2.2.5 Financial Conditions

(1) Revenue and Capital Expenditure of the Federal Government

The revenue of the Federal Government accrues from economic activities in the country through taxation system, external assistance and capital receipts such as external loans and credit. Table 2.7 shows Government revenue by source. Total estimated revenue for 1997/98 is 11,845 million Birr. The taxes accounted for about 48% of the total revenue. Though the external loans and credits of the capital receipt accounted for about 25% of the total revenue in 1993/94, its ratio gradually decreased and it is expected to be less than 10% in 1997/98 budget.

Table 2.7 Government Revenue by Source

(Unit: Million Birr)

Source	Year				
	1993/94	1994/95	1995/96	1996/97	1997/98
Direct Taxes	1,032.0	1,154.3	1,516.4	1,739.2	2,062.7
Indirect Taxes	1,013.3	1,023.9	1,039.1	1,267.0	1,384.3
Foreign Trade Taxes	1,264.0	1,682.3	1,904.4	2,166.7	2,380.4
Other Current Receipt	514.5	1,293.8	1,916.5	1,665.0	2,019.8
Contribution to Pension Fund	56.5	77.4	85.1	88.9	94.8
External Assistance	2,021.1	1,793.7	1,348.4	2,165.8	2,063.9
Capital Receipt	2,314.7	2,940.2	2,288.0	1,747.1	1,838.6
Total	8,207.1	9,956.6	10,097.5	10,839.7	11,844.5

Source: Ministry of Finance

Capital expenditure of the Federal Government for various kinds of development projects accounted for about 24% of the total expenditure in 1996/97. Table 2.8 shows capital expenditure by source of finance and purposes. Out of the capital expenditure, about 55% were allocated from local funds in 1996/97, while external assistance and external loans accounted for 13% and 32% respectively. About 88% of the capital expenditure were utilized for economic development such as road construction, mining and energy, transport and communication, industry development, natural resources, and agriculture development in 1996/97.

Table 2.8 Capital Expenditure by Source of Finance and Purpose in 1996/97

(Unit: Million Birr)

Capital Expenditure	Source			
	Local Funds	External Assistance	External Loans	Total
Social Development	109	11	75	195
Economic Development	1,219	332	768	2,319
General Development	120	0	0	120
Total	1,448	343	843	2,634

Source: Ministry of Finance

(2) Budget of Region 14 Administration

Table 2.9 shows summery of the budget of the Region 14 Administration in recent two years. Recurrent budget is the budget for regular cost, and capital budget is the budget for projects such as flood control, road betterment, school construction, and water supply improvement. Thus, the capital budget is allocated only when it is necessary.

Table 2.9 Budget and Expenditure of Region 14 Administration

	Planned			Actual		
	Recurrent	Capital	Total	Recurrent	Capital	Total
1996/97						
Region 14 total	285.2	426.9	712.1	272.0	246.3	518.3
Economic sector	35.7	392.1	427.8	34.9	228.0	262.9
AFCPO	-	7.6	7.6	-	0.7	0.7
1997/98						
Region 14 total	332.0	378.2	710.2	-	-	-
Economic sector	57.0	330.7	387.0	-	-	-
AFCPO	-	4.0	4.0	-	-	-

Source: Finance Bureau of Region 14 Administration

The total budget of the Region 14 Administration was about 710 million Birr and it was not changed much from the fiscal years 1996/97 to 1997/98. Actual expenditure in 1996/97 was small at 518 million Birr and it was about 73% of the planned amount.

Almost all development projects are executed by bureaus and offices of the Economic Sector. The budget of the Economic Sector was decreased from 427.8 million Birr in 1996/97 to 387.7 million Birr in 1997/98. Actual expenditure of the Economic Sector was small at 262.9 million Birr and this was about 61% of the planned amount.

Addis Ababa Flood Control & Prevention Office (AFCPO) has started its activity since 1995/96. The budget for the first fiscal year (1995/96) was 15.7 million Birr but it decreased to 7.6 million Birr in 1996/97 and 4 million Birr in 1997/98. Actual expenditure of AFCPO was only 0.7 million Birr in 1996/97.

Table 2.10 shows summery of the budget for the development projects of the Economic Sector in the fiscal year 1996/97.

Table 2.10 Budget for Development Projects of the Economic Sector in 1996/97

	Planned		Actual	
	Million Birr	%	Million Birr	%
1. Infrastructure development				
- Water supply and sewerage	232.6	59%	154.8	68%
- Road and drainage	52.9	13%	33.6	15%
- Comprehensive urban development	44.7	11%	13.5	6%
- Works and urban development studies	42.2	11%	20.4	9%
2. Flood control	7.6	2%	0.7	0%
3. Other projects	12.1	3%	5.0	2%
4. Others	-	-	-	-
Total	392.1		228.0	

Source: Finance Bureau of Region 14 Administration

The budget for water supply and sewerage amounted to 232.6 million Birr and it accounted for 59% of the budget for development projects. The budget for flood control was 7.6 million Birr and it accounted for 2% of the total budget for development projects.

Table 2.11 shows the budget of the Region 14 Administration and the Economic Sector by source in 1996/97.

Table 2.11 Budget by Source in 1996/97

	Region 14 Administration				Economic Sector			
	Planned		Actual		Planned		Actual	
	Million Birr	%	Million Birr	%	Million Birr	%	Million Birr	%
1. Municipal government revenue	293.6	69%	196.4	80%	276.3	70%	186.7	82%
2. Foreign loan	83.3	20%	28.1	11%	76.9	20%	23.8	10%
3. Foreign assistance/grant	37.3	9%	18.4	7%	26.2	7%	14.6	6%
4. Other source	12.7	3%	3.4	1%	12.7	3%	2.9	1%
Total	426.9		246.3		392.1		228.0	

Source: Finance Bureau of Region 14 Administration

The source from the municipal government revenue accounted for about 70% of the planned budget amount both in the Region 14 and the Economic Sector. On the other hand, the total of the foreign loans and assistants/grant accounted for nearly 30% of the planned budget amount.

(3) Foreign Aid in the Project Area

According to the Planning and Economic Development Bureau of the Region 14 Administration, there are several foreign aid projects under way or planed concerning water resources in the Study Area. Some of the projects are financed by soft loans extended by African Development Fund (ADF) or International Development Association (IDA). Most projects are water supply projects.

2.2.6 Land Use

Previous municipal area of Addis Ababa was 220 km^2. In 1991, the municipal area of Addis Ababa was expanded to the south and it became 510 km^2. Residential area including expansion area accounts for 185 km^2 or 36% of total area, while green area, woodland and green area for permitted use including agricultural land account for 250 km^2 or 49%. On the other hand, commercial and business center accounted only for 3 km^2 or 0.6% of the total area although a great number of traders run their business all over the urban area of the city. The land use regulation by the Region 14 Administration is basically conducted based on the Addis Ababa Master Plan prepared in 1986.

Table 2.12 **Present Land Use in Addis Ababa**

Land Use Categories	Area (ha)	Distribution
1. Existing Built-up Residential Area	8,054	15.7%
2. Residential Expansion	10,445	20.4%
3. Party, Government and Public Institutions	2,617	5.1%
4. Higher Education and Applied Research Center	247	0.5%
5. Commercial and Business Center	303	0.6%
6. Transport Related Activities	1,759	3.4%
7. Zonal Offices	324	0.6%
8. Industrial	2,269	4.4%
9. Embassies	238	0.5%
10. Green Area	14,850	29.0%
11. Wood Land	1,662	3.2%
12. Functional Green for Permitted Use	8,518	16.6%
Total	51,284	100.0%

Source: General Land Use Scheme of Proposed Core Area of the Addis Ababa City
National Urban Planning Institute

2.2.7 Culture

(1) Ethnic Groups

It is said that Ethiopia has more than 70 ethnic groups and more than 280 different languages. Addis Ababa also has a variety of ethnic groups. According to the 1994 Population and Housing Census, the population of Amhara accounts for 1,019,729 or 48.3% of the total population of Addis Ababa. The second largest ethnic group is Oromo, which has 406,518 persons or 19.2% of the total population.

(2) Religion

About 38% of the people of Ethiopia are Christians of the Ethiopian Orthodox Union Church (Orthodox), and Christianity is predominant in northern Ethiopia. The southern regions have Muslim majorities, who represent about 43% of the total population of Ethiopia. The most dominant religion in Addis Ababa is Orthodox. According to the 1994 Population and Housing Census, 82% of population in Addis Ababa was Orthodox. Muslim holds second (12.7%). Protestant (3.9%) and Catholic (0.8%) follow it.

(3) Education

In Ethiopia, the grades 1 to 6 are called elementary school, the grades 7 to 8 are junior secondary school, and the grades 9 to 12 are senior secondary school. In the urban area of Addis Ababa, about 85% of the population is attending or attended the school, while only 37% of the population is attending or attended the school in the rural area. Number of the population currently attending elementary schools (grade 1-7) in Addis Ababa decreased from 372,675 in 1984 to 331,216 in 1994. However, that attending junior and senior secondary schools and higher education increased remarkably in the same 10 years.

2.2.8 Environmental Aspects

(1) Environmental Protection

Following the United Nations Conference on Environment and Development that was held in June 1992 in Rio de Janeiro in Brazil, the Federal Government established the Ministry of Natural Resources Development and Environmental Protection. Then the National Environmental Protection Authority (NEPA) was formed under the Ministry as an independent agency. NEPA is responsible for environment policy and legislation. The Environmental Protection Bureau was established under the Region 14 administration.

Formulation of the Conservation Strategy of Ethiopia has been undertaken in three phases since 1989 following the signing of the first project agreement between the Federal Government and the World Conservation Union.

The Environmental Policy of Ethiopia is taken from "Vol. II Policy and Strategy" of the documentation of the Conservation Strategy of Ethiopia. The Environmental Policy of Ethiopia focuses on the environmental policy component of the Conservation Strategy of Ethiopia. The Environmental Policy of Ethiopia was issued on April 2, 1997 by the Secretariat for the Conservation Strategy of Ethiopia, the Environmental Protection Authority in collaboration with the Ministry of Economic Development and Cooperation.

The policy covers the natural and cultural heritage, soil, forest, woodland, tree resource, genetic, species, ecosystem bio-diversity, water resources, energy resources, mineral resources, human settlement, atmospheric pollution, water pollution, social and gender

issues, environmental research, environmental impact assessment, environmental education and awareness, institutional framework, legislative framework, monitoring, and evaluation.

After the approval of the policy in April 1997, related regulations will be formulated from now on under this established national policy on environment.

(2) Conservation Area and Cultural Heritage

In line with the policy of protection of wild life in the country, the Ethiopian government designated National Parks in the area where wild life concentration is found in the country. Presently 9 areas are designated as National Park and 4 wildlife sanctuaries have been established. The heritage of Ethiopia's long history is found especially in the northern part of the country. Some historical assets are also found near Addis Ababa. These National Parks and historical assets are located outside of the Study Area.

In the city of Addis Ababa, the important cultural assets are 1) The Menelik Mausoleum, 2) Trinity Cathedral, 3) St. George's Cathedral, 4) The Jubilee Palace, 5) Intoto Mariam church built in Menelik era. At present, there are 10 city parks, administered by the Park Team of the Region 14 Administration with the coverage area of 113.89 hectare. In addition, there are 2 nursery parks in the city. Most of these parks are located along the objective rivers of the Study. For formulation of the flood control master plan, this situation should therefore be taken into considerations of environmental protection. Locations of cultural asses and city parks in the Study Area are shown in Figure 2.9.

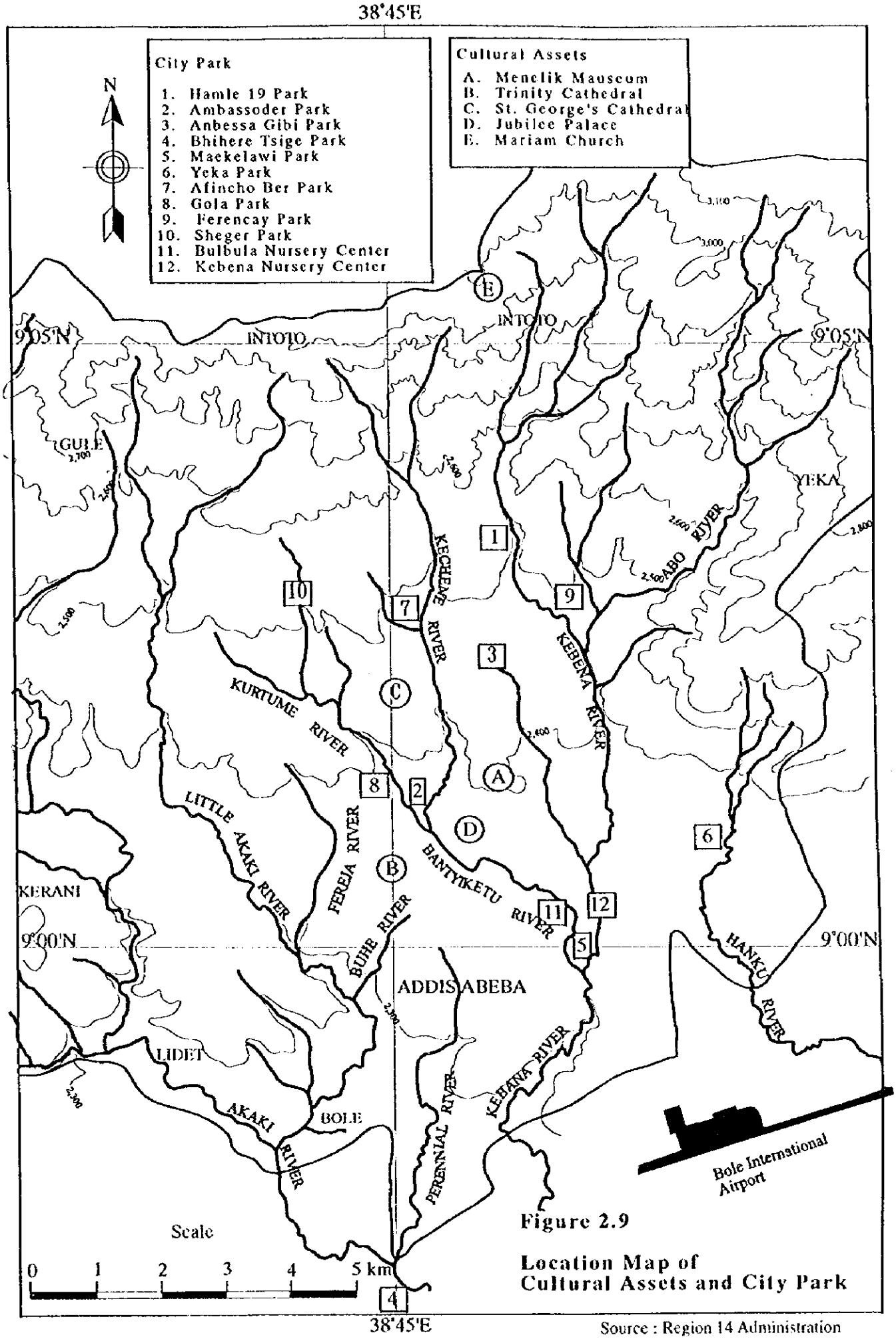


Figure 2.9

Location Map of Cultural Assets and City Park

Source : Region 14 Administration

2.2.9 Resettlement

(1) Present Practice

According to the present practice, the Works and Urban Development Bureau should prepare a new land for resettlement when resettlement is needed for implementation of a project. The compensation cost for houses should be estimated by implementing agency of project. The estimated compensation amount to house owner is paid by the Region 14 Administration.

On the resettlement, those people who have owned their houses can receive the compensation and may afford to construct their own houses on the site prepared by the government. Those people who have been living in rented houses are provided with the land and house. The cost of land preparation and construction of house is borne by the government. But the cost of the new rent should be borne by the people. In this case, some people may not afford to pay the new rent cost, then the people can not move from their place to the new resettlement place even though the land and houses are provided by the government.

Presently the government is considering a new policy that low cost house should be constructed in an appropriate area and the new rent should be decided based on the income level of the people so that the people can easily resettle to the new area. The rent to be paid by the settler based on the new system may not cover the maintenance cost of the houses. The insufficient portion will be borne by the government according to the new policy.

(2) On-going Program

In August 1994, there happened a disastrous flood making 462 families homeless, The Addis Ababa Flood Prevention Project Office is put under an obligation to implement the resettlement of those people. The first stage of the resettlement program was to construct 6 apartment houses of 4 stories for 120 families. The new land was prepared at 6 plots in Wereda 23 Kebele 13 about 3 to 5 km far from the original place. In 1995/96 fiscal year, a budget of some 15 million Birr was once allocated for the program but actual execution was not made. In this fiscal year of 1996/97, the budget is now pending due to some constraints of budget preparation.

2.3 Rivers

2.3.1 River Systems

The rivers in the Study Area are located in the most upper basin of the Awash river which is ranked at the fourth biggest one in Ethiopia in the size of basin area. The rivers in the Study Area are grouped into the five river systems: the West Akaki, the Little Akaki, the Kebena, the Bantyiketu with two tributaries of the Kechene and Kurtume, and the Hanku. Demarcation of the river systems in the Study Area is shown in Figure 2.10. The followings are the principal features of the river systems.

Table 2.13 Principal Features of River Systems in the Study Area

River System	Basin Area (km^2)	River Length (km)	River Slope
West Akaki	172.2	35.6	1/50-1/100
Little Akaki	30.8	20.5	1/25-1/100
Kebena	59.8	23.9	1/20-1/100
(Upper Kebena)	(54.8)		
(Lower Kebena)	(5.0)		
Bantyiketu	29.3		
(Bantyiketu)	(5.4)		1/100
(Kechene)	(13.6)	11.2	1/20-1/50
(Kurtume)	(10.3)	9.3	1/20-1/50
Hanku	11.1	8.6	1/50-1/70

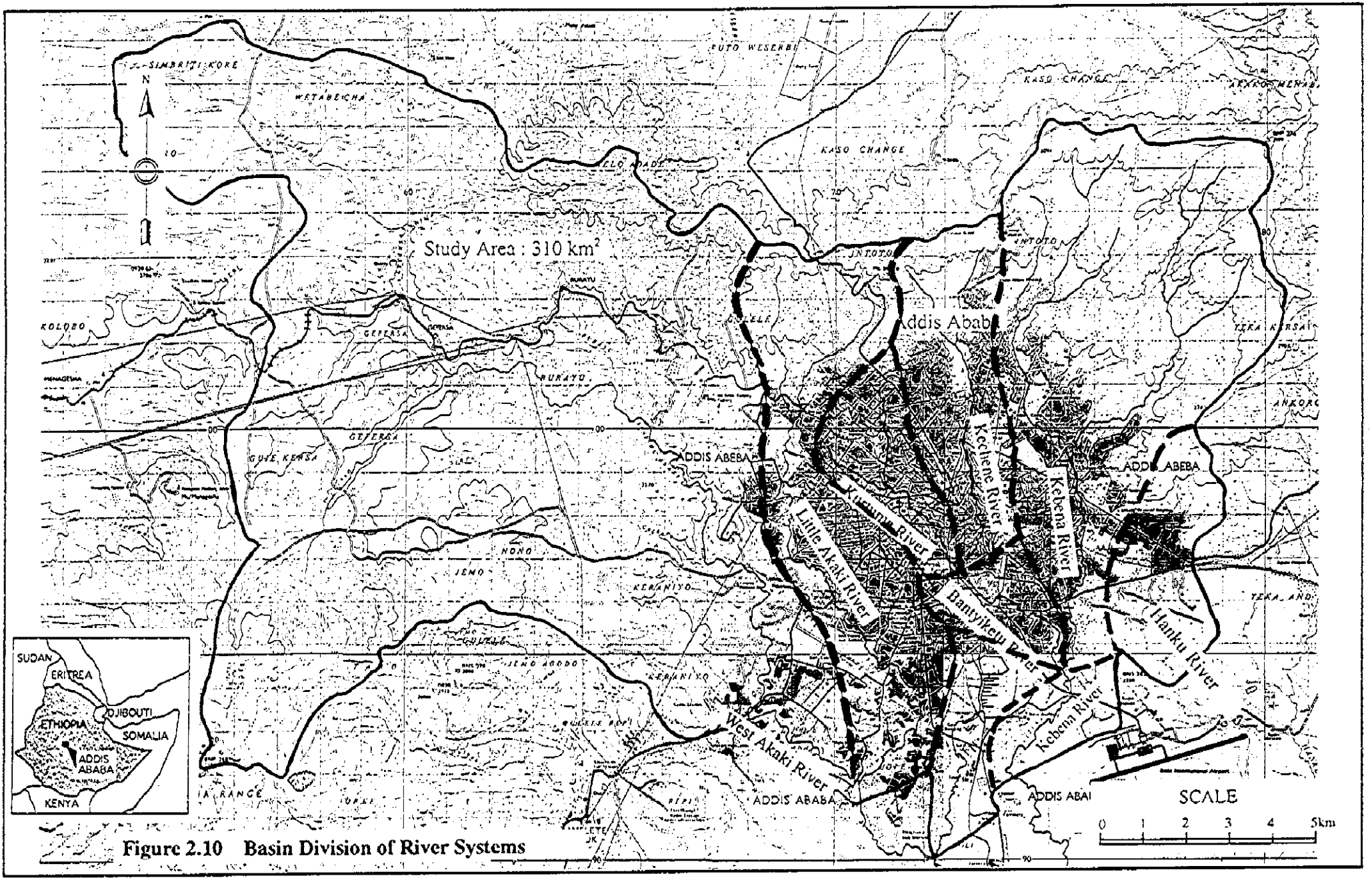


Figure 2.10 Basin Division of River Systems

Outline and characteristics of each river system are presented below.

(1) West Akaki River System

The West Akaki river originates in the west mountain ridge of the Study Area. After flowing down in the south-east direction for a distance of some 10 km, the river reaches the reservoir of the Gefersa dam. The West Akaki river further flows down for 20 km in the rural area, valley and suburban area of the city of Addis Ababa areas, collecting some tributaries. Then, it is joined by the Little Akaki river and a small drainage canal of the Perennial on the left. The West Akaki river in the suburban areas is the largest one, having an average width of more than 60 meters. The West Akaki river finally discharges into the lake of Aba Samuel.

(2) Little Akaki River System

The Little Akaki river originates on the Intoto mountain slope. After passing through the mountainous areas for about 3 km, it flows down in the urban area for about 4 km southward. Then it runs for about 5 km in the densely populated area southeastward, collecting two drainage canals of the Fereja and Buhe on the left bank.

The stretches upstream of the confluence with the Fereja are running in the deeply incised valley and the river course meanders at some points, though the meandering is within the valley area. Further, turning its direction to the south, the Little Akaki river joins the West Akaki.

The Little Akaki river in the reaches from the confluence of the Fereja up to the Ethiopian Abattoir Factory site is quite narrow due to construction of buildings and houses. The river width in the reaches is less than 10 meters at the narrowest site. The riverine area in the reaches is subject to flooding.

