Histographies of architecture: a first analysis of the changing roof landscape in rural Kenya

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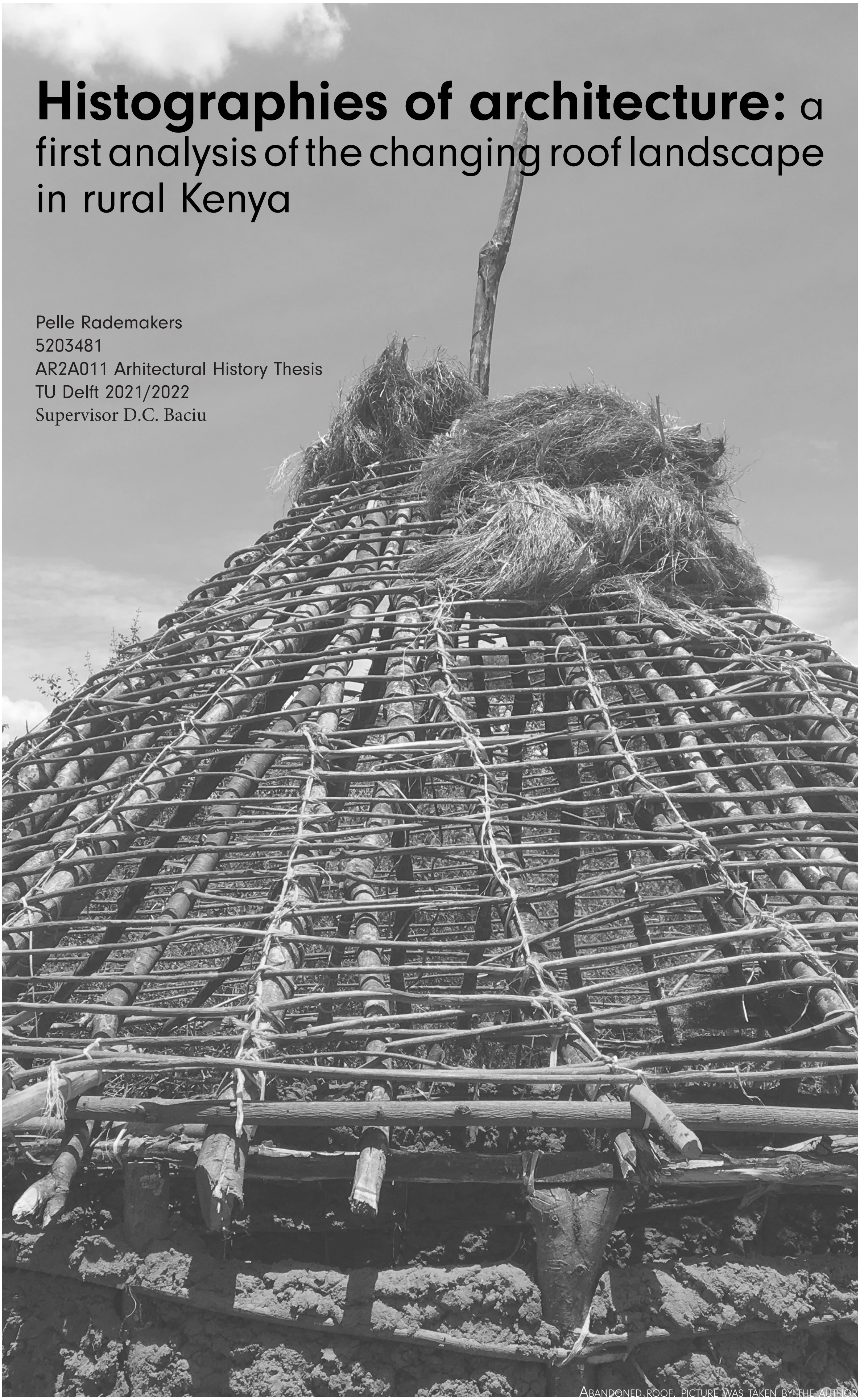

Abandoned roof, picture was taken by the author

Abstract

In the last 50 years, the roof landscape of Sub-saharan Africa has undergone a massive transformation that historians have not yet studied. Since the early 1980s, traditional grass-thatched roofs have mainly been replaced by corrugated iron sheet roofs (Kenya National Bureau of Statistics, 2019).

I witnessed this transformation while participating at the Rural Housing Studio on Mt. Elgon, Kenya, in September 2017. At first, it seemed hard to understand why someone in Kenya would choose a metal roof over the vernacular alternatives, as metal roofs bring dependence on skilled labour and a lack of comfort during the hot summer days. With this consideration in mind, the transformation that was taking place seemed all the more improbable and required an explanation. This present thesis is a first study of what is happening.

Using household surveys and satellite imagery, I study how metal roofing has spread in Kenya. My preliminary study will be a primer for those who will find interest in studying the broader context of housing in Africa. The continent is currently in the midst of a massive population boom, accompanied by considerable changes in housing conditions. The transition from grass-thatched roofs to corrugated iron sheet roofing is a part of this story that should not be neglected.

This thesis, among others, indicates that it will be relevant to collect more data on housing conditions in rural areas. All while developing more advanced remote sensing methods to better map and quantify the transition from grass to corrugated iron sheet roofing.

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Introduction

According to its gross domestic product, Kenya is East Africa's most prosperous economy and has seen significant growth in the past years. Kenya's economy will likely continue to grow with a well-educated labour force, East Africa's biggest port, and a strong tourist economy. The Mombasa port gives Kenya the position as the commercial and logistical hub of Eastern Central Africa. This position made the country one of the best investment destinations globally, accelerating its development and making it the fastest-growing globally (Embassy of the Republic of Kenya in Japan, 2022).

Kenya is a continent-wide example of the development currently happing in Africa. While the continent is still the poorest region globally, poverty is projected to decrease in the upcoming years (Statista, 2021). Also, the continent is seeing significant population growth. This growth will mean that 40% of the world population will live in Africa at the end of this century (Kristersson, 2019). With population numbers rising and poverty decreasing, the African housing landscape is undergoing significant change (Statista, 2021).

One notable element of this changing housing landscape is the shift from grass to corrugated iron sheets as the predominant roofing material. While the history of housing development in urban agglomerations has drawn considerable scholarly attention, comparatively little is known about the changing roofing landscape in rural areas, as in rural Kenya. To better understand the history of this phenomenon, this paper will research the changing roofing landscape in rural Kenya.

Kenya is a good case study to research the history of the changing roofing landscape because the country is at the forefront of Africa's development. Therefore, the country has already undergone significant economic and population growth in the past half-century, accompanied by a changing roof landscape (Statista, 2021).

While data on housing conditions in rural Kenya are scarce and hard to get a hold of, academic housing surveys provide knowledge about the housing conditions in the past 40 years. These surveys, combined with underlying income data, weather conditions and inhabitants' roofing materials, can give new insights into the history of the changing roofing landscape. Finally, satellite imagery can investigate more recent changes in the changing roofing landscape.

Literature review and methodology

To investigate the history of the changing roof landscape in rural Kenya. This thesis will review literature from primary and secondary sources, satellite data and housing surveys. The housing surveys conducted in the past 40 years will help understand the housing conditions as each household survey gives insight into the current roofing conditions of that time. Comparing this data to the region's characteristics, a clear picture of the roofing and social-economic conditions appears. Together with satellite imagery, it creates an outline of the roofing landscape in rural Kenya.

The first chapter discusses the academic field research of J. Sterkenburg, as he was among the first to investigate housing conditions in postcolonial Kenya. The five housing surveys conducted from 1978 to 1986 help get insight into roofing conditions in postcolonial Kenya. The housing surveys showed the earliest documented period when the roofing landscape changed. Combining this data with satellite imagery illustrates the changing roof landscape over the past forty years.

The second chapter investigates the roofing conditions on mount Elgon in 2017, where I witnessed this transformation first-hand. This experience, combined with household survey data, can explain roofing conditions in more current socioeconomic times.

The third chapter focuses on more minor sources that give extra insights into why this roofing transition is happening.

Finally, this paper summarises the findings and history of the changing roofing landscape and invites academia to research further this transition from grass to corrugated iron sheet roofing.

Chapter I: Roofing conditions in Rural Kenya from 1978 to 1990

A. Explaining the dataset from Prof. J. Sterkenburg

Professor Jan Sterkenburg from the department of Geography of Developing Countries at the University of Utrecht was among the first to research rural housing conditions in Kenya in the post-independence period, as there was, and still is, a significant gap in knowledge regarding housing conditions in rural areas (Sterkenburg, Megens, & Tempelman, 1981).

He conducted numerous housing surveys in collaboration with the Kiambu Institute of Science and Technology and the Department of Housing Research and Development Unit, University Nairobi. To better understand current housing conditions and shed light on the social-economic changes in Kenya.

The five surveyed Kenyan Counties provide the first well-documented dataset about housing conditions in postcolonial rural Kenya and are, therefore, a good starting point to look at the history of the changing roofing landscape in Kenya.

Figure 1. Kiambu County (County Government of Kiambu, 2018).

