

TEN YEARS OF POPULATION CHANGE AND THE *CHITEMENE* SLASH-AND-BURN SYSTEM AROUND THE MPIKA AREA, NORTHERN ZAMBIA

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ABSTRACT Newly cleared fields created by the *chitemene* slash-and-burn system were counted in two satellite images (Landsat TM 7: path 170, low 68) taken in 1994 and 2001 in the Mpika area of the Northern Province, Zambia. These images indicated that the number of *chitemene* fields was almost the same in 1994 and 2001. However, expansion of *chitemene* to the interior of forest reserves was apparent in the image from 2001, which clearly showed that the land area is not sufficient to maintain the *chitemene* system under the present agro-environmental and socio-economic conditions. The relationship between the number of *chitemene* fields and population revealed that the density of *chitemene* in the Standard Enumeration Area (SEA) increased up to 1 *chitemene*/km² with an increase in population density up to 10 people/km², while it decreased with a further increase in population density. The carrying capacity of the *chitemene* was thus estimated to be at most 10 persons/*chitemene*/km², a capacity achieved through farmers' efforts to diversify crop production. Between 1990 and 2000, the population in the resettlement project areas doubled, while in other areas, the population did not increase. This had diverse effects on the environment due to both immigration and emigration in the surveyed areas.

Key Words: *Chitemene*; Carrying capacity; *Miombo*; TAZARA; Resettlement; Zambia.

INTRODUCTION

A rapid population increase in sub-Saharan Africa is considered to be the major cause of environmental degradation and the decline in agricultural production per capita (Food and Agriculture Organization of the United Nations [FAO], 1995). However, there are arguments against such direct cause-and-effect relationships between the population and the environment. For example, Ness (1994) claimed that there is no direct relationship between a population and its environment, as technology and social organization always mediate between them. Cleaver and Schriber (1994) also concluded that population growth is only one of several possible causes of environmental degradation and has its place in a socio-economic nexus. The link between population and environment is not a premise but a hypothesis that should be tested and supported by scientific research. While there is no doubt that population pressure on land is a major factor influencing environmental degradation, it is more important to provide substantial data on the ways and extent to which population size affects the environment in areas exhibiting unique historical human-nature interactions.

In northern Zambia, the Bemba people have traditionally practiced a type

of slash-and-burn system known as *chitemene*. *Chitemene* is unique in that it involves cutting branches of trees in *Miombo* woodlands, but it requires only one-fifth to one-tenth of the land for growing finger millet after compiling and burning a heap of branches at the center of the cut area. The *chitemene* has been regarded to relatively less harmful than slash-and-burn technics found elsewhere in the world to the environment, as the coppiced trees regenerate rapidly, which makes it possible to harvest branches again after 10 years (Kakeya & Sugiyama, 1987). The adoption of such a labor-intensive method has been ascribed to poor plateau soil in the area (Allan, 1965), and the heavy burning of plant debris has helped to release soil nitrogen from soil organic matter, which would otherwise be unused by plants (Araki, 1993).

During the colonial period, Bemba land was an important source of labor for mining the copper belt (Moore & Vaughan, 1994). Men were forced into mining to pay a hut tax. The colonial government worried about the shortage of labor necessary for cutting trees in rural areas, as well as the sustainability of the system (Peters, 1950; Allan, 1965). In cases in which land was considered to be over-populated due to considerations of carrying capacity, people were moved from the chief's land (then termed Native Reserves before being renamed Customary Land) to a Trust Land re-allocated from the white colonials' Crown Land (Allan, 1965). Because of its remoteness from the railway lines that ran across the territory of the white settlers, the Northern Province remained underdeveloped and untargeted by any modern agricultural schemes during both the colonial and post-independence periods.

Allan's (1965) premise that *chitemene* is sustainable only in areas where population density is less than 5 people/km² is not realistic, for the *chitemene* system has survived until today even in areas of higher population density (Chizumayo, 1987). Stromgaard (1985) also advocated the breakdown of the *chitemene* and recommended more intensive cultivation methods such as mound cultivation (Stromgaard, 1989). Conflicting views and data show that it is still an open question how *chitemene* and *Miombo* woodlands can survive under the present socio-economic conditions.

After the adoption of the structural adjustment policy by the Government of Zambia in the early 1990s, peasants in the Northern Province received no more support by means of fixed pricing of maize or government loans, which resulted in the rapid decline of maize production using chemical fertilizers. As an alternative, farmers found *chitemene* to be a means of generating cash income by selling finger millet, and diversified their modes of production to include mound cultivation and small-scale slash and burn cultivation (Oyama, 1999).

