accra is one of largest cities in West Africa, and is projected to be growing at a rate of 4.59% in the current decade [26]. There are many factors which influence the urbanization of African cities, these factors range from current and historical governmental planning practices over traditional land ownership systems, private development interests to direct foreign investment and migration [10]. Not only is urbanization influenced by a lot of factors but it can also be defined using various indices and data, based on the field of study. Depending on the goal of the research urbanization will be defined using land use/cover, population, and/or economic data [14]. Despite classifying urbanization mainly using population data, urbanization can also be detected and classified using spacial analysis. There are e.g. two major studies which map urbanization of cities all over the world. One is termed "Global Urban Footprint" by the Earth Observation Center of DLR (German Aerospace Center) [4–8, 11] and the other is termed "Atlas of Urban Expansion" by Angle et al. [2]. Both use spacial imagery, but process and analyze them differently. The following images show the urban footprint and the urban extent of Accra in Ghana from within the last decade.

Figure 1.0.1: The urban extent of Accra, Ghana in 2012, from the "Global Urban Footprint" [11].

Figure 1.0.2: The urban extent of Accra, Ghana in 2014, from the "Atlas of Urban Expansion" [2].

Both images (fig. 1.0.1 and 1.0.2) show similar urbanization patterns for the Greater Accra Metropolitan Area (GAMA). The urban extent is widespread along the coastline and has compared to former less reach into the interior. Both of them also show certain areas inside the urban

extent, which are displayed to have mainly no urbanization. Three areas are noticeable because of their area size and location (fig. 1.0.3). The first is the Densu delta protected area (west of the center of Accra), secondly is the Campus from the University of Ghana (north) and thirdly is the Sakumono lagoon protected area (east).

Figure 1.0.3: Areas inside the urban extent displayed to have mostly no urbanization.

On Campus there are buildings from the University and dormitories, therefore small urbanization is existent inside the area, which is visible in figure 1.0.1. The other two areas are protected wetlands [13]. Both wetlands are experiencing pressure from rapid urbanization and population growth, while this pressure is much higher for the Densu delta wetland than for the Sakumono lagoon area [13]. Considering this and looking at the Global Urban Footprint and Atlas of Urban Expansion for the Densu delta area in particular, it is visible that both areas are shown to have limited to no urbanization encroachment into the wetlands. Comparing preceding knowledge to satellite imagery (fig. 1.0.4), it becomes clear that urbanization has encroached much further into the wetland area than both studies suggest. The cause of this might be that the wetland areas are often considered to be constituted out of water, although the area is only partly covered with water. The area coverage of water is of course dependent on the season: the rainy season leads to more water coverage, while the dry season leads to less water coverage.

The Densu delta wetland occupies approximately 60 km^2 [13] and the main river that drains into the Densu delta is called the Densu river. The river is controlled by the Weija dam, which is located

Figure 1.0.4: The Densu delta and surrounding areas, including the salt mines from the Panbros Salt Company

approximately 11 km stream upwards. During dry season the wetland has no direct connection to the sea, but during rainy season the Weija dam lets more water pass, which often leads to flooding and therefore also to discharge into the sea [13]. Consequences of increasing urbanization pressure are very diverse, starting at land degradation, over biodiversity loss, depletion and pollution of water sources to food insecurity [27]. Since a majority of the population in the region has no access to adequate toilets, human waste pollution is increasing and is posing a major threat to the status of the wetland [15]. In addition to that, the Oblogo Landfill lays on a slope bordering the wetland and just 250 m away from the Densu river [13]. Around 1,250 tons of solid waste are discharged there on a daily basis [17, 19]. Although the landfill was decommissioned in 2012 and is now an open dump, it still poses a threat, because harmful organic and non-organic pollutants as well as heavy metals, in solid and liquid form, can be found in the landfill. Furthermore, frequent burning of waste (including plastic) is a common method of disposal, which contributes to further pollution [9, 16, 23]. Since the Densu river is in close proximity the pollutants can easily leak into the wetland through groundwater and the flow of the river, which results in a relatively high pH-value and high alkalinity of the river [17]. Furthermore, directly in the wetlands, using an area of approximately 11 km², Panbros Salt Company harvests salt through solar evaporation [1, 13]. The pollution combined with the high salt concentration in surface- as well as groundwater is the reason why the water is not suited for domestic use and should not be used as such. Therefore encroachment presents yet another threat to the wetland [13], since a large informal settlement re-

sides inside the wetland (Tetegu) [10]. Since Urbanization is very impactful on the environment (as established above) and further encroachment will increase these already existing problems, the analysis of urbanization can help an understanding of why the problems exist and subsequently how improvement is possible.

In the following chapters the urbanization of this settlement (Tetegu) and the urbanization of the settlement directly north of Tetegu (SW McCarthy) will be objective of analysis in this research. The consecutive chapter elucidates the research methodology, including the conducted field work with the established mapping keys, as well as the data and statistics. Additionally the limitations of the data and the reflection of the fieldwork can be found within chapter 2 as well. Followed by this, chapter 3 comprises of the preliminary results and the discussion of former. Concluding chapter 4 gives an outlook on further research which can be done with this data.

2

Research Methodology

As broached before, there are various methods to analyze urbanization and urbanization patterns. Commonly, population size data in combination with spatial analysis is used to extract information about urbanization as shown e.g. in the book "Urban Development in Asia and Africa" edited by Murayama et al. in 2017 [14]. Ato Quayson, on the contrary, had a different approach to the topic "urbanization" in his published book "Oxford Street, Accra: City Life and the Itineraries of Transnationalism" [20]. In this book Quayson describes the development of Accra by focusing on the development of the most characteristic street of Accra, named "Oxford Street". As Caleb Owen summarized quite well: "Oxford Street represents a point of intersection in Accra where variegated planning processes shaping various districts, neighborhoods, and enclaves converged, creating overlapping points of reference for the negotiation and production of urban space" [18]. Although his work focuses much on the social geographic and historical development, the idea of focusing on one street to characterize the development of a neighbourhood or area is an interesting approach. Out of this, the idea to analyze and illustrate the urbanization of the study area and its patterns using one representative street emerged. For this research in particular the approach of analyzing the urbanization of an area using a representative street is especially practical, since mapping the entirety of an area is too time consuming for the set time frame.

For the map "Flood risk in Greater Accra and land use in the Densu Delta." published in the article "Institutional bricolage and the production of vulnerability to floods in an urbanising delta

in Accra" the encroachment of urbanization was displayed by mapping buildings in Google Earth satellite imagery from 2009 until 2016 [10]. For the years 2009 until 2016 finished houses, that were most encroached into the wetland were mapped. In addition for the year 2016 all unfinished construction sites were mapped as well. The map shows that the mapped buildings add up to an urbanization line for each year [10]. This represents the encroachment process. Since the encroachment area is only accessible through a single bridge north of the settlement, the urbanization spreads out starting at the point, where the bridge over the split Densu river gives access to the not flooded area of the wetland. Since one way [3] This means that the development of this settlement occurs along main roads [3], which start at the bridge and spread into the wetland. To better capture the development of the area a street should be chosen that runs lateral to the urbanization lines of the map described above [10].

For further analysis of the urbanization of this area ground truthing is a necessity. For this purpose field work in the Densu delta was conducted by Christel Weable in September and October of 2017.

2.1 Field Work

The aim of the field work was to look at the local urbanization and map former. Subsequently the data is to be analyzed and inspected to find out, if patterns emerge. Patterns can be detected in a way of general quantitative occurrence of mapping keys or in the spatial occurrence of mapping keys. Therefore, in preparation to the field work, a set of mapping keys were created. After exploring the study area in person for a short period of time it was clear, that the prepared mapping keys were not fully applicable in this area. This was due to a lack of perception of the way spaces are urbanized in Accra. The first set of mapping keys were too focused on the separation between residential buildings and commercial buildings. Further the building status of structures was not considered, but this is a very important part of the urbanization process, because buildings are not finished within a relatively short period of time. It can happen that the first floor is finished and the second floor initiated and the building stays in this status for years, until further construction is carried out. Therefore adjustments were made and a new set of mapping keys were created (see table 2.1.1).

