COENOSES 13(3): 149-158, 1998
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VEGETATION DYNAMICS AND MANAGEMENT IMPLICATIONS IN THE PUGU AND KAZIMZUMBWI FOREST RESERVES, TANZANIA

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Keywords: Africa; Coastal forest; Deforestation; Forest reserve; Land cover; Management; Vegetation mapping.

Abstract: This study examines spatial and temporal dynamics of land cover in the Pugu and Kazimzumbwi forest reserve region of Tanzania. Cultivation and harvesting of forest products are the main factors affecting the vegetation. These factors are more pronounced in the eastern and northern parts of the forest reserves. Elsewhere, notably in the western parts of the reserves, there has been substantial recovery of vegetation. This is particularly apparent in areas of where depopulation occurred following the 'villagisation' program of the 1970's. Although most of the vegetation change occurred outside of the forest reserves, increasing population pressure around the forest reserves will likely lead to encroachment into the forest reserves proper.

Introduction

Pugu and Kazimzumbwi are two of the 540 officially recognized forest reserves in Tanzania. These are coastal forests, which are biologically among the richest in the world. A recent survey has shown that approximately 30% of the plant species in the region are endemic ((Mbwana 1994). However, the conservation of biodiversity has not been taken into consideration in existing forest policies, nor in forest reserve management practices (Mbwana 1994).

In recent years the biodiversity of these forest reserves has been compromised by increasing population pressures, which has forced people to seek their livelihood in limited areas of good land with resultant resource over-exploitation (Mwalyosi 1994). Forest sustainability has been threatened by agrarian encroachment and over-exploitation of forest resources. The Pugu and Kazimzumbwi Reserves are particularly vulnerable, since they are proximate to the rapidly growing city of Dar es Salaam.

The biological and economical importance of these forest reserves is well known, but the magnitude of human impacts and the current status of these forest reserves is not well understood. This paper reports on a study on land cover changes in region of the Pugu and Kazimzumbwi Forest Reserves between 1952 and 1989. The impacts of human pressure on land and forest resources are also examined. The specific objectives of the study are: (a) to examine the current status of these forest reserves, and identify anthropogenic factors that may be contributing to agrarian encroachment and over-exploitation; (b) to assess changes in the extent and physiognomic composition in the reserves; (c) to assess changes in land cover and land use in these regions.

Study Area

The Pugu and Kazimzumbwi forest reserves and their immediate surroundings are located within 6°50' to 7°5' south and 38°58' to 39°10' east (Fig. 1). The dominant physiographic relief of the area is the Pugu Hills, which rise to about 300m above mean sea level. These hills are somewhat dissected, giving rise to near-level hill crests (probably representing remnants of a past peneplain), moderate to steep hillslopes, and valley depressions (Hawthorne 1984). Neogene kaolinitic sandstone, often overlain by acidic red sandy-clay soils, defines the surficial geology of the area [for more details on geology of the region, see Batholomew (1963), Temple (1970), Kent (1974) and Shultze (1991)]. The area encompasses one of the largest kaolin deposits in the world, resulting in a conflict between bioconservation and mining interests already present in the region.

The climate of the area is characterised by a bimodal distribution of rainfall, with peaks in December and April. The rainfall peaks correspond to the "short" rains (November-January) and the "long" rains (March-June). Higher relief results in the area receiving higher rainfall than surrounding lower-elevation areas: at Dar es Salaam, which occurs on the lower plain, rmean annual rainfall is approximately 1,095 mm (Woodhead 1968), while Kisarawe in the Pugu Hills receives about 1,250 mm (Howell 1981). Temperatures in the area range from 24-31°C, the period between July and October being relatively cool.

Under undisturbed conditions, the vegetation of the area appears to vary in a catenary sequence, presumably in response to a moisture gradient. Stubbefield (1994) describes the vegetation in terms of "distinct 'wet' valley bottom, 'dry' ridge-top, and 'intermediate' valley side communities". In

disturbed areas, vegetational varation is also encountered but this appears to reflect intensity of disturbance.

Materials and Methods

Most of the data presented here were obtained from remote sensing sources, complemented by field observations and existing literature on the Pugu and Kazimzumbwi Forest Reserves. The work progressed along the following procedural sequence:

(i) A bibliographical search on the coastal forests of East Africa, and the Pugu and Kazimzumbwi Forest Reserves in particular, was first undertaken. The information so acquired formed the basis for our study.

