IUCN Eastern Africa Programme

Mnazi Bay Ruvuma Estuary Marine Park

A Rapid Assessment of Live Coral Mining and Lime Production in Mtwara:

Description and socio-economics in the buffer zone of Mnazi Bay Ruvuma Estuary Marine Park

M. Guard

February 2004

IUCN The World Conservation Union

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For the UNDP/GEF Development of
Mnazi Bay - Ruvuma Estuary Marine Park (MBREMP) Project

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This publication has been made possible in part by funding from UNDP/GEF and FFEM

Published by:

Citation: Guard, M. (2004): *A RAPID ASSESSMENT OF LIVE CORAL MINING AND LIME PRODUCTION IN MTWARA: Description and socio-economics in the buffer zone of Mnazi Ruvuma Estuary Marine Park*, iv + 21pp.

Cover photo: M. Guard

Available from: IUCN EARO Publications Service Unit
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Acknowledgements

The author and the University of Dar es Salaam would like to express their gratitude to all the staff at the Mnazi Bay –Ruvuma Estuary Marine Park (MBREMP) for their assistance in this study. In particular a big thank you to the Warden, Mr Machumu and the IUCN Technical Advisor Dr Anthony King. This work would not have been possible without the assistance of Saidi Abdallah, District Fisheries Officer who helped throughout this study with searches for kiln sites, focus group interviews and Swahili translations, asante sana, kazi nzuri. Also our gratitude to the District Natural Resources Officer, Mr Kinyunyu and the District Commissioner, Mr Sadiki for agreeing to delay the enforcement operation until after this study was conducted. A big thank to Els for her assistant in map preparation and last but not least we thank Ahmadi for driving us around and providing us with good humour.

1. INTRODUCTION

The extraction of live coral to burn and produce 'white lime' or 'chokaa' has a long history in Tanzania and in particular the Mtwara district. Yet in many areas it is believed that this practice has reached unsustainable levels and is considered to be one of the main contributors to reef and forest degradation along the coast. The negative natural and socio-economics impacts of live coral mining are well known and include increased coastline erosion, declines in abundance of fish and invertebrates and the consequent impact on fisheries and livelihoods, changes in the composition of fish communities, loss of aesthetic value to reefs and shoreline that are important for tourism and reduced forest cover (Brown and Dunne 1988; Dawson-Shepherd et al. 1992; Dulvy et al. 1995).

Despite a recent local government ban (2002) on live coral mining in Mtwara, a combination of poor enforcement, a lack of alternative similarly priced building materials, and the fact that the sale of lime provides much needed income to local communities has meant the practice continues and in some areas has intensified (pers obs). This is highlighted by the situation in Mikindani Town, within the marine buffer zone of Mnazi Bay –Ruvuma Estuary Marine Park (MBREMP), where up to 35 kilns are now burnt every month compared to 25-30 kilns, per month, two years before (J.Luc-Solandt, 1999). This level of intensity suggest that significantly more than the 1500 tonnes, estimated by Spalding et al (2001) of live coral are being mined per year from a limited area. The majority of this activity is within the northern buffer zone of Mnazi Bay – Ruvuma Estuary Marine Park (MBREMP) and the implications of such intense exploitation are likely to be increased pressure on park resources and impacts on the ecological systems of the park.

It is therefore important for MBREMP to understand the coral mining industry in the buffer zone of the marine park, from a socio-economic perspective, and its impacts, both biological and economic, and to investigate options for alternative lime production. This is further highlighted by the widespread recognition that marine protected areas (MPA's) may only be effective for biodiversity conservation and sustainable marine resource use if the ecological integrity and health of marine resources around them are maintained. In particular, it is acknowledged that fragmented or isolated areas of protection in otherwise over-exploited deserts are not likely to persist in the long term.

In response to the above need an assessment to describe the size, geographic extent and socio-economics of the coral mining and lime production industry within the buffer zone of MBREMP was developed. More detailed research is further planned to assess the impact of the coral mining industry on MBREMP, and to make recommendations for alternative methods of lime production for communities within MBREMP and its buffer zone. This work is part of a larger national study on the coral mining issue conducted by the University of Dar es Salaam.

The necessity for an immediate rapid assessment of coral mining and lime production activities in the buffer zone of MBREMP came about from a decision by local district authorities to attempt to enforce a previously introduced ban on coral mining with effect from February 2004. The local government ban was introduced in late 2002 but due to a lack of enforcement coral mining continued unabated. The enforcement operation has now gone ahead and coral mining and lime producing activities have effectively ceased in the area. However, prior to this operation it was recognised that for this ban to be sustainable in the longer term more information and a greater understanding was required on the local coral mining industry and the alternative options for lime production. For this reason this study was initiated before the enforcement operation was implemented so as to fill in these information gaps.

The main objectives of this rapid assessment were;

1 To describe the live coral mining and associated lime production industry in the MBREMP buffer zone and highlight the contribution of this industry to local community livelihoods

2 Provide primary raw data and results for incorporation into the MBREMP GIS database for the production of maps and other planning tools

2. METHODS

2.1 STUDY SITES

This study was conducted over a period of five days at 13 coastal locations extending from Mtwara Town to the northern side of Mikindani Town where the study ended at Mgao village (Figure 1). These locations represent the main sites for coral collection, kiln construction and selling of lime in the northern MBREMP buffer zone.

2.2 DATA COLLECTION

2.2.1 Physical Information

In order to identify the location of each live coral landing sites, kiln construction sites and selling areas, extensive searches were conducted by car and by walking along the shoreline. As coral mining was officially banned in the region, kiln sites were often well hidden or in remote areas and sometimes situated well back from the coast. Once a site was found a standardised set of information was collected describing the extent and type of activities present:

Live coral landing sites

- Geographic position using GPS for each location or coral pile
- Number of landed coral piles
- Estimated number of boulders within each coral pile
- Average size of collected coral boulders (indicative of age of boulders and potential regeneration period)
- Maximum and minimum size of coral boulders
- Main species of coral boulder collected

Kiln construction and bagging sites

- Geographic position using GPS for each location or coral kiln
- Number of kilns
- Size of kiln (small = 3m diameter, medium = 4/5m, or large = 6/7m)
- Stage of preparation (being built, ready for burning, burnt, being bagged)
- Estimated weight of wood used for each kiln (based on conversion of timber to lime tonnage ratio (number of bags) for small, medium and large *open* kilns- see Wingate, 1985)
- Estimated weight of coral used for each kiln (based on approximate estimation of mean boulder weight multiplied by number of estimated boulders for small, medium and large kilns)
- Estimated number of bags for recently burnt kilns
- Number of bags filled

Selling sites

- Geographic position using GPS for selling site
- Number of bags at location
- Estimated weight of bag

Depending on circumstances at each site (e.g. presence and attitude of local people) either, prior to, during or after the above information was recorded, introductions were made with the people present and a letter in Swahili explaining the project was provided. Once the purpose of the project was known investigators requested a group interview with the people related to the identified activity in order to gather more information on the artisanal live coral mining and lime production industry.

