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GRASS ROOFS

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Grass Roofs

CONTENTS

1. INTRODUCTION

The objective of this study is to be a pilot-research as a preparation for a thorough research on grass roofing in Kenya's rural areas.

Kenya's rural population has in general little or no monetary income, and its housing is quite simple, responding to the basic requirements of shelter. With these types of houses it is always the roof that takes the biggest share of technology and of investments, needed for building. In the search for improvements in rural shelter, this is why it is desirable to give roofing its proper share of attention.

In rural areas the significance of grasses as a roofing material is obvious: its availability, low cost, light weight and good thermal properties in combination with a long-time experience of the rural population with this material makes it still favourable as a first choice for roofing.

Changing circumstances in the rural areas are the reason that grass as a roofing material is losing field in favour of other materials, mainly corrugated iron sheets. If this is a desirable development, it is left to the judgement of the reader.

This report is divided into two parts: the first part contains general information about advantages and disadvantages of grass roofing, and a list of grasses, growing in Kenya, that are used or could be used for thatching. One problem with the inventarisation of grasses is that existing litterature on this subject merely concentrates on its grazing value, while thatching grasses, that need to be tough and unpalatable, get the least attention, and then only in the aspect of how to eradicate them.

The second part describes the situation in the Kisii-district, where a field survey on grass roofing has taken place in March, April and May 1980, as a part of an integrated rural housing survey under the responsability of the Housing Research and Development Unit of the University of Nairobi.
In the questionnaire of the rural housing survey, presented to 297 families of 3 different sublocations in the Kisii-district, a number of questions were added dealing with grass roofing, and next to this, information was gathered by interviewing farmers with grass plots, thatchers and people who live in grass roofed houses.

2. GENERAL CHARACTERISTICS OF GRASS AND GRASS ROOFS

2.1. Factors of influence on the suitability of grass roofs

The quality, or suitability of a grass roof depends on quite a number of factors. Some of those factors can be regarded as typical for grass roofs, like its combustibility and vulnerability for insects, birds and rodents as negative factors, and its good insulative properties as a positive factor.

All other factors are dependent upon circumstances that are not typical for grass roofs; that means that they are not directly related to the intrinsic properties of a grass roof, but related to local circumstances. Durability, an important factor, depends on other factors like the quality of grass that is available, and the level of technology for thatching.
Availability of suitable grasses, and the price for it, are more factors related to local circumstances, especially climate, ecology and population density and growth. The "social value" or "status value" of a grass roof is another factor, that depends on the socio-cultural characteristics of a population group.

Those factors, that can decide whether a grass roof is suitable or not, are analyzed separately in the next pages.

2.2. The factor combustibility

To start with, this factor, the fact that a grass roof can be so easily destroyed by fire, is its main drawback.

In dealing with this subject , one thing should be made clear first: Up to now there has been no way to make a grass roof less combustible by means of chemical treatment. Even the specialists on thatched roofs in European countries do not have a solution for this problem. Chemicals, that are used for the fire-retardant treatment of wood; ammonium salts, have been tried on thatched roofs. Apart from the high cost of this treatment, the chemicals appeared to leach out quickly by rain, and they promote growth of mould, leading to an accellerated physical break-up of the grasses or reeds.
Impregnating is difficult anyway, because many grasses and reeds have a "shield" of cellulose, preventing the absorption of anything. Another possibility has been tried by giving the outside of a thatched roof a sealing with bitumen stabilized clay or loam plaster, a lime wash or a gypsum wash. Two problems here: a periodic application is needed, and the underlying layer of grass is insufficiently ventilated, leading to quick deterioration because of rot, while repairs on such treated roofs are much more complicated than untreated roofs.

To prevent a roof from catching fire on the inside, especially when open fire for cooking, heating or lighting inside is used, thoughts go towards the use of an inside protective cover of inflammable material like asbestos cement sheets, but there are problems of availability in rural areas, increased risk of cancer for people working with the material, and such an increase in investment that such a roof structure can lose the competition with other types of roof structures.

Whether the risk of the burning down of a house is acceptable or not, depends on a number of circumstances:

- When houses are situated close to each other, like in urban areas, villages and even rural areas where a family or clan occupies a cluster of houses, generally this risk is regarded to be unacceptably high. Once one house is burning, the nearby houses suffer a tremendous risk of catching fire because of the flying fragments of burning or glowing grass. When a house has an isolated situation, this risk is reduced to catching fire on the inside only, a risk that can be checked, more or less, by the inhabitants themselves. Although arson is sometimes a practice in case of quarrels, the fire-risk of a thatched house in an isolated position is generally regarded as acceptable.

- When a grass roof is so much cheaper than other inflammable roof structures, and the income of a family does not permit higher investments in housing, this risk has to be accepted anyhow.

- When the other parts of the house, like walls, fittings etc. required high investments, and the house is fitted with relatively expensive and durable goods, the financial loss of a house and its contents is so high that such a risk becomes unacceptable too.

The risk of personal losses has not been taken into account here, because the chance that a person gets trapped in a burning house is quite small; the size of such a house makes it possible to detect fire at an early stage.

This acceptability of fire-risk reduces the field, in which research on grass roofing is useful, to the rural areas, where we find the houses in an isolated position, where the inhabitants do not have the financial means for higher investments in housing, and where the interiors of the houses are soberly fitted.

2.3. The facor insulation

This factor represents one of the main positive values of a thatched roof. A layer of grass contains more air than grass. This air is a very effective insulation against heat and cold. Then, such a layer of grass has a very low specific gravity and as a result of that a very low heat storage capacity. The relatively small quantity of heated air at the underside of the roof will gather under the rooftop, where it will pass slowly through the grass to the outside.

Inside thermal comfort is influenced by two factors: the inside air temperature, and the quantity of heat radiation coming mainly from the underside of the roof. The inside air temperature can be checked by means of ventilation: important though, but not relevant in this report. Remains the quantity of heat radiation, which is regarded to be acceptable when the difference between the temperature of the underside of a roof and the temperature of the inside air does not exceed 4,5°C. Such a difference in temperature can hardly occur with grass roofs, provided the layer of grass has a thickness of 10 cm at least. Other roof structures only can compete with grass roofs in this aspect when a ceiling is applied from a material, that has some insulative properties itself.

The next table gives comparison with other roof types under average tropical conditions (humid climate).
Source: Koeningsberger/Lynn - Roofs in warm humid tropics

Roof type:	excess of ceiling over inside air T:
red clay tiles	25,0° C
idem, with horizontal fibreboard ceiling	7,6° C
corrugated asbestos cement, painted white	13,3° C
idem, with horizontal fibreboard ceiling	3,9° C
corrugated galvanised iron, new and shining	11,8° C
idem, with horizontal fibreboard ceiling	2,3° C
corrugated galvanised iron, old and rusty	36,3° C
idem, with horizontal fibreboard ceiling	7,3° C

2.4. The factor durability

The durability of a grass roof is not only dependent on the durability of the type of grass, but also dependent on protective measures against wind, on the angle of the roofshield, and other circumstances. Technology is very much of influence too, therefore it is subject of a separate chapter.

