Appendix 3-2

Isiolo River Basin Integrated Flood Management Plan

As of 3 August 2013

REPUBLIC OF KENYA
PROJECT ON CAPACITY DEVELOPMENT
FOR
EFFECTIVE FLOOD MANAGEMENT IN FLOOD PRONE AREA

ISIOLO RIVER BASIN
INTEGRATED FLOOD MANAGEMENT PLAN
- DRAFT -

August 2013

NEWJEC

Republic of Kenya
Project on Capacity Development for Effective Flood Management in Flood Prone Area

Isiolo River Basin Integrated Flood Management Plan
- Final Draft -

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1. POLICY OF RIVER BASIN FLOOD MANAGEMENT PLAN (DRAFT)

1.1 POLICY OF FLOOD MANAGEMENT IN THE RELEVANT RIVER BASIN (DRAFT)

The Isiolo river basin is located on the foot of Mt. Kenya and then the topographic slope is steep generally. Therefore reading time of flooding from rainfall starting is short and it has the feature that flooding peak discharge is high.

The Isiolo city area is a centre of socio economic activity in the region and is an important rural city. It has development plans as a strategic important place of transportation or a centre of sightseeing base, since the national highway is running from Nairobi to northern Kenya through Isiolo.

The Isiolo river basin is belongings to the jurisdiction of WRMA Middle Ewaso Ng'iro Sub Regional Office (SRO) concerning the general water resource management flood management inclusive flood management. Then, Isiolo WRUA is established in the Isiolo river basin, and implements grass-roots water management in collarroboration with WRMA.

The principal flood damages are, socio economic stagnation and human damage by both inundations inside and outside the levee in Isiolo city area, lost of farmlands and sediment related disasters by local inundation or bank erosion in various points of river basin and destruction of roads or bridges.

Therefore the important point of the flood management policy in relevant river basin shall be mitigation of damage in Isiolo city area and mitigation of local inundation or river bank erosion damage in socio economically important points.

In the course of drawing up the flood management plan, the appropriate combination of structural and non-structural measures or the view point of "Self-help", "Mutual support" and "Public assistance" should be considered. And also consensus building among the stakeholders through the participation of WRUA or communities should be implemented

WRUA and communities implement the distribution, evolution, maintenance of structural measures and non-structural measures with initiative.

WRUA and communities shall work together from the period of project planning so that incubate their ownership

The scoping period of this plan is 5 years from 2013 to 2018, the contents of plan will be revised properly in necessity.

1.2 THE ROLE AND RESPONSIBILITY OF WRMA

Main constituent of this plan is WRMA. WRMA should assist WRUA to make it possible for it to build realizable tasks in to the Sub-Catchment Management Plan (SCMP) by itself. In addition, WRMA provide the technical assistance to implement the countermeasures against

flooding matters.

Concerning the tasks that WRUA has no initiative, WRMA shall precede the implementation of tasks while coordinating it with relevant stakeholders.

1.3 RIVER BASIN COMMITTEE

Flood management cannot achieve the objectives without the cooperation of various stakeholders in the river basin.

Some river basins are divided by plural sub catchment such as upper stream, lower stream, left bank and right bank.

According to this condition, WRMA shall establish "Integrated Flood Management River Basin Committee" in order to share the information concerning flood management and coordinate in river basin unit.

The stakeholders in the relevant river basin preferable to participate in the committee are listed below.

Table 1.3.1 The Stakeholders in Isiolo River Basin

No	Institution/Organization	Remarks
1	Isiolo WRUA	One representative from each of the six Zones
2	Provincial Administration	County Commissioner
3	Ministry of State for Special Programmes	Active in providing humanitarian assistance to disaster victims in Isiolo area
4	Kenya National Highways Authority/Kenya Rural Roads Authority - Representative	One representative each from KenHA and KeRRA
5	Ministry of Water and Irrigation	Irrigation Department representative
6	Ministry of Lands	District Physical planner
7	Ministry of Agriculture	District Agricultural Officer
8	Ministry of Livestock	District Livestock Officer
9	Ministry Of Education	District Education Officer
10	Ministry of Development of Northern Kenya and Other Arid Lands	Active in providing humanitarian assistance to disaster victims in Isiolo area
11	Kenya Meteorological Department	Contact Person at National Level
12	Ewaso Ng'iro North Development Authority (ENNDA)	Representative from Regional Office
13	National Environmental Management Authority	District Officer
14	County Government of Isiolo	One representative
15	County Government of Meru	One representative
16	Kenya Red Cross Society	Representative from Regional Office
17	World Vision	Representative from Regional Office
18	Food for Hungry (fhi)	Representative from Regional Office
19	Lewa Conservancy	CAAC member
20	Pastoralists	One representative
21	Farmers	One representative
22	CAAC	Chairman
23	Environment/Natural Resources Management CBOs	Environment representative
20	Kenya Wildlife Service	One representative from Isiolo area
21	Religious Group	One each from Christian and Muslim
22	Northern Water Service Board (NWSB)	One representative
24	Kenya Forest Service	CAAC member
26	Department of Social Services	Registers WRUAs and other social welfare groups
29	Kenya National Chamber of Commerce and Industry	Isiolo chapter
30	Catholic Diocese of Isiolo	One representative
31	Kenya Airpot Authority	
32	WRMA	HQ, RO, SRO

In the committee, exchanging of opinions between the relevant stakeholders, approval of flood management plan, consensus building, discussion of role sharing and activity evaluation etc. shall be done

Committee members shall be discussing about the following themes once in every some months for the time being.

