

Table H.1-26 Study Districts Total Data (Horticultural Crops & Cropping Pattern)

TABLE H-26	Study Districts Total Data : Horticultural crops				TABLE H-26 (Sheet 2)				Study Districts Total Data : Total Horticultural crops					
	Area		Areas in ha		Production		Yields in tonnes/ha		Production		Yields in tonnes/ha			
	1,994	%	1,995	%	1,994	%	1,994	%	1,994	%	1,995	%		
CROP	Area	%	Area	%	Area	%	Area	%	Production	%	Production	%	Yield	%
Tomato	2,807	9.6%	2,727	9.7%	3,122	7.1%	31,388	36.346	52,766	12.0	13.3	16.9	16.9	
Cabbage	2,448	9.0%	2,789	10.0%	2,451	3.6%	35,706	47,128	40,097	14.6	16.9	16.4	16.4	
Kale	1,546	5.7%	1,248	4.5%	1,170	7.1%	24,523	17,211	14,410	15.9	13.8	12.3	12.3	
Carrot	581	2.1%	607	2.2%	552	0.8%	5,378	5,484	5,472	9.3	9.0	9.9	9.9	
B.Onion	1,181	4.4%	928	3.3%	1,012	1.8%	8,328	8,076	8,962	7.1	8.7	8.9	8.9	
Field Pea	350	1.3%	220	0.8%	185	0.0%	1,225	1,100	962	3.5	5.0	5.2	5.2	
Garlic	18	0.1%	98	0.3%	100	0.0%	72	686	800	4.0	7.0	8.0	8.0	
Peppers	211	0.8%	260	0.9%	76	1.8%	846	877	286	4.0	3.4	3.8	3.8	
Total Vegetables	8,942	33%	8,877	32%	8,668	22%	106,858	117,806	123,765	12.0	13.3	14.3	14.3	
Banana	9,534	35.2%	10,188	36.4%	8,549	60.7%	82,794	93,660	78,114	8.7	9.2	9.1	9.1	
Mango	971	3.6%	1,112	4.0%	1,060	4.1%	7,547	9,284	11,426	7.8	8.3	10.8	10.8	
Apples	3	0.0%	4	0.0%	2	0.0%	20	14	8	8.0	4.0	4.0	4.0	
Citrus	498	1.8%	487	1.7%	432	0.0%	3,172	2,743	2,502	6.4	5.6	5.8	5.8	
Papaya	787	2.8%	872	3.1%	628	2.9%	7,007	7,419	6,500	9.1	8.5	10.4	10.4	
Passion Fruit	353	1.3%	336	1.2%	364	1.1%	2,736	2,511	2,813	7.8	7.5	7.7	7.7	
Pineapple	52	0.2%	63	0.2%	58	1.4%	311	598	304	6.0	9.6	5.2	5.2	
Avocado	1,327	4.9%	1,382	4.9%	1,406	1.6%	21,300	22,508	23,050	16.1	16.3	16.4	16.4	
Guavas	27	0.1%	11	0.0%	12	0.0%	50	75	60	1.9	6.8	5.0	5.0	
Plums	5	0.0%	5	0.0%	5	0.0%	20	20	30	4.0	4.0	6.0	6.0	
Melons	21	0.1%	13	0.0%	0	0.0%	168	104	0	8.0	8.0	0.0	0.0	
Total Fruit	13,557	50%	14,472	52%	12,516	72%	123,522	138,155	124,747	9.1	9.5	10.0	10.0	
French Bean	1,858	6.9%	1,730	6.2%	3,530	0.0%	10,835	11,207	25,901	5.8	6.5	7.3	7.3	
Snowpea	548	2.0%	616	2.2%	780	0.0%	1,816	1,902	2,480	3.3	3.1	3.2	3.2	
Brijal	146	0.5%	113	0.4%	68	1.3%	702	467	374	4.8	4.1	5.5	5.5	
Karella	161	0.6%	146	0.5%	85	0.9%	1,100	829	450	6.8	5.7	5.3	5.3	
Dudhi	11	0.0%	18	0.1%	15	0.0%	150	162	150	13.6	9.0	10.0	10.0	
Okra	186	0.7%	229	0.8%	160	1.1%	1,710	1,534	1,110	9.2	6.7	6.9	6.9	
Valore	23	0.1%	18	0.1%	20	0.0%	99	60	100	4.3	3.3	5.0	5.0	
Turia	17	0.1%	19	0.1%	10	0.4%	8	10	8	0.5	0.5	0.8	0.8	
Chillies	131	0.5%	125	0.4%	108	1.1%	364	363	290	2.8	2.9	2.7	2.7	
Macadamia	1,450	5.4%	1,586	5.7%	1,397	0.0%	4,074	4,219	4,743	2.8	2.7	3.4	3.4	
Total Export Hort.	4,531	17%	4,600	16%	6,173	5%	18,489	19,379	35,193	4.1	4.2	5.7	5.7	
Other crops	36	0.1%	67	0.2%	58	1.3%	279	220	10	7.9	3.3	0.2	0.2	
TOTAL	27,064	100.0%	28,015	100.0%	27,412	100.0%	247,079	273,208	280,596					

Study Districts Overall Horticultural Cropping Pattern										
CROP	w/o Project		With Project		w/o Project		With Project		With Project	
	Hectares	%	Hectares	%	Yield kg/dec	Prod. tons	Yield kg/dec	Prod. tons	Yield kg/dec	Prod. tons
Potato	37,290	57.0%	38,820	54.0%	963	359,013	1,043	359,013	1,043	405,070
Tomato	2,840	4.3%	3,580	5.0%	1,268	36,007	1,652	36,007	1,652	59,130
Cabbage	2,563	3.9%	3,175	4.4%	1,599	40,974	1,702	40,974	1,702	54,050
Kale	1,343	2.1%	1,380	1.9%	1,420	19,069	1,609	19,069	1,609	22,200
Carrot	580	0.9%	565	0.8%	939	5,445	1,131	5,445	1,131	6,390
B.Onion	1,043	1.6%	1,245	1.7%	792	8,257	1,283	8,257	1,283	15,975
Field Pea	252	0.4%	250	0.3%	435	1,096	550	1,096	550	1,375
Garlic	72	0.1%	105	0.1%	721	519	750	519	750	788
Peppers	182	0.3%	175	0.2%	367	670	517	670	517	905
Total Vegetables	46,165	70.6%	49,295	68.6%	887	86,749	1,087	86,749	1,087	128,800
Banana	9,781	14.9%	11,850	16.5%	894	9,694	1,250	9,694	1,250	15,425
Mango	1,084	1.7%	1,234	1.7%	525	14	600	14	600	18
Apples	3	0.0%	3	0.0%	591	2,855	0	2,855	0	0
Citrus	483	0.7%	399	0.6%	915	7,639	1,045	7,639	1,045	8,413
Papaya	835	1.3%	805	1.1%	766	2,708	828	2,708	828	4,970
Passion Fruit	354	0.5%	600	0.8%	710	418	870	418	870	653
Pineapple	59	0.1%	75	0.1%	1,621	22,351	1,944	22,351	1,944	26,530
Avocado	1,379	2.1%	1,365	1.9%	395	85	406	85	406	89
Guavas	22	0.0%	22	0.0%	800	136	1,200	136	1,200	900
Melons	17	0.0%	75	0.1%	673	16,177	905	16,177	905	25,425
Total Fruit	14,015	21.4%	16,428	22.9%	319	2,066	462	2,066	462	4,670
French Bean	2,403	3.7%	2,810	3.9%	456	547	570	547	570	735
Snowpea	648	1.0%	1,010	1.4%	631	890	786	890	786	1,258
Brdnjai	120	0.2%	129	0.2%	1,050	154	1,100	154	1,100	165
Karella	141	0.2%	160	0.2%	801	1,675	959	1,675	959	2,063
Dudhi	15	0.0%	15	0.0%	407	92	425	92	425	128
Okra	209	0.3%	215	0.3%	57	9	93	9	93	19
Valore	23	0.0%	30	0.0%	281	385	345	385	345	518
Valore	16	0.0%	20	0.0%	294	4,345	346	4,345	346	5,300
Turia	137	0.2%	150	0.2%	367	225	426	225	426	363
Chillies	1,477	2.3%	1,530	2.1%	630	630	630	630	630	630
Macadamia	5,189	7.9%	6,069	8.4%	630	630	630	630	630	630
Total Export Hort.	61	0.1%	85	0.1%	367	225	426	225	426	363
Other crops	65,430	100.0%	71,877	100.0%	630	630	630	630	630	630
TOTAL	65,430	100.0%	71,877	100.0%	630	630	630	630	630	630

Table H.1-27 Study Districts Average Yields

TABLE H-27	Study Districts Average Yields: Horticultural crops												Study Districts Average Yields											
	Nyeri			Kirinyaga			Embu			Tharaka			Meru			Nyambene			Totals					
	94	95	96	94	95	96	94	95	96	94	95	96	94	95	96	94	95	96	94	95	96			
CROP																								
Tomato	14.0	18.0	15.0	12.0	12.0	20.0	11.6	7.1	0.0	8.4	8.4	12.4	10.0	10.0	10.0	7.0	8.0	10.0	18.0	20.0	17.5	12.0	13.3	16.9
Cabbage	15.0	18.0	18.0	15.0	15.0	15.0	0.0	0.0	0.0	14.8	14.4	15.3	8.5	9.0	8.0	10.0	10.0	10.0	25.0	30.0	17.5	14.6	16.9	16.4
Kale	10.0	10.5	6.0	15.0	15.0	15.0	15.4	20.1	0.0	14.8	14.4	14.8	11.3	12.0	12.0	2.0	2.0	4.0	25.0	30.0	15.0	15.9	13.8	12.3
Carrot	10.0	10.0	10.0	10.0	10.0	10.0	0.0	0.0	0.0	7.5	7.6	7.6	7.0	7.0	0.0	4.0	5.0	8.0	15.0	15.0	17.2	9.3	9.0	9.9
B.Onion	6.0	7.0	7.0	12.0	12.0	15.0	0.0	8.0	0.0	6.6	6.6	6.5	7.5	7.0	7.0	5.0	8.0	5.0	8.0	8.0	4.8	7.1	8.7	8.9
Field Pea	3.5	5.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	5.0	5.2
Garlic	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	7.0	8.0	0.0	0.0	0.0	4.0	7.0	8.0
Peppers	8.5	6.0	8.5	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.4	1.3	4.0	3.4	3.8
Banana	5.5	5.6	5.5	10.0	10.0	15.0	8.5	8.6	0.0	8.5	8.6	9.9	11.9	12.0	12.0	12.0	12.0	12.0	7.7	10.1	5.8	8.7	9.2	9.1
Mango	10.5	11.0	12.0	10.0	10.0	10.0	7.0	8.0	0.0	7.0	8.0	10.0	9.5	9.0	10.0	8.0	9.0	15.0	6.4	6.5	6.4	7.8	8.3	10.8
Apples	8.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0
Citrus	2.0	2.5	3.5	0.0	0.0	0.0	5.0	4.5	0.0	5.0	4.5	3.6	0.0	0.0	0.0	7.0	6.0	6.0	0.0	0.0	0.0	6.4	5.6	5.8
Papaya	13.0	13.0	12.0	13.0	13.0	0.0	9.0	7.7	0.0	9.0	7.7	8.8	5.0	5.0	5.0	10.0	10.0	14.0	6.6	7.8	12.0	9.1	8.5	10.4
Passion Fruit	8.5	10.0	9.0	10.0	10.0	10.0	8.0	8.0	0.0	8.9	8.1	8.3	6.0	6.0	0.0	6.0	5.0	6.0	2.1	4.4	5.0	7.8	7.5	7.7
Pineapple	8.5	8.5	8.0	0.0	0.0	0.0	10.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	11.3	4.0	6.0	9.6	5.2
Avocado	20.0	20.0	20.0	15.0	15.0	15.0	9.3	9.9	0.0	9.7	9.9	9.0	12.0	0.0	0.0	16.0	16.0	18.0	6.0	6.4	4.4	16.1	16.3	16.4
Guava	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	4.0	6.8	5.0	1.9	6.8	5.0
Plums	4.0	4.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	6.0
Melons	0.0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	0.0
French Bean	6.0	6.0	6.0	8.0	8.0	8.0	5.1	9.3	0.0	4.6	4.6	5.6	0.0	3.0	3.0	2.5	2.0	3.0	0.0	0.0	0.0	5.8	6.5	7.3
Snowpea	3.8	3.5	3.0	4.0	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	3.5	0.0	0.0	0.0	3.3	3.1	3.2
Brinjal	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	5.2	8.0	3.0	3.1	3.1	4.8	4.1	5.5
Karela	0.0	0.0	0.0	0.0	0.0	0.0	10.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	7.0	8.0	0.7	0.9	0.8	6.8	5.7	5.3
Dudhi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	9.0	10.0	0.0	0.0	0.0	13.6	9.0	10.0
Okra	0.0	0.0	0.0	0.0	0.0	0.0	14.8	9.0	0.0	0.0	0.0	0.0	6.0	6.0	6.0	6.3	8.5	9.0	5.0	4.9	6.0	9.2	6.7	6.9
Valore	0.0	0.0	0.0	0.0	0.0	0.0	3.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	4.0	5.0	0.0	0.0	0.0	4.3	3.3	5.0
Turpia	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.8	0.5	0.8
Chillies	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	4.0	4.0	2.4	2.2	2.3	2.8	2.9	2.7
Macadamia	3.5	3.5	3.5	2.9	2.8	0.0	0.0	1.7	0.0	1.9	1.7	2.9	0.0	0.0	0.0	5.0	5.0	6.0	1.4	1.4	1.4	2.8	2.7	3.4

Table H.1-28 Some Strategies for Agricultural Development

1. Work only with gravity, group based irrigation schemes
2. Work on the basis of full cost recovery
3. Work on improving the efficiency of the existing schemes
4. Work also on developing new model schemes
5. Work with smallholders.
6. Work with land owners (rather than tenants)
7. Work with a maximum of 30 Farmers per management unit.
8. Encourage diversity of cropping, to ensure independence from vagaries of market, and plan to irrigate a range of crops, food, fruit, cash, fodder to ensure food security.
9. Support both domestic and export horticultural production.
10. Focus on the drier areas, as incremental production greater (assuming soils and market access similar)
11. Focus on supplemental rather than complete irrigation in wetter areas.
12. Work in areas that already have a critical mass of horticultural production.
13. Alternatively, place new schemes only within close proximity of large markets
14. Support directly only irrigated agricultural production.
15. Focus on fruits and vegetables, (not flowers).
16. Focus on profitable crops.
17. Select appropriate labour ex/intensive technologies by location.

1. The choice of group based vs. individual schemes is official government policy. Some of the investments envisaged under the development of the irrigation sector will benefit both groups and individuals, such as improvement to access roads and input supply. Both production and marketing are facilitated by the purchasing power available to groups. The issue is complicated by the fact that in some areas group based schemes are not a technical option and the topography and land/water availability only allow individual actions. In some cases, such as for access to credit, these individuals have been associating to form a cluster. The definition of "group" needs careful consideration.

2. Again full cost recovery is the stated government policy. However, there have been proposals for cost sharing between farmers and the government in areas where the social contribution of irrigation to food security etc. is of paramount concern.

3. Many of the existing schemes are not functioning at full efficiency. The farmers are not receiving the expected volume of production, for a variety of reasons. Sustainability requires that they repay their investments. Improvements in group management, infrastructure rehabilitation, marketing, etc. may require further investment to ensure sustainability.

5. The rationale behind this suggestion is that larger land owners have the capital and the access to expertise which enables them to develop their own irrigation independently, and so they are not suitable candidates for government and/or donor assistance. The upper limit on land ownership by the smallholder category will vary by location and needs thoughtful and careful definition.

6. Tenants are seen as less likely to make the long term investments needed into on-farm infrastructure, such as levelling, nor are they likely to invest their capital into infrastructure development off the farm that benefits the entire group, such as piping to replace furrow supply. A further consideration is that tenants are frequently outsiders, to the group and to the area and are thus less susceptible to group control.
7. This is a suggestion for an upper limit based on the group dynamics and the strength of the relationships between members of a smaller rather than a larger group. This proposal to limit the management unit to a maximum of 30 is not intended to restrict the scheme size to this level. Management units can be aggregated to form larger geographical and technical units.
8. The focus on subsistence crops, as well as cash crops, reflects the reality in the area, and the premium placed by smallholders on risk avoidance.
9. There is a likelihood of encouraging greater equity by focusing on the drier areas. Not only is the marginal utility of the water higher, reducing upstream extraction will result in a greater availability of a scarce resource for all purposes, domestic, livestock and irrigation in the drier downstream areas.
10. Supplemental irrigation is predicated on the criteria of valuing water at its opportunity cost downstream and making decisions on what, when and where to plant to choose only those crops that generate the greatest returns to the investment.
12. This is simply a question of building a critical mass to reduce the unit costs of providing support and marketing services. However, the choice to build on, expand and improve the existing production assumes that the primary objective is efficiency, if food security is seen as another key goal then this strategy may need to be modified for those districts with food deficit areas, like Tharaka Nithi.
13. Access to markets with steady demand is the issue, not geographical proximity. Improving infrastructure such as roads and the supply of market information can radically influence this criteria.
14. Although it is clear that on the same farm both irrigated and rainfed agriculture are going on concurrently, and that they continually interact, such as in the production of irrigated forage for the livestock, or the demand for labour, for the purpose of simplicity the assumed focus is on improving the efficiency and profits of only the irrigated portion of the farm production.
15. Because of the size of the capital investment required to establish commercial flower production, and the complexity of the marketing, the focus will be primarily on vegetables, then on fruits. Furthermore, the overall focus is on smallholders, and unlike Rift valley Province, there are no larger production/marketing enterprises in the study area that could engage smallholders as contract outgrowers, providing encouragement, and expertise in production and marketing.
17. In some areas and at some times of the year, labour availability is a key constraint to expanding horticultural production.

