

Mission report

*Identification of Alternative Building Options
on the Islands of Mafia, Tanzania*

WWF Project No: TZ0057



by
John Norton
Development Workshop
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for



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Identification of Alternative Building Options on the Islands of Mafia, Tanzania

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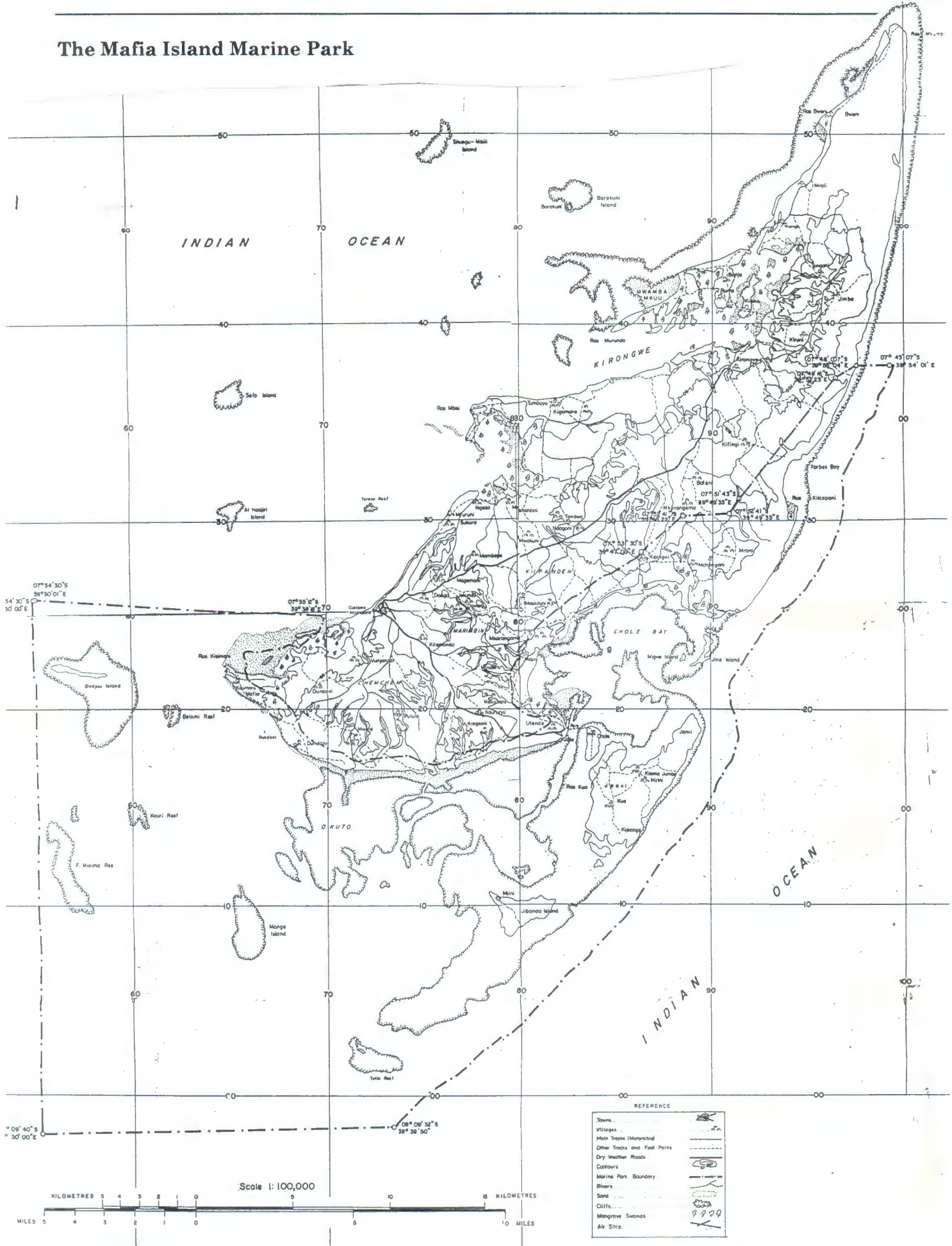
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Marine coral to be used in building

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The Mafia Island Marine Park



Executive Summary

In this report, the MIMP and periphery area has been considered under eight areas. (See map on page 8).

One can grade each area in terms of:

- its present actual drain on marine based resources,
- the potential risk of overconsumption, and
- landbased resources that may become overused if economic growth takes place.

Area	Name	Level of marine resource use	Potential risk if building activity increases	Impact on land based resources if their consumption increases	Urgency rating
1.	Jibondo Island	Very high; Coral for lime and building; Mangrove for fuel	Little change; use of coral remaining very high; mangrove consumption more detrimental	Less sea based consumption; land based resource require management	High: consumption of coral at damaging level
2.	Juani Island	For building, coral consumption medium to low; for lime production, mangrove and coral consumption high	Lime production could increase	Low, as population low	Medium for lime production
3.	Chole Island	For building, medium to low; for lime production low	Increase in coral and lime consumption if domestic revenue increases	Sand consumption might become too much	Medium, as pop. density is high
4.	Bwejuu Island	Low	Low	Low	V. Low
5.	Utende (Mafia Island)	Medium, some coral used, and some lime	High use possible if high quality alternatives not promoted	Sustainable	Medium, because of potential growth in economic activity
6.	Baleni/Kungwi (eastern sector, Mafia Island)	Low sea resource use	Low, more related to land based resource	Unlikely to change, except pole and aggregate production could increase	Low; useful source of land based materials, needs promoting
7.	Chemchem/ Dundani (south western sector, Mafia Island)	Low sea resource use	Low	Low	Low; coconut tree exploitation could be developed
8.	Kilindoni (Mafia Island)	Low	Low	Low, except aggregate	Low

This grading suggests that promotion and demonstration activities should be focussed on Jibondo #1, and on Chole #3 and Utende #5, with pressure relieving activities promoted in Kungwi #6 and Chemchem #7. On Bwejuu #4 there is no justification for action.

On most of Mafia Island, marine resource use is not critical, but on the smaller islands and at Utende, action needs to be developed that will be a viable replacement that will be approved by the public. Any action at the moment should be considered as a presentation of alternatives to the population for their assessment.

Popular adoption of earth blocks would probably be slow. However, given the indications of a slight move to solid masonry building on Jibondo, one could expect a greater degree of interest in limestone blocks on this island, and there might even be an export potential when they are compared to cement block use in Utende.

A building materials and building process strategy should consider three levels of action, as follow:

1. Promoting publicly accessible materials and technologies —
 - To reduce the consumption of both lime and coral, the production of limestone blocks should be actively developed on Jibondo island. This would require a land use plan, a technical demonstration, and making simple equipment available.
 - To reduce the risk of high coral consumption on Chole and at Utende, earth block production should be demonstrated - with high quality - and actively promoted.
2. Developing resource conserving technologies which are available to the public —

Lime cannot be eliminated as a resource, and the options are mainly to reduce the amounts required, and to reduce the amount of fuel needed to produce it —

 - The MIMP should encourage the development of more fuel efficient lime production methods, where less energy is wasted through poor kiln design.
 - The MIMP should encourage the processing of coconut timber with hand tools, unless local very local demand could justify higher investment.
3. Promoting local resource based products on the market through co-operation with local organisations —
 - The MIMP should encourage the development of material banks to distribute poles from plantations, including coconut rafters.
 - The MIMP should explore the possibilities of helping Mafia Coconuts Ltd. (or similar) to re-establish their coconut timber milling plant, through requests for coconut timber for the MIMP HQ and other similar projects. Coconut wood also provides a good source of charcoal, (as do the nuts). This should be promoted through the demonstration of charcoal production. Charcoal production can be undertaken by any members of the population with access to old timber.

In addition and in parallel to the above —

- The MIMP should take every opportunity to use its own building needs, including houses and offices, as a clear statement of how it believes marine and land based resources should be used. This does not seem to be a sufficiently clear part of MIMP policy at the moment.

1. Mission

1.1 Introduction

The mission was undertaken by John Norton, Director of Development Workshop, an international non-profit organisation with twenty years' experience in the field of human settlements, the built environment which people create, and the natural environment in which we live. The issues raised by the relationship and the interaction between the natural and built environment are central to the theme of the present report. It is not always easy to achieve an equitable balance between the two. The mission has focussed on considering options that will be in the interest of the population and the way in which they achieve their physical living environment, and at the same time, options that will not be to the detriment of the environment in which people live.