(ii) Available aerial photographs and satellite imagery for the study area were examined. The following data were available in this study:

- 1953/54 aerial photographs at the scale of 1:25,000.
- 1966 aerial photographs at 1:20,000 and 1:40,000 scales.
- 1977 aerial photographs at the 1:50,000 scale.
- 1981 aerial photographs at the 1:50,000 scale.
- 1986/87 SPOT panchromatic hard copies at the 1:50,000 scale.

However, after examining these data it was found that the photographs for 1966, 1977 and 1981 covered only portions of Pugu and Kazimzumbwi Forest Reserves. These were therefore not used in the final analysis. In detecting vegeta-

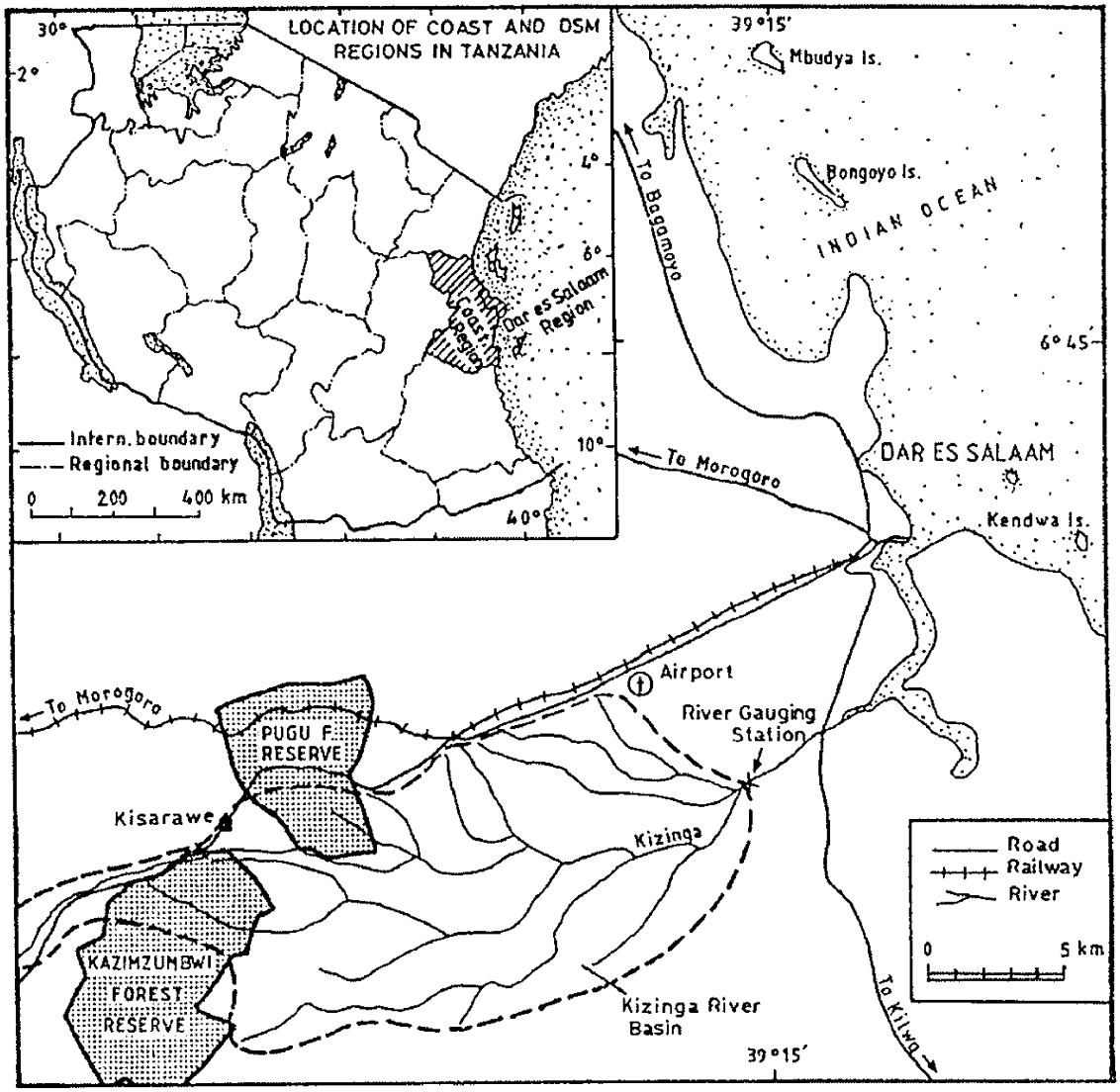

Figure 1. Location of the study area, Tanzania.

tion change, the information extracted from the 1953 aerial photographs was used as a 'baseline' for comparison to the 1987 panchromatic SPOT images.