These mapping keys were separated in three categories: "Structure", "Use" and "Size". The category "Structure" represents the status of construction, while "Use" represents the purpose of the building. Since there are all sorts of different stages of construction to be found, the category "Structure" should be flexible enough to reflect most of them. Especially the mapping key "initiated/ stated" was important, since on some plots there has been some construction, but it is not yet visible what type of building it is supposed to be. For the category "Use" it was also important to

Table 2.1.1: Mapping Keys - each mapped property had a three digit code, consisting out of the three categories (Structure, Use and Size), assigned to it.

	Structure		Use		Size
1	**done** • roof • windows • doors • paint/ tile	1	**housing** • layout of domestic house • no sign of people living inside	1	**tiny** • 1 room
2	**almost done** • roof • windows • doors • no paint	2	**residential** • people live inside	2	**small** • 2 to 3 rooms
3	**unfinished** • more than paint missing	3	**commercial** • people sell things	3	**small with 2nd floor** • 2 to 3 rooms on each floor
4	**initiated/ started** • brick structure • no roof • or just walls	4	**church/ mosque** • has obvious Church elements or I was told it was a church	4	**large** • 3 to 5 rooms on each floor
5	**mixed structures** • almost done or done & • unfinished or initiated • on same plot	5	**mixed: residential and commercial** • flat and shop in same building	5	**large with 2nd floor** • 3 to 5 rooms on each floor
6	**kiosk** • rudimentary structure like wooden stand and Container	6	**not identifiable** • no indication of what the building is used for	6	**huge** • $\geq$ 5 rooms
7	**no structure**	7	**agriculture** • growing crops -> somewhat structured vegetation	7	**huge with >2nd floor** • $\geq$ 5 rooms on each floor
		8	**natural vegetation** • no structure in vegetation • no obvious maintains	8	**other** • no size relation to rooms, like street vendors and vegetation
		9	**other**		

be flexible to show how the building is being used, despite of whatever building status the structure has. One important difference lays between the mapping key "housing" and "residential". Some houses looked finished, but there was no sign of people living inside, so to see how many of potentially uninhabited buildings were constructed, the mapping key "housing" was added. To have an indication what size a building is, the category "Size" gives an idea through estimation of rooms inside a building. With these set of mapping keys all statuses of construction and different usages with their size could be represented. Even if no structure could be found on a property, the usage of "agriculture" and "natural vegetation" with "other" as no size relation was added. As a definition for what is mapped, each GPS coordinate stands for a plot. A plot is defined as an area that a house and its clearly associated surroundings take up. To specifically define a plot is complicated, since the urbanization of the area is less planed and organized as e.g. in Germany, becasue it developes independently of any spatial urban planning [12].

While mapping, each GPS coordinate recorded got a 3-digit code - consisting out of one digit from each column - assigned to it, which reflects the status of urbanization. As an information back-up, each plot was also photographed and the picture number was noted as well. In this research, based on the information collected from the locals residents, the settlement south from N1, down Tetegu Rd to the bridge is considered to be SW McCarthy and everything south of the bridge is considered to be Tetegu. The plan was to map a street in Tetegu and one street in SW McCarthy. At first the street in Tetegu heading straight south from the bridge was chosen to be mapped for this research, but since the fieldwork was conducted in September and October, there was higher precipitation and therefore large parts of the street heading south was flooded and not accessible. As an alternative the street heading east from the bridge is the focus of this research, since it starts in the original village and heads all the way to the end of the inner wetland, where the Densu river flows (see fig. 2.1.1). It should also cross most urbanization lines from the map "Flood risk in Greater Accra and land use in the Densu Delta." [10]. As the secondary street, a street in SW McCarthy heading east right before the bridge was also mapped during the field work (see fig. 2.1.1). The street in SW McCarthy was mainly mapped to have a comparison of how the development of urbanization varies between the two areas. Both street head from the main road east, close to the Densu delta, while the street in Tetegu is after the bridge, the street in SW McCarthy is before.

2.2 Data and Statistics

The GPS coordinates have sequenced numbers which were manually connected to the respective mapping key code. In total about 300 coordinates were taken across both streets (approximately $^2/_3$ of them in SW McCarthy and $^1/_3$ in Tetegu). Firstly the data from both streets were checked

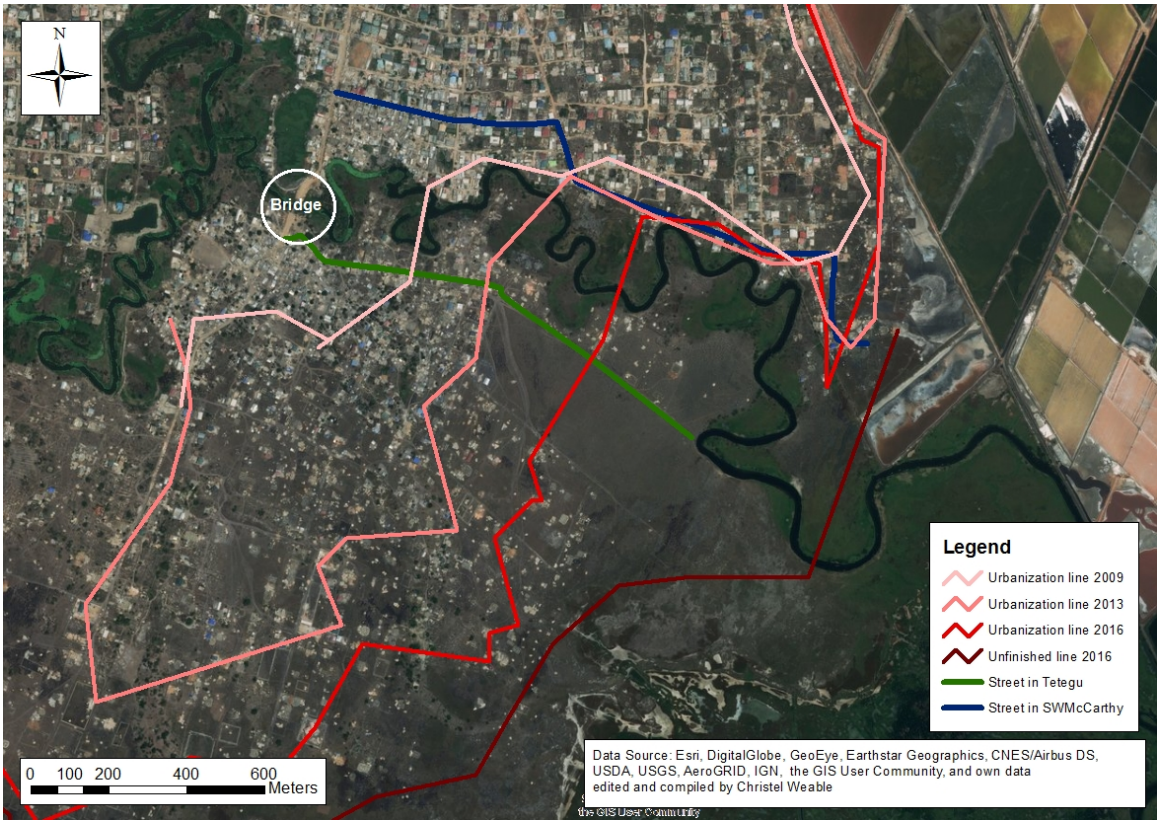


Figure 2.1.1: Overview of the study area showing the two mapped roads and the urbanization lines from the map "Flood risk in Greater Accra and land use in the Densu Delta." [10].

and all coordinates containing streets and other information taken for orientation purposes was disregarded. Then the data was sorted and examined for each mapping key separately (see figures 3.0.1, 3.0.2 and 3.0.3). Since both streets have a different length, the frequency is also displayed as percentage, in consideration of the total GPS points taken per street, to make the results of the two streets more comparable. Afterwards using the program R for statistical computing the frequency of mapping key combinations were detected. Out of a total of approximately 90 mapping key combinations that occurred, the most frequent were selected for further analysis.

From this point on the focus of analysis was the street in Tetegu, due to time limitations.