Using Landsat TM images and population census data, I attempted to assess the present status of *chitemene* cultivation in the last decade of the 20th century, a time of rather drastic agricultural changes, and to analyze the dynamic relationships between the population, *chitemene* cultivation, and the environment.

STUDY AREA

The Mpika District occupies the southeastern part of the Northern Province of Zambia. Since 1983, studies of ecological anthropology and agro-ecology have been conducted in several villages in the Mpika District (Kakeya & Sugiyama, 1985, 1987; Araki, 1993; Oyama, 1996). Villages are situated along the Kopa road (the thoroughfare to the area governed by Chief Kopa), about 30 km west of Mpika township, and are locally administrated by Chief Luchembe. The northern part of the villages along the Kanchibiya River was allocated as Farm Block No. 5 (Kanchibiya) via the Tanzania Zambia Railway (TAZARA) Corridor Resettlement Scheme in the late 1980s, when land was opened up to settlers after they obtained title deeds. To the west and south, villages are surrounded by a forest reserve along the Rwitikra River where people are prohibited to open *chitemene* fields, as the land belongs to the state. Villagers mostly engage in *chitemene* cultivation. Each household clears several hectares of the woodland every year, creating fields between 0.2 and 0.5 ha to grow finger millet in the first year and subsequently growing crops such as groundnut and cassava for 3 to 4 years. The land shortage forced villagers to leave their fields fallow for less than 10 years, and/or to move into remote areas by making temporary huts, sometimes beyond the administrative boundaries of the village. Hybrid maize cultivation with chemical fertilizers became popular in the late 1980s and early 1990s, which corresponds to the penetration of the market economy by subsistence farmers. However, at the same time, this ameliorated the shortage of staple foods due to the decline of productivity, for maize was not only sold but became part of the daily diet (Oyama, 2001). After the government abandoned the Maize Marketing Board in 1997, farmers received no more support, including supplies of fertilizer, seed, loans, and collection of maize. Farmers in some villages gave up maize cultivation in 1998 (Oyama, 1999). Facing such environmental and economic problems, some farmers left the villages and moved to areas where sufficient wood was available for *chitemene*. For them, *chitemene* was not only a means of subsistence, but also a way of earning money by selling finger millet. Others remaining in the villages started keeping pigs to trade in exchange for maize flowers, but this scheme was abandoned in 1999, as pigs severely damaged crops in nearby villages (Sugiyama, 2007). Some farmers relied on charcoal making. All of these efforts are represent coping strategies against environmental and policy changes, causing the farmers to place primary importance on sustaining a cash income and staple food stores. However, *chitemene* remained a major production system.

METHODOLOGY

I. TM Image Processing

Landsat TM images (path: 170, row 68) taken on 22 September 1994 and 3 October 2001 were used in this study. Prior to the analysis, images were geometrically corrected into a UTM projection using GPS referenced point data collected in the field in 2000. ERDAS IMAGINE was used for this purpose. By using false-color images (red: band 4, green: band 3, blue: band 2), newly opened *chitemene* fields were identified manually on the screen, and point vector files were created in Arc View. Both images were taken during the September-October period when preparation of most of the *chitemene* fields was complete and awaited burning. Sharp contrasts in color between woodland, cleared land (outfields), and the center fields where plant debris are gathered made it possible to visually identify the newly opened *chitemene* fields. For the second year of *chitemene* cultivation, there were no clear black center fields, although sometimes they appeared whitish because of their bareness. For abandoned fields and those beyond the second year of cultivation, center fields and outfields were indistinguishable, because grass and bush had regenerated in both areas. However, remnants of old *chitemene* fields could be identified in the images, because even when trees recovered to a level where they were indistinguishable from the woodland matrix, center fields remained pale in color because trees had once been completely destroyed, strongly retarding regeneration. Newly opened *chitemene* fields were identified on images from both 1994 and 2001. The number of *chitemene* fields was counted in each Standard Enumeration Area (SEA), which will be explained in the next section.

II. Population Census Data Analysis

Data of population censuses conducted in 1990 and 2000 were collected from the Central Statistics Office in Lusaka for the areas concerned. The SEA is a basal unit in which each enumerator operated that corresponds with about 400 persons on average. For the 1990 census, SEAs were delineated by roads and rivers regardless of village boundaries, while for the 2000 census, SEAs were established such that the SEA boundary coincided with the ward boundary. SEAs are indicated in 1/50,000 scale maps for the entire country. The level above the category of SEA is the Census Supervisory Area (CSA), which is summarized in 1/250,000 scale maps. In collecting the 1990 census data, CSA boundaries were traced onto 1/250,000 scale topographic maps, and SEA boundaries in 1/50,000 scale maps were transcribed onto those maps. In the case of the 2000 census, the relevant SEA maps were photocopied. The SEA boundaries were manually traced onto TM images using a computer to calculate the area and to count the number of *chitemene* fields in the corresponding areas.