(iii) Vegetation and land-use classifications were based on guidelines used in the preparation of provisional land-cover and land-use legends used in Tanzania (Shishira 1994a,b). These classifications constituted the working legends for interpretation and map compilation. Details on the vegetation and land use classifications are presented in Appendix 1.

(iv) A preliminary interpretation of the aerial photographs and satellite imagery was then undertaken. Difference in tonal signatures and textures were used to distinguish different land-cover classes. On the basis of the preliminary interpretation, field transects were planned. The strategy was to sample as many land cover variations on the landscape as possible. When choosing transects, consideration was also given to accessibility: representative points had to be picked along motorable tracks. Following the ground surveys, a verification exercise was undertaken in which imagery characteristics were correlated with actual ground features. It was also possible to gather information on the composition of the different land cover categories at specific sample points.

(v) A final photo interpretation was made to accommodate information collected during the field verification exercise.

(vi) The work resulted in final line maps, which were digitised. Cartographic manipulations were made to establish spatial and temporal land cover changes. Land cover maps were produced as end-products. In addition, data sets on area coverage for different land cover types were generated from these maps using a geographical information system.

Limitations of aerial photography and satellite images

The aerial photographs available were uncontrolled and differed in their scales. Also, as already been pointed out, the aerial photographs cover only portion of the study area. This situation made it difficult to detect change by overlaying one set of data over another. This circumstance partly accounts for not utilising the aerial photograph sets of 1966, 1977 and 1981. In the absence of suitable data for the intermediate periods, it was difficult to make a breakdown analysis of any notable changes between 1952 and 1987.

Results

The extent of various land cover types of the Pugu and Kazimzumbwi areas in 1953 and 1988 are summarized in Table 1. The spatial distributions of the various land-cover types for these two periods are shown in Figs. 2 and 3. These results are discussed further, considering each land-cover type in turn.

Natural Forests

Table 1 shows that areal coverage of natural forest has decreased by about 14.24 km^2 between 1953 and 1988. Comparison of Figs. 2 and 3 shows that some areas of natural forest in 1953 are now under cultivation , while others are degraded types of vegetation (discussed below). The most affected areas include the northern edge of Pugu Forest Reserve, the Central Railway corridor, and areas around the town of Kisarawe, south and southwest of Chanika towards Kazimzumbwi. In some areas, such as the north and east of the Pugu Forest Reserve and south-east of Kazimzumbwi, encroachment has extended into the Forest Reserve itself. The encroachment into Kazimzumbwi Forest Reserve is still going on, judging from the ongoing conflict between forest conservationists and agricultural expansionists.

Forest Plantations

Forest plantations have increased by 3.59 km^2. The maps show that this increase has been largely at the expense of natural forests. Since 1951, there has been deliberate clearing of parts of the Pugu and Kazimzumbwi Forest Reserves for various purposes, particularly the establishment of rubber, Cassia, Eucalyptus and Pine plantations. For example, between 1952 and 1961 a total of 210 hectares of natural forest were cleared in Kazimzumbwi and replanted with exotic tree species (Mung'ong'o et al. 1997). Replacement of natural forests by forest plantations will necessarily affect the biological diversity of the area. However, lack of proper management has resulted in some of these plantations being over-grown by thickets. These plantations will likely disappear, probably to be replaced by climax vegetation.

Woodland

This land-cover type includes two categories, the dense and open woodlands. Dense woodland increased by 1.64 km^2 (39.05%), while open woodland declined by 2.88 km^2 (49.91%). It should be noted that the overall extent of woodland in the study area is relatively small. The observed increase between 1953 and 1988 mainly occurred in the area west of Kazimzumbwi Forest Reserve. This area was subject to depopulation during villagization. The release of population pressure on forest resources accounts for natural growth from bushland to woodland. Despite of the overall increase in the woodland, the woodland east of the Kazimzumbwi Forest Reserve had decreased in coverage and density. This degradation of woodland is the result of increased human occupation following expansive pressure from the city of Dar es Salaam.

Thickets

There has been a net increase in the area covered by thickets, by 26.16 km^2 (47.48%). As noted above, this increase is attributed to conversion from bushlands into thickets west of the forest reserves due to the release of population pressure (depopulation) in the area.

Bushland

Two categories of bushland are recognised: dense and open bushland. The areal coverage of dense bushland has decreased by 19.09 km^2 (38.58%), since most of the bush-

Table 1. Area covered by the different land cover types in Pugu/ Kazimzumbwi and the surrounding areas.

