JAPAN INTERNATIONAL COOPERATION AGENCY (JICA) No. 02

MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES (MENR)

THE REPUBLIC OF ZAMBIA

THE FOREST RESOURCES MANAGEMENT STUDY FOR ZAMBIA TEAK FORESTS IN SOUTH-WESTERN ZAMBIA

FINAL REPORT

Volume 1

(Summary Section)

March 1996

JAPAN FOREST CIVIL ENGINEERING CONSULTANTS FOUNDATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES (MENR)
THE REPUBLIC OF ZAMBIA

THE FOREST RESOURCES MANAGEMENT STUDY FOR ZAMBIA TEAK FORESTS IN SOUTH-WESTERN ZAMBIA

FINAL REPORT
Volume 1
(Summary Section)

March, 1996

JAPAN FOREST CIVIL ENGINEERING CONSULTANTS FOUNDATION

PREFACE

In response to a request from the Government of the Republic of Zambia, the Government of Japan decided to conduct a development study on the Forest Resources Management Study for Zambia Teak Forests in South-western Zambia, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zambia a study team, headed by Mr. KEIJI TAKESHITA, five times during the period August 1994 to February 1996.

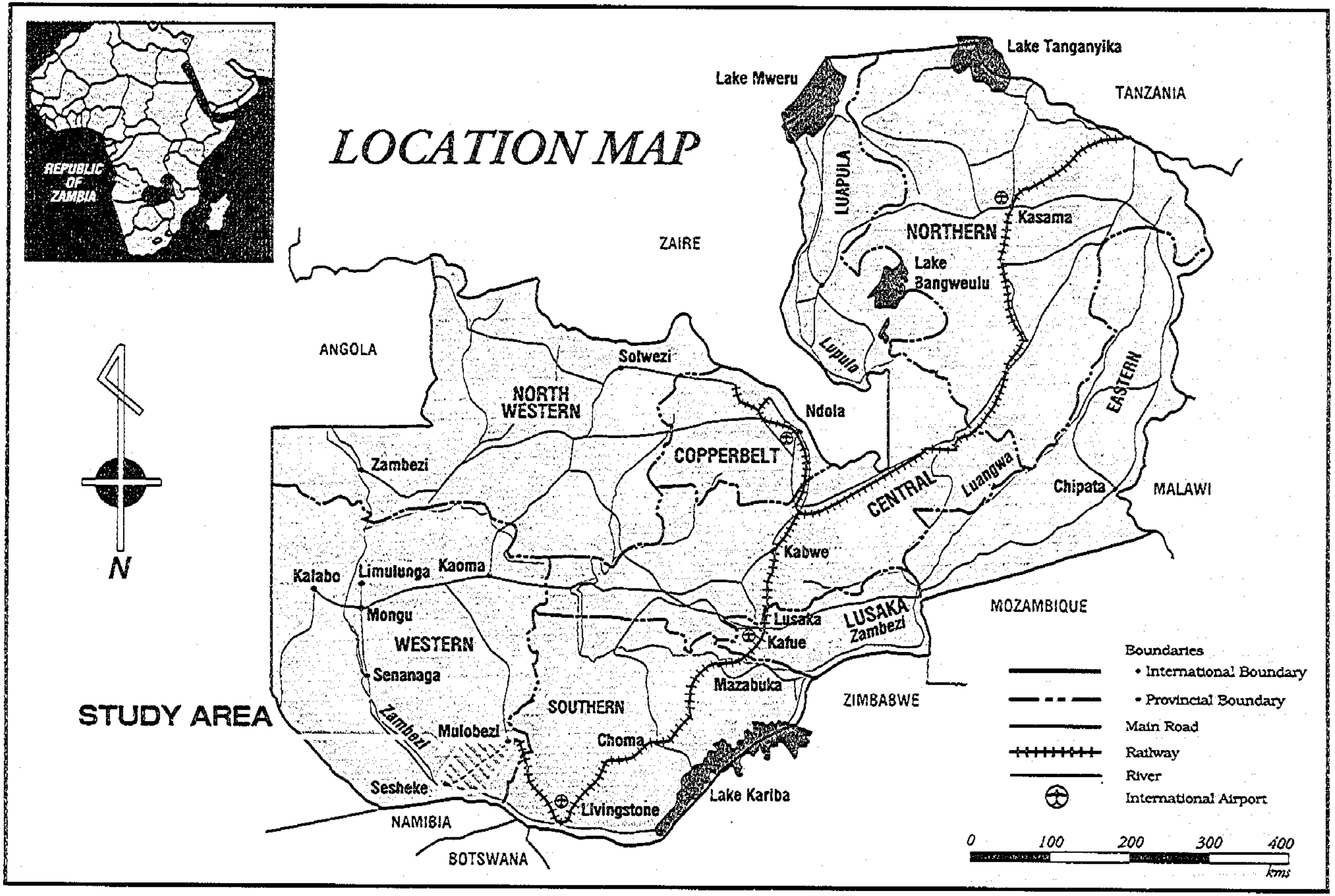
The team held discussions with the officials concerned of the Government of Zambia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made, and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Zambia for their close, cooperation extended to the team.

March, 1996

Kimio Fujita
President
Japan International Cooperation Agency


LOCATION MAP
REPUBLIC OF ZAMBIA
Lake Tanganyika
Lake Mweru
TANZANIA
LUAPULA
NORTHERN
Kasama
Lake Bangweulu
Lupula
ZAIRE
ANGOLA
Solwezi
NORTH WESTERN
Ndola
COPPERBELT
Zambezi
CENTRAL
Luangwa
EASTERN
Chipata
MALAWI
Kabwe
Kalabo
Limulunga
Kaoma
Mongu
WESTERN
Senanaga
Lusaka
LUSAKA
Zambezi
Kafue
MOZAMBIQUE
Mazabuka
ZIMBABWE
STUDY AREA
Zambezi
Mulobezi
SOUTHERN
Choma
Sesheke
Livingstone
Lake Kariba
NAMIBIA
BOTSWANA
N
Boundaries
• International Boundary
• Provincial Boundary
Main Road
Railway
River
International Airport
0
100
200
300
400
kms

THE FOREST RESOURCES MANAGEMENT STUDY
FOR ZAMBIA TEAK FORESTS
IN SOUTH-WESTERN ZAMBIA

FINAL REPORT Volume 1 (Summary Section)

Contents

FINAL REPORT Volume 2 (Main Section)

FINAL REPORT Volume 3 (Data Section)

1. OBJECTIVE OF SURVEY AND SURVEYED REGION

The region covered by this survey is the 500,904 ha located at the south-western portion of Zambia on the left bank of the Zambezi River and includes Mulobezi and Sesheke.

This region has continuously produced wood, primarily Mukusi, from the 1920s to the present day. During that time, however, no quantitative survey has been made of the forests. The amount of Mukusi and other forest resources remains unknown even today. Further, since the mid-1970s, there has been a sharp rise in the incidence of forest fires and over 40% of the forests once covered with Mukusi have been lost to fire. The forests which remain after the fires have lost succeeding trees of Mukusi and have stopped regenerating. Despite this situation, local residents have little to do with the Forest Estates managed by the Forest Department and so have extremely little interest in preservation of the forests, so are doing nothing to stop the devastation. Many issues have to be tackled to rebuild the ties between the forests and people. In addition, the amount of precipitation in the region has plummeted. Burning has further aggravated the situation. Harvests of crops have fallen and there are even concerns of an increase in the area of desertified land which cannot support growth of vegetation.