III. TAZARA Corridor Resettlement Scheme

In the late 1980s, the Zambian government opened up two areas belonging to customary land under the supervision of local chiefs under an agricultural development and resettlement scheme. These areas primarily consisted of unutilized *Miombo* woodlands, including Farm Blocks No. 5 (Kanchibiya) and No. 6 (Mansha), whose area extended 40,000 ha 30 km north of Mpika and 25,000 ha 90 km north of Mpika, respectively. The areas were opened to individuals or enterprises capable of doing farm business, and once accepted, these individuals were required to demarcate the areas for the title deed and pay a registration fee and annual rent. Maps at a 1/50,000 scale showing information on the project boundary, roads, and individual farm locations were obtained and were traced onto transparent papers; the data were then incorporated into a computer. TM images from 1989, 1994, 2000, and 2002 were used to calculate the area of farms and *chitemene* production.

IV. Field Observations

The reliability of the identification of newly opened *chitemene* areas using TM images was tested through field observations in 1993, by referring to TM images taken in 1992 (not used in this paper). The newly opened *chitemene* fields in 1992 were identified in the field near the village of Ndonga, and relevant information was collected. The resettlement area was visited in 2001, and some of the fields were tracked by GPS, and their owners were interviewed for land management and cultivation histories.

V. Analysis of the Population-*Chitemene* Relationship

The number of *chitemene* counted in each SEA was compared to corresponding population data in 1990 and 2000 in our first approximation. However, since the SEAs of 1990 did not always coincide with those of 2000, I selected 26 SEAs that were identical in both censuses and compared them in terms of population and numbers of *chitemene*.

RESULTS AND DISCUSSION

I. Distribution of *Chitemene* Fields in TM Images

Figure 1 shows the land allocation and roads in the survey area corresponding to an entire TM scene (path 170, low 68). The Great North Road connecting Lusaka and Nakonde (a town bordering Tanzania) runs in a north-south direction. The Kasama Road intersects with the Great North Road at Mpika and runs to the northwest. Polygon numbers indicate customary land, a national

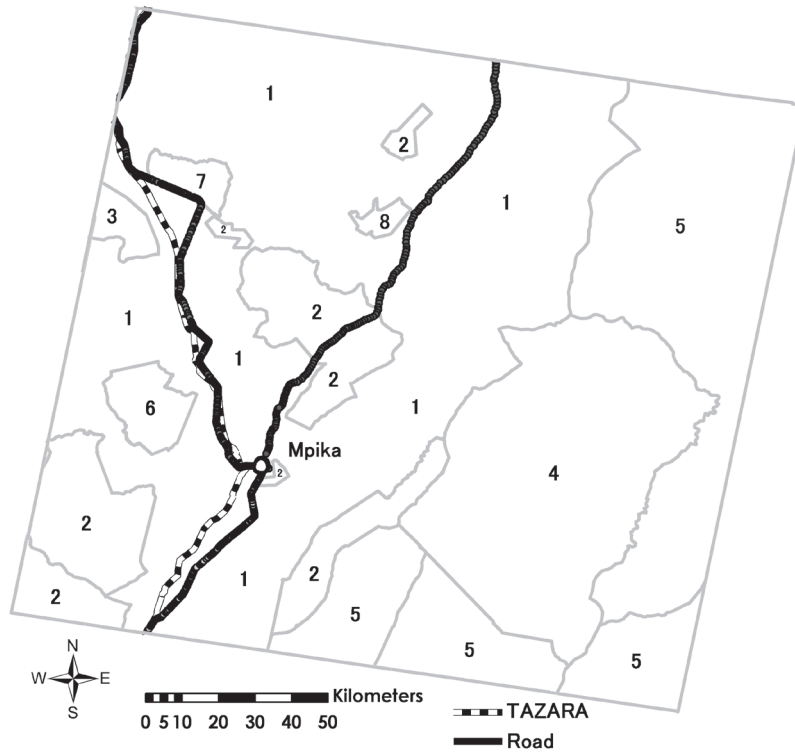


Fig. 1. Land allocation in a TM image (path 170, low 68)

1: Customary land, 2: National forest, 3: Local forest, 4: National park, 5: Game management area, 6: Kanchibiya farm block, 7: Mansha farm block, 8: Siwa Ngandu (privately owned)