Considering the results already found, this information was looked at in a spacial context to discover spatial patterns in urbanization. At first every mapping key was analyzed individually and then the most frequent mapping keys were analyzed as well.

2.3 Limitations and Reflection

All data collected during the field work is subject to limitations and errors. Firstly the assignment of the mapping key to the GPS coordinates is subjective. Especially the size can differ from reality, since the mapping was carried out from the street and there was no applicable way to find out the exact numbers of rooms inside a building. Furthermore it was common that locals tried to engage a lot out of curiosity of what was being mapped and why. This might have lead to variations in concentration and receptivity of the mapping objective. {There was especially one incident, where a local kept talking to me for approximately six hours straight, which was nerve-racking and could have lead to some error in the data.} Moreover the data management included a lot of manual handling, which is always prone for mistakes.

Nevertheless, the data was checked for errors as much as possible.

Opposed to the limitations, field work and the contact with the locals also improved the data. Conversing with local people helps understand how and why people urbanize areas. For this field work there were several local people, who helped getting to know the area. They accompanied me while mapping the study area, by answering any questions that came to mind and also helped engage more with other locals. Locals that have lived in the area for long periods of time could also give a brief history of when certain events happened, such as the construction of the bridge or report about an increase of floods in the area. They also told me about their community and way of life. All this makes mapping easier, because one has a better comprehension of what one is actually seeing and mapping.

While mapping the map "Flood risk in Greater Accra and land use in the Densu Delta." [10] I was able to map the finished buildings and construction sites, but it was hard to identify what type of structure I was mapping and I did not quite understand how the process of constructing a building can be, since some construction sites can stay at a certain level for a long time. Furthermore the type of houses one can find in the area can by very different from what we know from Germany, which makes identifying them over satellite imagery or similar, without further knowledge, very difficult.

3

Preliminary Results and Discussion

The preliminary analyses of the data are displayed in figures 3.0.1, 3.0.2 and 3.0.3. In these, every mapping key is considered individually.

By looking at the mapping key "Structure" (fig. 3.0.1) it appears that the street in SW McCarthy has slightly more "done" and "almost done" structures. Whereas both streets have similar percentage of "unfinished", "initiated" and " mixed" structures. However, the street in Tetegu has more "kiosk" and "no structure" plots. From observations during field work, this could be owed to the fact that the street in Tetegu started in the original village, where a lot of kiosks were prominent and the end of the street was not yet urbanized as much as the street in SW McCarthy. The data also suggests that the street in Tetegu in total has more "initiated", "mixed", "kiosk" and "no structure" than of "done", "almost done" and "unfinished" plots, which could also be an indication of the degree of urbanization. Considering the urbanization lines in figure 2.1.1, the street in SW McCarthy was already urbanized before 2009, it is consistent with the urbanization degree suggested by this data.

Focusing on the mapping key "Use" (fig. 3.0.2), for the street in SW McCarthy "residential" sticks out with 32% and if one adds the 15% from "housing", this means that almost half of the street is purely for residential purposes. Whereas in the street in Tetegu the use and purpose of 26% of the structures were not identifiable. In both streets the percentage of "church", "agriculture" and "other" are negligible. Considering the total distribution, it seems that Tetegu has more commer-

cial ("commercial") and plots in development ("not identifiable" and "natural vegetation") which is coherent with the findings of the mapping key "Structure" and the suggested degree of development.

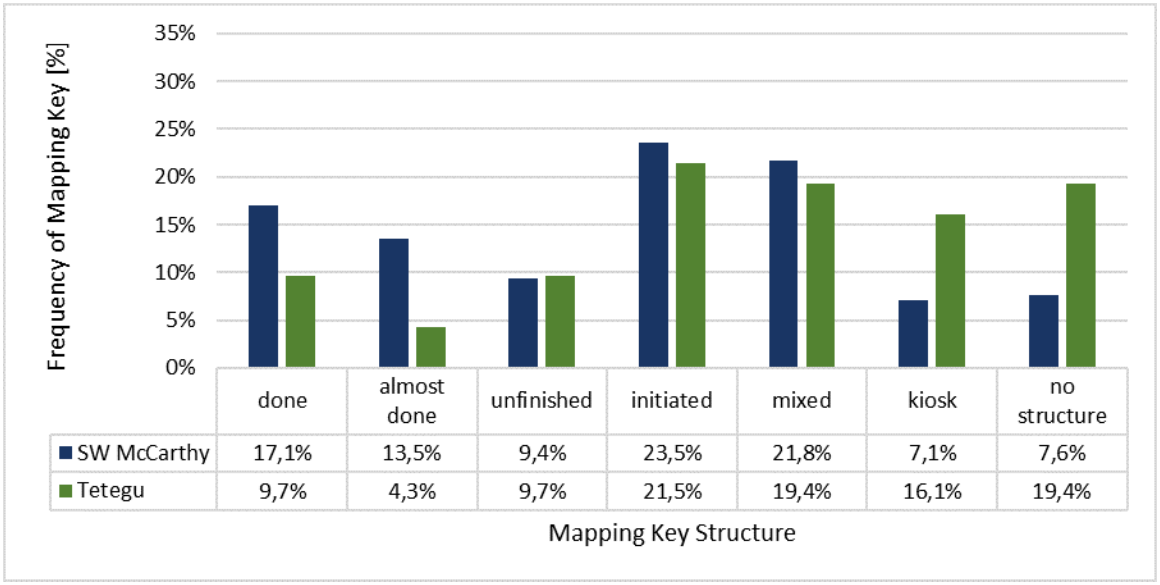


Figure 3.0.1: Graph showing the frequency of each "Structure" mapping key in percentage relative to the size of the street.

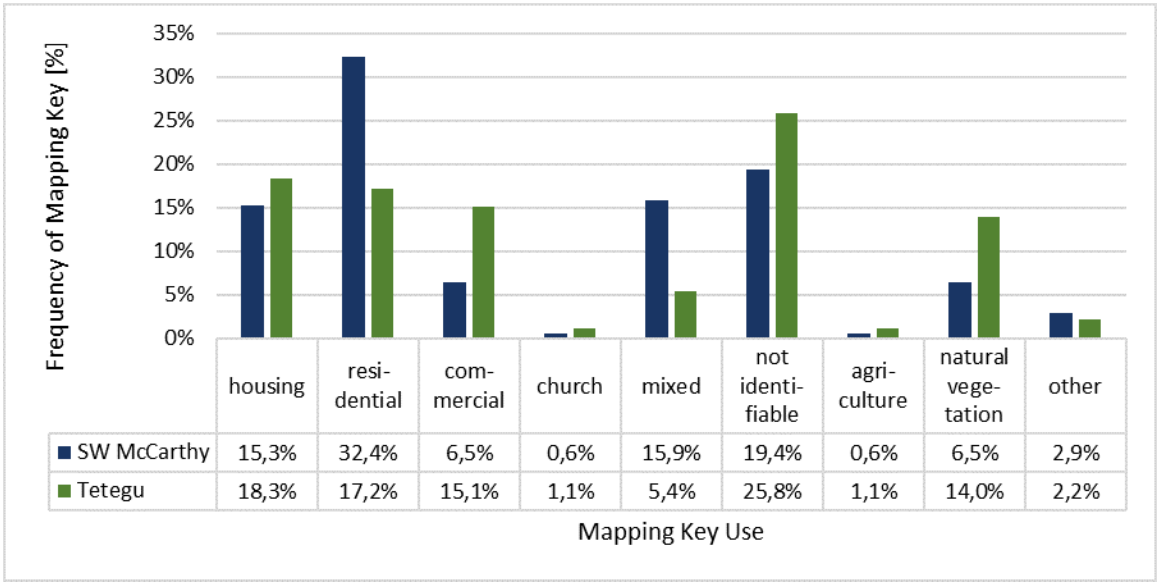
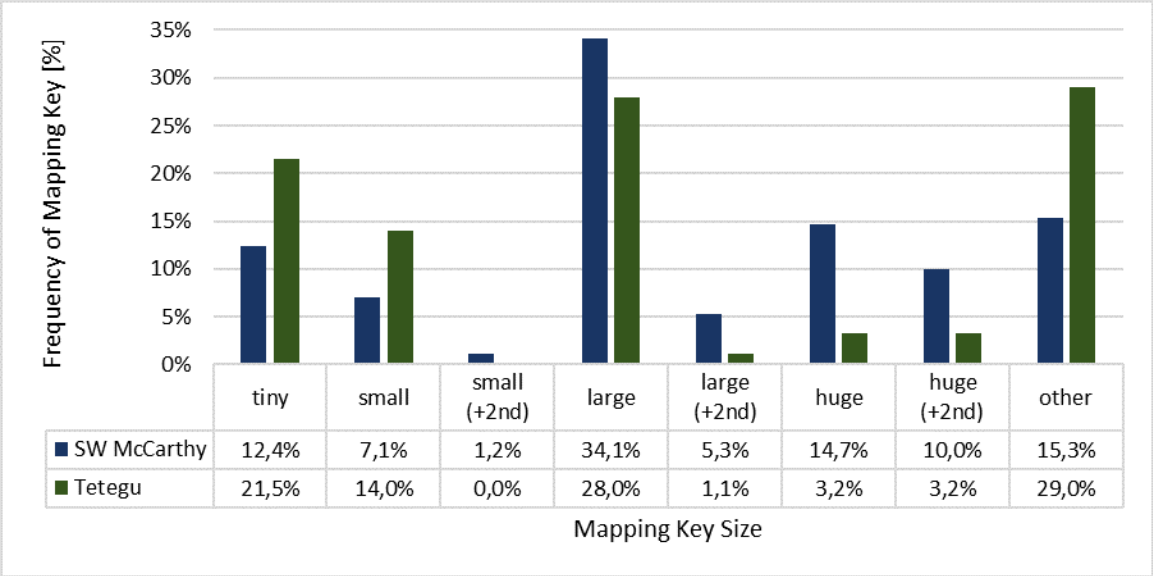