(3) Kebena River System

The Kebena river has its origin in the Intoto mountain ridge. Collecting rainwater in the mountainous areas, it takes route in the south direction. About 700 meters upstream of the Tesfa Aseged bridge, the Abo river joins the Kebena. The Kebena river in this stretch flows in the wide and incised valley.

The Kebena river flows down southward for a distance of 5 km in the populated area and is joined by the Ginfile, a small drainage canal, just upstream of the Uracl bridge on the right. In this stretch, the original river width has been relatively kept, because of destructive flood flow directly coming from the mountain areas.

Then, the Kebena river flows down for 1.5 km and is joined by the Bantyiketu river about 700 meters upstream of the Bole bridge. A natural retarding basin stretches at the confluence with the Bantyiketu river. No serious flood damage in this river has been reported so far due to relatively wide channel of about 25 meters on average. In the lower reaches of the Bole bridge, the Kebena river runs in the deep valley area.

(4) Bantyiketu River System

The Bantyiketu river has two tributaries of the Kechene and Kurtume. The Kechene is the main tributary of the Bantyiketu. The Kechene and Kurtume join at the Filwiha bridge and the river is called the Bantyiketu river in the lower reaches. The Bantyiketu river takes its route south-easterward for a distance of 3.5 km towards the confluence with the Kebena river.

1) Bantyiketu River

The Bantyiketu river runs in the central area of Addis Ababa and reaches a natural retarding basin located at the confluence with the Kebena. The channel width in the upper and middle reaches is narrow, having a width of around 10 meters. The riverine areas has habitually suffered from recurrent flooding.

2) Kechene River

The Kechene river originates at the Intoto mountain slope and flows down southward. The river upstream of the Kechene bridge flows in an incised, wide and deep valley. After flowing down in the valley for further 1 km, the Kechene river is joined by the Kostre. Then, the Kechene river flows down for 3.5 km towards the confluence with the Bantyiketu. Some sites (around bridges) of this reach are constricted by private houses and buildings. The river bank areas (terrace of the valley) have been densely covered by houses subject to flooding. Therefore, area along this reach has habitually suffered from flooding. Especially, the lower reach has been vulnerable to flooding.

3) Kurtume River

The Kurtume river originates on the southern slope of the Intoto ridge. Five major drainage canals join together in the upstream of the Habte Giyorgis bridge. Then, the Kurtume river flows south-eastward in the very urbanized area for about 2 km down to the Churchill Avenue which is one of the main streets in Addis Ababa. The channel between the Habte Giyorgis bridge and Churchill Avenue is relatively wide having an average width of 10 meters. At the crossing point of the Churchill Avenue, the Kurtume river flows through a culvert under the Avenue and building area of the Post Office. The size of culvert is 4.5 meters wide, 4 meters height, and about 500 meters long. Due to sudden decrease of flow area at the culvert inlet, river water often overflows onto the Avenue during floods. After passing the culvert, the Kurtume river as an open channel joins the Bantyiketu river.

(5) Hanku River

The Hanku river originates on the Intoto mountain slope in the eastern part of the Study Area. After flowing through the mountain slopes, it flows down towards south direction for about 2 km. Then, the river including a left drainage way crosses under the Fikre Maryam Aba Techan Street through small culverts. Therefore, during the rainy season, the river water especially in the left drainage way frequently flows over the street towards the downstream area at this site.

After crossing the Street, it is joined by the left drainage way just upstream of the Asmera Street. In the far lower reaches, there exists an extensive natural retarding basin which is presently an open area. Further, the Hanku river flows down for about 7 km south-eastward in the valley area and finally joins the Akaki river to the southeast of the Bole International Airport.

2.3.2 River and Related Structures

(1) Flood Protection Work

There are several completed flood protection works along the Little Akaki river. They are mainly walls to protect houses from flood flow. These walls are of wet masonry gravity type with direct height varying from 5 to 6 meters. The Addis Ababa Flood Control and Prevention Project Office of the Region 14 Administration (AFCPO) has constructed these walls in the last 2 years. Besides, there are many walls and

revetment works along the major channels. These have been constructed privately as bank protection works and building foundations.

Major riverbed protection works are observed at the Filwiha bridge and at a bridge downstream of the Bantyiketu bridge along the Bantyiketu river.

(2) Bridge

There exist some 150 bridges over the major river channels in the urban area. Most of the listed bridges are for car traffic furnished with sidewalks. Bridge type is mainly limited to either stone masonry arch bridge or reinforced concrete (RC) bridge. Abutment and pier are mostly made of stone masonry. Out of those bridges, some bridges form a constriction of river due to short span, although they have the function of flood flow retardation and velocity control towards lower reaches.

(3) Water Supply Pipes and Sewers

There are many water supply pipelines and sewers which cross the major river channels. Such pipelines are under the administration of the Addis Ababa Water Supply and Sewerage Authority of the Region 14 Administration (AAWSA).

(4) Dam and Intake Weir

The Gefersa dam is located in the upper basin of the West Akaki river. The dam type is of gravity arch, and the reservoir is used for water supply to Addis Ababa. The dam is under the administration of AAWSA.

There exist 17 irrigation intake weirs in the Study Area for growing vegetables managed by vegetable grower associations. These weirs are of wet masonry wall type and no gate is provided. The withdrawal method is of gravity flow. The direct heights of the weirs vary depending on the locations from about 0.5 to 2.5 meters. Some of these are damaged or flushed away. The crop fields are all located in the strip area along the river banks.

2.3.3 Water Use

(1) Irrigation

There exist five vegetable grower associations that take water of the rivers in the Study Area for irrigation purpose. They are:

a) Kebena and Bulbula Vegetable Grower Association,
b) Makenisa Furi and Saries Vegetable Grower Association,
c) Karanyo and Akaki River Surrounding Area Vegetable Grower Association,
d) Shankla River and Kacha Fabrica River Vegetable Grower Association, and
e) Kolfe and Lideta Area Vegetable Grower Association.

The total irrigation area is 223 hectare. The records of water intake from those rivers are not available.

(2) Domestic Water

AAWSA is supplying domestic water for the city. The intakes for domestic water are located along the Legedadi river near the Legedadi reservoir which is located outside of the Study Area to the east and along the West Akaki river near the Gefersa reservoir which is located in the Study Area in the west. These intakes are located far upstream of the objective area of the flood control master plan of Addis Ababa.

(3) Industrial Water

Data of industrial water use are under the management of the Data Processing and Documentation Services, Trade, Industry and Tourism Bureau of Region 14 Administration. According to the Services, there is no water right of surface water in the Study Area.

(4) Water Quality

For the water supply in Addis Ababa, raw water is taken near the Legedadi and Gefersa reservoirs. Raw water and treated water quality are investigated by AAWSA. On the other hand, water qualities of the rivers flowing in Addis Ababa were investigated by previous studies.

According to the results, raw water at Legedadi and Gefersa keeps acceptable quality for water supply with treatment because of the absence of significant pollution sources around intake.

On the other hand, water quality in the city of Addis Ababa was deteriorated since long time ago. BOD_5 of the Little Akaki was between 60 and 470 mg/l in 1976, 160 mg/l in 1990 and 339 mg/l in 1993, respectively. BOD_5 was also recorded with a high rate in the Kechene and Kebena, 140 mg/l in the Kechene in 1990 and 60 mg/l in 1993, respectively. Surface water Quality in Addis Ababa as of 1993 is shown in Table 2.14.

Table 2.14 Surface Water Quality as of 1993

Item	Unit	Location			
		Little Akaki	Kebena	Great Akaki	Aba Samuel Lake
Ph	mg/l	8.2	8.0	7.6	7.0
DO	mg/l	0.8	0.6	1.0	1.4
COD	mg/l	542	112	37	7.0
BOD_5	mg/l	339	60	32	2.2
Coliforms	Counts per ml	56 mil.	38,000	5	350

Source: The Master Plan Study for the Development of Wastewater Facilities for the City of Addis Ababa, August 1993

2.4 Urban Drainage and Sewage

2.4.1 Urban Drainage

(1) General

The rivers and the canals in the city flow generally in the north-south direction with steep slope. The rivers and the canals are generally deeply dissected and the rainstorm in the city can easily flow into the rivers and canals just by gravity drainage.

With such circumstances, the city of Addis Ababa formerly did not suffer from serious drainage congestion. Consequently the city has no Master Plan of Urban Drainage at present. The responsible agency of the Region 14 Administration for urban drainage is Works and Urban Development Bureau. The activity of the Bureau concerning the urban drainage is presently the maintenance works of the existing drainage canals.

Recent migration of people to the city from various parts of the country resulted in settlement in a greater part along the rivers and canals where the open space was available as flood water flowing area. In addition, the open space, rivers and canals in the city area are being used as the solid waste cast area at various locations causing the flowing congestion in the city.

(2) Drainage Congestion

In the rainy season, stagnant water is observed at places in the Addis Ababa. Especially the local drainage area that drains to the Bantyiketu river in the reaches between the Filwiha bridge and the Finfine bridge on the Menelik II avenue, suffers from drainage congestion almost every time of heavy rainfall. This is mainly due to the lack of appropriate drainage facilities to the Bantyiketu river.

In this area there exist many important facilities, such as the independent square, the agencies of the central government of Ethiopia, the international agencies, shops, hotels, and offices of private enterprises. This area is also an important place from the view point of road and railway transportation.

In view of the above, the drainage congestion in this area should be solved as soon as possible in keeping step with the river improvement of the Bantyiketu river.

2.4.2 Sewerage

The sewerage system in Addis Ababa city was commissioned in 1981. The capacity of the system is sufficient for some 200,000 people. But the system has been only connected to some 800 to 1,000 dwellings, a few institutions and city center offices. Large water consumers such as hotels are not connected. Of the sewerage that is collected, only a portion reaches the treatment works at Akaki located 15 km south from the city center. The balance leaks into the watercourse due to maintenance problems.

Sludge from pit latrine and septic tank is discharged directly into river without any treatment. The consequential pollution of river is causing severe environmental damage.

Due to the above situation, the risk of major epidemic in Addis Ababa city was increasing. With such circumstance, the Master Plan for the Development of Wastewater Facilities for the City of Addis Ababa was formulated in 1993.

The Master Plan consists of structural measures and non-structural measures. The structural measures consist of the improvement of the collection system of domestic sludge, expansion of service area connected to sewerage system, and the improvement/new construction of the treatment plants.

Expansion of service area is to be achieved by the increase of connection to the existing sewerage network and extension of the present sewerage system. These are planned to be achieved by laying pipes of around 1,200 km.

The sewerage system in Addis Ababa does not take into account of rainstorm drainage in urban area at all.

2.5 Flood and Flood Damage

2.5.1 Flooding Mechanism

(1) General

The Study Area is characterized by intensive rainfall in short time and steep riverbed slopes. In addition, the river courses, especially in the middle reaches of the Little Akaki and Bantyiketu including two tributaries of the Kechene and Kurtume, are constricted owing to occupation of buildings and houses. When heavy rainstorm occurs in the upper basins, water level in the middle and lower reaches rises rapidly with a short concentration time of 2 to 3 hours. The floods are considerably flashy with destructive flow velocities. Average duration of high water level is also short within 3 to 6 hours.

In combination with the rainfall characteristics and steep terrain of the basins, the deforestation in the mountain has worsened the conditions due to reduction of water retention in the upper basins.

(2) Flood Characteristics of Objective Rivers

The characteristics of the flooding in the objective rivers are summarized below, based on the site investigation and study results.

1) West Akaki River

This river is relatively wide and deep compared with the other rivers in the Study Area. The land use in the river bank is in proper condition as open area covered with grass land and woodland. The flooding problem is therefore quite small.

2) Little Akaki River

The river in the upstream of the confluence with the Fereja river is of deep valley. Contrary, the river channel in the middle reaches has been constricted due to occupation of buildings, houses and dumping garbage, especially in the reaches from the Mekanisa bridge up to the Ethiopian Abattoir Factory. Accordingly, the middle reaches of the Little Akaki river are subject to habitual flooding with destructive flow velocity.

3) Kebena River

The Kebena river is, as a whole, of wide and deep channel. Not serious flood damage has been reported up to now. However, the lower reaches downstream of the Urael bridge appears to be vulnerable to flooding.

4) Kechene River

The Kechene river in the valley area is also wide and deep. The river channel in the urban areas was originally deep and wide with terrace. However, many houses have constructed on the said terrace and the channel has been further constricted by such houses, walls, soil and garbage dumped. Accordingly, the river bank areas in the lower reaches are subject to flooding with destructive flow velocity directly coming from the mountain areas. Especially, the confluence area with the Bantyiketu river are habitual flooding zone.

5) Kurtume River

The upper basin of the Kurtume is drained by the five small ditches. Their secondary channels are very poor in drainage. Therefore, the upper basin is subject to local flooding due to shortage capacity of secondary and tertiary channels. The lower reaches of the Habte Giyorgis bridge are generally deep and wide, except just downstream of the said bridge which has been constricted to less than 5 meters width due to building. In addition, flow area of the culvert across under the Churchill Avenue is quite small compared with that of the upstream. Accordingly, the riverine areas near the confluence including that of the Kechene river are subject to flooding.

6) Bantyiketu River

The Bantyiketu river is characterized by shallow and narrow compared with its size of basin area including those of the Kechene and Kurtume. Therefore, all reaches of the Bantyiketu river are subject to habitual flooding.

7) Hanku River

Passing through the mountain area, the Hanku river crosses under the Fikre Maryam Aba Techan Street through quite small culvert in size. Due to this reason, flood flows over the street towards downstream. However, it is limited to as local flooding.

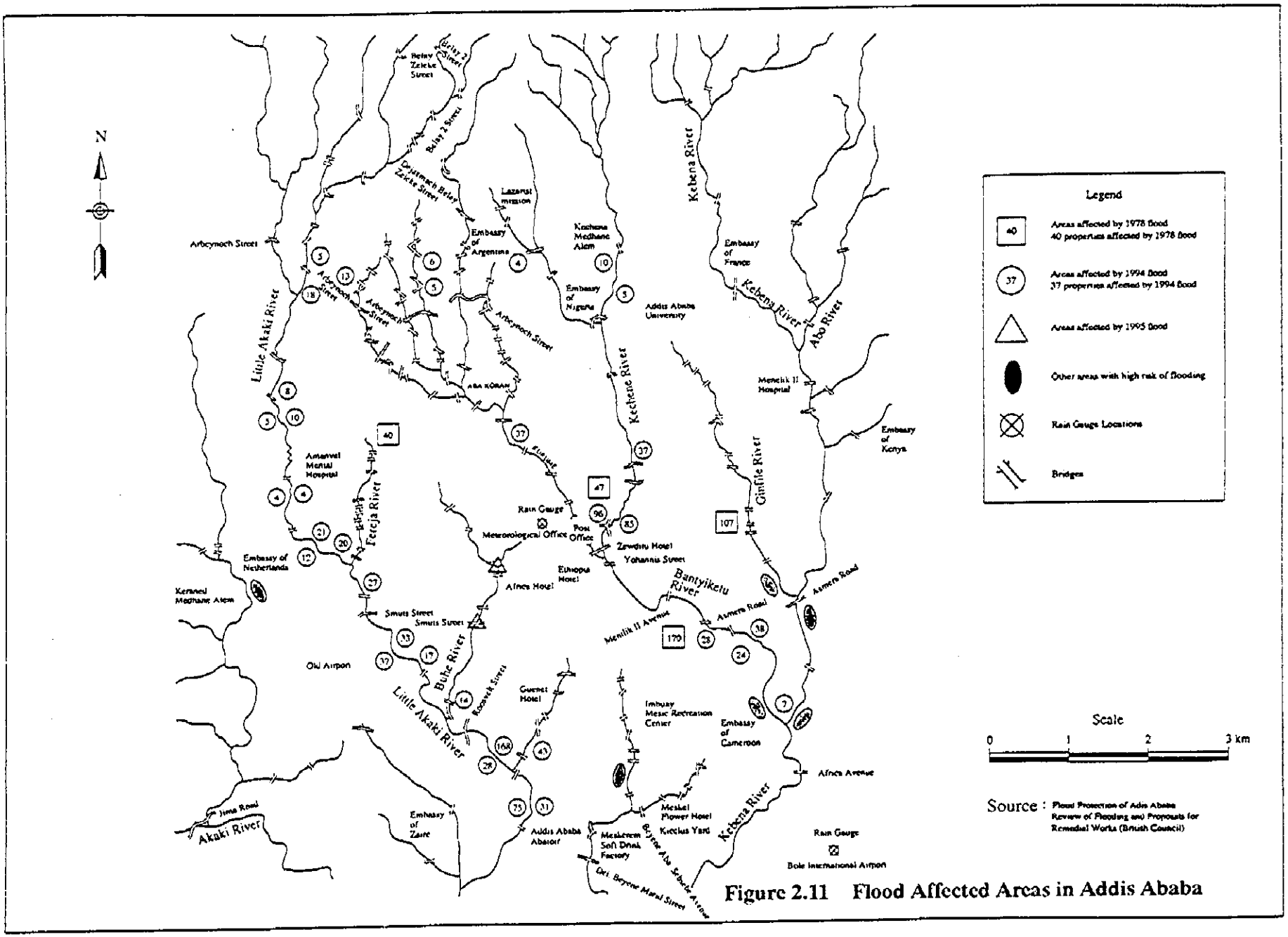
(3) Causes of Flooding

In compliance with the said flood characteristics and present conditions of the river basins, the causes of the flooding in the urban areas of Addis Ababa are summarized below.

a) Deforestation in the mountain areas especially in the eastern basins,
b) Shortage of flood retention areas in the mountain,
c) Shortage of channel capacity of main rivers,
d) Constriction by private facilities such as foundation and wall of buildings, and by illegal cast of solid waste and earth soil,
e) Shortage of flow area under bridges, although those bridges function as flood regulation and velocity control to downstream reaches,
f) Shortage of carrying capacities of the secondary and tertiary canals, and
g) Lack of public awareness to flooding (construction of houses near riverbank and cast of solid waste and soil) is also one of the causes of flooding.

2.5.2 Flood Damages and Areas

Due to natural and social characteristics mentioned above, damages by recurrent floods are inevitable in the urban areas, especially in the flood prone areas along the middle reaches of the Little Akaki and the Bantyiketu rivers including the lower reaches of the Kechene and Kurtume rivers. The urban areas suffered from serious damages in 1978, 1994 and 1995. Affected areas by flood are shown in Figure 2.11.


N
Legend
Areas affected by 1978 flood
40 properties affected by 1978 flood
Areas affected by 1994 flood
37 properties affected by 1994 flood
Areas affected by 1995 flood
Other areas with high risk of flooding
Rain Gauge Locations
Bridges
Scale
0 1 2 3 km
Source : Flood Protection of Adis Ababa Review of Flooding and Proposals for Remedial Works (Britsh Council)
Little Akaki River
Kebena River
Abo River
Kechene River
Ginfile River
Bantyiketu River
Bulbe River
Akaki River
Fereja River
Arbeynoch Street
Embassy of Argentina
Embassy of Nigeria
Embassy of France
Embassy of Kenya
Embassy of Netherlands
Embassy of Cameroon
Embassy of Zaire
Addis Ababa University
Menelik II Hospital
Amanuel Mental Hospital
Meteorological Office
Post Office
Ethiopia Hotel
Africa Hotel
Zewditu Hotel
Yohannis Street
Smuts Street
Menilik II Avenue
Asmera Road
Africa Avenue
Oki Airport
Guenet Hotel
Imbuay Music Recreation Center
Meskel Flower Hotel
Kyoclus Yard
Addis Ababa Abattoir
Meskerem Soft Drink Factory
Rain Gauge
Bole International Airport
Figure 2.11 Flood Affected Areas in Addis Ababa

According to Feasibility Study Report on Flood Protection and Storm Sewer System of Addis Ababa, the flood occurred throughout Addis Ababa; 23 keftegnas out of 25 keftegnas, 108 kebeles out of 289 kebeles. Six thousand people and 1,255 houses were affected by the flood, and most of them were made homeless. Kebele offices, vehicles and community facilities were also damaged. Total damage by the flood was estimated at 2 million Birr. This damage amount is only direct damage to dwellings, and it does not include damages to infrastructure or damages to economic activities (indirect damage). Furthermore, 12 people were killed by the flood.

According to the report of "Conditional Survey and Fundamental Information on Flood Affected Areas in Addis Ababa (September 1994 - October 1995)" by a member of Japan Overseas Cooperation Volunteers, 7,655 people were affected and 2,880 people were made homeless by the flood in August 1994. Three people were killed by the flood. Total direct flood damage has been estimated at 16.4 million Birr. This does not include indirect damage.

Detailed flood damage survey has not been made for August 1995 flood. However, according to the results of the interview survey which was conducted in this study, it seems that considerable number of houses suffered from flood damages.

2.5.3 Previous Studies and Plans

(1) Feasibility Study on Flood Protection and Storm Sewer System of Addis Ababa

The feasibility study was conducted by the Municipality of Addis Ababa with BCEOM in 1982. The proposed plan consists of a priority program and first phase works, respectively for flood protection and storm sewer improvement. However, the first phase works (urgent works) have not been realized yet so far.

According to the feasibility study, the objective rivers of the priority program were the Kechene, Kurtume, Bantyiketu, Little Akaki, and Kebena rivers and the total investment cost for flood control works was estimated at 14.26 million Birr in 1982 price level

The first phase works proposed in the feasibility study was channel improvement of the Bantyiketu river and the total construction cost was estimated at 7.8 million Birr in 1982 price level.

(2) Review of Flooding and Proposal for Remedial Works

The review and proposal were conducted by the Addis Ababa Flood Control and Prevention Project, assisted by the British Council for two weeks from the end of November to the beginning of December in 1994. The recommendations were: to prepare houses for homeless people due to flooding, to give priorities for urgent repair works, to reduce vulnerability by land use control, and others.

(3) Conditional Survey and Fundamental Information on Flood Affected Areas in Addis Ababa

A historically recorded flood occurred in August 1994. Immediately after the flood, a detailed survey was conducted to investigate flood damages, to clarify causes of flooding and to recommend measures for flood protection. The detailed survey was conducted by Mr. Takuji Kono, a member of Japan Overseas Cooperation Volunteers of JICA, in cooperation with AFCPO in Region 14 Administration.

The report of the survey made recommendations for mitigation of flooding damage. These are construction of a regulating pond in the lower reaches of the Filwiha bridge on the Bantyiketu river, construction of a regulating pond in the lower reaches of the Mekanisa bridge on the Little Akaki river, improvement and reconstruction of bridges, and rehabilitation and maintenance of retaining walls.

2.5.4 Completed and Ongoing Works

Several flood prevention works have been completed so far. The works are locally limited to protect houses on the river banks from flooding. Such works were designed by AFCPO and constructed by the selected contractors through competitive bidding. Table 2.15 shows the list of completed works. But, as of June 1997, no further works are planned.