Land cover type	Extent of land cover in the Pugu - Kazimzumbwi Forest reserves and surrounding areas as at 1953 and 1988 (Km^2)					
	1953		1988		Change (1953-1988)	
	Area Km^2)	Percentage	Area (Km^2)	percentage	Area (km^2)	Percentage
Natural forest (FN)	58.24	9.83	44.00	7.43	-14.24	-24.52
Plantation forest (FP)	1.02	0.17	4.61	0.78	+3.59	+351.96
Dense woodland (Wd)	4.20	0.71	5.84	0.99	+1.64	+39.05
Open woodland (Wo)	5.77	0.97	2.89	0.49	-2.88	-49.91
Dense bushland (Bd)	49.48	8.35	30.39	5.13	-19.09	-38.58
Open bushland (Bo)	94.65	15.98	67.77	11.45	-26.88	-28.40
Bushland with scattered cultiv. (Bsc)	255.91	43.20	144.14	24.34	-111.77	-43.67
Thicket (Th)	55.09	9.30	81.25	13.72	+26.16	+47.48
Bushed grassland (Gb)	42.37	7.15	53.14	8.97	+10.77	+25.42
Open grassland (Go)	22.13	3.74	10.58	1.79	-11.55	-52.19
Cultivation with tree crops (Ctc)	1.38	0.23	144.61	24.42	+143.23	+10378.98
Bare/Cleared Land (Bl)/settlement	1.40	0.24	1.98	0.34	+0.58	+41.43
Swamp	0.68	0.12	0.86	0.15	+0.18	+26.47
Dam	0.07	0.01	0.09	0.02	+0.02	+28.57
Total	592.39	100.00	592.14	100.00		