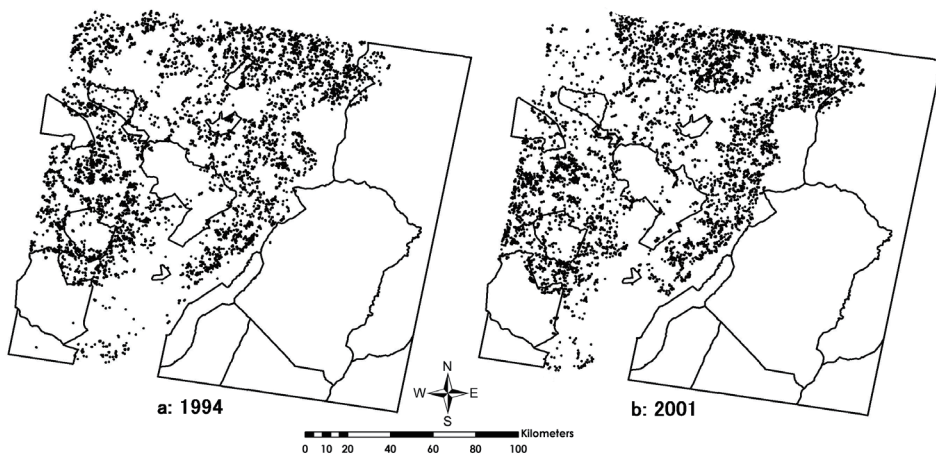


Fig. 2. Newly opened *chitemene* field in 1994 (a) and 2001 (b)

park, a game management area, national or local forests, and resettlement areas, all of which belong to the state with the exception of customary land. The eastern part of the scene belongs to the Ruanguwa Valley agro-ecological region (elevation <1,200 m), dominated by mopane and acacia trees, while the western part belongs to the Zambia Plateau (elevation 1,200–1,500 m), dominated by *Miombo* woodland.

Figure 2 shows the newly opened *chitemene* fields in 1994 and 2001. The distribution of *chitemene* fields is restricted to the Zambia Plateau region, as *chitemene* is practiced only in *Miombo* woodland vegetation. The figure shows that *chitemene* activity is so extensive that it characterizes the agro-ecology of the entire plateau region. However, there are also areas with few *chitemene* fields. In the eastern area, *chitemene* is restricted by vegetation, and within the plateau region, it is restricted by the boundaries of national and local forest areas and resettlement areas. Some other areas inside customary land have few *chitemene* fields, due to rocky terrain with shallow soil unsuitable for this kind of cultivation. The total number of *chitemene* fields counted was 3,907 in 1994 and 3,886 in 2001. Taking into consideration that the situations in the two years when the images were taken were not exactly the same in terms of coverage, I estimated that the *chitemene* continued to be active to roughly the same extent over the two periods. A detailed discussion on the number of *chitemene* fields will be presented in the next section. It appears that the number of *chitemene* fields shown in the 2001 image increased inside the state lands, e.g., number 3 for local forest, 6 for Kanchibiya farm block and 2 for national forest south of 6, toward the interior. This indirectly suggests that land resources became scarcer over time.

II. Distribution of *Chitemene* Fields in Relation to the Population

In Figures 3a and 3b, some of the SEAs in the Mpika District are shown for the 1990 and 2000 censuses, respectively. The outer boundary of the area is identical between the two years except for the southeastern part, but the SEAs of the 1990 census are more finely divided than those of 2000, particularly along the more densely inhabited Great North Road. The number of *chitemene* fields in each SEA was counted, and the area was measured on a pixel basis. The relationships between population and *chitemene* densities are shown in Figures 4a and 4b for 1990 and 2000, respectively. The figures cover all SEAs except the Mpika township, where population density exceeded 100 people/km². There is a tendency for an increase in population density to reduce *chitemene* density. Both figures show that the maximum *chitemene* density is around 1.0/km², which corresponds to a population density of about 10 people/km². For more detailed analysis, 26 SEAs that were identical between the two years were selected (Fig. 5), and their attributes are shown in Table 1. I found a positive correlation between population densities of 1990 and 2000 (Fig. 6), but it is clear from the figure that in some areas, the population density remained almost the same for 10 years ($r=1.04$), whereas in other areas it more than doubled