Table 2.15 Completed Flood Control and Prevention Works by AFCPO

Work Item	Location	Completion Date	Work Quantity	Construction Cost (Birr)
Retaining Wall	Little Akaiki River	July 1995	H : 5.75 m L : 327 m	387,000
Retaining Wall	Little Akaiki River	July 1996	H : 5.00 m L : 297 m	359,000
Retaining Wall River Widening	Little Akaiki River	July 1996	H : 5.00 m L : 168 m V : 2,400 m^3	209,000
Retaining Wall	Little Akaiki River	Dec. 1995	H : 5.50 m L : 510 m V : 4,600 m	602,000
Retaining Wall River Diversion	Little Akaiki River	Nov. 1996	H : 5.25 m L : 83 m V : 4,600 m	359,000
Steel Bridge	Little Akaiki River	Aug 1995	W : 5.60 m L : 9.40 m	38,600

Note: H: Height, L: Length, V: Excavation Volume, W: Width

Source: Addis Ababa Flood Control and Prevention Project Office (AFCPO)

2.5.5 Interview Survey for Riverine People

(1) Outline of Survey

Interview survey for riverine people has been carried out to get information regarding their living condition, past flood damages and their opinions on flood control plan. The survey has been conducted for riverine communities in the five river basins which suffered from damages by past floods as shown in Figure 2.12. Random sample survey was conducted on 115 riverine residents in the Study Area.

Results of the interview survey are summarized below. Though the number of samples is limited compared to the number of households in the Study Area, the results of the survey are to be considered as indicative figures representing some average households.

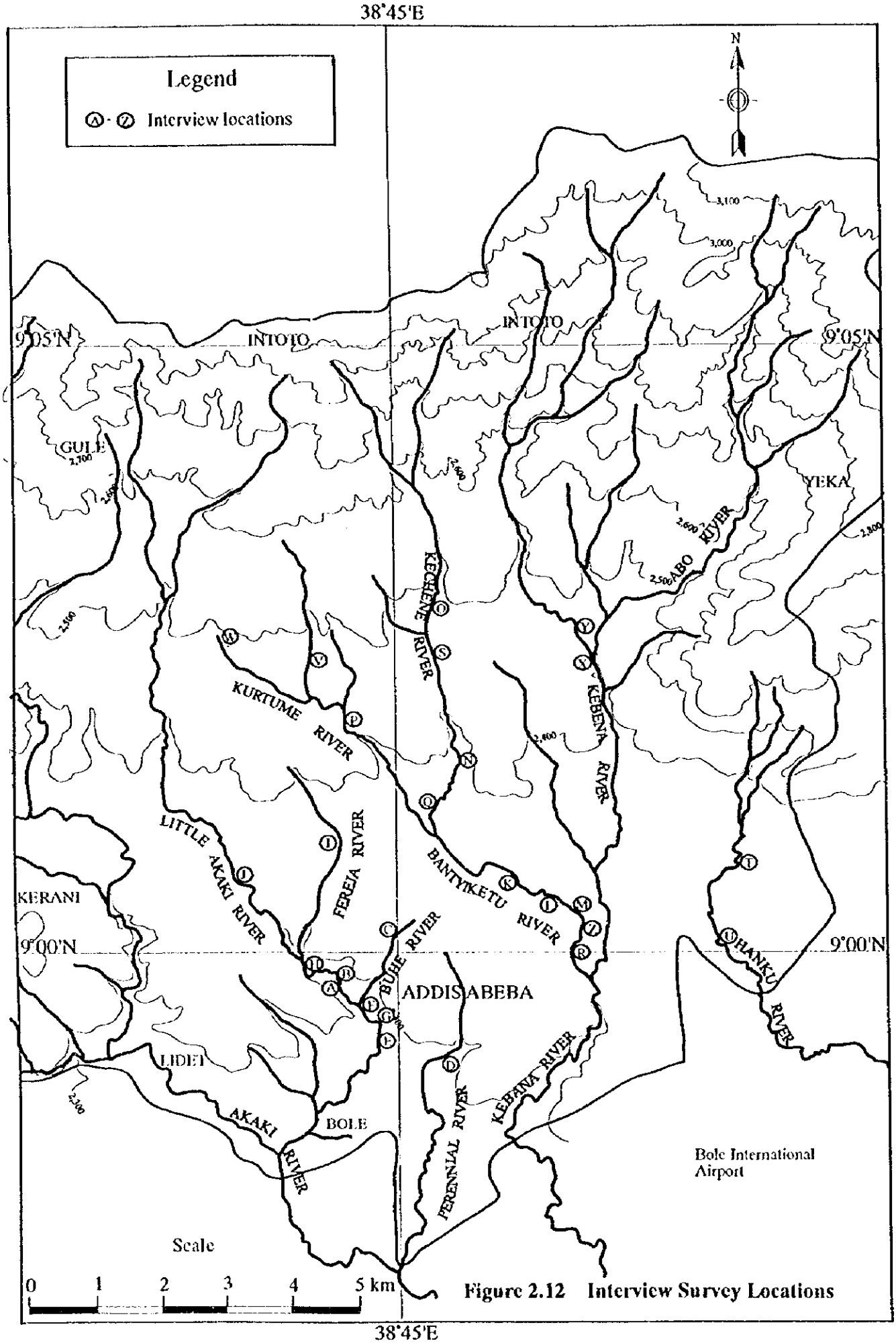


Figure 2.12 Interview Survey Locations

(2) General Information

Average duration of dwelling at the present location is about 19 years. 78% of the households live at their present address for more than 10 years.

Average family size is 7.5 persons and this is more than average family size of 5.5 persons in whole Addis Ababa.

29% of the households answered that the major source of income is pension, while 28% answered employee, 18% answered daily labor and 13% answered merchant.

Distribution of income per households is as presented above. 79% of the interviewed households get monthly income of 300 Birr or less, while 39% of the household get 100 Birr or less. Average monthly income of family is about 250 Birr.

87 % of the households live in a typical local house made by wood and mud plaster locally called "Chika" type house. 6% live in concrete block houses and 4 percent live in brick masonry houses, while 3 % live in temporary shanties.

The average floor area of Chika type house, which is dominant in the Study Area is 44 m^2 and it is almost same as that of the concrete block type house. The brick masonry type house is rather larger than those two types.

Table 2.16 General Information of Interview Survey

1) Duration of dwelling at present location

Duration of dwelling	Percentage
3 years or less	8%
3 - 5 years	5%
6 - 10 years	10%
11 - 20 years	29%
21 - 30 years	39%
More than 30 years	10%
Total	100%

2) Family size

River Basin	Average Family Size (persons)
Little Akaki	8.8
Kurtume and Kechene	6.4
Bantyiketu	6.9
Kebena	6.8
Hanku	6.8
Total	7.5

3) Major source of revenue of family

Occupation	Percentage					
	Little Akaki	Bantyiketu	Kechene & Kurtume	Kebena	Hanku	Total
Pension	41%	32%	12%	30%	17%	29%
Employee	22%	24%	30%	50%	33%	28%
Daily labor	15%	12%	30%	10%	17%	18%
Merchant	7%	20%	15%	0%	33%	13%
Tailor	5%	0%	0%	0%	0%	2%
Guard	0%	0%	6%	0%	0%	2%
Rent	2%	8%	0%	0%	0%	3%
Other	6%	4%	6%	10%	0%	6%
Total	100%	100%	100%	100%	100%	100%

4) Monthly Household Income

Monthly Household Income	Percentage
100 Birr or less	39%
101 - 200 Birr	22%
201 - 300 Birr	18%
301 - 700 Birr	13%
701 - 1,000 Birr	5%
More than 1,000 Birr	3%
Total	100%

5) Type of House

Type of House	Percentage
Temporary type	3%
Chika type	87%
Concrete block type	6%
Brick masonry type	4%
Total	100%

6) Size of House

Type of House	Average Floor Area
Temporary type	22 m^2
Chika type	44 m^2
Concrete block type	44 m^2
Brick masonry type	67 m^2

(3) Flood Damages

With regard to frequency of flood occurrence, the households suffered twice in the past were 36%, once were 17%, three times were 12%, while who answered every year were 23%.

Overflow of river water plus poor local drainage was stated as major causes of flood by 68% of the households. This shows both river improvement and drainage improvement are considered to be the key for solving the flood problem in the Study Area.

Major flood damage was damage to house, household equipment, and clothes. 3% of the respondents answered that their land and corrugate fence were taken away by floods.

Inundation depth varies by landform condition of the residence. 80% of respondents answered that the inundation depth was 1 meter or more.

About 70% of the respondents answered that the flood in August 1995 was most serious. Probably this is because the flood is still fresh in their memories. About 70% of the respondents answered that the flood lasted more than one day. About 40% of the respondents answered that the road traffic near by their house was affected by the flood.

Almost all household interviewed recognized the importance of flood control works, especially construction of retaining walls and improvement of drainage facilities in the riverine community. This means that the flood control facility is poor and not sufficient for their daily life, the needs of urgent improvement for which are dully recognized.

About 61 % of households answered that they will accept resettlement in case it is necessary for flood control works with reasonable compensation. However, about half households in the Little Akaki and Hanku river basins are not willing to accept the resettlement. With the above situation, special attention should be paid for formulation of flood control plan applying measures to mitigate the number of resettlement be minimized.

Table 2.17 Flood Damages

1) Frequency of Flood Occurrence

Frequency of Floods	Percentage
Once in the past	17%
Twice in the past	36%
3 times in the past	12%
4 times in the past	5%
5 times in the past	6%
Almost every year	23%
Total	100%

2) Cause of Flood

Cause of Flood	Percentage
Overflow of river water	30%
Poor local drainage	3%
River water + local drainage	68%
Total	100%

3) Flood Damages

Flood Damages	Percentage
House only	22%
House, household equip., and cloths	75%
Merchandise	1%
Fence and land	3%
Total	100%

4) Flood Condition

Inundation Depth	Percentage
Less than 50 cm	9%
50 - 99 cm	11%
100 - 199 cm	50%
200 - 299 cm	23%
300 cm or more	4%
Not sure	3%
Total	100%

5) Acceptance of Resettlement

Resettlement	Percentage					
	Little Akaki	Bantyiketu	Kechene & Kurtume	Kebena	Hanku	Total
Accept to move	29%	44%	55%	60%	50%	43%
If better place, willing to move	22%	20%	15%	20%	0%	18%
Not accept to move	49%	36%	30%	20%	50%	38%

(4) Community

About 85% of respondents answered that local community is kebele. Existence of smaller community than kebele was not recognized by this interview survey. On the other hand, 17% of the respondents answered no community exists or no idea on community.

Though the interview survey tried to clarify the cooperation system within the communities, almost all respondents explained the assistance made by kebeles during and after flood disaster. Many respondents answered that the kebeles provided shelters, foods and blankets during and after floods.

Almost all respondents answered that any information is transmitted by kebeles.

Almost all respondents answered that any decision making is made through kebele. With the above circumstances, it will be important that kebeles will play a key role to organize flood-fighting system in the communities.

2.5.6 River Survey

The river survey for Phase 1 of this Study was conducted for the period from May to July 1997. The quantity of 450 river cross sections with an average interval of 200 meters was surveyed for the objective rivers in the Study Area. The objective river stretches are shown in Figure 2.13. The total river length surveyed is approximately 70 km.

Leveling survey by the third order was carried out in order to measure an elevation of established benchmarks, cross-section posts and existing structures such as bridges. These heights was tied to reference bench marks or polygonal points which had been surveyed for the Blue Nile Geodetic Control Project and the Mapping Project for urban planning in Addis Ababa.

Measurement of river cross-sections has been carried out at approximate intervals of 200 meters. Supplemental cross-sections at the bridges, other related structures and narrow portions of the respective rivers have been also measured. Method of measuring is either by direct leveling by using the auto-levels with measure staffs or indirect leveling by using the theodolites with measure staffs in accordance with the terrain features at the respective cross-sections.

The survey results were compiled into the following products:

a) Report and Survey Data,
b) Location Maps of River Cross Sections (Scale 1:2,000),
c) Drawings of River Cross Sections (Scale H=1:200, V=1:200), and
d) Drawings of Longitudinal Profiles (Scale H=1:1,000, V=1:20,000).

2.5.7 Installation of Staff Gauge and Water Level Observation

In order to obtain supplement hydrological data for runoff analysis, the three staff gauges were installed by the Study Team. The locations of the installed staff gauges are as follows:

a) Downstream of the Urael bridge in the Kebena river,
b) Downstream of the Filwiha bridge in the Bantyiketu river, and
c) Downstream of the Mekanisa bridge in the Little Akaki river.

The observation of water levels and velocities to check relationship between water level and discharge (H-Q curve) were conducted by the Study Team in cooperation with the counterpart personnel. The observations were made three times at each staff gauge. The observatory dates were July 9, July 16 and July 27 (except Urael bridge measured on July 29), 1997.

The water levels were observed at an interval of 5 minutes considering characteristics of flood concentrating in a few hours. The duration of observation varies from 1 hour or more, depending on flood condition. The flow velocities were stimulatory checked by using float having a total length of 65 cm and 50 cm draft. The flow velocities were checked twice at a time of water level observation.

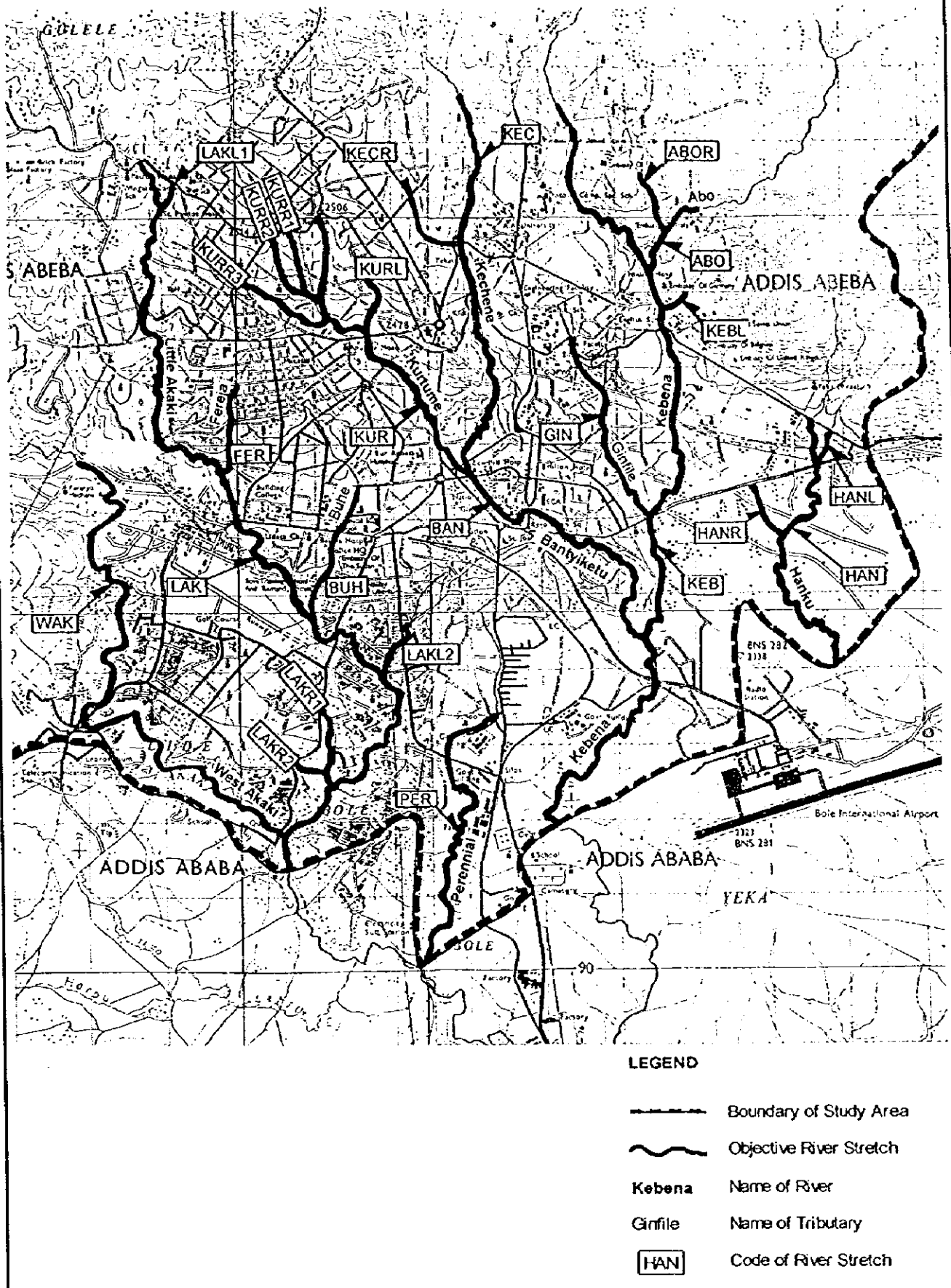


Figure 2.13 Objective River Stretches for River Survey (Phase 1)

2.5.8 Rainfall and Runoff Analysis

(1) Storm Rainfall

Flood in Addis Ababa is subject to very intense rainfall coupled with steep terrain of river basins, which result in rapid rise of river runoff. Heavy rainstorm in the Study Area is generally caused by small atmospheric disturbance bringing local thunderstorms with very high intensity of rainfall.

The rainfall depth, duration and frequency analysis (IDF) is carried out using the rainfall records at Addis Ababa Observatory of NMSA in order to estimate design storm rainfall for flood runoff estimation. In compliance with the depth-duration analysis for the storm rainfall records, the magnitude of flood peak discharge in the rivers in the Study Area is subject to heavy rainstorm with duration of 60 to 120 minutes. In addition, the estimated flood traveling time from uppermost catchment to objective flooding areas is found to be not more than 120 minutes. The duration of design storm rainfall is therefore decided to be 120 minutes. The rainfall depths in 120 minutes duration for different return periods are shown below.

Table 2.18 Storm Rainfall Depth in the Study Area

Return Period (years)	Rainfall Depth in 120 Minutes Duration (mm)
50	85.9
40	83.0
30	79.2
20	73.8
10	64.4
5	54.5
2	39.5

Time distribution of design storm rainfall is established applying the average for percentage of accumulated rainfall depth of the past major rainstorms. Percentage of rainfall depth is obtained by 10 minutes interval as seen in Figure 2.14.

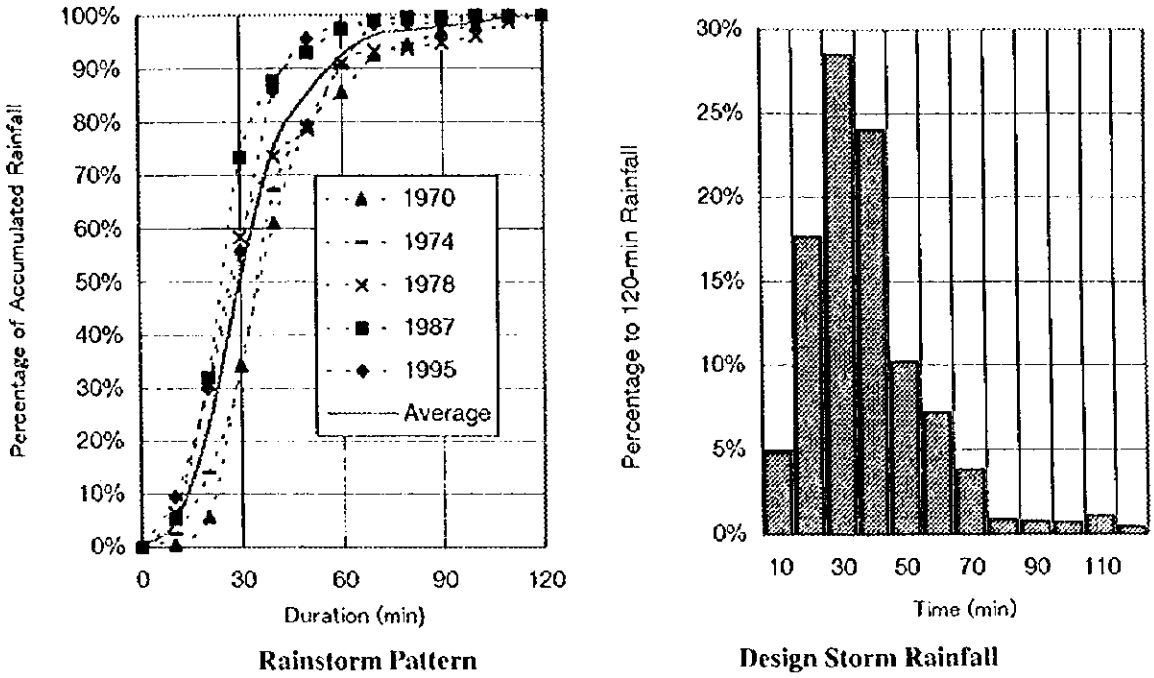


Figure 2.14 Time Distribution of Design Storm Rainfall

(2) Probable Flood Runoff

For the purpose of flood control plan, it is necessary to estimate the magnitude of flood as design value, which is indicated by flood peak discharge and hydrograph. The analysis is therefore carried out for estimation of flood peak discharge as well as flood hydrograph for each objective river. The magnitude of flood is evaluated by runoff calculation on the basis of the design storm rainfall discussed above due to the absence of runoff data in the Study Area. In consideration of the scale and hydrological characteristics of the river basins, the rational formula as given below is applied for runoff calculation.

$$Q = 1/3.6\ C\ I\ A$$

where,

Q : *peak discharge* (m^3/sec)

C : *runoff rate*

I : *rainfall intensity* ($mm/hour$)

A : *catchment area* (km^2)

Flood runoff hydrograph is obtained by the rational formula in combination with triangular unit hydrograph. The estimated flood peak discharges are presented below.

Table 2.19 **Probable Flood Peak Discharge**

River System	Catchment Area (km^2)	Flood Peak Discharge (m^3/sec)				
		2-year	5-year	10-year	20-year	30-year
Bantyiketu						
Bantyiketu River	29.3	120	160	190	215	230
Kechene River	13.6	65	90	105	120	130
Kurtume River	10.3	50	70	85	95	100
Kebena	54.8	200	280	320	370	400
Little Akaki	30.8	110	145	170	195	215
West Akaki	172.2	280	380	450	510	550
Hanku	11.1	50	65	75	90	95

2.5.9 Sediment

Major rivers in the Study Area indicate steep riverbed gradient and their river beds are generally composed of volcanic rocks. Colluvial of alluvial fans can not be observed according to site investigation and geological maps. Small volume of alluvial materials can be observed at the gorges of the valleys and in the lower reaches of the Little Akaki, Kebena and Bantyiketu rivers where the topography changes to relatively flat one. The alluvial materials consist of silly clay and clayey silt.

With the limited data presently available, suspended load estimated at the proposed Gerbi dam, which is planned in the northern part of Addis Ababa.