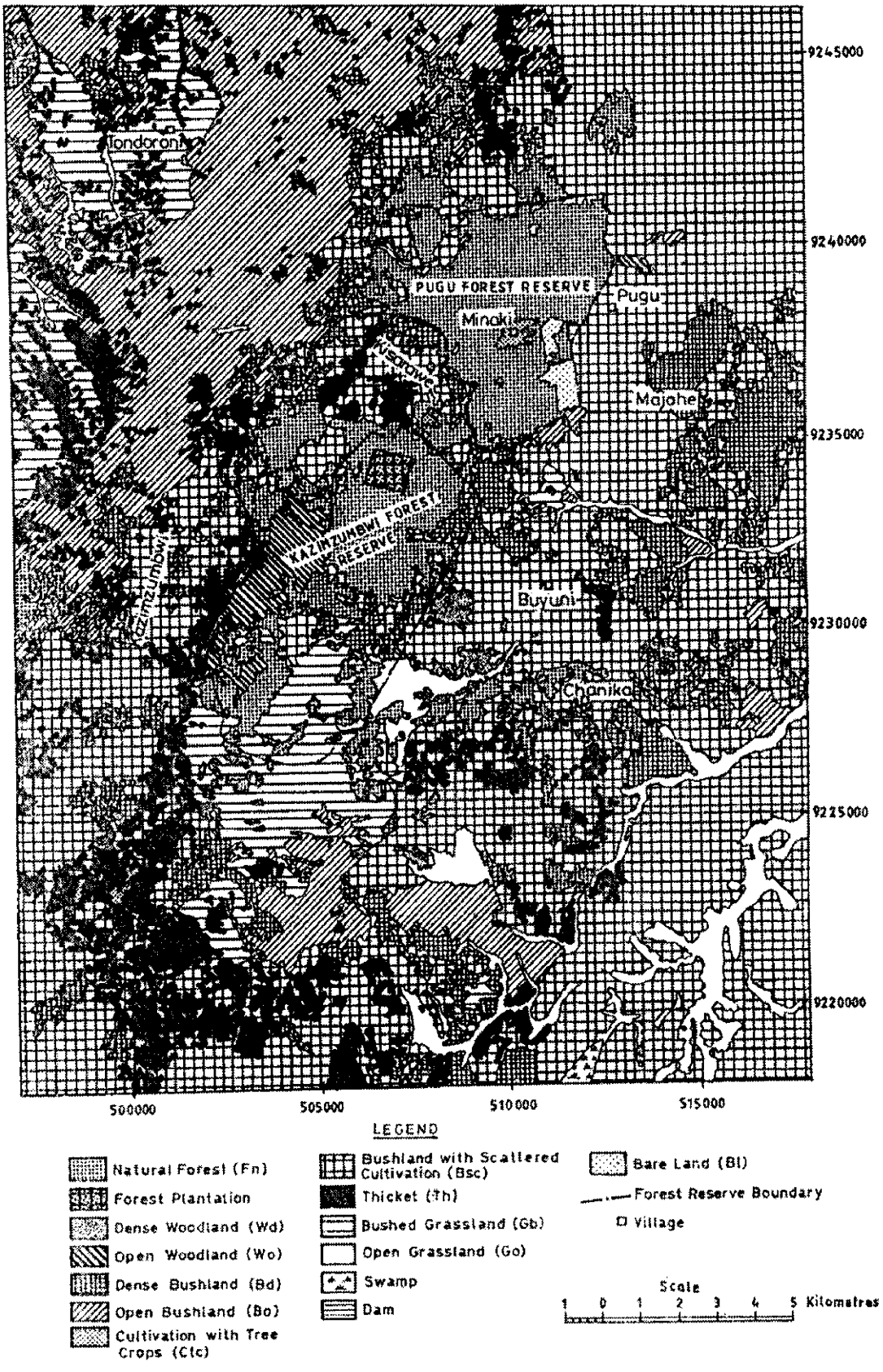

Figure 2. Land-cover classes in 1953.