Figure 3.0.2: Graph showing the frequency of each "Use" mapping key in percentage relative to the size of the street.



	tiny	small	small (+2nd)	large	large (+2nd)	huge	huge (+2nd)	other
SW McCarthy	12,4%	7,1%	1,2%	34,1%	5,3%	14,7%	10,0%	15,3%
Tetegu	21,5%	14,0%	0,0%	28,0%	1,1%	3,2%	3,2%	29,0%

Figure 3.0.3: Graph showing the frequency of each "Size" mapping key in percentage relative to the size of the street.

The mapping key ”Size” (fig. 3.0.3) also shows, that there are more ”tiny” and ”small” structures and less ”large (+2nd)” , ”huge” and ”huge (+2nd)” in the street of Tetegu than in the street in SW McCarthy, which again strengthens the conclusions from the other two mapping keys. Nevertheless the amount of ”large” buildings is high in both streets and therefore seems to be the most common size to be build.

Since looking at the mapping keys individually does not give any information about how the keys interact with each other, it is important to also look at the combinations of the three mapping key groups. In both streets combined approximately 90 mapping key combinations occurred. From those the following are the four most common combinations:

1. 788 (”no structure”, ”natural vegetation”, ”other”), with 19% frequency
2. 468 (”initiated”, ”not identifiable”, ”other”), with 16% frequency
3. 631 (”kiosk”, ”commercial”, ”tiny”), with 14% frequency
4. 524 (”mixed”, ”commercial”, ”large”), with 10% frequency

This frequency does not mean that e.g. 19% of the mapped plots are of this combination, but that from all combinations that occurred, this combination has a 19% frequency. The high frequencies of these combinations are easily explainable. The first combination (788) has a high frequency due to the fact that if a plot is declared to have ”no structure”, it is almost bound to have ”natural vegetation” and ”other”, since there are no alternatives, despite of the usages ”agriculture” and ”other”.

Same goes for the combination 468. If a plot is considered ”initiated” it is more likely to be ”not identifiable” and ”other”. Same goes for 631, since ”kiosk” is ”commercial” and usually ”tiny”. Interesting is the frequency of the combination 524 as 10% of all combinations are of the former. This leads to suggest that ”mixed” structures are more likely to have a ”commercial” use and a ”large” size. This could be an indicator of how the urbanization of an area takes place. While communicating with the people in the study area, some of the plot owners explained that they would first build a shop on their property to finance the building of a residential house. In this case the shop would be ”done” or ”almost done” and the residential house could be ”unfinished” or ”initiated” and the plot would be categorized as ”mixed”. If the shop is the only visible usage, then it would be categorized as ”commercial”. And since ”large” is the most common size for structures, it is reasonable that this would also be the most frequent in this combination. This could be an explanation for a large part of the plots, that fall under the combination 524. But for conclusive argumentation further analysis of the data must take place.

A combination which has a high frequency in the street of SW McCarthy compared to the street in Tetegu is 124 (”done”, ”residential”, ”large”), with 8% frequency. This is another indication that the urbanization in the street of SW McCarthy is further along in the development, because the houses are categorized as ”done”. The connection to having more ”residential” plots, once the structures are ”done” could lie in the fact that once the houses are finished there are less people around working on the construction, which leads to less demand of shops. Further, a lot of people open a shop to finance their construction (as broached above) and once the residential house is finished, there is no use for the commercial structures any more. This is up to now only a theory and could be aspect of further research [21]. Successively another frequent combination, but mostly in the street in Tetegu and not so much in the street in SW McCarthy is 314 (”unfinished”, ”housing”, ”large”) with 7% frequency. Since the main difference between ”housing” and ”residential” is the fact of people living inside, this combination goes hand in hand with the combination just above. Since the structure is ”unfinished”, people are not living inside, but it is visible that this house is build for residential use. Further information about the owners of plots and for whom they are building would be very interesting for further analysis. During the field work, people also explained, that they are often times building houses in the study area to rent out or sell. And from that money they want to build themselves a house elsewhere. Since in Tetegu ”housing” is slightly more common than ”residential” (see fig. 3.0.2), the question is, if there is enough demand for these houses, of if they will stay empty. It could also be an aspect of further research to see how these values change over time and therefore get more information on the development of the area.

The next analysis was to set the analyzed and shortly discussed data above into spacial context (see appendix fig. .0.1 .0.2 .0.3 and .0.4).

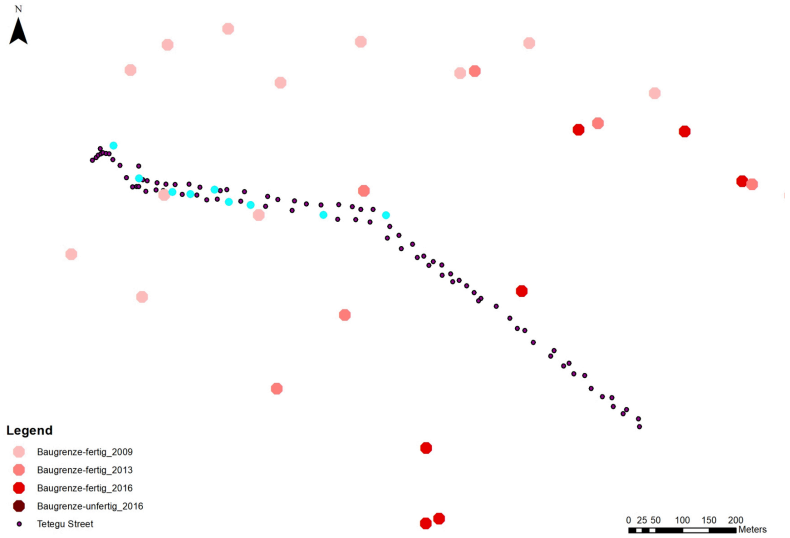


Figure 3.0.4: The mapping key "done" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