The objective of this survey is to obtain a grasp of the current state of the forests to enable these issues to be dealt with and to formulate a plan for forest management which takes into account protection of the environment. Another objective is to transfer technology to Zambian counterparts.

2. SOCIOECONOMIC ENVIRONMENT AND NATURAL ENVIRONMENT

This situation was analyzed by studies of available written matter and by a broad area site survey.

2.1. Socioeconomic Environment

Zambia has an area of 73.3 million ha and a population of 7.82 million. The majority of the national revenue is from copper production. The forestry sector produces an average of US$26.2 million a year or 0.9% of the gross domestic product. Zambia had 32.2 million ha of forests in 1990—a decline of 3.63 million ha in the 10-year period from 1981. This means a decline of as much as 1.1% a year (FAO, 1990). The main crop of the country is maize.

Sesheke District has an area of about 3 million ha and a population of 65,000. Almost all of the people are small-scale farmers producing just enough to meet their own needs. The main crop is maize. With the exception of some sawmills, there are no manufacturing operations of any relatively large size.

The chief system remains particularly strong in the western province in Zambia.

2.2. Natural Environment

2.2.1. Climate

The majority of Zambia falls under a semi-arid belt of a tropical climate, but the region surveyed was an area of little precipitation of less than 700 mm a year. Sesheke is subject to major swings in temperature and has recorded low temperatures causing frost damage to vegetation. Over 90% of the rain falls in the four months starting from mid-November. In the six months from May to the middle of October, the region changes to a harsh arid environment where plants rely on the moisture in the soil to survive.

The north-western area of Zambia continues to be favored with good rainfall. The south-western area, however, has experienced an approximately 22% decline in precipitation in the 20 years since 1975 and is changing to a semi-arid region. In recent years, the flow of the rivers in the surveyed region, such as the Loanja, Loazamba, and Machili, has dropped dramatically. This is backed up by analyses of weather observations. As a result, the south-western region has changed to a region of little precipitation and a much harsher dryness than before (20 years ago).

2.2.2. Site characteristics

The south-western region of Zambia is covered as a whole with a thick layer of sand called "Kalahari sand." This sand layer differs from general sand layers in that it forms an environment conducive to the healthy growth of some types of plants. The reasons are as follows:

- Since the sand particles originate from the desert, they are chemically non-weathered and contain some mineral particles rich in bases. Further, chemical weathering is occurring due to the moisture in the sand layer and thereby the inorganic nutrients are being replenished. In particular, the older age sand layer has been subjected to red weathering and forms soil rich in clay.
- A thick sand layer of 5 to 6 m taken all together has a porosity equal to or more than that of general soil. Accordingly, even during the dry season, it retains a considerable amount of water in its depths. This rises by capillary action and moistens the area, though poorly, near the surface. Mukusi directly absorbs this deep moisture.
- A sand layer is excellent in water permeability, so a level of ground water linked with the level of the rivers is formed in alluvial land along rivers. Accordingly, abundant water is retained at relatively shallow locations.

There are large pores at the surface however, and the surface therefore is dry. In particular, the surface of the highland areas is remarkably dry during the dry season and was found to provide a harsh environment for production of farm crops.

2.2.3. Ecological characteristics

The relationship between the state of development of the root systems of plants and moisture conditions of the soil layer in the dry season was surveyed. The survey revealed the ecological characteristics of the forests, woodlands, and grasslands.

Herbs have shallow root systems, so the root systems die or become dormant in the dry season. The root systems develop and grow in the rainy seasons. Shallow-rooted trees become dormant in the dry season. Almost all are deciduous tree species. In alluvial plains and low terraces which hold abundant ground water, many trees remain green even during the dry season. On the other hand, Mukusi, Muzauli, and other species which remain green year round or semi-year round are deep-rooted species which make direct use of the deep lying water even if the sand layer is deep and thereby remain green in the dry season. At locations with shallow soil layers or overly wet areas where the level of the ground water is high during the rainy season, even these deep-rooted species develop shallow root systems and like with the shallow-root species are forced to compete for moisture at the surface of the soil. These drop their leaves and become dormant early in the dry season. Even at the highland areas, at areas where the sand layer is deep, deep-rooted Mukusi and shallow-rooted species segregate in habitat in the soil in the vertical direction, thereby easing the competition for water. Under such conditions, high stock forests with high stand densities and closed forest canopies appear. The same configuration is seen even in low terraces which are favored by moisture the year round. Conversely, in locations where even deep-rooted species are inhibited in root growth (locations where the soil layer is shallow or locations where the ground water is too shallow in level in the rainy season), this vertical segregation of habitats is difficult, so the competition among trees for water becomes fierce in the dry season. Accordingly, the stand density and the forest crown closure become low and forests or woodlands with little stock appear.

3. LAND-USE AND VEGETATION AND STATE OF FOREST RESOURCES AND SOIL

3.1. Land-Use and Vegetation

This survey was conducted through determination and classification of ground surveys and interpretation of aerial photographs. It was conducted in parallel with a later-explained land-use survey.

As a result, the state of land-use and vegetation for 500,904 ha of land was classified as shown in Table YI and maps of land-use and vegetation (1/50,000) were prepared.

This survey revealed quantitatively the fact that the distribution of vegetation has changed greatly from the past due to burning and the dry climate.

The most widely spread type of vegetation is the woodlands. Next comes artificially degraded tree grasslands. Even in Forest Estates which had previously been forests, there is as much as 54,000 ha of these tree grasslands. This shows the area of burned forests and corresponds to 42% of the entire area of forest Estates. It starkly reflects the severity of forest fires.

There are 33,000 ha of natural tree grasslands. The dry climate has been accompanied by an increased area of flood plains (including dambos), marshes, and tributary valleys which no longer flood even during the rainy season and grasslands in which trees are beginning to encroach.

Table YI Present condition of land use and vegetation

Land use and vegetation	Area	
Forest	86,021 ha	(17%)
Closed woodland	153,152 ha	(31%)
Open woodland	43,383 ha	(9%)
Mupane tree grassland	30,824 ha	(6%)
Natural tree grassland	33,548 ha	(7%)
Artificially degraded tree grassland	105,962 ha	(21%)
Natural grassland	22,472 ha	(4%)
Farmland	25,542 ha	(5%)

3.2. Forest Resources

The survey of the forest resources revealed the amount of the resources in the region for the first time.

The total resources were found to be 16,179,835 m³. Note that the total forest resources were found to be 8,201,580 m³ and the total resources of closed woodlands were 7,978,255 m³.

The total stock of Mukusi was 4,061,683 m³. Of this, 3,234,215 m³ was on Forest Estates.

During the survey, preparation was made of standing tree volume tables for the Mukusi and Mukwa and crown-volume conversion table (aerial stand volume table). These materials may be used for all areas over which Kalahari sand is distributed in the south-western portion of Zambia in the future.

Note that the Forest Inventory Book and forest resource maps (1/50,000) have already been completed.

The Forest Inventory Book lists the areas of each forest compartment, total stock, Mukusi stock, Mukusi mixing rate, crown density class, crown diameter class, site index, amount of middle story trees, and soil types. It can be able to be put to effective use in methodical forest management.

Note that the state of the forest resources and vegetation is appended at the end. (Table Y2)

3.3. Soil

The soil types were classified in accordance with the FAO/UNESCO "Soil Map of the World, Revised Legend (1988)" and subclassified by soil color.