1.2 Objectives

The objectives of the mission to Mafia Island were as follow:

To carry out a preliminary fact finding and identification mission to Mafia, with the following specific objectives:

- a) Broadly review the shelter and building needs in Mafia, and if desired, adjacent islands.
- b) Review the availability and quality of potential local building resources and compare these with the available non-local resources; comment on their passive or active impact on sustaining the land and seas based ecology of the area.
- c) Make recommendations about the possible actions which would (a) alleviate pressure on local resources, with a particular reference to Mafia Island Marine Park (MIMP), and (b) help the population satisfy their needs within the scope of the MIMP objectives and the broader context of survival on these islands.

To carry out any other activities pertaining to the Identification of Alternative Building Technologies as requested by the Technical Advisor.

1.3 Dates

The mission to Dar es Salaam and to Mafia Island was undertaken between the 6 and 17 June 1995. Time was spent on Mafia Island from the 9th to the 16th June. In Dar es Salaam, meetings were held with the Department of Fisheries and WWF Country Office for Tanzania.

1.4 Geographic and climatic context

Mafia consists of a main island, 50 km long from north to south, and 15 km at its widest. It lies opposite the mouth of the Rufiji River on the Tanzanian mainland. There are also six small inhabited islands. Two are in the north and outside the MIMP, and are not considered in this report. The islands of Chole and Juani lie on the south eastern side of Mafia, Jibondo island lies at the southern extreme of the Park, and Bwejuu island at the western limit. The MIMP follows a line one kilometre inshore from the high water mark, except at its northern limits where it increases to include Mlola forest, the only remaining indigenous forest on the island.

Mafia has a subhumid climate, with annual rainfall in the 2 000 mm range affected by the south-east monsoon system. Rain mainly falls in the period from November to June, but no month is sure of being totally dry. Rainfall has been lower in recent years. From the point of view of building and building protection, maximum rainfall is in the March to June period, with a peak in April rising to 500+ mm in the month, but varying in different parts of the island. Winds are southerly in March to June, northerly in January to March, and variable in the rest of the year. The local micro climate near the sea does show a daily wind pattern reflecting diurnal differences in sea and land temperatures, but the prevailing winds are often strong enough to override such local effects. Average maximum temperatures range between 27°C and 38°C, but are normally in the low 30°C range. Overall conditions are sufficiently comfortable to make climate not an overriding criterion in building design.

The overall population was 33 054 in 1987, with an annual growth rate of 3.5%. Of this, 13 301 people were living in the MIMP zone. Apart from Kilindoni, none of the "wards" in Mafia has a large population.

The main activities on Mafia are fishing, coconut harvesting, and subsistence agriculture. A lot of produce is imported from the mainland.

1.5 Presentation of findings

A review and analysis of resources, living conditions and building methods in Mafia District is provided in sections 2, 3 and 4 which deal respectively with:

- a general description of house form and house building process;
- each island or sub area of the island in the case of Mafia itself;
- building materials and their production.

Comments on the design and development of the MIMP HQ complex are given in Section 5 and main conclusions and recommendations in Section 6.

2. House form and building process

2.1 House form

An appreciation of the dominant local house form and the building process on Mafia and its smaller islands is essential in both evaluating the use of materials and in considering which - if any - can viably be replaced by other resources.

Although there are various houses sizes, and many differences in quality, the single most dominant building type is the framed house with infill wall materials, covered by a facing of mud, lime plaster, or coral and mortar. The houses are evolutionary: the most important characteristic is that a simple framed structure can be and frequently is developed into a high quality and durable masonry house.

2.2 Building process

Despite local variations, the following outlines the main stages of building.

Construction Stage 1

Step 1. Construction of the lattice wall frame, consisting of vertical poles 11 - 13 cm Ø, with horizontal battens on either side, forming a cavity which will then be filled in. Vertical and horizontal poles and battens most often make use of mangrove, but sometimes bush poles or coconut branches are used. The poles are either placed in a stone foundation plinth, or stuck directly into the ground. Termites are a problem in some places.

Step 2. Construction of the roof frame, using mangrove poles. The roof is frequently covered before further building takes place, especially in the case of thatched houses. Most houses also have a false ceiling of poles placed closely together, and this may be plastered over to give a smooth finish, with just the main beams at 50 cm centres left visible.

Step 3. The wall cavity is filled in. Filling materials vary, and the following are used: mud; mud and coral; lime mortar and coral. The amount of coral varies from almost none to almost solid coral infill. The surface of the wall is very rough. The surrounds of doors and windows are often built up with a facing of coral and mortar, to the thickness that will be achieved by the future facing coat of coral over all the wall.

Step 4. Optional plastering: many houses, especially where coral is scarce, are plastered with mud, and also finished with a lime based plaster or whitewash.

The house may stop being built after either step 3 or step 4. The floor may be of compacted earth, or coral infill and a cement or lime screed.



*Construction Stage 1 —
The wall and roof frame complete with the walls filled in with coral lumps and mortar.*

Construction Stage 2

Step 5. Where time and resources permit, internal walls may be plastered or, if possible, faced with coral stone and lime; the outside front façade is faced with coral stone and lime mortar, to a smooth and neatly squared finish.

Step 6. Remaining walls (in secondary façades) are faced with coral and lime mortar.

Step 7. The steep thatched roof may be replaced by GI sheeting on a shallower pitch.

Carved wooden doors and if possible quite decorated windows will be added according to the owner's means.



Construction Stage 2 —

Coral and lime facing on a completed house. Annex buildings are at different stages of development

Completion of the house may take several years. Skilled builders can be brought in for specific and difficult tasks, such as getting the framing straight, or putting on the coral facing on the walls. But economies can be made by collecting one's own materials, by supplying one's own labour, and by getting help from neighbours. The cost of a house can thus be varied, and one can stop building work at various stages in the house's development.

Although a simple framed house can deteriorate quite quickly, and especially in areas where there are termites, the finished quality of a stage 7 house is very good, and can last for many years. However, in the case of Chole, interviews suggest that from generation to generation new houses are built and old ones left to decline. This is possibly less the case in Jibondo, where much more coral is used and a more substantial house achieved.

Overall, the house building process has the great advantage of being flexible, allowing each family to adapt the quality and the rate of construction according to their means.

2.3 House construction costs

Figures are based on the construction of a 64m² house on Jibondo, where coral consumption is the greatest; and compared by substitution with other islands. In all cases, economies are made by each family through the collection of materials and through their own labour. The figures do however give a basis for comparison.

<i>Item</i>	<i>Unit</i>	<i>N°</i>	<i>Unit cost</i>	<i>Cost (Tanzanian shillings)</i>		
				<i>Jibondo</i>	<i>Chole</i>	<i>Jibondo Wall building material costs alone</i>
Labour for walls	(given cost)		30,000	30,000	30,000	
Skilled labour for walls	(given price)		30,000	30,000	30,000	
Binding twine	bundle	1	10,000	10,000	10,000	10,000
Water	sea water			0	0	
Large poles	pole	400	125	50,000	24,000	50,000
Small poles in walls and roof	pole	2000	50	100,000	gathered	50,000
Coral stone, infill	trip	4	10,000	40,000	gathered	40,000
Earth	trip	4	10,000	0 or 40,000	0	
Sand	trip	3	10,000	30,000	0	30,000
Lime	bag	70	500	35,000	0	35,000
Thatching	mat	1,000	500	30,000	30,000	
Facing coral	trip	4	10,000	40,000	40,000	40,000
Sand	trip	5	10,000	50,000	Gathered	50,000
Lime	bag	80	500	40,000	4,000	40,000
Floor - coral 12 m ³ or compacted earth				48,000 or 0	48,000 or 0	
Total				573,000	252,000	345,000
<i>Assuming max savings in paid materials</i>				<i>485,000</i>	<i>204,000</i>	

The substitution of earth for lime mortar, and the gathering of loose land based coral on Chole quickly drops the price of a house construction to half the priced cost of a house on Jibondo. The wall materials **alone** on a house in Jibondo amount to 345,000 TSh, which gives a basis for calculating the pricing of limestone block production, (see below) in the event that these might replace framed coral wall construction. In reality many of these materials are not paid for.