2.3 SOCIO-ECONOMIC INFORMATION

2.3.1 Focus group interviews

Focus group interviews were conducted with groups ranging from two up to 20 individuals. Interviews were carried out in Kiswahili, based on standardised interview quide that addressed the socio-economics of the coral mining and lime production industry as well as the perceptions and knowledge on the biology and function of living coral (Appendix 1). While large numbers of adults and children often gathered round during interviews only a small group of people (average of six people) were involved with discussing and providing answers to questions. All answers were recorded and additional relevant comments were noted. Each interview took about two hours to complete.

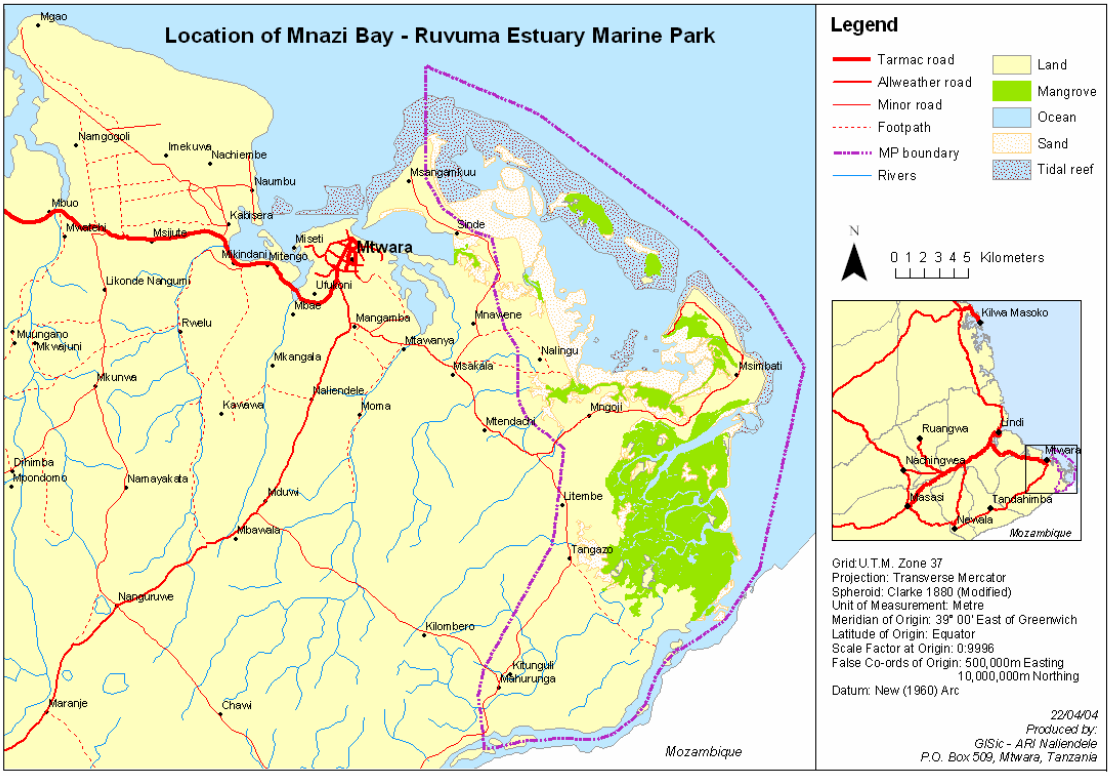

Figure 1: Map of the Mnazi Bay-Ruvuma Estuary Marine Park (MBREMP) and the buffer zone of MBREMP until Sudi Bay.

3 RESULTS AND DISCUSSION

3.1 DESCRIPTION AND SOCIO-ECONOMICS OF ARTISANAL CORAL MINING AND LIME PRODUCTION

3.1.1 Coral collection

Collection of live coral boulders is conducted by hand during low spring tide periods. Collectors travel to the collecting areas in wooden dugout canoes and sometimes small dhows'- which they fill with coral boulders. Generally the coral boulders are comprised of one genera, *Porites*, and mainly a single species, *Porites lutea*, although other species such as *Astreopora* were noted in coral piles. The reason why this coral is preferred is due to its widespread occurrence and it's higher density from its 'massive' form that results in higher quantities of lime being produced compared to the burning branching corals or shells. The average size of coral boulders noted in coral piles was 200-400mm, although some individual stones were as large as 700mm. The majority of coral boulders are collected from shallow sub-tidal areas (0.5-2m) and the main collecting sites identified were Shangani reef, Naumbu reefs, Mgao reefs and Msangamkuu (Figure 2). Historically Shangani was recognised as being the main collecting area with collection from Msangamkuu having only recently started.