The decay of a grass roof is taking place in several ways:

- Weathering: sunlight and rainfall make grass brittle, causing the exposed ends to break off in the wind, which makes the grass layer gradually thinner.
- Mould: occurring when humidity is too high and the grass contains too much easily digestible nutritients; also resulting in a loss of strength of the grass.
- Insects: can make nests and passages in the grass
- Rodents and birds: interested in the seeds of the grasses and able to mess up the layer of grass considerably.

There are however a number of grasses, which hava quite a good resistance against above-mentioned attacks, and those are the durable and suitable types for thatching. Its properties should be:

- Fibrous and tough; preferably with high contents of silicates and oils.
- A low content of easily digestible nutritients like carbohydrates, starch and proteins; this makes the grass unattractive for mould, rot and insects.
- The grass should not carry seeds; this is just a matter of harvesting the grass when it is not carrying them.

In general those are the grasses which have a low palatability for cattle.

The risk of damage on a grass roof, caused by gusts of wind from tropical thunderstorms, should not be underestimated. Trees growing around a thatched house can provide an effective windshield. The trees must not be planted too close to the house, to prevent damage from the abrasive action of branches, or from falling branches. Also dripping rainwater from the trees plus their shadow will keep the roof longer moist than necessary. The shape of a roof itself can offer a good protection against the destructive forces of wind. Edges, where the wind is able to attack , to rip off the grass, like in the case of a saddle roof, must be avoided. A conical or pyramidal roofshape is most favourable, and the eaves of the roof should be close to the ground.

The angle of the roof has also influence on its durability; a steep roof of about 45^{o} has a quick and easy runoff of rainwater and only a relatively thin part of the grass gets wet. If a roof does not have such a steep angle, the rainwater reaches deeper into the grass layer and the grass remains wet for a much longer period. Then the conditions for mould and rot are much more favourable.

Something else that has an effect on the durability of a grass roof is the smoke from inside woodfire. This smoke has a disastrous effect on corrugated galvanised iron sheets; the oxides from the smoke in combination with condensation water on the underside of the sheets dissolve the zinc protection and cause the iron to rust very quickly. On thatch however, the effect of smoke is antiseptic: when the smoke passes slowly through the roof, it kills mould and repels insects and rodents.

2.5. Technology and durability

The way in which the grass is fixed on the roof structure, in other words the thatching technique, plays an important part in the quality and the durability of a grass roof.

The grass should be fixed neatly, the stems as much parallel as possible, all pointing to the outside of the roof, so they will "guide" the drops of rainwater to the outside. In this way only about 3 - 4 cm of the layer of grass gets wet. After the rain stops, this will dry very quickly. When the grass layer is untidy, with many stems pointing from outside to inside, rainwater gets the chance to reach deeper into the grass, where it will take much longer to evaporate. This moisture will create favourable conditions for mould and rot. Moreover, a densely and neatly packed layer of grass giver the single grass-stem good support. In this way the grass is prevented to break off easily under the force of wind.

Proper tying has to keep the grass on its place, whereby each horizontal row of grass should be tied at intervals of at least 30 cm. This distance however is dependent on the length and rigidness of the grass. When the grass is long and rigid, the tying intervals can be longer of course.

Grasses with long, hard and straight stems are most favourable for thatching, but there is a limit to this too, mainly because of the problems, that these kind of grasses give in making a waterproof solution for the rooftop or the ridge. Here a flexible type of grass has more possibilities. It has been observed in the Kano-plains in South-Nyanza, where long, tough and thick papyrus reed is used for thatching, the rooftops were covered with thinner and more flexible grasses.

The waterproofing problem of thatched rooftops can be solved in many ways, and the inventiveness with which this is done gives an indication of the level of thatching craftsmanship.

There are two ways to fix the grass on the roof; one way is with the top of the grass to the outside, and the other way is with the underside of the grass, where it has been cut, to the outside of the roof. As the underside of any stem is harder, more lignified and more fibrous, it is stronger and has more resistance against the physical deterioration by means of weathering and wind. Of course this last way is to be preferred, though more grass may be needed to get a waterproof roof. Sometimes those two ways of thatching are both in use at the same place and with the same grass, whereby the way with the top of the grass to the outside is called semipermanent thatching by the local population, and the way with the stems to the outside of the roof is called permanent thatching.

2.6. The factor availability

Ecological circumstances: rainfall, temperature, height, moisture, soil structure, soil type, chemical composition of soil etc. decide whether any suitable grass for thatching can or cannot grow. In most areas the grasses for thatching grow on marginal land, and when nobody has a claim on such land, everybody is free to take it. Such a situation is not very favourable, because harvesting could take place too early, when the grass is not yet at its strongest, and because it can grow mixed with weeds and useless grasses.

In some areas such problems are avoided by cultivating the right kind of grass. The owner of such a plot of thatching grass will keep this free from trees and other competing plants. Harvesting is easier and can be done at the right time. Mainly perennial grasses will be cultivated in this way because of their continuous growth. Cultivating leads to a better quality of thatching grass, but it will be worth a certain price. Provided that such a grass does not impoverish the soil, a very positive aspect of this material is that its resource is renewable: after harvesting it grows again. Another positive aspect is that this material can be provided locally, so it requires very little input in transport and distribution.

The availability of thatching grass can become affected by the tremendous population increase that Kenya suffers. On one side more houses and more building materials are required, and on the other side more and more land is needed for subsistence food production. Marginal land, where thatching grass used to grow, and cultivated grass plots are changed gradually into land for food production.

2.7. Conclusions

Qualifications for a good and durable grass roof:

- Hard, fibrous and tough thatching grass, with high content of silicates and oils, and low content of easily digestible nutritients like carbohydrates, starch and proteins.
- Thatching grass without seeds and harvested at the right time.
- Thatching grass with straight stems and straight, thin leaves (lanceolate), at least 1 metre long.
- Thatching grass that grows in colonies, without useless weeds or grasses, preferably cultivated.
- Proper thatching: stems parallel, densely packed, with the cut side pointing outward.
- Steeply sloping roof; 40^{o} or more.
- Conical or pyramidal roof-shape with low eaves.

Protective measures:

- Smoke from woodfire.
- Planting trees around the house as a windshield.
- Careful use of open fire inside the house.
- No thatched houses close to each other.