3. Housing and building in the Mafia Island Marine Park

The Marine Park area and adjacent parts of Mafia island can, for the purpose of this study, be considered as eight different regions or categories. These are:

1. Jibondo Island
2. Juani Island
3. Chole Island
4. Bwejuu Island
5. Utende (Mafia Island)
6. Baleni/Kungwi (eastern sector, Mafia Island)
7. Chemchem/Dundani (south-western sector, Mafia Island)
8. Kilindoni (Mafia Island)

The latter four areas on Mafia Island itself typify relatively distinct conditions, either in terms of resource use or wealth.

3.1 Jibondo Island

The southern most island in the Park, with a limestone base and only a very thin covering of soil. Low coral cliffs surround the island, and there is almost no land based sand. The eastern part of the island is covered by low coastal bush, whilst there are small areas of coconuts trees in the west to the west and east of the only settlement.

The population of Jibondo was 1301 in 1987, probably nearer 1500 in 1995. Compared to the other islands, and judging from the quality of building, the population appears wealthier than that of the other islands. The main activity is fishing and sale of marine products, including octopus.

Settlement

All the houses are clustered into one dense area in the village of Mzini. The older part of the village on the northern shore is most densely built on, whilst to the west and south the houses are all laid out in neat rows, with 8 to 10 metre spacing between each plot. It was suggested that this has been to reduce the risk of fire from thatch.



Houses at different stages of completion on Jobondo

Water on the island comes exclusively from water catchment, there is one large water reservoir and catchment system in the village, and another under construction by the school. Many of the houses have their own catchment system and small reservoir when the roof is made of galvanised iron sheeting. Water is channelled from roofs on GI sheets. A cheaper solution enabling more people to do this would come from using GI gutters.



Water catchment from tin roofs, Jibondo

Pits excavated into the limestone are also used for latrines and rubbish. These pits are an example of how the limestone base of the island can be quarried down to depths of four or five metres.

Building

Roofs on houses are either coconut thatch or GI sheeting. The former still predominate.

Houses and other buildings on the island can be categorised in four main wall building groups.

1. Mangrove pole frame, substantial coral infill with mud mortar, except round openings, where lime mortar is used;
2. Mangrove pole frame with substantial coral infill and lime sand mortar;
3. Solid coral and lime mortar construction in four recent cases;
4. Cement block construction.

There are very few cement block houses, but the use of lime mortar would appear to be replacing mud for those who can afford it. Earth is a scarce commodity and has to be imported by boat. A high proportion of houses have well finished coral and lime facing on all walls. Given the use of large quantities of coral stone and lime mortar used in the walls and in the wall facing, the mangrove frame is structurally almost redundant. Solid coral masonry probably uses little more material. Coral and lime facing provides protection from rain and makes the walls stronger.

Building activity can either be a family and community operation, or it can involve a skilled builder (*fundi*) who contracts for a complete job, although not necessarily for the complete house construction. This may be done in several stages over several years.

Building materials and costs

A lot of people collect their own materials, and thus the costs given below are not always the cost that has to be actually paid.

- Almost all the coral being used is sea based, and much of it is live coral, some of it coming from quite far away. A boat load costs 10,000 Tsh.
- Sand is imported by boat mostly from Chole, and costs 10,000 Tsh per boat load (about 2m³).
- Earth comes from Mafia, and costs about 10,000 Tsh per boat load.
- Mangrove poles come from Rufiji, in preference to Juani, because the poles are straight and strong. A bundle of 20 poles costs 2,500 purchased on the island.
- Lime is produced on the island using sea based coral, with mangrove wood being used for fuel.

The mangrove wood comes from Juani or Mafia, although Jibondo mangroves were used in the past. There are at least six different lime production sites, and on some of these there is space for three or four pyres. See section 4.1 for lime burning and kiln details.



*Lime from coral and mangroves for fuel:
lime "kiln" on Jibondo*

Because of the use of a lot of coral inside the mangrove wall frame as well as in the wall facing, and the increased use of lime based mortar at all stages of construction, the volume of coral being consumed in each house is considerable. From data collected during interviews with local builders, the construction of a 64m² house with walls 2.8 metres high using lime mortar at all stages of construction, and with a coral stone floor, consumes about 60m³ of coral, of which over half in the production of lime. Quantities depend on floor finish and wall thickness, but in all cases the use of coral in both infill and wall facing represents a huge extraction of coral from the sea.

In Jibondo, with approximately 220 households, piles of stone for facing are being collected outside at least one third to half of the houses, representing a conservative volume of coral to be used in the medium term future in the order of 2,000 m³, or 4,000 m² of coral. Since the majority of the houses have already been built to the completion of stage one (wall infill) there is urgent need to promote a reduction in the consumption of coral in facing in new building.



Coral lumps ready for facing an existing house, Jibondo

This will not be easy. The buildings have thin irregular framed walls, which will inevitably consume large volumes of mortar and coral chips to achieve the desired smooth finish. Whilst in new building solid land based limestone blocks can be promoted, the best option for facing of existing building lies in replacing sea coral with limestone chips from land based quarries. Under the present circumstances it is difficult to imagine that volumes of lime used in facing could be significantly reduced. However, as in other parts of MIMP, fuel consumption in lime production could be reduced, and in time land based limestone promoted for use on kilns.

Cement use is not practical, as it is both more expensive and requires fresh water.



Wall building on Jibondo

Resources

On Jibondo, land based limestone is the most available building resource, essentially unexploited. The MIMP should promote the quarrying of land based limestone to produce fafaced regular building blocks, which can be laid with less mortar to build load bearing walls needing little or no facing. The limestone is sufficiently soft to allow cutting. Pits from quarrying can be used for water collection in the future, and limestone chips can be used for facing on existing buildings.

Limestone quarrying can be done mechanically, but with soft limestone it can also be done manually using sharp cutting bars or hand saws.

3.2 Juani Island

Juani island has a limestone base, with in many parts a soil covering of 1 to 3 metres, seemingly with a quite high clay content even near to the surface. The island is surrounded by an extensive coral reef, narrow on the eastern shore. There is only a little sand near the main inhabited part of the island, but sand is available by boat in the north of the island.

There are large areas of mangrove round the island, but the land itself is mainly covered by quite low tree and bush cover stunted by the effect of hot winds blowing off the Indian Ocean. Vegetation gets taller towards the west, but the exposure of the island means that mangroves trees are shorter and twisted when compared to those of the Rufiji delta.

There are small areas of cultivation, mainly in the western and more protected side of the island which is more fertile.

Fresh water comes essentially from rainwater harvesting, and there is one large government built water catchment site near Kisima Jumbe. There are a few wells.

Although the population figures for Juani and Chole are combined in the 1989 census with a total of 1,258 people, Juani has a very low population density, and much lower than Chole. The village council representative said there is no problem of land availability, and houses are very widely scattered.

Settlement

The main concentration of dwellings is near to the bay at the central northern part of the island, although even here the buildings are scattered.

Juani is reputed as a source of lime production from live coral, and seven separate kiln sites were counted just along the northern shore, using local mangrove for fuel. The quality is reputed to be better than that of Jibondo, and lime sells for up to 700 Tsh for a 50 kg bag. Production is undertaken when an order has been placed, but supplies of lime are currently available, some in sacks. The revenue from lime production must in past years have been quite considerable. The airport runway project apparently helped to raise prices, but this market has stopped and production appears to have dropped.



Severely cropped mangrove forest on Juani

In the vicinity of the kiln sites there are signs of quite severe mangrove cutting, with large patches where on stumps of trees show out of the water, and little greenery. Should there be a renewed demand for lime on the scale called for over the past ten or more years for the airport runway at Kilindoni, both coral consumption and mangrove cutting could present a serious problem given the number of lime production sites. When demand for coral was high, coral is apparently taken from the reefs at the southern end of the island, and over a wide area. Land based coral limestone is also available on Juani.

Scarcity of fresh water is one constraint in developing alternatives to the use of lime.

Building materials

The mangrove forests on Juani produce poles which are not as long and straight as those that come from Rufiji, and the price for 20 poles is lower, but many people from Chole and Juani use these and bush poles for construction.