The survey found that the soil types were orange ferralic arenosols, reddish ferralic arenosols, yellow-orange ferralic arenosols, haplic arenosols, albic arenosols, and gleyic arenosols.

Putting together the findings of the survey, the need for ground coverage in the Mukusi forests and the deterioration of the soil accompanying the continued burning were revealed.

The distribution of the types of soil was shown in the soil maps (1/50,000).

4. SURVEY FOR FORMULATING FOREST MANAGEMENT PLAN

4.1. Survey for Resource Management

4.1.1. Preparation of yield tables

The following factors were analysed for the preparation of the yield tables essential for forest management:

- Relation between the diameter at breast height and the tree height
- Relation between the diameter at breast height and stand density
- Relation between the diameter at breast height and forest stand volume by layer
- Relation between the diameter at breast height of dominant trees and the forest stand volume of the middle layer trees
- Relation between the diameter at breast height and the forest age
- Relation between the tree height and forest age
- Relation between stand density and forest age
- Volume growth curve
- Relation between forest stand volume by layer and forest age

The yield tables for different site classification were prepared for Mukusi forests with closed crowns through the above analysis. The yield tables may be used in all areas of the south-western region covered by Kalahari sand.

Table Y2 Present condition of vegetation and forest resources

No.	Forest estate	Total area(ha)	Area(ha) of each vegetation: Forest	Closed Woodland	Open Woodland	Mupane tree grassland	Natural tree grassland	Artificially degraded tree grassland	Natural grassland	Farm-land	Rate of "Forest" (%)	Remark	Total stand volume: Vol. per ha(m^3)	Stand volume(m^3)	Mukusi volume(m^3)
1	Masese group of forest	54,933	25,228	612	0		2,480	26,319	291	3	46	Total(a-h)	104	2,626,240	1,688,323
a	Sichinga	5,974	1,220	137			216	4,350	48	3	20		40	53,654	17,339
b	Monze	6,083	769				1,136	4,178			13		52	39,614	13,282
c	Kasiki	5,540	2,022				818	2,700			36		96	194,544	110,289
d	Malavwe	5,681	2,291				116	3,274			40		71	163,366	81,735
e	Simungoma west	7,990	5,734				194	2,062			72		125	717,222	435,337
f	Simungoma east	8,540	6,237					2,303			73		129	801,522	621,779
g	Sikubingwa	5,385	3,391	279				1,555	160		63		92	336,525	222,470
h	Sisisi	9,740	3,564	196				5,897	83		37		85	319,793	186,092
2	Zungubo	950	191	65				694			20		81	20,782	2,582
3	Kateme	2,560	1,043	132				1,343	42		41		97	114,496	31,386
4	Mululwe	7,276	899	127	505			5,588	108	49	12		58	59,476	12,246
5	Nanyota	3,432	763	212	222			2,211		24	22		68	66,492	31,641
6	Samatela	6,485	1,389	1,062	1,529			2,497		8	21		51	125,463	39,474
7	Lumino	4,000	1,742	32				2,168		58	44		115	203,596	85,369
8	Kayumbwana	3,575	1,919		120			1,536			54		109	208,394	81,000
9	Nangombe	2,380	855		84			1,441			36		111	94,768	13,959
10	Sijulu	2,770	1,731	77	385			452		125	62		124	224,627	76,888
11	Kalama	1,006	302		216			308		180	30		53	16,070	3,968
12	Kazu-Namena	7,860	5,287	23	944			1,582		24	67		100	529,917	134,436
13	Nanga	1,450	1,149					295		6	79		171	197,002	114,580
14	Kanyanga	1,980	1,337	57				542		44	68		98	136,190	58,792
15	Lonze	9,295	6,519					2,744		32	70		114	742,353	351,576
16	Nalwama	3,340	2,084					1,125		131	62		77	161,167	64,613
17	Lwangula	2,131	1,212		29			674		216	57		98	118,641	32,507
18	Situmpa	10,520	8,020		135			2,318	17	30	76		127	1,017,401	410,875
	Subtotal(Forest estate)	125,943	61,670	2,399	4,169		2,480	53,837	458	930	49		104	6,663,075	3,234,215
Sheet No. of Topographic map															
	1724A2	42,570	418	31,283	1,850	0	2,390	4,342	1,593	694			51	1,626,928	2,532
	1724A4	36,703	2,009	9,229	566	0	4,420	18,348	178	1,953			46	518,569	18,025
	1724B1	46,663	1,935	26,280	2,878	0	3,083	8,275	1,567	2,645			61	1,724,379	269,367
	1724B2	55,398	5,072	10,107	9,816	16,683	10,972	1,465	128	1,155			58	881,903	136,618
	1724B3	19,635	3,643	1,369	1,260	0	1,748	7,426	1,285	2,904			58	288,757	78,429
	1725A1	20,306	3,100	0	1,362	13,071	156	52	1,255	1,310			60	185,157	66,083
	1624D3	37,943	687	28,522	179	0	0	2,286	4,522	1,747			52	1,509,796	92,006
	1624D4	33,648	1,656	20,071	4,008	0	1,952	3,058	385	2,518			45	985,605	14,537
	1625C1	34,848	1,065	16,413	2,647	0	360	4,342	6,193	3,828			59	1,023,271	39,334
	1625C3	38,234	4,657	7,479	11,256	618	3,290	1,144	4,086	5,704			63	766,110	110,458
	1625C4	9,013	109	0	3,392	452	2,697	1,387	822	154			58	6,285	79
	Subtotal(Sheet)	374,961	24,351	150,753	39,214	30,824	31,068	52,125	22,014	24,612			54	9,516,760	827,468
	Total	500,904	86,021	153,152	43,383	30,824	33,548	105,962	22,472	25,542			68	16,179,835	4,061,683

4.1.2. Findings in resource management revealed from yield tables

It was found that the cutting rate, when considering only the sustained yield from the quantitative standpoint, would be about 20 to 25% in 20-year-cycle selective cutting. Further, the guidelines for the amount of allowable harvesting and the method of creating stands with the maximum stock in the case of cutting just large diameter trees were revealed. Further, stands with stocks of over 75 m^3/ha have naturally dwindled to about 35% of the stock of over 75 m^3. Accordingly, it became clear that growth in each stand could be sustained by selective cutting of the amounts calculated by the following formula in the corresponding cases:

$$\Delta V = 0.35\,(V - 75)$$

where, V : stand stock (m^3/ha)

The mixing ratio of intermixture of Mukusi saplings in the young forest trees, however, is extremely low. The density of saplings is extremely low even in Mukusi forests. This shows a lack of succeeding trees and that the problem of sustaining the forests cannot be solved as long as the practice of burning continues.

4.1.3. Resource management as viewed from existing resources (Forest Estates)

The amount of Mukusi being cut each year is 13,000~14,000 m^3 in terms of standing tree volume. This assumingly will be continued in the future.

There are 10,223 ha of stands with the mixing ratio of Mukusi of over 50% and closure by large diameter trees which serve as candidates for cutting. The stock there comes to 1,999,988 m^3.

Therefore, using the discovery that the rate of cutting when considering of only the sustained yield from the quantitative standpoint would be about 20 (to 25)% by 20-year-cycle selective cutting, the area required for continued selective cutting of 14,000 m^3 a year was calculated. The result was that 356 ha was needed every year or 7,120 ha over 20 years.

This 7,120 ha area constitutes 70% of the previously calculated candidate area for cutting, but would ensure cutting of Mukusi in the future as well. Accordingly, it would be possible to sustain the forest resources in terms of quantity.