2.8. List of grasses for thatching

This list is only a first trial to enumerate the grasses and reeds that could be used for thatching in Kenya. Many species of the grasses mentioned are selected only on size, toughness and unpalatability, but those factors alone do not determine fully whether the grass is suitable or not for thatching. With the risk of being incomplete, this list could be helpful with further research though.

About the Cymbopogon grasses it is for example not certain if they are suitable for thatching, but they have an interesting quality. They spread a scent that repels insects. It could be used pure or mixed with other suitable thatching grasses, but the usefulness of this suggestion has yet to be tested in practice.

Common reed (Phragmites Communis) has been included in this list. In Europe this is the most favourite thatching material, still in use for luxurious old country-houses and old-style farm-houses. There the harvesting of the reed takes place in winter, after the frost has stripped the stems from its leaves. For Kenya, where this reed does not occur in extensive colonies, it has to be observed whether this material has possibilities for thatching, and if it is needed to find a way to strip the leaves from the stems.

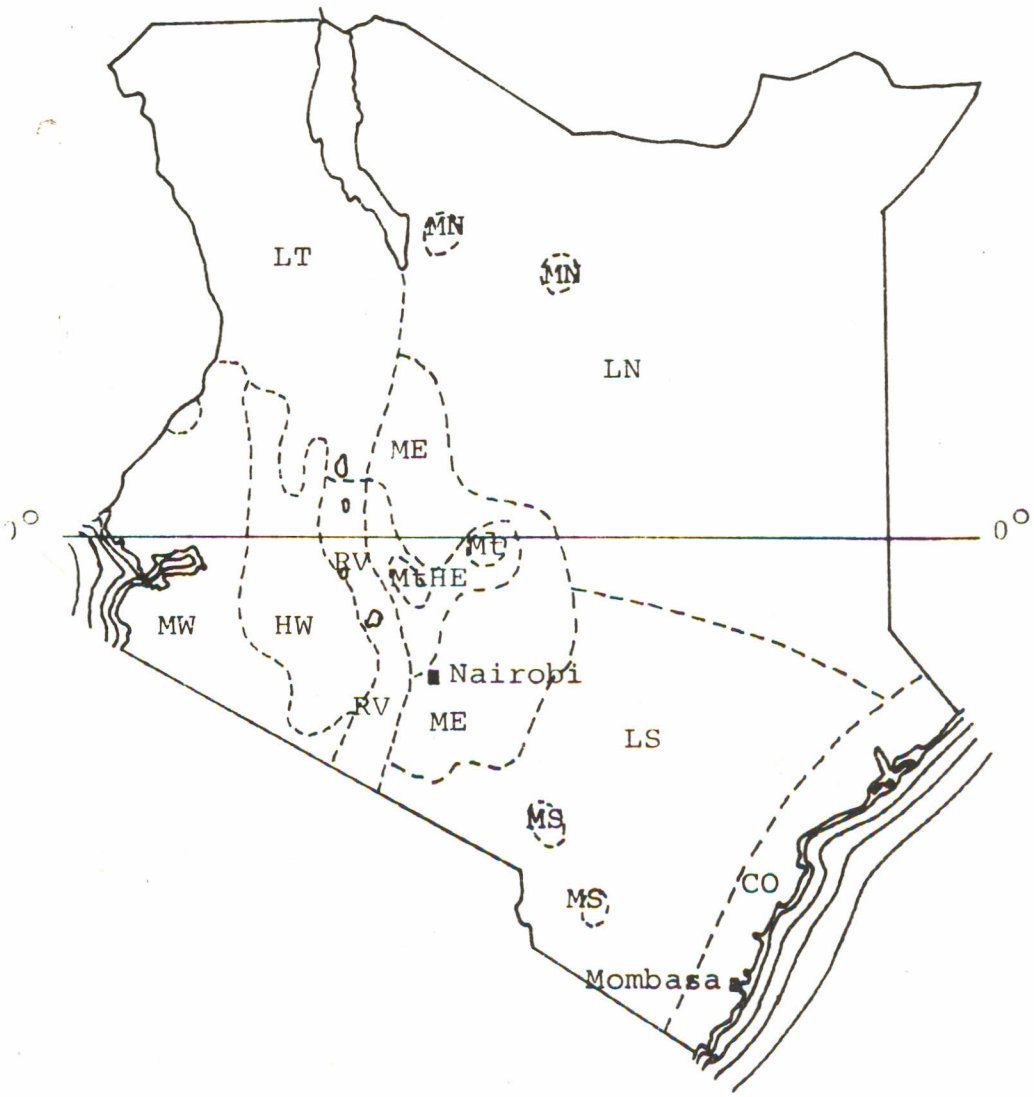
List of grasses with possibilities for thatching

Scientific name	English name	Occurrence	Growth mode, length and environment
Cymbopogon Afronardus	blue citronella	HE,MW	TP 90-210 cm very common in Nyanza
Cymbopogon Validus	giant citronella	ME	TP 120-300cm Mt Kenya, bush, grassland
Exotheca Abyssinica	unicorn grass	HE,MW,ME,MW,MS	TP 60-150 cm grassland
Hyparrhenia Bracteata	- - -	occasional	TP 120-210cm swamps
Hyparrhenia Cymbaria	coloured hood grass	HE,HW,ME,MW,RV	TP 120-600cm bush, forest edges
Hyparrhenia Diplandra	sword hood grass	MW,ME	TP 120-360cm moist grassland
Hyparrhenia Dissoluta	yellow hood grass	HW,MW,ME,LS,CO	TP 90-300 cm Combretum woodland zone
Hyparrhenia Nyassae	nyassa hood grass	ME,MW	TP 60-150 cm swamps, moist grassland
Hyparrhenia Papillipes	- - -	HW,HE,ME,RV	TP 90-180 cm grassland, rocky soil
Hyparrhenia Rufa	brown hood grass	MW,ME,CO	TP 90-210 cm grassland, woodland
Imperata Cylindrica	cotton grass	MW,LS,CO	P 45-120 cm swampy and arable land
Loudetia Kagerensis	sour russet grass	HW,MW,ME	TP 20-100 cm poor soil
Loudetia Phragmitoides	reed russet grass	MW	TP 120-500cm swamps
Loudetia Simplex	common russet grass	HW,MW	TP 30-150 cm rocky soil
Miscanthidium Violacaeum	- - -	HE,MW,LS	TP to 300 cm swamps
Papyrus reed (no information available, but occurs in Kenya:			MW and possibly elsewhere; swamps)
Pennisetum Schimperi	wire grass	HW,HE,RV	TP 45-120 cm grassland
Pennisetum Mezianum	bamboo grass	MW,ME,RV,LN,LS	TP 30-120 cm grassland on black soil
Phragmites Communis	common reed	MW,LS,CO	P 150-450cm stream banks
Sorghastrum rigidifolium	tussock sorghum	MW,ME	TP to 180 cm swamps, moist grassland