When comparing the distribution of where each "Structure" mapping key was mapped, with a few exceptions most of them are spread over the length of the street. The plots mapped as "done" only occur in the first half of the street (see fig. 3.0.4). This is coherent with the observation, that the urbanization is developing along the road, therefore houses at the beginning of the road are more likely to fit the description of "done". The plots declared as "kiosk" only occur in about the first third of the street (see fig. 3.0.5). This is due to two reasons: Firstly the kiosks in the original village, so at the beginning of the street do not belong to a bigger plot with residential buildings as the kiosks further down the road do and secondly is the original village where most people of the area walk across, so it is logical for there to be more kiosks to sell their product, than further down the road where it is less likely for people to walk by and buy things. The most "Use" mapping keys are also distributed across the length of the street, but some show a tendency. "Commercial" plots are mainly at the very beginning and then a few in between (see fig. 3.0.6). Near to the point where most "commercial" plots stop, "mixed" plots begin, which shows that the way shops are embedded in the street changes slightly (see fig. 3.0.7). Instead of "kiosks" or other "commercial" buildings, they are on plots where people have their residents. The mapping keys "agriculture" and "natural

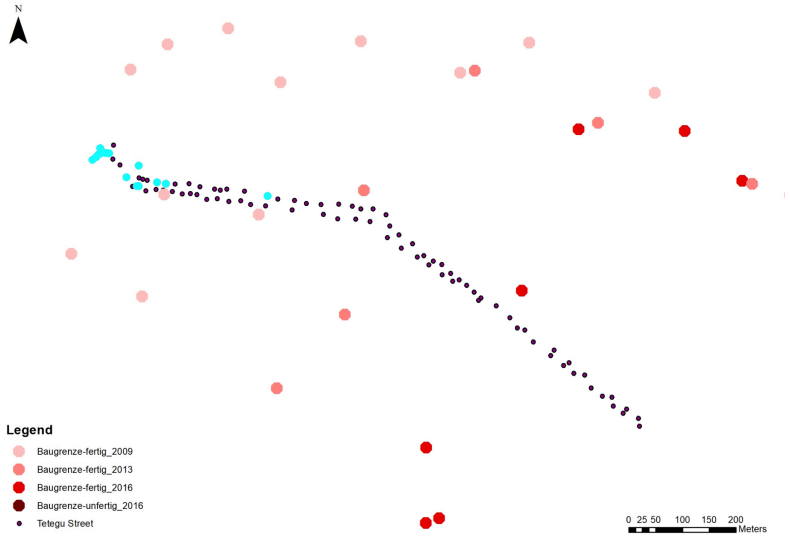


Figure 3.0.5: The mapping key "kiosk" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

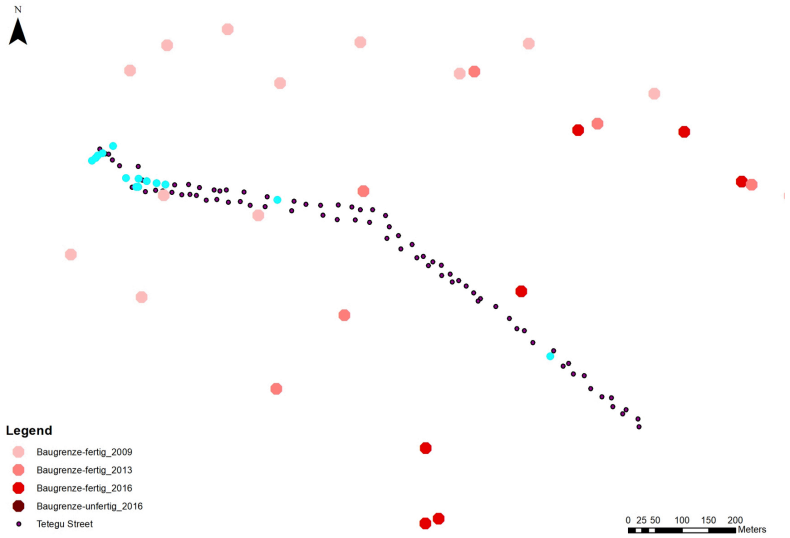


Figure 3.0.6: The mapping key "commercial" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

vegetation" only occur in the second half of the street (see fig. 3.0.8 and 3.0.9). This is shows that in the second half of the street there are still plots which are not yet urbanized and therefore the plots still have the natural vegetation and that there is still some space for agriculture. This shows again that the urbanization process moves along the length of the road. For the mapping key category "Size" no particular pattern could be detected (see appendix .0.3). Focusing on the five most frequent combinations only the combinations 631 and 788 shows a tendencies (see appendix .0.4). The combination 631 ("kiosk", "commercial", "tiny") is very frequent at the beginning of the street,

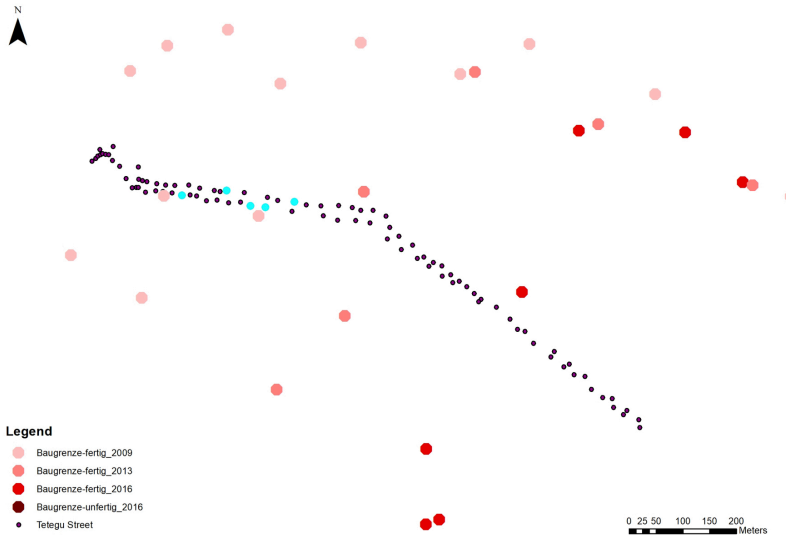


Figure 3.0.7: The mapping key "mixed" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

but does not occur further down the street. Which is a consequence of "kiosk" only occurring in the same area. While the combination 788's ("no structure", "natural vegetation", "other") frequency increases further down the street. This shows that down the street there are more plots that are not yet urbanized, which is to be expected.

As the street in Tetegu crosses all three urbanization lines from the map "Flood risk in Greater Accra and land use in the Densu Delta." [10] the data can be looked at in a temporal context as well. Unfortunately there are no conclusive patterns in relation to temporal context that can be detected. Therefore the only temporal statement that can be made is, that the street in Tetegu is development wise younger than the street in SW McCarthy, as established above. This is due to the fact that the encroachment into the wetland is fairly recent. According to local residents the bridge was build around 2012. Before the bridge was build there was a already a settlement with the name of Tetegu which originated from an old tribe settlement. The only way to reach Tetegu before the bridge was via boat over the Densu river. Therefore the construction of the bridge accelerated the urbanization process. An indication of how the street is is developing could seen through the location of the individual mapping keys, but not in relation to the urbanization lines. For more conclusive temporal statements further research must be done.

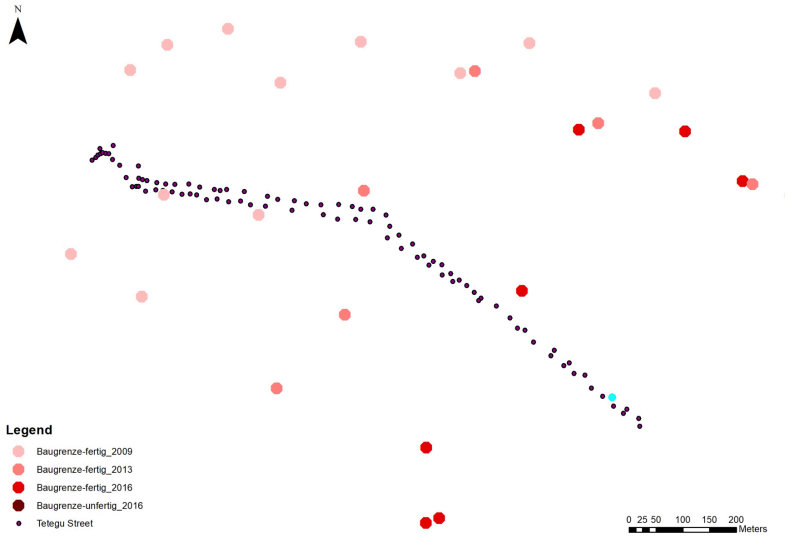


Figure 3.0.8: The mapping key "agriculture" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