According to the HYDROLOGY OF GERBI DAM, DRAFT FINAL REPORT in Addis Ababa Water Supply Project- Stage IIIA by AAWSA, January 1997, average annual suspended load is estimated at 60.9 ton/km^2/year or 36.9 m^3/km^2/year. This means that land erosion is 0.004 cm in thickness per year and is quite small. On the other hand, the river banks are composed of and covered mainly by clayey silt with sand. Some river banks slightly eroded by flow are observed. In this regard, it seems that the river bank materials are the dominant sources of the sediment mainly as suspended load to lower reaches.

Sediment materials sampled at river terrace, downstream of the Bole bridge in the Kebena river are very fine. Therefore, such materials are easily transported to the lower reaches by flood. Accordingly, it seems that river bed fluctuations of these rivers are rather negligible and an attention must be paid to bank erosion.

2.5.10 Flooding Analysis

(1) Present Carrying Capacity

Present carrying capacity of the objective rivers is evaluated by hydraulic analysis using the results of the river cross section survey conducted from May to July 1997. The survey results are compiled into longitudinal profile, river width diagram and carrying capacity diagram as seen in Figure 2.15 to 2.21. From these figures, the channel characteristics of the rivers are summarized as follows.

Table 2.20 River Channel Characteristics

River	Average Slope	Channel Width(m)		Carrying Capacity (m^3/sec)
		Minimum	Average	
West Akaki	1/100	15	40	400 - 800
Little Akaki	1/50	5	20	50 - 300
Kebena	1/50	5	25	150 - 800
Kechene	1/30	8	15	50 - 250
Kurtume	1/35	8	10	30 - 150
Bantyiketu	1/120	10	20	30 - 150
Hanku	1/60	5	10	20 - 150

From the carrying capacity diagrams, major problematic areas due to flooding are identified.

In the Bantyiketu, the cross sections around the distance of 0.8 km, 2.3 km and 3.6 km from the Kebena confluence show quite low carrying capacity less than 50 m^3/sec. Almost 50% length of the surveyed stretch has carrying capacity less than 150 m^3/sec or probable 5-year flood.

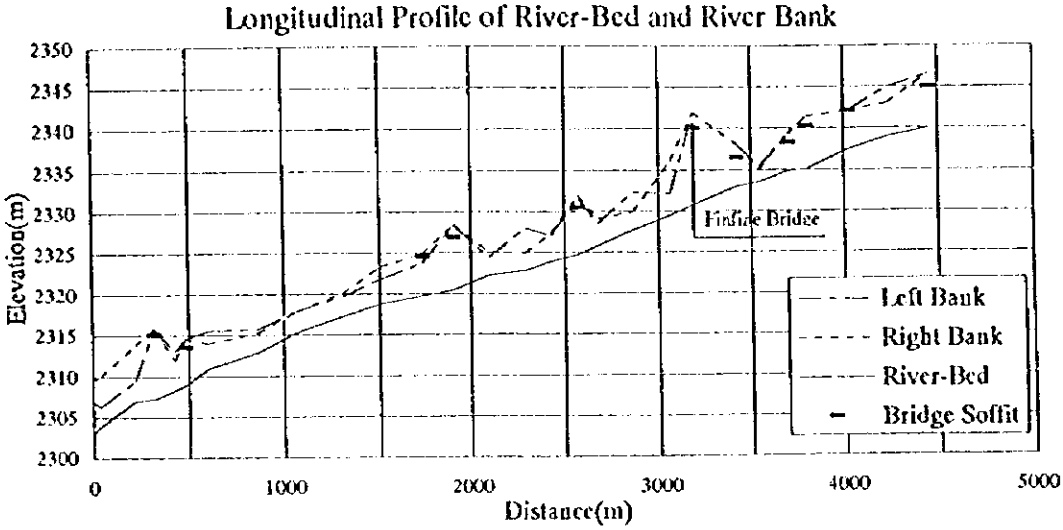
The Kechene and the Kurtume show sufficient carrying capacity for probable 10-year flood in general but the cross sections with lower carrying capacity exist at a few locations.

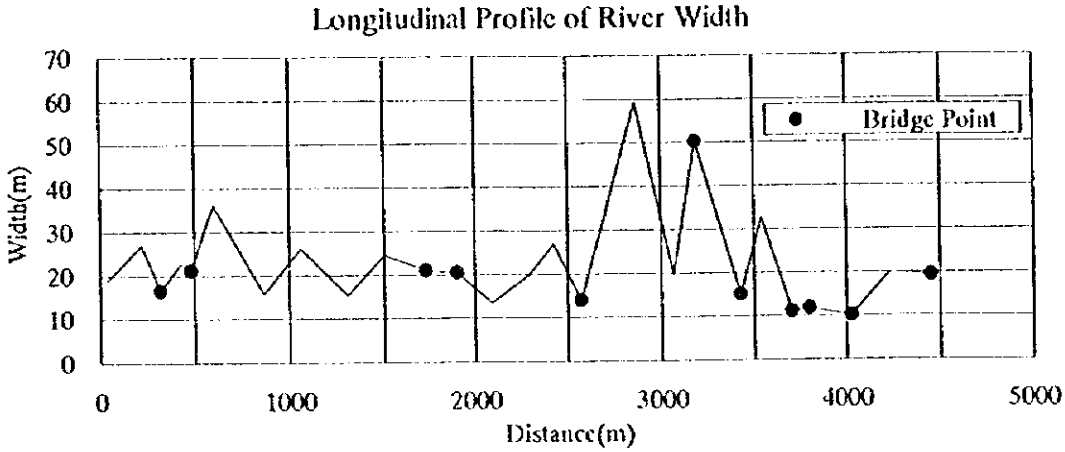
The stretch of the Little Akaki in the distance between 3 km and 9 km from the West Akaki confluence has a several number of cross sections with low carrying capacity ranging from 40 to 100 m^3/sec, which is less than probable 2-year flood.

The middle reaches of the Kebena in the distance between 4 and 7 km from the boundary of the Study Area, shows the minimum carrying capacity of 120 m^3/sec. The most of this stretch has carrying capacity less than 300 m^3/sec or probable 7-year flood.

The stretch of the Hanku in the distance between 1.5 km and 2.5 km from the southern boundary of the Study Area indicates quite low carrying capacity of 20 m^3/sec or less. This stretch is a part of the natural retarding basin expanding over the lower reaches. Low carrying capacity is also seen around the distance of 4 km where the small culvert exists.

The West Akaki indicates sufficient carrying capacity against 500 m^3/sec or probable 20-year flood in the most of the surveyed reaches.





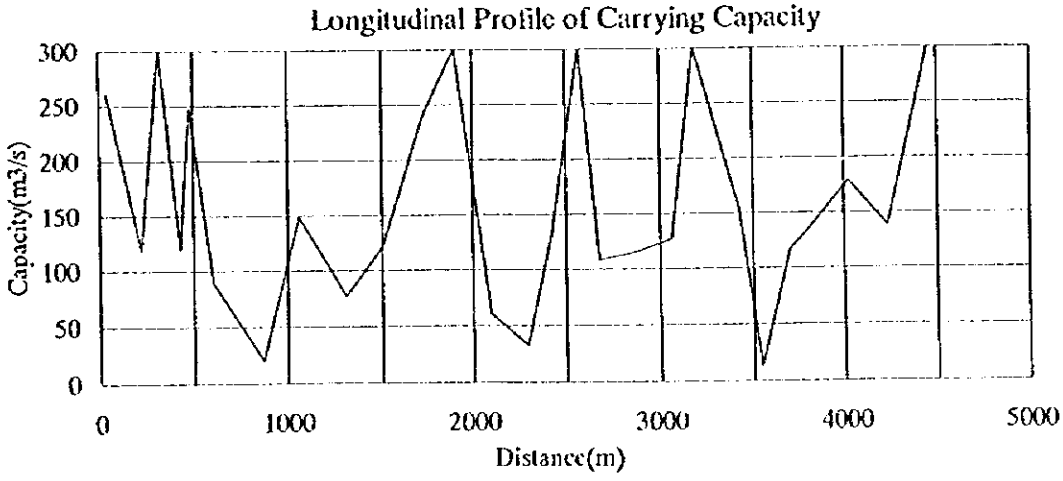
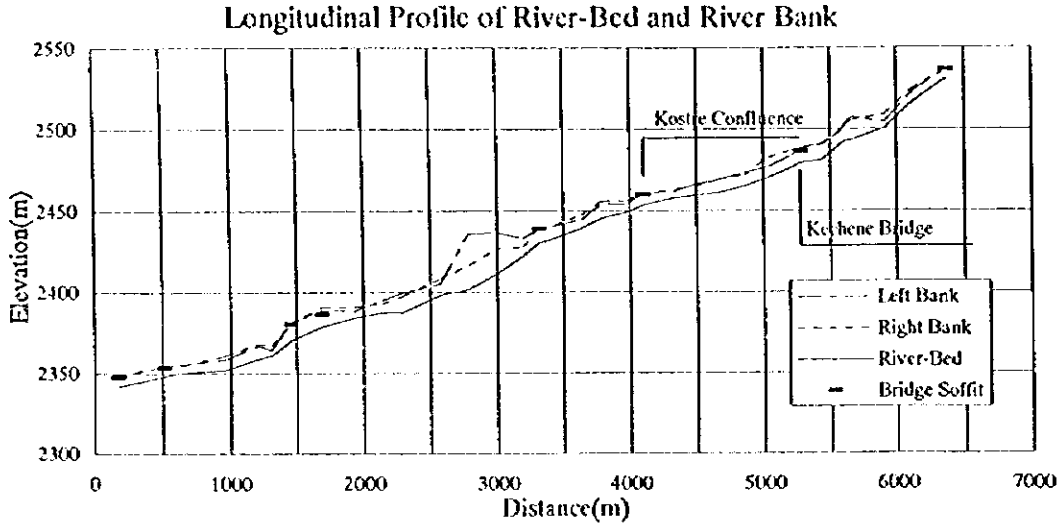
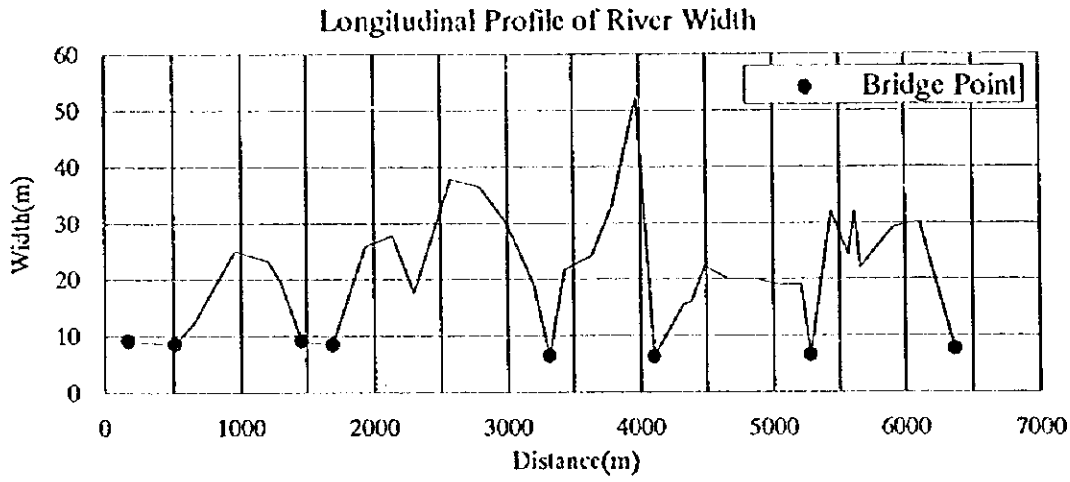


Figure 2.15 Longitudinal Profile of Bantyiketu River





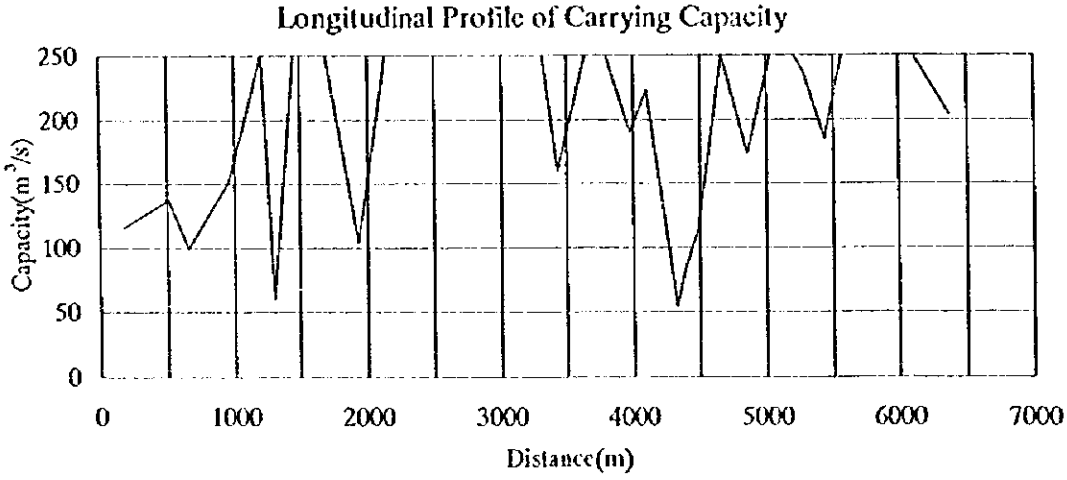
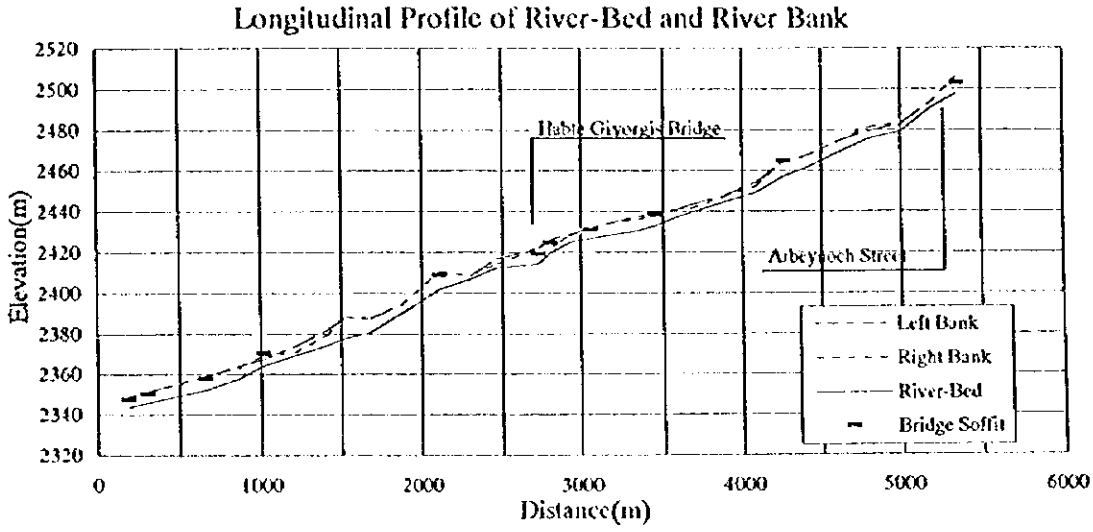
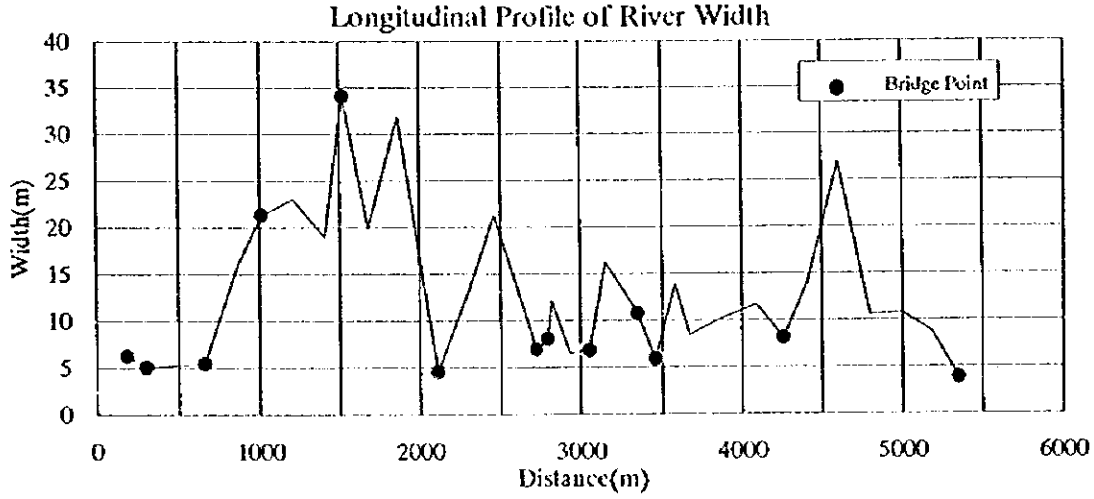


Figure 2.16 Longitudinal Profile of Kechene River





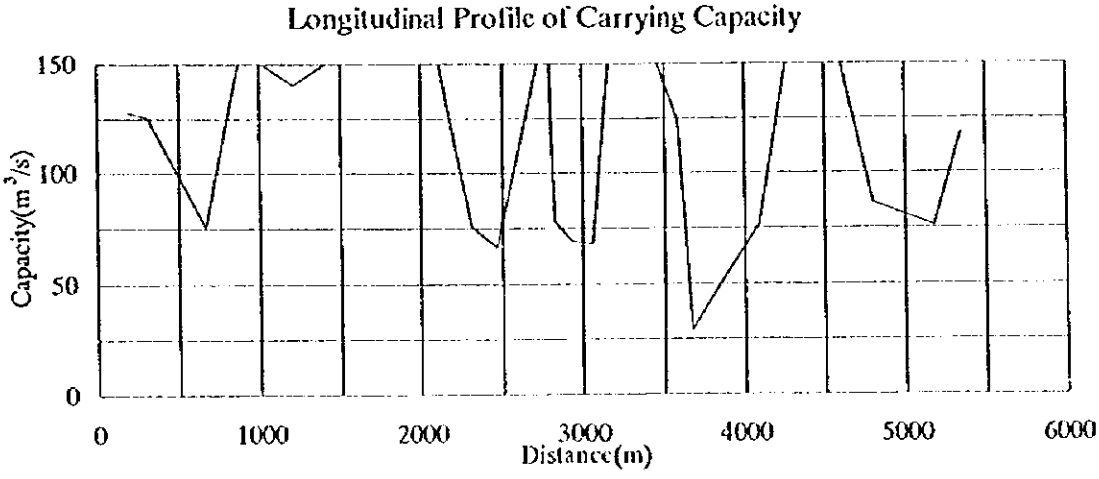
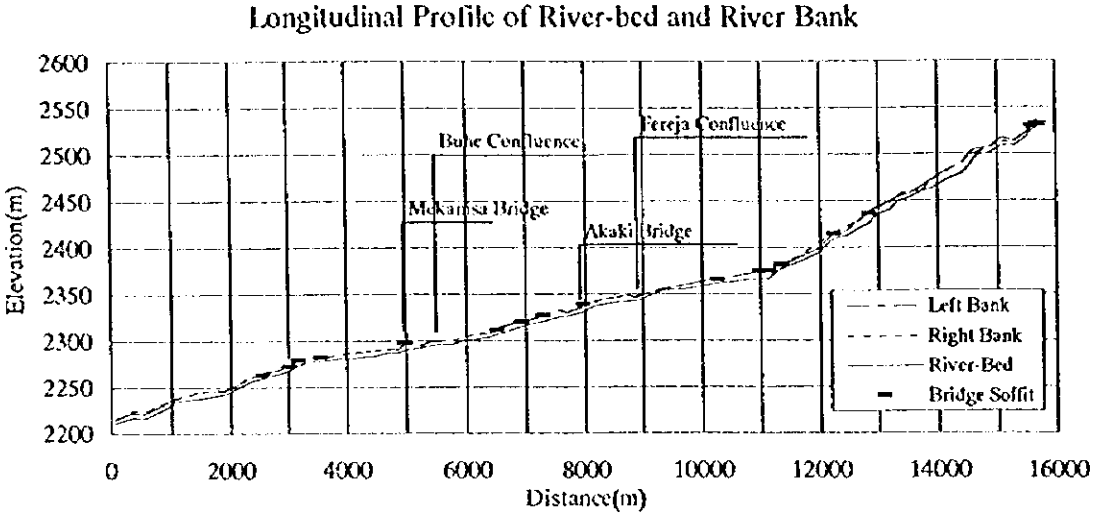
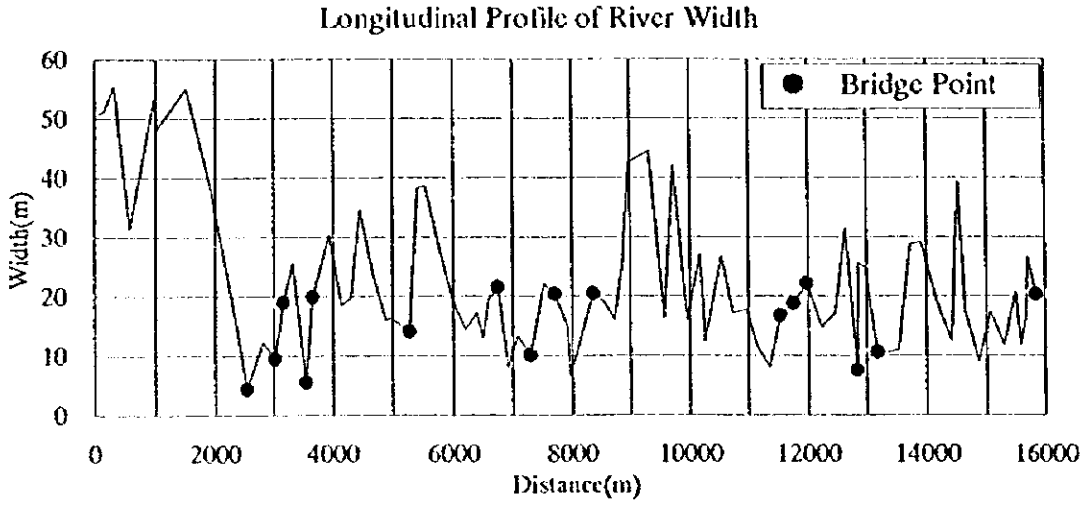