B. Characteristics of Kiambu County in 1978

Kiambu County has an area of 2451 km2 and lies centrally within Kenya, just north of the capital Nairobi. With an estimated 558 thousand inhabitants in 1975 (Sterkenburg, 1978) and an estimated 2.4 million inhabitants in 2019 (Statista, 2019), it is the second most populated County in Kenya. Kiambu has a favourable physical environment, with a high percentage of marketed agriculture and a substantial share in total employment combined with a good road connection. These factors explain why Kiambu has a relatively high employment rate compared to other Counties in Kenya. While there is overall high employment and agriculture output, there is significant inequality in farm seizing and wealth as 2% of inhabitants own 50% of available farmland whilst 90% own 36% of the land. This big income difference, combined with pressure on available materials, leads to significant differences in roofing conditions (Sterkenburg, 1978).

Traditional vernacular dwelling typologies in the region are predominantly round with a grass thatched roof. The materials used in these dwellings are all locally sourced. Inhabitants built these dwellings between agricultural activities. However, from 1978, observers noted that homes slowly changed to rectangular shapes with non-traditional roofing materials like corrugated iron sheets (Sterkenburg, 1978).

1. History of roofing conditions in Kiambu County from 1978

The housing surveys took place in four villages in the County. Kiambaa, Rironi, Nyaga/Ngewa and Kamuchege. The four villages were chosen with the distance to the closest urban centre in mind as this would likely affect inhabitants' income. The first two villages, Kiambaa and Rironi, are nearest to Nairobi with a good connection by road. The third village Nyaga-Ngewa is indirectly connected to the capital but still quite close. In contrast, the last village has a relatively long distance and poor connection to any urban centre (Sterkenburg, 1978).

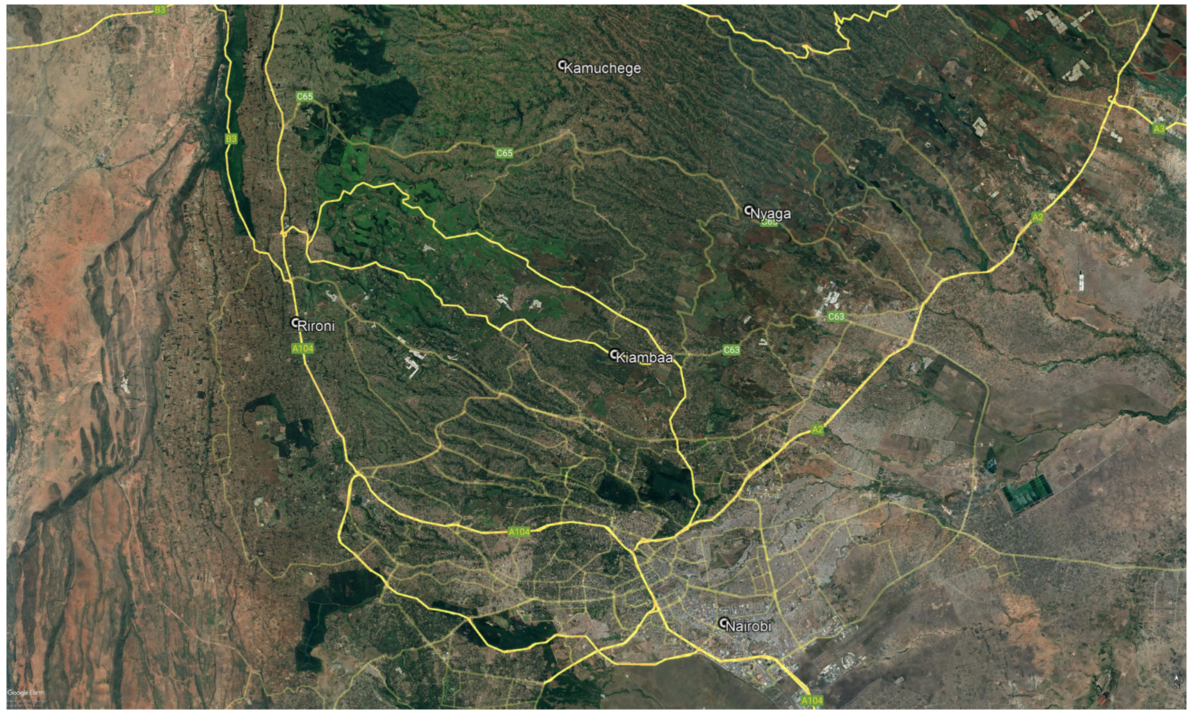

Figure 2. The four surveyed villages (Google Earth, 2021).

The four villages are relatively small. While exact numbers are unknown, estimates of the number of plots and observed inhabitants per plot result in 1200-1500 inhabitants in Kiambu, Rironi and Kamuchege and about 2000 in Nyaga-Ngewa. The size of these villages is related to their history. Before the armed struggle for independence, people lived shattered in traditional dwellings with thatch roofs, but during the Mau-mau rebellion, people must live in "emergency villages". These villages had to be built quickly with local materials and thatched roofs. However, during the land demarcation period in 1957, people with more than 4 acres left the village as they were allowed to build on their land. As a result, the people without land had to move to the rift valley to find jobs, leaving only those who could buy a plot in the village to build a new dwelling (Sterkenburg, 1978).

Apart from Kamuchege, the villages have a good connection to Urban centres and excellent agricultural conditions. Agricultural products are sold at the local market or find their way to the markets in Nairobi. Most people in the village have small farmland or work as drivers or traders in neighbouring urban centres (Sterkenburg, 1978).

Long term income and roofing conditions are closely correlated, as dwellings made out of mud and wattle with a thatched roof are almost free to construct and require no skilled labour, making it the only solution for people with low income. In comparison, a mud and wattle house with iron sheets costs 60 Kshs/m2 and a wooden house with iron sheets 200-600 Kshs/m2. On average, a mud and wattle dwelling has 2.9 rooms (Sterkenburg, 1978), resulting in an estimated building cost of 2000 Kshs.

Household income can vary significantly due to its dependence on agricultural activities, table 1. Show the observed income in the different villages. 43% of households earn less than 500 Kshs a month (Sterkenburg, 1978), meaning they currently can not afford iron sheets.

Kshs	Kiambaa	Rironi	Nyaga	Kamuchege	All vilages
0 - 100	20	13	12	20	16
101 - 500	26	27	26	24	27
501 - 1000	29	19	25	26	24
1001 - 1500	15	18	15	20	17
1501 - 2000	6	9	7	3	6
2001 - 3000	-	4	7	2	3
> 3000	4	10	8	5	7
Total %	100	100	100	100	100
Total no. of households	54	57	60	54	225

Table 1. Household income in survey villages (Sterkenburg, 1978).

Rural Kiambu has three common roof materials, thatch, flattened tins and corrugated iron sheets. These materials strongly correlate to the dwelling's construction type and overall shape. For example, the round mud and wattle dwellings have mostly thatched roofs, while rectangular mud and wattle dwellings have primarily tin or corrugated iron sheet roofs. Most timber and stone houses never have thatched roofs, and all stone houses have corrugated iron sheets as a roofing material (Sterkenburg, 1978). This correlation shows the effects of income on roofing conditions. People choose iron sheets if they can afford them.

Interestingly, the survey showed no direct link between current income and housing conditions as the dwellings are related to past expenditures. As this income fluctuates due to labour migration or favourable commodity prices, yearly income varies significantly. Long term income is the actual variable that dictates the housing conditions, but this is not easy to study. Nevertheless, people in stone houses also had the highest income, but the survey size was too small to find a direct correlation. Finally, there is a clear desire for corrugated steel roofs as all survey participants with thatch and flattened tin roofs considered iron sheets an improvement (Sterkenburg, 1978). This desire will likely result in more people building with iron sheets as the Kenyan Gross domestic product per Capita rises (Statista, 2022).

Whilst the exact percentage of thatcht roofs was not mentioned in this report in Nyaga, 80% of dwellings had mud and wattle walls. Compared to the regional average of 51%, this is significantly higher (Sterkenburg, 1978). As expensive dwellings are more likely to have corrugated iron sheets, it is interesting to see the roofing material on satellite images.

The earliest available satellite data is from 1985, but the resolution is too bad to analyse anything.

Figure 3. Nyaga satellite image December 1985 (Google, 1985).

The earliest readable satellite data is from 2008. As the reflection and colours suggest, all houses have metal roofs. The only possible thatched roofs are highlighted in the image; however, it is impossible to know for sure from the image alone.

Figure 4. Nyaga satellite image June 2008 with possible thatched roof highlighted (Google, 2008), edited by the author.

The latest satellite data shows an expansion of houses in the area, but now all houses seem to have a metal roof. As almost half of the inhabitants could not afford iron sheets in 1978, the socio-economic factors have changed within the village.

Figure 5. Nyaga satellite image November 2021 (Google, 2021).