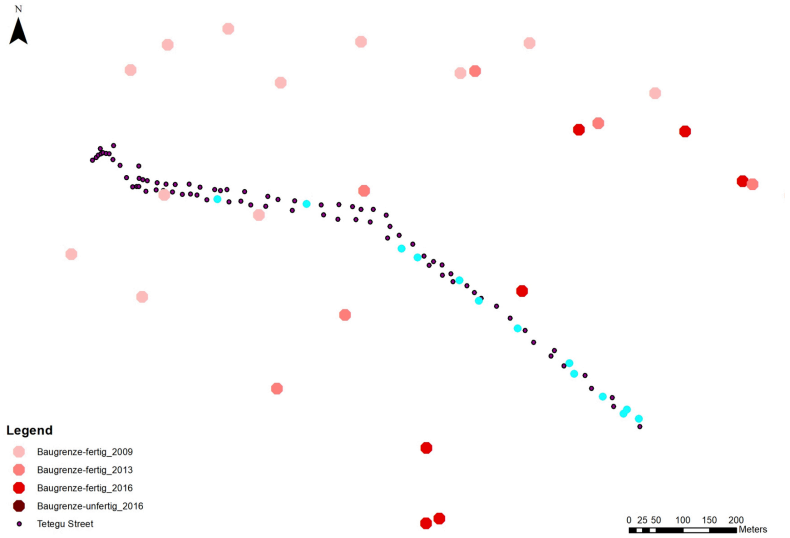


Figure 3.0.9: The mapping key "natural vegetation" displayed in a spatial context for the street in Tetegu, as well as the urbanization lines represented by dots.

4

Outlook

Summarizing, based on the results shown above, the street of Tetegu is not yet as urbanized as the street in SW McCarthy. This was shown epecially through the street of SW McCarthy having more ”done” and ”almost done” plots and the street of Tetegu opposing having more ”not identifiable” and ”natural vegetation” plots. There is much more potential for further analysis of this data, for starters could the data of the street in SW McCarthy be analyzed in the spatial context, as the data of the street in Tetegu was. Also grouping the existing mapping keys thematically to describe observed phenomenons could also lead to more understanding about the urbanization of this area. One could create thematic clusters and analyse these further. Moreover, having a bigger data pool, for example a different street, but in the same exact area (e.g. Tetegu) would be very intriguing. Furthermore it would also be very interesting to see the results out of different areas of the city and see if even more different urbanization patterns can be detected this way. Looking at the temporal aspect it could also be an aspect of further research, to see how these values change over time and therefore get more information on the development of the area. Especially since no conclusive relations could be found between the mapped street in Tetegu and the urbanization lines from the map ”Flood risk in Greater Accra and land use in the Densu Delta.” [10], which could have indicated trends for concrete time frames. Concluding, since urbanization is a very dynamic and complex prozess, mapping an area to detect urbanization patterns or trends is challenging, but through using adequite mapping keys, it is well possible.

References

[1] Affam, M. and Asamoah, D. N. (2011). Economic Potential of Salt Mining in Ghana Towards the Oil Find. *Research Journal of Environmental and Earth Sciences*, 3(5):448–456.

[2] Angel, S., Blei, A. M., Parent, J., Lamson-Hall, P., and Sánchez, N. G. (2016). Atlas of Urban Expansion - 2016 Edition: Volume 1: Areas and Densities.

[3] Doan, P. and Oduro, C. Y. (2012). Patterns of Population Growth in Peri-Urban Accra, Ghana. *International Journal of Urban and Regional Research*, 36(6):1306–1325.

[4] Esch, T., Marconcini, M., Felbier, A., Roth, A., Heldens, W., Huber, M., Schwinger, M., Taubenbock, H., Muller, A., and Dech, S. (2013). Urban Footprint Processor—Fully Automated Processing Chain Generating Settlement Masks From Global Data of the TanDEM-X Mission. *IEEE Geoscience and Remote Sensing Letters*, 10(6):1617–1621.

[5] Esch, T., Marconcini, M., Marmanis, D., Zeidler, J., Elsayed, S., Metz, A., Müller, A., and Dech, S. (2014). Dimensioning urbanization – An advanced procedure for characterizing human settlement properties and patterns using spatial network analysis. *Applied Geography*, 55:212–228.

[6] Esch, T., Schenk, A., Ullmann, T., Thiel, M., Roth, A., and Dech, S. (2011). Characterization of Land Cover Types in TerraSAR-X Images by Combined Analysis of Speckle Statistics and Intensity Information. *IEEE Transactions on Geoscience and Remote Sensing*, 49(6):1911–1925.

[7] Esch, T., Taubenböck, H., Roth, A., Heldens, W., Felbier, A., Thiel, M., Schmidt, M., Müller, A., and Dech, S. (2012). TanDEM-X mission—new perspectives for the inventory and monitoring of global settlement patterns. *Journal of Applied Remote Sensing*, 6(1):061702–1.

[8] Esch, T., Thiel, M., Schenk, A., Roth, A., Muller, A., and Dech, S. (2010). Delineation of Urban Footprints From TerraSAR-X Data by Analyzing Speckle Characteristics and Intensity Information. *IEEE Transactions on Geoscience and Remote Sensing*, 48(2):905–916.

[9] Essumang, D. K., Adokoh, C. K., Afriyie, J., and Mensah, E. (2009). Source Assessment and Analysis of Polycyclic Aromatic Hydrocarbon (PAH's) in the Oblogo Waste Disposal Sites and Some Water Bodies in and around the Accra Metropolis of Ghana. *Journal of Water Resource and Protection*, 01(06):456–468.

[10] Frick-Trzebitzky, F., Baghel, R., and Bruns, A. (2017). Institutional bricolage and the production of vulnerability to floods in an urbanising delta in Accra. *International Journal of Disaster Risk Reduction*, 26:57–68.

[11] German Aerospace Center (2016). Global Urban Footprint.

[12] Grant, R. and Yankson, P. (2003). Accra: City profile. *Cities*, 20(1):65–74.

[13] Kondra, M. (2016). The status of the wetlands in the Greater Accra Region.

[14] Murayama, Y., Kamusoko, C., Yamashita, A., and Estoque, R. C., editors (2017). *Urban Development in Asia and Africa: Geospatial Analysis of Metropolises*. Springer Singapore, Singapore.

[15] Ntiamoa-Baidu, Y. and Gordon, C. (1991). Coastal Wetlands Management: Plans: Ghana.

[16] Nyame, F. K., Tigme, J., Kutu, J. M., and Armah, T. K. (2012). Environmental Implications of the Discharge of Municipal Landfill Leachate into the Densu River and Surrounding Ramsar Wetland in the Accra Metropolis, Ghana. *Journal of Water Resource and Protection*, 04(08):622–633.

[17] Osei, J., Osae, S. K., Fianko, J. R., Adomako, D., Laar, C., Anim, A. K., Ganyaglo, S. Y., Nyarku, M., and Nyarko, E. S. (2011). The Impact of Oblogo Landfill Site in Accra-Ghana on the Surrounding Environment. *Research Journal of Environmental and Earth Sciences*, 3(6):633–636.

[18] Owen, C. (2016). The Variegations of Globalization in the African City: Urbanism and Accra's Oxford Street.

[19] Owusu, G., Nketiah-Amponsah, E., Codjoe, S. N. A., and Afutu-Kotey, R. L. (2014). How do Ghana's landfills affect residential property values? A case study of two sites in Accra. *Urban Geography*, 35(8):1140–1155.

[20] Quayson, A. (2014). *Oxford Street, Accra: City Life and the Itineraries of Transnationalism*. Duke University Press, Durham.

[21] Silver, J. (2014). Incremental infrastructures: Material improvisation and social collaboration across post-colonial Accra. *Urban Geography*, 35(6):788–804.