The mixing ratio of Mukusi saplings in the young forests as a whole, however is low and excessive burning (forest fires) has caused a scarcity of young trees of Mukusi to serve as succeeding trees. Considering this fact, if Mukusi is cut, then the number of Mukusi will be reduced by that amount and in the end Mukusi forests will change to stands dominated by other species, for example, Mwangula.

Accordingly, even if it is possible to maintain the volume of forest resources in the future, the conclusion is drawn that it would be difficult to sustain forests of a useful quality without greater effort in proliferation such as raising young Mukusi trees.

4.2. Socioeconomic Survey for Local Development

This survey was conducted to smooth the implementation of the forest management plan and consisted of interviews in four villages and 20 farm households. Further, a survey was conducted of sawmills and pitsawing.

4.2.1. Socioeconomic characteristics

There is are two coexisting systems of governing in the country: that by the tribal chiefs and that by the government proper. It was found that the subchiefs are highly respected by the people and serve as informal advisors to them.

Under the system of land ownership, national land belongs to the president. The western province, however, constitutes a special reservation where the Lozi tribal common law (Barotse Royal Establishment) prevails. The forest land is divided into "traditionally used land" where preference is given to custom and Forest Estates managed by the Forest Department where the Forest Law is given precedence. Forest Estates, it was learned, are viewed by the local residents as places where they were driven out from and where they harvests have been reduced.

The system for protection of the forests also is constituted by Lozi tribal common law and the Forest Law. Under tribal law, cutting of fruit trees is prohibited. Further, special species of trees are protected under both tribal law and the Forest Law. Under the Forest Law, charcoal making is possible when authorized, but this is prohibited under tribal law. As a result, there is no official charcoal making in the western province.

4.2.2. Village and farm household survey

The survey of the four villages covered the economic circumstances of the residents and their harvesting of fuel. The survey enabled a grasp to be obtained of the state of harvesting of fuelwood (dead wood) as fuel. The decline in precipitation in recent years has caused harvests of crops to plummet and has resulted in food shortages. Overall, a large number of people are finding it difficult to feed themselves.

The survey of 20 farming households covered the state of their production activities and clarified the circumstances of small-scale farming. A shortage of farming equipment was found. The need to improve this situation and provide more ploughs was pointed out.

A survey was also held of the species of trees used for fuelwood, the species used for housing materials, and the species used for harvesting fruit and a grasp was obtained of persons with experience in planting fruit trees.

Through these surveys, the need for having the senior chiefs understand and cooperate in forest management was found. It was confirmed that agroforestry was important in this region.

4.2.3. Commercial utilisation of Mukusi and Mukwa

A survey was made of the sawmills to study the utilisation of wood and determine the trends and state of the same.

The sawmills of two companies were found to be using integrated production systems starting from the cutting of standing trees to the production of lumber. Most of the Mukusi production was concentrated at one company. The other company was planning to shift to production of Mukwa. The two companies employed a total of 430 workers so have little ability to employ large numbers of workers in the region.

Mukusi is mainly used for railroad sleepers and additionally used for flooring and panel plywood. One of the companies was exporting 30% of its production and selling the remaining 70% domestically, while the other was exporting 50% and selling 50% domestically. Mukwa further has come into increased demand in recent years as a furniture material and constitutes 40% of the exported material. Demand for wood is sluggish and there is little prospect for increased production or increased sales. Therefore, the focus is now on processing Mukusi logs into panel plywood so as to achieve more efficient processing of wood and effective utilisation of resources. This survey studied the prospects for utilisation of wood in the future and pointed out a need for formation of resources for the future.

A survey was also conducted of pitsawing, that is, the production of lumber from Mukwa. The scale of production was small and demand also low, but there is room for expansion in the future.

4.3. Survey of Silvicultural System

4.3.1. State of growth of man-made forests and naturally regenerated forest

Measurements were made of test sites of direct sowing and test sites of planting of pot plants approximately 30 years old. As a result, it was found that the direct sowing approach was effective for afforestation of Mukusi. Mukusi grows to a height of 5 to 10 m and a diameter at breast height of 5 to 11 cm when 30 years old. Further, Mukwa may be inferior to Mukusi terms of number of standing trees, but can be expected to grow to a height of 9 m and a diameter at breast height of 17 cm when the same 30 years old. Note that the problems in afforestation using pot plants and measures against them were also clarified.

A survey was also made of the root systems and important information provided on the growth characteristics of Mukusi and Mukwa.

4.3.2. Cutting and regeneration of natural forests

Material regarding the state of regeneration of natural forests from 100 locations was analysed and the situation clarified. Further, the process of extinction of saplings due to burning was traced and a quantitative grasp was obtained of the impact of burning on natural regeneration. Further, the 30-year process of growth of Mukusi grown by regeneration by natural seeding was clarified.

The arrangement of stumps was measured in cut natural forests and the importance of leaving behind seed trees was pointed to.

4.3.3. Wood transport roads, firebreaks, and management system

A study was made of the roles and standards of forest roads and spur roads in relation to the cutting of wood and its transport. A need for a road network and management roads serving also as firebreaks was found.

Further, a study was made of the system of forest management and the need for improvement of management functions was pointed out.

4.4. Survey for Land-Use Management

The region is being utilised in accordance with the land conditions for forests, farmland, and pastureland, so a survey was conducted for the purpose of clarifying the best method of utilisation of the land based on the natural site characteristics.

4.4.1. Site classification

The land conditions of an approximately 640,000 ha area including the surveyed region were classified and the characteristics of the sites clarified.

4.4.2 Land characteristics and the growth of forest trees

A study was made of the relation between land characteristics and the growth of forest trees, the relation between ground water levels and plant distribution, differences between forests and woodlands with regard to plant growth patterns, and changes in plant distribution as a result of an increasing dry climate.

Table Y3 Classification of land condition

- Flood plains and low terraces along the river
  - Flood plains and low terraces along the Zambezi River
    - Low flood plains
    - Middle flood plains
    - High flood plains
    - Low terraces
  - Flood plains and low terraces along Zambezi River tributaries
    - Low flood plains
    - Channel of flood plain in rainy season
    - Concave and dish-like slope of diminishing gradient in flood plain
    - High flood plains
    - Concave and valley-like slope of diminishing gradient
    - Low terraces
- Middle and high terraces
  - Overly humid places in back of plateau
    - Marshes
    - Wet places
    - High plains around the marsh
  - Thick Kalahari sand layers
  - Distribution area of orange to reddish sand layer
    - Thickness of sand layer is more than 4 m
    - Thickness of sand layer is less than 2 m
  - Bare area of subsoil layer

Distribution area of low terraces along Zambezi River	:	21,454 ha	(3.5%)
Distribution area of flood plains along Zambezi River	:	24,136 ha	(3.8%)
Distribution area of low terraces along tributaries	:	56,701 ha	(8.8%)
Distribution area of flood plains along tributaries	:	108,421 ha	(16.9%)
Distribution area of middle terraces	:	309,939 ha	(48.4%)
Distribution area of high terraces	:	119,148 ha	(18.6%)

5. FOREST MANAGEMENT PLAN

The forests and woodlands of the region, primarily the Mukusi forests (Zambian teak forests) in the south-western region of Zambia were ecologically and environmentally grasped. A study was made of the most suitable approach for forest management based on the scientific composition, state, and features and guidelines were given and recommendations made as to necessary matters.