Figure H.1.1-1 Existing Land Use in Nyeri, 1995

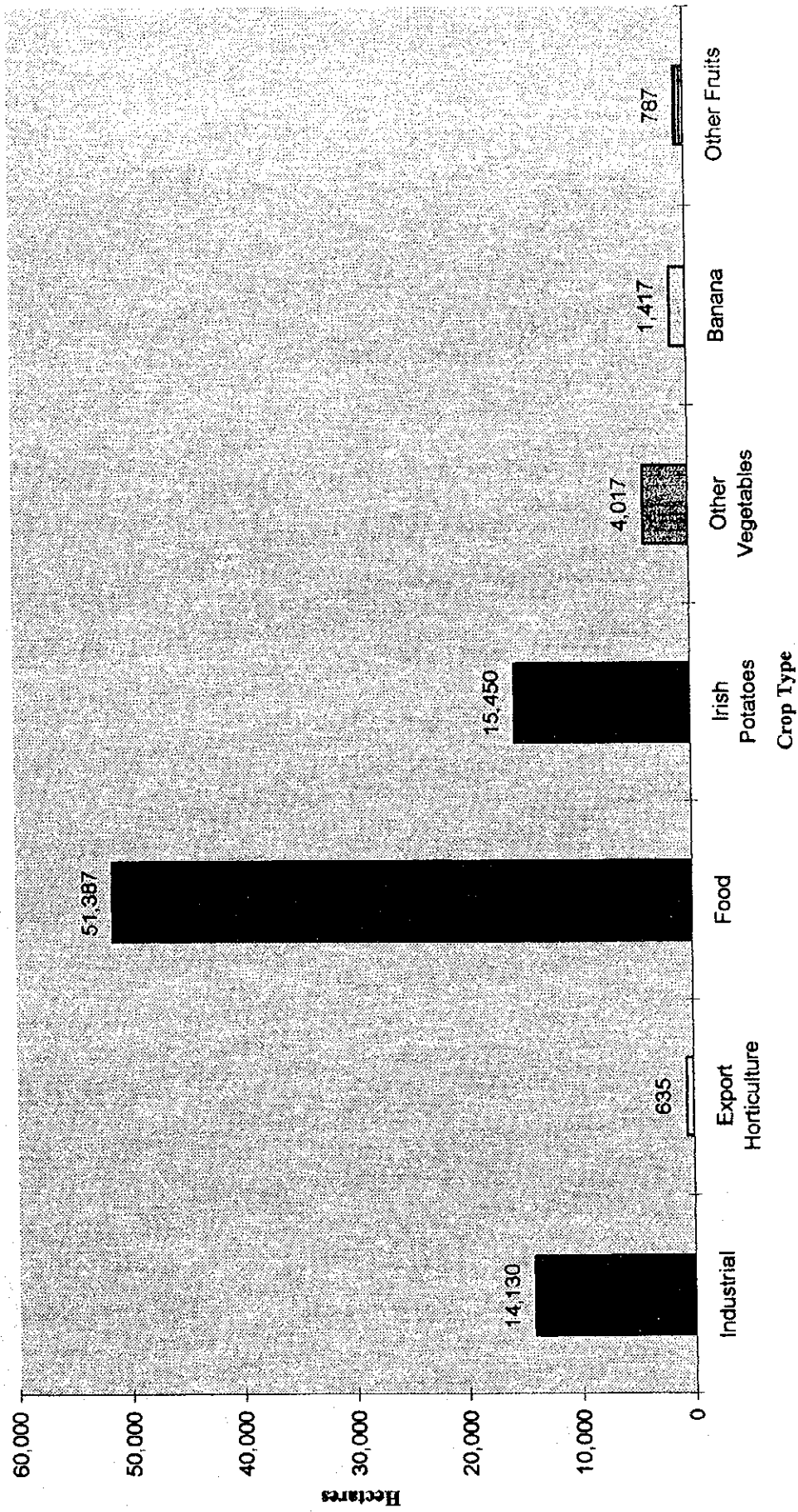


Figure H.1-2 Existing Land Use in Kirinyaga, 1995

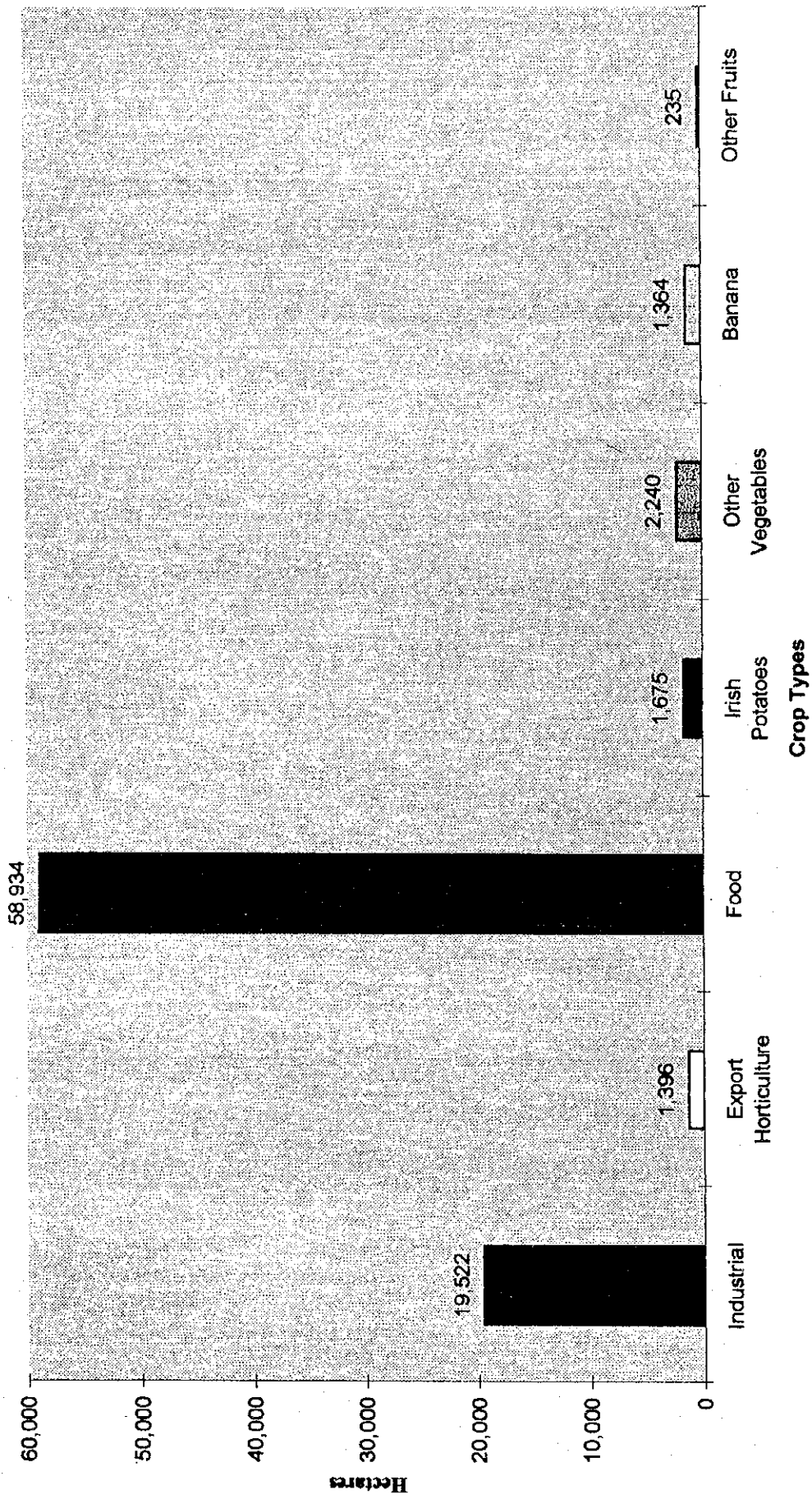


Figure H.1.3 Existing Land Use in Old Embu District, 1995

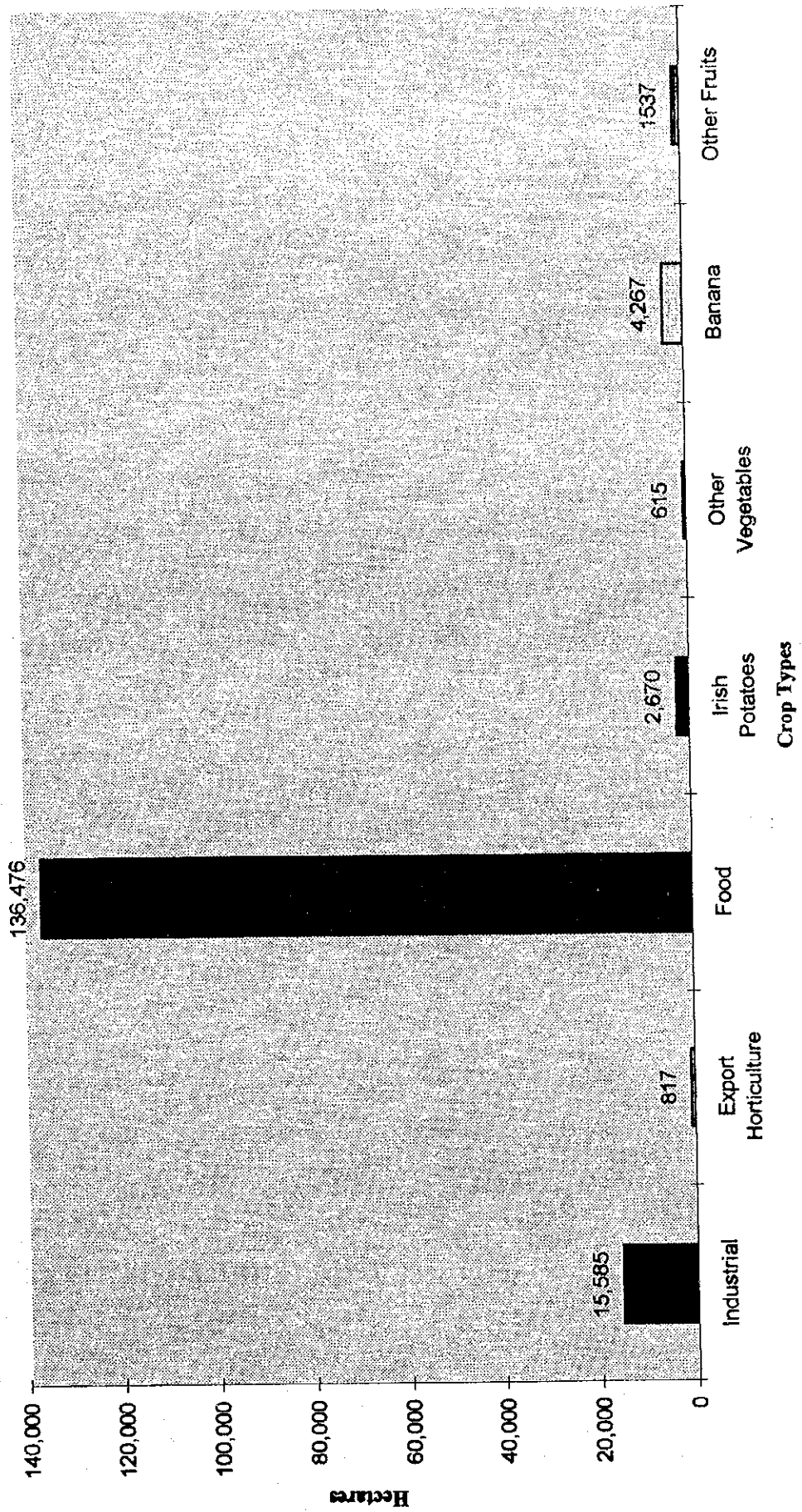


Figure H.1-4 Existing Land Use in Tharaka Nithi

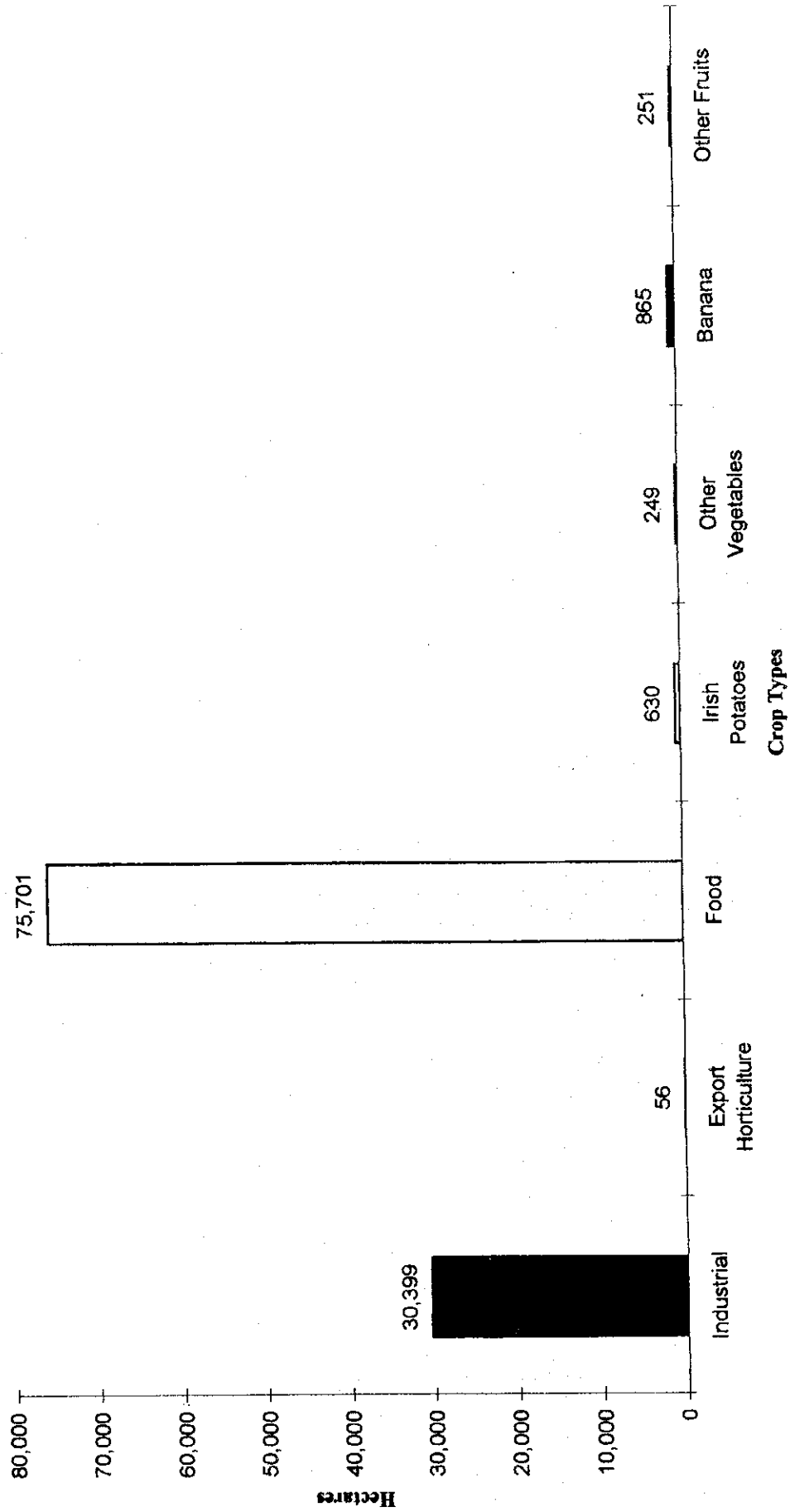


Figure H.1.1-5 Existing Land Use in Meru, 1995

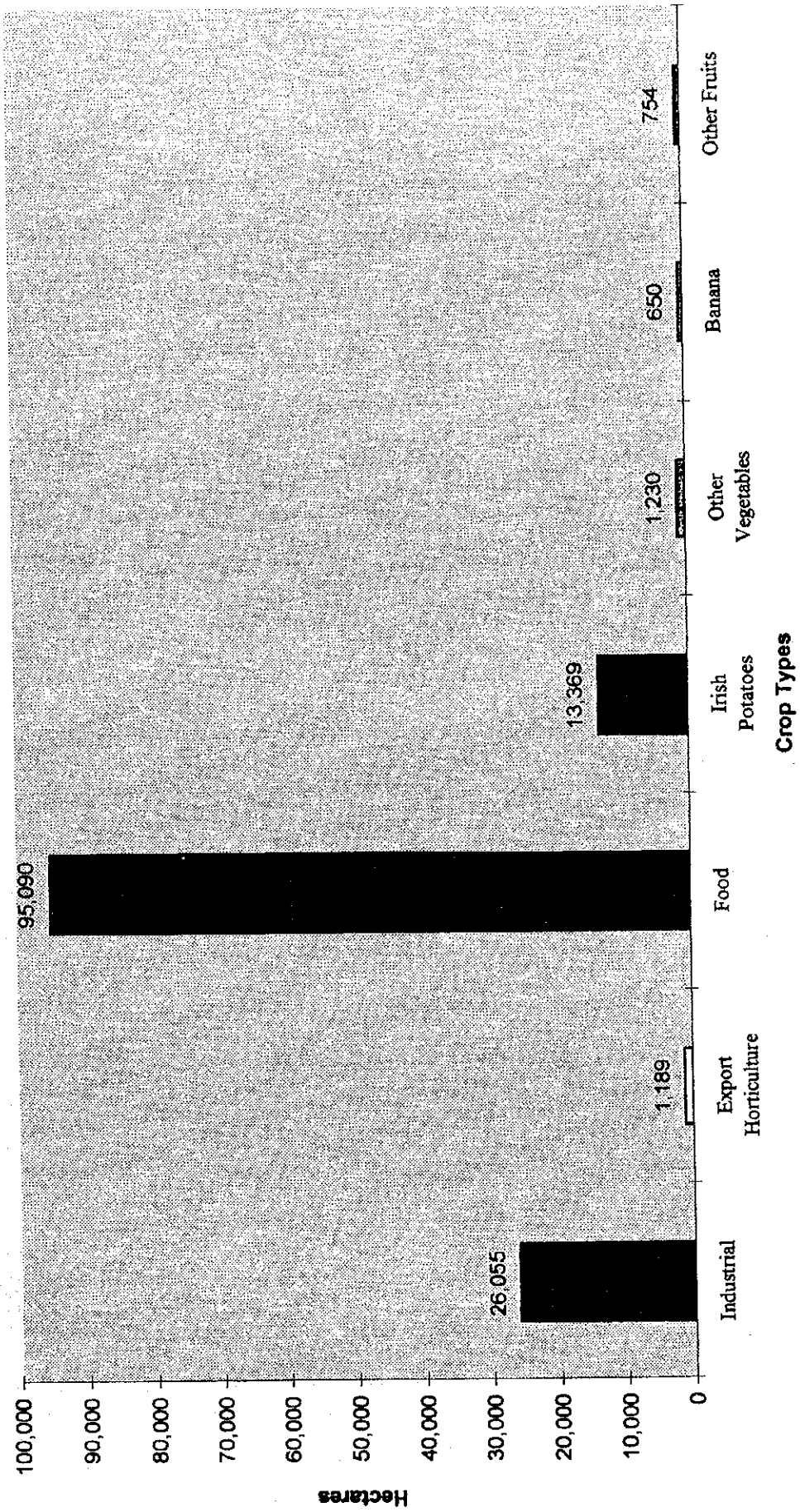


Figure H.1-6 Existing Land Use in Nyambene, 1995

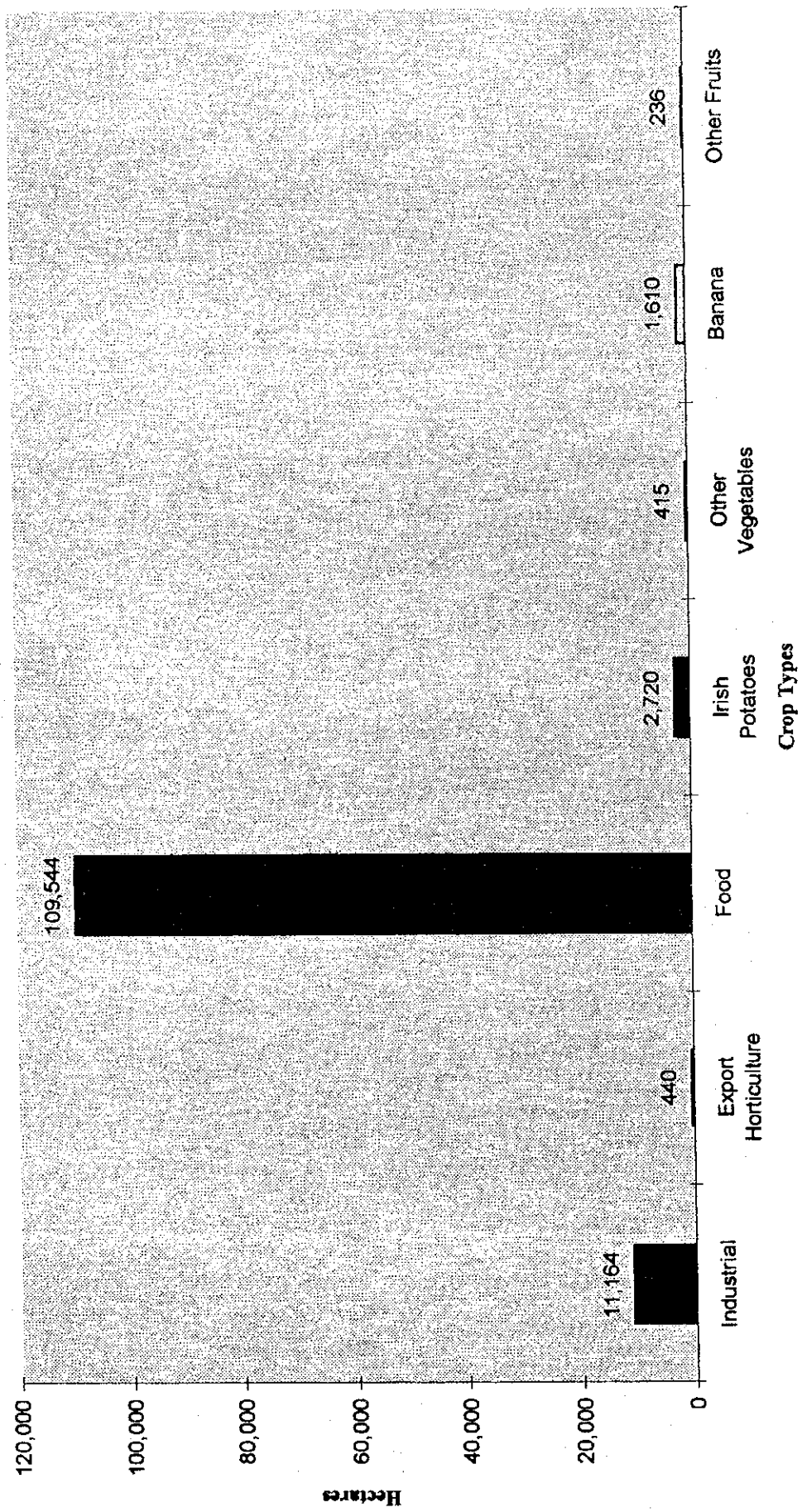
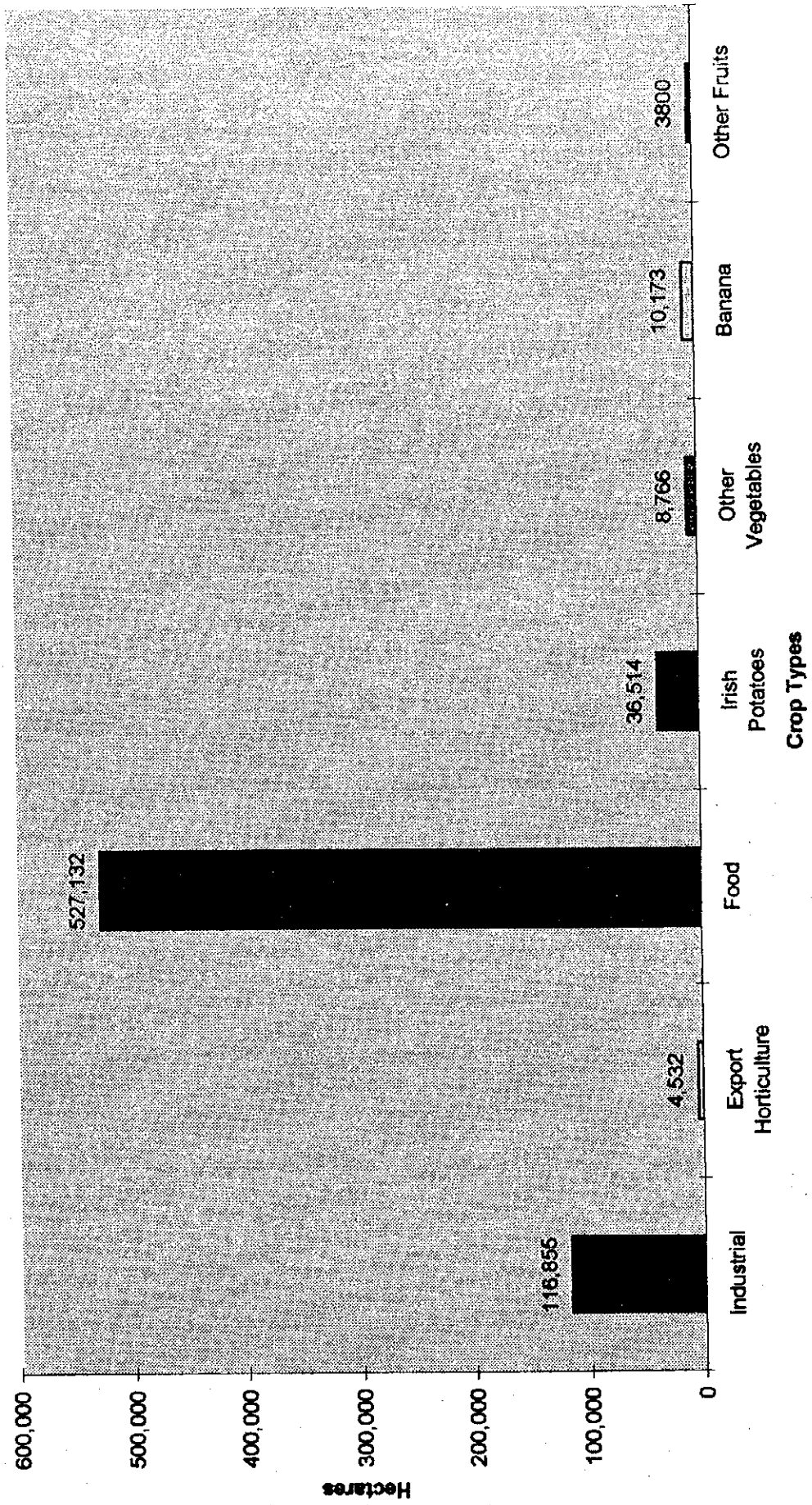


Figure H.1-7 Existing Land Use in the Study Area



PRELIMINARY SOIL SURVEY FOR MODEL AREAS

1. Introduction

The Preliminary soil survey for four Model Areas were carried out by first reconnoitering each of the area and establishing the location and the number of profile pits that could be representative of the irrigable soils in each scheme. It was not therefore the objective of these survey to map the soils in each irrigation scheme.

Nkuunjumo, Rupingazi Ngerwe, Ngomano/Nyangati and Ruungu/Karocho irrigation schemes are located in Meru, Embu, Kirinyaga and Tharaka-Nthi districts respectively. Whereas irrigation has been taking place in the three schemes except in Ruungu/Karocho scheme..

According to Sombroek et al(1982) Nkuun Njomo occurs in agro-climatic zone I which is humid with an average annual rainfall to average annual evaporation ratio greater than 80 percent which means the area has a very high potential for plant growth. The zone receives an average annual rainfall between 1,100 and 2,700 mm. The area occurs in temperature zone 9 which is cold to very cold with an average mean annual temperature is less than 10^o C.

Ngerwe Rupingazi irrigation scheme occurs in agro-climatic zone II which is sub-humid with an average annual rainfall to average annual evaporation ratio of 65-80 percent with high potential for plant growth. The are occurs in a zone that receives an average annual rainfall between 1,000 and 1,600 mm. The area is in temperature zone 3 which has an average annual temperature of 20 - 22^oC and is fairly warm.

Ngomano Nyangati irrigation scheme occurs in agro-climatic zone 3 with an average annual rainfall to average annual evaporation ratio of 50-65 percent and thus has high to medium potential for plant growth. The area receives an average annual rainfall between 800 and 1,400 mm. The area is in temperature zone III which is fairy warm.

Ruungu/Karocho irrigation scheme is in agro-climatic zone IV which is semi-humid to semi-arid with an average mean annual rainfall between 600 and 1,100 mm. The average annual rainfall to average annual evaporation is between 40 and 50 percent. The mean annual temperature is 24-30^o C.

In this report, the soils of each irrigation scheme have been described separately.

2. Soil Profile

2.1 Soils of Nkunjumo Water Project

Parent material	: Intermediate igneous rocks.
Macro relief	: The crests are gently undulating to undulating with slopes ranging for 3 to 8% while the steep sides of the footbridges are have slopes greater than 15%.
Land use	: Coffee is the major cash crop grown in the area. Other crops grown are bananas, yams, sugarcanes and vegetables.
Soils, general	: The area has well drained, very deep to extremely deep, dark red to dark reddish brown, friable, clay loam to clay soils. The soils show a clear and smooth boundary between A and B horizons. The boundary within the B horizons ranges from clear and smooth to diffuse and smooth.
Colour	: A-horizon: dark reddish brown(5YR3/3 moist) to dark brown(7.5YR3/2). B-horizon: dark red(2.5YR3/6) to dark reddish brown (2.5YR2.5/4).
Texture	: A-horizon: clay loam to clay. B-horizon: clay loam to clay.
Structure	: A-horizon: moderate, fine to medium crumbly and weak to moderate fine to medium, angular and subangular blocky structure.
B-horizon	: Moderate to strong, fine to medium, angular and subangular blocky structure.
Consistence	: A and B horizons are both friable when moist, sticky and plastic when wet.

For representative soil profiles, see Appendix, profile description Nos.1, 2 and 3.

Recommendations

1. There was an indication that the soils are acidic due to the occurrence of ferns in the area. This pinpoints to high level of leaching of the exchangeable cations from the soils. This therefore calls for use of non-acidifying fertilizers like CAN, double and triple super phosphates and N,P,K containing fertilizers.
2. Where non-acidic tolerant crops like tomatoes, cabbages and citrus are to be grown the pH of the soil should be brought between 5.3 and 6.0 by liming with dolomitic limestone which would supply the leached calcium and magnesium ions.
3. Use of manure or compost is necessary to raise the topsoil organic matter content. This will improve the soil structure and reduce susceptibility to erosion due to rain drop impact in addition to supplying nutrients upon decomposition.

2.2 Soils of Rupingazi Ngerwa Irrigation Scheme

Parent material	: Volcanic ash and intermediate igneous rocks.
Macro relief	: On sites very gently undulating to undulating with slopes 2-8 %.