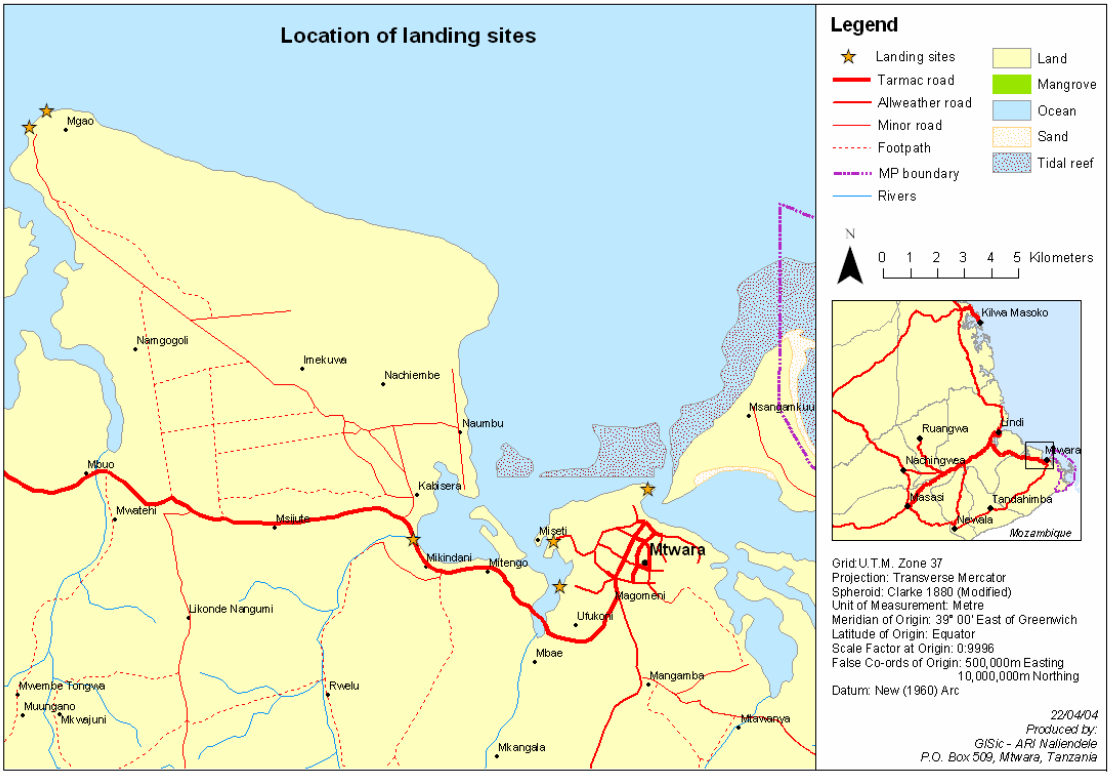

Figure 2: Map indicating the main live coral collecting sites and landing sites identified in this study. Map credit: Els at NARI

Plate 1: Coral boulder piles at landing sites and canoes used for live coral collection.
Photo credits: A. King

Plate 2: Collected coral boulders and broken pieces from larger coral heads of *Porites lutea.*
Photo credit: A. King

3.1.1.1 Trends in availability of live coral production

When asked if coral boulders have decreased in the area, a small percentage of interviewees agreed they had, especially over the past two years. However, the majority said they had not, yet in slight contradiction many explained that they were now starting to collect at Msangamkuu because there were more coral boulders, inferring that there were less nearby. On several occasions large pieces of coral broken from a larger coral head were observed suggesting that small ones that are more easily collected are harder to find. When asked about these pieces, interviewees explained they were taken from deeper water on the main Shangani reef. This may indicate that shallow sub-tidal sites may be over-mined with collectors now needing to mine from deeper water sites.

3.1.1.2 Uses of coral boulders

Coral boulders are used both for the production of lime and as building material for the base of houses. A total of 41piles of coral for building material were observed within villages, with 17 coral piles recorded in the village of Kianga, where extensive house construction was occurring.

3.1.1.3 Economics of live coral mining

Collectors are paid for each canoe full of coral. The price paid is dependent on the size of the canoe and also varied between different landing locations with the lower prices paid at those sites directly adjacent to collecting areas, reflecting the costs of transporting the coral from collection areas (Table 1). For a small canoe load, prices ranged between Tsh 1000-2500 and for a larger canoe prices were between Tsh 2500-4000 also depending on distance from the collecting site. The overall number of canoe loads needed for a small kiln (3m diameter) was estimated to be six loads while for a two storey large kiln, 10-16 loads are required. Collecting of coral boulders may continue for 4-5 days in one spring tide period and both small and large kilns may require a total of two to four consecutive spring tide periods respectively for enough coral to be collected. A total of 59 collectors were estimated to collect coral for the kilns identified in this study and their potential income is provided in Table 1. However, from the group interviews an estimated 88 coral collectors are believed to work in the study area. The highest number of collectors come from Kianga and Misete Villages which lie adjacent to Shangani reef the site where live coral collection has historically been most intensive. Collectors from these villages usually collect live coral for other lime producing sites such as Kilimahewa and Ufukoni. (See figure 1).

3.1.2 Lime production

3.1.2.1 Kiln construction

To produce lime or 'chokaa' coral boulders are placed on open coral kilns and burnt. The construction of a typical kiln consists of a circular base of fuel wood in ordered size layers with broken pieces of coral laid on the top (Plate 3). The size and amount of fuel wood and coral used varies in relation to kiln size which range from small kilns a few metres in diameter to large two storey kilns five metres across (Plate 3). It is estimated that two tonnes of fuel wood and four tonnes of coral are used for a small kiln and 5-6 tonnes of fuel wood and 8-10 tonnes of coral are used on a large double storey kiln (based on calculations indicated in section 2.2.2.1). To aid the burning process a small tunnel is often constructed from the side to the middle of the kiln which enables the fire to be ignited in the centre so an even burn is produced (Plate 4). This tunnel is also angled towards the predominant wind direction to increase the heat of the fire. The aim of this design is to obtain an optimum and evenly distributed temperature so that better quality lime is produced. Higher or lower than optimal temperatures produce under or over burnt lime of less quality.

Table 1: Estimated intensity of live coral collection and monthly and annual income of coral collection for coral kilns identified in the MBREMP buffer zone * estimated number of kilns for Mtwara based on landing sites

Location	No. of kilns per month	Mean price for canoe	Est. tot. no. of trips for kilns	Est. No. of collectors for kilns	Est. tot. income per month (Tsh 000)	Est. tot. income per year (Tsh 000)
Mtwara	*3 small	2000	18	2	45	540
Misete	3 small	2-4,000	18	2	45	540
Kianga	7 small/2 large	2,000	54	5	165	1,980
Ufukoni	2 small/3 large	2-2500	48	4	120	1,440
Kilimahewa	2 small/1large	2-2500	24	2	60	720
Miteng o	4 small/3 large/3 double storey	2-3500	105	9	263	3,156
Naida	6small/2 large/2 double storey	3-5000	90	8	225	2,700
Milumba	7 small/2 large/2 double storey	1-2000	96	8	240	2,880
Pemba	4 small/1 double storey	1-2000	36	3	98	1,176
Mkungu	3 small	2-3000	18	2	45	540
Mgao	6 small/5 large/5 double storey	4000	171	14	428	5,136
Total/ mean	**80**	**2500**	**678**	**59**	**1,734**	**20,808**

3.1.2.2 Status of kilns

A total of 77 kilns were identified in the study area in various states of preparation, with a further 24 kiln sites observed but considered unused at the time of the study (Figure 3). The majority of kilns were located adjacent to landing sites around Mikindani Bay but many were situated in remote areas so as to hide these sites from local authorities. Several sites were found far inland which would appear to have no benefit except to keep these sites undercover. The highest number of kiln sites in a single area was found in Mgao

Plate 3:Fuel wood base construction for a medium sized kiln and part construction of a larger two storey kiln. Photo credits: A. King

Plate 4: Tunnel constructed into the middle of the kiln to enable fire to be placed at the centre to produce an even burn. Photo credit A. King