C. Characteristics of Kisumu County in 1982

Kisumu County lies next to lake Victoria in the western part of Kenya and has a land area of 2093 km2. The whole region consists of a flat river plain bounded between lake Victoria and escarpments on the north- and south-side (Sterkenburg, Brandt, & van Beinum, 1982). Heavy rain showers combined with humidity and fluctuating temperatures require strong roof construction. The Leo tribe first permanently inhabited the County in the 18th century, living in round homesteads with thatch roofs protected by thorns or mud and wattle walls. While the walls and thorns have mostly disappeared, the typology of the individual homestead has prevailed (Sterkenburg, Brandt, & van Beinum, 1982). However, the traditional Leo homestead slowly disappears as the dwellings change from round to rectangular with metal roofs. Most of the population is self-employed agriculturalists with various farm sizes and cash crops, resulting in a wide range of income levels and housing conditions (Sterkenburg, Brandt, & van Beinum, 1982).

Figure 6. Kisumu County (NordNordWest, 2015).

The Leo homestead generally consists of separate dwellings for the male head and his wife; however, most Leo have polygamous relationships; in that case, each wife has a separate dwelling in the homestead. Married sons and grown-up unmarried sons also have their unit in most cases. The roofing conditions of separate dwellings within this homestead differ heavily as the most expensive building materials are used for the main house (Sterkenburg, Brandt, & van Beinum, 1982).

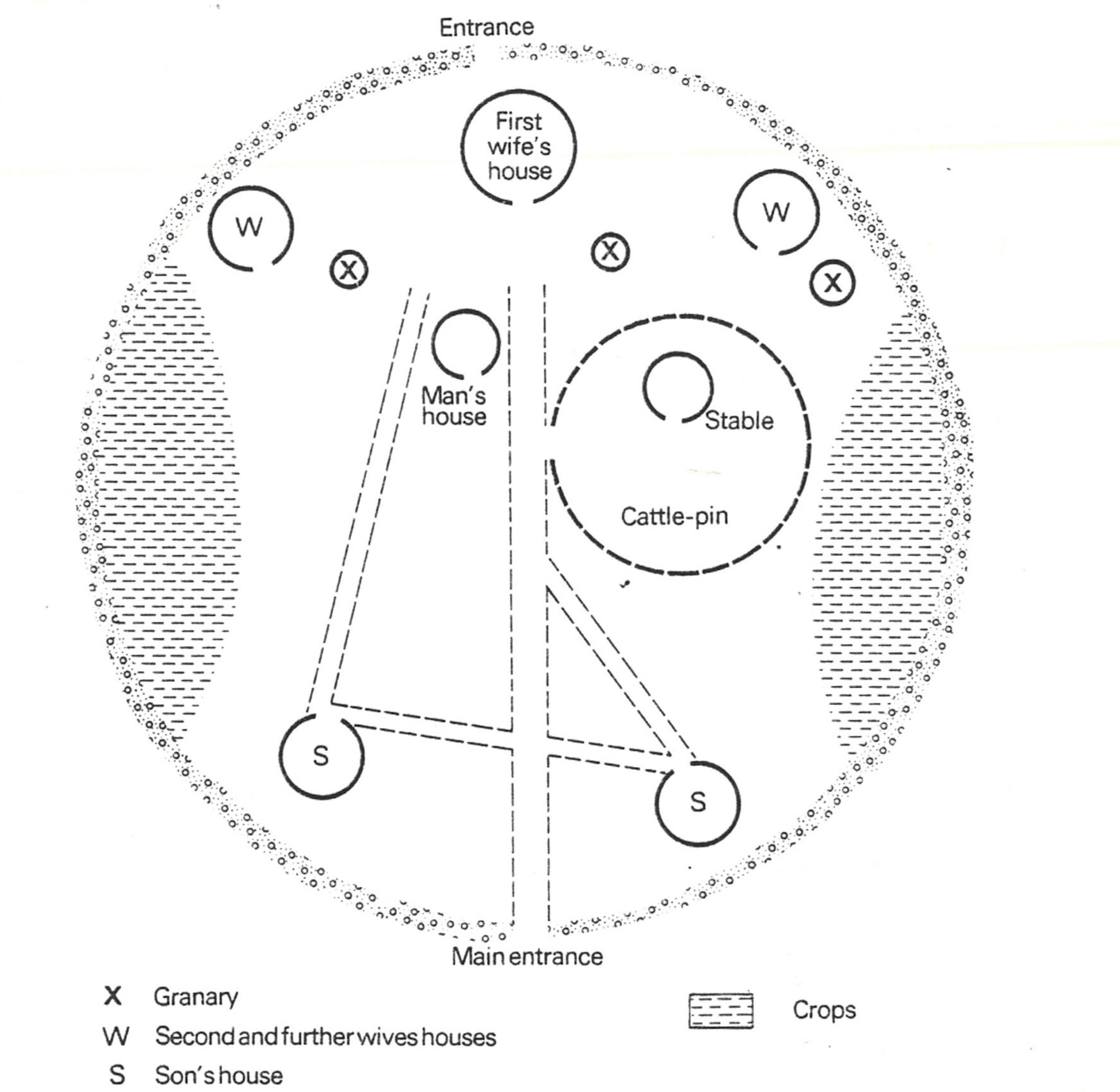

Figure 7. Floorplan of the traditional Leo homestead (Sterkenburg, Brandt, & van Beinum, 1982).

Figure 8. Leo homestead in the northern Kano Plains (Sterkenburg, Brandt, & van Beinum, 1982).

1. History of roofing conditions in Kisumu County from 1982

The Kisumu agriculture sector can be divided into many small scale producers and a small number of large scale estates, occupying 12% of agricultural land. As agricultural activities are inhabitants' primary source of income, the type of agriculture likely influences the housing conditions. Kisumu has three main agricultural areas; the sugar belt, irrigation schemes with sugar/rice, and tiny mixed farming areas. Therefore, the housing survey was conducted in all agricultural areas, as displayed in figure 9 (Sterkenburg, Brandt, & van Beinum, 1982).

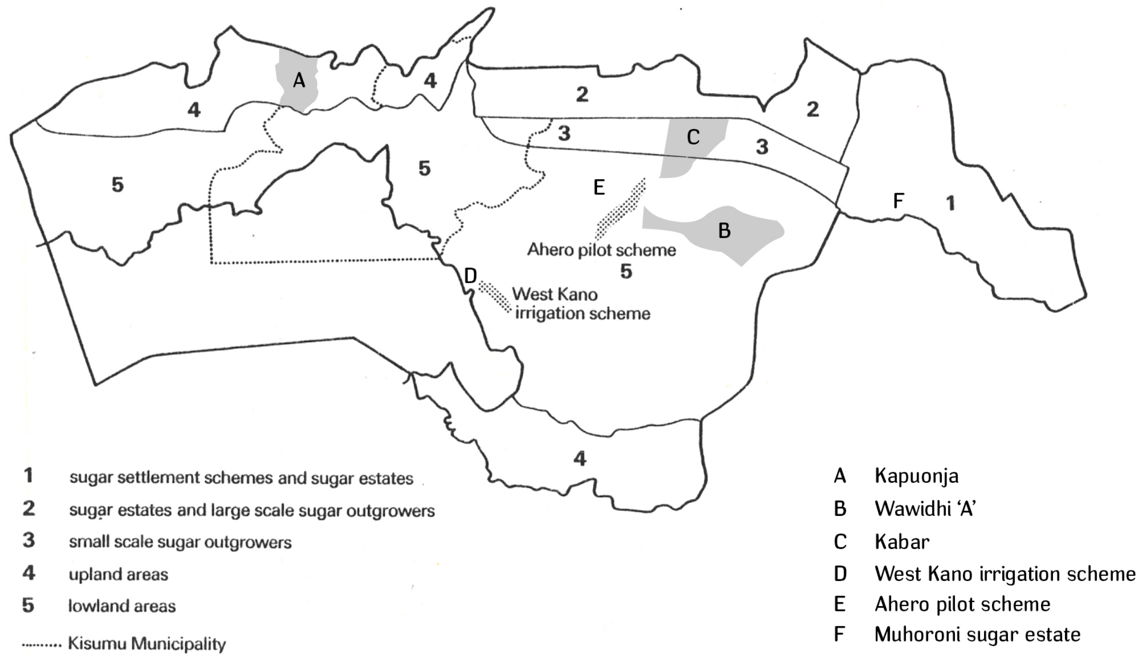

Figure 9. Kisumu County, agricultural subdivision and survey data (Sterkenburg, Brandt, & van Beinum, 1982), edited by the author.

The outcome of the survey data shows that 78.6% of all dwellings have thatched roofs (Sterkenburg, Brandt, & van Beinum, 1982). Also, almost all walls consist of mud and wattle, compared to Kiambu, where only 51% of dwellings still had mud and wattle walls. Therefore, one can state that Kisumu was less commercialised in the 80s.

Building materials	Main house	2nd and further wives' houses	Son's house	Other relat. house	Main house if only house	All houses
I Wall surface outside						
- no treatment						
- clay plaster	7.6	7.8	8.3	13.9	7.6	7.6
- clay-dung	20.0	4.0	9.1	13.9	20.0	20.0
- other	64.8	85.3	79.3	69.4	64.8	64.8
	7.6	2.9	3.3	2.8	7.6	7.6
II Floor surface						
- earth						
- earth + clay	11.6	7.6	10.7	25.0	17.8	11.7
- earth + Clay-	27.2	24.0	24.6	19.4	31.1	25.1
dung	51.0	66.5	60.7	55.6	44.4	57.4
III Roof type-						
- Thatch	68.0	81.8	89.3	80.6	82.2	78.6
- Corr.iron sheets	23.1	16.2	6.5	19.4	6.7	16.1
- Do - + ceiling	7.4	1.0	4.1	-	8.9	4.4
I Windows						
- no window	19.9	17.1	15.6	13.9	29.5	17.3
- 1 window	11.1	23.7	18.0	33.3	9.1	17.8
- > 1 window	69.0	59.2	66.4	52.8	61.4	64.9

Table 2. Used building materials in survey areas (Sterkenburg, Brandt, & van Beinum, 1982).