Of the houses visited most were only built to the first stage of pole framing, mostly with earth as the predominant infill material, and only a relatively small amount of large coral infill between the framing. Several houses have an external finishing of mud plaster with inset coral chips, some in the form of decoration.

Roofing on most houses is of coconut palm thatch, lasting about three years. The use of a specialist builder is not always considered necessary, at least not for the first stage of construction.

On a few houses work had commenced with building up the outer facing of coral stone in lime mortar, starting with the front facade of the house. The level of development of the houses and the size of the population suggest that at present domestic building does not present a major drain on sea based resources around Juani. This would change slightly should there be an increase in the amount of coral stone and lime based mortar facing being done on buildings which could be spurred by an increase in economic activity.

Resources

The island is quite self sufficient in building resources, although dependant on marine based products. There is sufficient earth to make earth block production possible for wall building.

3.3 Chole Island

Chole island is about two hundred metres long and less than one hundred metres wide. The island has a covering of earth, and supplies of sand. Top soil appears sandy overlaying a clayey base. Agriculture takes place on much of the land. There are coconuts and other tree cover, including baobab trees, a potential source of tannin that can be used in stabilising earth in building.

Water on the island comes from wells. Population figures are shared with Juani, but taking local indications of population and density, probably upward of 800 people live on Chole.

Settlement

From the air Chole island appears to have a fairly equal distribution of housing over its whole area. People live by subsistence farming and fishing, although a number also work on the Mafia mainland. There is a regular ferry service. There are remains of the colonial administrative centre established by the Germans on the north of the island, built with load bearing land based coral masonry. The island has the only two storey building in the area and there are plans to develop these ruins into a tourist hotel complex (see annex). Interviews on the island suggest that supplies of land based coral were good in the past during the period of German occupation, and a large labour force was used to get this stone.

Houses are mainly situated in small family farming plots, sometimes two or three dwellings close together, occupied by succeeding generations.

House form and building process

All the houses built by the inhabitants use mangrove and bush pole frames. In the majority of cases the frame has a mud infill and a moderate amount of coral. Some of these houses have been finished off with an earth based plaster and then a lime based final coating, but several were also being faced with coral and lime. Facing is applied above all to the public facade of the house, and in many cases this was the only facade with any finishing. Interviews suggest that people would aim at facing the main facade, and that some people will then go further and complete facing on other external walls. However, facing and/or plastering is done on firstly on walls that can be seen from the public footpaths, and bears no visible relationship to climatic orientation. Tree cover and the protection from the Indian Ocean afforded by Juani island reduce the need for external protection from rain bearing storms. Compared to Jibondo, evidence of wealth in building is less, and discussion with Chole inhabitants suggests that the availability of fruit and crops make life easier but less cash based.

Building activity on Chole does not at present represent a serious depletion of sea based resources, but even more so than on Juani, this situation could change quite significantly if there was an increase in revenue on the island, leading to more facing of existing buildings with coral and lime. Proximity to the main tourist reception sites here on Chole and on the opposite side of the channel at Utende mean that almost certain future tourist development may in turn lead to an increase in coral, lime and mangrove consumption on Chole. Alternatives need to be promoted actively before this potential becomes an increased reality.

Building materials

Mangrove poles and bush poles are brought from Juani or bought from Rufiji.

Earth for building is available locally, and coral stones used as infill are gathered, some from the land.

Sand is available (and is exported). In the case of the new school sea sand has been left to wash with rain for a year, and cement has been used instead of lime, but with sea water, which gives poor results.

There are a few lime burning sites, but not on the scale of either Juani or Jibondo.

One small experimental building was constructed by the Frontier Tanzania project¹ in 1994 on the island using unstabilised compressed earth blocks and a Cinva-ram type manual press. The quality of the blocks was perfectly acceptable, but the quality of building work was extremely poor. In addition, apparently due to shortage of funds the building was not roofed, and part of the exposed walls collapsed during the rains. This has been rebuilt using mangrove poles and mud infill, and the overall result gives a very poor impression of the potential of earth blocks as a load bearing building material. This is unfortunate, since earth suitable for making uncompressed or compressed blocks is available, and probably in sufficient quantities to meet new domestic building demand, provided that any top soil removed during excavation is replaced for further agricultural use. The depth of pits should be determined site by site.

Trees available on the island are probably too few to be considered a sustainable source of building wood or fuel. Non-destructive use of bark and leaves from baobab trees could be used for obtaining tannin to mix with earth in buildings, in order to increase rain water resistance.

Resources

Less autonomous than Juani, Chole exports some of its materials (sand) but brings in others (poles). Earth is available for building on the Chole, in quantities that would make a medium demand for building sustainable. But should demand increase, competition with agriculture needs will inevitably limit how much sub-soil can safely be taken.

¹ Frontier Tanzania is a joint research effort of the Society For Environmental Exploration, UK, and the University of Dar es Salaam, Tanzania.

3.4 Bwejuu Island

Bwejuu island lies in the western corner of the MIMP, between Mafia and mainland Tanzania and the Rufiji river. The island is a narrow sand cay, largely covered by coconut trees. There are three shallow wells (very dirty), and three water catchment pits, one at least built by the government and roofed with GI sheets. The resident population is about 400 people, but an additional temporary population also use the island as a fishing base. With one or two exceptions all the houses are pole constructions, and probably over half have walls made with woven palm fronds, supported by horizontal palm leaf stems. More substantial houses have an earth infill with some coral, taken from the sea to the south of Bwejuu.



Housing using coconut palm products on Bwejuu

Earth for building is brought in sacks for mainland Mafia, excavated freely in the area near the village of Mlongo. It costs about 500 Tsh for a 50 Kg bag. Very few houses have any external facing with coral.

Mangrove poles are either collected from Rufiji, in which case the cost (permit included) is about 1,000 Tsh for 20 poles, or 2,000 Tsh if delivered to the island.

Sand is available freely on the island. Lime if used comes from other islands, notably Jibondo.

Most houses have coconut palm thatched roofs. Overall, the housing is poor and simple, and generally smaller than on the other islands. With the present state of building, the island is a very low user of marine based resources. The serious shortage of water makes any masonry construction difficult, and almost precludes the use of cement.

Termites appear to be a problem here (more than on the other small islands), and houses start to need serious repairs after three years.

Resources

On Bwejuu building activities have at present a very limited impact on marine resources. In addition, the limited scope of resources are such that the existing building methods are probably the best adapted to this islands conditions. Changes would require a radical alteration in revenue, materials supply, and technical knowledge, any of which would be hard to justify under present circumstances.

3.5 Utende (Mafia Island)

Utende is the main village in the south east of Mafia Island, and faces Chole Bay and the heart of the MIMP. It is the site of two tourist lodges and more are under construction or planned. The MIMP HQ buildings will also be sited here.

Resources

Situated 15 - 30 metres above sea level, the Utende area has loamy soils with more clayey soils and sand also available. Rich clay deposits can be seen below the sandier soils. The area is partly covered with a variety of trees, including coconut. Water is available from wells, and the two lodges are connected to a piped water system. Over consumption of water is a serious threat, and could destroy the existing water supply by drawing up salty water into the upper layer of fresh water. There is electricity carried across the island from Kilindoni.

Settlement

Away from Utende village houses are scattered and sited on their own farm plots. Utende consists of a concentrated group of dwellings and stalls, spread along either side of the main dirt road. With few exceptions houses are built with mangrove framing and mud infill, sometimes plastered very neatly, and there is no indication of major use of coral in stage one house construction. This is not the case for some of the wealthier houses, including expatriate accommodation, and there are several examples of major use of coral as an infill material inside the framework, similar to buildings on Jibondo.

Tourist construction appears to use cement/sand blocks, and limestone gravel from the north. There are traces of lime burning sites along the main dirt road, probably for specific building construction.

Utende typifies the divide between building methods and resource use by the better off, and resource use by the poor: most village buildings are low users of marine based materials, whilst more expensive construction in the area to the south-west of the main road make considerable use of coral. One can foresee the potential effect of increased revenue amongst the local population that might come from both increased tourism activity and activities attracted by the MIMP HQ's presence. As in Chole, it will be important to put in place a demonstrated and viable alternative to using coral in construction before there is an increase in local building activity. In this area, earth is one of the materials that could be promoted, and a variety of technical options can be presented to suit different needs amongst local and incoming building needs. Building with cement blocks, although a low marine resource user, nevertheless requires using fresh water which is in short supply. All building projects should promote economic water use both in building and in washing and waste handling.