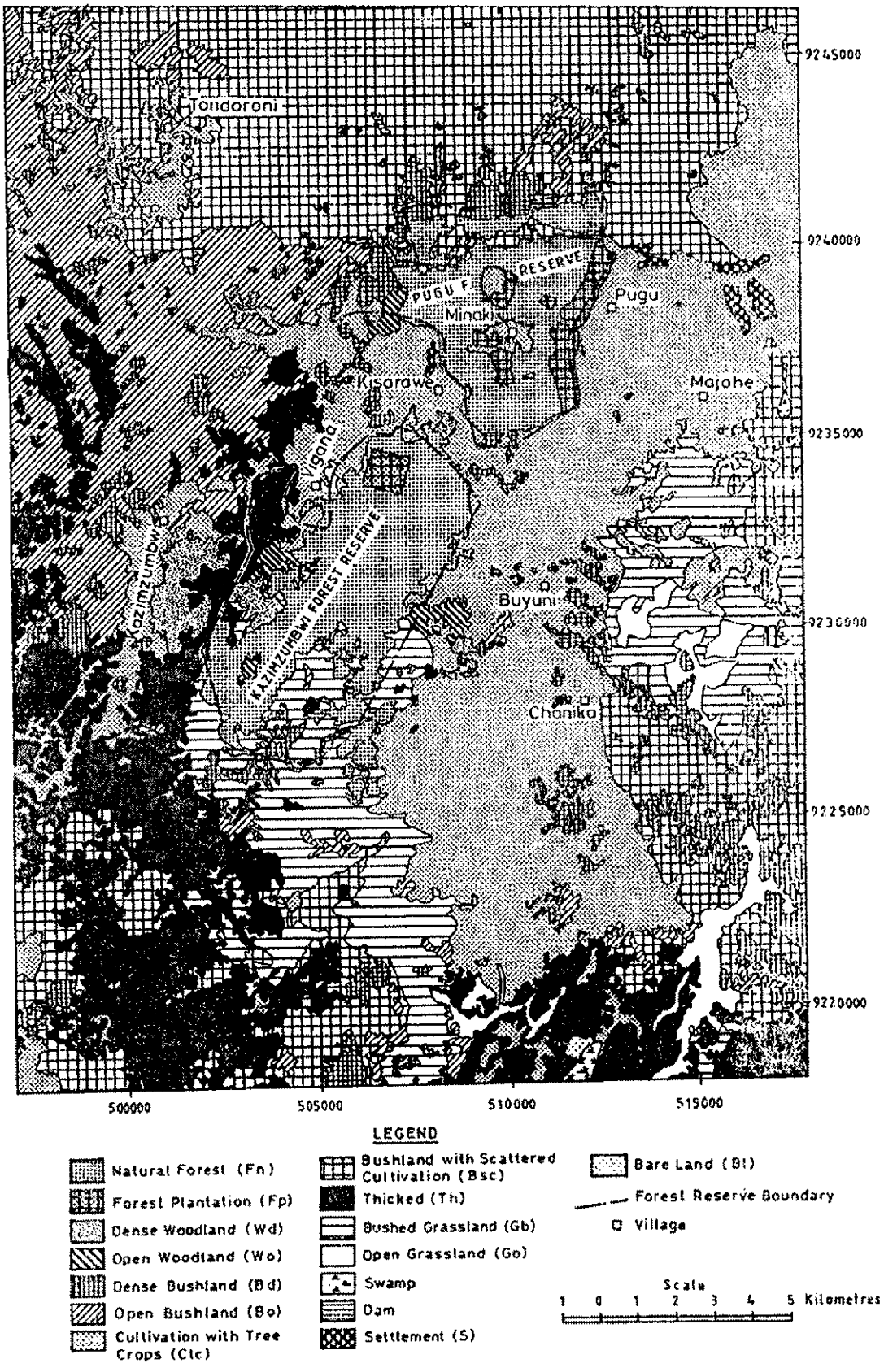

Figure 3. Land-cover classes in 1987.

Table2. Population changes between 1978 and 1988 in villages surrounding Pugu and Kazimzumbwi Forest Reserves.

Village/Year	1978	1988	% change
Pugu	3129	6231	49.8
Chanika	1322	6146	78.5
Buyuni	915	2270	59.7
Majohe	914	1146	20.2
Kazimzumbwi	1525	1186	-28.6
Kisarawe	1434	3690	61.1

Source: Modified from 1978 and 1988 population census data.

land in the east of the Pugu and Kazimzumbwi Forest Reserves was thinned to open bushland or bushed grassland. Conversely, the dense bushlands west of the Pugu and Kazimzumbwi Forest Reserves have succeeded into thickets or even into woodlands. The degradation of the dense woodland in the east and the aggradation in the west are due to the imbalance of population pressure between the two areas.

The area covered by open bushland has declined by 26.88 km^2 (28.40%). This decrease is also mainly accounted for by the expansion of cultivation north of the Pugu Forest Reserve, and succession to thickets west of the forest reserves. The development of thickets west of the forest reserves is attributable to depopulation as a result of villagization.

Bushland with Scattered Cultivation

The areal coverage of bushland with scattered cultivation has decreased by 111.77 km^2 (43.67%). The biggest proportion of the noted changes occurred in the east of the forest reserves, where an extensive area of bushland with scattered cultivation has been completely converted to cultivation. The other change took place west of the forest reserves, where large areas formally covered by bush and scattered cultivation are now bushlands and thickets. Again, the disparity of population pressures governed the differences in changes between these areas.

Bushed Grassland

Bushed grassland has increased by 10.77 km^2 (25.42%). These changes have mostly occurred east of the forest reserves beyond the Majohe village, where a formally large area of dense bushland was opened up to form bushed grassland. This is presumably through frequent clearing of bush to provide wood for making charcoal and for other domestic uses. According to WWF (1991), charcoal burning occurs along the forest reserve margins and may extend 1 km or more into the reserves.

Open Grassland

Open grassland has decreased by 11.55 km^2 (52.19%). This is partly due to some of the grassland being converted into agricultural land. Some grasslands to the south-east of Kazimzumbwi forest have succeeded into bushland.

Cultivation

The most common type of cultivation in the area are tree crops, including cashew, mangoes, coconuts, etc. Land under cultivation has increased from 0.23% in 1953 to 24.42% in 1988. In addition, the coverage of land under settlement and bushland with scattered cultivation has also increased (Table 1). Cultivation has been spreading, particularly from areas east and north-east of the forest reserves. Such human activities constitute the main form of encroachment along the eastern side of the forest reserves, and into the Kazimzumbwi Forest Reserve.

Apparent Causes of Vegetation Changes in the Forest Reserves

The last two census results (1978 and 1988) reveal that the human population of the Dar es Salaam region has increased tremendously over the last 10 years, from 843,140 in 1978 to 1,360,865 in 1988, an annual increase of 4.8%. The urban population contributes 88.6% of the regional population count (Bureau of Statistics 1996). This population growth is attributable to both natural population growth and the influx of peoples from various parts of the country. The population growth rate of 4.8% experienced in Dar es Salaam is remarkably high, and well exceeds the growth rate of 1.6% registered in the neighbouring Coast Region which borders Dar es Salaam Region to the west. The overall national growth rate is estimated at 2.9% (Bureau of Statistics 1996).