While this data shows the overall percentage of building materials, the conditions of roofs are generally bad, as 90% of houses did not receive any improvements after they were built (Sterkenburg, Brandt, & van Beinum, 1982). However, the poor quality of maintenance of roofs is strange as most dwellings have been built by traditional methods, making self-repair easier as it does not rely on craftsmanship and commercialised building materials.

Interestingly, the various income levels do not result in a wide variety of roofs, as houses in the district slightly differ in building materials. While some dwellings changed to corrugated iron sheet roofs, this percentage is minimal. Roofing conditions seem to correlate to the income of households over a long period and the interest in attaining better roofs (Sterkenburg, Brandt, & van Beinum, 1982). As agriculture activities are the primary source of income and crop yield can fluctuate every year, inhabitants tend to prioritise education and farm improvements over housing improvements, hence a homogenous roof landscape.

Income catergory Villages (Kshs)	Kapuonja	Wawidhi 'A'	Kabar	Total	Income catergory Estates/ Scheme's (Kshs)	Muhoroni estates	Ahero scheme	West Kano scheme
< 100	8.3	13.5	19.0	13.3	< 100	-	13.7	6.9
101 - 300	12.0	8.1	9.6	10.1	100 - 1000	-	11.8	3.4
301 - 1000	14.3	8.1	11.9	11.8	1001 - 2000	-	9.8	13.8
1001 - 2000	26.5	21.7	11.9	20.3	2001 - 5000	75	31.4	44.9
2001 - 3000	8.3	10.8	11.9	10.1	5001 - 10000	25	19.6	20.7
3001 - 5000	10.2	5.4	7.1	7.9	> 10000	-	13.7	10.3
5001 -	18.4	27.0	16.7	20.4				
10000	2.0	5.4	11.9	6.1				
> 10000								
Mean	5555	7062	9805	7385	Median	4633	3375	3633
Median	3900	5000	4550	4250				

Table 3. Annual monetary household income for sub-areas Kisumu County (Sterkenburg, Brandt, & van Beinum, 1982).

Generally, the estates and housing schemes have a different housing situation from the rest of the County, providing employees housing for rent or labour purchase. These houses are better planned, have fewer variations, and are built with cement blocks and corrugated iron sheets. However, there can be a big difference in roofing conditions between estates. For example, at the Ahero rice estate, dwellings were constructed with a weak foundation. As a result, the walls cracked, and within ten years, most houses were in a complete state of dilapidation. This inadequate housing caused people to build their own houses on the estate, as seen in table 3 (Sterkenburg, Brandt, & van Beinum, 1982).

Characteristics of houses	Official-scheme houses	Self-built houses on scheme	Scheme farmer houses outside scheme
I Wall type			
- mud and wattle	-	97.5	98.4
- ement blocks	100.0	-	1.6
- others	-	2.5	-
II Wall surface outside			
- no treatment	86.6	15.0	18.0
- clay	-	15.0	4.9
- clay-dung	-	67.5	77.1
- cement plaster	6.7	2.5	-
- others	6.7	-	-
III Partition walls			
- no	-	45.0	41.0
- mud and wattle	-	50.0	55.8
- cement blocks	100.0	2.5	1.6
- others	-	2.5	1.6
IV Roof type			
- thatch	-	52.5	60.6
- mabati	93.3	45.0	31.2
- mabati + ceiling	6.7	2.5	4.9
- others	-	-	3..3
V Windows			
- no	-	17.5	16.4
- 1	-	22.5	24.6
- 2	100.0	37.5	21.3
- 2+	-	22.5	37.7
VI Floor			
- earth	20.0	10.0	18.0
- earth + clea	13.3	32.5	21.3
- earth + claydung	46.7	52.5	57.4
- concrete/ cement	20.0	5.0	3.3
VII Size (sq. meters)			
- <30	-	53.8	44.3
- 30 - 50	100.0	41.1	40.9
- >50	-	5.1	14.8
VIII No of rooms			
- 1	-	45.0	39.3
- 2	100.0	50.0	39.3
- 3	-	5.0	21.4
No of houses in survey	15	40	61

Table 4. Ahero rice estate housing compared to self-built houses (Sterkenburg, Brandt, & van Beinum, 1982).

As table 3 shows, inhabitants tend to divert back to vernacular building methods when building the dwelling themselves, as more than half of the self-built dwellings have traditional building materials. In addition, the roofs of self-built dwellings follow the County's average roof conditions, as almost half of the roofs are in bad or very bad condition (Sterkenburg, Brandt, & van Beinum, 1982). However, iron sheets are slightly used more among these self-build estate dwellings.

The commercialisation of Kisumu County's building methods has not happened yet in the 80s, as almost all dwellings consist of vernacular building materials. While the climate conditions require solid well-insulated roofs, most areas' roofs are in bad condition and seem unsuitable. However, this data is very much a snapshot in time. Satellite imagery can give insight into the roofing conditions of the past 20 years. The imagery below is from Kabar, one of the surveyed small scale sugar outgrowers areas, as it had the highest percentage of grass-thatched roofs.

The earliest available satellite data from 1985 is unclear and unsuitable for analysis.

Figure 10. Kabar satellite imagery December 1985 (Google, 1985)

The earliest readable satellite imagery was taken in 2004. The blue metal roofs are clearly visible in the image. However, after close inspection, there are still some possible thatched roofs in the area. The earth tone colours combined with soft corners and lack of reflection could suggest that there are still thatched roofs in the area. These possible thatched roofs are highlighted in Figure 11.

Figure 11. Kabar satellite imagery June 2004 with possible thatched roofs highlighted (Google, 2004), edited by the author.

Figure 12 shows the most recent satellite imagery. The quality of the image is good enough to conclude that all houses now have metal roofs. Apart from that, all highlighted dwellings from figure 11 have disappeared, and the area has become more populated.

Figure 12. Kabar satellite imagery July 2021 (Google, 2021)

D. Characteristics of Kakamega County in 1983

The Kakamega disctrict borders Kisumu on the north side. Within 3520 km2, it has two different geological zones—Hills in the south, up to 1950 meters, with deep river valleys, while the rest of the region has vast peneplains between 1100 and 1700 meters. The rainfall pattern is closely correlated to the height and is overall high. This intense precipitation requires well-maintained roofs with robust construction (Sterkenburg, Huybens, & Wentholt, 1983).

However, poles and thatch have become increasingly scarce as the population grew. While farmers tried to plant new Eucalyptus trees and thatch, this did not fix the supply shortages. With a population of 1 million in 1779 (Sterkenburg, Huybens, & Wentholt, 1983) and 1.86 million in 2019, it is among the highest rural densities in the country (Statista, 2019). Due to the lack of available resources, 20% of inhabitants (seasonally-) migrate to other regions to acquire enough income. As a result, households in the area are generally poor as the overall monetary income of agriculture is low. Interestingly, iron sheets are the predominant roofing material of the main house (Sterkenburg, Huybens, & Wentholt, 1983). An explanation for this could be that iron sheets hamper the smoke produced by fire; however, almost all homesteads in Kakamega have separate kitchens (Sterkenburg, Huybens, & Wentholt, 1983), so this is not an issue.

1. History of roofing conditions in Kakamega County from 1983

The housing survey took place in three different rural areas with distinct characteristics. First, there is Gisambai, a very dense rural area with good agricultural conditions. However, due to the high density, farm income is low. Therefore, most men seasonally migrate to urban centres to make ends meet. This seasonal migration leaves the woman behind, further unfavourably affecting agricultural income. Secondly, the Eluche sugar area has, compared to Gisambai, less density and bigger farms. Inhabitants cultivate more cash crops and are generally wealthier. Lastly, Shikulu sits between the two densities, but people are less prosperous due to bad soil, high migration, and the lack of cash crops (Sterkenburg, Huybens, & Wentholt, 1983).

The three agricultural characteristics lead to three different income levels, as seen in table 5. However, this does not dictate the roofing conditions in these villages because roofing conditions are closely linked to past income, off-farm activities, and close relatives' income (Sterkenburg, Huybens, & Wentholt, 1983).

Income category (Kshs)	Gisambai	Eluche	Shikulu	Total
< 500	8.3	-	15.0	8.2
500 - 999	11.7	6.0	25.0	14.7
1000 - 1999	18.3	12.0	23.3	18.2
2000 - 3999	18.3	18.0	15.0	17.1
4000 - 7999	28.3	26.0	10.0	21.8
8000 - 11999	6.7	22.0	6.7	11.2
12000 - 19999	6.7	12.0	-	5.9
> 20000	1.7	4.0	5.0	2.9
Total	100.0	100.0	100.0	100.0
Total average	4794	8387	3374	5349
Median income	3475	6130	1235	2905

Table 5. Annual monetary household income for sub-areas Kakamega County (Sterkenburg, Huybens, & Wentholt, 1983).