Land use	: Growing maize, beans, bananas, kales, cassava, coffee and in few places tea.
Soils, general	: The soils generally are well drained, very deep, dusky red to dark reddish brown, clay. The boundary between A and B horizons is clear and smooth while that within the B horizon is clear to gradual and smooth to wavy. The soils show ABC sequence of horizons.
Colour	: A-horizon: dark reddish brown(5YR3/3) to dark brown (7.5YR3/2). B-horizon: dusky red(2.5YR3/2) to dark reddish brown(5YR2.5/2).
Texture	: A-horizon: sandy clay loam to sandy clay. B-horizon: clay.
Structure	: A-horizon: strong, very fine to medium, crumbly and weak, very fine to medium, subangular blocky structure B-horizon: weak to strong, very fine to coarse, angular and subangular blocky structure.
Consistence	: A-horizon: friable to loose when moist, slightly sticky and slightly plastic when wet. B-horizon: friable when moist, sticky and plastic when wet.

For representative soil profiles, see Appendix, profile description Nos. 4 and 5.

Recommendations

1. The soils are very compact between 40 and 70 cm depth. This may hinder root penetration in addition to causing water-logging due to reduced infiltration. This causes oxygen unavailability to the roots of the shallow rooting crops like maize and beans for example. This can be corrected by practicing deep plowing to break any plow pan that may be forming with continued plowing.
2. Field observations showed deficiency in nitrogen and phosphorous in maize crop. This pinpoints to the need of applying N and P containing fertilizers that are non acidifying(eg CAN and super phosphates) since the soils are predicted to be moderately acidic.
3. The use of manure is necessary in order to improve the structure of the top soils and thus improve the drainage of the deep plowed layers.

2.3 Soils of Ngomano Nyangati Water Furrow Project

Parent material	: Intermediate igneous rocks.
Macro relief	: Gently undulating to undulating with slopes ranging from 3 to 5 %.
Land use	: Growing maize, beans including french beans, cotton, water melons and mangoes.
Soils, general	: The greater part of the area is covered by well drained, very deep, dark reddish brown, clay loam to clay soils. A clear and smooth boundary exists between the A and B horizons while a gradual and smooth one occurs within the B horizon.
Colour	: A-horizon: dark reddish brown(5YR3/3 -2.5/2). B-horizon: dark reddish brown(2.5YR3/4).
Texture	: A-horizon: clay. B-horizon: clay loam to clay.
Structure	: A-horizon: strong, very fine to medium, crumbly and weak to moderate, very fine to medium angular and subangular blocky structure. B-horizon: weak to moderate, very fine to medium, angular and subangular blocky structure.
Consistence	: A-horizon: friable when moist, sticky and plastic when wet. B-horizon: friable when moist, slightly sticky to sticky and slightly plastic to plastic when wet.

For a representative soil profile, see Appendix, profile description Nos. 6 and 7

Recommendations

1. A compact layer occurs between 20 and 55 cm depth. There is therefore the need for deep plowing to break this layer and enhance the infiltration of the soils and thus prevent impeded drainage which would result in disastrous crop performance for shallow rooted and moderately rooted crops like french beans and maize.
2. Use of organic manure is highly recommended to improve the soil structure and nutrient status upon decomposition.
3. Use of the right fertilizers is recommended. This means that where the soils are alkaline, acidifying fertilizers like sulphate of ammonia, diammonium phosphate and ammonium sulphate nitrogen can be applied but where the soils are acidic, non - acidifying fertilizers should be utilized(eg CAN and Super phosphates).
4. Monitoring the physical and chemical soil aspects in selected plots after 3 - 5 years is necessary.

2.4 Soils of Ruungu/Karocho Irrigation Project

Parent material	: Basic and intermediate igneous rocks but metamorphic rocks occur around the area.
Macro relief	: Flat to gently undulating with slopes ranging from 0 to 5%.
Land use	: Mainly growing pigeon peas, sorghum, maize and grazing.
Soils, general	: The flat gently undulating parts of the area have well drained, deep to very deep, dark red to dark reddish brown, friable, clay soils. The soils have a clear and smooth boundary between A and B horizons and gradual and smooth within B horizon. The soils show ABC sequence of horizons. The shoulders between the Thingithu river and the flat to gently undulating plain have well drained, shallow, dark reddish brown to dark brown, gravelly, clay loam to clay ; over pisoferric material (murrum).
Colour	: A-horizon: dark reddish brown(5YR3/3). B-horizon: dark red to dark reddish brown(2.5YR3/6 - 3/4).
Texture	: A-horizon: Clay. B-horizon: Clay loam to clay.
Structure	: A-horizon: Weak, very fine to medium, angular and subangular blocky structure. B-horizon: Weak to moderate, very fine to medium, angular and subangular blocky structure.
Consistence	: A-horizon is friable when moist, sticky and plastic when wet B-horizon is friable when moist, slightly sticky to sticky, and slightly plastic to plastic when wet.