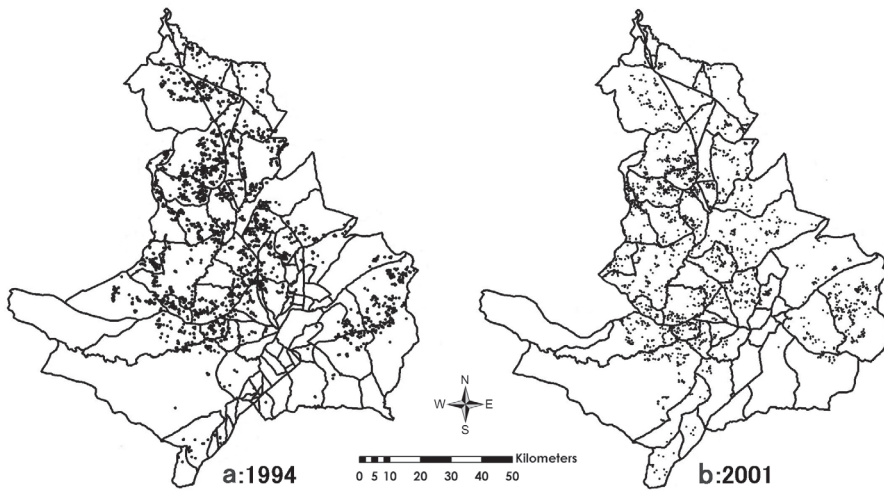


Fig. 3. Location of *chitemene* in 1994 and 2001 and SEA boundary
 * SEA of 1990 for (a), SEA of 2000 for (b).

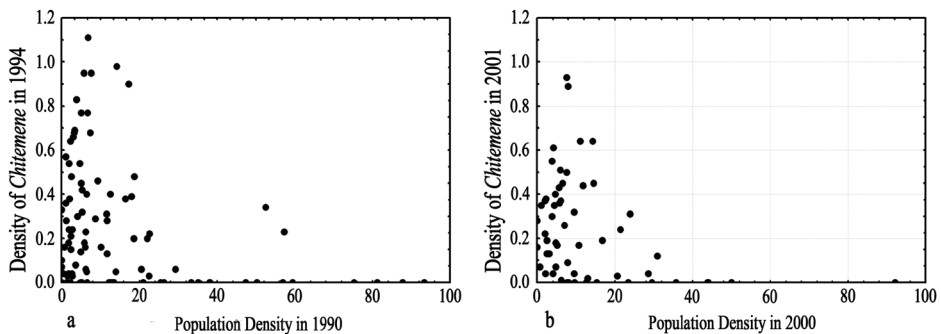


Fig. 4. Relationship between density of *chitemene* and population density

($r=2.41$), including four of the resettlement areas. The latter reflects an inflow of settlers from outside, but the former strongly suggests that the natural increase in population should have been compensated by an outflow of people, thereby maintaining a minimal population increase in the villages. In other words, the population itself cannot be counted as an accelerating factor for environmental degradation, particularly deforestation, in a period of only 10 years.

Figure 7 shows the relationship between the density of *chitemene* fields cleared in 2001 and 1994. The regression line with a coefficient of 0.91 shows that on average, the activity of *chitemene* decreased by about 10% in 10 years, although the value more than doubled in some SEAs. This slight decrease of *chitemene* activity may reflect agro-environmental and socio-economic changes. Sprague and Oyama (1999) estimated that the *chitemene* activity decreased by 20% between 1984 and 1992. Such a gradual decrease in *chitemene* cultivation agreed with my result in the areas concerned.