Figure 2.17 Longitudinal Profile of Kurtume River





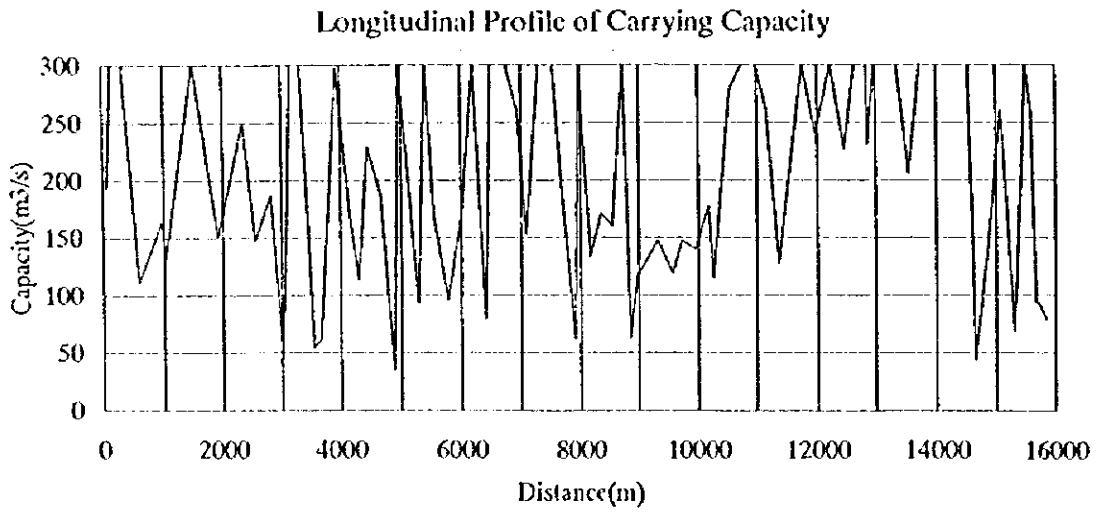


Figure 2.18 Longitudinal Profile of Little Akaki River

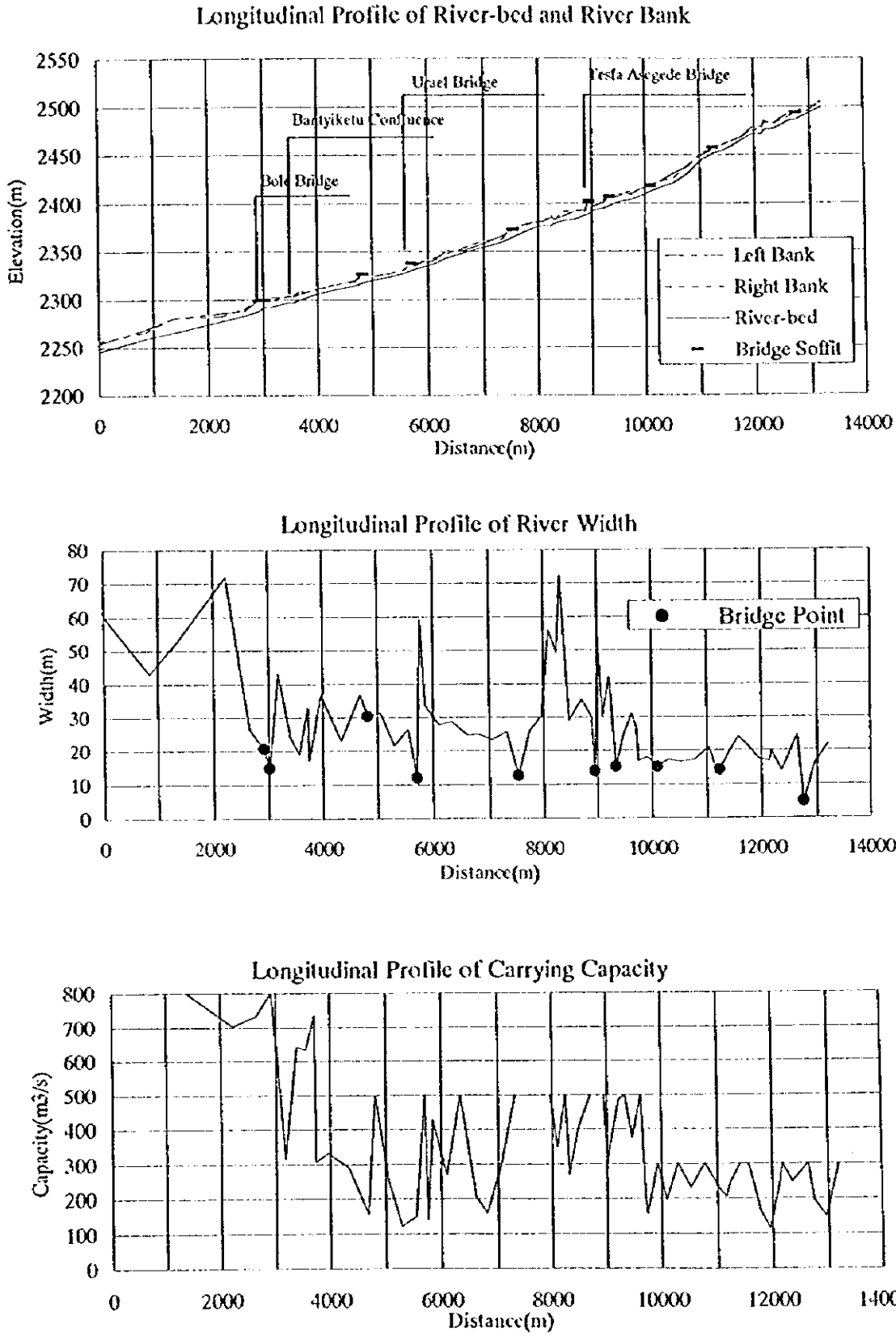
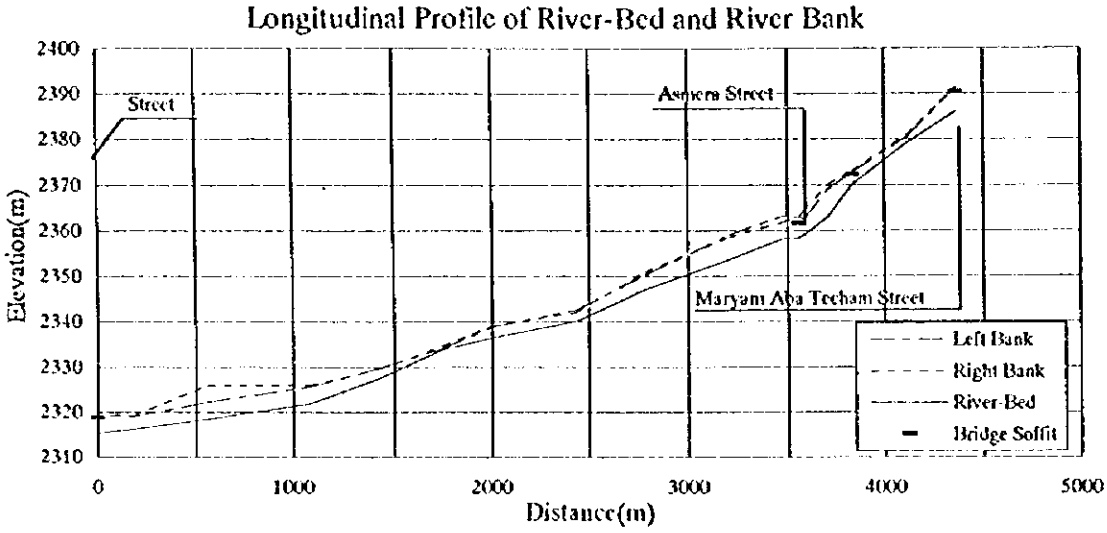
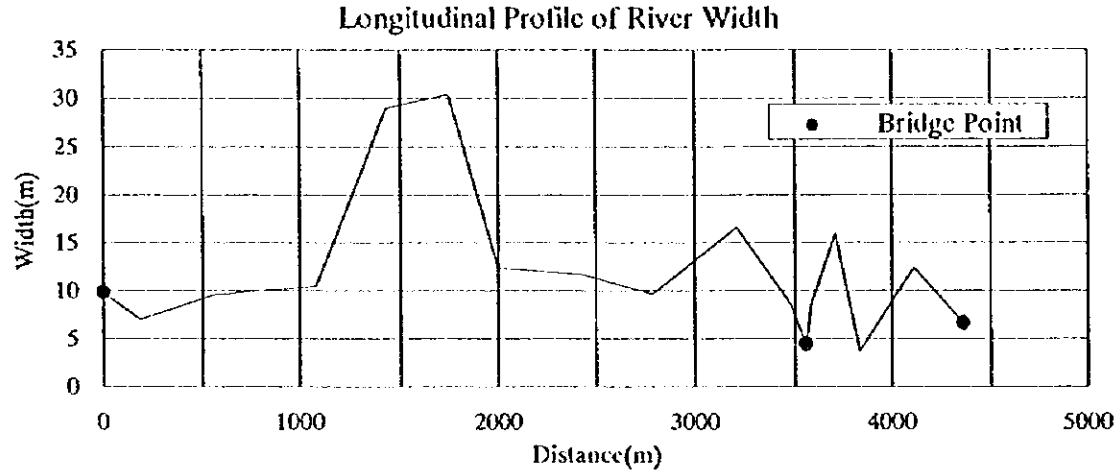


Figure 2.19 Longitudinal Profile of Kebena River





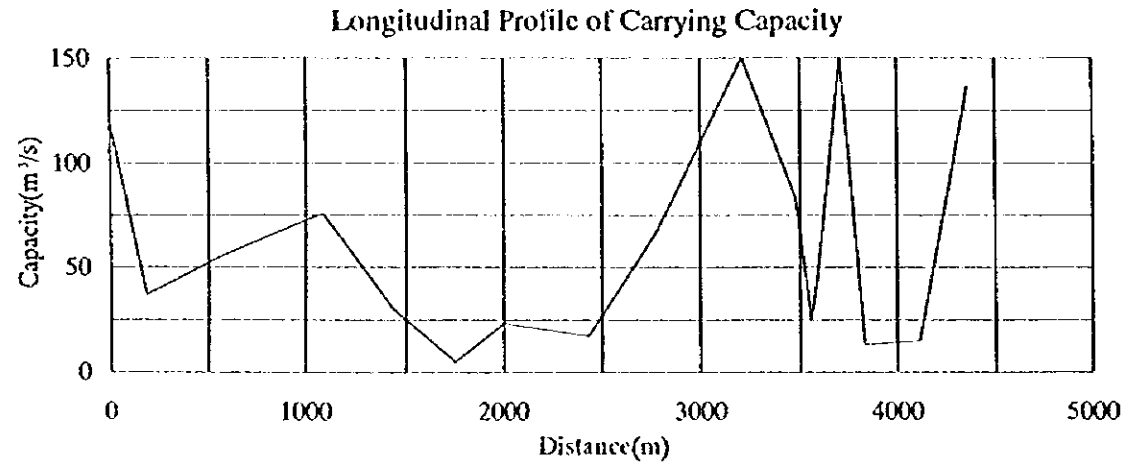
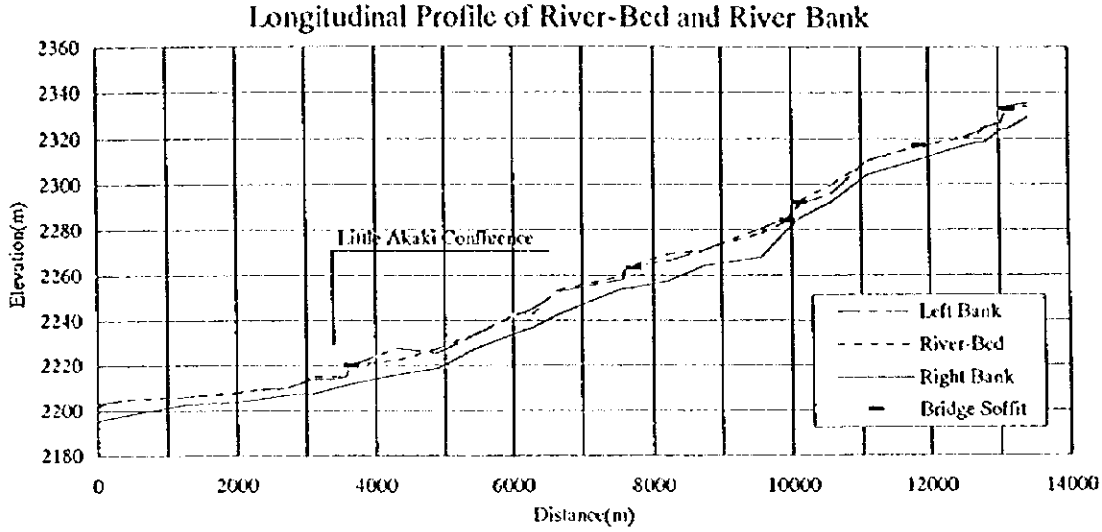
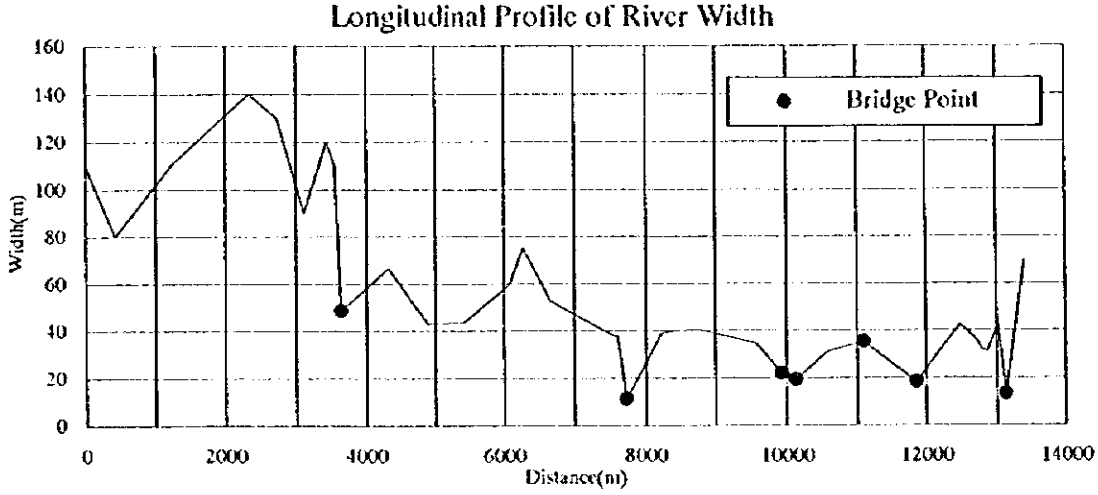


Figure 2.20 Longitudinal Profile of Hanku River





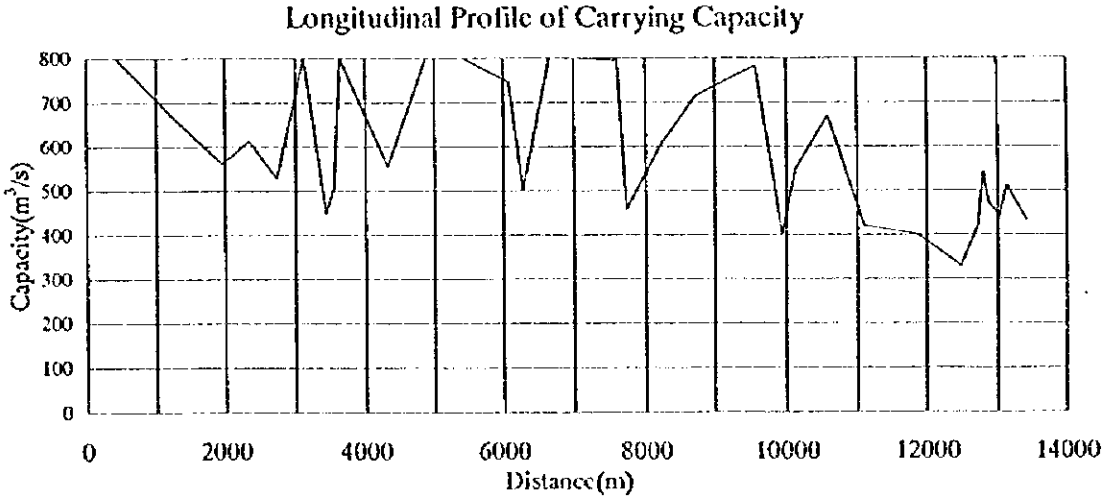


Figure 2.21 Longitudinal Profile of West Akaki River

(2) Flooding Area

For the purpose to evaluate potential flood damage, flooding area due to probable flood is estimated in compliance with review of existing damage reports of 1978, 1994 and 1995 flood events, interview survey for riverine people and hydraulic analysis.

Extent of estimated flooding areas generally corresponds with the river stretches with low carrying capacity as described above. The results of flooding analysis are compiled into the relationship between flooding area and the magnitude of flood. The summary of flooding analysis is tabulated below.

Table 2.21 Flooding Area (Unit: ha)

River System	Return Period (years)			
	5	10	20	30
Bantyiketu	36	43	56	66
Kebena	7	10	17	21
Little Akaki	16	21	30	36
Hanku	4	14	27	30

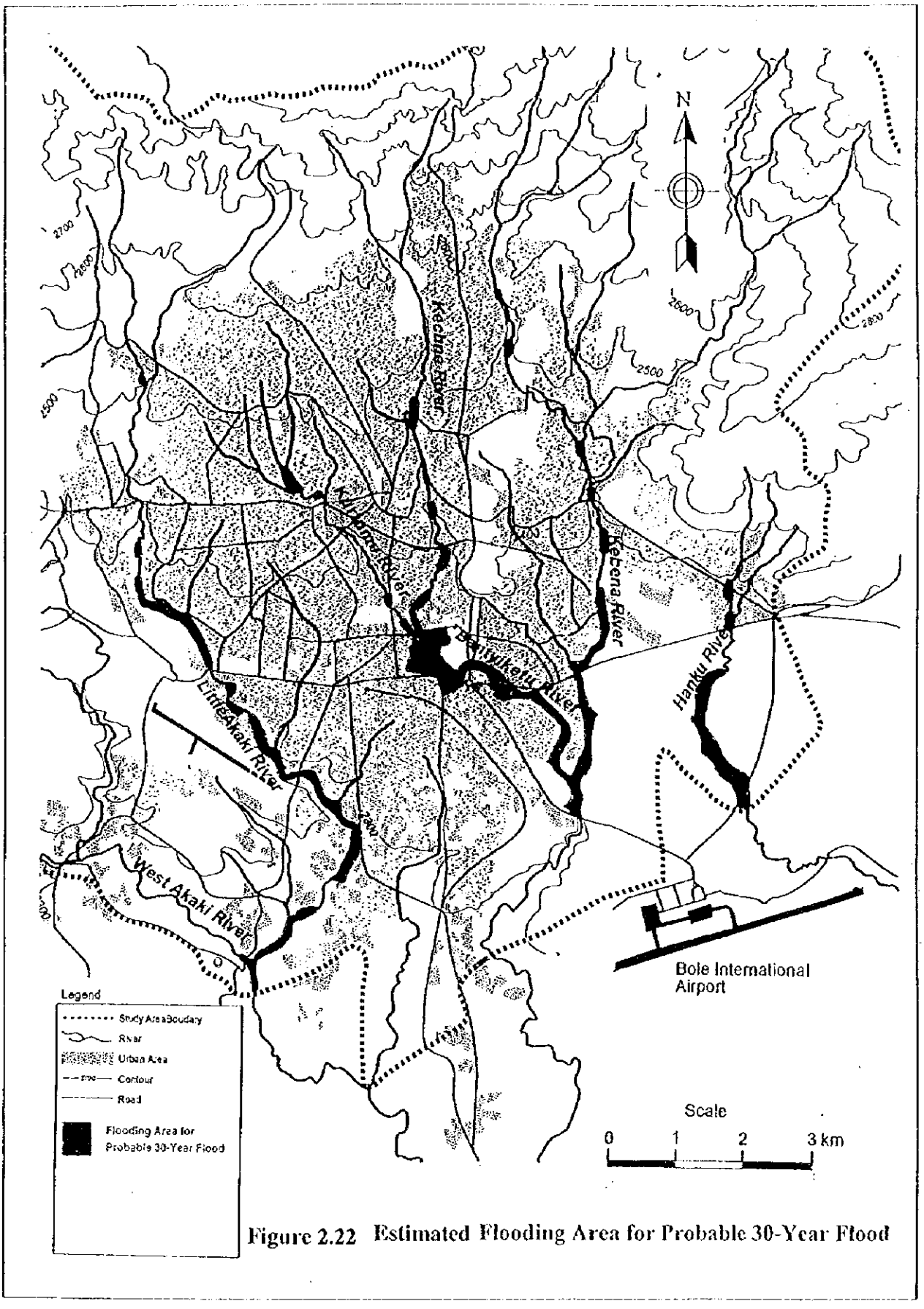


Figure 2.22 Estimated Flooding Area for Probable 30-Year Flood

2.6 River Management Issues

2.6.1 Disaster Prevention and Management

Ethiopia has been frequently threatened by disasters induced by drought, flood and other causes. The Federal Government, to warn in advance to the questioned areas and provide relief assistance to the affected people, has established a national disaster prevention and management policy. In emergency case of serious flooding, such warning and relief assistance will be, in this regard, applicable to the questioned riverine areas. A conceptual organization chart of the national disaster prevention and management is shown in Figure 2.23.

The national disaster prevention and management are being administrated by the National Disaster Prevention and Preparedness Committee (NDPPC) and its secretariat committee of the National Committee for Early Warning (NCEW) in the national level. Figure 2.24 shows those organizations

The regional level is being administrated and controlled by the Regional Disaster Prevention and Preparedness Committee (RDPPC), which is supported by the International Relation and Development Cooperation Bureau of the Social Sector of the Region 14 Administration.

The wereda level is being controlled by the Wereda Disaster Prevention and Preparedness Committee (WDPPC) supported by the Wereda Disaster Relief Cell (WRDC). WRDC acts as an actual implementing body for the relief action. Various non-government organizations (NGO) will be also expected to involve, depending on condition of the disasters.