[22] The World Bank (2015). Rising through Cities in Ghana: Ghana Urbanization Review Overview Report.

[23] Tuani, E. M. (2008). Managing urbanisation and waste disposal in West Africa: Case study of Oblogo, Accra-Ghana.

[24] UN-Habitat (2016). Urbanization and development: Emerging futures: World cities report 2016.

[25] United Nations, Department of Economic and Social Affairs, Population Division (2016). The World's Cities in 2016: Data Booklet.

[26] United Nations Human Settlements Programme (2014). The State of African Cities 2014: Re-imagining sustainable urban transitions.

[27] Yorke, C. and Margai, F. M. (2007). Monitoring Land Use Change in the Densu River Basin, Ghana Using GIS and Remote Sensing Methods. *African Geographical Review*, 26(1):87–110.

Appendices

Appendix

The following two tables show the count as well as the percentage of each mapping key mapped for a plot in the study area for each street.

Table .0.1: Total count of properties assigned to each mapping key and the percentage of properties assigned to each mapping key in relation to the number of houses in the mapped street in Tetegu.

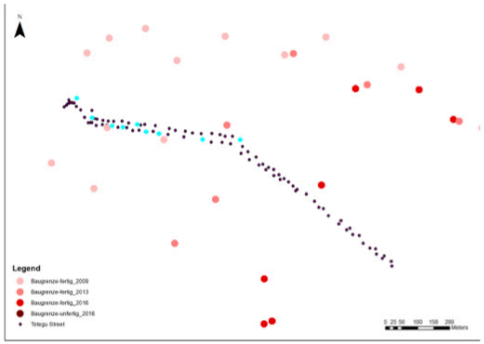
	Structure			Use			Size	
1	9	9%	1	17	17%	1	20	19%
2	4	4%	2	16	16%	2	13	13%
3	9	9%	3	14	14%	3	0	0%
4	20	19%	4	1	1%	4	26	25%
5	18	17%	5	5	5%	5	1	1%
6	15	15%	6	24	23%	6	3	3%
7	18	27%	7	1	1%	7	3	3%
			8	13	14%	8	27	29%
			9	2	2%			

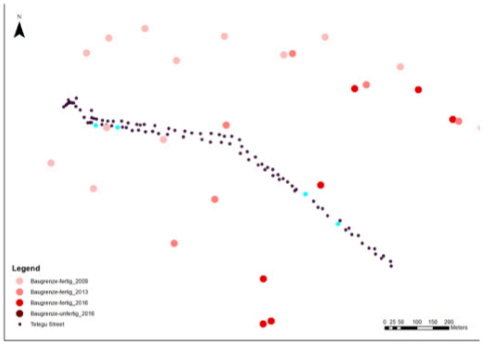
Table .0.2: Total count of properties assigned to each mapping key and the percentage of properties assigned to each mapping key in relation to the number of houses in the mapped street in SW McCarthy.

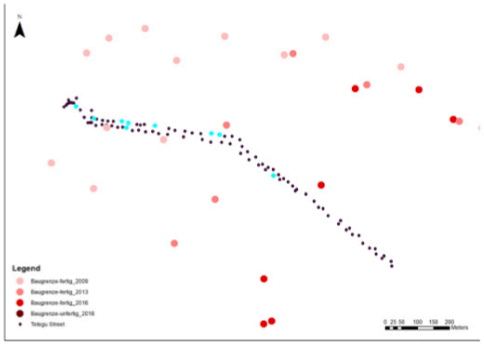
	Structure			Use			Size	
1	29	17%	1	26	15%	1	21	12%
2	23	14%	2	55	32%	2	12	7%
3	16	9%	3	11	6%	3	2	1%
4	40	24%	4	1	1%	4	58	34%
5	37	22%	5	27	16%	5	9	5%
6	12	7%	6	33	19%	6	25	15%
7	13	8%	7	1	1%	7	17	10%
			8	11	6%	8	26	15%
			9	5	3%			

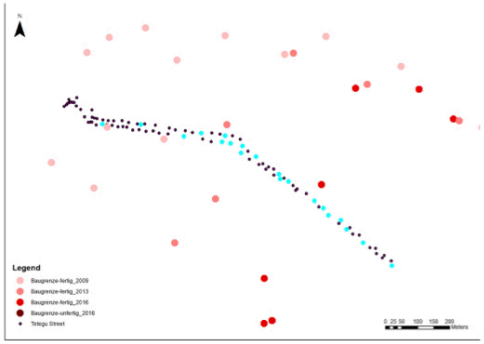
In the following figures all mapping keys and most frequent combinations of former, as well as the urbanization lines represented by the dots are displayed in a spatial context for the street in Tetegu.

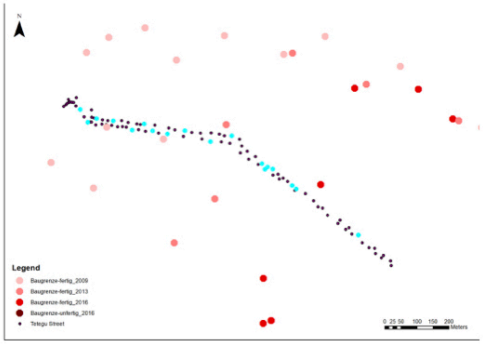
Figure .0.1 ***(following page)*****:** Here all "Structure" mapping keys as well as the urbanization line represented by the dots (which is the coordinate of the original mapped buildings) are displayed in a spacial context for the street in Tetegu.

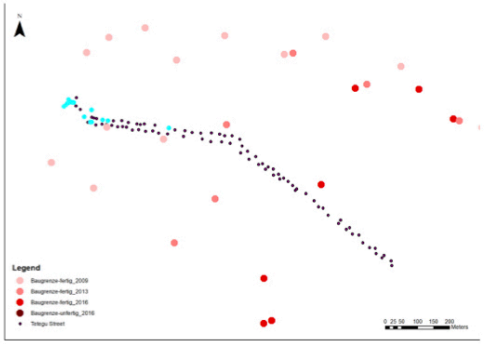

N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters

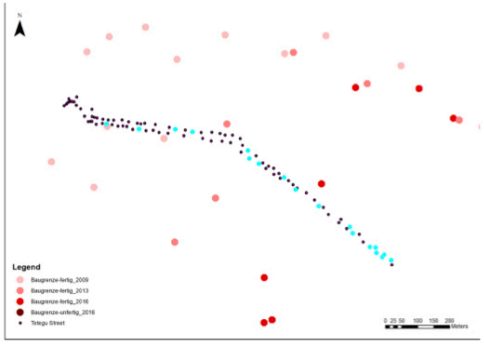
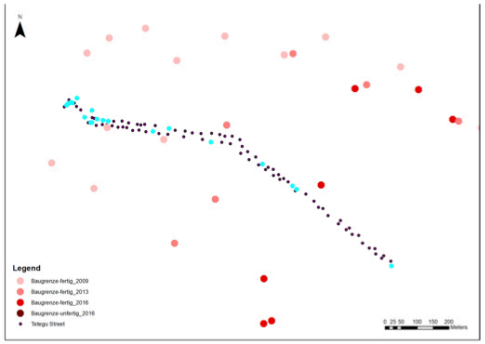
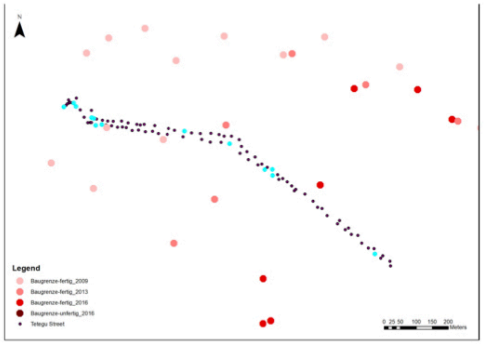
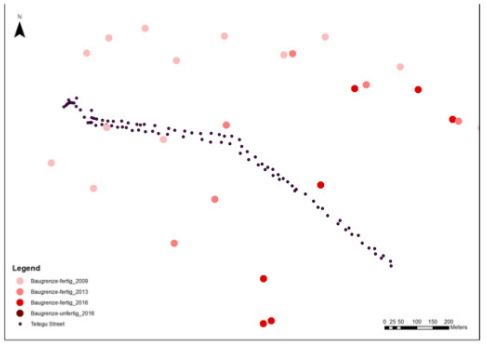

N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Tetegu Street
0 25 50 100 150 200
Meters

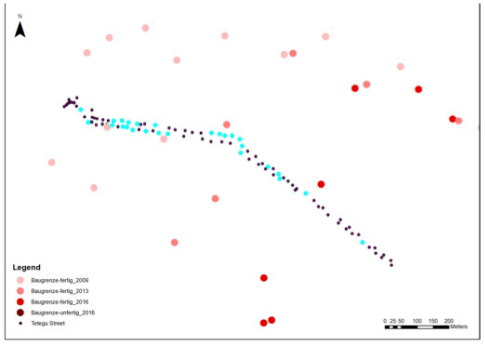
Figure .0.2 ***(following page)*****:** Here all "Use" mapping keys as well as the urbanization line represented by the dots (which is the coordinate of the original mapped buildings) are displayed in a spacial context for the street in Tetegu.