Source: A revised list of Kenya grasses, by A.V. Bogdan
printed by the Government Printer, Nairobi

P = perennial
TP = tufted, perennial

Indication of regions for the list of grasses for thatching



Mt - Mountains
HW - Western Highland
HE - Eastern highland
MW - Western Midland
ME - Eastern Midland
MN - Northern Midland
MS - Southern Midland
RV - Rift Valley
LT - Turkana Lowland
LN - Northern Lowland
LM - Magadi Lowland
CO - Coast

Source: A revised list of Kenya grasses
by: A.V. Bogdan

3. THE LOCAL CONDITIONS OF THE KISII DISTRICT

3.1. Climate

The altitude of the Kisii-district varies from about 1500m in the west to about 2100m in the east. This height results in quite a cool climate: annual mean maximum 24.0°C and minimum 11.1°C. This height is the reason that solar radiation can be very strong, which easily can lead to temperatures above 30°C, and nights can be very cool in the rainy season, forcing people to keep a small fire going inside the house at night, use blankets and have an interest in the insulative properties of their house.

Rainfall is quite high: the annual precipitation varies between 1500mm and 2000mm. Heavy tropical downpours are common, mainly during the long rains in March, April, May and June and during the short rains in September and October. These heavy rains make high demands upon the waterproofing properties of the roofs of the houses.

3.2. Population

According to several estimations and calculations the population of the Kisii-district must have passed the one-million-mark in 1980. The average density per square kilometer is then about 450 persons. Some sub-locations in Kitutu location, however, have an estimated density of 700 persons per square kilometer and more. The annual growth percentage is conservatively estimated at 3.8%, a number that is expected to increase because of the fact that more than half the population is younger than 14 years old. Population growth control is very difficult to establish because of a number of social and cultural obstructions.

So far there is not yet a sign of outmigration from the area, which can indicate that the area is still able to sustain its inhabitants. But it must be expected that, with this continuing expansion of the population, problems will arise, and one of the smaller problems will be the supply of local building materials.

3.3. Settlement pattern

The Kisii tribe is one of farmers, and each farmer has his own piece of land, where he grows subsistence and cash crops, keeps some cattle, and where he lives with his family. This results in a very dispersed settlement pattern.

Apart from the bigger towns (Kisii-town, Keroka and Ogembo), where the population lives concentrated, there are the smaller market centres and rural centres, but there the buildings are often only temporarily occupied, during market days, and the real home of the owner is mostly on his land somewhere in the neighbourhood.

In the history of the Kisii the settlement pattern has been much different from the present situation. Before British rule, hostilities with the neighbouring Kipsigis and Maasai forced the Kisii to live in fortified villages, close to each other for protection. Since peaceful coexistence was established early this century, the process of dispersal over the whole district has continued, and at this moment almost all land is cultivated.

Originally each clan occupied a continuous area; a hill, a ridge or a slope with natural boundaries, and each clanmember had his own strip of land from uphill running straight down to the valley-bottom. Succession from father to sons resulted in continuous subdivision in narrow and long strips of land, at right angles to the contour lines of the landscape.

3.4. Family settlement pattern

A Kisii family settlement may consist of one or a number of houses, depending on size and wealth of the family. A young man, just married, may decide to live the first years of his marriage in the house where he has been living since his initiation. Such a boys' house is small, about 16 square meters, and has one room. After some years he can decide to build a bigger house, about 25 - 30 square meters, and containing 3 rooms. When his land is big enough, and he can afford it, he could marry a second and even a third wife, and each wife will get her own house. After his father dies, he could invite his mother to live on his land. When his sons are initiated, they will get their own house or houses, and sometimes initiated daughters will get their own house too. Then sometimes houses of relatives, separate kitchens and separate latrines can be found, and always there is one or a number of granaries. Sometimes a house can get another function, for example when a new house is built with a roof of corrugated iron sheets and the old house is left to function as a kitchen.

There are no rules about the respective positions of the different houses on the compound. Each family decides for itself where the next building will be situated, to their own convenience. In general the lower part of the holding is avoided for settlement, because the damp air from a swamp or a stream is unhealthy and uncomfortably cold at night, and there the concentration of mosquitoes, which can carry malaria, is high.

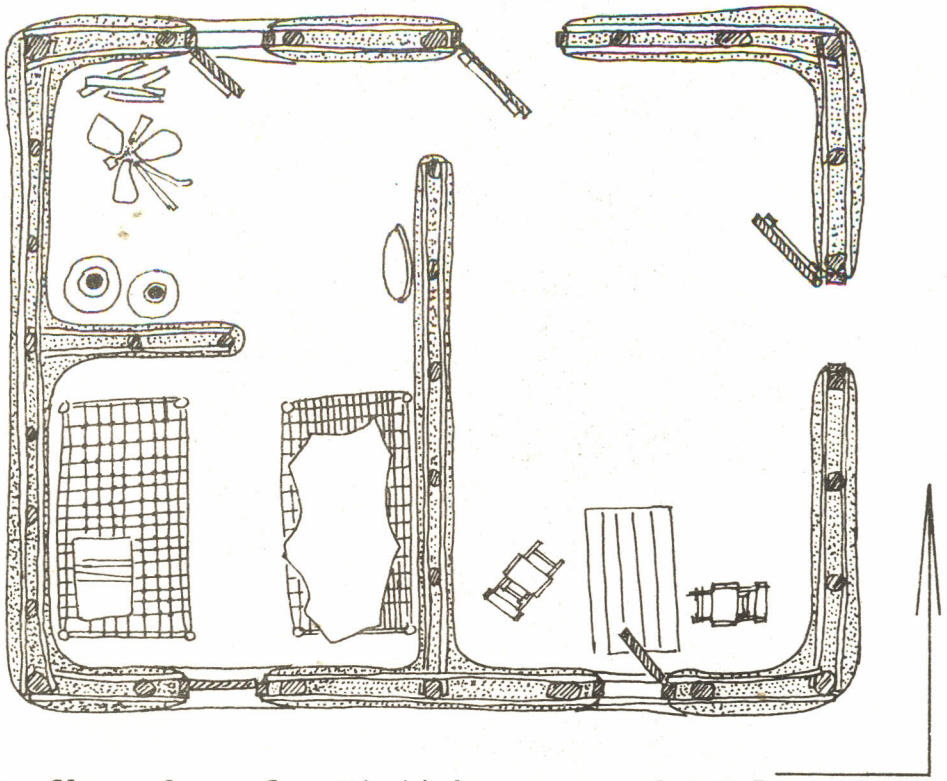
4. THE KISII HOUSE

4.1. Form and use

Apart from the difference between "ordinary" houses and houses for initiated boys and girls, which are small and have one room, the houses are quite uniform. The rectangular shape has completely taken over from the original round shape. Less than one percent of the houses are round, and those houses are generally older than 25 years.