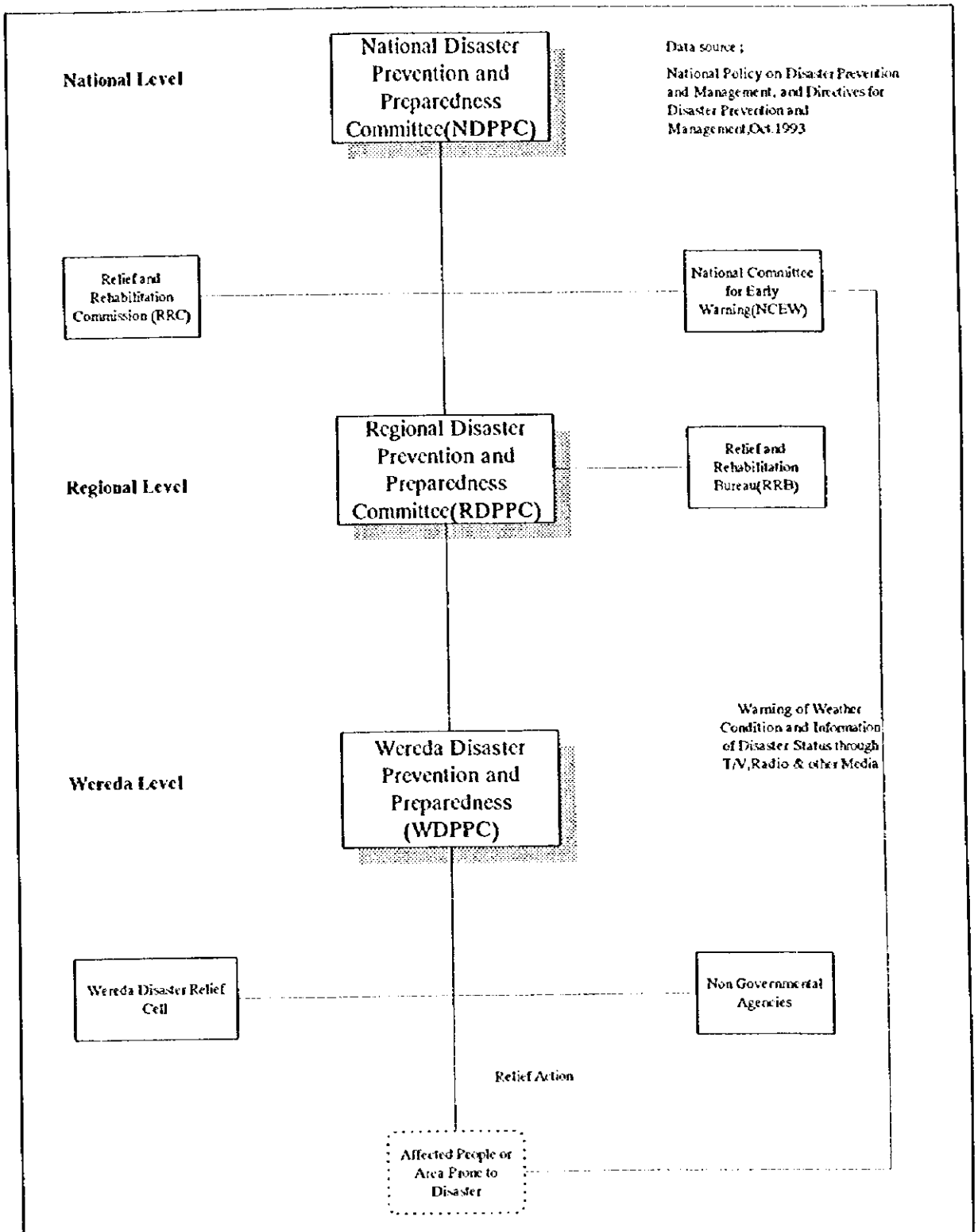


Figure 2.23 Organization Chart of Disaster Prevention and Preparedness Management

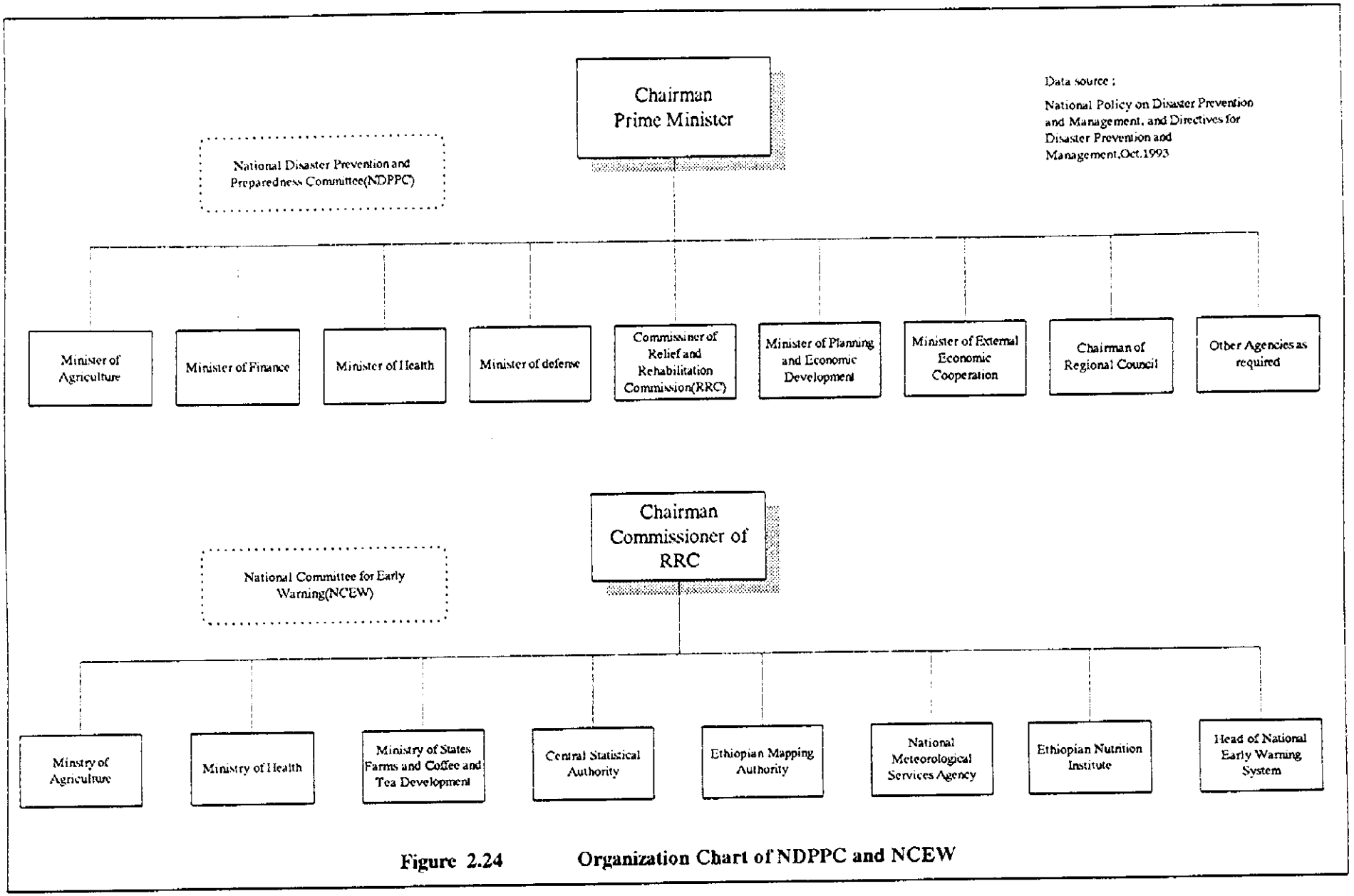


Figure 2.24 Organization Chart of NDPPC and NCEW

2.6.2 Addis Ababa Flood Control and Prevention Project Office

After the serious flooding in August 1994, the Region 14 Administration established the Addis Ababa Flood Control and Prevention Project Office (AFCPO) in September 1994. AFCPO was organized in line with a development policy of the national disaster prevention and management for the target year of 2020. AFCPO belonging to the Economic Sector of the Region 14 Administration, is being directly administrated and controlled by the Steering Committee of the Addis Ababa Flood Control and Prevention Project. The Steering Committee is governed by the President (Mayor) of the Region 14 Administration. Figure 2.25 shows the present organization chart of AFCPO.

AFCPO is responsible for implementation of urgent flood control measures, and investigation and implementation of long term measures to protect the city of Addis Ababa from flooding, and to resettle people who are living in dangerous areas due to flooding. At present, AFCPO principally provides studies, designs and tender documents for its projects. Land acquisition and compensation required for the construction works are proceeded in cooperation with the Works and Urban Development Bureau of the Economic Sector in the Region 14 Administration.

However, the organization of AFCPO has not been fully setup. Therefore, it is still under organization and insufficient even for daily activities. The activities of AFCPO have been limited to design and supervision of local works since its establishment in 1994, due to the absence of authorized flood control plan.

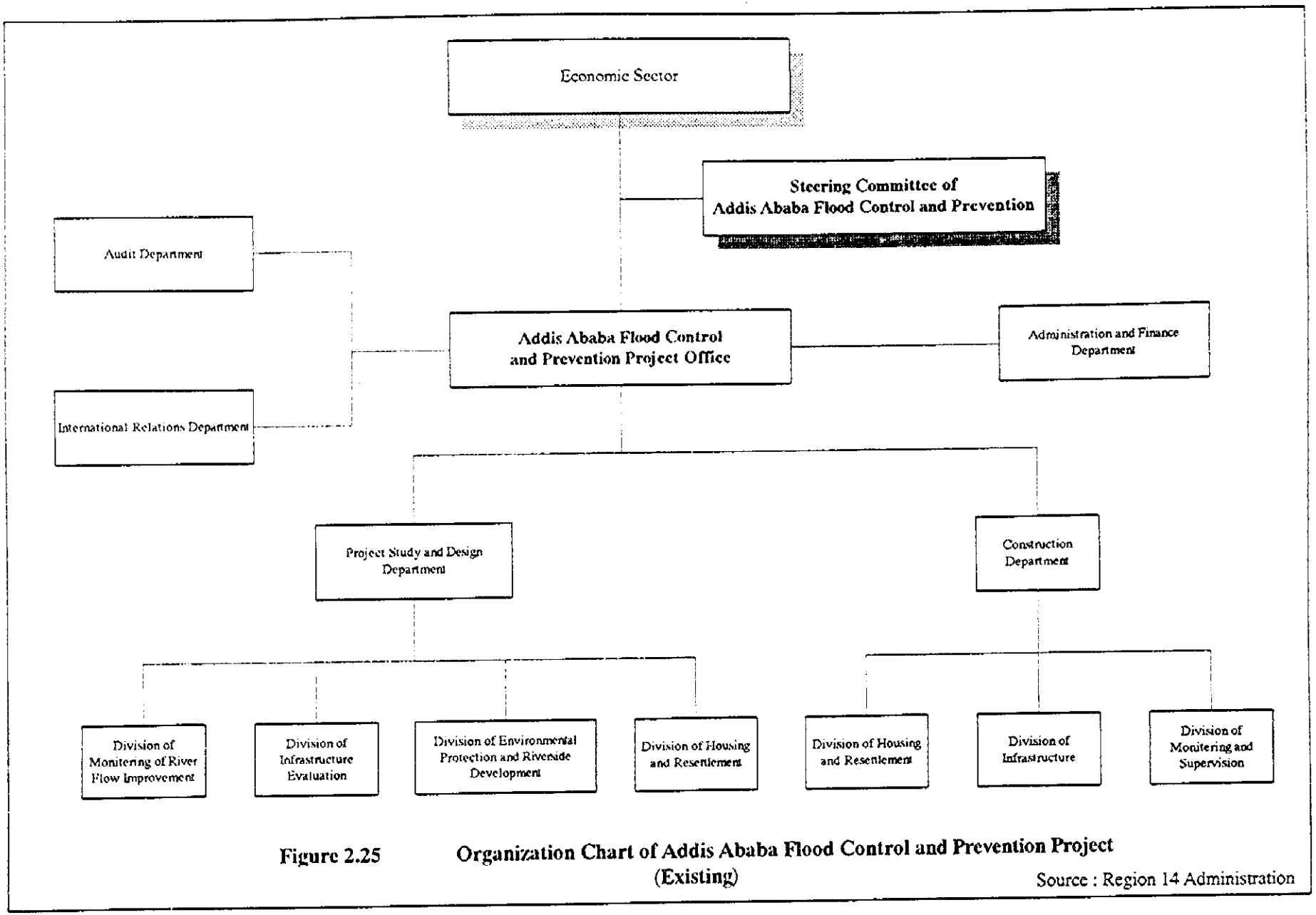


Figure 2.25 **Organization Chart of Addis Ababa Flood Control and Prevention Project (Existing)**

Source : Region 14 Administration

2.6.3 Flood Forecasting and Warning

There has been no flood forecasting and warning system established in the Study Area.

The run-off basins of the Kebena including the tributaries of the Kechene, Kurtume and the Little Akaki rivers, are located so close to the urban area of Addis Ababa. The Intoto ridge as the boundary of those basins to the north is located at only about a few kilometers from the northern boundary of the urban area especially for the basins of the Kurtume and the Little Akaki. Besides the average slope of these basins toward the urban area is only about 1/10 – 1/20. Due to these topographical conditions, the run-off of rainstorm in these basins to the city area is very rapid only within a few hours.

Velocity of the flood flow is so high due to the very steep slope even in the city area. In view of such hydrological situations, a flood forecasting system depending on runoff simulation or water level correlation may not be applicable in the basins. Whereas, a flood warning system on the basis of rainfall observed by automatic recorder, seems to be applicable and needed very much since flood flow is very destructive and there still exist so many houses vulnerable to flood flow with high speed along the rivers.

2.6.4 Reforestation

Reforestation activities in the Study Area on the mountain slope of the Intoto are presently conducted independently by three agencies: 1) Addis Ababa Fuel Wood Development and Marketing Organization, 2) Bureau of Agriculture of Region 14 Administration, 3) Ethiopian Heritage Trust and other agencies.

The main objective of the reforestation by the Enterprise of Addis Ababa Fuel Wood Development and Marketing Organization is to supply fuel wood and construction material for Addis Ababa. Accordingly the planting species is limited to eucalyptus. The objective area is some 5,000 hectare and the location is mainly along the Intoto ridge.

The present reforestation activity by the Bureau of Agriculture of the Region 14 Administration was started three years ago. The agency has 5-year program of reforestation. The objective area is also located on the slopes of the Intoto. The objectives of the activity are for 1) soil conservation, 2) supply of fuel wood and

construction material for Addis Ababa, and 3) supply of seeds of eucalyptus for local people to plant them around their settlements.

The objective area of the activity by Ethiopian Heritage Trust and other agencies is some 1,300 hectare. The details of their program are now under the process of formulation. The activities include construction of small check dams, replacing the eucalyptus tree species with indigenous species of vegetation. The aims of the activities include; 1) to bring back to the area the native trees, shrubs, flowers, birds, and animals that used to be found on Intoto, 2) to help preventing soil erosion and flooding.

2.7 Construction and Procurement

2.7.1 Procurement of Construction Works

Public construction works are executed by both methods of direct operation and contract basis under the control of Region 14 administration. The method is selected case by case depending on the kind, scale and specialty of work.

The Addis Ababa Road Authority carries out the maintenance works of the regional roads in Addis Ababa in direct operation. The large-scale project works, which are undertaken by the authorities and offices other than the Addis Ababa Road Authority, are usually executed on contract basis.

Owners estimate of public construction works is prepared based on the norm, which was authorized by the Ethiopian Building Construction Authority in 1980's.

2.7.2 Labor

As mentioned in the section of socio-economics, there are abundant labors looking for job opportunity in Addis Ababa. Enough number and types of skilled and common workers are expected to be employed for the project construction works. Interview survey reveals that net wage of a daily common worker is Birr 8 for temporary employment in Addis Ababa.

2.7.3 Construction Materials

Sand, gravel and stone materials can be procured from the domestic resources within a range of 160 km at Addis Ababa. Cement, brick, galvanized iron pipe and PVC pipe are purchased from domestic manufacturers. Ready mixed concrete is also produced and sold by a domestic manufacturer at the Akaki Industrial Estate.

Other materials, such as reinforcing bar, steel materials, iron wire, asphalt and fuel are usually imported from other countries of Italy, Egypt and Turkey, etc.

2.7.4 Construction Equipment

Almost all the construction equipment is imported. Some larger private construction companies and some governmental offices and authorities have such equipment. In

the Region 14 administration, the Addis Ababa Road Authority has the construction equipment such as bulldozer, backhoe, loader, motor grader, dump truck, lorry, roller and compactor, water tanker, asphalt related equipment, pick-up, portable pump, air compressor, generator and so on.

No manufacture of construction equipment is available. There is no such market that some local or international rental agents of heavy equipment are competing among them in Addis Ababa. Only import agents of equipment and spare parts are available.

CHAPTER 3 MASTER PLAN

3.1 Framework

3.1.1 Target Year and Protection Area

The target year for the master plan is set at the year 2020. Protection area is the present densely populated area and under-developing area in the eastern part of the Study Area. Whereas, for new urban areas to be extended in the future, land use regulation in line with the Addis Ababa Master Plan, is recommended to avoid flooding problem which will be newly involved.

3.1.2 Objective River Systems

The following seven rivers in the five major river systems are the objective rivers for flood control master plan.

Table 3.1 River Systems in the Study Area

River System	Catchment Area (km^2)
1. Bantyiketu River System	29.3
Kechene River	
Kurtume River	
Bantyiketu River	
2. Kebena River System	59.8
Kebena River	
3. West Akaki River System	172.2
West Akaki River	
4. Little Akaki River System	30.8
Little Akaki River	
5. Hanku River System	11.1
Hanku River	
6. Other	6.5
Total	309.7

The total catchment area (the Study Area) is 310 km^2 covering the central and eastern part of Addis Ababa Administration and the western part of Oromia region. The catchment area covered with the urban area is around 168 km^2 as of 1997.

3.1.3 Population Projection

(1) Population Projection in Addis Ababa

The Study Area covers most area of Addis Ababa municipality as of 1984 and some part of the rural area of Oromia region. The Addis Ababa Master Plan covers some part of the Study Area and some part outside of the Study Area. The area of Addis Ababa municipality was greatly expanded in 1991 from the area in 1984. The locations of these areas are shown in Figure 3.1 to make clear the discussion hereunder about population projection.

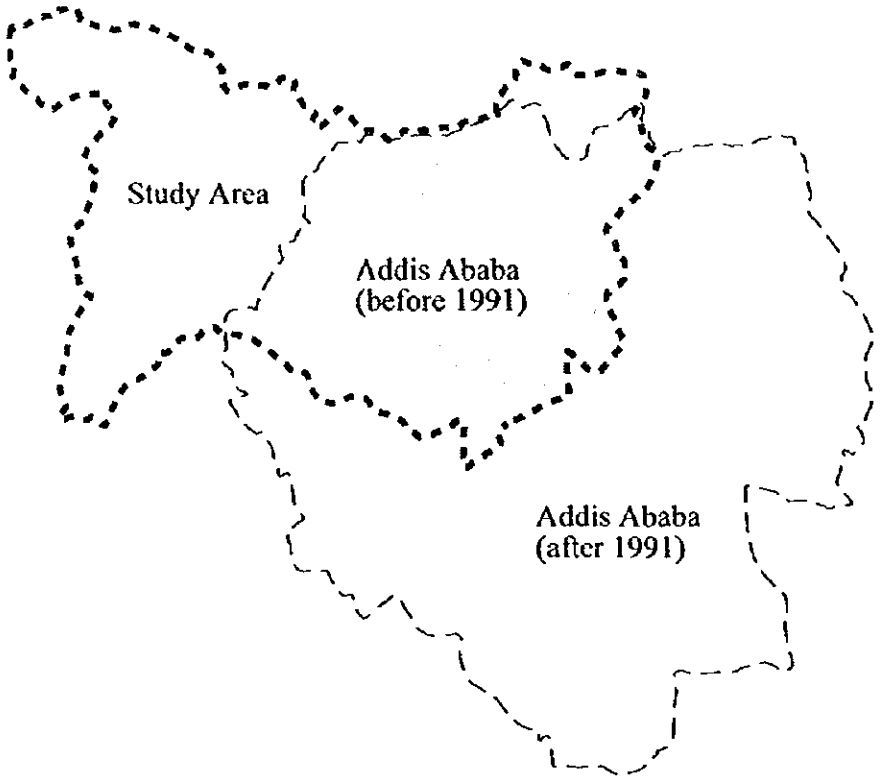


Figure 3.1 Area of Addis Ababa

The national population census was conducted in 1978, 1984 and 1994 in the past. According to the census, the population of Addis Ababa in 1994 was 2,112,737. The population of Addis Ababa in 1994 was that of the area comprising the area in 1984 and additional area of zone 6 and farmers association areas. On the basis of the previous area of Addis Ababa, the population in 1994 was 2,000,321.

The population growth rate between 1984 and 1994 in the previous area of Addis was 3.46%. By using this growth rate, the population projection in the said area starting from 1984 is shown below together with those of the Addis Ababa Master Plan and the census result:

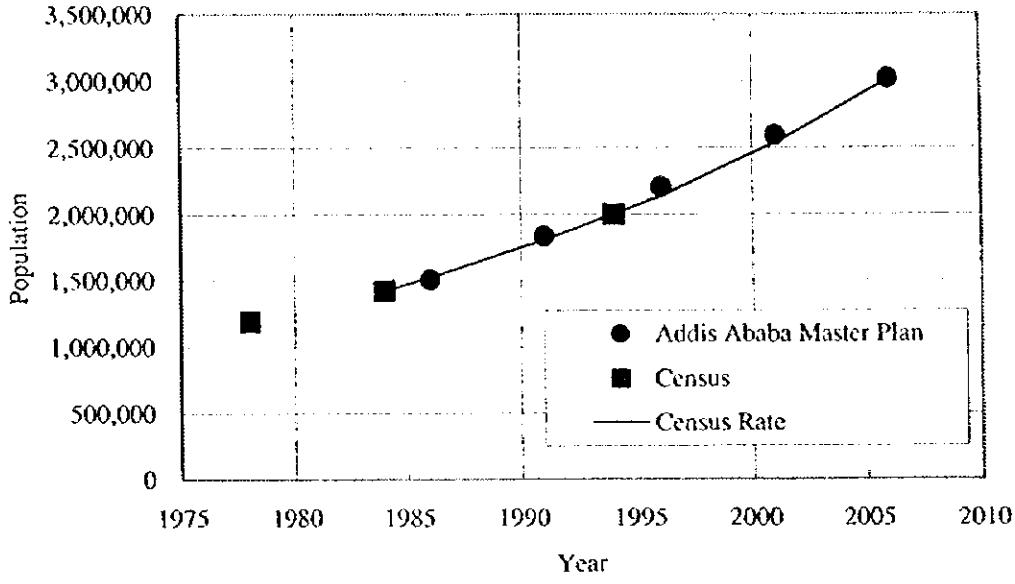


Figure 3.2 Population Projection in Addis Ababa

As can be seen in Figure 3.2, the population projection by the Addis Ababa Master Plan conducted in 1986 seems to be in conformity with the national census result in 1994 and the population projection by using the growth rate of 3.46%. Accordingly, it is concluded that the population projection in Addis Ababa in the Study Area can be conducted by using the growth rate of 3.46% up to 2020.

(2) Population Projection in Study Area

As can be seen in Figure 3.1, the Study Area comprises the Addis Ababa as urban area and rural area included in the Oromia region. Accordingly the population projection in the Study Area is conducted by dividing the whole area into urban and rural areas.

Regarding the population projection in the urban area, the growth rate of 3.46% is to be used as mentioned above. As can be seen in Figure 3.1, the Addis Ababa extends over the Study Area. Accordingly, the population projection in the urban area is conducted

starting the population in the corresponding urban area in Addis Ababa, which was estimated at 1,724,511 in 1994.

On the other hand, the population projection in the rural area is conducted based on the growth rate of 2.94%. This is the average growth rate used in the Addis Ababa Master Plan in due consideration of the projection conformity in urban area and the data availability on population in rural area in the past.