3.6 Baleni/Kungwi (eastern sector, Mafia Island)

Several villages are located in the eastern part of the island bordering onto the MIMP zone. For the most part this is an area with good building soils, but there are also accessible sources of land based limestone. Part of the area has been planted with coconuts, but there are also large areas of heath. On the eastern side of the area the Mlola forest in one of the last remaining natural forests on the island, which serves as an important windbreak for villages and farming inland. Water comes from ponds and wells.

Settlement

Houses are scattered within village groups, situated amongst the plantations of coconut and other trees.

Building

Buildings are mostly constructed with a pole frame and earth infill. Little coral is used as infill for most domestic construction, although there are exceptions to this where means allow. In addition to good building soil, the area has other potentially useful resources that can be developed.

The eucalyptus and acacia pole plantation

Planted by the Tanzanian Electricity company, and ceded to the Mafia District, the plantation area appears totally neglected, with many of the trees in poor condition. This resources could be exploited in order to reduce the level of consumption of mangrove poles. Harvested poles from the plantation could be marketed through material banks on the coast.

Earth for building

The Frontier Tanzania project evaluated the local soil for building with compressed earth blocks (CEB) in 1994, and confirmed to the village council that the soils are suitable, and that they hoped to put in place a pilot building project. It should be noted that the soils are also quite suitable for simpler, non compressed earth construction which could be more accessible to the local population with little loss in building quality.

Adopted measures for controlling resource use

The population of Kungwi have been informed in 1994, apparently by members of the Frontier Tanzania project (unconfirmed) that various conservation measures are necessary in the context of the MIMP. These measures included not using sea based coral, not using land based coral for building or gravel production, (apparently because the land based coral harbours rare snakes); not using wood from the forest. The village council discussed these ideas and agreed to respect them. However, the level of information appears confused: the forestry assistant in Kungwi said that local inhabitants could exploit local timber for their own use, but that non residents of the village could not; whilst the villagers thought they could not get wood from the forest. On another front, the villages now believe that using land based coral is not allowed, but the representatives of the village also said that pressure to supply aggregate for the construction of the Kilindoni police station also created a conflict of interest. Therefore, it will be important, as in other parts of the island, to define a clear policy with the village, to demarcate areas where land based stone resources can be exploited, and to promote a better management of forest and plantation resources.

3.7 Chem Chem/Dundani (south-western sector, Mafia Island)

This area to the south of Kilindoni has loamy soils with a clay underlay, suitable in places for building. Coarse sand and clay was extracted from a quarry to the south of Dundani for surfacing the runway. The area has the main Mafia Coconuts plantation in it, and there are other large stands of coconut.

Settlements and building

There are several very scattered villages, where most of the houses are pole construction with earth infill. Very little coral is used in most of this area. There are also a few cement block buildings.

Materials production

A very small vertical shaft lime kiln was established at Chem Chem in 1970 with technical assistance from the Tanzanian Small Industries Development Organisation (SIDO). No land based coral is available in this area, and the kiln used sea coral from Manga Reef. It was operated by the village union, and ceased production in 1989. Reputedly the quality of lime was very good, but the location of the site 4 km inland from the sea and the nearest source of coral, and the costs of transport contributed to the cessation of production.



Disused lime kiln at Chemchem

3.8 Kilindoni (Mafia Island)

Kilindoni is the administrative centre of the island on the eastern coast, and has the largest population. There are quite regular boat links to Dar es Salaam, and non local materials including timber, galvanised iron sheeting and cement are available.

For building, the town can be divided into three zones.

1. Construction, essentially in the centre and north of the town, using cement blocks and GI roofing;
2. Construction on the Kilindoni - Utende axis, where there is a mix of cement block and GI sheet construction, and mangrove pole and coral infill construction.
3. Construction in the southern extension of the town, nearer the sea, where pole frame and mud infill with some or no coral dominate.

People would seem to aspire to the cement block building, but many cannot afford it.

Overall, Kilindoni is not a high consumer of coral for construction, but mangrove poles are imported here from Rufiji, and there is one formal importer.

Lime for construction also comes from other parts of Mafia and the islands, notably Juani and Jibondo. During the period from the early 1980's until 1993 lime was also obtained by Mafia Investments, the sole authorised agent for lime purchase. Lime was destined for the stabilisation of the airport runway. There are plans to asphalt the runway, and this will reduce the likelihood of further high demand for this programme.

Larger construction projects make more use of cement. Construction with reinforced concrete does however create a demand for aggregate, which is produced by breaking up lumps of land based limestone, mainly from the north of the island. Conflicting information about aggregate production has been given to some of the communities on the edge of the MIMP, and this needs clarification.

Kilindoni does not represent a significant drain on marine based resources.

4. Building materials and their production

4.1 Lime

On Jibondo, Juani, Chole, and Mafia, lime is produced from sea based coral, and to a much lesser extent, from land based coral. There are many kiln sites, including at least half a dozen each on Juani and Jibondo. Some sites group a number of 'kilns', and are obviously used repetitively; other sites are for one-off firing, and are situated near to where someone is building. In reviewing lime production one is more interested in the main kiln sites, but nevertheless, the fact that lime production is an accessible activity is socially, and perhaps economically, important: one can make one's own lime, and in times of need, it is an alternative economic activity.

Kilns are rudimentary. Single batches of limestone are fired, using wood for fuel. Logs are piled up in a 2 - 2.5m radius, to a height of 1 metre. Coral, broken into fist sized lumps, is piled up on top of the wood, to a central height of about 1.5 metres. Coral provides high calcium limestone with a total oxide content over 90%.

The pyre is built completely above ground, and no effort is made to protect it from wind and to control heat loss, although a screen is sometimes used to shelter the structure. Each firing consumes about 13m^3 of coral/limestone, and about the same volume of wood. One kiln produces about fifty 50kg bags of quicklime per firing, which has to be slaked with water to produce lime.



Mangrove fuel for lime production. This pile is ready for loading coral.



Burnt lime.

Firings could probably take place as often as once a month, but in practice lime is fired only when a client asks for this, and the volume of lime produced per kiln is (a) very varied, and (b) subject to market demand. During the mission, three firings were in preparation, and fired lime was available on Juani and Jibondo. Lime is left to slake on the spot.

The quality of lime produced is good, thanks to the porosity of the coral, which allows heat to easily reach the centre of each lump. The lime, because of its purity, produces good whitewash and plasters, but land based lime, with a slightly higher density that needs more care in firing, would also produce perfectly satisfactory lime for building, and especially for making mortar, which is the largest lime consumer in the building process.

Batch kilns, because of intermittent firing and no benefit from pre-heating, are not fuel efficient. On the other hand, wood is the most suitable fuel for use in batch kilns.

There is technical scope for improvement in lime production, with benefits in reducing mangrove consumption and sea based coral consumption. But there are social and economic constraints.

Permanent vertical shaft kilns could be developed at low cost. These work at their simplest to protect the kiln chamber from heat loss, but can also progressively improve the quality of the product. In the case of coral, the interest would be in reducing fuel consumption, in reducing coral waste through better firing, and in making it easier to fire denser land based coral to a good quality through better heat control and possible pre-heating. Given that the MIMP would like to see a reduction in overall coral consumption, continuous kilns that are fed from the top are not going to be very interesting, despite their technical advantages. Centralising lime production into the hands of a few people also means losing the social benefit that anyone can make lime, and might increase prices. Innovation should therefore focus on:

1. reducing fuel consumption;
2. actively promoting the use of land based limestone, which is at the moment regarded as being inferior to sea based coral;
3. making simple techniques accessible to most lime producers, in preference to making lime production exclusive.

The following innovations should be possible:

1. Excavation of firing pits, especially on Jibondo, to create a semi interred kiln base, with a controlled supply of ventilation and protection from wind. Pits can be excavated at many of the existing sites. On Jibondo, extracted material can be used in the next firing. Pits would help to reduce energy loss.
2. Partial use of charcoal: charcoal from coconut trees and shells has a high calorific value, but burns with a clear gassy heat which is not ideal for lime production. However, given the need to reduce mangrove consumption, at least partially, the mixed use of charcoal placed in the kiln would help, where the charcoal is mixed in with the limestone. The product will be less useful for whitewash, but will produce good, or even better lime for mortar. Wood, including old coconut, would also be needed, as the dampness in wood provides a better fuel supply for lime burning.
3. Promoting the use of land based lime chips for burning, where the lime chips are a side product of lime block quarrying. Fuel consumption and the optimum stone lump size should be determined to make sure that heat passes slowly through the limestone.