5.1. State of Stand Stock and Causes for Destruction

The forest survey revealed that the stock and area of stands which can realistically be utilized are extremely small. Here, if forests with stocks per ha of over 75 m^3/ha are defined as cuttable stands, then the area would be just 32,000 ha (25%) of the 120,000 ha of Forest Estates. The average stock per ha is a small 156 m^3/ha as well (80% of standard). Note that among this, Mukusi has a high volume occupancy in forests with a high forest crown closure. In stands with closed forest crowns, Mukusi is intermixed at a rate of about 55%, but in stands with a low degree of closure, it is intermixed at a rate of less than 50%.

At the present time, the total stock of the cuttable stands of 32,000 ha is 4.95 million m^3, of which Mukusi accounts for 2.67 million m^3. Assuming that this stock is obtained in 80 to 100 years, the annual growth (harvestable volume) can be roughly calculated to be 50,000 to 60,000 m^3/year for all species and 27,000 to 33,000 m^3/year for Mukusi. The current demand for Mukusi logs is estimated to be about 13,000 to 14,000 m^3/year in terms of standing tree volume, so this cutting demand is under the maximum allowable level even now with advancing forest destruction.

Normally, excessive cutting is mentioned as the cause of forest destruction, but as mentioned above the amount of cutting is under the amount of growth. Even if there had been a large amount of cutting in the past compared with now, healthy forests should have grown by more than three times the current forest volume, so the cause could not have been excessive cutting. Accordingly, the forest destruction may be considered to have progressed due to causes other than cutting. The first cause taken up here is forest fires spreading from burning.

5.2. Cutting Yield

5.2.1. Cutting method

In uniform man-made forest belts accompanied by clear cutting, effort is being made to sustain the forests for the region as a unit. However, within natural broad-leaved trees, regeneration is under natural conditions, so forests are sustained in units of stands. Cutting has to be performed in a manner enabling the continued existence of seed trees or succeeding trees. For the cutting method, selective cutting in 20-year cycles is adopted in consideration of the cutting efficiency.

The objective in forest management is to maintain stands which are close to the ideal forest state and bring destroyed stands to close to the ideal forest state. As to what constitutes the ideal forest state, a look at the forest composition in the case of healthy Mukusi broad-leaved trees shows that there is a characteristic tendency for there to be a greater number of trees the smaller the tree diameter and, even in the dominant tree group, for there to be fewer trees the larger the diameter. That is, when cutting and harvesting older trees in a stand, a normal composition is considered to be one where succeeding trees are successively prepared (in the form of a greater number of young trees).

5.2.2. Allowable amount of cutting

The allowable amount of cutting, by common sense, must not be more than the growth of the stand. Viewing the state of growth of the stands, it is found that the general trend is for the maximum stand stock to be exhibited at an average age of 80 to 100 years. After that (100 years or more), the stock declines somewhat, but a constant value is shown. Accordingly, the average growth in the cutting cycle of years (Yc) is judged to be within the following range:

$$\text{Average growth } \Delta Vc = Yc\,(V/100) \ \text{ to } \ Yc\,(V/80)$$

The yearly growth ΔVcm of Mukusi in the case of selective cutting of just Mukushi is

$$\Delta Vcm = 0.5Yc\,(V/100) \ \text{ to } \ 0.5Yc\,(V/80)$$

For opened forests or woodlands, a stand of $V \geq 75$ (m^3/ha) is considered the cuttable stand and the allowable amounts of cutting $\Delta V_{20}'$ (all species) and $\Delta V_{20m}'$ (Mukusi) in 20 year cycles become

$$\Delta V_{20}' = 0.35\,(V - 75)$$

$$\Delta V_{20m}' = 0.10\,(V - 75)$$

5.2.3. Large succeeding trees to be left and seed trees

At the present time, the only guideline for allowable cutting is the diameter class. In this case, even if trees of a certain diameter class or more are cut, there should be no problem in ensuring tree seeds so long as a large number of trees of smaller diameters are left alive. Under the present rules, trees of a diameter at breast height of over 30 cm may be cut. This report argues that this standard should be raised to 40 cm from the viewpoint of improvement of the yield, but even if this rule were observed, it would not be enough in that the survival of succeeding trees and seed trees would not be guaranteed.

When considering the continuation of a stand, such a diameter standard or allowable cutting volume is unsuitable as a standard of allowance. The question is to what extent large diameter trees (here meaning trees of diameters of at least 30 cm) able to serve as seed trees remain after cutting. Here, considering the fact that the driftability of the seeds of the Mukusi is at most about double the spread of the tree crown, to maintain a mixing ratio of at least 50% in the stands in the future, it is considered necessary that at least 30 trees of diameters of over 30 cm (tree crown area: 90 m^2) remain per ha. Ideally, the mixing ratio should be close to 80%. In this case, survival of at least 50 trees/ha is required. Accordingly, if 30 seed trees cannot be left standing per ha, then it is necessary to prohibit cutting or, when there are few saplings or young trees able to serve as succeeding trees, that is, fewer than 100 per ha, to reforest the stand (reforestation by direct sowing) or necessary to make reforestation in the cutover land obligatory.

5.3. Reforestation and Management

In this region, there are large areas of forest land damaged by fire. There are 50,000 ha of almost treeless forest land in the Forest Estates alone. Restoring these areas to forests once again is important in sustaining the resources and environmental protection. Further, raising the mixing ratio of Mukusi, Mukwa, and other useful trees in the forests is necessary as a resource measure.

The following would be important as means for reforestation to realize this objective:

- There is a great possibility of strain being caused in the seed tree composition due to selective cutting of Mukusi in the forests and for a danger to the continuation of Mukusi. It is necessary to provide technical assistance for regeneration of Mukusi by natural seeding and to artificially grow saplings in the forest by reforestation by direct sowing.
- In forest land where the forest crowns are open, increased planting of saplings and growth of succeeding trees must be promoted by reforestation of Mukusi by direct sowing.
- It is necessary to develop creative nursing techniques commensurate with the vertical rooting of Mukusi.

- Mukusi and other climax species are believed to be strong in nature as semi-tolerant trees when they are young and saplings. When trying to regenerate forests in treeless areas or extremely open areas where the direct sunlight is strong, it is crucial to first introduce intolerant species (species comprising woodlands such as Mukwa) and when these have matured to a certain extent and a shaded environment is formed, then introduce Mukusi and other climax species (reforestation by direct sowing: 100 to 400 trees/ha).
- It is necessary to develop techniques for the creation of preceding covering trees.

Up to now, consideration has been given to management of reforestation focusing on the continuation and regeneration of forest. In the inventory books, the stands are classified taking note of the magnitude of their forest crown coverage (D_1, D_2, D_3), the magnitude of the size of the individual tree crowns comprising the forest crowns (C_1, C_2, C_3), and the site index (H_1, H_2), so specific facets of management of reforestation were shown for each individual stand classification ($C_1D_1H_2$, $C_1D_2H_2$... $C_3D_2H_1$, $C_3D_3H_1$).

5.4. Soil Conservation Measures

The soil in this region is not inherently fertile by any means, but there appear to be large areas where the local residents depends on the fertility of the soil for cultivation and livestock raising. In fact, however, there is a contradiction in that the residents themselves are causing the fertility of the soil to fall by burning off land and overgrazing while not being aware of this. It is important that they understand the mechanism of soil formation and take steps for its conservation.

5.4.1. Basics of soil conservation

Viewed overall, the central role in maintaining and promoting the functions of the soil is played by herbs.