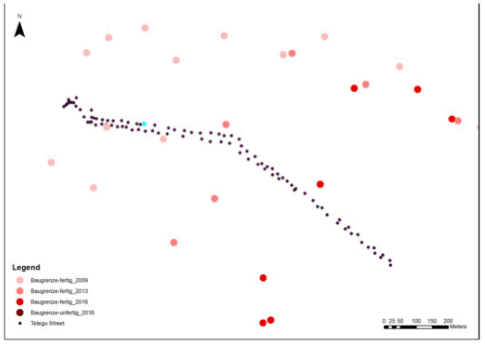
Figure .0.3 ***(following page)*****:** Here all "Size" mapping keys as well as the urbanization line represented by the dots (which is the coordinate of the original mapped buildings) are displayed in a spacial context for the street in Tetegu.

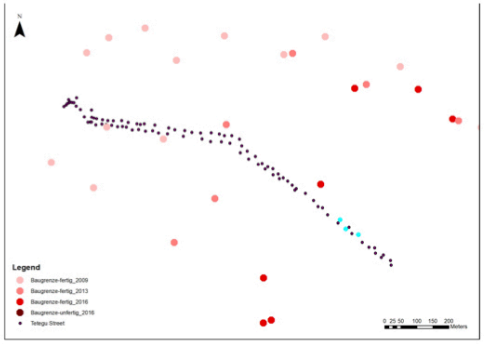

N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters

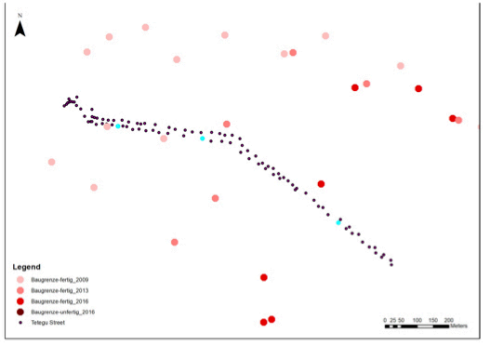

N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters

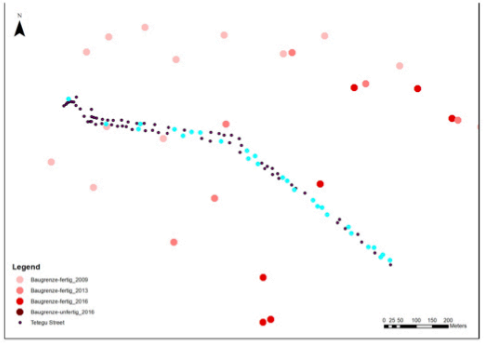
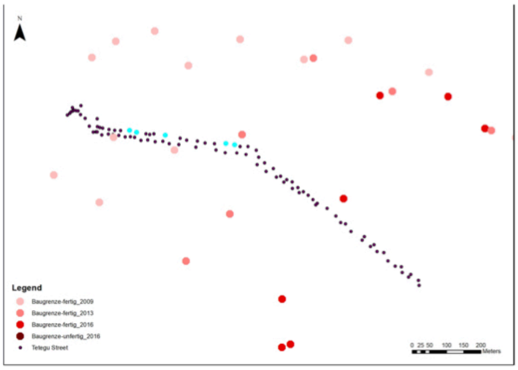
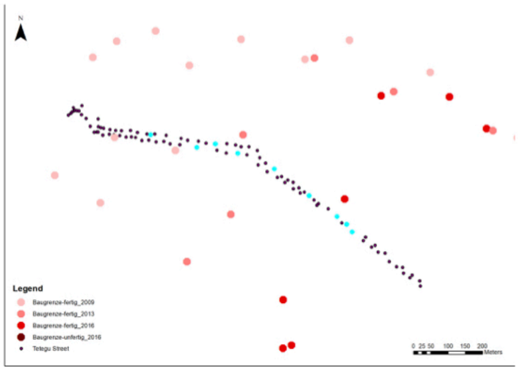
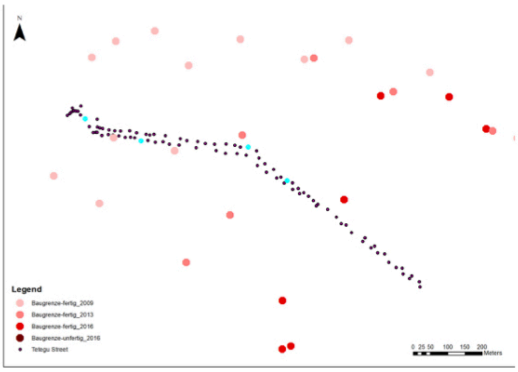
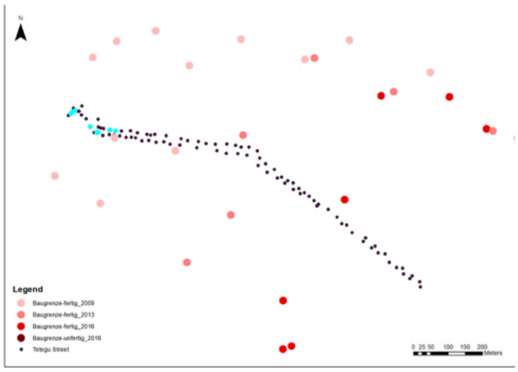

N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters

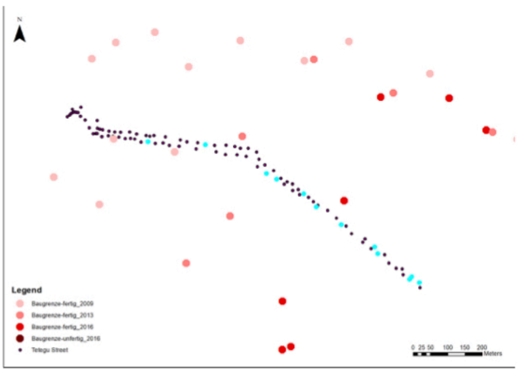
Figure .0.4 ***(following page)*****:** The five most frequent combination of mapping keys as well as the urbanization line represented by the dots (which is the coordinate of the original mapped buildings) are displayed in a spacial context for the street in Tetegu.


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters


N
Legend
Baugrenze-fertig_2009
Baugrenze-fertig_2013
Baugrenze-fertig_2016
Baugrenze-unfertig_2016
Telegu Street
0 25 50 100 150 200
Meters

WaterPower is a laboratory for experimenting with novel ways of doing research based on the integration of multiple disciplines, approaches, methods and non-academic knowledge through dialogue and collaboration.

We contribute to current debates on society-nature relations by mapping, analyzing and understanding processes that unfold in the urban water sphere.

Our analyses critically study the interplay of socio-political and ecological processes and how they configure place and scale.

Governance and Sustainability Lab

Faculty VI - Regional and Environmental Sciences
Prof. Dr. Antje Bruns
University of Trier
www.uni-trier.de
www.waterpower.science

WaterPower is funded by

SPONSORED BY THE
Federal Ministry of Education and Research

FONA
Research for Sustainable Development
BMBF