One 50 kg bag of lime normally costs 500 Tsh.

4.2 Aggregate

Aggregate for concrete is presently produced by hand, breaking down lumps of land based limestone with a hammer. This is laborious, but does mean that the revenue from this activity can be shared. In villages where there is limestone available, aggregate production sites need to be designated.

Mechanisation of aggregate production would be possible, but would place production in the hands of one organisation. Nevertheless, given the absence of gravel on the island, future large scale construction projects would probably justify setting up a gravel crushing plant in the north of the island.



Landbased limestone being broken for aggregate

4.3 Lime block

On Jibondo island, the only realistically exploitable resource is the consolidated aragonite limestone base of the island. This is a thick and uniform, and soft enough to be cut easily.

Blocks can be produced by manual or mechanical cutting. Hand cutting has been widespread in east Africa, to the north in Oman. Cutting is normally done with a sharp and heavy steel crow bar, a hammer and wedges. A groove is cut down vertically, and then when the desired depth and shape cut out, the base of the block is prised off with the wedges. One man can produce about 20 large blocks in a day. Blocks can be excavated out of shallow pits. Excavated pits can be developed into rainwater catchment areas if lined with mortar.

Blocks can also be cut with a two person rip saw, and productivity can be increased by adding more than one blade to a hand operated sawing frame. This method requires quite careful organisation of the quarrying terrain.

Chips from excavation can be used in lime production.

In the construction of a 64 m² house, the total wall, including partitions to a height of 2.8M, comes to a surface area of 134m². With traditional construction, the value of materials in a mangrove lattice and coral/lime mortar wall with facing stone, comes to 345,000 Tsh.

Using fairfaced load bearing block work, with a limed based mortar, one would require some 1,700 blocks with a face surface area of 40 cm x 20cm. On an average of 20 blocks a day per person, a production cost per day of 150 Tsh would be realistic, of which 100 Tsh for cutting, giving a wage of 2,000Tsh/day.

4.4 Earth block

Examination of earth used in buildings in different parts of Mafia show that in most areas of the main island, on Juani and Chole, sub-soil earth is suitable for building. The Frontier Tanzania project has tested soils in these same areas, and indicated that earth was suitable for compressed earth block production using manual compaction presses. In making a choice of product and production technology, the following points need to be considered.

- Uncompressed adobe bricks would be perfectly suitable for most domestic construction, and will work where the soil is not too sandy.
- Cement stabilisation of earth is very unlikely to be economically accessible for the population. Lime can be used to stabilise more clay rich soils, and where suitable could be used in the foundations of houses.
- Compressed earth blocks made with compaction presses produce blocks of higher density than hand moulded adobe bricks, and are moulded at a lower moisture content which will be an important factor on Chole, Juani and at Utende. However, the introduction of metal presses would restrict block production to those who could have easy access to the press. Alternatively, blocks tamped by hand in a wooden mould would have a lower equipment cost, keep the advantage of a low moisture content during moulding, but remain quite accessible to all. This would not exclude presses, but avoid making them appear indispensable.

A suitable range of options would be:

- promoting hand moulded brick production in simple wooden moulds for adobe bricks, notably where there is access to water;
- hand tamped blocks production for sites where water is in short supply;
- possible use of compressed earth blocks in prestige construction

In the latter case, where possible, one should avoid promoting a double standard of construction where the local population can conclude that they are getting an inferior product.

In all promotion activities potentially undertaken by the MIMP, the accent must be placed on high quality of construction.

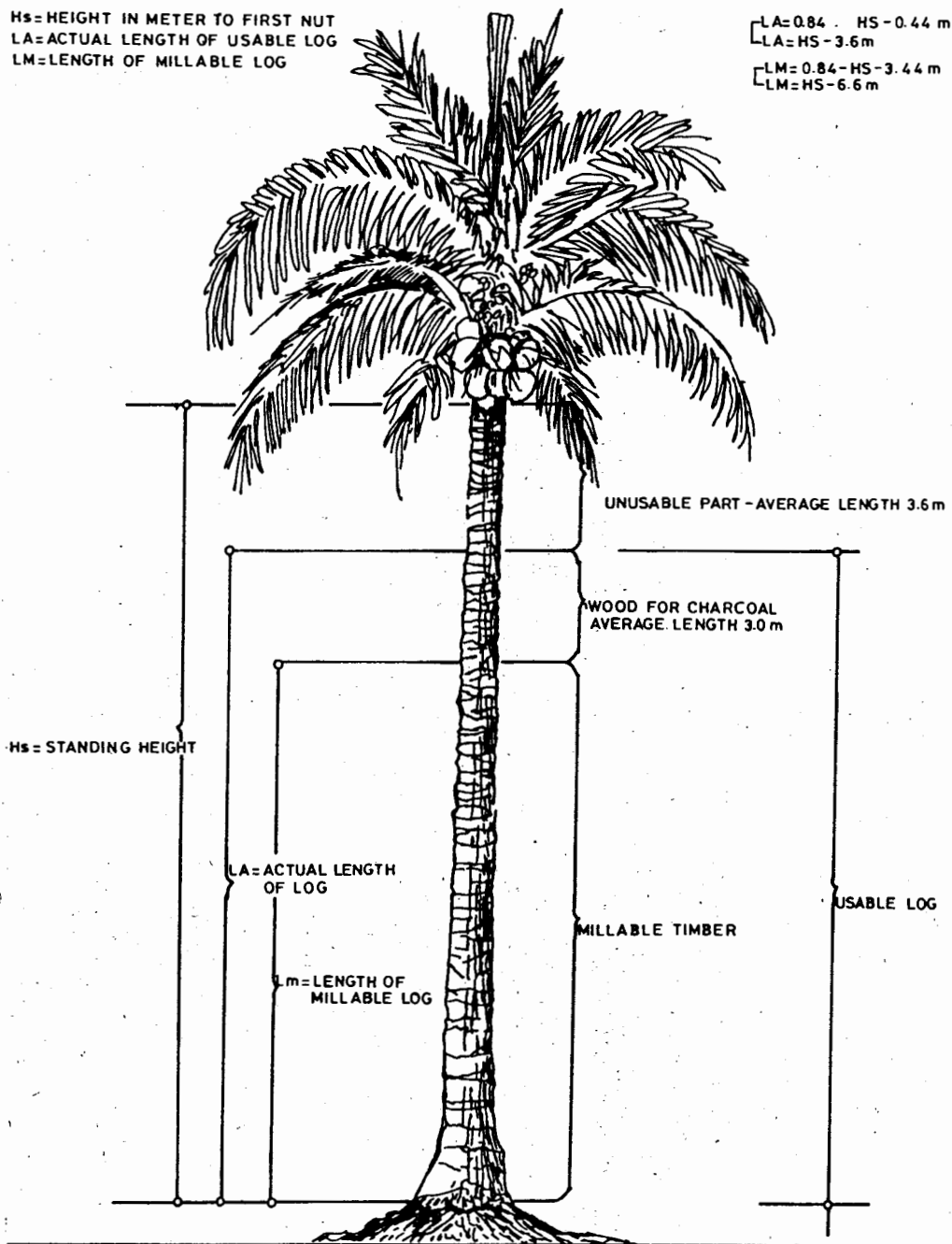
4.5 Coconut

Coconuts are one of the main renewable resources on Mafia, but remain inaccessible to the poor. Over 1.7 million coconut trees grow on Mafia. Many were planted at the beginning of the 20th century, but some new planting does take place. The main producer is Mafia Coconuts Ltd., who manage 5,600 acres of palms, with an average of 40 to 60 palms per acre. The situation of these plantations gives an idea of the potential of coconuts as a resources for the formal and informal building sector:

Mafia Coconuts Ltd. estimates that of a tree population of some 250,000, about 15% at least need the cleared, because they are not productive. On some of the plantations, the level of productivity is as low as 25%, although with care this could be improved. Trees that need to be felled are either unproductive or too old, and this does not represent a drain on productive

trees, but on the contrary is a necessity. Overall, the volume of potential timber is considerable and should be exploited.