(1) Soil erosion and herb coverage

If herb coverage is lost and the surface of the soil is exposed, raindrops directly striking the surface will cause a deterioration in the soil quality. Healthy soil under herb or leaf coverage has a large infiltration structure and allows water to infiltrate into the soil, but when the surface of the soil is exposed and struck by direct rainfall (including tree crown rain), the infiltration structure at the surface will be destroyed to thereby cause a reduction in the infiltration. As a result, surface flows will occur and soil erosion will be caused. Even in Zambia, there has been remarkable devastation caused by soil erosion in red soil areas where the herb coverage has been destroyed by overgrazing and burning. To avoid this situation, it is necessary that the surface of the soil be covered by some sort of buffer against rain drops so as to protect the surface structure from their destructive force. This protective role is played by the layer of fallen leaves and foliage of the herbs.

(2) Leaching in sandy soil, formation of pans, and herb coverage

If there is no plant coverage, the sandy soil is exposed, and water strikes the soil directly, then the bases, iron, and other weathering substances and organic matter which had been held at the outside of the sand particles are leached out and a situation occurs where only the rock-like sand particles which are poor in fertility (white or grey inorganic sand particles) remain. Such a layer of leached out sand particles has a strong acidity. If it covers the surface of the soil, then even herb-like plants, which have a strong ability to proliferate, will be hindered in growth and recovery of the vegetation will become difficult. Therefore, once leaching occurs, this phenomenon spreads and in some locations white layers of more than 20 cm thickness are found.

This whitening of the surface soil is accompanied with not only chemical deterioration, but also movement of fine particles freed or suspended by the leaching to the lower layers. There is a problem in that these cause the formation of an impermeable pan at locations of a depth of 30 to 50 cm. If such a pan is formed at a relatively shallow location of the soil, then infiltration of the water to the deep parts of the soil will be inhibited even with the precious rainfall of the rainy seasons and conversely a layer of stagnant water will be formed at the surface layer to cause an overly wet state. If this situation occurs, then even if vegetation regenerates and there is a recovery in intermixture of humus in the surface soil, there is a good chance that the forest will not return to a good quality. It is believed that desertification and formation of savannas occur in this manner.

(3) Replenishment of soil organic matter (humus) and herb root systems

The fertility of soil is expressed by the content of the humus at the soil surface. The humus is derived from the residue of living matter, in particular plants, but more directly is derived from the residue of root systems distributed in the soil. Here, a comparison of the fine and small roots of the trees and herbs in the soil shows that the density of the herbs is 20 to 30 times that of the trees. Further, the root systems of herbs are shorter in lifetime, so the residue is supplied to the humus layer on a yearly basis. That is, the fertility of the soil in the short term or on a yearly basis may be considered to be supported by the herbs.

Note that soil containing humus often displays resistance to the above leaching.

5.4.2. Guidelines for forest management considering soil conservation: coexistence of herbs and trees

When forests are burned and the resultant land is used for shifting cultivation, the fertile soil formed during the forest period becomes a source of nutrition for the crops, but many people appear to believe that the humus which had served as the storehouse of the fertilizer components is created solely by the trees. The direct suppliers of the humus layer which supports the fertility is, however, the herbs. Further, it is the herbs that protect the physiochemical properties of the soil. If there is no undergrowth of herbs in the forest, then rich soil will not be formed or sustained.

If the role of the herbs in supporting the fertility of the soil is understood, forest management from an environmental viewpoint should end up by consequence promoting of the coexistence of trees and undergrowth and inhibiting forest utilisation or treatment which reduces the herbs on the forest floor.

5.5. Fire Prevention Measures

There is progressive destruction of the forests by fire in the south-western region. Not only are the area and stock of forest land declining, but there has also been a sharp drop in the number of saplings and young trees of less than 30 years' age. Management of the natural forests includes observance of suitable amounts of cutting or silvicultural operations so as to ensure sustained growth of healthy seed trees and succeeding trees, but forest fires cause the extinction of the critical saplings and young trees, so make all of this patient forestry work meaningless.

1) Herbs and burning

The fact that the soil environment is sustained and restored mainly by the herbs appears not to be understood. This causes people to feel easy about eradicating them. Local residents should be made to understand that herbs are the major factors in maintaining and restoring the fertility of the soil and should be made to protect the growth of herbs in forest land, cultivated cutover land, and pastureland and in turn observe orderly burning.

2) Bushes and burning

Most bushes are dangerous plants with sharp thorns, so are considered negative in value. Further, they have stems which, while thin, are extremely tough and pliant, so cannot be easily cut. In this respect, burning in the middle of the dry season or later for the purpose of eradicating bushes can be understood. To enable safe cutting of thorny bushes, it is necessary to introduce long-handled bush cleaners. Cutting should be performed in combination with burning so as to prevent burning from spreading to forest fires.

3) Reevaluation of efficacy of burning

Various objectives are given for burning. Officially, almost all burning is evaluated as being useful. In fact, however, it inflicts destructive damage to the forests and the natural environment of the forests. From the standpoint of forest management, first priority should be assigned to suppressing it.

Even if burning such as early burning is somewhat justified, if performed very frequently, it would appear to the general populace that burning was a socially acceptable practice. In recent years, local residents have felt free to burn off land along with the spread of devices such as matches and lighters enabling fires to be easily started. This seems to be a causative factor behind the greater incident of fires.

In the fields of agriculture, animal husbandry, and prevention of disease, burning is actually justified, but one feels that the time has come for the efficacy of this to be reassessed and a study made of how this action is perceived in the minds of the general populace.

5.6. Improvement of Infrastructure for Forest Management

The following infrastructure is necessary for maintenance and management of healthy growth of the forests and their efficient utilisation in keeping with the needs of modem society:

- Transport vehicles, roads (forest roads and spur roads), and bulldozers for road construction and repair.
- Management roads serving also as firebreaks: Construction of management roads serving also as firebreaks (6 m wide) along the boundary between the forests and other land-use so as surround the forests. Deployment of bulldozers as machinery for construction and repair.
- Forestry machinery and equipment: Provision of small-sized forestry equipment such as hatchets, sickles, saws, axes, spades, and saw sharpeners and deployment of small sized forestry machinery such as long handled bush cleaners and chain saws.
- Seed storehouses: Securing good quality seeds for reforestation by direct sowing. Establishment of seed storehouses (with air-conditioning) for them.

5.7. Linkage of Forests and Local Residents

Large diameter trees, the main product of forests, are used primarily as material for lumber. There is no demand for them amount local residents. Further, there is no system established for the hiring of local residents when cutting them down. In this respect, there is a strong feeling among local residents that they are being left out. Accordingly, even when old forests burn down, they appear to feel little regret.

Recently, the importance of the forests has been stressed in the world in relation to protection of the environment, but this scientifically backed environment theory is hard to understand by and irrelevant to local residents. It is a fact, however, that these hard to understand changes in the ecological and environmental mechanisms are starting to threaten their livelihoods. It is most important to convince them of this and make them understand the value of their nearby forests, including undergrowth.

Note that when moving toward actual implementation of forest management plans, it is necessary to fully explain the background and nature of the plans to the organization of chiefs who will play a role in this management and secure their opinions and agreement. In particular, there is a great need for this in regard to issues close to the local residents such as burning, agroforestry, and fuelwood forests.