The ordinary house is divided in two halves by a partition wall, one half is used as living room, the other half is divided again, one part for cooking and one part for sleeping.

The orientation of the house is always dependent on the slope of the site. Standing inside the house and looking downhill, the right half of the house is the living room, with two entrance doors, one up front and one in the right wall. The left front part of the house is kitchen, and the left rear part of the house is for sleeping, and this room is connected to the kitchen. This kind of floorplan and use of the house is the most common, but there are deviations from this pattern, according to the needs of the owner.



common floorplan of a Kisii house, scale 1:50

4.2. Walls and floor

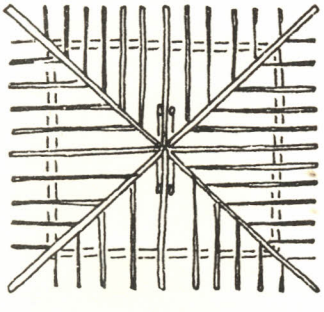
The walls are mainly of the mud and wattle type. Poles are dug in the earth on a distance of about 50cm. Straight twigs are nailed horizontally on the outside and inside of the rows of poles. The space between the poles and twigs are filled with mud after the roof is finished. Then mus is smeared over the surface until the twigs are out of sight and the surface is smooth. Then a thin layer of light coloured plastering clay is applied.

Door- and windowframes are made of sawn timber, doors are made of vertical planks with a simple nailed-on jointing. There are no windows, but wooden shutters of the same make as the doors and mostly not bigger than 50 x 40cm.

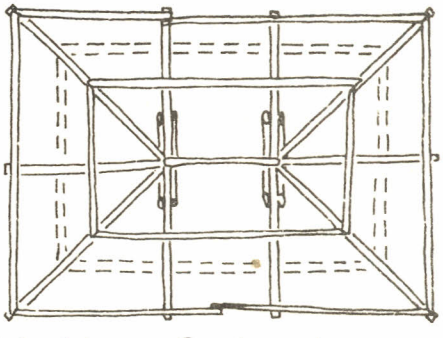
The floor is the soil from the spot, levelled and and smoothly finished with light coloured clay plaster.

4.3. Roof

There are two types of roofs: the roof thatched with cotton grass, and the roof covered with corrugated iron sheets. Not only the roofing material is different then, but also the roof pitch, the supporting structure and the average size of the house. Thatched houses have a much steeper roof, sloping about 45^{o}, while a corrugated iron roof has a slope of about 30^{o}. The average size of a house with a grass roof is about $25m^2$, and the houses with corrugated iron roofs are bigger, in average about $32m^2$. The supporting structure of a grass roof requires much more timber because the rafters are placed close to each other. The corrugated iron roof has a smaller number of rafters and purlins, but the diameter of the used poles is bigger, which results in about the same expenditure on timber for both rooftypes.



Grass roof structure



Mabati roof structure

In the Kisii-district it is a very common practice to use corrugated iron sheets for roofing instead of grass as soon as the financial position of the family allows this. In general a corrugated iron roof is regarded as an expression of wealth or modernity. Boys' an girls' houses are generally thatched; only when parents are very wealthy or a boy has a paid job there were some houses found with c.i. roofs. The total percentage of grass roofs on residential structures is about 72%, but it could be better to indicate that about 40% of the families do have at least one house with a corrugated iron roof.

Percentages of thatch and c.i. roofs for the different house types from a sample of 624 houses in Kisii-district:

House type	grass roof		c.i. roof	
	abs.	perc.	abs.	perc.
parents' houses	159	61%	101	39%
other wives' houses	17	52%	16	48%
init. boys'/girls' houses	173	84%	33	16%
other relatives' houses	98	78%	27	22%
All residential struct.	447	72%	177	28%

The high percentage of c.i. roofs of houses of other wives can be explained from the fact that a farmer needs to be wealthy to afford himself 2 or 3 wives, a wealth also expressed in a higher expenditure on housing.

Separate kitchens are found with about 35% of the families and have all thatched roofs, because thatching grass is a more suitable material when smoke from woodfire occurs. The earlier mentioned corroding effect of smoke on corrugated iron sheets forces people who have a house with a corrugated iron roof to look for another place to cook (girls' house, separate kitchen) or to look for another type of fuel (kerosene, charcoal).

4.4. Building stages of the Kisii house

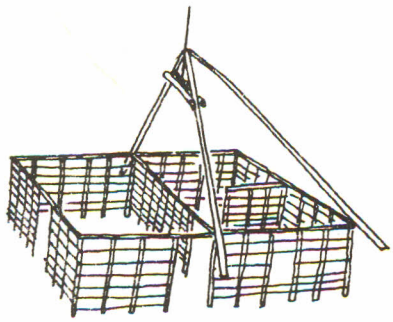
The construction of a thatched house is taken as an example, in the first place because this report concentrates on this subjest, and in the second place the building stages of a mabati house are not different from this example.

Very often the construction of a house takes more than one month, because the building process is interrupted several times. A reason for this can be the spreading of expenditures on materials and salaries, or the influence of bad weather. Moreover, the raising of the wooden frame is done by men, at a moment that they are not occupied in agriculture or in other jobs. Then the waiting is for a thatcher to be available. After the roof is finished, the women will take care of the filling of the walls with clay.

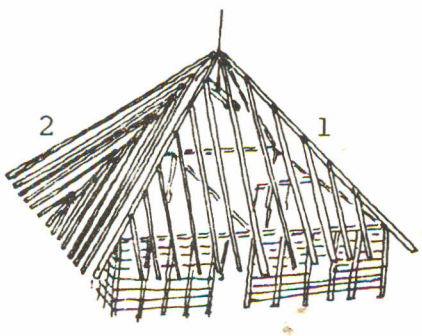
Building stages of the Kisii house

The plan is set out and the poles are dug in.

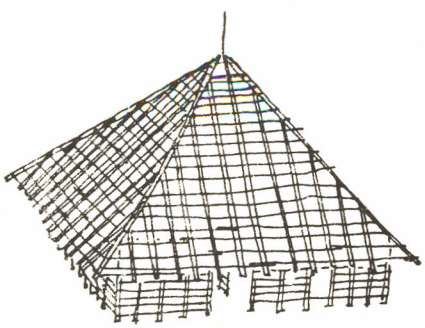
The poles are sawn to the right height and beams are nailed on top of the poles. Then laths are nailed or tied to the poles.