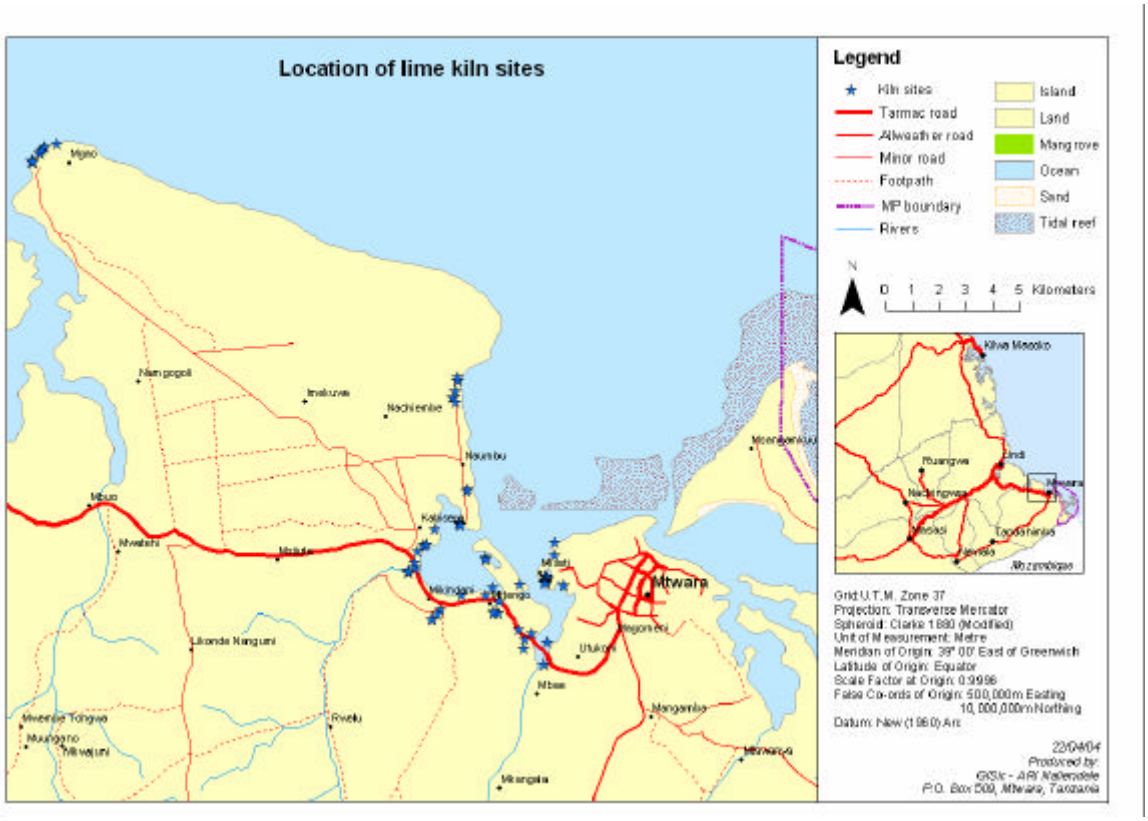

Figure 3: Used and unused kiln sites in the study area. Map credit: Els at NARI

Village where a total of 16 kilns were being constructed or recently burnt. Nearly a third of these were large two storey kilns.

Older interviewees explained that three kiln sites historically operated in Mikindani. However, over the past five years and especially in the last two years, the number of kiln sites have increased due to increased demand for lime from inland sites and the recognition that this industry could provide a good livelihood.

3.1.2.3 Socio-economics of kiln construction

At all villages, interviewees stated that local family or co-operative groups owned kilns with no outside sponsors or *'tajiri'* involved.

While in some cases the kiln owner and relatives conduct kiln construction, the usual practice is to contract local youths working in groups of two to four individuals. Contracts may be worth Tsh 5,000 for a small kiln that may take two days to complete, Tsh 10,000-15,000 for a medium kiln which may take a week, and up to Tsh 25,000 for a large two storey kiln which can take up to two weeks to prepare. The annual total revenue for the identified coral kilns in this study was estimated at Tsh 8,484, 000 or US$ 8,080 (Table 2).

The fuel wood used for kiln construction is predominantly from old cashew-nut or mango trees although mangrove timber was widely considered the best fuel wood as it burns at a higher heat. Most interviewees stated that this timber was not used as it was illegal to cut mangroves. However at Mgao Village it was openly admitted that mangrove was the primary fuel wood used. For a typical large kiln two lorry loads of fuel wood are required and costs for cutting, loading and unloading and transport are between Tsh 50-60,000 per large kiln. At the time of the study, most fuel wood came from Usijute, Likonde and Nalela (see Figure 2). Interviewees indicated that local fuel wood trees were already depleted.

Table 2: Estimated daily, monthly and annual revenue for construction of coral kilns identified in the MBREMP buffer zone *** estimated number of kilns for Mtwara based on landing sites**

	Estimated no. of kilns per month	Mean no. of people to construct kiln	Mean price paid for contract (Tsh 000)	Est. daily income per person per day (Tsh)	Est. tot. revenue per month (Tsh 000)	Est. tot. revenue per year (Tsh 000)
Mtwara	*3 small	2	6	1,250	18	216
Misete	3 small	2	6	1-1,500	18	216
Kianga	7 small/2 large	2	6/12	1,250-1,500	63	756
Ufukoni	2 small/3 large	2/3	6/10	1,500	42	504
Kilimahewa	2 small/1large	2/3	6/10	1-1500	32	384
Mitengo	4 small/3 large/3 double storey	2/3	6/10/18	1-1500	108	1,296
Naida	6small/2 large/2 double storey	2/3	6/10/18	1-1500	92	1,104
Milumba	7 small/2 large/2 double storey	2/3	6/10/18	1-1500	98	1,176
Pemba	4 small/1 double storey	2/3	6/18	1-1500	42	504
Mkungu	3 small	2	6	1-1500	18	216
Mgao	6 small/5 large/5 double storey	2/3	6/10/18	1-1500	176	2,112
Total/mean	**80**	**2/3**	**6/10/18**	**1-1500**	**707**	**8,484**

3.1.3 Burning, hydration and bagging

After the coral kiln is prepared it is burnt (Plate 5). The length of time for a kiln to burn and cool down varies from 48hrs for a small kiln to up to seven days for a large two-storey kiln. Once the kiln has cooled to workable temperatures hydration of the burnt coral is conducted using either salt or freshwater (Plate 6). For inland kiln sites water is taken from local wells. The pouring of water over the burnt coral causes the chemical reaction;

$$CaO + H_2O \rightarrow Ca(OH)_2 + HEAT$$

Calcium oxide + water → calcium hydroxide

(quicklime) (slaked or hydrated lime)

to produce the finished lime product. For a large sized kiln approximately 1000 litres of water are required.

After hydration, the coral lime powder is placed into second-hand cement bags which are then sown together using nylon thread. The number of people used for bagging is again dependent on the size of the kiln but is typically between two and five individuals. For each bag filled and sown a fee of between Tsh 20-35 is paid at sites from Mtwara Town to Mitengo Village and from Naida onwards to Mgao Village a higher fee of Tsh 50 is paid. The reason for the difference in the prices paid was seen to reflect the availability of workers and also it seems the altruistic nature of the kiln owner. Approximately 200 bags are obtained from a small kiln, between 300 to 400 for a medium kiln and up to 700 bags for a large two-storey kiln. Each person can fill and sow about 80 bags per day earning between Tsh 1500-4000. Based on the estimated number of bags filled from the identified kilns the total income/cost is estimated at approximately Tsh 750-900,000 for the month and Tsh9-10.5 million or US$8,571-10,000 annually (Table 3).