The following countermeasures are considered necessary to increase the interest of the local residents in the forests:

- It is crucial to change thinking through education so as to make the residents feel a sense of closeness to and usefulness in the forests, but no immediate results can be expected by this. For a more direct effect, a possible shortcut would be to set up some kind of incentive system. For example, the right to harvest fuelwood or assistance for the digging of wells able to provide water on a year round basis could be given to nearby villages if there were no fires in the nearby forests and woodlands for a certain year-long period. Alternatively, assistance could be given to modernisation of farm equipment or other practical incentives provided.
- In parallel with the above measures for prevention of forest fires, reforestation projects could be launched and local residents employed. Since the area for reforestation would be large, the projects would go one for a long time. If the projects proceed stably, the residents would have an increased opportunity to earn cash from the forests and therefore would become more interested in them.

5.8. Expansion of Demand

At the present time, Mukusi is used mainly for railroad sleepers. Future demand is expected to shrink. If current trends continue, then the amount of demand in terms of standing trees for sleepers may well drop to even less than the present. On the other hand, if reforestation is proceeded with aiming at heathy forests, the total growth (allowable amount of cutting) can be expected to grow each year, so greater utilisation of the resources will be desired. Positive effort is required to develop demand so as to solve this contradiction.

Here, the important thing in the lumber industry when investing in sawmill equipment is whether there is a sufficient amount of the available resource to warrant the installation of machinery. If there is a certain amount of stock of a resource in a certain area, then the machinery can be used at a high efficiency. How to process and use the production is a second issue with a broad range of available options.

In this regard, Mukusi is a hard species of superiority durability and is the species of the most concentrated stock in the forests of the south-western region. This species can be evaluated as having sufficient conditions for capital investment. The point is to develop and seize applications. If this can be done, then Mukusi should become the number one useful species for the sector of the wood industry using natural forests. It is desirable to develop new demand taking note of the properties of Mukusi.

Mukwa enjoys stable demand as a furniture material and higher added value processing is being targeted. It is uncertain, however, if enough of the resource can be secured in the future if demand increases. In particular, it is unknown how much can be cut when considering the need to leave enough seed trees for continuation of the forests. This must be surveyed in the future.

Due to the slow demand for wood in Zambia, there is a desire to increase exports. At the present time, exports of railroad sleepers, plywood, etc. are being promoted, but the future is not necessarily bright. Zambia is an inland country far from any seaport, so the bottleneck when considering broader exports would be the overland transport. In this regard, it would be more advantageous to transport higher added value lumber products, plywood, etc. rather than raw materials, but this would require fuller market surveys and product development.

5.9. Land-Use Management

There is abundant ground water linked with the water level of the river under the alluvial land. In this region, the constitutes the best land in terms of moisture conditions. Due to the quality of the site, it is believed that the low terraces (including the alluvial terraces in tributary valleys) are believed to have been fertile locations with flourishing forests in the past. With human utilisation now progressing, however, there are farm plots, villages, and pastureland spread over the region. The highland areas which are not so well blessed with ground water have become forests and woodlands. The floodplains, which flood in the rainy season, have become grasslands. In this region, most of the alluvial land is occupied by traditional lands, so almost all of the issues relating to land-use may be considered to involve areas under the control of the chiefs.

The crops cultivated in this region up until now depended on the natural nutrients (humus) held by the soil for their growth. The farmers cut down the forests, burn off the vegetation, and use the resultant cleared plots (slashes) for cultivation. The nutrients are however consumed completely after three to four years of continuous cultivation, so the residents move off in search of new forest land.

In general, in the organized shifting cultivation engaged in around the world, the common practice after ending cultivation is to wait for the farm plot to return to its natural forest state and the fertility of the soil to be restored, then again cut down the trees and burn off the land for cultivation. Accordingly, in regions where sound shifting cultivation is performed, there should be farm plots and forests (four to five times the area) adjoining each other. In this region, however, the land is not being used in a manner enabling such coexistence of farm plots and forests.

When cultivation ends, herbs invade even these areas and start to grow, but perhaps because the residents do not know about the mechanism for soil restoration by herbs, livestock is allowed to graze on it or sometimes the land is burned off. Grazing by a suitable number of livestock and suitable burning in a manner allowing herbs to sufficiently grow would promote the regeneration of new herbs, so do not have to be prohibited. However, in many cases, an excessive number of livestock is allowed to graze and the growth of herbs declines with each passing year. This trend is a problem.

Further, excessive grazing and burning are being conducted even in the forests where large diameter trees grow, so the soil is being degraded in many locations. That is, despite the soil fertility being apparently restored by the forests, the environment is being worsened. As a result, even at what appear to be healthy forests and woodlands, the soil is exposed, the surface is leached out, and pans are formed at the medium to low layers. The fertility declines and barren land of a quasi-desert state appears.

As a result, not only does the abandoned farm plot not recover, but it is further reduced in strength. Therefore, the state of cyclic utilisation of land spaces is not observed. The farm plots and abandoned land just steadily increase. As a result, cultivators lose places to go in the alluvial plains and search for new land in the highland forest belts. There, however, they cannot enjoy the benefits of the ground water, so good farming cannot be expected. Residents, however, do not understand this land mechanism and appear to intrude into forest belts in search of soil with better nutrients.

The following recommendations are made to deal with the above situation:

- Alluvial land is suited for shifting cultivation using land spaces. Abandoned farm plots resulting from shifting cultivation even if left alone will in many cases gradually return to a forest state. Herbs will grow in the early process of regeneration, but to promote the restoration of soil fertility, it is crucial that the number of livestock allowed to graze on this be kept down to a suitable level. In particular, care must be taken with grazing by goats as there is a high risk of overgrazing.

- Since there is a shortage of the forests needed for restoration of the soil fertility and fuelwood forests are becoming short in supply as well, broad-leaved tree forests comprised mainly of small diameter trees with 20 to 25 year cutting cycles should be created. By combining this periodic cutting of broad-leaved trees and shifting cultivation, it should be possible to sustain continuous agroforestry on alluvial land.
- The forest belts in highland areas are inferior in terms of water conditions to alluvial land although containing some soil nutrients. Accordingly, they are not suitable for cultivation. Shifting cultivation in highland areas should in principle be prohibited.
- Floodplains, which flood during the rainy season, are fertile, but cannot be used during the rainy season. The land enjoys good moisture conditions in the dry season, however, so can be seasonally used as farm plots. At the present time, they are not being used due to the difficulties in tilling, but they should be put to use as somewhat intensive farm plots by the introduction of tilling machines. Further, these are locations with the most flourishing growth of herbs, so grazing should preferentially be kept to the floodplain areas.
- Alluvial plains offer abundant ground water for use. If ground water is pumped up, fertilizer applied, and the land tilled and used as intensive farm plots, then it would be possible to engage in farm operations without even being affected by droughts. Further, a large area of the alluvial plain satisfies these conditions. If full-scale agricultural production were engaged in there, then harvests far exceeding the demand of the local residents could be expected. Further, by switching over to stable agricultural production in this way, it is believed that senseless forest destruction would also be suppressed. At the present time, this would be impossible to implement in view of the fact that local residents have no cash income, but it would be desirable to move them to intensive land-use in the near future.

5.10. Future Issues and Proposals

The issues which should be particularly stressed will be listed here and proposals will be made.

5.10.1. Forestation techniques for restoring resources

There is remarkable forest destruction in the south-western region. About 40% of the area of Forest Estates is treeless and 20% has extremely open forest crowns. It is necessary to reforest these areas where the forests are disappearing so as to restore the forests. Even forests which appear to be healthy are suffering from strain in the composition of species, so reforestation is necessary to readjust them. In traditional areas as well, reforestation for raising the mixing ratio of Mukwa in the woodlands, formation of forests for restoring fertility to the soil, and reforestation for forming fuelwood forests are necessary. Along with this, it is necessary to form groves of fruit trees required by residents.