Wood in the lower parts of the tree are best for construction uses, but all parts of the tree can be used in one way or another. Coconut wood has been very successfully used to build houses, make roof shingles, and to make furniture. The difficulties lie mainly in the abrasive nature of coconut timber which wears out saw blades; and in the reticence of people to cut a food producing tree, even after it has in reality come to the end of its useful life as a fruit producer.



Source: *Use of the Coconut Palm Stem*, Jensen and Killman, 1981, in "How to process coconut palm wood", Wulf Killman, a GATE/GTZ publication, Vieweg, 1988.

Freshly cut timber is best for sawing, whilst still green. For durability, sawn timber should be treated against insect attack. The best timber comes from the outer ring of high density wood, whilst the innermost core of the tree trunk is of little use as timber, but can have other uses.

- **Splitting:** the tree trunk can be split using wedges. The inner and perishable part of the trunk has to be removed. With hand tools, split boards and rafters can be made. All that is needed is an axe, a mallet and wedges. Investment is low and depends on labour. The finished product is rough, but good for building. But in the same manner that planks are locally prepared for boat building, a quite acceptable smooth finish can be achieved with an axe.
- **Sawing into planks or beams:** short logs can be cut with a two man hand operated rip saw and can produce short planks. It is quite laborious. Chain saws can be used, with low costs but high re sharpening needs. The production rate is higher than manual sawing, but creates dependency on tools that may brake down. Sawing with a circular saw is possible, but needs much more investment, and hard blades with tungsten carbide tipping. Of the three options, chain saw and rip sawing would probably be the most adapted to local milling activities.
- **Firewood and Charcoal:** the nuts of coconuts produce good charcoal. The diagram shows the parts of the tree that can be used for milling and or for firewood or charcoal. For lime production, using stems split into 30cm long billets will give a better result than charcoal because of the manner in which heat is diffused. The best results come from the lower part of the stems, which are also the part that can be used for milling. Where there is a choice, one should use green wood for milling, and dry wood for burning.

Mafia Plantations have a single saw for milling coconut timber into planks, but this is currently broken, due to lack of spares for the VW engine which runs the saw. The 8 metre saw bench can process normally two trunks a day, and the MCL are keen to get this working again, since new management took over in 1994.

Mafia Coconuts Ltd also have a capacity to produce light weight aggregate from coconut shells.

Any exploitation of coconut timber is going to depend on transporting the trunk, or the sawn products, to the 'market' place. Developing and promoting the use of carts and animal traction (donkeys or cattle) could make a contribution, since any land based activity will have to compete with the ease of sea based transport.

4.6 Pole farming and distribution

The 35 ha. plantation at Kilombero in the northern part of Mafia has a dense stand of Eucalytus, and stands of acacia. Both show no signs of being exploited. Planted by the Tanzanian Electricity Company the plantations are now owned by the District. Where stands of trees like this are available, pressure could be taken off the consumption of mangrove poles by promoting the organised harvesting of poles in the plantations, and their delivery to purchase points, in the form of material banks, where the local population can easily come and buy, by boat as well as by road. The purchase price should be lower than mangrove poles. Mangrove poles from Rufiji sell at 2,500 TSH for 20 poles thick poles (Borito) on Juani, but 2,000Tsh delivered to Bwejuu - and 1,000 Tsh if people from Bwejuu collect poles themselves from Rufiji. Mangrove pole prices are cheaper on Juani, but the quality is inferior.

5. Design and development of the MIMP HQ complex

Considerable importance should be attributed to the manner in which the MIMP HQ and infrastructure is developed. It represents one of the largest single visible capital investments that is likely to be made in the park's development. More important, it is a significant opportunity for the MIMP to make a strong and practical statement about how the MIMP views and applies resource use, job and skill development, construction techniques, architectural style, and respect for the overall natural environment it is meant to serve.

The manner in which the MIMP develops its infrastructure will influence, for better or for worse, the local population, the public administration, and the development of commercial and tourist activities.

Whilst park infrastructure provides some opportunities to address the building methods of the population, the Park HQ can significantly demonstrate the ground rules of an approach to building which others, including the tourist industry, should seek to emulate. The selection of the design, siting, materials choice and building process should not miss this opportunity. It is realistic to think that the MIMP will be partly judged on the way it handles its infrastructure.

In this present mission, whilst useful discussion took place with the Directorate of Fisheries about the MIMP HQ, it was regrettable that the Directorate was unable to arrange a meeting between the consultant and Mr. Canacoco, the architect responsible for developing the overall design concept.

Nevertheless, the issues of park architecture are sufficiently complex that it is recommended that the MIMP Board of Trustees profits from WWF's experience of Park architectural development in helping to devise a design philosophy for the MIMP HQ and other buildings in the park.

Taking in consideration an assessment of the site at Utende, the following comments are intended to help in the development of a building concept, and the specific building design.

The site for the proposed HQ has excellent potential. It is defined by high ground and short cliffs to the south overlooking the bay, but descends into an almost natural amphitheatre site on the landside to the north, from which visitors and Utende villagers would always approach.

The land disposition provides an opportunity for the Park HQ to present its public facade towards the point of arrival of visitors from the main road and the Chole ferry. It could then provide routes through the HQ building complex to lead people to the promontory from which one surveys much of the marine park area, or the different offices and functions of the HQ itself.

At the same time, viewed from the sea, where the natural environment of the shoreline and promontory should dominate, the buildings can either be masked by the higher ground, or be sufficiently low to avoid standing out as intrusive landmarks. In this context, the Kinasi Lodge development is almost invisible from the sea, and although much less well masked by trees the Mafia Lodge is not too intrusive thanks largely to the choice of green roof covering. On the contrary, as an example, the new school on Chole stands out sharply because of its white walls. In this context, should a viewing platform be deemed important for the HQ, its construction should be of timber and thus discreet.

The HQ complex should seek to maximise the use of available local resources. The size of the building project should serve as a seed activity for promoting innovative materials production practices, and for training people in required skills:

- developing the use of land based limestone block cutting for masonry;
- promoting the use of earth bricks in certain parts of the HQ complex;
- developing assigned sites for land based limestone gravel production which the population can exploit;
- developing the use of coconut tree timber for construction and furniture;
- developing the use of acacia and eucalyptus poles as a mangrove substitute.

The complex should aim to demonstrate water conservation practices, notably through the choice of low consumption appliances, and it should encourage rainwater harvesting.

Certain resources such as lime will need to be used, and the park HQ should encourage the use of land based limestone in its production, in conjunction with local charcoal as a fuel.

6. Conclusions and recommendations

In this report, the MIMP and periphery area has been considered under eight areas. One can grade each area in terms of:

- its present actual drain on marine based resources,
- the potential risk of overconsumption, and
- landbased resources that may become overused if economic growth takes place.

Area	Name	Level of marine resource use	Potential risk if building activity increases	Impact on land based resources if their consumption increases	Urgency rating
1.	Jibondo Island	Very high; Coral for lime and building; Mangrove for fuel	Little change; use of coral remaining very high; mangrove consumption more detrimental	Less sea based consumption; land based resource require management	High: consumption of coral at damaging level
2.	Juani Island	For building, coral consumption medium to low; for lime production, mangrove and coral consumption high	Lime production could increase	Low, as population low	Medium for lime production
3.	Chole Island	For building, medium to low; for lime production low	Increase in coral and lime consumption if domestic revenue increases	Sand consumption might become too much	Medium, as pop. density is high
4.	Bwejuu Island	Low	Low	Low	V. Low
5.	Utende (Mafia Island)	Medium, some coral used, and some lime	High use possible if high quality alternatives not promoted	Sustainable	Medium, because of potential growth in economic activity
6.	Baleni/Kungwi (eastern sector, Mafia Island)	Low sea resource use	Low, more related to land based resource	Unlikely to change, except pole and aggregate production could increase	Low; useful source of land based materials, needs promoting
7.	Chemchem/ Dundani (south-western sector, Mafia Island)	Low sea resource use	Low	Low	Low; coconut tree exploitation could be developed
8.	Kilindoni (Mafia Island)	Low	Low	Low, except aggregate	Low

This grading suggests that promotion and demonstration activities should be focussed on Jibondo, and on Chole and Utende, with pressure relieving activities promoted in Kungwi #6 and Chemchem #7. On Bwejuu there is no justification for action.