For kiln sites situated close to the road, filled bags are usually taken using hand carts to the selling site of the kiln owner. In more distant kiln sites such as Pemba, Mkungu and Mgao Villages, filled bags are

Table 3: Estimated number of bags of lime and total monthly and annual income of bag fillers for the coral kilns identified in the MBREMP buffer zone * estimated number of kilns for Mtwara based on landing sites

	No. of kilns	Est. tot. no. of bags per kiln	Est. tot. no. of bags per mth	Est. tot no. of person days filling bags	Mean price paid per bag (Tsh)	Est. tot. income per mth (Tsh 000)	Est. tot. income per year (Tsh 000)
Mtwara	*3 small	200	600	6	20	12	144
Misete	3 small	200	600	6	20	12	144
Kianga	7 small/2 large	200/400	2200	18	20	44	528
Ufukoni	2 small/3 large	200/400	1400	16	20-30	28-42	336-504
Kilimahewa	2 small/1large	200/400	800	8	20-30	16-24	192-288
Mitengo	4 small/3 large/3 double storey	200/400/700	4100	32	20-35	82-144	984-1,728
Naida	6small/2 large/2 double storey	200/400/700	3400	28	35-50	119-170	1,428-2,040
Milumba	7 small/2 large/2 double storey	200/400/700	3600	30	35	126	1,512
Pemba	4 small/1 double storey	300/700	1900	12	50	95	1,140
Mkungu	3 small	300	900	6	50	45	540
Mgao	6 small/5 large/5 double storey	100/200/350 @ 20-25kg	3350@ 20-25kg	56	50	168	2,016
Total	**80**		**22850**	**218**	**-**	**747-882**	**8,964-10,584**

Plate 5: The burning of a coral kiln. Photo credit: A. King

Plate 6: Water is poured over burnt coral in the process called hydration which causes the chemical reaction to produce the lime. Photo credit A.King

usually stacked to await lorries sent by wholesale buyers. There is often a problem at these villages to obtain used cement bags and on occasions buyers may buy the lime loose for a set price and bag it up themselves. The average or standard weight of a bag of lime is between 12-15kg except at Mgao where the filled weight and size of a bag is larger at 20-25kg. As Mgao is located a long distance from the main road the larger bag size is a direct ploy to encourage buyers to the village. The larger bag size is attractive as wholesale buyers can then divide the lime into two smaller bags thus doubling the number of bags for their money.

3.1.4 Demand and selling of lime

A total of 24 banda's containing 5930 bags of lime were observed at six locations (Figure 4). Of these, four villages, Ufokoni, Kilimahewa, Mitengo and Naida accounted for over 88% of the bags recorded (Table 4). Due to their adjacent positions and competition between selling bandas the price for a bag of lime at these sites was Tsh 500. Nearer to Mtwara Town the price increased to between Tsh 600 and 800. In the more distant villages such as Pemba, Mkungu and Mgao bags are sold to wholesale buyers from Mikindani and inland locations such as Masasi. Bags are sold for Tsh 300 from Pemba and Mkungu and interviewees stated they cannot keep up with demand. At Mgao bags of lime are sold for Tsh 500 but as these bags are larger and can be divided in two the mean bag price is lower at Tsh 250. A total turnover of over Tsh 3 million shillings is estimated for bags observed in the main selling bandas (Table 4). The number of bags observed however, represents only a quarter of those produced in one month and total turnover is expected to be three times this amount (see below). The main use of lime is to mix with cement for building mortar or for the production of cement blocks. The mixing of the two products enables the more expensive cement (e.g. Tsh 9000) to go further thus reducing overall building costs. Lime is also used as a whitewash for buildings. Demand for lime has markedly risen due to increased building activities in coastal and inland areas. The number of bags sold at inland sites is presently unknown but should be studied.

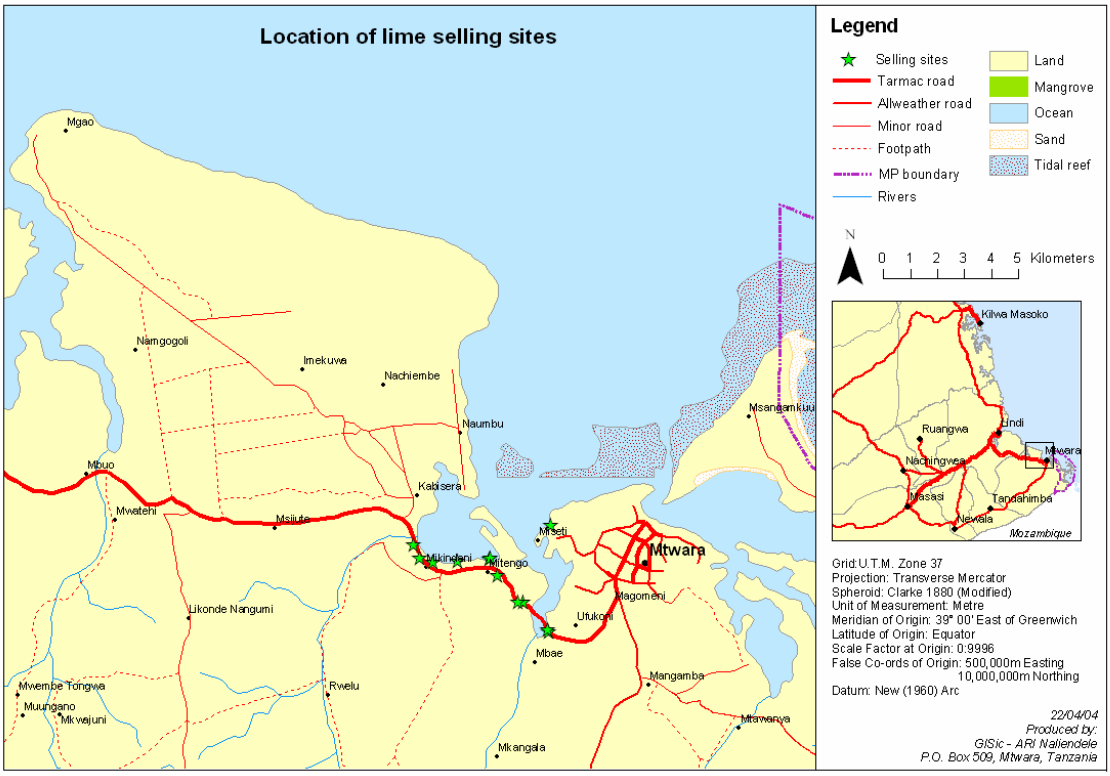

Figure 4: Map indicating the main selling sites located on the main road.
Map credit: Els at NARI

Sellers, explained that bags are sold to individuals as well as to larger wholesale buyers arriving from Masasi, Newala, Nachingwea, Songea and Tunduru. Wholesale buyers if purchasing a high number of bags may get a discount price as low as Tsh 400 per bag. When interviewees were asked for the selling price of lime at other locations, most said they didn't know, as the buyers were reluctant to reveal this information. A few however, stated that bags were sold for Tsh 1200 to 1500 at Masasi increasing to Tsh 2000 at Songea.