While Shikulu has the lowest average income and least metal roofs, the data proves no direct connection between current income and roof conditions as Eluche had a significantly higher income but not the most metal roofs.

Housing indicators	Gisambai	Eluche	Shikulu	Total
Corrugated iron roofs: - % of houses with	47.4	30.8	18.3	31.5
Wall surface: - clay/ clay-dung plaster	82.3	50.4	70.1	67.9
Partition walls: - no - mud + wattle	 1.7 90.0	 22.0 70.0	 12.3 71.9	 22.6 77.8
Doors: % of houses with - 2+	91.7	24.0	69.5	63.9
Windows: % of houses - without - with 3+	 1.7 63.0	 24.0 42.0	 20.7 41.4	 15.0 54.5

Table 6. Housing conditions in the surveyed villages (Sterkenburg, Huybens, & Wentholt, 1983).

While only 31.5% of all dwellings have corrugated iron roofs, houses have become more commercialised, as most inhabitants purchase materials and rely on paid artisans to complete their dwellings. As a result of scarcity and rapid populations growth, this trend is likely to continue. Besides, scarcity makes the overall cost of vernacular building materials more expensive, further excelling the changing roof landscape.

Variables	Gisambai	Eluche	Shikulu	Total
I Type of builder - owner - owner + fundi - fundi only	 20.0 45.0 35.0	 24.0 48.0 28.0	 25.0 50.0 21.7	 23.1 48.5 28.4
II Main source of building materials Poles - own land - obtained free - buy nearby - buy far	 40.7 10.2 32.2 10.2	 30.0 2.0 52.0 14.0	 31.0 8.6 39.7 17.2	 34.1 7.2 40.7 13.8
Thatching grass - own land - obtained free - buy nearby - buy far	 30.8 11.5 46.2 11.5	 31.0 21.0 38.0 7.0	 18.6 7.0 44.2 30.2	 25.5 12.2 42.9 19.4

Table 7. The commercialisation of building materials and labour.

Satellite data can help to see if this trend of commercialisation within the roof landscape has continued over the years. Shikulu is a prime case study for this as it has the least corrugated iron roofs. Therefore there is a higher chance that the satellite data still shows this change.

The earliest available satellite data came from Google in 1985, but the resolution is not good enough to identify any roof.

Figure 13. Shikulu satellite image December 1985 (Google, 1985).

The first satellite imagery with enough resolution to see individual roofs dates back to 2001. The blue metal roofs are clearly visible, but there are still some round dwellings with thatched colour roofs. It is difficult to know for sure if the earth-tone square dwellings have thatched roofs or metal roofs, as there are also brown rusty metal roofs available. All possible thatched roofs are highlighted in figure 14.

Figure 14. Shikulu satellite image April 2001 with possible thatched roofs highlighted (Google, 2001), edited by the author.

Figure 15 shows the latest available satellite imagery of the area. The high-resolution image clearly shows that all dwellings have metal roofs. The dwellings with supposed metal roofs are also non-existent anymore as other buildings have replaced them.

Figure 15. Shikulu satellite image October 2020 (Google, 2020)

E. Characteristics of Nakuru County in 1984

Nakuru County lies centrally in the great rift valley province and has a diverse topography. Encarponents surround the Rift valley floor on the east and west. There is a wide variation in rainfall and temperatures. Due to high humidity and considerable temperature changes between day and night (Sterkenburg, Gosselink, & Huizenga, 1984), inhabitants need suitable insulating roofs.The County has seen significant population growth in the rural areas. The population in 1979 was around 520 thousand (Sterkenburg, Gosselink, & Huizenga, 1984), while currently, 2.14 million people live in the County (Statista, 2019). This densification led to pressure on available farmland and building materials.

1. History of roofing conditions in Nakuru County from 1984

The surveyed areas were in all different topographical zones. The first two surveyed areas were the Bahati settlement and Ruguru company farm, two high altitude areas with lots of rainfall. The Piave settlement scheme, the Rumwe cooperative farm and the Mutukanio company farm for the dry Rift Valley region. Income in the areas differs significantly from each other. This deviation has mainly to do with cultivating cash crops, available land and the number of cattle (Sterkenburg, Gosselink, & Huizenga, 1984).

Variables	Gisambai	Eluche	Shikulu	Total
I Building costs (Kshs)				
< 500	23.3	29.9	45.8	32.7
500 - 999	14.2	10.6	28.8	19.8
1000 - 4999	48.2	40.4	20.3	35.2
5000 - 9999	10.7	10.6	3.4	8.0
> 10000	3.6	8.5	1.7	4.3

Table 8. Total household income, sub-areas Nakuru County (Sterkenburg, Gosselink, & Huizenga, 1984).

Rumwe is far out the wealthiest area. Apart from Piave, Nukura County has a relatively high median income compared to others.

Traditional homes were built by the community in one day, with wooden poles and thatched roofs. However, as monetary income grew, more commercialised building methods became standard. Thatched roofs often got replaced by iron sheets, making building costs more expensive. Houses with iron sheets cost 7 to 8 times more than the thatched alternative due to the need for specialised labour and more expensive materials (Sterkenburg, Gosselink, & Huizenga, 1984). The number of thatched roofs on the main house is the lowest so far, as seen in table 9.

Building materials	Main house	Boys' house	Other relatives' house	All houses
I Wall type material				
- mud and wattle	55.7	48.6	66.7	58.0
- wood	34.9	51.4	29.7	37.0
- stone	8.7	-	-	5.0
- other				
II Floor surface				
- earth + (clay plaster)	73.8	83.8	90.5	80.4
- cement	24.8	5.4	4.8	15.9
- wood	0.7	10.8	4.8	3.3
III Roof type				
- thatch	14.1	29.7	36.9	23.3
- mabati	59.7	62.2	57.1	60.0
- mabati + ceiling	26.2	8.1	4.8	17.0
Total no. of structures	149	37	84	270

Table 9. Building materials according to the type of house, Nakuru County (Sterkenburg, Gosselink, & Huizenga, 1984).

While commercialisation often benefits the overall housing conditions, maintenance is still inadequate in the region as 19.5% of roofs need repair, and 3% of roofs need replacement (Sterkenburg, Gosselink, & Huizenga, 1984) because commercialisation has the negative side effect that inhabitants are not capable of repairing their dwellings anymore.

Nakuru county is among the first areas that show the changing shift in roofing landscape as almost all villages only have corrugated iron roofs. Only Piave is behind in the number of metal roofs, as seen in table 10.

Type of building material	Bahati	Ruguru	Rumwe	Piave	Mutukanio	Nakuru
% with corrugated						
- iron roofs	90.0	100.0	100.0	60.0	80.0	85.9
% with						
- stone walls	0.0	20.0	20.6*	0.0	3.3	8.7
- wooden walls	26.7	66.7	17.2	20.0	43.3	34.9
% with 1+ windows	95.0	95.0	95.0	95.0	95.0	95.0

Table 10. Building materials of the main house in sub-areas Nakuru County (Sterkenburg, Gosselink, & Huizenga, 1984).

As Nakura County is at the forefront of the transition toward metal roofs, it is interesting to analyse if Piave cached up with the rest of the region. The earliest data available dates back to 1973, but as with all satellite images before 2000, the resolution is too low to distinguish individual roofs.

Figure 16. Piave satellite image January 1973 (Google, 1973).

Satellite imagery from 2003 is sharp enough to see the individual roofs. Almost all roofs seem to be made of metal, as there are only three possible thatched roofs in the image.

Figure 17. Piave satellite image May 2003 with possible thatched roofs highlighted (Google, 2003), edited by the author.

The latest satellite imagery shows a significant increase in overall density. However, there is only one possible thatched roof among all dwellings, which means that Piave now also has metal roofs as the predominant roofing material like the rest of the surveyed villages.

Figure 18. Piave satellite image June 2020 with possible thatched roof highlighted (Google, 2020), edited by the author.

F. Characteristics of Meru County in 1986

Meru County lies in the middle of Kenia, with an area of 9922 km2 and a wild variety of ecological conditions. After independence, the region has seen significant population growth. With 1 million inhabitants in 1983 (Sterkenburg, Gosselink, & Huizenga, 1984) and 1.54 million in 2019 (Statista, 2019). This sharp population growth put pressure on the available (farm) land and building materials. Interestingly, rural population growth is more rapid than urban population growth. As a result, 90% of inhabitants live in rural areas (Knoema, 2019). As agricultural conditions have the highest chance of affecting housing conditions, field surveys have been conducted in nine rural areas.