Truss is raised over the middle wall, whereby the purlin over the poles of this wall takes the pulling force of this triangular truss, which is fixed on its place by putting the twills, running from the corners of the walls to the top of the roof.



The remaining rafters are placed. There are two ways of placing them:
1. connected to the twills, which are heavier then
2. connected to the central rafters in the roofshield, which are heavier then.



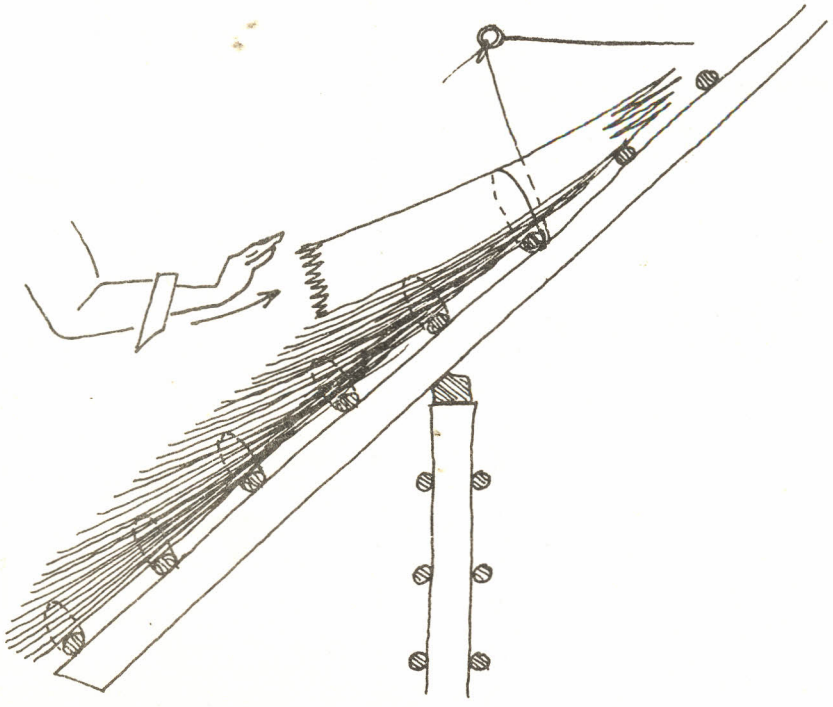
Laths from straight, young gumtrees are stripped from their bark, which is used as rope to tie the laths to the rafters, or the laths are not stripped and nailed to the rafters. The rafters are sawn to the right length at the underside.

The roof is thatched, the top at last. then the door- and window-frames are mounted, and the walls are filled with moist clay, taken from the area just around the house. After drying the cracks in the wall are filled again, and finally a thin layer of plastering clay is applied.

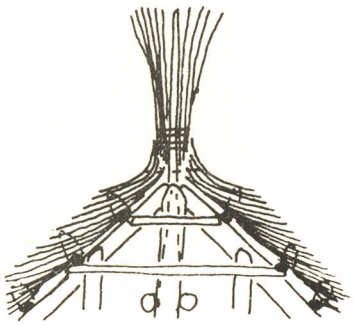
5. THE KISII GRASS ROOF

5.1. Thatching

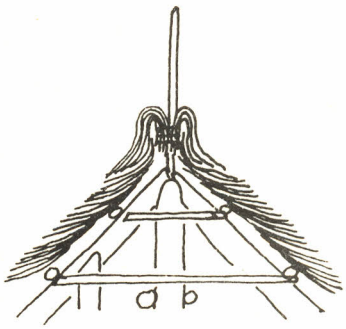
The level of technology in thatching in the Kisii-district is developed so far, that the thatching is done by a specialist thatcher. These thatchers are generally not fully occupied with those jobs, and do it as an extra next to farming. Most of the thatchers are quite old men, which could be an indication that younger men are not so much interested in this job, and that the thatchers' profession could die out and together with that their know-how could disappear. The thatcher sometimes has his own helper, and sometimes the owner of the house helps the thatcher to carry the grass to the roof, so the thatcher can work without interruptions. The roof is thatched from down to the top, which is the only possible way of course, in widths of about 1 metre. A number of grass bundles are put next to each other on the roof, with the down-part of the grass stems to the outside. A long metal pin with an eye on one side is used to tie the bundles of grass onto the roof-laths with rope. Then the bundles themselves are untied, and with the hands the grass is pushed into the right position. Then the rope is pulled and this fixes the grass definitively. Another way of thatching is to leave the bundles of grass as they are, which gives the roof a stepped surface. The thickness of the new thatch layer varies between 15 and 20cm, but this will become somewhat thinner afterwards because of setting.



The rooftop, where the grass comes together from several directions, requires always some inventiveness to get a waterproof solution. The rooftop finish that is common in the Kisii district is nice and effective, and can be regarded as an indication for the care and the level of craftsmanship with which a grass roof is constructed.



A bundle of grass is fixed to the vertical stick coming out of the apex of the roof



his bundle is bent downward

and fixed with rubber rings cut from car-tyres, which are held in place with pointed sticks. Inverted metal bowl (kitchen) on top.

5.2. Cost of thatching

It takes a thatcher with one helper about three days to thatch one roof of average size. The payment to the thatcher is mostly in food and beer, at the equivalent of Kshs 80.- to Kshs 100.-.

5.3. Mixing with old grass

Old grass from a previous house can be used again in a new roof, mixed with new grass. This happens in about 35% of the newly constructed roofs. This grass can be still of reasonable quality, and this is an indication, that the lifetime of the roof is shorter than the lifetime of the thatching grass. After about 10 years a roof can start leaking, and then other parts of the house start deteriorating very quickly too. In general this is the moment that the house-owner starts thinking about building a new house. Although it can be that the roof is not worthwile to repair, because of too many leaks, the grass from the parts that are still entire will often appear to be good enough for recycling.

5.4. Quality and lifetime of grass roofs

According to the field survey, 68% of all grass roofs were in a good condition, 29% showed leakage somewhere and 3% of the roofs was in such a bad condition that replacement was required.

The lifetime of the grass roofs in the Kisii-district is quite high. A steep roof angle, a good quality of thatching grass and a proper way of thatching contribute to this. As an average, a roof can remain in a good condition for 10 years, but with a little bit of extra care and repairs when needed, a roof can last for many more years. Roofs were found that were 20 and more years old and still in a good condition. Some farmers, who have an easy access to thatching grass, can thatch their houses themselves, without the know-how of a thatcher and sometimes such a roof is already leaking after two or three years.

In the Kisii-district also the temporary way of thatching occurs, whereby the grass-tops are pointing to the outside. This practice is only in use for temporary repairs or temporary roofing, pending the arrival of the thatcher.