Table 4: Number of bags, mean selling price and estimated turnover for identified selling sites

Location	No. of bandas/selling sites	Tot. no. of bags at selling sites	Mean selling price per bag (Tsh)	Turnover from bag selling (Tsh)
Misete	2	134	600	80,400
Kianga	3	52	600	31,200
Magomeni	3	502	700	351,400
Ufukoni	2	905	500	452,500
Kilimahewa	6	1507	500	753,500
Mitengo	4	1156	500	578,000
Naida	4	1674	500	837,000
Total/mean	**24**	**5930**	**558**	**3,084,000**

3.1.5 Estimated total costs and gross profit

The total costs for the kilns identified in this study are provided in Table 5. As expected the highest costs are incurred for the procurement of fuel wood and live coral. One of the main reasons for the high cost of fuel wood at most sites is the depletion of local fuel wood supplies and the long distances from where fuel wood is presently sourced. However, at Pemba, Mkungu and Mgao Villages fuel wood supply is still provided mainly from local cutting and fuel wood costs are therefore lower. At Mkungu and Pemba where most of the kilns observed were small, collected fuel wood consists of small to medium poles only. At Mgao, where larger kilns are built, much of the fuel wood supply is obtained from local mangrove areas or from the numerous dead palm trees in the area although cashew-nut and mango tree timber is occasionally purchased. A few interviewees stated that coral collection costs have also risen over the past two years as collectors now need to travel further distances to collect the same amounts. The total estimated monthly costs for the study area are approximately Tsh 6.5 million or US$ 6190.

By subtracting total estimated costs from estimated turnover calculated from the sale of bags from the identified kilns we can arrive at an estimation of gross profit for each site and the study area (Table 6). Profit ranged between 41-60% for each site and in business terms indicates the lime production industry to be highly profitable. Estimated financial profits for individual locations per year ranged from Tsh 2-14 million (US$ 1,904-13,333) and for the study area was estimated between Tsh 71-73 million (US$ 67,619-69,523) per annum making the lime production industry one of the most profitable artisanal activities in the region. It is estimated that the industry supports over 250 individuals and therefore is likely to be an important contributor to a similar number of households.

3.1.6 Estimated monthly and annual coral extraction and fuel wood use

Based on the number of kilns identified in this study (80 kilns) it is estimated that a minimum total of 4,800 tonnes of live coral and 3,000 tonnes of fuel wood are used per annum for the production of lime (Table 7). These figures represent more than treble the previous estimation of 1500 tonnes of coral extraction provided by Solandt (1999) and considering the slow growth of *Porites* and the changing resource use patterns of collectors indicates that exploitation has increased beyond sustainable levels. Coral extraction was highest at Mgao village where an estimated 1,128 tonnes of coral are removed per year and for Mitengo, Naida and Milumba Villages where over 600 tonnes of coral was extracted at each site (See Figs 1-2). Similarly, the high demand for fuel wood to burn the collected coral is also likely to be unsustainable and is emphasised by its synergistic effect with shifting slash and burn agriculture and charcoal burning that has resulted in local deforestation in surrounding areas and the need for fuel wood supply from timber areas long distances from Mikindani. Furthermore while the use of cashew-nut timber may be justified by the high number of old and dying trees in the region, it is unlikely that old and dying mango trees are present in high numbers and may mean that valuable and healthy mango trees are being felled, removing the long term benefits of their fruit harvest and other uses such as for dug-out canoes. With a single dug out canoe already costing more than Tsh100,000

any timber reduction could further increase their price and force line fishers to switch to fishing in net teams which can be more destructive to coral reefs and lead to declines in fish populations.

Table 5: Estimated total monthly costs for the coral kilns identified in the MBREMP buffer zone

Location	No. of kilns per mth	Coral collection costs per mth (Tsh 000)	Est. Fuel wood costs per mth (Tsh 000)	Est. kiln construction costs per mth (Tsh 000)	Est. bagging costs per mth (Tsh 000)	Total est. costs per mth (Tsh 000)
Mtwara	3 small	45	60	18	12	135
Misete	3 small	45	60	18	12	135
Kianga	7 small/2 large	165	300	63	44	572
Ufukoni	2 small/3 large	120	180	42	28-42	370-384
Kilimahewa	2 small/1large	60	100	32	16-24	208-216
Mitengo	4 small/3 large/3 double storey	263	420	108	82-144	873-935
Naida	6small/2 large/2 double storey	225	360	92	119-170	796-847
Milumba	7 small/2 large/2 double storey	240	360	98	126	824
Pemba	4 small/1 double storey	98	100	42	95	335
Mkungu	3 small	45	-	18	45	108
Mgao	6 small/5 large/5 double storey	428	200	176	168	972
Total	**80**	**1,734**	**2,040**	**707**	**747-882**	**6,378-6513**

Table 6: Estimated number of bags of lime, total monthly turnover and costs and monthly and annual gross profit for the coral kilns identified in the MBREMP buffer zone

	Est. tot. no. of bags per mth	Mean Selling price per bag	Est. tot. turnover per mth (Tsh 000)	Est tot costs per mth = collection, fuel wood, construction and bagging (Tsh 000)	Est. tot. gross profit per mth (Tsh 000)	Est. tot gross profit per year (Tsh 000)	% rate of return
Mtwara	600	600	360	135	225	2700	63
Misete	600	600	360	135	225	2700	63
Kianga	2200	700	1,540	572	968	11,616	63
Ufukoni	1400	500	700	370-384	316-330	3,792-3960	45-47
Kilimahewa	800	500	400	208-216	184-192	2,208-2,304	46-48
Mitengo	4100	500	2,050	873-935	1113-1177	13,356-14,124	54-57
Naida	3400	500	1,700	796-847	853-904	10,226-10,848	50-53
Milumba	3600	500	1,800	824	976	11,712	54
Pemba	1900	300	570	335	235	2,820	41
Mkungu	900	300	270	108	162	1,944	60
Mgao	*3350@ 20-25kg*	*500*	*1,675*	*972*	*703*	*8,436*	*42*
Total/mean	**22850**	**500**	**11,425**	**5,328-5,463**	**5,962-6,097**	**71,544-73,164**	**52.8-53.7**

Table 7: Estimated monthly and yearly weight of fuel wood and coral used for the production of lime in the MBREMP buffer zone.