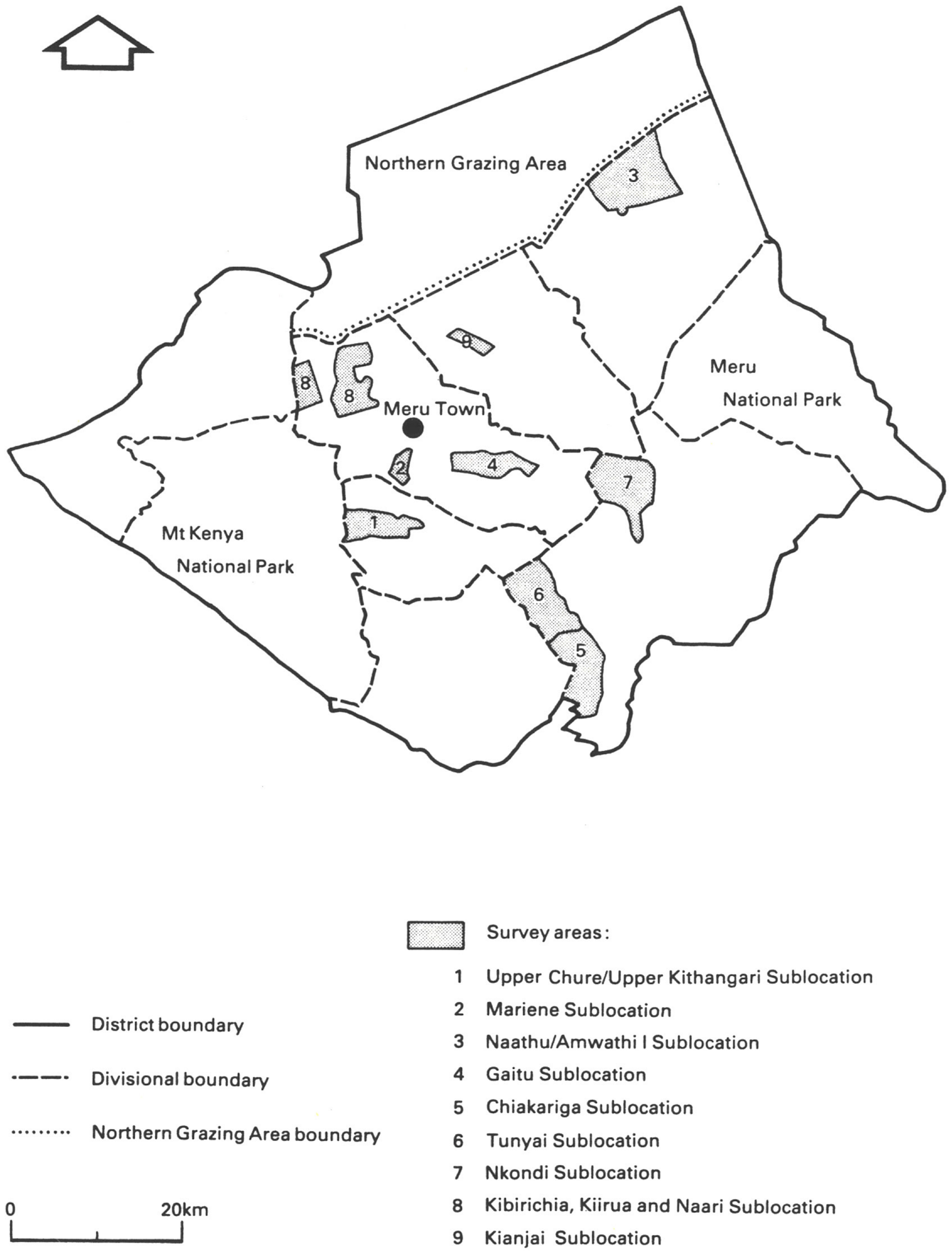

Figure 19. Research sublocations in Meru County (Sterkenburg, Herlaar, van Iterson, & Jansen, 1986).

1. History of roofing conditions in Meru County from 1986

As agricultural activities vary greatly in every sublocation, there is a wide range of income levels. Generally, the region is more prosperous than the other surveyed areas, as cash crops boost the household's income. While profits from cash crops are high, they are also more susceptible to droughts. Therefore farm income can fluctuate heavily every year. However, in 1986 there were no droughts that affected overall farm production.

Income category (Kshs)	MT Kenya tea area	Mt kenya coffee area	Miraa area	Cotton settlement area	Dryland area
less than 1,000	0.0	2.2	2.2	4.4	2.9
1,001 - 2,500	0.0	2.2	15.6	4.4	42.8
2,501 - 5,000	2.2	4.4	28.9	15.6	24.3
5,001 - 10,000	2.2	24.4	24.4	37.8	17.1
10,001 - 15,000	2.2	24.4	8.9	15.6	2.9
15,001 - 30,000	11.1	33.5	15.6	17.8	0.0
30,001 - 50,000	28.9	6.7	0.0	4.4	0.0
more than 50,000	53.4	2.2	4.4	0.0	0.0
mean total income	58,310	15,850	10,810	10,260	3,820
median total income	50,930	12,800	5,290	7,500	2,800

Table 11. Frequency distribution of total household income in sublocations Meru County (Sterkenburg, Herlaar, van Iterson, & Jansen, 1986).

While median income is high in Meru County, the roofing landscape is not commercialised. More than half of dwellings are built without the help of a craftsman (Sterkenburg, Herlaar, van Iterson, & Jansen, 1986). As a result, 41.5% of all dwellings still have grass-thatched roofs.

Building materials	Main house	Wives' house	Boys's	Girls'/ children	Head of household only	Other residential	All houses
I Wall							
- poles	4.6	6.7	2.4	9.8	9.8	12.2	7.7
- mud and wattle	53.3	52.7	60.5	54.9	78.0	70.1	59.0
- timber	27.1	26.4	33.9	29.4	9.8	14.9	25.5
- timber + quarry-stone	9.2	9.1	2.4	3.9	0.0	1.4	5.3
- quarry-stone blocks	5.4	4.7	0.0	0.0	2.4	0.0	2.5
II Roof							
- grass	32.1	31.1	42.7	43.1	70.7	58.0	41.5
- corrugated iron sheets	35.8	37.8	44.4	49.1	19.5	36.6	38.8
- corrugated iron sheets + ceiling	32.1	31.1	12.9	7.8	9.8	5.4	19.7
Total number of structures	240	254	124	51	41	74	254

Table 12. Used building materials according to type of house, Meru County (Sterkenburg, Herlaar, van Iterson, & Jansen, 1986).

Not surprisingly, the dryland area (Chiakariga, Tunyai and Nkondi) is experiencing the highest percentage of grass-thatched roofs, as this vernacular local building solution is far cheaper than the metal alternatives.

	Upper Chure & Upper Kithangari	Mariene	Naathu & Amwathi	Gaitu & Kibiricha, Kiirua and Noari	Kianja	Chiahariga, Tunya, Nkondi
Grass thatched roof	11.0	7.0	34.0	20.0	60.0	77.0
Corrugated iron sheets roof	89.0	93.0	66.0	80.0	40.0	23.0

Table 13. Types of main house in sub-areas of Meru County (Sterkenburg, Herlaar, van Iterson, & Jansen, 1986).

The satellite images from these three villages clearly show the use of corrugated iron roofs. No grass-thatched roofs can be distinguished in the areas. While this proves that the transition towards metal roofs has happened, it does not show the transition period. Therefore, it is not clear when precisely this phenomenon occurred. Interestingly, the villages have seen barely any growth in the past ten years as not much has changed.

Figure 20. Chiakariga satellite image December 1985 (Google, 1985).

Figure 21. Chiakariga satellite image August 2009 (Google, 2009).

Figure 22. Chiakariga satellite image April 2022 (Google, 2022).

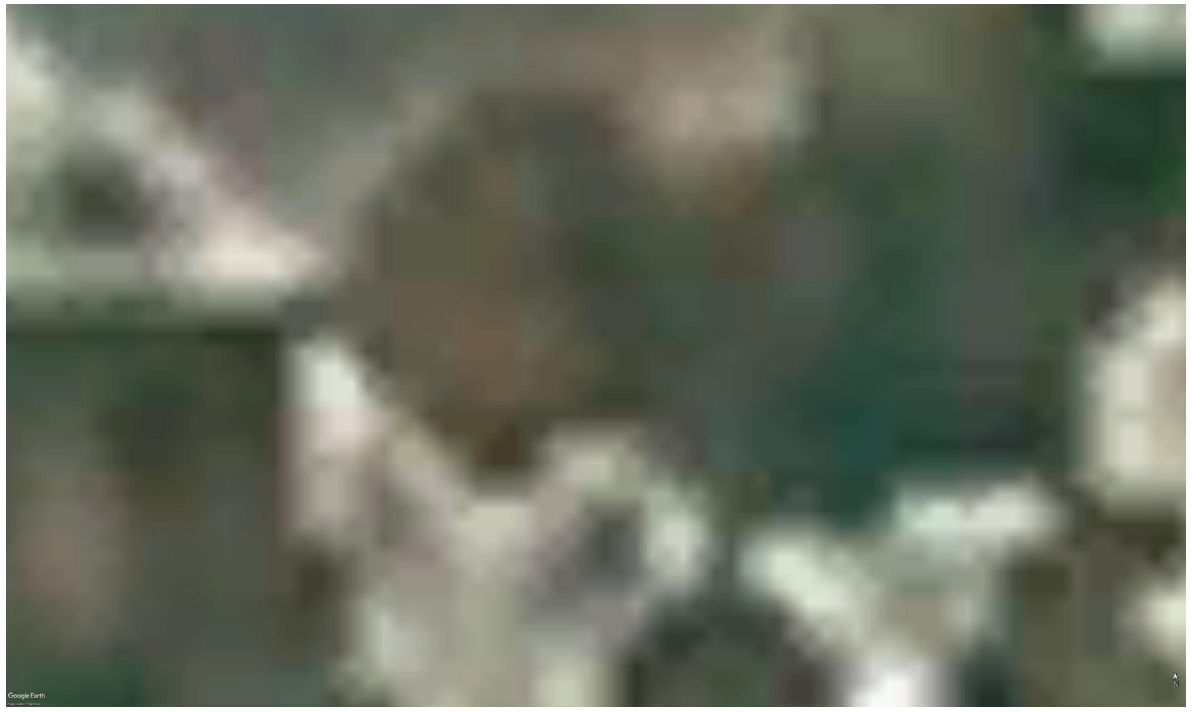

Figure 23. Nkondi satellite image December 1985 (Google, 1985).