5.5. Fire hazard

As already mentioned before, the houses are located very dispersedly, which prevents an easy spreading of fire from one house to another.

Cooking is taking place inside of the houses, but this is done very carefully on a small woodfire between stones. Bush-fire does not occur in the Kisii district. The vegetation remains green because of the regular rainfall. So, in general, fire hazard is not a very serious problem in the Kisii situation.

5.6. Other drawbacks for grass roofs

One problem that is difficult to control, is the presence of big black beetles that house in the rafters of the roof, and make a passage through the grass, which in due time can cause leakages.

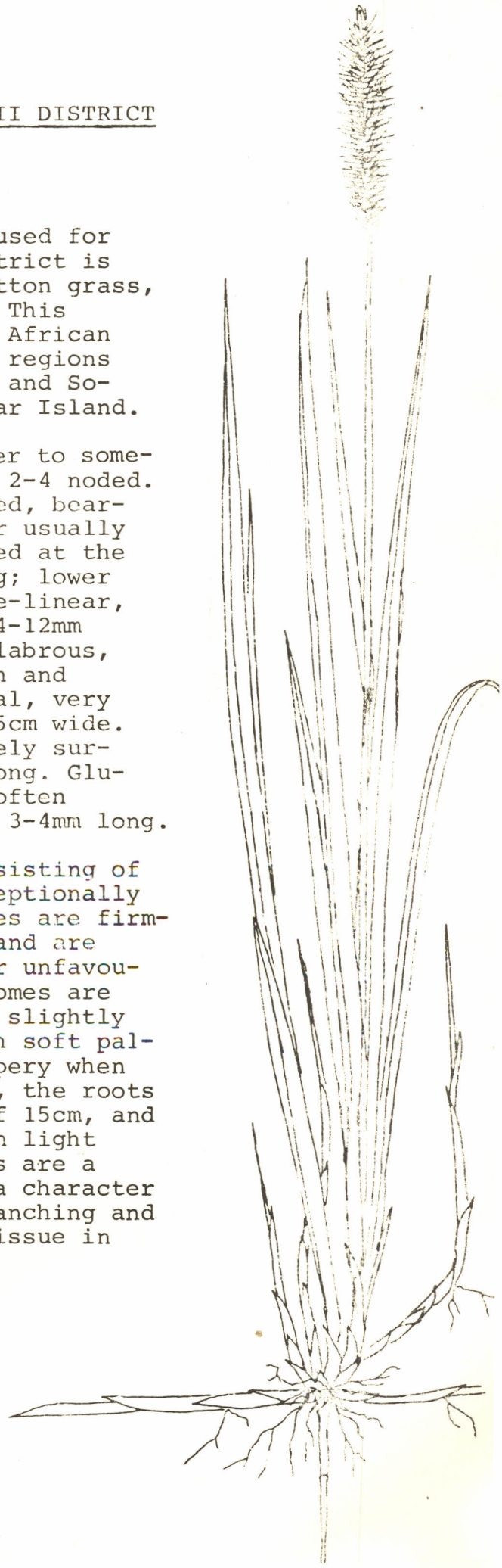
6. THATCHING GRASS IN THE KISII DISTRICT

6.1. Imperata Cylindrica

The type of grass that is used for thatching in the Kisii-district is Imperata Cylindrica, or cotton grass, of the variation Africana. This variety occurs in th whole African continent south of the dry regions of Sahara, Sudan, Ethiopia and Somalia, and on the Madagascar Island.

The culms are erect, slender to somewhat stout, 20-120cm high, 2-4 noded. Lower leaf sheaths elongated, bearded at the mouth, the upper usually glabrous, less often bearded at the nodes; ligules 1-1,5mm long; lower blades linear to lanceolate-linear, up to 100cm or more long, 4-12mm wide, flat, firm, erect, glabrous, or hairy towards the sheath and smooth. Panicles cylindrical, very dense, 4-18cm long, 1,5-2,5cm wide. Spikelets 4-6mm long, densely surrounded by hairs 10-15mm long. Glumes membranous, obtuse or often acute, 3-9 nerved. Anthers 3-4mm long.

The underground parts, consisting of roots and rhizomes, are exeptionally well developed. The rhizomes are firmly rooted, spread rapidly and are very persistent, even under unfavourable conditions. The rhizomes are white, somewhat succulent, slightly sweetened, and covered with soft pallid scales which become papery when dry. In an impervious soil, the roots may penetrate to a depth of 15cm, and to a depth of about 40cm in light soil. Very short internodes are a feature of this rhizomes, a character favouring close lateral branching and a formation of a compact tissue in the soil.



These rhizomes are a very active and effective means of reproduction, apart from the reproduction by the light, plumed seeds, which can be dispersed by wind over a long distance.

Because the rhizomes are hidden deep enough in the soil, this grass is resistant to destruction by fire, which will even favour the development of Imperata Cylindrica by destroying competing types of vegetation.

Imperata Cylindrica has a wide tolerance towards soil conditions, and only extreme aridity will prevent its development. The range of temperature and its shifts, occurring on the African Continent, are not a limiting influence on the presence of Imperata Cylindrica. Light is important for this grass, because it will not grow in heavy shadow.

In agriculture, the system in which weeds, grass and young trees are burnt annually has been mainly responsible for the establishment of extensive Imperata savannahs. As a weed in agriculture, this type of grass is regarded as a serious burden, because it is difficult to outweed, and its grazing value is low, because only the young leaves are eaten by cattle, when there is nothing else to be found.

The chemical composition of Imperata Cylindrica, as with many other plants, varies considerably under different soil and climatic conditions, but in general this grass has a low nutritive value for cattle, a low moisture percentage, a low protein percentage, a high percentage of fat and oils and a very high percentage of fibres.

In many places in the tropics cotton grass is used as thatching grass; Nigeria, Uganda, Kenya, Zimbabwe, South Africa, India, Sri Lanka and many countries in south-east Asia are some of them.

6.2. Growth of cotton grass in the Kisii-District.

In the Kisii-District this cotton grass is specially cultivated for thatching purposes. One reason for this is that the area is densely populated, and very fertile, so each piece of land has an owner, and is cultivated. Marginal land, where thatching grass could grow, is very scarce, and if there is any, it is overgrazed by cattle.

So many farmers do have a plot with cotton grass on their shamba's, which they protect against cattle with hedges of acacia or other thorny bushes, and cultivation means only the outweeding of young trees.

Planting or seeding new plots of cotton grass seems to be impossible or impracticable. Generally the practice is to wait for the grass to invade a part of the shamba and then not to outweed it or not to let it be overgrown by trees or crops. A dense hedge around the plot will prevent further propagation and infestation of adjacent fields. The seeds of cotton grass are only rarely fertile in the Kisii situation.