Location	No. of kilns per month	Est. mean wt of fuel wood per kiln (tonnes)	Est. mean wt of coral per kiln (tonnes)	Est. tot. wt of fuel wood per month (tonnes)	Est. tot. wt of coral per month (tonnes)	Est. tot. wt of fuel wood per year (tonnes)	Est. tot. wt of coral per year (tonnes)
Mtwara	3 small	2	4	6	12	72	144
Misete	3 small	2	4	6	12	72	144
Kianga	7 small/2 large	2/4	4/6	22	40	264	480
Ufukoni	2 small/3 large	2/4	4/6	16	26	192	312
Kilimahewa	2 small/1large	2/4	4/6	8	14	96	168
Mitengo	4 small/3 large/3 double storey	2/4/6	4/6/8	38	58	456	696
Naida	6small/2 large/2 double storey	2/4/6	4/6/8	32	52	384	624
Milumba	7 small/2 large/2 double storey	2/4/6	4/6/8	34	56	408	672
Pemba	4 small/1 double storey	2/6	4/8	14	24	168	288
Mkungu	3 small	2	4	6	12	72	144
Mgao	6 small/5 large/5 double storey	2/4/6	4/6/8	62	94	744	1,128
Total	**80**	**-**	**-**	**250**	**400**	**3,000**	**4,800**

3.2 LOCAL PERCEPTIONS OF LIVE CORAL AND ITS NATURAL FUNCTION

In order to understand local attitudes and understanding of the impacts of live coral mining and to highlight potential educational and awareness raising needs in the study area a series of questions were asked on the biology and natural function of live coral

From the enquiries made in the focus group interviews it was apparent that local knowledge and understanding of live coral biology and its natural function was misinformed or lacking. For instance, all of the groups interviewed referred to the collected live coral, simply as rock or 'jiwe', and none used the word '*matumbawe*' which is the literal Swahili translation for coral. Similarly, interviewees believed the main areas from where coral boulders are collected were not part of the coral reef system so do not damage coral reefs but are instead an area of natural rock boulders called the '*fulungu*'. All interviewees, however, agreed that once removed the pieces of rock or *jiwe* return as small pieces, which then grow, to a larger size. When questioned how these apparently non-living rock boulders grow most interviewees could not at first answer. However, after general probing along the line what they themselves needed to grow, many of the interviewees came to the conclusion that the *jiwe* collected must eat to grow. One individual explained that boulders got bigger because of the sun but could not expand further when questioned what he meant. Concerning what the *jiwe* ate most interviewees replied that the main food was water while others stated that the *jiwe* ate sand. Four individuals independently answered that coral boulders have roots like trees which spread out and uptake food from under the sand.

To gauge understanding of the time frame for coral growth a single coral boulder was shown separately to a selected group of interviewees at each site for which they had to estimate the time period to reach its final size. Estimates varied markedly on all occasions and ranged from six days to 2 years although by far the majority of estimates were less than six months. After results were shared and discussed within the group researchers explained that the likely timeframe for the coral boulder to grow to this size was approximately 8-10yrs. On all occasions interviewees strenuously denied this was the case but in conclusion all interviewees agreed that these results indicated that no-one was absolutely sure and an experiment to prove the true time/age period would help. The coral boulder used for these estimations is now being aged and the results of the ageing will be provided to the village groups.

regards the natural function of coral in the sea, most interviewees had a more precise understanding. Of the 13 groups interviewed nine claimed that coral provides shelter for reef fish and animals, five indicated that coral boulders reduced the power of waves and two groups suggested coral boulders provide a nursery for juvenile reef fish. When asked further, what happens after coral is collected, five groups stated that larger more powerful waves would result, leading to beach erosion and three groups suggested fish populations would decline. In contrast, however, four groups stated that coral removal has no negative effects whatsoever.

3.2.1 Local perceptions on alternative materials for lime production

The final questions asked in this session related to alternative materials or methods for lime production. Nearly all of the groups recognised the possibility of producing lime from a variety of bi-valve and gastropod shells. Nonetheless, all interviewees claimed for commercial purposes that enough shells could not be collected and that live coral was the only product from the sea that they could use. When questioned about the use of fossilised coral or *'mawe ya kulima'* not a single group recognised its potential and generally claimed that the rock was too hard and could not be easily extracted or burnt. This was actually surprising, as we were informed subsequent to the interviews, that after the earlier ban of live coral mining local communities met with representatives from the Department for Mines and local Government who discussed the potential for fossilised coral use and even suggested areas suitable for fossil coral quarries.

Generally local knowledge in relation to shallow water coral biology and function could be improved through an applied education programme that should include collaborative experiments with village groups. Such experiments would enable villagers to learn first hand of the potential impacts of particular actions as well as possible benefits from community interventions. This study has therefore highlighted a need for awareness raising of local communities to be addressed.

3.3 FOSSILISED CORAL MINING: A VIABLE ALTERNATIVE?

The production of lime from fossilised coral is widely practiced in Dar es Salaam, Zanzibar and in Kenya but in southern Tanzania is not yet known. Considering the expansive areas of fossilised coral in the MBREMP buffer zone there is an opportunity for fossilised lime production to provide an alternative to the use of live coral. However, despite residing in areas of extensive fossil coral, none of the groups interviewed in this study have considered or recognised this potential and are presently unaware of the methods involved. There is nonetheless, one person, Mr Ali Hamisi from Zanzibar, who has been producing lime from fossilised coral for the past two years at Ndumbwe Village approximately 20km north of Mikindani Town. Mr Hamisi claims that he spent several years looking for a suitable site along the coast where the best coral rag is found but was not welcomed by local live coral users as they perceived him as competition for their business and subsequently drove him away. He therefore settled inland at Ndumbwe Village where suitable fossilised coral was available but also a labour force who were used to physical labour and digging in the fields. The technique and kiln type used for the production of fossilised lime is principally the same as for live coral except that the kiln is larger and enclosed in a stone wall with a stone roof. The fuel wood used is primarily palm trunks which burn at the high heat needed to break down the stones to form the lime. An estimated 1500 bags of lime are obtained for one kiln from an estimated 16 tonnes of fossilised coral. An estimation of the costs involved with a single kiln are provided in Table 8 and the potential gross profit and rate of return is provided in Table 9. Based on these figures the rate of return is higher than for live coral lime production and provides an additional reason for the switch to fossilised lime production (King, A. pers. comm. based on an interview with Mr Ali Hamisi of Ndumbwe)