Figure 24. Nkondi satellite image March 2009 (Google, 2009).

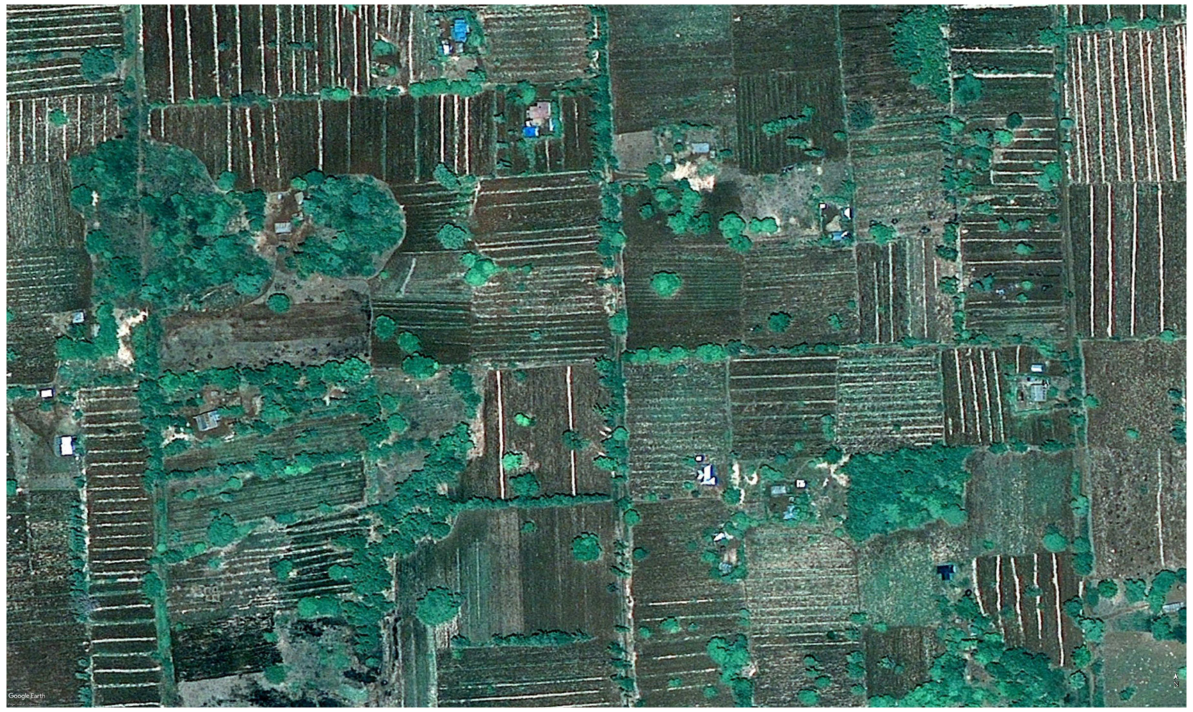

Figure 25. Nkondi satellite image March 2021 (Google, 2021).

Figure 26. Tunyai satellite image December 1985 (Google, 1985).

Figure 27. Tunyai satellite image October 2011 (Google, 2011).

Figure 28. Tunyai satellite image March 2021 (Google, 2021).

Chapter 2: Roofing conditions in the 21st century

A. Explaining the dataset from M. Smits

I participated in the Rural Housing Studio from July 2017 to January 2018. The Rural Housing Studio was a quasi-experiment for the promotion 'Towards an Architecture of Self-Reliance' by M. Smits. Smits investigated the inhabitants' capacities and self-reliance to improve their ability to maintain, extend or replicate their (desired) housing (Smits, 2020). To achieve this, Smits designed a support tool practitioners and inhabitants could use to create housing within inhabitants' capacities. The quasi-experiment tested this support tool in the field for six months.This experience gave a clear insight into the roofing conditions in this period. It helped me understand the context of the overall changing roofing landscape. At the same time, the data is solely from mt. Elgon and therefore not suitable for projecting these findings on the rest of Kenia. However, this data can be used as a moment in time and be part of the dynamic history of the everchanging roofing landscape in Kenya.

B. Characteristics of mt. Elgon in 2017

The Rural housing studio took place in Vamia on Mount Elgon in Tranz-Nzoia County in the west of Kenya. Vamia is a village behind the rural centre of Chepchoina, located adjacent to Kitale Suam road, a significant road connecting Nairobi with Uganda. Generally, a majority of inhabitants work in four different categories:

- Employee at Mount Elgon Orchards, a commercialised roses and avocado farm run by the Andersen family.
- Employee at Japatta ADC farm, a government ran farm where generally working conditions and salary are worse compared to the commercial farms.
- Employee or shop owner in one of the shops in Chepchoina/Vamia.
- Self-employed farmer

Due to these two farms, there are many work opportunities in the region. The housing survey conducted by M. Smits gives additional context to the overall characteristics of the area. The housing survey was conducted in the four different settlements:

- The Habitat Village, built by mt. Elgon Trust in 2010. Inhabitants can buy a dwelling with an interest-free loan if they work at the farm. These dwellings cost around 200.000 Kshs and are repaid between 6-10 years (Mount Elgon Trust, 2022).
- Chepchoina is a village adjacent to Kitale Suam road. Most inhabitants in Chepchoina do not own their dwelling but rent a property (Smits, 2020).
- Vamia is the village behind Chepchoina, as Chepchoina is only the first row of houses near the main road. Most inhabitants of Vamia have their farmland and do own their dwellings (Smits, 2020).
- Japatta ADC Village is a small village where employees of the Japatta ADC farm can live Overall, housing conditions differ not much from the vernacular archetype (thatched roofs with mud and wattle walls)

Figure 29. Surveyed sublocations (Google, 2022).

Income between sublocations varies due to the primary income source every sublocation has. For example, most people living in the habitat village have a steady income at mount Elgon Ocharrds while inhabitants in Vamia are independent farmers. Table 14 shows the household's income in the four sublocations.

	Habitat Village	Viama	Chepchoina	ADC Japatta village
Income catergory (Kshs)				
< 1000	0.0	6.0	5.0	0.0
1000 - 2499	2.0	3.0	5.0	9.0
2500 - 4999	4.0	17.0	9.0	20.0
5000 - 7499	2.0	18.0	16.0	41.0
7500 - 9999	21.0	6.0	16.0	14.0
10000 - 24999	61.0	32.0	37.0	16.0
> 25000	10.0	18.0	12.0	0.0
Stable income	64.0	20	29	18
Fluctuating income	36.0	80	71	82
Owner of the house				
- yes	96	81	2	41
- no	4	19	98	59

Table 14. Household income sublocation Mt. Elgon (Smits, 2020).

1. History of roofing conditions on mt. Elgon from 2017

Table 15 shows the overall roofing conditions in the four sublocations. However, due to a small sample size of only 198 surveys, this data is not entirely representable for the whole area. .

	Habitat Village	Viama	Chepchoina	ADC Japatta village
Walls				
- mud	100.0	100.0	94.0	100.0
- brick	0.0	0.0	2.0	0.0
- other	0.0	0.0	4.0	0.0
Roofs				
- grass	0.0	3.0	2.0	50.0
- iron sheets	100.0	97.0	80.0	31.0
- other	0.0	0.0	18.0	19.0

Table 15. Building materials in sublocations Mt. Elgon (Smits, 2020).

The thatched roofing landscape is commercialising as thatch grass is not locally available anymore. Some grass is grown for employees only at the government-led farm. This shortage means that grass must be imported from other regions for additional costs. Inhabitants tend to dislike grass roofing because it has a higher likelihood of leaking, resulting in the disfavour of grass-thatched roofs over metal ones (Smits, 2020).

Inhabitants with grass-thatched roofs	Viama*	Chepchoina*	ADC Japatta village
Are you satisfied with the house?			
- yes	0.0	100.0	28.0
- no	100.0	0.0	72.0
Does your roof leak?			
- yes	0.0	0.0	72.0
- no	100.0	100.0	28.0
Did you build the house yourself?			
- yes	100.0	0.0	92.0
- no	0.0	100.0	8.0
Did you hire labour?			
- yes	100.0	0.0	48.0
- no	0	100.0	24.0
Is the grass locally available?			
- yes	0.0	0.0	32.0
- no	100.0	100.0	68.0
Did you hire somebody to ship the grass?			
- yes	100.0	100.0	84.0
- no	0.0	0.0	16.0

Table 16. Commerlasation of grass-thatched roofs (* the sample size was too small to be representable for the whole village) (Smits, 2020).