For a representative soil profile, see Appendix, profile description No. 8

Recommendations

1. The rates of decomposition in the area are high due to the high temperatures. As such therefore, in order to maintain high organic matter content in the top soils, use of manure is necessary. This will apart from supplying nutrients upon decomposition make the surface soil aggregates stable and thus prevent the formation of surface crusts which reduce infiltration rates and thus generate runoff.
2. To increase crop yields, there is need to use the appropriate fertilizers the choice of which will be governed by the soil pH.
3. There is need to carry out a detailed soil survey of the area and establish the extent of each of the soil since the area is vulnerable to salts accumulation that may lead to soils

becoming saline and/ or sodic due to the nature of the parent materials and the climatic conditions.

4. The physical and chemical conditions of the soils need to be monitored after 3 to 5 years to determine the extent of their deterioration(degradation).

3. Appendix; Description of Representative Profiles

<u>Profile Description No.</u>	<u>Irrigation scheme</u>
1	Nkunjumo
2	"
3	"
4	Rupingazi Ngerwe
5	"
6	Ngomano/Nyangati
7	"
8	Rungu/Karocho

Profile Description No. 1

Irrigation scheme	: Nkunjumo Water Project
Location	: Plot No. 639
Agro-climatic zone	: I
Parent material	: Intermediate igneous rocks and volcanic ash
Physiography	: Footridges
Relief/slope	: Very gently undulating to undulating on the crests; slopes 2-8%
Land use	: On site growing maize, bananas and vegetables; coffee grown in adjacent areas
Drainage class	: Well drained
Effective soil depth	: More than 150 cm

Profile Description:

Ap	0-5cm	dark reddish brown(5YR2.5/2); clay; moderate to strong, fine to coarse crumbly structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores and many biopores; common, very fine to medium roots; clear and smooth transition to;
AB	5-17cm	dark reddish brown(5YR3/3); clay; weak to moderate, fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; clear and smooth boundary to;
Bt1	17-40cm	dusky red(2.5YR3/2); clay; moderate to strong, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, very fine and fine roots and many, medium roots; gradual and smooth transition to;
Bt2	40-67cm	dark reddish brown(2.5YR3/4); clay loam; strong, fine to medium, angular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many very fine and fine pores; very few, very fine and fine roots; gradual and smooth transition to;
Bt3	67-120cm	dark reddish brown(2.5YR2.5/4); clay loam; moderate, fine to medium, angular and subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many very fine and medium pores; very few, very fine and fine, and many coarse roots; gradual and smooth transition to;
Bt4	120-150cm	dark reddish brown(2.5YR2.5/4); slightly silty clay loam; moderate, fine to medium, angular and subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many very fine and medium pores; very few, very fine to coarse roots.

Profile Description No. 2

Irrigation scheme	: Nkunjumo Water Project
Location	: Plot No. 634
Agro-climatic zone	: I
Parent material	: Intermediate igneous rocks and volcanic ash
Physiography	: Footridges
Relief/slope	: Gently undulating to undulating on the crests; slopes 2-8%
Land use	: On site growing maize, bananas, yams and sugarcane; coffee is grown in adjacent sloping areas
Drainage class	: Well drained
Effective soil depth	: More than 150 cm

Profile Description;

Ap	0-20cm	dark brown(7.5YR3/2); clay; moderate, fine to medium, angular and subangular structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores and biopores; many, fine to medium roots; clear and smooth transition to;
AB	20-36cm	dark reddish brown(5YR3/3); clay; weak, fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine, fine pores and biopores; common, very fine to medium roots; clear and smooth transition to;
Bt1	36-49cm	dark reddish brown(2.5YR3/4); clay; strong, fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; gradual and smooth transition to;
Bt2	49-62cm	dark reddish brown(2.5YR3/4); clay; strong, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; common, very fine and fine pores; very few, very fine and fine roots; gradual and smooth transition to;
Bt3	62-102cm	dark red(2.5YR3/6); clay; weak to moderate, fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine and medium pores; very few, very fine and fine roots; gradual and smooth transition to;
Bt4	102-125cm	dark reddish brown(2.5YR3/4); clay; moderate, fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine and medium pores; very few, very fine and fine roots.
Bt5	125-150cm	dark reddish brown(2.5YR3/4); clay; moderate, fine to coarse, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, very fine and fine roots.

Profile Description No. 3

Irrigation scheme : Nkunjumo Water Project
Location : Plot No. 691
Agro-climatic zone : I
Parent material : Intermediate igneous rocks and volcanic ash
Physiography : Footridges
Relief/slope : Very gently undulating; slopes 2-5%
Land use : On site growing irrigated french beans but coffee is grown
in adjacent farms
Drainage class : Well drained
Effective soil depth : More than 150 cm

Profile Description;

Ap 0-25cm dark reddish brown(5YR3/3); clay loam; strong, very fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, fine to medium pores and biopores; very many, very fine to medium roots; clear and smooth transition to;

AB 25-53cm dusky red(2.5YR3/2); clay; moderate, very fine and fine, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; common, very fine and fine roots; clear and smooth transition to;

BU1 53-94cm dark reddish brown(2.5YR2.5/4); clay; weak, very fine and fine, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; common, very fine and fine roots; clear and smooth transition to;

BU2 94-136cm dark reddish brown(2.5YR2.5/4); clay; weak, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; clear and smooth transition to;

BU3 136-150cm dark reddish brown(2.5YR3/4); clay; weak, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, very fine and fine roots. transition to;

Profile Description No. 4

Irrigation scheme : Rupingazi Ngerwe Irrigation Scheme
Location : Plot No. 1498
Agro-climatic zone : II
Parent material : Volcanic ash
Physiography : Uplands
Relief/slope : Very gently undulating to gently undulating; slopes 2-3%
Land use : On site growing maize and bananas
Drainage class : Well drained
Effective soil depth : More than 150 cm

Profile Description;

Ap	0-16cm	dark brown(7.5YR3/2); sandy clay loam; porous massive; friable to loose when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; common, very fine and fine roots; clear and smooth transition to;
BU1	16-35cm	dusky red(2.5YR2.5/2); clay; porous massive; friable when moist, sticky and plastic when wet; many, very fine to medium pores; common, very fine and fine roots; clear and smooth transition to;
BU2	35-60cm	dusky red(2.5YR2.5/2); clay; weak, fine and medium, subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine and fine pores; few, fine roots; clear and wavy transition to;
BU3	60-75cm	dark reddish brown(5YR2.5/2); clay; moderate, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; gradual and smooth transition to;
BU4	75-130cm	dusky red(2.5YR3/2); clay; weak to moderate, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, fine roots; gradual and smooth transition to;
BU5	130-150cm	dusky red(2.5YR3/2); clay; weak to moderate, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, very fine roots.

Profile Description No. 5

Irrigation scheme	: Rupingazi Ngerwe Irrigation scheme
Location	: Plot No. 1335
Agro-climatic zone	: II
Parent material	: Volcanic ash and igneous rocks
Physiography	: Uplands
Relief/slope	: Gently undulating to undulating; slopes 4-8%
Land use	: On site fallow but on the farm growing maize, bananas vegetables and coffee takes place
Drainage class	: Well drained
Effective soil depth	: More than 150 cm

Profile Description;

Ah	0-20cm	dark reddish brown(5YR3/3); sandy clay; strong, very fine to medium, crumby and weak, fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; many very fine and fine roots; clear and smooth transition to;
AB	20-40cm	dusky red(2.5YR3/2); sandy clay; weak, fine to coarse, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; many, very fine and fine roots; clear and smooth transition to;
Bt1	40-72cm	dark reddish brown(2.5YR3/3); clay; moderate to strong, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; gradual and smooth transition to;
Bt2	72-125cm	dark reddish brown(2.5YR2.5/2); clay; strong, very fine to medium, angular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; gradual and smooth transition to;
Bt3	125-150cm	dark reddish brown(2.5YR2.5/2); clay; weak, very fine to coarse, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots.

Profile Description No. 6

Irrigation scheme : Nomano Nyangati Water Furrow Project
Location : Plot No. 385
Agro-climatic zone : III
Parent material : Intermediate igneous rocks
Physiography : Uplands
Relief/slope : Gently undulating; slopes 3-4%
Land use : Fallow but previously under beans cultivation
Drainage class : Well drained
Effective soil depth : More than 150 cm

Profile Description;

Ap	0-18cm	dark reddish brown(5YR3/3); clay; strong, fine crumby and weak, fine to medium, subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; many very fine and fine roots; clear and smooth transition to;
AB	18-54cm	dusky red(2.5YR3/2); clay; weak, very fine to medium subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine roots; clear and smooth transition to;
Bt1	54-70cm	dark reddish brown(2.5YR3/4); clay loam; weak, very fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; few, very fine and fine roots; gradual and smooth transition to;
Bt2	70-105cm	dark reddish brown(2.5YR3/4); clay loam; fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine and fine pores; very few, very fine and fine roots; gradual and smooth transition to;
Bt3	105-150cm	dark reddish brown(2.5YR3/4); clay loam; weak, very fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine and fine pores; very few, very fine and fine roots.

Profile Description No. 7

Irrigation scheme	: Ngomano Nyangati Water Furrow Project
Location	: On the lower side of the canal opposite the C.P.K church gate
Agro-climatic zone	: III
Parent material	: Intermediate igneous rocks
Physiography	: Uplands
Relief/slope	: Gently undulating; slopes 3-5%
Land use	: Growing french beans and maize
Drainage class	: Well drained
Effective soil depth	: More than 150 cm

Profile Description;

Ap	0-21cm	dark reddish brown(5YR2.5/2); clay; strong, very fine to medium crumbly and moderate, very fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; many, very fine to medium roots; clear and smooth transition to;
Bt1	21-42cm	dark reddish brown(2.5YR3/4); clay; moderate, very fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; common, very fine to medium roots; clear and smooth transition to;
Bt2	42-80cm	dark reddish brown(2.5YR3/4); clay loam; weak, very fine to medium, angular and subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine and fine pores; common, very fine and fine roots; gradual and smooth transition to;
Bt3	80-115cm	dark reddish brown(2.5YR3/4); clay loam; weak, very fine to medium, subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine and fine pores; few, very fine and fine roots; gradual and smooth transition to;
Bt4	115-155cm	dark reddish brown(2.5YR3/4); clay loam; weak, very fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine and fine pores; very few, very fine and fine roots.

Profile Description No. 8

Irrigation scheme	: Ruungu Karocho Irrigation Project
Location	: On the farm behind the dispensary
Agro-climatic zone	:IV
Parent material	: Intermediate and basic igneous rocks
Physiography	: On site are uplands but plains form a greater part of the area
Relief/slope	: On site gently undulating; slopes 3-5%
Land use	: Previously under maize and sorghum cultivation
Drainage class	: Well drained
Effective soil depth	: More than 150 cm

Profile Description;

Ap	0-25cm dark reddish brown(5YR3/3); clay; weak to moderate, very fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores and biopores; common, very fine and fine roots; clear and smooth transition to;
AB	25-43cm dark reddish brown(2.5YR3/4); clay; weak, fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores and biopores; few, very fine and fine roots; gradual and smooth transition to;
Bt1	43-61cm dark reddish brown(2.5YR3/4); clay; moderate, very fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; few, very fine and fine, and few medium roots; gradual and smooth transition to;
Bt2	61-100cm dark red(2.5YR3/6); clay; moderate, very fine to medium, angular and subangular blocky structure; friable when moist, sticky and plastic when wet; many, very fine to medium pores; very few, very fine to medium roots; gradual and smooth transition to;
Bt3	100-153cm dark red(2.5YR3/6); clay loam; weak, fine to medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; very few, very fine and fine roots.

Reference

Sombroek, W.G., Braun, H.M.H. and van de Pouw, B.J.A 1982. Exploratory soil map and agro-climatic zone map of Kenya. Report No. E1, Kenya Soil Survey, Nairobi.

ANNEX I

GOVERNMENT AND OTHER ORGANIZATION

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Figure I.1.1-1 Organization Chart of the Kenya Government

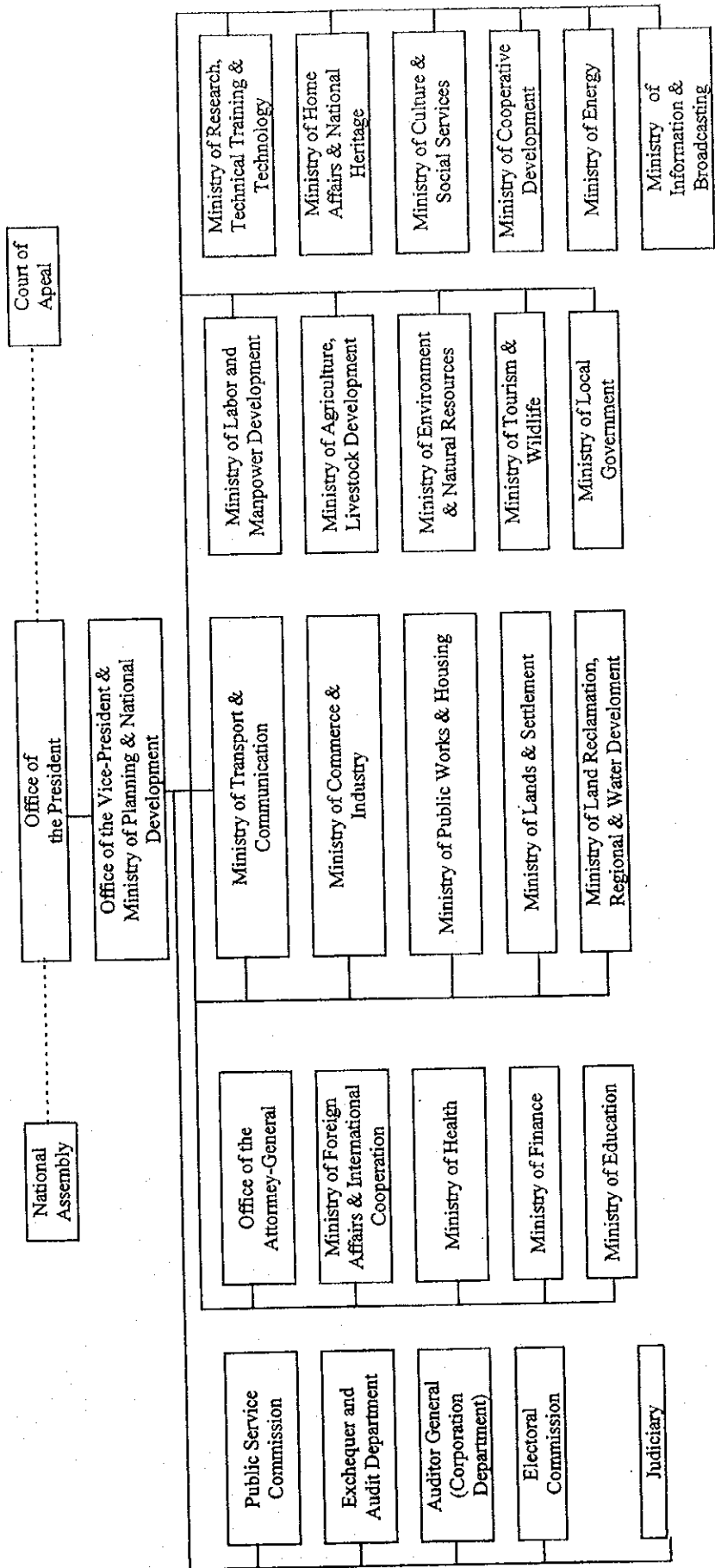


Figure I.1-2 Organization Chart of Ministry of Agriculture and Livestock Development

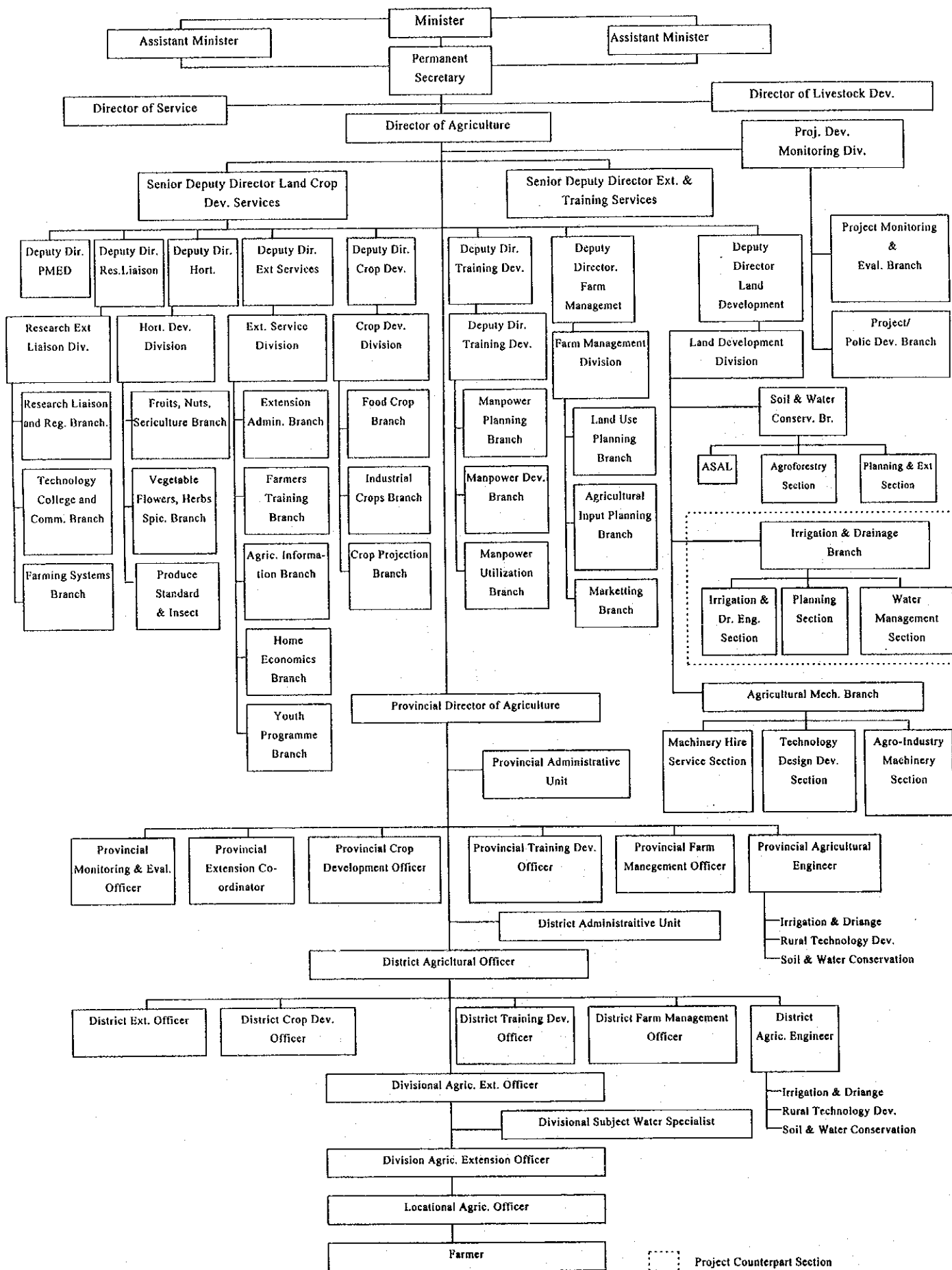


Figure I.1-3 Organization Chart of Land Development Division and Irrigation and Drainage Branch