Table 8: Estimated costs of fossilised lime production for a single large kiln

	Cost of bags (Tsh000)	Timber and transport costs (Tsh 000)	Quarried stone & transport 3.3.6 Costs (Tsh 000)	Kiln construction costs (Tsh 000)	Water slaking costs (Tsh 000)	Bag filling costs (Tsh 000)	Transport of bags to Mtwara (Tsh 000)	Total costs (Tsh 000)
1 large kiln	75	60	38	50	10	30	150	413

Table 9: Estimated turnover , gross profit and rate of return for fossilised lime production for a single large kiln

	Est. No. of bags	Bag price (Tsh)	Total turnover (Tsh 000)	Total costs (Tsh 000)	Total gross profit (Tsh 000)	Rate of return %
1 large kiln	1500	800	1,200	413	787	65.6

4 CONCLUDING REMARKS

The results of this rapid assessment clearly indicate that, prior to the recent enforcement operation in the area, the rate of coral extraction and fuel wood use in the MBREMP buffer zone far exceeded sustainable levels of exploitation. Much of this problem has been brought about by newcomers to the industry attracted by the large potential profits, and the rising demand for lime in coastal and inland areas.

Considering collected coral is primarily of one genera, *Porites*, which in terms of coral reef structure is the most important reef framework builder (Obura, 2004), and whose slow growth can result in minimal recovery, the potential for long term negative impacts to surrounding coral reefs, if collecting continues, is clearly apparent. Moreover, as these massive corals play an important role both for providing shelter to fish populations and in shoreline protection, their removal may have already, and may still further, cause fish declines and extensive erosion in the area. Major erosion has already been noted along the Shangani reef shorefront of Mtwara town. Similarly, unsustainable fuel wood use, contributed to by the lime industry, has led to local deforestation

Although these negative impacts are recognised, the important income opportunities for local communities, which this lime production industry provided, cannot be ignored. Indeed, this industry is recognised for providing one of the higher levels of income in the MBREMP buffer zone and in terms of profit return may supersede most, if not all other local coastal resource activities in the area. For this reason if live coral collection is to be stopped, or at least markedly reduced, without consideration of the livelihood impacts to local communities and the expanding demand for lime, this initiative may face local resistance, simply result in more clandestine operations, lead to high and unrealistic enforcement costs and in the longer term may fail, as it did the first time an attempt to introduce a ban was made.

There is however, a viable opportunity for lime production to be switched from the use of live coral to fossilised coral which if combined with efforts to negate the fuel wood issue through fuel wood planting, the use of more efficient kilns (less wood), and possible use of alternative fuels (e.g. brickettes, fossil fuels such as diesel or natural gas – which may become available if the natural gas to power project is initiated in Mtwara) could help to cancel the negative impacts of this industry. Furthermore with recognition that alternative lime production techniques may also provide supplementary or alternative income generating activities to communities residing within MBREMP

and the fact that the ecological systems of the marine park may only be protected if the ecological integrity of the buffer zone is maintained, then MBREMP together with district government should take a pro-active role to ensure these alternative methods are developed. It is therefore strongly recommended that a comprehensive study of the potential, needs, and limitations of alternative lime production using fossilised coral and improved fuel use technologies be initiated by MBREMP together with government and private sector partners as a matter of priority.

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APPENDIX

List of questions asked during focus group interviews

Kiln sites, coral and timber use	
No of landing sites	
No. of kilns	
GPS location code	
Amount of coral?	
Amount of fuel wood?	
Type of fuel wood?	
Where doe it come from?	
How much does the fuel wood cost?	
Where is the coral collected from?	
Have these areas changed over time?	
Average size of coral on the kiln or landing site?	
Minimum and maximum size?	
Estimated number of boulders in kiln?	
Estimated number of boulders landed?	
Socio-economics of coral collection, kiln construction and lime production	
How many people in total collect coral at this site?	
How many people collect coral for a single kiln?	
How long does it take to collect for one kiln?	
When do they collect?	
How are they paid? By trip/day? How much?	
How many people in total build kilns at this site?	
How many people are to build a single kiln?	
How much are they paid?	
How long does a kiln burn?	
How many bags of lime from one kiln?	
How many people to bag the lime?	
How much are they paid?	
Do you sell the lime direct or to someone else?	
How many people own the business and where are they from?	
Selling sites and trade info	
GPS location code	
No of bags?	
Weight of bag?	
Selling price?	
Who do you sell too?	
Where does the lime go?	
How many bags are sold every week?	
How much does a bag sell for elsewhere?	
What is the lime used for?	

How much is the seller paid?	
Who owns the business?	
Local perceptions of coral mining, coral biology and function	
What size of coral do you collect?	
Why do you collect this size?	
What is coral?	
Is the coral replaced? If so over what time period?	
How old is this coral boulder?	
What does coral do in the sea?	
What happens after you collect coral?	
Has coral collecting increased? If so over what time period?	
Can you get lime from other materials?	
Why do you not use this?	
Would you consider changing to another material	

IUCN – Eastern African Regional Office

IUCN established the Eastern Africa Regional Office (EARO) in Nairobi in 1986. EARO facilitates the implementation of the IUCN Programme in Sudan, Eritrea, Djibouti, Somalia, Kenya, Tanzania, Comoros, Seychelles, Uganda and Ethiopia. Through its technical group, established in the early 1990s, the IUCN Programme assists members and partners in the region with capacity building through the implementation of programmes and projects, networking and technical advice. Specific areas of expertise include: protected areas, ecosystem management, biodiversity conservation, sustainable livelihoods, environmental planning and strategies, and support to environmental NGOs.

IUCN – Eastern African Marine and Coastal Ecosystems Programme

The aim of the IUCN's Eastern African Marine and Coastal Ecosystems Programme, which has been operating since 1992, is to maintain the biodiversity and ecological processes of marine and coastal ecosystems in Eastern Africa, to restore their functioning where this has been impaired, and to facilitate the sustainable and equitable use of marine resources. Current priorities include: the establishment and effective management of marine protected areas, sustainably managed fisheries, integrated coastal zone management and sustainable coastal livelihoods.

Mnazi Bay Ruvuma Estuary Marine Park

Mnazi Bay Ruvuma Estuary Marine Park (MBREMP) in southern Tanzania, was gazetted in 2000 having been identified as an area of biodiversity value at both the national and international level. The development of the park is being assisted through a GEF/UNDP funded project initiated in 2002, which will continue to the end of 2006. The MBREMP Project is a partnership between the Marine Parks and Reserves Unit of the Ministry of Natural Resources and Tourism, IUCN – The World Conservation Union and UNDP/GEF. Further support is being provided by the Fonds Français pour l' Environment Mondial (FFEM) through the Agence Française de Development (AFD).

Publication available from:

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