The population projection in the rural area is conducted starting in 1994. But since the population data in rural area even in 1994 is not available, the population in the rural area is estimated by multiplying the population density in rural area in the present Addis Ababa area and the rural area in the Study Area. The estimated population in the rural area in the Study Area as of 1994 is 16,046 persons by using the estimated population density in rural area of 113 persons in 1 km^2, and the rural area in the Study Area of 142 km^2. The population projection in the Study Area thus conducted is shown in Table 3.2.

Table 3.2 Population Projection in the Study Area

Year	Urban	Rural	Total
1994	1,724,511	16,046	1,740,557
1996	1,845,912	17,003	1,862,915
2001	2,188,131	19,654	2,207,785
2006	2,593,795	22,718	2,616,513
2011	3,074,667	26,260	3,100,927
2016	3,644,688	30,354	3,675,043
2020	4,320,388	35,086	4,355,475

3.1.4 Future Land Use

According to the Addis Ababa Master Plan, the upstream basins of the Hanku, Kebena and Little Akaki rivers are to be preserved as forest area. Though some portions of the basins are presently covered by grassland or cultivated area, it is estimated that the whole area will be covered with forest of not only the eucalyptus but also various indigenous species in consideration of the reforestation activities.

On the other hand, the present urban area is already adjacent to the present and future forest area on the north and the east. According to the Addis Ababa Master Plan, the

future urban area is to be expanded to the west and the south. The expansion of the urban area including industrial and commercial area to the south is going to exceed the Study Area.

Addis Ababa Ring Road is now under planning. The plan alignment is nearly adjacent to the present urban area on the west. According to the Addis Ababa Master Plan, the urban area expansion is to exceed the alignment of the ring road by about 2 to 3 km to the west. The urban area expansion of Addis Ababa to the west to the target year of 2020 seems to be limited to the urban area of the Addis Ababa Master Plan in the west in due consideration of the topography and the ring road plan. The western area in the Study Area exceeding the urban area of the Addis Ababa Master Plan accordingly will remain to be forest and cultivated area with dotted resettlement.

The trunk road for economic activities extends to the south and leads to the main seaport for the country located in Djibouti. Topography to the south is relatively flat compared with the present urban area. In this regard, the urban area expansion to the south seems to be going on towards the target year of 2020.

With those considerations, the future land use is estimated as shown in Figure 3.3. The classification of present and future land use is summarized in Table 3.3.

Table 3.3 Land Use in the Study Area

Land use categories	Area in 1997 (km^2)	Area in 2020 (km^2)
Industry	23	28
Commercial and business	3	10
Residential	80	92
Other urban use	52	60
Green area	116	83
Wood land	27	27
Functional green	9	10
Total	310	310

3.1.5 Gross Regional Domestic Product (GRDP)

Gross Regional Domestic Product (GRDP) of the Study Area has not been officially announced yet. For the purpose of flood control master plan, GRDP of the Study Area is estimated in a simple method using the predicted number of household and an average household income.

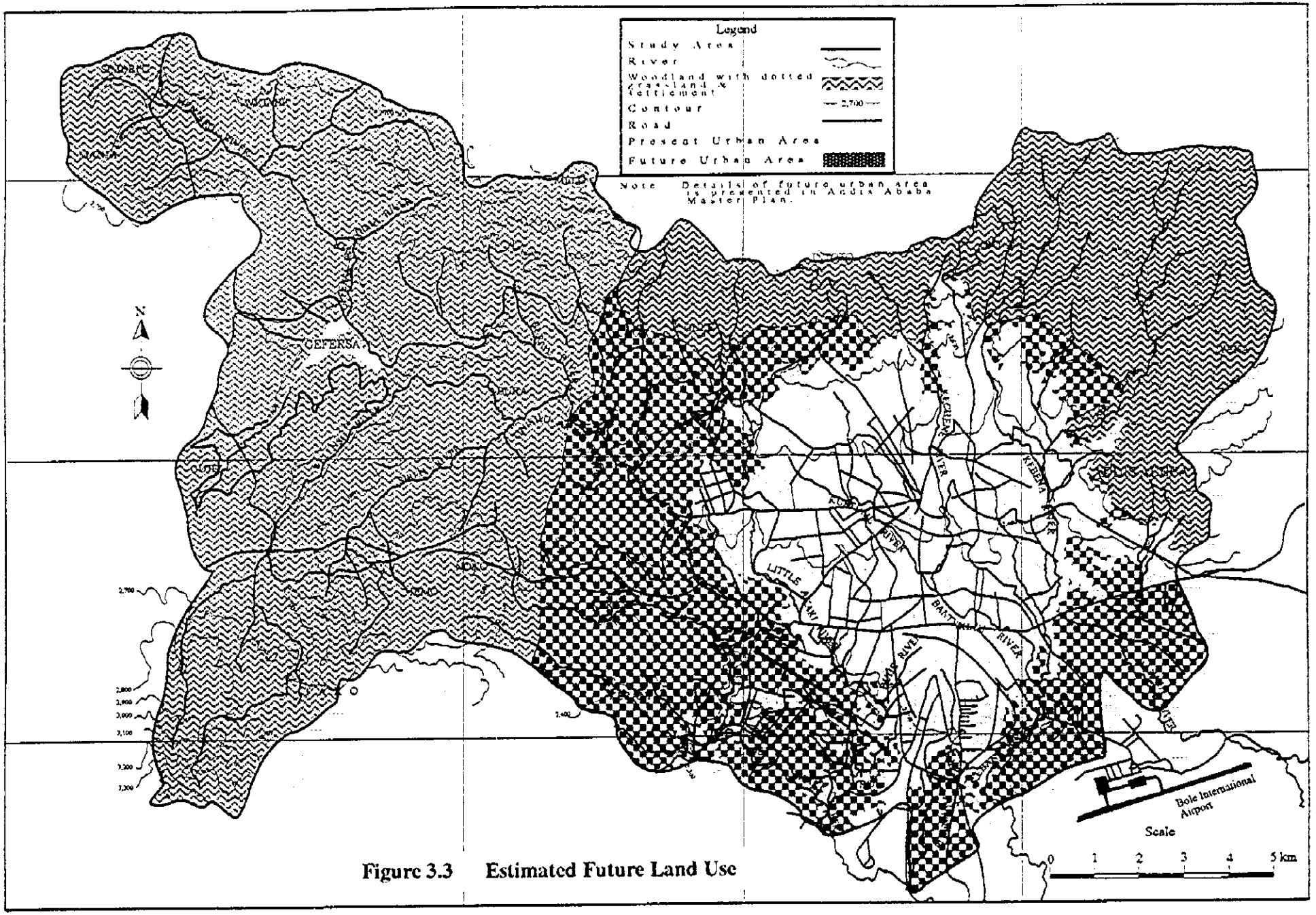


Figure 3.3 Estimated Future Land Use

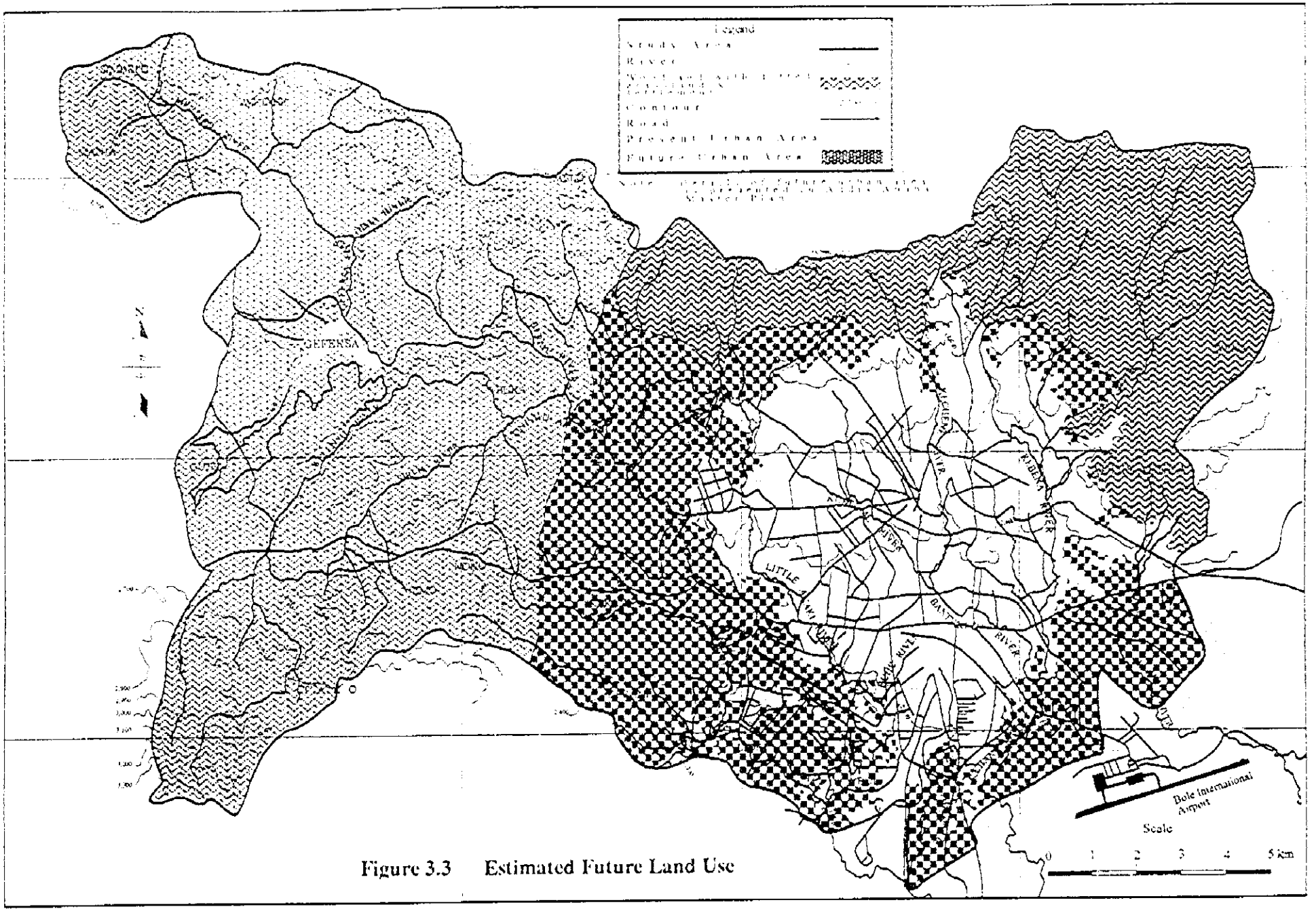


Figure 3.3 Estimated Future Land Use

According to the results of the interview survey for the riverine people, the average household income is 250 Birr/month and this amount can probably be considered the disposable income and savings of each household. The number of households in the Study Area in 1997 is estimated at 320,000 households from the population in the Study Area and the average family size. Total household disposable income and savings in the Study Area are therefore estimated at 960 million Birr. The total household disposable income and savings are assumed to be 70 % of GRDP and the total of depleting assets, indirect taxes and subsidies, and income other than households are assumed to be 30 % of GRDP from other countries' sample. Based on this assumption, GRDP of the Study Area is estimated at 1,370 million Birr in 1997.

The Five Year Program of the Federal Government aims average annual economic growth rate at 7 to 10 %. The rate has been set in order to achieve 4 to 5 % of economic growth for population. Based on this target, GRDP in 2020 has been estimated. The household income in 2020 is estimated to be 610 Birr/month with annual growth rate of 4 % from 1997 to 2020. The number of households in the Study Area in 2020 is estimated at 780,000 households from the projected population in the Study Area and the same average family size. Total household disposable income and savings in the Study Area are estimated at 5,710 million Birr. Using the same assumption for the total household disposable income and saving, GRDP of the Study Area in 2020 has been estimated 8,156 million Birr

3.1.6 Related Plans and Projects

For the formulation of the flood control master plan, the following plans and projects are taken into consideration:

a) Addis Ababa Master Plan
b) Addis Ababa Flood Control and Prevention Project
c) Reforestation
d) Addis Ababa Water Supply Project
e) Master Plan for Development of Wastewater Facilities for the City of Addis Ababa
f) Addis Ababa Ring Read Construction Project
g) Feasibility Study on Flood Protection and Storm Sewer System of Addis Ababa

3.2 Basic Concept of Flood Control Plan

3.2.1 Protection Area and Objective River Stretches

Protection area and objective river stretches of a flood control master plan, are decided with due considerations of the present situation of flood damage, land use and socio-economic development in the future in the target year of 2020.

The flood control plan covers 5 river systems consisting of 7 rivers in the present densely populated area and under-developing area in the Hanku river basin in the eastern part of the Study Area. These objective rivers are principal ones characterized by destructive flood flow coming directly from the mountain areas.

Table 3.4 Objective River Stretch

Objective River Stretch	Length	Description
Kurtume river stretch	5.5 km	Confluence with Bantyiketu river and Dajazmach Yiges bridge
Kechene river stretch	5.4 km	Confluence with Bantyiketu river and Kechene bridge
Bantyiketu river stretch	4.5 km	Confluence with Kebena river and confluence with Kechene
Kebena upper stretch	7.1 km	Confluence with Bantyiketu river and Tesfa Aseged bridge
Kebena lower stretch	0.7 km	Confluence with Bantyiketu river and Bole railway bridge
Little Akaki river stretch	15.6 km	Confluence with West Akaki river and Arveynoch Street
West Akaki river stretch	8.8 km	Confluence with Little Akaki river to upstream
Hanku river	3.5 km	Bridge on Road going to Bole International Airport to upstream

As for urban areas to be developed in the future such as southern part out of the Study Area, land use regulation in line with the Addis Ababa master plan are recommended to avoid the similar flooding problems in the future.

The local drainage area that drains to the Bantyiketu river in the reaches between the confluence of the Kurtume and the Kechene rivers and the Finfine bridge on the Menelik II avenue has poor condition of drainage of local storm. This area is one of the most important areas in Addis Ababa from the view point of existence of important agencies of the central government of Ethiopia and the international agencies, and the place of importance of the road and railway transportation. In due consideration of the above from the socio-economic view point, this area is selected for the objective area for drainage improvement.

3.2.2 Design Scale

Basic flood discharge is a fundamental design value for the flood control plan and estimated in consideration of future river basin conditions in the target year 2020. The magnitude of basic flood discharge is regarded as equivalent to the design scale of the flood control master plan.

The design scale (protection level) of the flood control master plan is justified based on a preliminary study for 3 alternative scales as discussed in the subsequent section. Scales of the remarkable past floods, basin size, and balance of safety level between main channel and tributaries are also considered in the justification.

In compliance with this alternative study, the design scale is selected as 30-year return period for the main river channels (Bantyiketu, Kebena, West Akaki and Little Akaki) and 20-year return period for tributaries (Kechene, Kurtume and Hanku), respectively.

3.2.3 Flood Control Measures

(1) Characteristics of Natural and Social Conditions of Floods and Rivers

Rainfall in the questioned area is of remarkably torrential one. In addition, slopes of the objective river channels are considerably steep ones varying from 1/20 to 1/100. Therefore, flood has destructive flow with high velocity, and that duration of flood is quite short lasting from 3 to 5 hours.

According to site reconnaissance, it can be said that the objective rivers had been originally wide and deep in size. In the recent decades, many people have moved into the river bank areas, which are easily submerged by flood, especially on the terraces in the incised valleys. As the results, tremendous numbers of houses and buildings exist on the river bank areas, above all in the Kechene, Kurtume and the middle reaches of the Little Akaki.

These natural and social characteristics of the floods and rivers are basic considerations in setting up the flood control measures. In mitigation of flood damage in the urban areas, a special attention must be paid to resettlement of riverine people to be involved. The flood control measures are therefore prepared in terms of both structural and non-structural measures as shown in Figure 3.4.

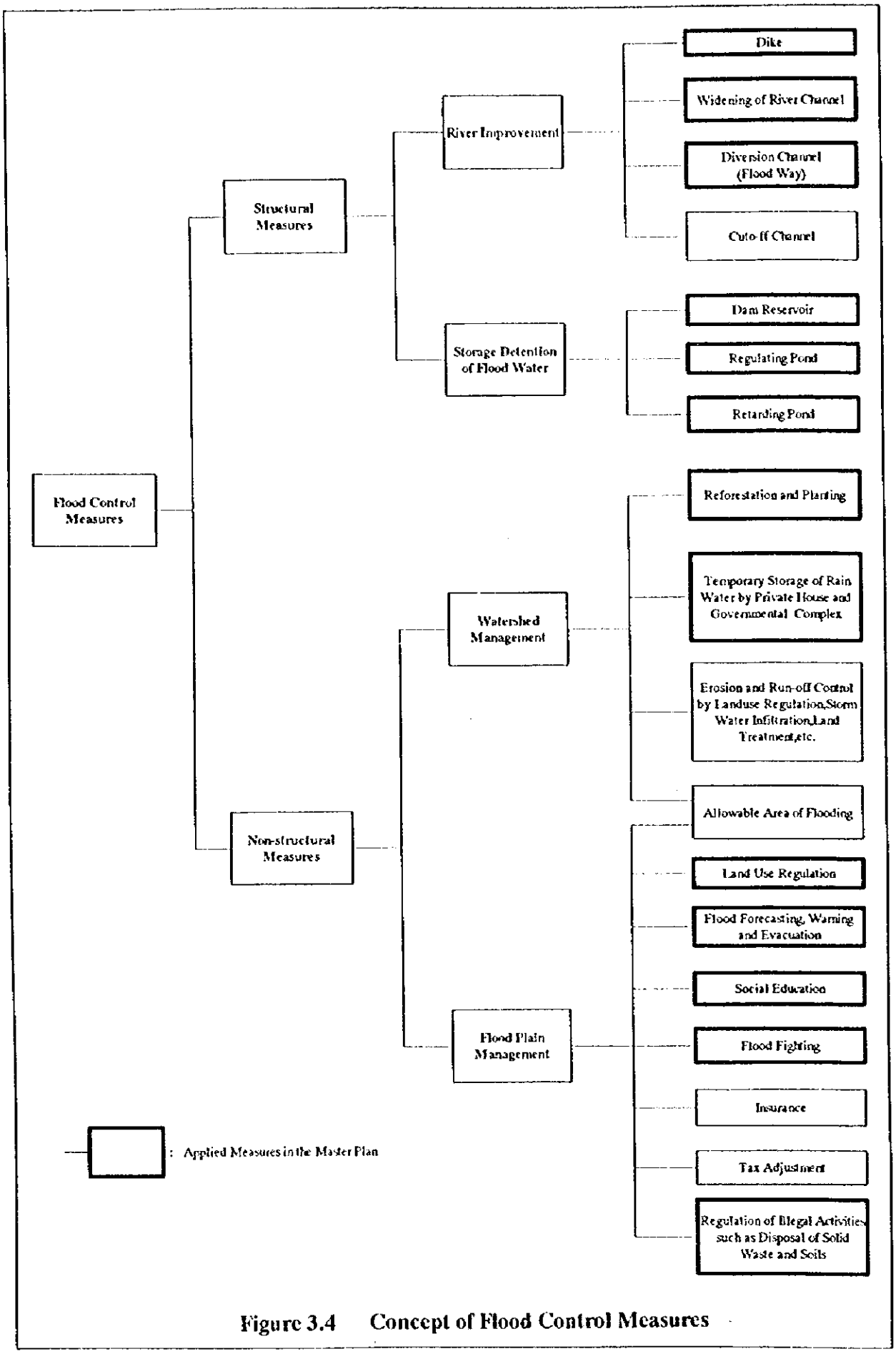


Figure 3.4 Concept of Flood Control Measures

(2) Basic Concept of Structural Measures

Structural measures are provided on the condition that flood discharge will be regulated by flood retention facility as much as possible in upstream reaches and remaining discharge to downstream reaches will be protected by river channel improvement. It aims at minimizing negative social impact, namely, resettlement by implementing river channel improvement with due consideration to the present condition that most of riverine areas to be protected has already been built up densely. Promising river structures are reservoir or regulating pond, diversion channel, river channel improvement including flood wall and bank protection. Structural measures therefore consist of limited extent of river channel improvement in combination with the said flood retention facilities and diversion.

(3) Basic Concept of Non-structural Measures

Non-structural measures are proposed in relation to the river management, watershed management and flood risk management.

River management aims at discharging flood safely and keeping functions of river channels and flood control facilities. For this purpose, 1) Authorization of river zone, 2) Social education for river and flood and 3) Guideline of structural design are proposed.

Watershed management purposes conservation of soil and flood retention in the mountain areas. It is an essential part of the non-structural measures from the viewpoint of not only flood control to directly reduce runoff to downstream reaches but also environment. Reforestation of the deforested mountain areas and planting of trees in the open spaces of urban areas are taken up.

Flood risk management includes 1) Flood warning system by means of rainfall observatories, communication lines and sirens, and 2) Flood fighting system organized by community, 3) Storm water storage in gardens, public spaces and private houses.

3.3 Structural Measures

3.3.1 Flood Control Alternatives

(1) Bantyiketu River System including Kechene and Kurtume Rivers

1) Kurtume River

A structural measure by channel improvement only is not socially accepted in view of present riverine area conditions. On the other hand, open areas to retard run-off from upper basins are available in the middle basins. These areas are designated to reduce flood peaks to downstream as the regulating pond. In this regard, the following alternative plans are taken up, as shown in Figure 3.5.

Table 3.5 Alternative Plans of Kurtume River

Alternative 1	Alternative 2
• 2 Regulating Ponds - (1) storage: 7,200 m^3 - (2) storage: 23,000 m^3	• 4 Regulating Ponds - (1) storage: 7,200 m^3 - (2) storage: 23,000 m^3 - (3) storage: 12,000 m^3 - (4) storage: 7,200 m^3
• River Channel Improvement (length of objective stretch: 5.5 km) - flood protection wall - bank protection - flow velocity control structure/drop structure	• River Channel Improvement (length of objective stretch: 5.5 km) - flood protection wall - bank protection - flow velocity control structure/drop structure

2) Kechene River

The basic idea for the Kechene river is the same as those of the Kertume river. In the Kechene river basin, one site for construction of weir with fairly large storage capacity and one open area for regulating pond are identified in the upper and middle reaches, respectively. The following alternative plans are taken up and their schemes are shown in Figure 3.6.

Table 3.6 Alternative Plans of Kechene River

Alternative 1	Alternative 2
• 1 Reservoir by Weir - storage: 115,000 m^3	• 1 Reservoir by Weir - storage: 115,000 m^3 • 1 Regulating Pond - storage: 21,000 m^3
• River Channel Improvement (length of objective stretch: 5.4km) - flood protection wall - bank protection - flow velocity control structure/drop structure - repair of 1 bridge	• River Channel Improvement (length of objective stretch: 5.4km) - flood protection wall - bank protection - flow velocity control structure/drop structure - repair of 1 bridge

3) Bantyiketu River

The river channel is constricted in the stretch between the Filwiha and Finfine bridges. There is an open area just downstream of the Filwiha bridge on the left bank. A combined scheme of regulating pond and channel improvement is therefore conceivable. Further, the existing natural retarding basin in the lower reaches is taken into account. For each plan to be selected in the Kurtume and Kechene rivers, the following alternative plans are taken up, as shown in Figure 3.7.