While metal roofs are generally more waterproof, they have key disadvantages. For example, metal roofs have bad thermal- and sound insulation, resulting in unpleasant noise when it rains and uncomfortable temperatures day and night. Apart from these disadvantages, iron sheets make inhabitants more reliant on skilled labour as they cannot repair or construct the roof. This paid labour, combined with material costs, makes the roof one of the main expenses while building a dwelling, as seen in table 17.

Inhabitants with metal roofs	Habitat Village	Viama	Chepchoina	ADC Japatta village
Does the roof radiate heat when the suns shines?				
- yes	55.0	92.0	93.0	96.0
- no	45.0	8	7	4
Does the roof make a lot of noise when it rains?				
- yes	78.0	85.0	93.0	96.0
- no	22.0	15.0	7.0	4.0
Are you satisfied with the house?				
- yes				
- no	64.0	23.0	48.0	21.0
	36.0	77.0	52.0	79.0
Did you build the house yourself?				
– yes				
- no	0..0	77.0	95.0	21.0
	100.0	18.0	5.0	79.0
Did you hire labour?				
- yes				
- no	27.0	64.0	16.0	4.0
	5.0	8.0	18.0	17.0
Roof costs as percentage of total building costs	- (build by company)	17.0	29.0	- (build by company)

Table 17. Commerlasation of metal roofs (Smits, 2020).

While the overall income of inhabitants has risen over the years, housing prices have also grown significantly. In 1982, J. Sterkenburg (Sterkenburg, 1990) observed that around 80% of all rural housing consists of the following four categories listed with their average building cost:

1. Houses with mud and wattle walls and a thatch roof (Ksh 300-1000)
2. Houses with mud and wattle walls and a corrugated iron sheets roof (Ksh 900-2000)
3. Houses with timber walls and corrugated iron sheets roof (Ksh 5000-25000)
4. Houses with stone walls and corrugated iron sheets roof (Ksh > 30000)

The average house on mt. Elgon cost 163 thousand Kshs (Smits, 2020). However, this figure counts the habitat houses built with an NGO's help. Without the Habitat Village, the average is about 105 thousand Kshs (Smits, 2020).

Satellite imagery of the four sublocations can help identify the current and past roofing landscape. For example, for Japatta ADC Village, the earliest available satellite data came from 1985. However, the quality of all satellite data before the 2000s is inferior.

Figure 30. Japatta ADC Village satellite image December 1985 (Google, 1985).

The earliest satellite data with individual roofs comes from 2010, but it is very hard to identify thatched and metal roofs due to the black and white picture.

Figure 31. Japatta ADC Village satellite image February 2010 (Google, 2010).

The latest satellite imagery shows one possible thatched roof. While there could be more, the red coloured iron sheets make it very hard to distinguish the difference between metal and grass roofs.

Figure 32. Japatta ADC Village satellite image October 2020 (Google, 2020).

The earliest available satellite data for the Habitat Village has not the sufficient resolution to see any roofs.

Figure 33. Habitat Village satellite image December 1985 (Google, 1985).

While the earliest readable satellite data comes from 2010, the Habitat Village got built later that year.

Figure 34. Habitat Village satellite image February 2010 (Google, 2010).

The following available satellite imagery shows the habitat village. The reflection of the roof clearly shows the iron sheets.

Figure 35. Habitat Village satellite image December 2013 (Google, 2013).

The latest satellite data show that nothing has happened to the roofing landscape after the initial construction phase.

Figure 36. Habitat Village satellite image October 2020 (Google, 2020).

The earliest satellite data from Chepchoina/Vamia is too unclear to distinguish any roofs.

Figure 37. Chepchoina and Vamia satellite image December 1985 (Google, 1985).

The earliest visible satellite imagery shows Chepchoina and Vamia before a significant expansion happened. However, it is impossible to spot the grass-thatched roofs due to the image's colour.

Figure 38. Chepchoina and Vamia satellite image February 2010 (Google, 2010).

The latest satellite data from Chepchoina and Vamia show a big increase in total dwellings. However, as the reflecting white roofs suggest, all roofs in the area seem to be metal roofs.

Figure 39. Chepchoina and Vamia satellite image October 2020 (Google, 2020).

Chapter 3: Roofing conditions three minor sources

Next to the primary sources used in this thesis, there are still many minor sources that help picture the history of the changing roof landscape in Kenya. These sources go into minor detail about the topic and, therefore, can not be used to create a whole coherent chapter. However, this data is still helpful to understand the overall context of the roofing landscape. In no particular order, these sources are listed below.

A. The Rural Reply

In the rural reply, T. Kristersson collaborates with the Power Woman Group on a participatory designed woman centre in Kibera, Kisumu County (Kristersson, 2019). For this collaborative design assignment, multiple workshops were conducted to investigate women's current and preferred housing conditions in the region. The outcomes of these workshops give insight into the roofing conditions of Kibera in 2019. Most dwellings are constructed out of mud and iron sheets. Inhabitants noted that these iron sheets make the residences too cold at night and too warm during the day. However, women felt safe in their homes because of the robust roof construction (Kristersson, 2019). From these workshops, it also became clear that women did not like the area's traditional architecture as these building methods were too renewable. Therefore iron sheets are the preferred long-lasting roofing material (Kristersson, 2019).

B. An Assessment of housing conditions in rural Kenya: The case of Murang'a district

T. N. Kibutu wrote a thesis in 1996 for the Department of Geography, Kenyatta University, about the housing conditions in Rural Murang. He said, "considerably, very few people still use grass; the majority opting for such materials as Corrugated iron sheets on timber frame truss" (Kibutu, 1996). Grass-thatched is being faced out for corrugated iron sheets or other metal roofs. In addition, 93.3% of all dwellings had iron sheets as the roofing material within his sample size. Inhabitants tend to prioritise permanent materials for roof construction as the rainy season comes with heavy tropical downpours (Kibutu, 1996). Grass-thatch used to be the most commonly used roofing material. However, as it became unavailable due to scarcity, people switched to more commercialised building materials like iron sheets (Kibutu, 1996).

C. African Traditional Architecture

Professor Andersen described the roof of dwellings in 1977 as renewable, import-saving and ecologically conformist materials, like thatch. However, most materials are too renewable and short-lived. Good thatch fibres are no longer accessible to get a hold of as crops and cattle use the available land. Moreover, there is no solution to carrying smoke out of a thatched building. At the same time, termites and other pests flourish within the thatch, all while iron sheets combined with a gutter can save many trips of water fetching (Andersen, 1977).

D. Improvement of Housing Conditions and the Performance of an Aided Housing Scheme in Selected Rural Areas of Kenya

M. Muller and H. Job replicated J. Sterkenburg's survey in 2004. As steel roofs went from 24% in 1980 to 78% in 2004, it proves that inhabitants favour semi-permanent housing over non-permanent traditional solutions. Even though farm sizes have significantly decreased over the years, corrugated iron sheets have replaced grass as the dominant roofing material (Muller & Job, 2006). This trend continues as the 2019 Kenya Population and Housing Census show that 80.3% of all dwellings have iron sheets (Kenya National Bureau of Statistics, 2019).

Chapter 4: Conclusions

The roofing landscape of rural Kenya has undergone a massive change in the past decades. The use of iron sheets as the prominent roofing material has irreversibly altered the way inhabitants build their dwellings. Corrugated iron sheets mark the beginning of the changing housing landscape in Africa as inhabitants continue to become wealthier. As traditional architecture will slowly make way for more modern and contemporary housing typologies in the future, the change to metal roofs is the first step in this direction.

Pinpointing the exact history of this phenomenon is difficult due to the unavailability of good data. Also, the matter is complex and dependent on many socio-economic factors. Nevertheless, the overall roofing landscape has changed to iron sheets, unregarding the region. For example, the housing surveys showed that many inhabitants preferred iron sheets over the grass alternative, and satellite imagery suggests that this trend only continued.

The unavailability of natural roofing materials helped accelerate inhabitants' choice of more commercialised materials like iron sheets. As natural thatch became scarce, inferior thatcht roofs tended to leak often. Therefore, the new, durable metal roofing materials improve overall living standards. However, iron sheets have higher building costs, higher dependency on skilled labour and bad insulating qualities. Therefore while a step in the good direction, there is still much room for improvement.

As housing conditions correlate with income over long periods, the poorest regions still have a higher percentage of grass-thatched roofs. Shikulu and Kabar showed the most grass-thatched roofs in the earliest visible satellite images among the surveyed areas. Almost no grass-thatched roofs were found in the latest satellite images, with the example of one possible grass thatched roof in Piave.

This thesis leaves the question if high-resolution satellite images combined with advanced remote sensing methods could map out the history of the changing roofing landscape. This data could be used to see which areas are more prosperous as roofing conditions and long term income show a strong correlation. Also, mapping out the regions with comparably bad roofing conditions could help NGOs focus on the areas that need it the most. Hopefully, as rural areas receive scholarly attention, this will become a reality.

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