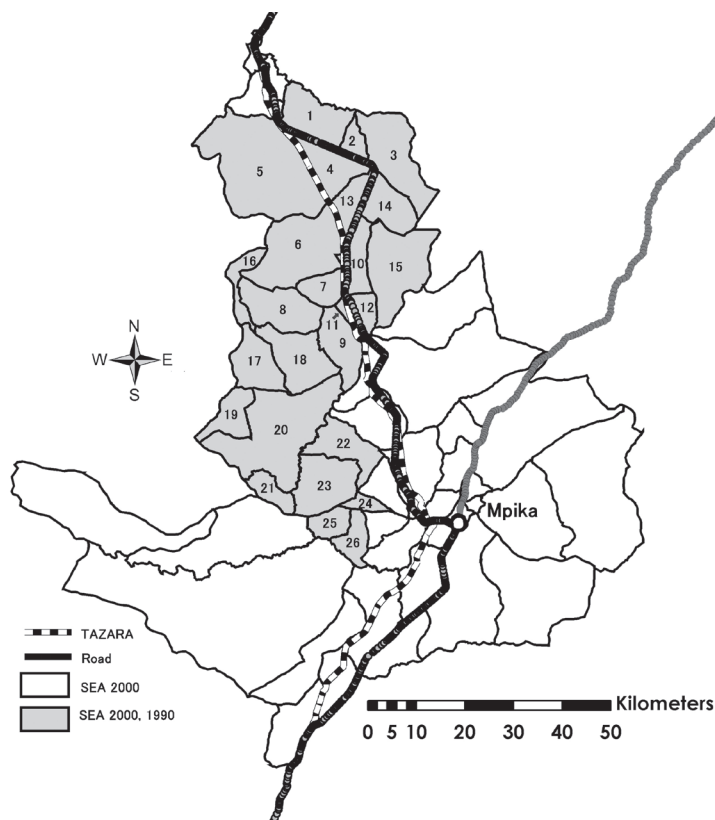


Fig. 5. SEAs that are common in both 1990 and 2000 census

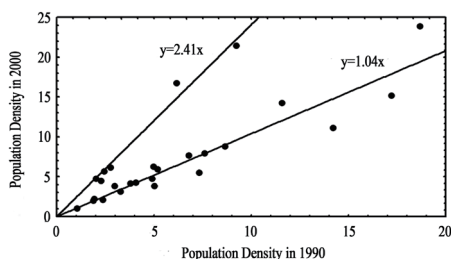


Fig. 6. Relationship between 1990 and 2000 population densities in each SEA

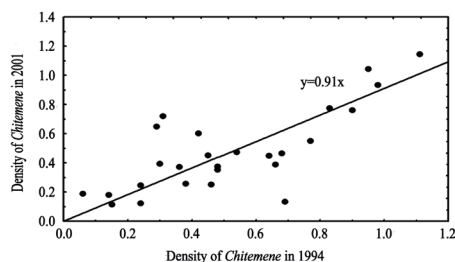


Fig. 7. Comparison of *chitemene* densities between 1994 and 2001 in each SEA

Figure 8 shows the relationship between population density and *chitemene* density between the 10 years in each SEA. The line connecting two points indicate the direction of change from 1990 to 2000. The 1990 census data were coupled with the 1994 data of *chitemene*, as TM images for the year 1990 were not available, and census data of 2000 were coupled with the 2001 data of *chitemene* for the same reason. Such discrepancies in years can be justified

Table 1. Standard Enumeration Areas (SEA) common in both 1990 and 2000 census and their attributes

No.	SEA	Area (Km ²)	Population (1990)	Household (1990)	Population density (1990)	Chitemene (1994)	Chitemene density (1994)	Population (2000)	Population density (2000)	Chitemene (2001)	Chitemene density (2001)
1	Chambeshi4-1	122.1	337	78	2.76	29	0.24	754	6.18	15	0.12
2	Chambeshi4-2	31.9	197	72	6.17	2	0.06	535	16.75	6	0.19
3	Chambeshi4-3	171.5	842	226	4.91	24	0.14	816	4.76	31	0.18
4	Chambeshi4-4	96.5	317	79	3.28	67	0.69	301	3.12	13	0.13
5	Chambeshi3-4	391.5	737	161	1.88	94	0.24	773	1.97	97	0.25
6	Mumbubu1-1	223.8	431	92	1.93	121	0.54	498	2.22	106	0.47
7	Mumbubu1-2	60.3	410	102	6.80	67	1.11	462	7.66	69	1.14
8	Mumbubu1-3	127.5	483	110	3.79	106	0.83	528	4.14	99	0.78
9	Mumbubu1-4	97.7	506	109	5.18	41	0.42	581	5.95	59	0.60
10	Mumbubu2-1	67.5	623	149	9.23	31	0.46	1446	21.42	17	0.25
11	Mumbubu2-2	20.3	289	72	14.22	20	0.98	226	11.12	19	0.94
12	Mumbubu2-3	36.0	417	96	11.58	11	0.31	514	14.27	26	0.72
13	Mumbubu3-1	60.6	387	97	6.38	24	0.40			10	0.16
14	Mumbubu3-2	90.5	450	101	4.97	41	0.45	567	6.27	41	0.45
15	Mumbubu3-3	196.7	481	114	2.45	95	0.48	1115	5.67	74	0.38
16	Lubaleshi6-1	44.6	769	198	17.22	40	0.90	677	15.16	34	0.76
17	Lubaleshi6-2	101.2	412	94	4.07	30	0.30	434	4.29	40	0.40
18	Lubaleshi6-3	131.3	390	92	2.97	86	0.66	505	3.85	51	0.39
19	Lubaleshi7-1	70.6	518	117	7.33	48	0.68	388	5.49	33	0.47
20	Lubaleshi7-2	318.1	331	95	1.04	114	0.36	328	1.03	119	0.37
21	Lubaleshi7-3	45.3	228	60	5.03	35	0.77	174	3.84	25	0.55
22	Chibwa1-1	108.7	221	59	2.03	41	0.38	515	4.74	28	0.26
23	Chibwa1-2	139.9	319	84	2.28	89	0.64	624	4.46	63	0.45
24	Chibwa2-1	22.7	424	109	18.68	11	0.48	542	23.88	8	0.35
25	Chibwa2-2	45.1	343	85	7.61	43	0.95	358	7.94	47	1.04
26	Chibwa2-3	44.7	387	101	8.66	13	0.29	394	8.81	29	0.65