Table 3.7 Alternative Plans of Bantyiketu River

Alternative 1	Alternative 2
	• 1 Regulating Pond - storage: 54,000 m^3
• River Channel Improvement (length of objective stretch: 4.5 km) - channel excavation - flood protection wall - bank protection - rehabilitation of 1 aqueduct - rehabilitation of 1 intake weir	• River Channel Improvement (length of objective stretch: 4.5 km) - channel excavation - flood protection wall - bank protection - rehabilitation of 1 aqueduct - rehabilitation of 1 intake weir

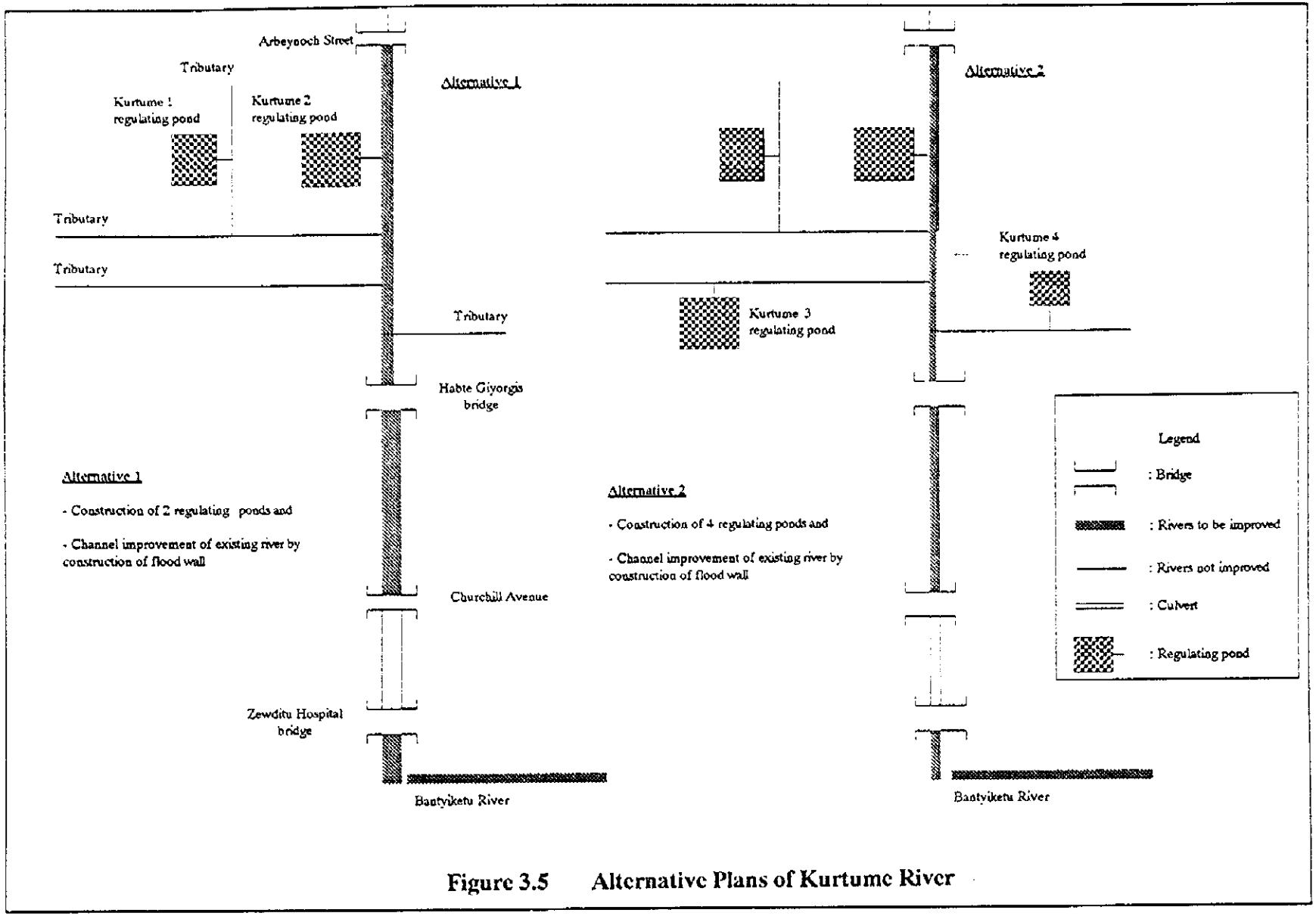


Figure 3.5 Alternative Plans of Kurtume River

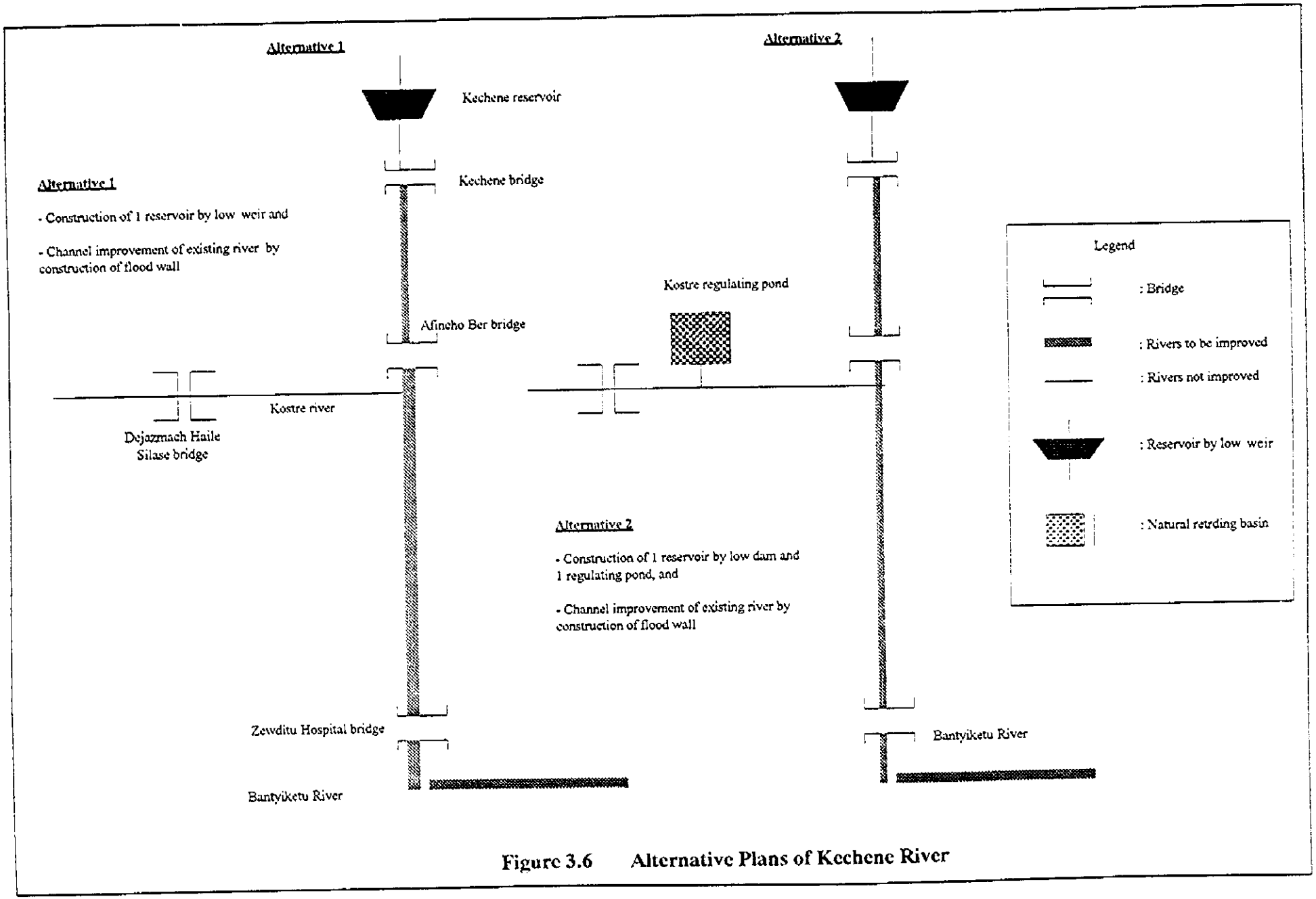


Figure 3.6 Alternative Plans of Kechene River

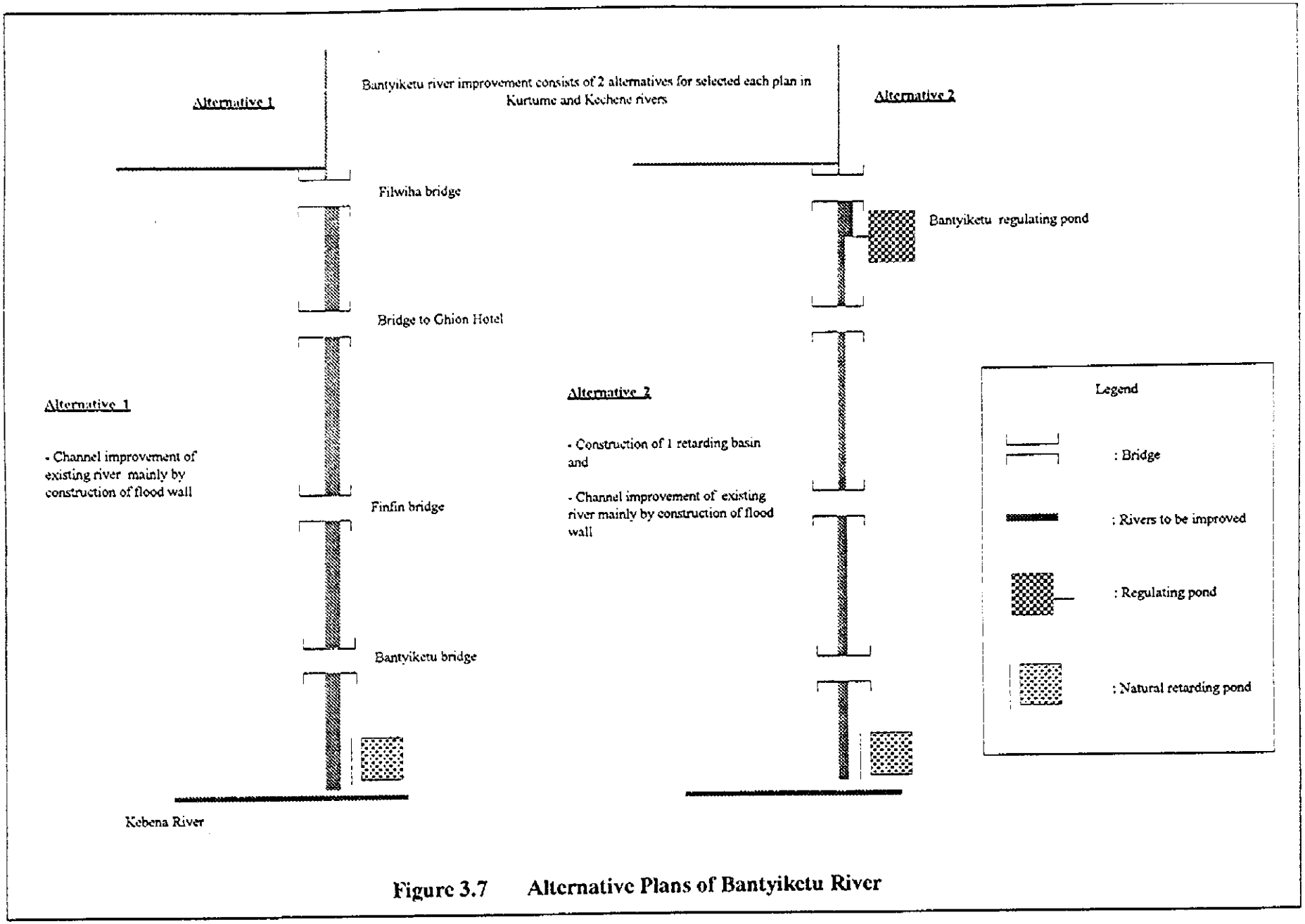


Figure 3.7 Alternative Plans of Bantyiketu River

(2) Kebena River System

1) Kebena River upstream of the Confluence with the Bantyiketu

The upper basin has several promising sites of flood retention. In order to minimize resettlement in the riverine areas, reservoir schemes reducing flood peaks to the downstream reaches is taken up in the alternatives. The existing retarding basin in the upstream of the Urael bridge is also taken into account. The following alternative plans are taken up, as shown in Figure 3.8.

Table 3.8 Alternative Plans of Kebena River

Alternative 1	Alternative 2
• 2 Reservoirs by Weir - (1) storage: 212,000 m^3 - (2) storage: 332,000 m^3	• 3 Reservoirs by Weir - (1) storage: 212,000 m^3 - (2) storage: 332,000 m^3 - (3) storage: 22,000 m^3
• River Channel Improvement (length of objective stretch: 7.8 km) - flood protection wall - bank protection - flow velocity control structure/drop structure	• River Channel Improvement (length of objective stretch: 7.8 km) - flood protection wall - bank protection - flow velocity control structure/drop structure

2) Kebena River from the Confluence with the Bantyiketu to Bole railway Bridge

For each plan to be selected in the upper Kebena and Bantyiketu rivers, the lower Kebena from the confluence with Bantyiketu up to the Bole railway-bridge is to be improved by means of a channel improvement.

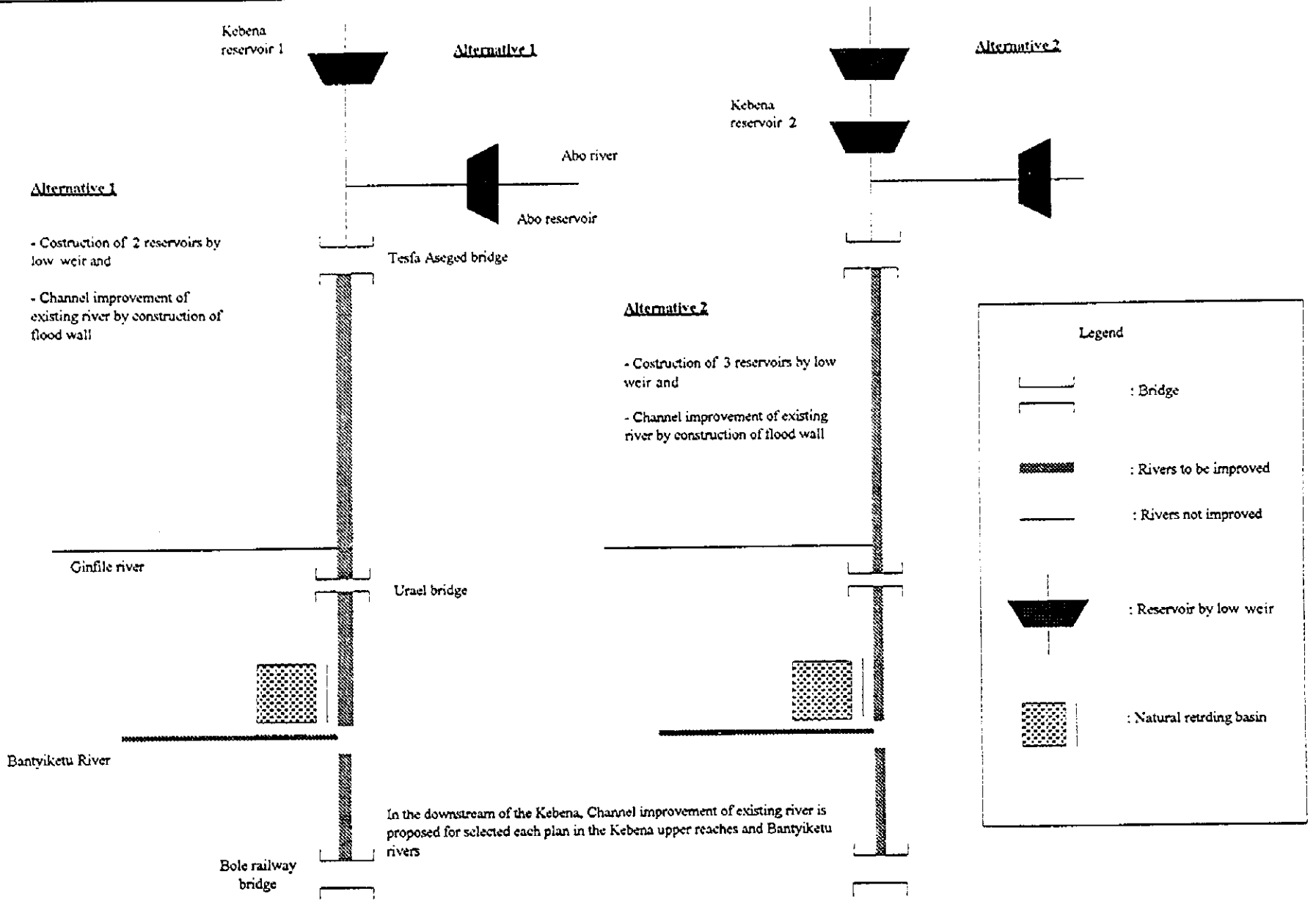


Figure 3.8 Alternative Plans of Kebena River

(3) Little Akaki and West Akaki River System

The West Akaki river generally forms deep and wide valley with sufficient carrying capacity. Land use along the West Akaki river are, as a whole, of open areas covered by grassland and woodland. It is therefore proposed that the present land use along the West Akaki river be maintained and regulated in the future.

On the other hand, the river bank areas in the middle reaches of the Little Akaki are presently occupied by the dense houses and buildings. In case a channel improvement only is applied, voluminous resettlement will be needed. Accordingly, river channel improvement of the Little Akaki needs to be limited. Whereas, a flood diversion plan from the Little Akaki river to the West Akaki river is conceivable as shown in Figure 3.9 on the condition that the present land use along the West Akaki river be maintained and regulated in the future.

Table 3.9 Alternative Plans of Little Akaki River

Alternative 1	Alternative 2
• 1 Regulating Pond - storage: 54,000 m^3 • 1 Flood Diversion - length: 970 m • River Channel Improvement (length of objective stretch: 15.6 km) - flood protection wall - bank protection - flow velocity control structure/drop structure	• 1 Regulating Pond - storage: 54,000 m^3 • River Channel Improvement (length of objective stretch: 15.6 km) - flood protection wall - bank protection - flow velocity control structure/drop structure

(4) Hanku River System

The existing flooding problem in the river basin has been locally limited. There is no suitable place to retard run-off in the mountain areas. In the lower reaches of the Hanku river near the International Airport, there exist extensively wide natural retarding basins. Under the condition that such natural retarding basins remain and be maintained as they are at present condition, widening of the existing culverts across under the Fikre Maryam Aba Techan Street in the middle reaches of the left tributary is taken up.

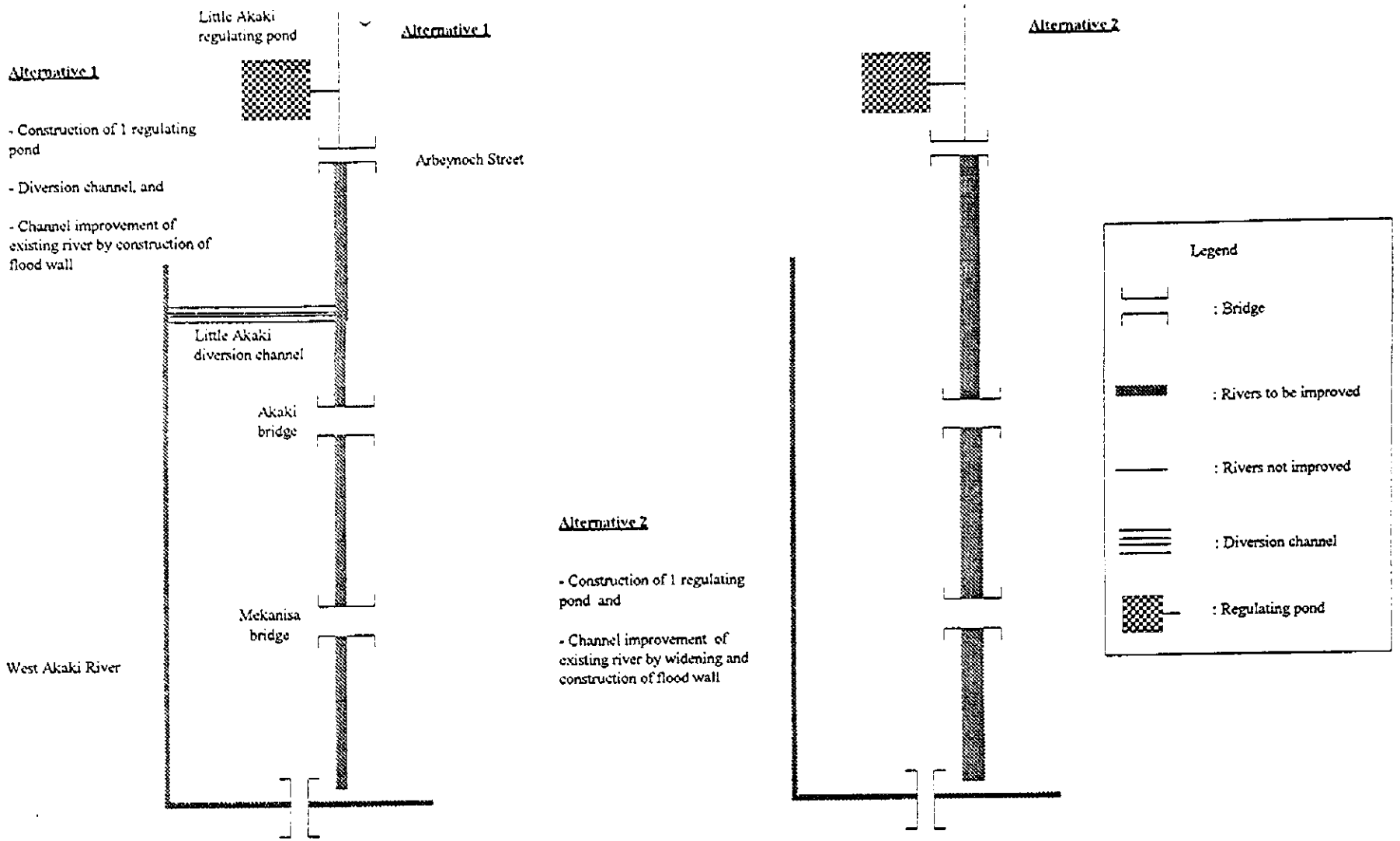


Figure 3.9 Alternative Plans of Little Akaki River