Population expansion in the city of Dar es Salaam region has resulted in high demands of lands for settlements and cultivation, as well as high demand for forest products. This situation has lead to people moving to villages near Dar es Salaam, including those surrounding Pugu and Kazimzumbwi Forest Reserves. For example, the population in the villages on the eastern part of the Pugu and Kazimzumbwi Forest Reserves has increased considerably (Table 2). The most affected areas are those situated on the eastern and northern parts of the forest reserves, which are the frontiers of

the expansion of Dar es Salaam City. The increasing population has consequently increased land demand in some of these villages. According to Mung'ong'o et al. (1997), the value of land has also increased recently in these villages as people from Dar es Salaam have bought land at prices that are astronomical by village standards. Hence clearing of new land has become a speculative economic venture. The land acquisition process seems to be driven by the desire of certain employees from the public and private sector to possess land. Land is acquired as a social and economic asset for the future. In addition, once land is acquired it forms a base for establishment of permanent housing and economic activities (e.g. cultivation, diary cattle, poultry keeping, piggery, vegetable gardening, etc.) to supplement wages.

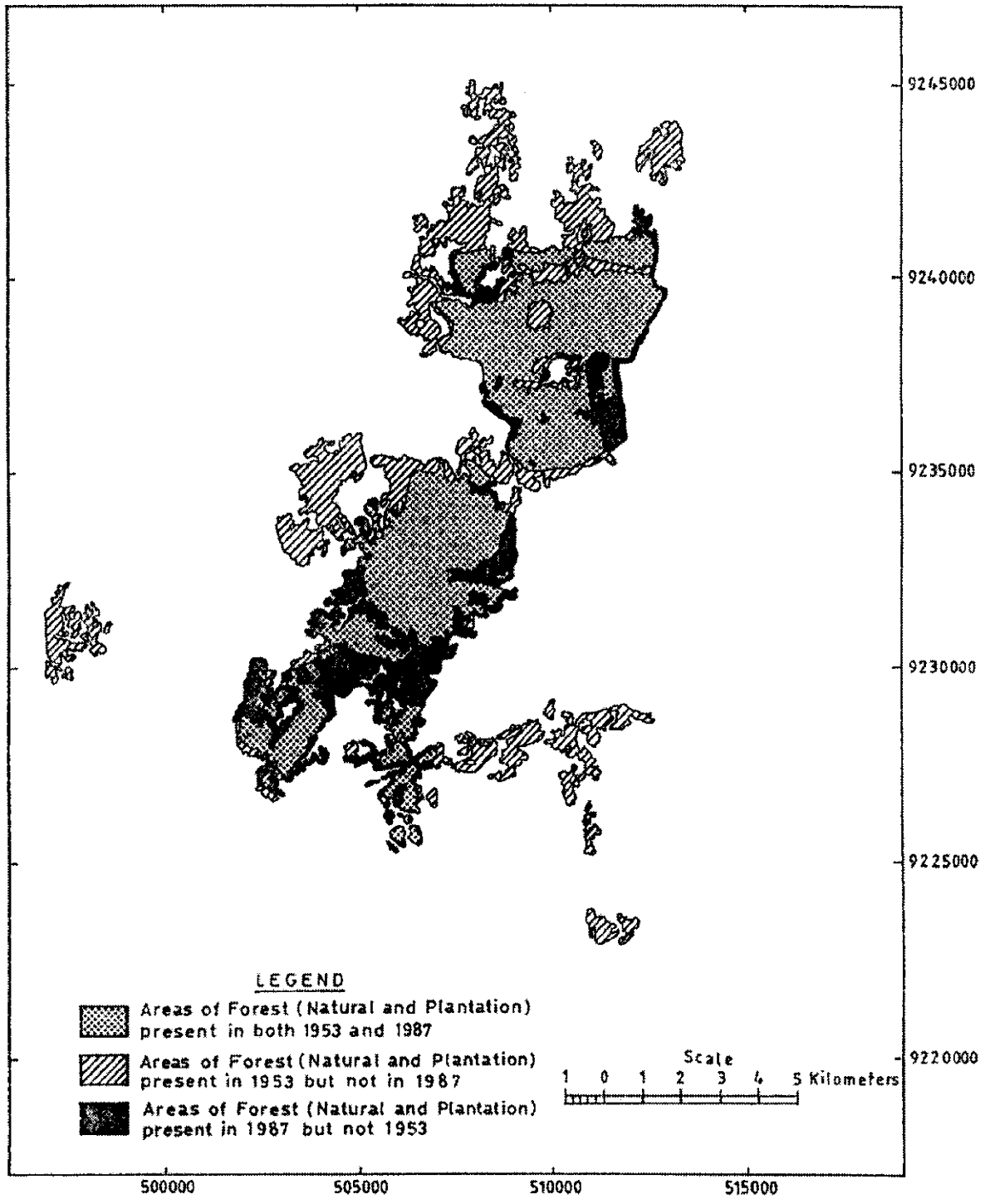

Figure 4. Forest land-cover changes between 1953 and 1987.