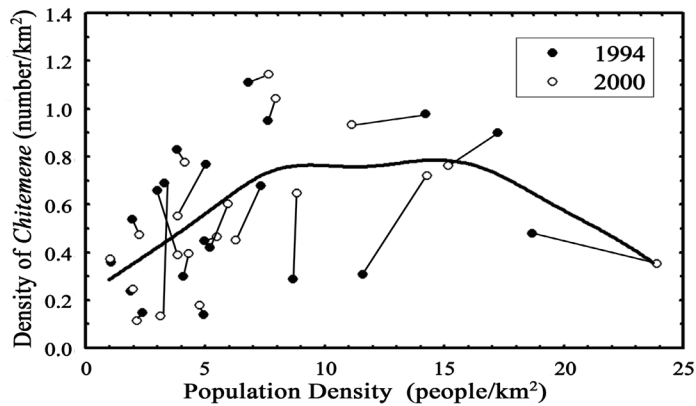


Fig. 8. Relationship between density of *chitemene* and population density in 1994 and 2000

* Lines connect values for the same SEA

given that the change in population over the 10 years was minimal (Fig. 6), if resettlement areas were excluded. This means that discrepancies between years is not critical in viewing the general trend between population density and *chitemene* density, as annual differences in *chitemene* activities are not likely caused by population changes. The overall data indicate a relationship between population density and *chitemene* density as shown by the non-linear regression curve with the least square method; i.e., the density of *chitemene* is positively correlated with the population density up to 10 people/km², but negatively correlated if the density exceeds 15 people/km² with a maximum of about 0.7 *chitemene*/km². As far as these SEAs are concerned, the main agricultural activities are confined to *chitemene* cultivation, considering the distance from both Mpika township and the Great North Road, and the carrying capacity of the *chitemene* can be estimated to be at most 10 persons/*chitemene*/km² under the present agro-environmental and socio-economic conditions.

Allan (1965) estimated that during the colonial period, *chitemene* was sustainable in areas with a population density of less than 5 people/km², meaning that a fallow period of over 25 years could be maintained. This figure is obviously a low estimate according to our view today, as otherwise the *chitemene* system could not have survived until now. This may partly be because, besides *chitemene*, farmers can rely on subsidiary gardens to grow sweet potato and cassava, or try to find other opportunities for income generation. However, as far as the woodland in the customary land is concerned, it has become impoverished beyond a sustainable level of 16 years (Oyama, 1996).

III. TAZARA Corridor Agricultural Development and Resettlement Area

The Kanchibiya State Farm Block of the TAZARA Corridor Development Project occupies about 40,000 ha along the Kanchibiya River, north of the Kopa road. The project started in the late 1980s, on state-owned land that had