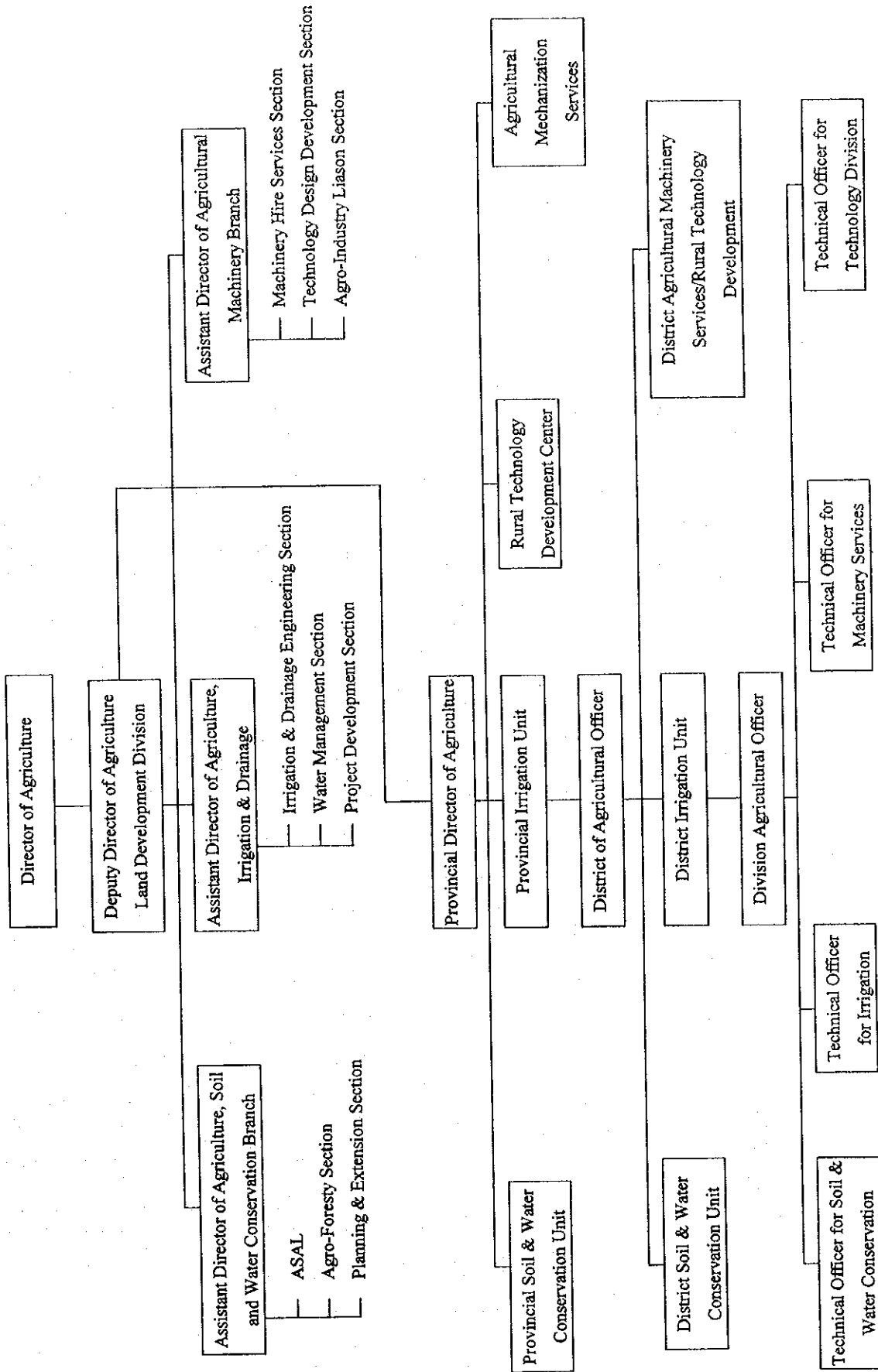


Figure I.1-4 Organization Chart of Provincial Agricultural Office

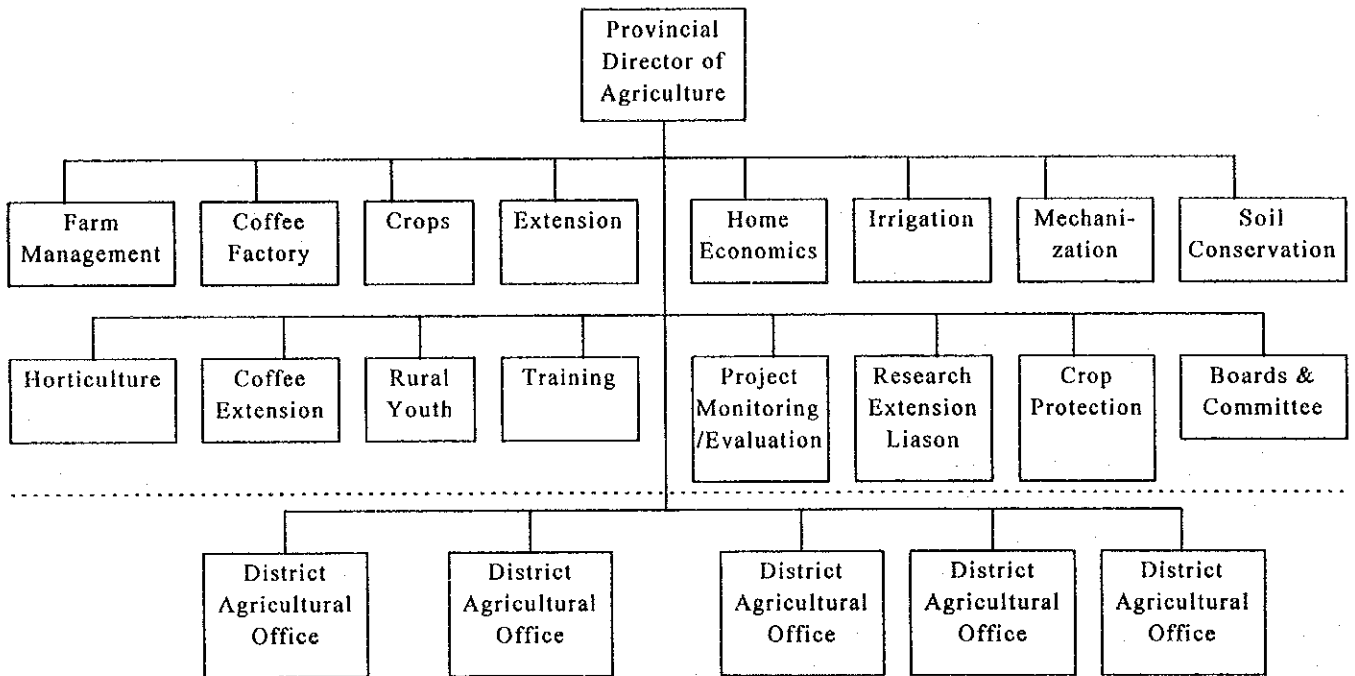


Figure I.1-5 Organization Chart of District Agricultural Office

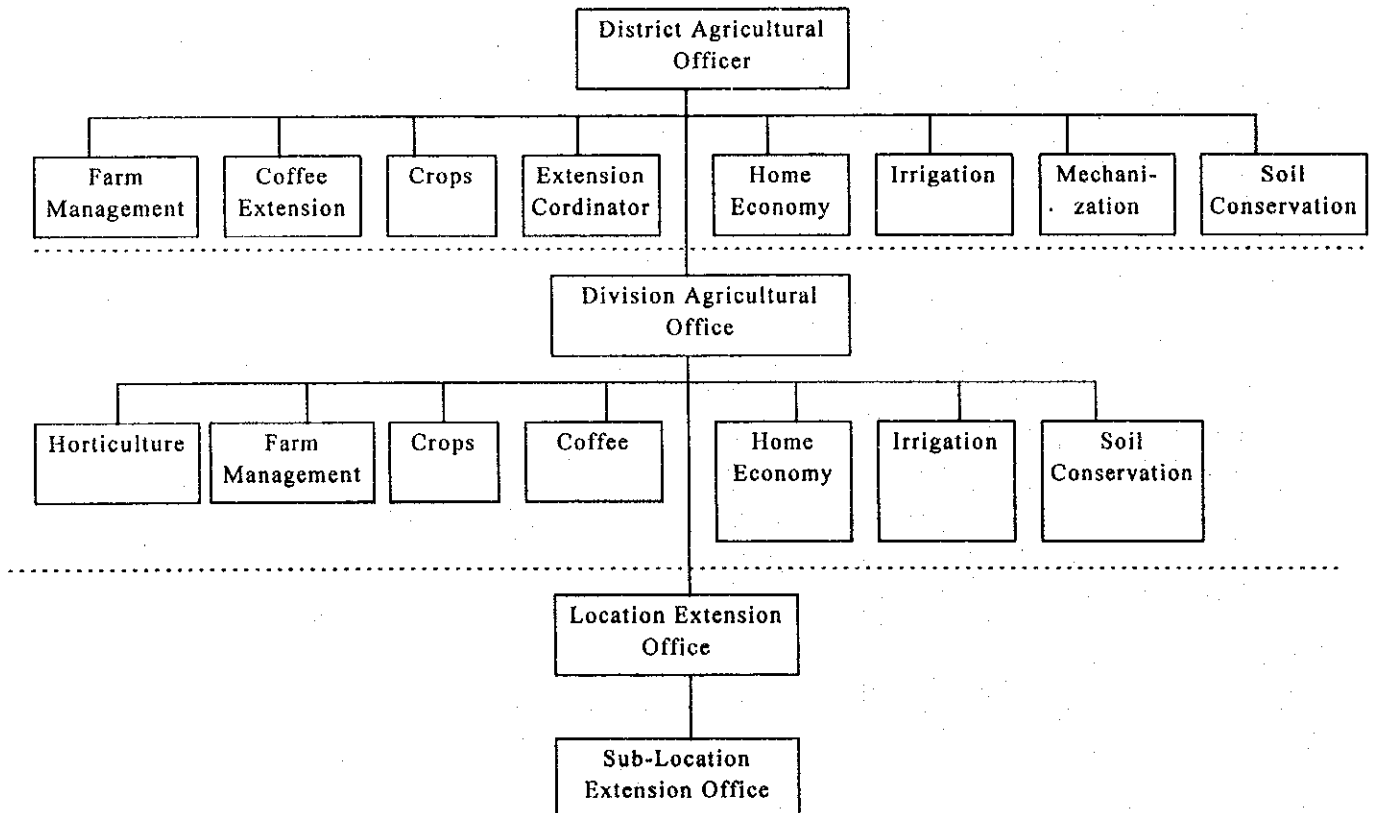


Figure I.1-6 Organization Chart of District Office

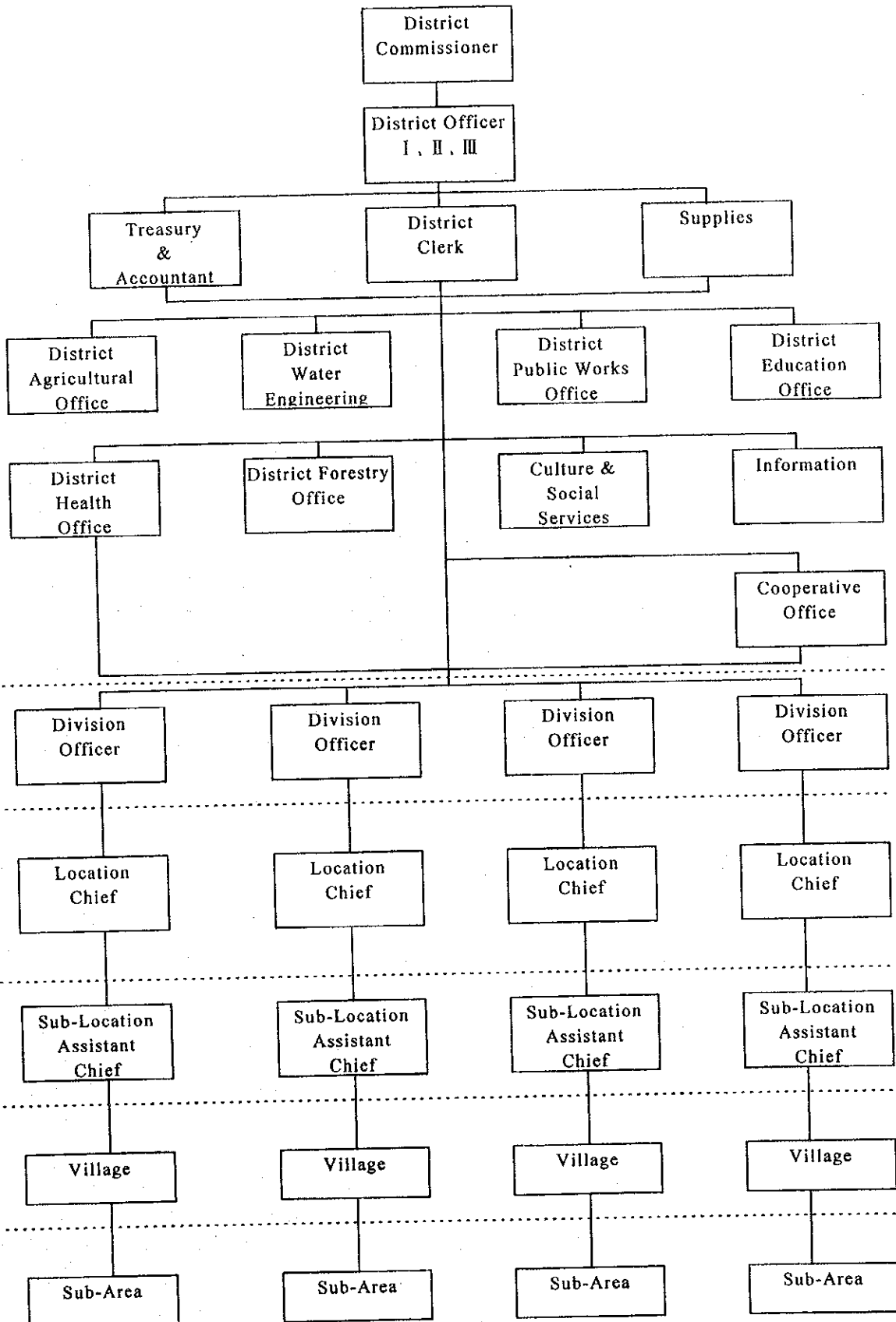


Figure I.1-7 Organization Chart of Provincial Government

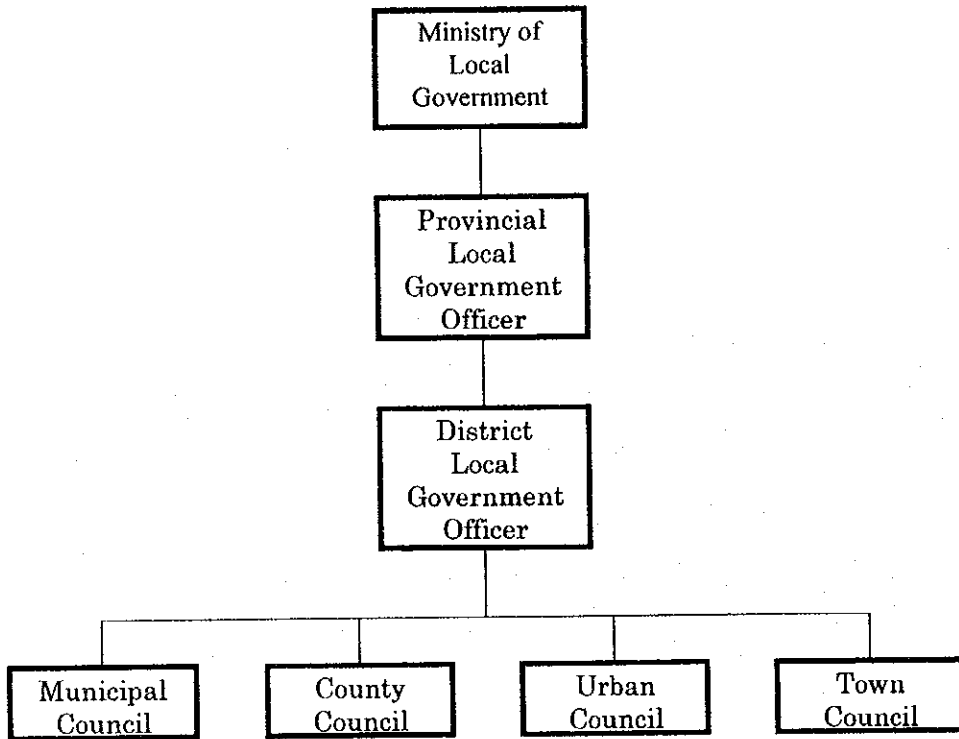


Figure I.1-8 Organization Chart of Project Community for Community-Based Rural Water Supply Project