It is not certain whether the practice of cultivation originated in the Kisii-District or if it was introduced from abroad. There is a possibility that immigrants from the north-eastern parts of India, where each farmer has his "khane-berrie" (field of cotton grass for thatching), have introduced this practice to the Kisii farmers.

In the Kisii-District about 30% of the farmers have a plot with cotton grass on their estate, its size being between 0.3 and 1 acre on an average. Of the total area of cultivated land about 2% is used for cotton grass production. It is possible to obtain three crops annually from one field.

6.3. Origin and transport of thatching grass in Kisii.

The farmer who owns a grass plot sells the grass when it is still on the land. The buyer takes care of harvesting and transport. As families in general live close to each other, grass is sometimes obtained freely from a neighbouring relative, a possible service in return can be offered later.

In 35% of the newly constructed thatched roofs not only new grass is used, but it is mixed with a certain percentage of old grass from the previous house (15-25% in quantity). When kitchens, granaries or latrines are thatched, the mixture with old grass is often much higher, and sometimes only old grass is used. Only very occasionally residential structures are thatched with old grass only.

Origin of thatching grass for each type of house:

house type	own land	free near	buy near	buy far	old house
parents	39	8	100	11	2
other wives	3	3	10	-	-
boys/girls	56	20	83	11	1
other residential	24	7	63	5	-
total number	122	38	256	27	3
percentage	27%	9%	57%	6%	1%

Transport of the grass takes place on a three-legged branch; the two long legs are covered with lateral branches on which the bundles of grass are placed, and are dragged over the ground. The third, short leg is used as a pulling hook, and this is dragged by one ox or two oxen. Three of four rides are needed to transport the quantity of grass that is needed for an average-sized roof. It is not usual to transport the grass over a longer distance than 3 to 4 kilometers, because the cost of transport, which is on an average Kshs 60.- to Kshs 80.- in food and beer, will become too high. For short distances, the grass is carried in big bundles on the head.

6.4. Supply and demand of thatching grass in the Kisii-District.

To check whether supply and demand balance each other more or less, one area was tested of a size of approximately 670 acres. Here the area with cultivated cotton grass was 14 acres. Some plots with thatching grass, however, were in a neglected state, which resulted in a productive area of about 12 acres.

In that area of 670 acres 200 houses were situated with grass roofs. Although a number of houses are thatched with a mixture of old and new grass, the resulting "savings" on new grass are supposed to be neutralized by the demand for new grass for kitchens and granaries. The objective of this supposition is to make this rough calculation not too complicated. For one roof of an average-sized house and a roof-surface of about 110m^2, one harvest of one acre of cotton grass will be sufficient. So the available 12 acres of cotton grass, which give three crops annually, could supply thatching grass for 36 houses each year.

A grass roof can last for 10 years on an average, so 20 of the present 200 roofs need to be replaced or rethatched each year. Then there is a population growth of about 4% annually, which, roughly, results in an extra requirement of 8 roofs each year. This makes the total requirement for 1981 28 roofs, for 1982 36 roofs, and this is the moment when the break-even point will be reached.

Of course this estimate about supply and demand is a very rough one, but it does illustrate one thing that was already emphasized by the Kisii-people during the field-survey: shortages of grass are to be expected.

In some areas of the district the situation is not yet so bad, but in other areas there is a shortage of grass already; a situation which can be easily related to the density and growth of the population in that area.

Such a situation will automatically lead to reactions, which bring about a postponement of the above-mentioned break-even point of supply and demand. Although the local population will not make a calculation as above, their experience with the local situation will tell them enough, specially when the price of grass rises. A number of people will postpone the moment to rethatch their roofs or to build a new house, and help themselves with repairs. Another number of people will use a higher percentage of old grass in a new roof and for some people the increased price of a grass roof will shift the balance of competition towards the use of corrugated iron sheets for roofing.

On the other side it will be attractive to increase the production of thatching grass, first by improving the cultivation of neglected plots of thatching grass, and then to increase the acreage under cotton grass. This is, however, not so easy because the expansion of cotton grass occurs mainly because of the underground expansion of the rhizomes, which can occur at a speed of about 3 meters annually and such a recently invaded area will take some years to become fully productive.

Then another tendency became apparent: When a farmer with a small holding gets into trouble to feed his ever increasing family, he will easily decide to uproot his field of thatching grass and to grow a subsistence-crop there. This happened several times already.

6.5. Cost of thatching grass in the Kisii-District.

From the research it appeared that the cost of a quantity of thatching grass for one roof has been quite stable for a long time, varying between Kshs 70.- and Kshs 100.-. But during the last few years a rise in price is noticeable, in some areas quite dramatically. Obviously this is a result of shortages. At this moment the price of such a quantity of grass varies within the district from Kshs 100.- in areas with a low population-density (south-west) to Kshs 200.- to Kshs 300.- in areas under average conditions, and in areas with shortage of thatching grass to Kshs 400.- and even more.

7. CONCLUSIONS AND RECOMMENDATIONS

Thatch roofing has virtually no use in urban areas. There the high concentration of houses makes the use of thatch unacceptable because of the fire-risk, while there are little or no possibilities to give thatch a fire-retardant treatment. But as a roofing-material in rural areas it is up to now most favourable for a number of reasons:

- It is a right answer to the policy of local self-suffieciency.
- The production of this material does not require fossil energy.
- There are little or no inputs in distribution and transport
- Its resource is renewable.
- Low cost, which leaves more room for investments in more productive sectors of the household-economy.
- No need for the introduction of a new and alien technology, but only for improvements of existing technologies.
- A thatched roof has an exellent thermal performance.

For those reasons it is useful to keep an interest in the use of thatch as a roofing material, and to try to make thatched roofing even more attractive by:

- Improving the quiality of grass, either by improvements in cultivation or by the introduction of more feasible species of thatching grass,
- Conserving and improving thatching craftsmanship and the transfer of thatching know-how, for example in Village Polytechnics,
- Introducing the use of combs: grass that is treated with combs has a much better parallel packing, which makes a grass roof more durable and waterproof,
- Using the right, steep, roof-pitch, using windshields.

As this study is a preparation for a more comprehensive research on grass roofing in Kenya, some recommendations follow here for further research:

For each region or tribe an inventarisation of:

- Species of grass that are in use for thatching,
- supply of thatching grass,
- level of craftsmanship in thatching,
- quality and durability of thatched roofs,
- cost of thatched roofs.

With this information a comparative study can be made of the different types of roofs and the different species of thatching grass, from which conclusions could follow for further research.

A study on possibilities and methods for cultivating thatching grass species, and a study on the most effective way to transfer the gathered know-how to the rural areas, where this is required.

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