On most of Mafia Island, marine resource use is not critical. but on the smaller islands and at Utende, action needs to be developed that will be a viable replacement that will be approved by the public. Any action at the moment should be considered as a presentation of alternatives to the population for their assessment.

Popular adoption of earth blocks would probably be slow. However, given the indications of a slight move to solid masonry building on Jibondo, one could expect a greater degree of interest in limestone blocks on this island, and there might even be an export potential when they are compared to cement block use in Utende.

A building materials and building process strategy should consider three levels of action, as follow:

1. Promoting publicly accessible materials and technologies —
 - To reduce the consumption of both lime and coral, the production of limestone blocks should be actively developed on Jibondo island. This would require a land use plan, a technical demonstration, and making simple equipment available.
 - To reduce the risk of high coral consumption on Chole and at Utende, earth block production should be demonstrated - with high quality - and actively promoted.
2. Developing resource conserving technologies which are available to the public —

Lime cannot be eliminated as a resource, and the options are mainly to reduce the amounts required, and to reduce the amount of fuel needed to produce it —

 - The MIMP should encourage the development of more fuel efficient lime production methods, where less energy is wasted through poor kiln design.
 - The MIMP should encourage the processing of coconut timber with hand tools, unless local very local demand could justify higher investment.
3. Promoting local resource based products on the market through co-operation with local organisations —
 - The MIMP should encourage the development of material banks to distribute poles from plantations, including coconut rafters.
 - The MIMP should explore the possibilities of helping Mafia Coconuts Ltd. (or similar) to re-establish their coconut timber milling plant, through requests for coconut timber for the MIMP HQ and other similar projects. Coconut wood also provides a good source of charcoal, (as do the nuts). This should be promoted through the demonstration of charcoal production. Charcoal production can be undertaken by any members of the population with access to old timber.

In addition and in parallel to the above —

- The MIMP should take every opportunity to use its own building needs, including houses and offices, as a clear statement of how it believes marine and land based resources should be used. This does not seem to be a sufficiently clear part of MIMP policy at the moment.

Annexe 1: Calendar of activities

- 5 June Documentation survey / mission preparation.
- 6 June Travel Toulouse (France) to Dar es Salaam (Tanzania), arrival 2225 hours.
- 7 June Dar es Salaam: meetings with WWF Country Office staff; visit to Directorate of Fisheries.
- 8 June Phone contacts; visit to Zanzibar.
- 9 June Travel to Mafia Island (morning); visit to MIMP HQ proposed site and shoreline.
- 10 June Visits to Chole Island; Misiri; Kilindono.
- 11 June Visit to Jibondo Island.
- 12 June Visits to Chemchem, Kilindoni and Juani Island.
- 13 June Visits to northern and central Mafia; Mafia Coconuts Ltd.
- 14 June Visits to south-west; Jibondo Island.
- 15 June Visits to Bwejuu Island; Utende.
- 16 June Return to Dar es Salaam: meetings with WWF staff and Directorate of Fisheries
- 17 June Departure for Toulouse 2345 hours.
- 18 June Arrival Toulouse (France) 1520 hours.
- 19 - 23 June Report writing.

Annexe 2 List of contacts during the mission

Fisheries Division, Ministry of Tourism, Natural Resources & Environment, Dar es Salaam

- Thomas W. Maembe, Director of Fisheries
- C.K. Rumisha, Coordinator
- O. Karia, Planning
- Modest Kiwia

WWF Country Office for Tanzania, Dar Es Salaam

- John I. Boshe, Country Representative
- Dr Peter J. Stephenson, Programme Officer
- Lucy Kashaiga, Trainee Programme Officer
- Mary Shuma, Environmental Education Programme Coordinator

WWF, Mafia Island Marine Park

- Greg Andrews, Technical Adviser
- Membosho Hisluc, Community Development Officer
- Ally Rashidi Mgeni, Assistant Community Development Officer

Mafia District Commission

- Winifred Francis Mgubi, District Commissioner
- Florian Oscar Hemile, District Natural Resources Officer

UNCHS Habitat, Dar es Salaam

- Mr. Montegno

Village representatives and building/fisheries industries representatives

- Aziza H. Alawi, Village Executive Officer, Chem Chem
- Mohamed Bakin
- George Sam, materials supplier, Kilindoni
- NMadi Omari, clerk, kiln company, Kilindoni
- Salmana Suleymani, Village Council representative, Juani Island
- Atrumani Abdallah Chatto, Village Executive Officer, Kungwi
- Thabit Hussein, Forest Assistant
- H. Maloulou, Estate Manager, Minaki plantation
- M.R.V. Thatpi, General Manager, Mafia Coconuts Ltd, Mombeni
- Seleymani M. Kiboko, Ward Executive Officer, Miburani
- Mawlidi Kamazani Gendemu, Chairman, Village Council, Mlongo village (inside the Mombeni plantation)
- J.O. Kaduga, District Executive Officer
- M. Mtani, Senior Fisheries Officer
- Mohamed Hassan, 60 year old householder, 4 family members (Bwejuu)
- Shaabam Bakari, 50 year old householder, 15 family members
- M. Hamili

Annexe 3: Documentation consulted

Reports, papers

Mafia Island Marine Park, Tanzania - General Management Plan, Institute of Marine Sciences for the ministry of Tourism, Natural Resources and Environment, funded by WWF, 1993.

The Proposed Mafia Island Marine Park, Tanzania - Part I. A rationale & strategy - WWF for the Ministry of Tourism, Natural Resources & the Environment, 1992.

The Proposed Mafia Island Marine Park, Tanzania - Part II. Proceedings of the planning workshop, Mafia Island, October 20 -24, 1991, - WWF for the Ministry of Tourism, Natural Resources & the Environment, 1992.

Marine Resource Use in the Proposed Mafia Island Marine Park, Jessica Andersson, February 1995. (Paper forming part of SIDA working paper series *Studies in Environmental Economics and Development*, Göteborg University, Sweden.)

People and Bats: Conservation of the Comoros Lesser Fruit Bat on Mafia island, Tanzania, Kathryn M. Clark, August 1994. (M.Phil dissertation, modified for use by Ofisi ya Ardhi, Mafia Island, and Frontier Tanzania, a joint research effort of the Society for Environmental Exploration, UK, and the University of Dar es Salaam, September 1994.)

Proposal regarding geological survey for lime and technical assistance in construction and design of lime kiln in Mafia Island, Tanzania: elimination of recent degradation of coral reefs in the area, Torben Berner on behalf of the Chole Economic Development Society, undated.

The Vegetation of Mafia Island, Tanzania, P.J. Greenway, revised by W.A. Rodgers, R.J. Wingfield and L.B. Mwasumbi, *Kirkia* 13 (1), 1988.

Marine Resource Use in the Proposed Mafia Island Marine Park: A preliminary survey, J.C. Horrill and C.J. Mayers. Report for the Mafia Island Marine Park Technical Committee funded by WWF, 1992.

Mafia Island Marine Park Project, Mafia Island, Tanzania: Scientific Report, Gudrun Gaudian and Matt Richmond for The People's Trust for Endangered Species, Imperial College, London, 1990.

Results of the Physical, Biological and Resource use Surveys: Rationale for the Development of a Management Strategy, J.C. Horrill and M.A.K. Ngoile. Frontier Tanzania Mafia Island Report N° 2, 1991.

Architectural plans (to develop ruins of colonial administrative centre on Chole Island into a tourist hotel complex), Derek Jacob Architects, Cape Town, 1994.

Books, monographs

How to process coconut palm wood, Wulf Killman, a GATE/GTZ publication, Vieweg, 1988.

Small scale production of lime for building, John Spiropoulos, a GATE/GTZ publication, Vieweg, 1985.

The coral buildings of Suakin, Jean-Pierre Greenlaw, Oriel Press, London, 1976.

Oman: the problems and potentials of the indigenous built environment in a developing country, Development Workshop (Allan Cain, Farokh Afshar and John Norton), Architectural Association, London, 1975.

Island Technology, ed. Tony Marjoram, IT Publications Ltd., London, 1994.