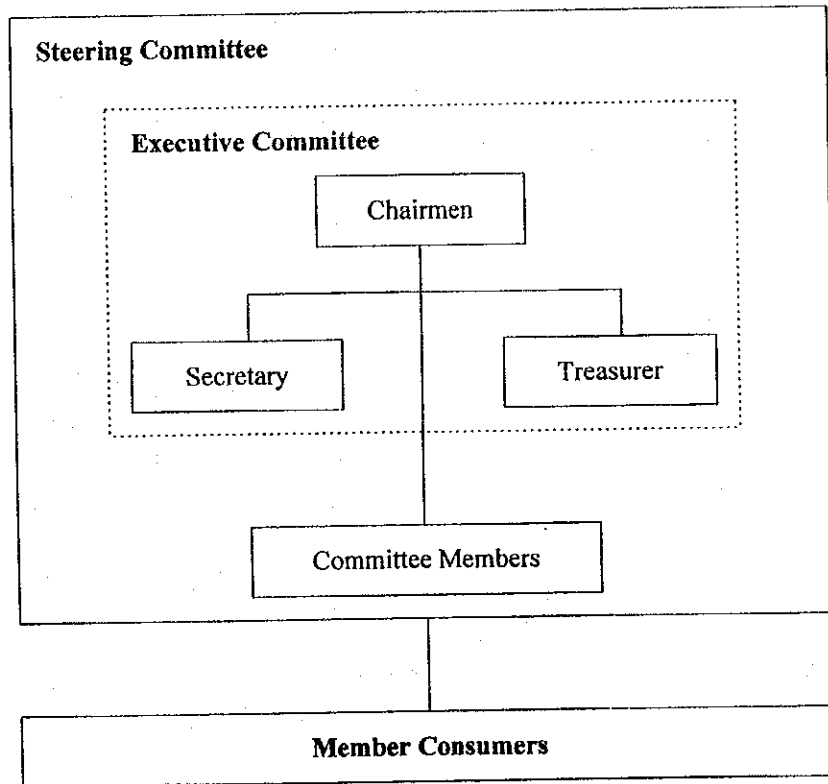


Figure I.1-10 Organization Chart of Nyeri District Water Office

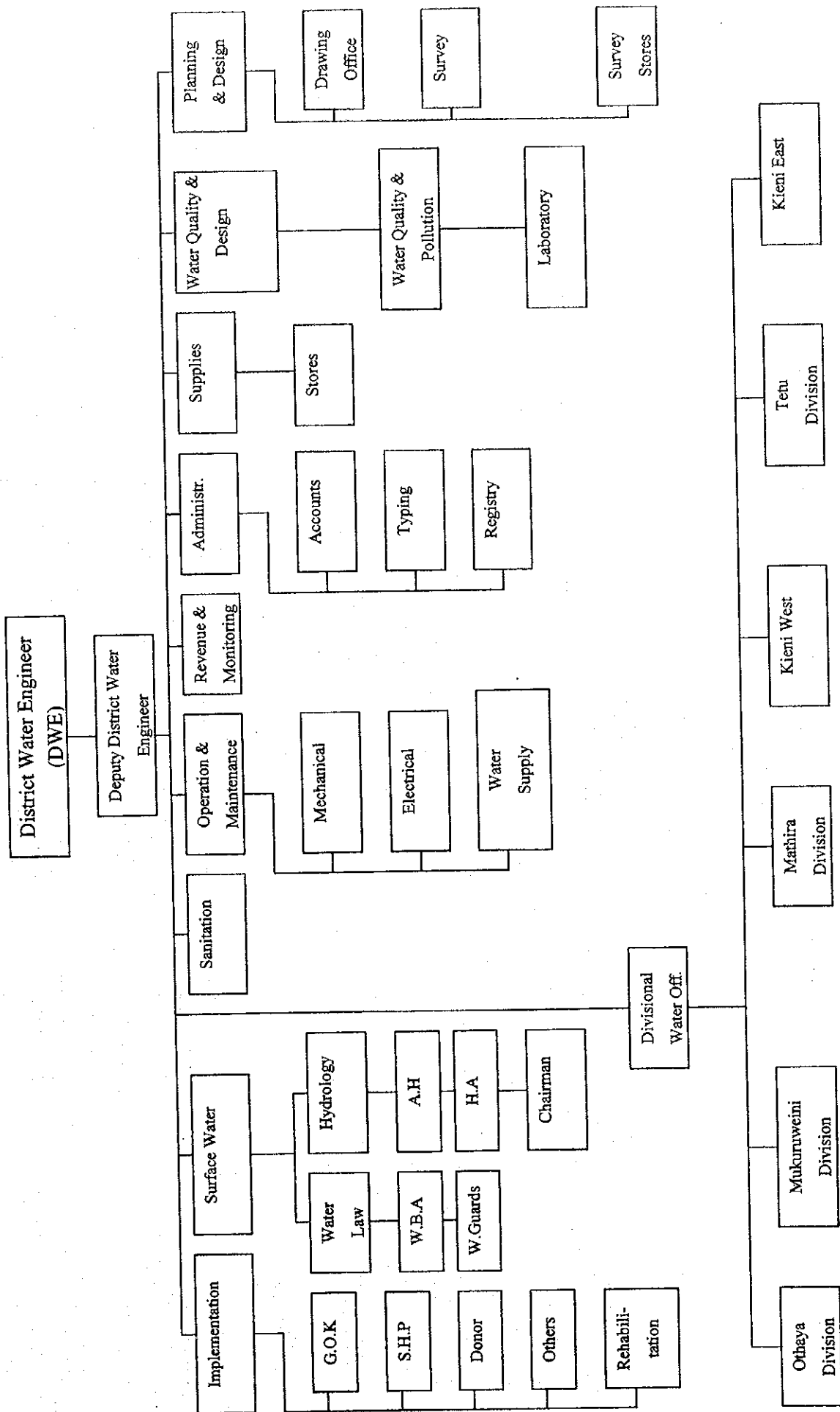


Figure I.1-11 Organization Chart of Kirinyaga District Water Office

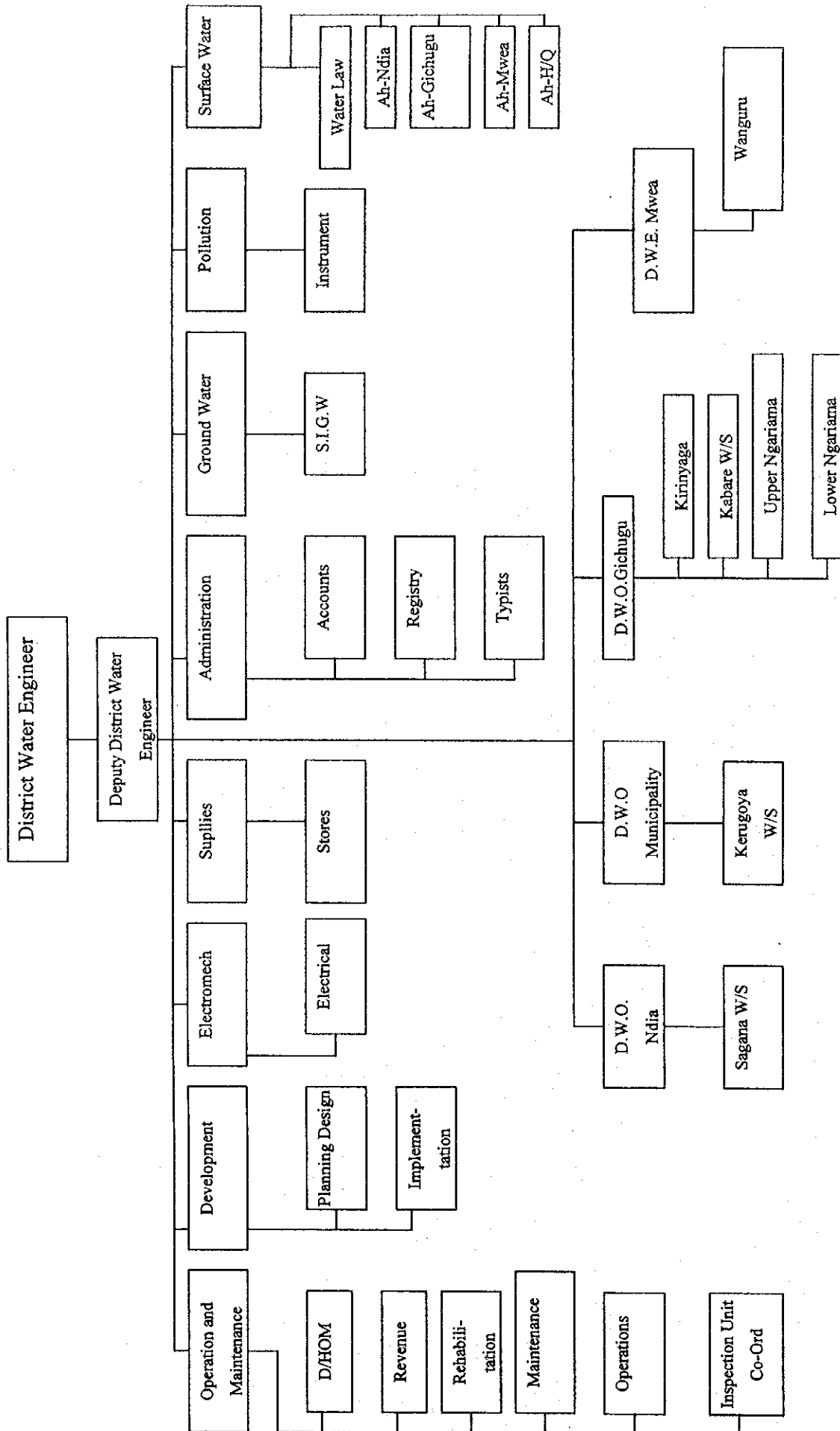


Figure I.1-12 Organization Chart of Ministry of Public Works and Housing

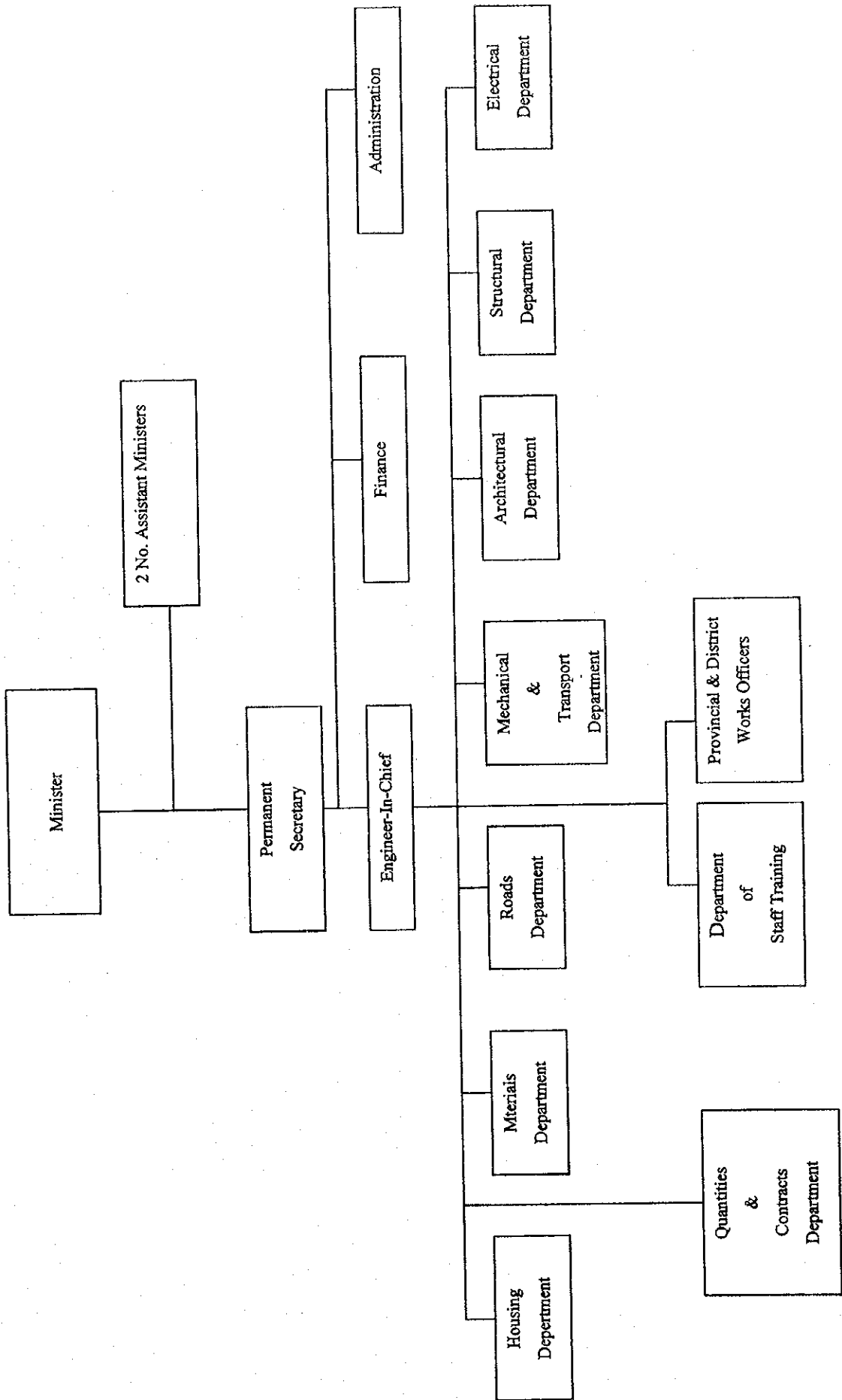
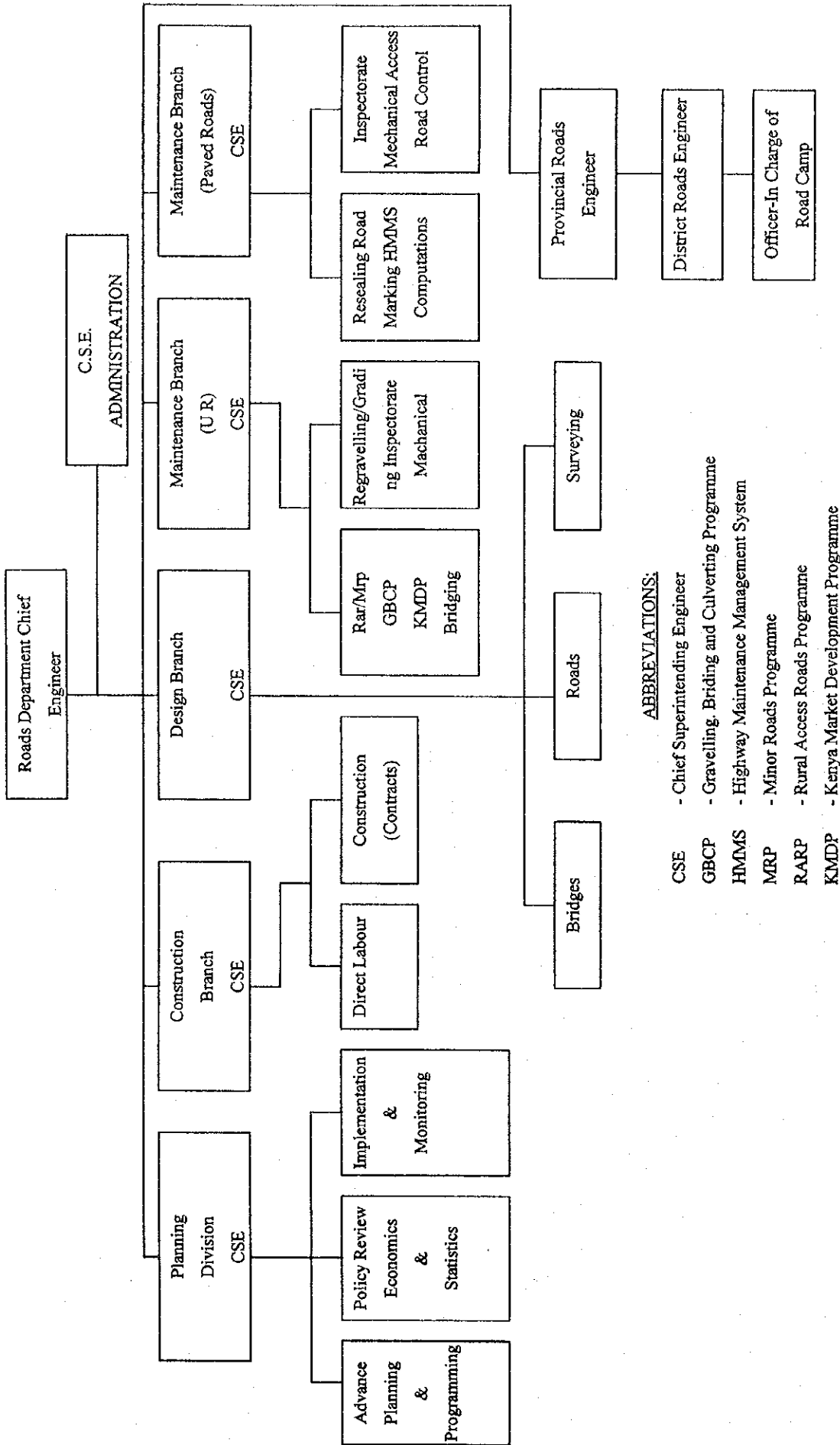


Figure I.1-13 Organization Chart of Road Department



ABBREVIATIONS:

- CSE - Chief Superintending Engineer
- GBCP - Gravelling, Bridging and Culverting Programme
- HMMS - Highway Maintenance Management System
- MRP - Minor Roads Programme
- RARP - Rural Access Roads Programme
- KMDDP - Kenya Market Development Programme

Figure I.1-14 Organization Chart of Kirinyaga District Works Office

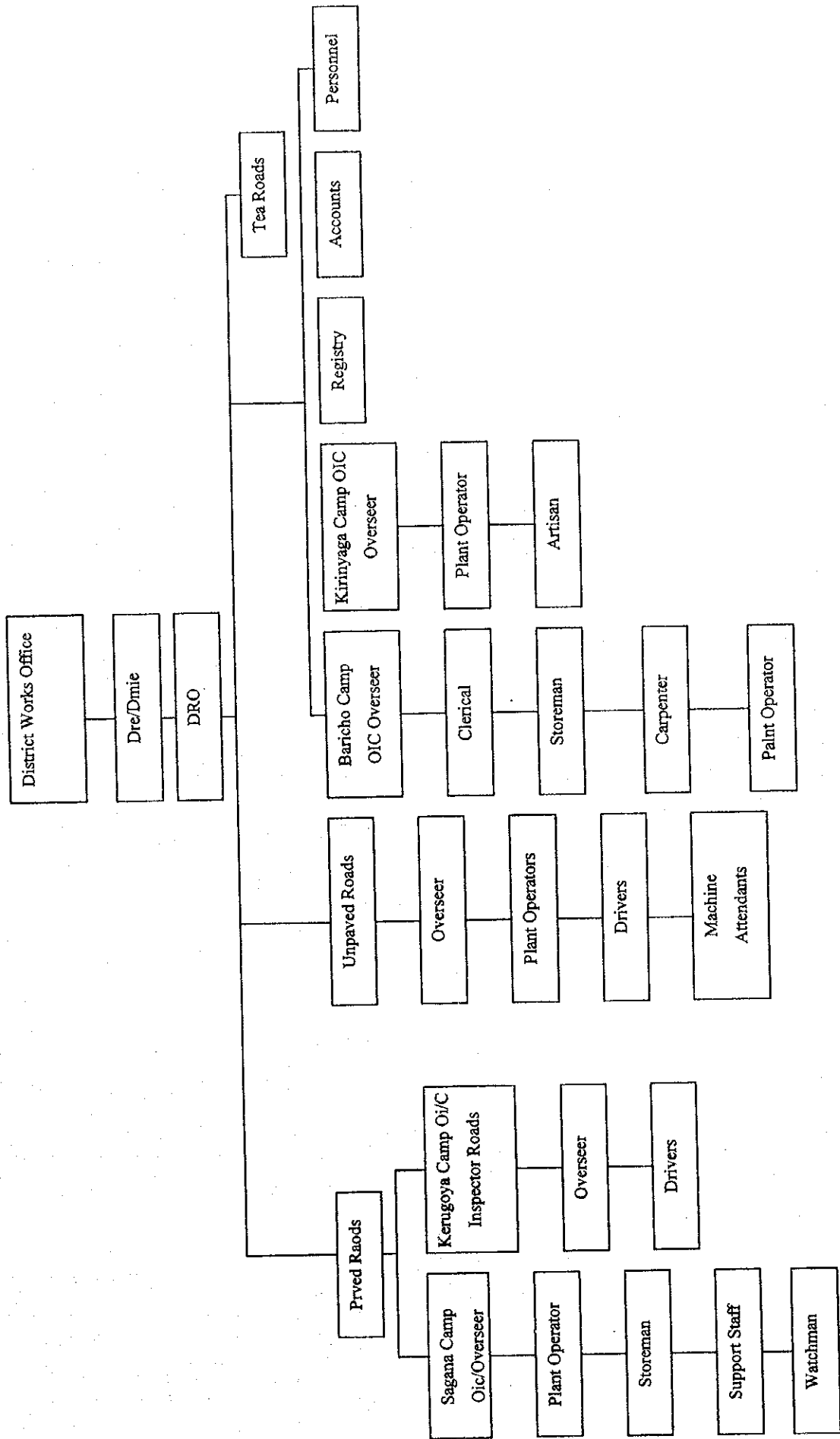
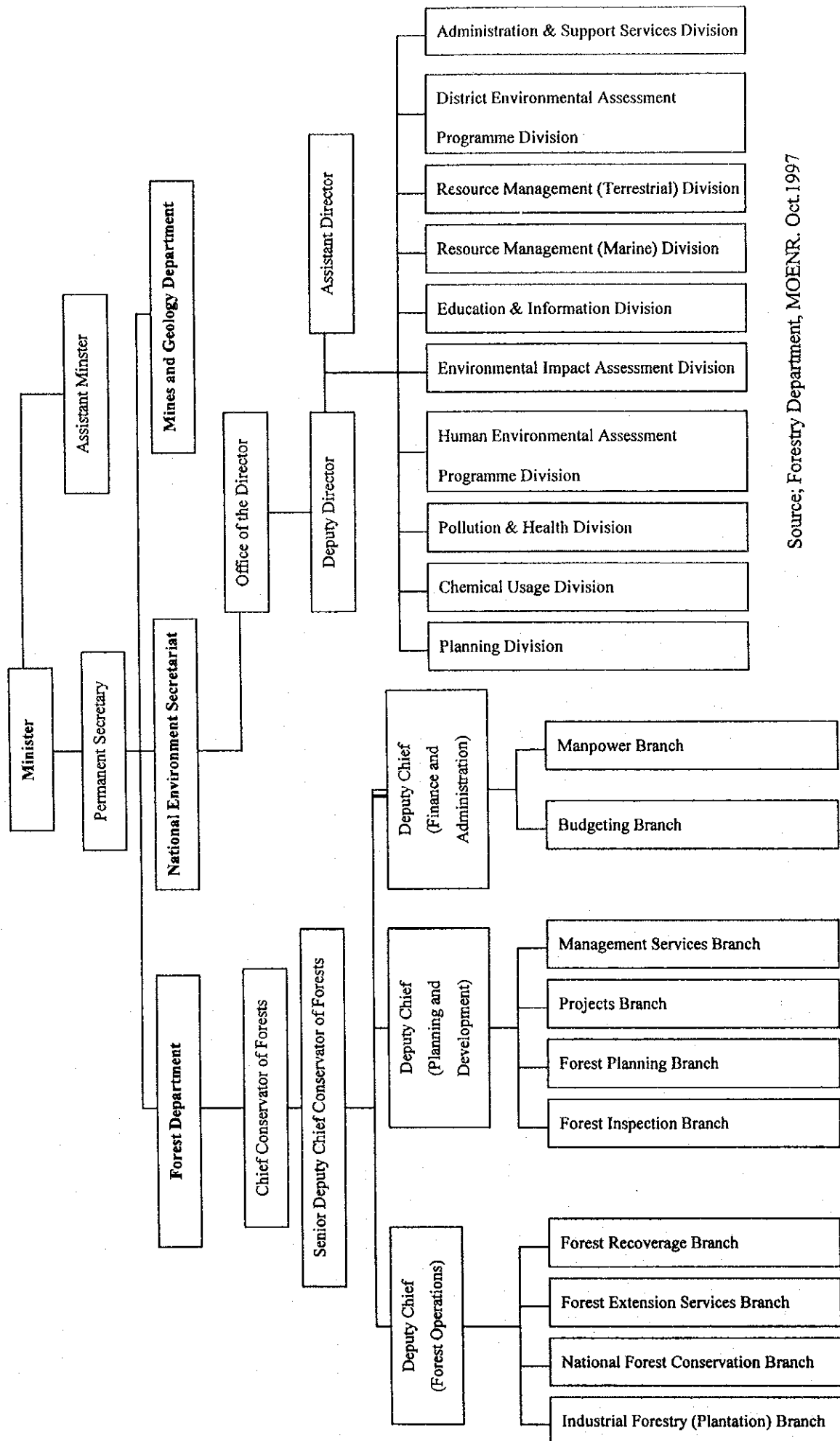


Figure I.1-15 Organization Chart of Ministry of Environment and Natural Resources