Among the reforestation techniques for this, at the present time, only reforestation by direct sowing is being implemented. Methods of nursing and methods for growing young trees individually for species and sites of course and the systems for the same have still not finished being developed. Further, there are many aspects of the ecosystem of the forests which remain unclear after the current research. There is much for which follow-up surveys should be performed over the coming years. Surveys and studies on reforestation will be necessary to solve these problems.

5.10.2. Wood utilisation and forest management

Since specific species are mostly cut in forests for industrial wood production, strain occurs in the composition of the regenerated species. It is necessary to bear the cost of forestation (including forestation in the forests) so that "the strain caused by harvesting is corrected by the harvesters."

Effective from 1995, cutting fees are being received from sawmill operators currently engaged in cutting. This money should be used for reforestation.

5.10.3. Management of Mukwa-mixed woodlands

Mukwa seeds have a large driftability, so do not require as many seed trees as with Mukusi, but even so it will be necessary to leave about five trees/ha. If there are less than five large trees of diameters of 30 cm, then even if the other conditions for allowance (diameter class of over 35 cm and cutting allowance of 20 to 25%) are satisfied, there should be no cutting.

Mukwa and other intolerant tree species are mostly shallow-rooted. Compared with the deep-rooted Mukusi etc., they are believed easier species to nurse and plant. At the present time, forest fires have created broad areas of treeless land or extremely open land, but regeneration of the forests in these locations would probably require first starting with intolerant tree species and creating a woodland condition rather than directly planting Mukusi and other semi-tolerant tree species. It is believed that it would be wise to use Mukwa and other useful species for formation of this preceding forest. It is important to plan for planting useful intolerant tree species not only in existing woodlands, but also in the broader forest land.

5.10.4. Management of Mupane stands

To establish a healthy cycle of cultivation and restoration of soil fertility in this region, establishment of fuelwood forests in the alluvial land (low terraces) is necessary. Alluvial land represents a good location for trees in terms of moisture conditions, so reforestation works should be technically easy, but whatever the case since there has been no actual experience with this yet, it is necessary to tackle it as a new technical issue.

On the high floodplain in the south-eastern part of Seshcke, there is a wide area of Mupane stands. It is estimated that over 50,000 m^3/year may be added as firewood due to plant growth. At the present time, from the standpoint of preventing reckless cutting, charcoal-making activities are prohibited in this region by the Lozi tribal common law, but it is judged that there are broad avenues for use as firewood.

5.10.5. Practical application of survey findings and close linkage with site

The present survey was designed to throw light on the basic requirements for moving to actual forest management and providing guidelines for the same. Surveys, studies, and spread of technology for adaptation to local conditions and new surveys, tests, and research on areas still not clarified will become necessary for practical application of the findings of this survey. It will probably be necessary to continue with more technically oriented activities.

5.10.6. Urgently required reforestation tests

When considering forest regeneration projects, the most required basic thing is to perfect the individual techniques and systems for the process before the growth of young forests such as the nursing, planting in the forests, reforestation by direct sowing, etc. At the present time, none of these have yet been perfected. At this stage, no specific plans can be drawn up for formation of forests. To enable quick development of these techniques, it is recommended that nurseries and experiment forests be established and the required techniques realized.

6. ENVIRONMENTAL CONSERVATION

The state of the environment was compared against the natural state of a forest and points to be maintained and points to be rectified clarified. At the same time, measures necessary for the same were recommended. A study was also made of the impact on the environment of the forest management and land-use.

6.1. State of Land and Environment

In the surveyed region, almost all of the environmental factors in play are natural. The south-western region of Zambia has experienced a decline in its annual precipitation in the past 15 to 20 years and a continuation of dry climatic conditions. These are major negative natural factors. The problem is that in the midst of all this, there has recently also been a greater impact from aggravating human factors. In particular, there has been a remarkable decline in the fertility of the soil due to the destruction of the forests by forest fires and overgrazing.

Note that these are problems relating directly to forest management and land-use management. This was summarized earlier so will be omitted here.

6.2. Desertification

The region surveyed has undergone at least two periods of desertification in its past history. The decline in precipitation in the past 15 to 20 years is feared as presaging desertification of the climate. It is clear that the drop in the level of ground water accompanying this causes changes in the type of the vegetation. Further, the decline in the soil nutriets and conversion of the soil to an inorganic state in the desertification of the sand layer and the progressive destruction of vegetation caused by burning and overgrazing which aggravate this may also be pointed to.

It is accordingly recommended to restrict actions which would invite further reduction of herbs both inside and outside the forests. Specifically, clear objectives and areas for burning should be determined and these strictly observed. Further, grazing should be kept to the floodplains at times other than the rainy season and the floodplains used as much as possible even during the rainy season so as to keep use of the areas of growth (or potential growth) of trees to a minimum.

6.3. Conservation Measures Regarding Damage by Burning

The following were recommended as measures to prevent fires:

- Promoting understanding of the beneficial functions of forests and natural vegetation, in particular herbs, and strengthening of education regarding the damage caused by uncontrolled burning.
- Planting of food-bearing trees to stimulate interest in preventing forest fires.
- Encouraging local residents to engage in apiculture in the forests and the cultivation and production of forest by-products products so as to make them realize the need for preventing fires.
- Application of an incentive system for villages around forests which have been protected well for a long period.
- Establishment of a firebreak (bare strip) around the forests.
- Strengthening firefighting capabilities (equipment and current budget).

The following were recommended for reassessment of the efficacy of burning:

- A quantitative survey of the effects and damage of the currently authorized various burning practices.
- A survey of the psychological effects of currently authorized or promoted burning on local residents.
- Reassessment of the efficacy of burning through the above surveys and then taking specific steps such as toughening regulations, establishing a period of prohibition, or establishing prohibited locations.

The following were recommended as measures for sustaining the forests:

- Raising awareness of the importance of sustaining the forests, at the Forest Department and the rest of the government as well, and taking steps for reforestation.
- Taking measures regarding the forests, grasslands, and farmland stressing soil conservation in the forests and taking steps to prevent desertification.

It is necessary to get the local residents away from sustenance farming in the outlying areas and change the surroundings in which the residents live to a commodity economy so as to enable promotion of more intensive utilisation of land based on natural scientific conditions of the land. It was pointed out that it is crucial to open up avenues for the local residents to earn cash and at the same time to encourage them to make more rational use of the land.

6.4. Other Environmental Phenomena

Regarding soil erosion, mention was made of the correlation with the reddish sandy soil and grazing by goats.

Concerning the quality of the river and ground water, mention was made of the possibility of chemical pollution through future use of agrochemicals and suspension pollution resulting from soil erosion at reddish sandy soil areas accompanying overgrazing.

Turning to the protection of wildlife etc., it was indicated that selective cutting in normal forests would be a possible approach by the forestry side, but that priority should be given right now to prevention of fires in the forests.

As for air pollution and global warming, mention was made of the correlation between forest fires and overgrazing and the decline in forest stocks.

6.5. The Effect of Forest Management on the Environment

A natural forest environment can be considered to be an ideal environment. Since the Forest Management Plan aims at the maintenance and restoration of forests to their natural state, the effect on the environment should be evaluated as being good in almost every respect. However, since a return to a natural state partially means a return to a wild state, some adjustments in developing land use (farming, grazing) will be necessary in the interests of progress.