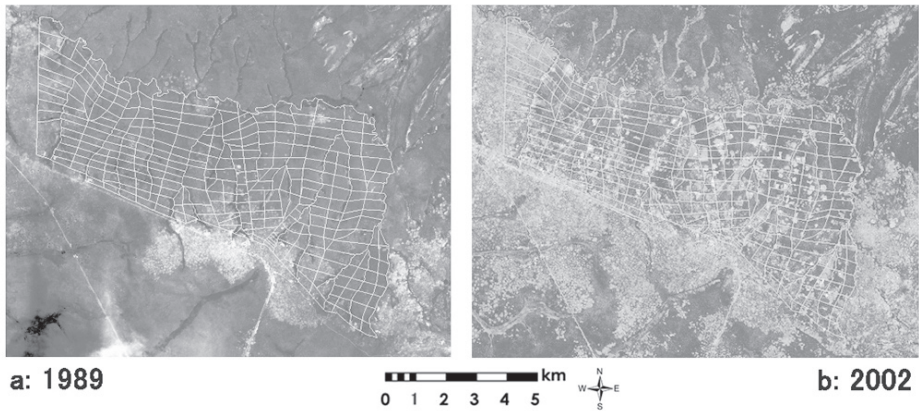


Fig. 9. Expansion of farm and *chitemene* in and around Mansha farm block

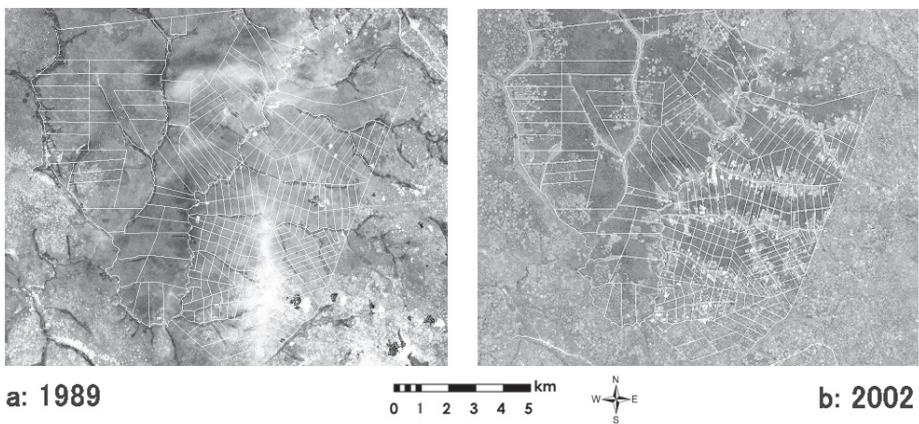


Fig. 10. Expansion of farm and *chitemene* in and around Kanchibiya farm block

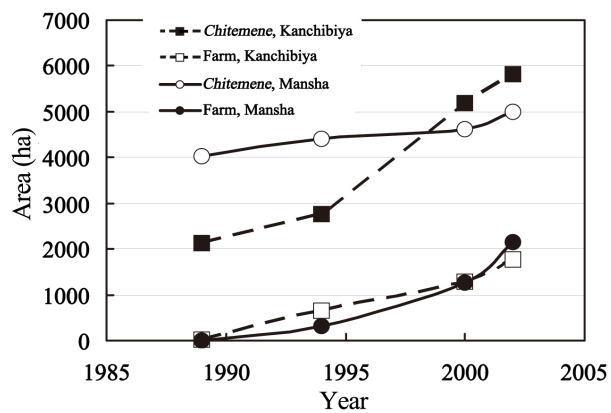


Fig. 11. Change of *chitemene* and farm areas over years

previously been customary land belonging to the local chief. Soon after the demarcation of the farm block in 1989, the first farmers settled there. The area is divided into two blocks. The northwestern block has large farm units of 100–200 ha, which are restricted to commercial farming by business investors or companies. The southeastern block has smaller farm units of 10–50 ha, which are devoted to small-scale farmers from outside who can afford to purchase the land. Such people include retired civil servants and the Tonga people who face land shortages in southern Zambia. At present, the land has occupancy rates of 30% in the northeastern block and 75% in the southeastern block. The number of households increased from 97 in 1991 to 170 in 2001. During a December 2001 survey, the present land use of the resettlement area was observed and recorded, and interviews with farmers were conducted. In case of Mansha farm block, the number of registered household amounted to 223 in 2003.

Figures 9 and 10 show TM images of Mansha and Kanchibiya farm blocks, respectively, between 1989 and 2002. Over the 13-year period, the allocation of land was almost completed, and cleared farms can be seen in the images. The light colored rectangular farm blocks are clearly visible. Expansion of *chitemene* fields outside of the block is also obvious. Figure 11 shows that cleared farms increased annually up to 2,000 ha in both farm blocks, while the area of *chitemene* also increased inside the blocks. It should be noted that the *chitemene* area does not indicate the net field acreage, but aerial coverage subjected to *chitemene* activity that includes both cleared and intermediate spaces. This increase in *chitemene* inside the block may have been because landowners often hire local peasants to open their farms using the *chitemene* method on the one hand, and the invasion of *chitemene* cultivators from outside of the area on the other. In the case of the Kanchibiya farm block, the latter is most probable, for the invasion is most apparent at the periphery of the block (Fig. 10).

From a conservation point of view, such a resettlement scheme has dual implications, i.e., seeking land to use for intensive permanent cultivation, but destroying woodland that otherwise should have been reserved for *chitemene* cultivators.

CONCLUSION

According to the preliminary report of the 2000 census (Central Statistical Office, 2001), the population of the Mpika District was 145,315, with an annual growth rate of 1.7% based on the total population of 123,099 as enumerated in the 1990 census. This growth rate is the second lowest among all districts of the Northern Province, although as a whole, the Northern Province recorded the highest growth rate (4.3%) in Zambia, the overall growth rate of which is 2.9%, from 7,759,167 people in 1990 to 10,285,631 in 2000. Such a high rate is achieved largely by a population increase at Nakonde at the Tanzanian border (11.9%), and at Mungwi and Mporokoso, likely due to immigration. The average population density of the Northern Province has increased to 9.5 /km² in

2000 from 5.8 /km² in 1990, while those of the SEAs in the study area went to 4.9 /km² from 3.9 /km² in the last decade. This increase was achieved not through a natural population growth but through immigration into the resettlement areas. Therefore, population pressure is apparently not the main cause of the present shortage of land that pushes people to reserved areas. Instead, this could be the outcome of the long-term depletion of soil and vegetation through overburdening the land, caused by semi-permanent dwellings in villages along main roads. Such a process may be accelerated by the present socio-economic environment, which forces farmers to rely on *chitemene* cultivation because of the lack of incentives to intensify cultivation and to invest in their lands.

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