Source: Forestry Department, MOENR, Oct.1997

Figure I.1-16 Organization Chart of SISDO

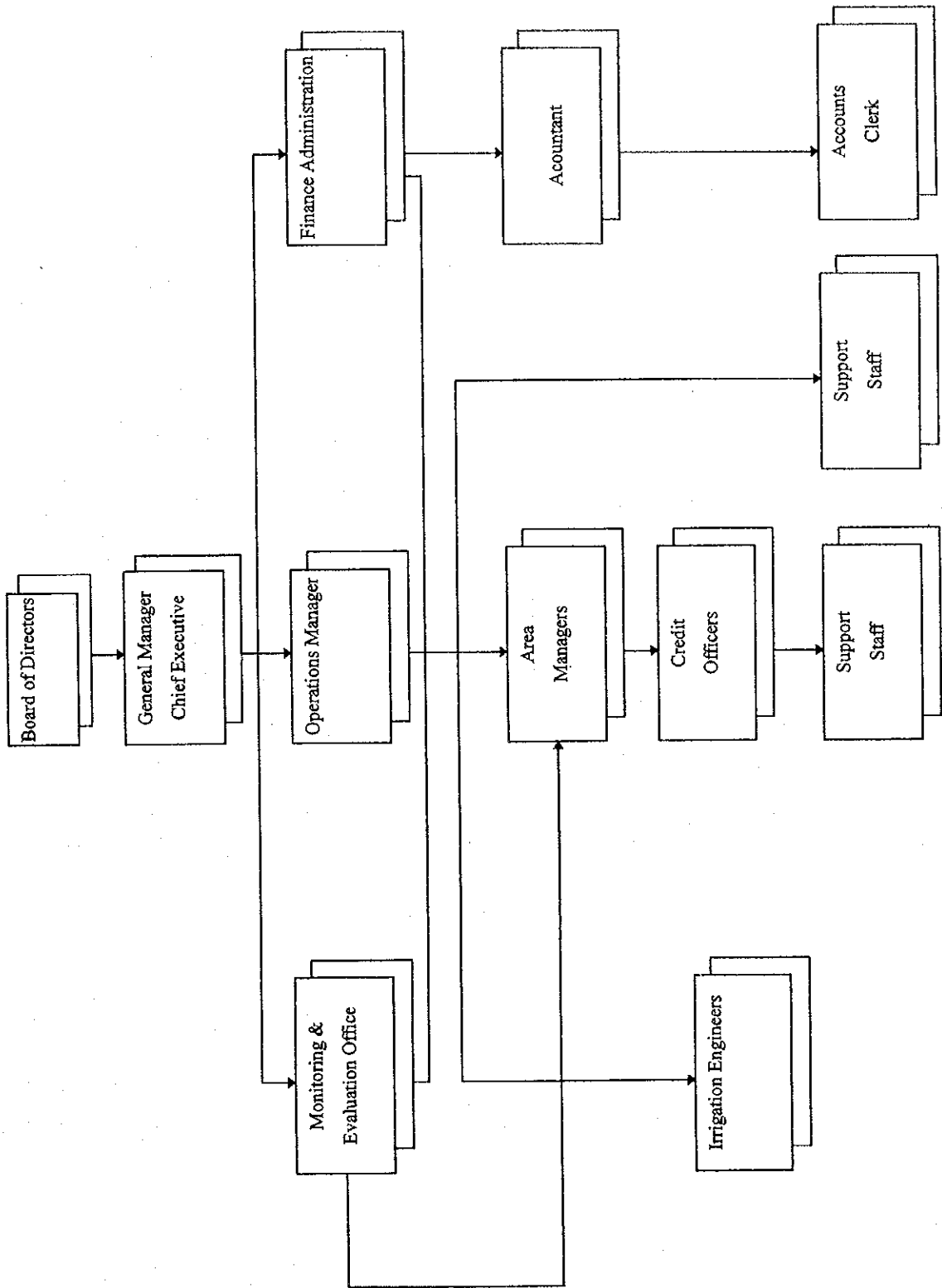


Figure I.1-17 Organization of Kirinyaga County Council for Works Department

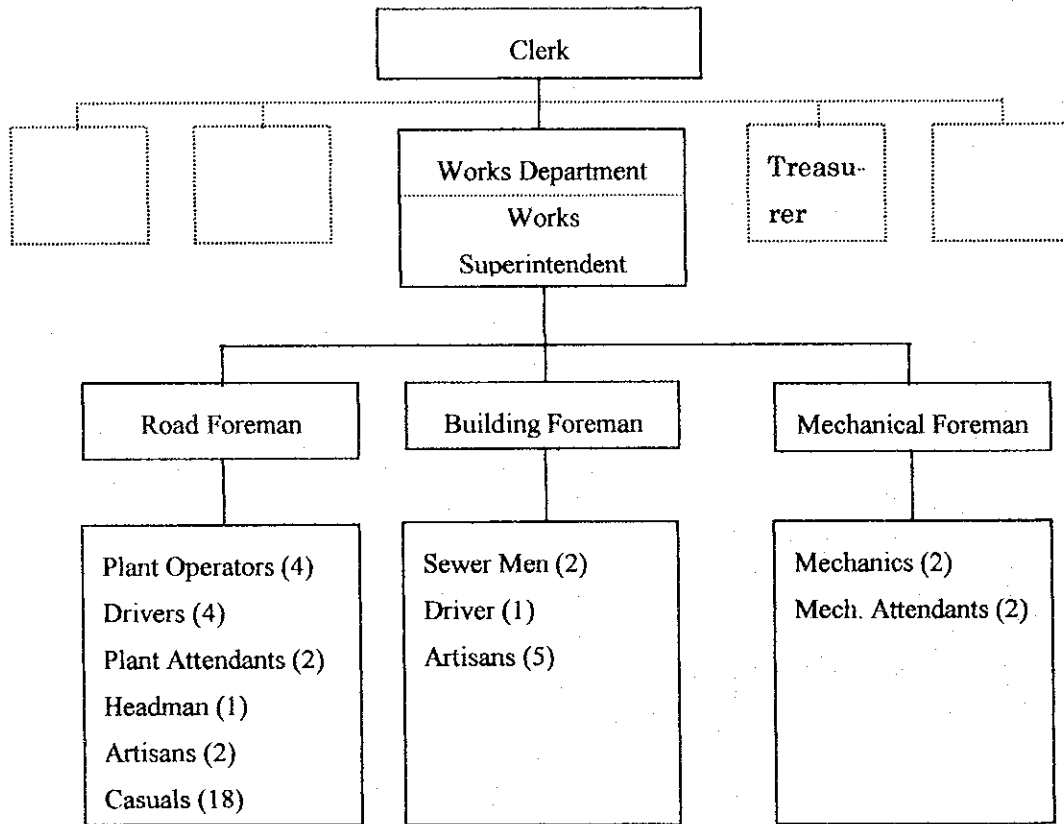


Figure I.1-18 Organization of Embu County Council for Works Department

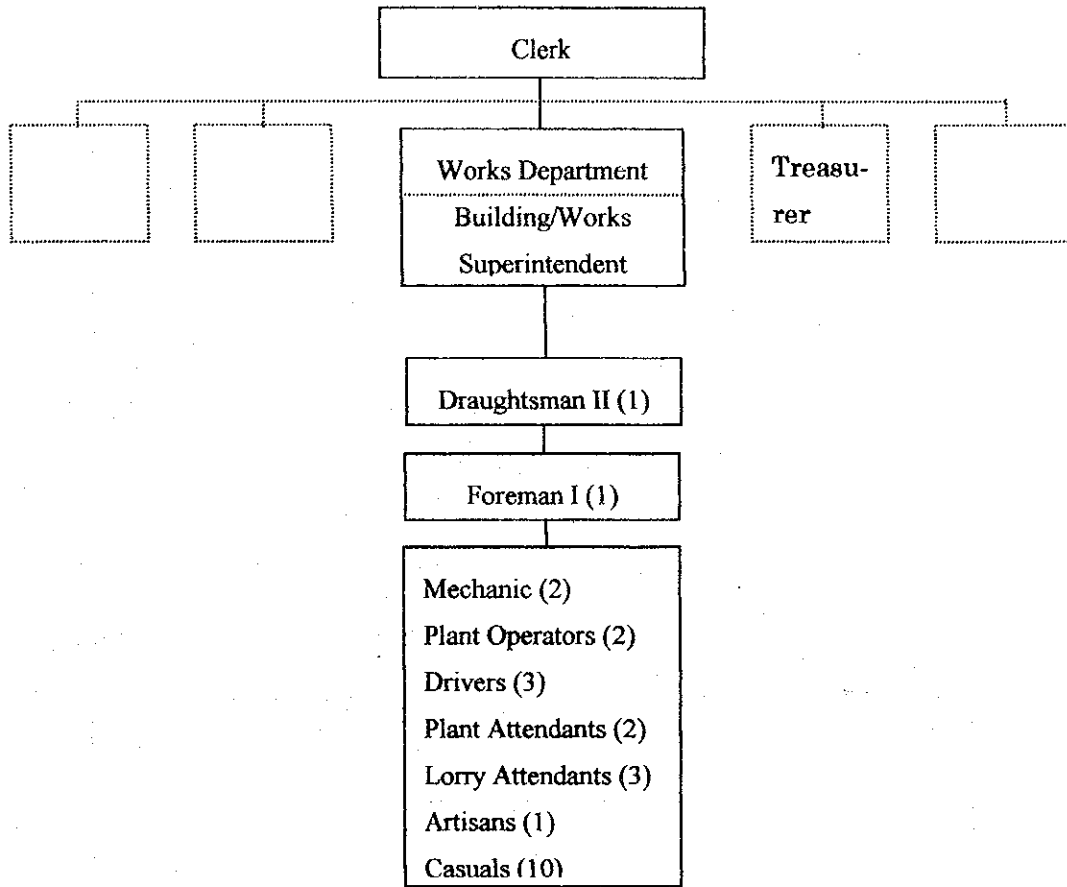


Figure I.1-19 Existing Organization of Nkunjumo Water Association

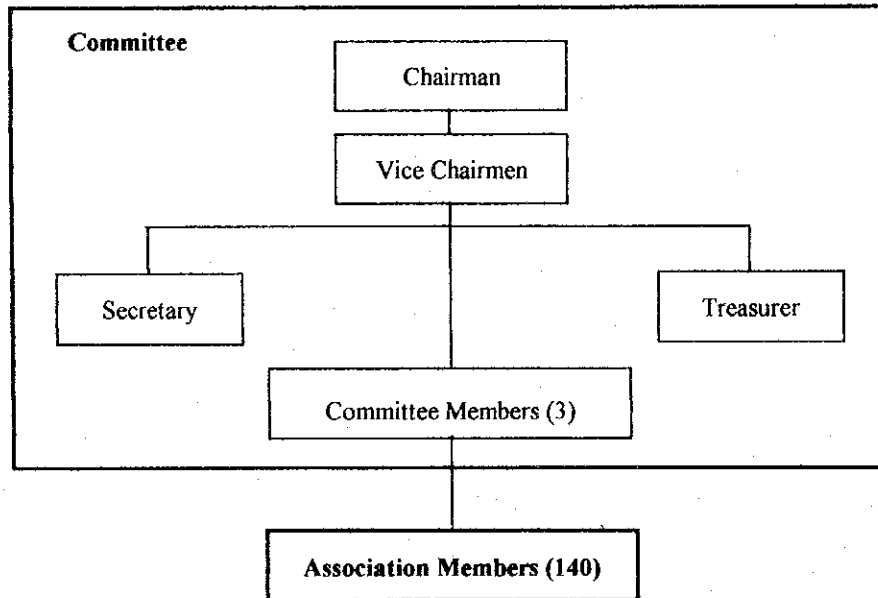


Figure I.1-20 Existing Organization of Ruungu/Karocho Irrigation Association

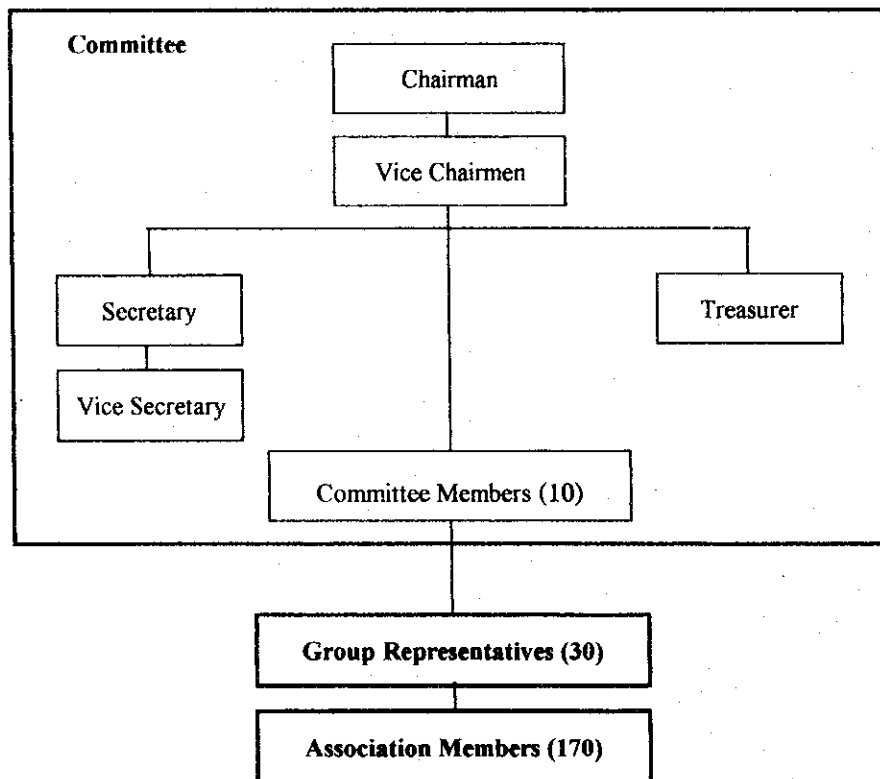


Figure I.1-21 Existing Organization of Rupingazi Ngerwe Irrigation Association

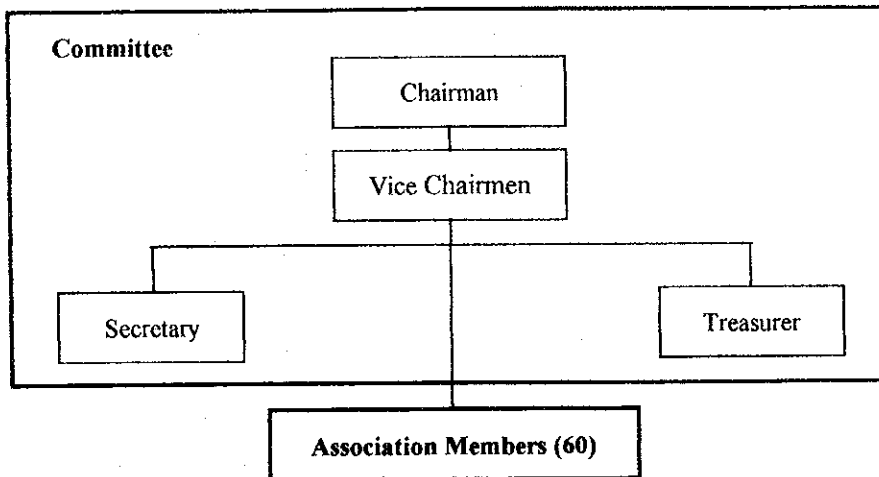


Figure I.1-22 Existing Organization of Ngomano/Nyangati Water Furrow Association

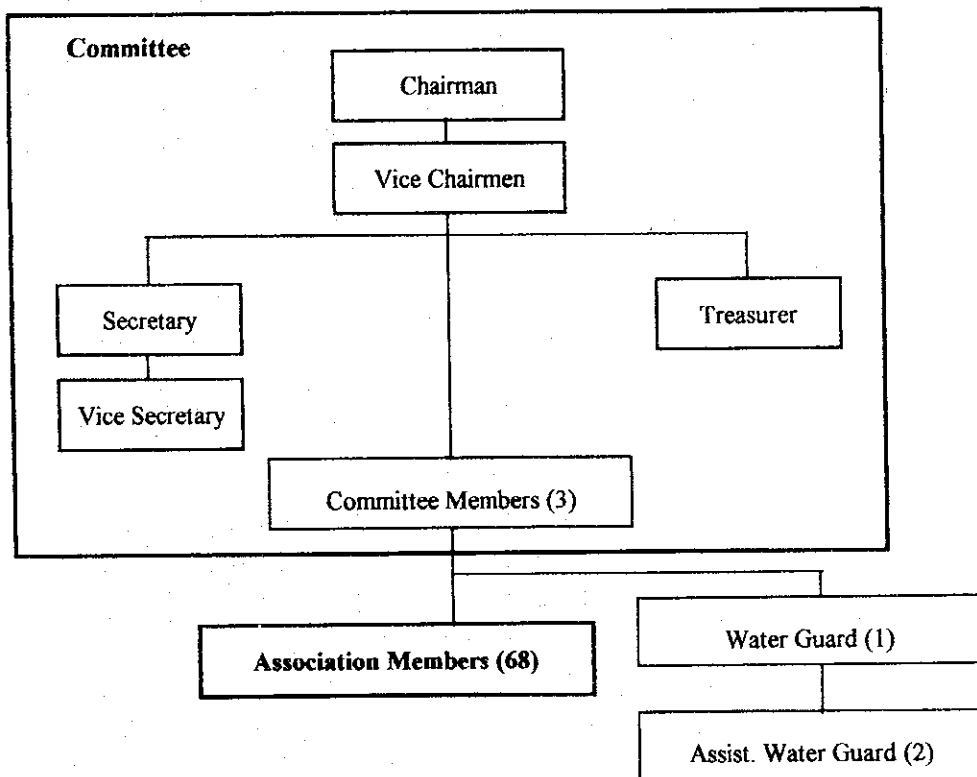


Figure I.1-23 Organization Chart of Nyambene District Water Office

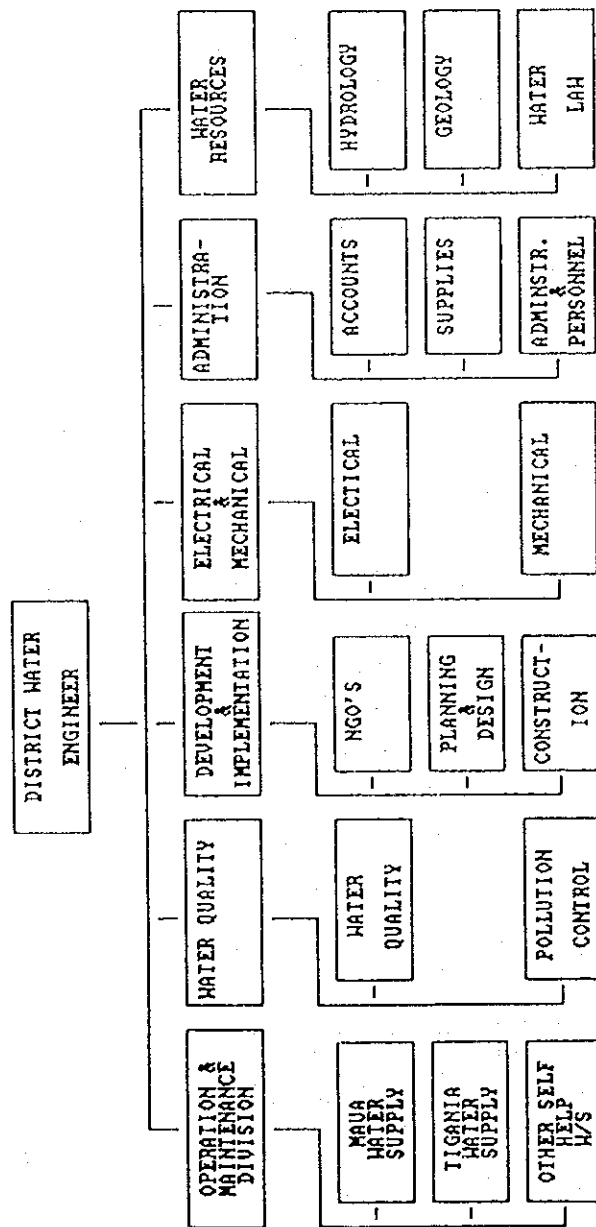


Figure I.1-24 Organization Chart of Embu District Water Office

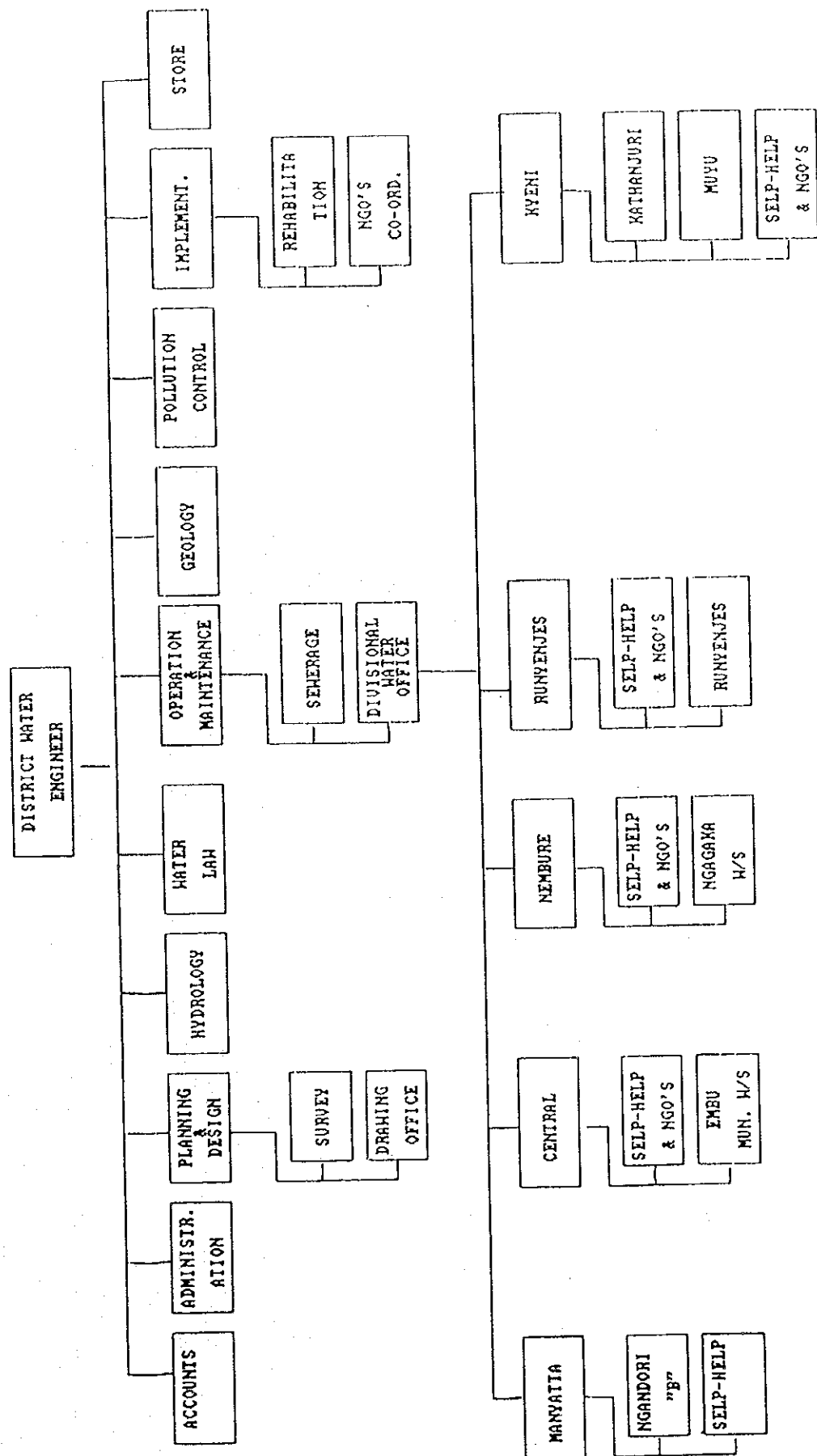
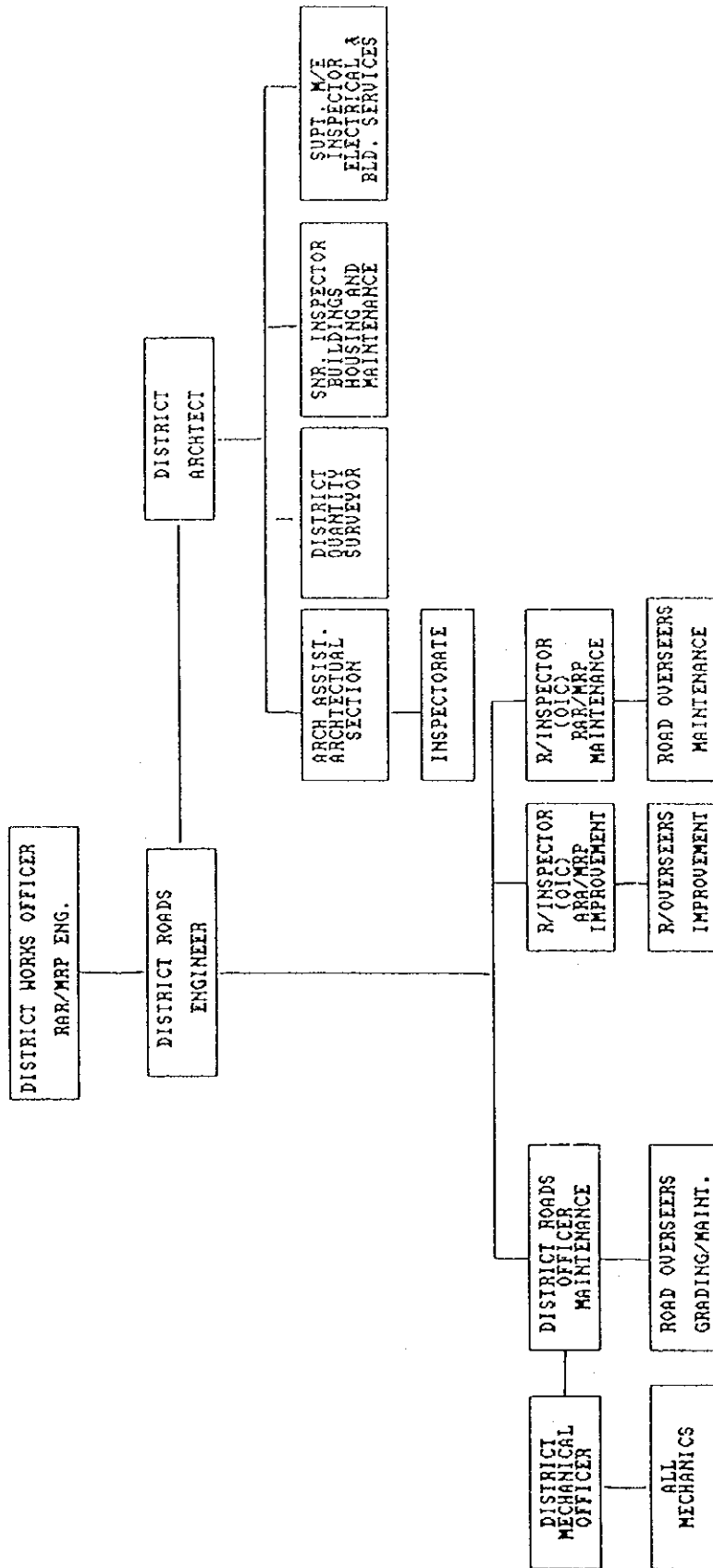


Figure I.1-25 Organization Chart of Tharaka Nithi District Works Office



ANNEX J

**FARMERS' ORGANIZATION AND AGRICULTURAL
SUPPORTING SERVICES**