Table 3. Quantity of charcoal brought in Dar es Salaam through Ilala and Temeke Districts in 1987.

Month	Temeke District (bags)	Ilala District (bags)
January	18,180	41,236
February	35,545	16,200
March	30.414	14,989
April	24,840	16800
May	6,943	9,800
June	9,949	11,650
July	21,980	8,900
August	19,708	25,297
September	23,907	16,800
October	16,605	42,329
November	16,190	18,081

Note: One bag of charcoal weighs about 55 kg.

Source: Malisa (1996).

Normally, the land acquisition process involves employees purchasing land from residents of villages surrounding the City. The displaced villagers in turn move further outwards, opening up new settlements and cultivation. This land may be acquired free, or be obtained at minimal cost for purposes of selling again and moving on. In this process, villagers are gradually pushed outwards from the City and may encroach into the Forest Reserves. The villagers involved in this process are of different ethnic groups, and come from various parts of the country. Many of these peoples are former migrant labourers who once worked on sisal estates. These sisal estates have since undergone urban development, and now form many of the built-up areas of Dar es Salaam.

The expansion of urban population, coupled with population growth in villages, has lead to increased demand for forest products such as wood for charcoal production, building poles and timber. About 85% of urban population in Dar es Salaam, and more than 99% of rural population in the villages surrounding the forest reserves, depend on wood as the major source of energy for both heating and cooking (Mng'ong'o et al 1997).

Due to high costs of alternative energy sources such as electricity and kerosene, charcoal has become the major affordable source of energy. In many of the villages surrounding the forest reserves, commercial charcoal production has become a big business due to the existence of readily accessible markets in Dar es Salaam and the small towns of Pugu and Kisarawe. The quantity of charcoal brought into Dar es Salaam through Ilala and Temeke Districts in 1987 is summarized in Table 3. These two Districts are adjacent to villages surrounding the forest reserves. On average, about 20,000 bags of charcoal passed through these two Districts every month. This figure may be far below the actual quantity supplied from the villages, since it only includes charcoal registered in the official recording stations. It is common knowledge that substantial quantities of charcoal pass unrecorded through numerous routes. By bypassing the official recording stations, the paying of taxes is avoided.

The exploitation of forest resources in the area surrounding Dar es Salaam is driven by the high demand of such products. The exploitation process involves producers in the field, who are often villagers in proximity of the resources. Agents, mainly based in Dar es Salaam, buy from these producers and transport forest products to the city for wholesale and retail selling.

Discussion and Recommendations

Several factors have facilitated human encroachment into Pugu and Kazimzumbwi Forest Reserves. These include unclear forest boundaries, inadequate manpower to enforce existing forest reserve management regulations, and lack of community awareness.

Unclear Forest Boundaries

Although beacons demarcating the forest reserves have been in place since the forest reserves were gazetted, they were not readily detectable without clearings marking the boundaries of the forest reserves. In some areas (e.g. in the north-east), exotic tree species such as *Eucalyptus* and *Casia*

siamea were planted along the forest reserve boundary. This border of trees has helped mark the boundary and has contributed to the prevention of encroachment. Recently, clear demarcation of the forest reserves has been undertaken as part of the Coastal Forest Management Project activities.

Inadequate Manpower

While existing legislation on the management of Pugu and Kazimzumbwi Forest Reserves exist, it has been difficult to enforce the legislation since both the necessary manpower and required facilities are lacking. Despite efforts made by the Coastal Forestry Biodiversity Project to address this issue, the effort may not be sustained in view of recent government policy calling for massive retrenchment in the civil service, including the Forestry Sector.

Lack of Community Awareness

Lack of community awareness on the need to conserve the forest reserve is probably the major factor contributing to ongoing encroachment into forest reserves. For example, while efforts have recently been made to clearly demarcate and guard the forest boundaries, encroachment (particularly in the south east of the Kazimzumbwi Forest Reserve) has continued. It would appear that the only effective measure to prevent encroachment must involve villagers from areas surrounding the forest reserves. Recent efforts by the government in creating awareness of the need to conserve forest reserves is a commendable step in the right direction.

Acknowledgements. Many people facilitated the completion of this study. Survey and Mapping Division provided aerial photographs. Mr. F. Msuya and Mr. S. Kajula undertook the aerial photo interpretation. Ms. Anna Mushi and Mr. David Hall did cartographic work. We thank them for their contributions. We also thank the GEF/FAO (Biodiversity Project) for providing funds to undertake this study.

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