Tabel 1.3.2 The Schedule of Integrated Flood Management Committee Meeting(Draft)

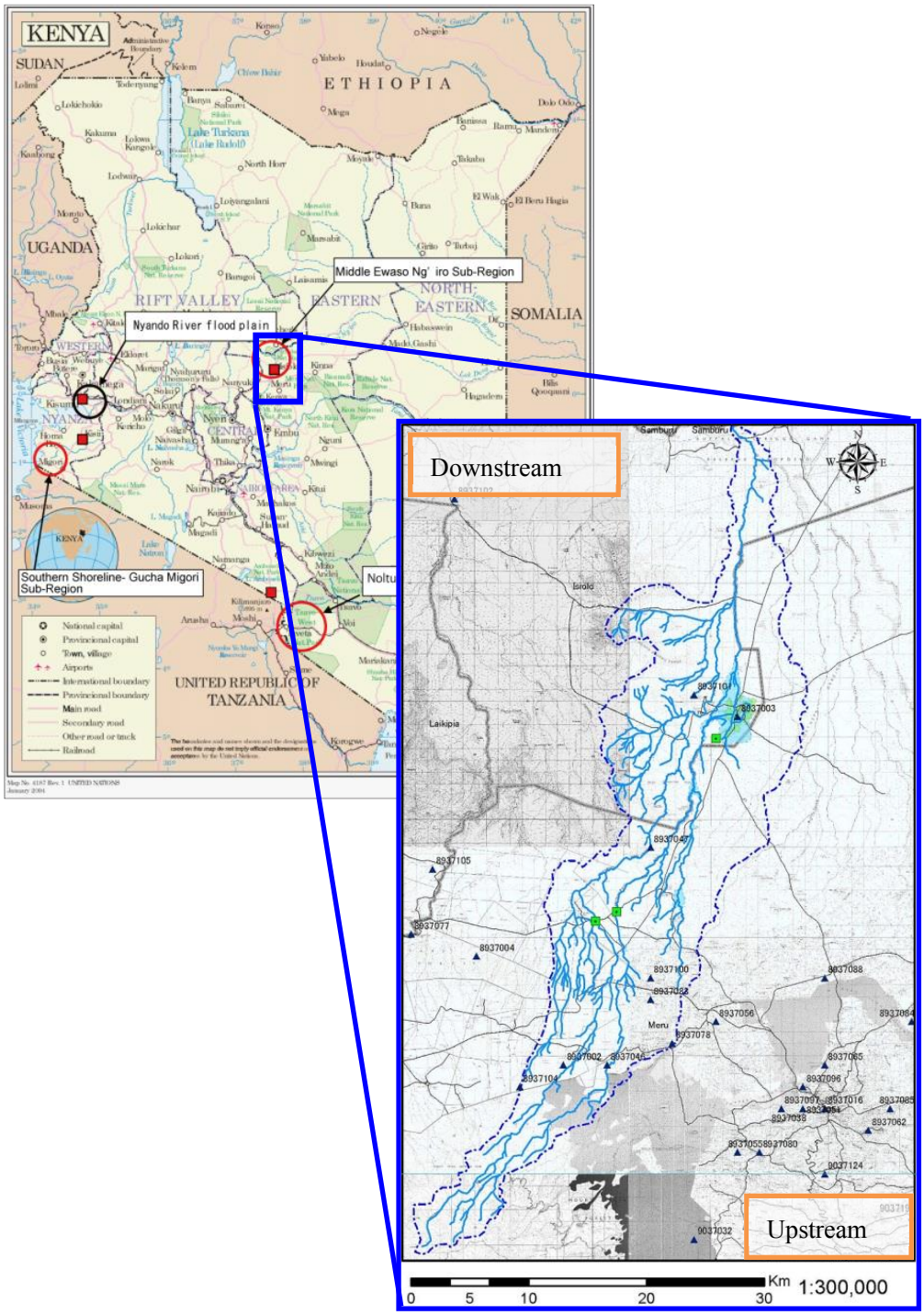
	Discussion Themes	Remarks
1st Meeting	・Information sharing on current situation and problems in flooding ・Discussion on conceivable flood measures	Already done in Jan. 23rd , 2013
2nd Meeting	・Suggestion of flood management plan(draft) ・Discussion on flood management plan(draft) ・Consensus building on pilot project(This project only)	
3rd Meeting	・Discussion on flood management plan(draft) ・Progress reporting of pilot project(This project only)	
4th Meeting	・Evaluation of pilot project(This project only)	

1.4 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

On planning the flood measures project, the appropriate environmental and social consideration shall be done based on Kenyan regal code “Environmental Management and Coordination Act (EMCA) 1999”.

2. OUTLINE OF ISIOLO RIVER BASIN

Isiolo River Basin is located at the northern part of the piedmont of Mt. Kenya in the central part of the Republic of Kenya.



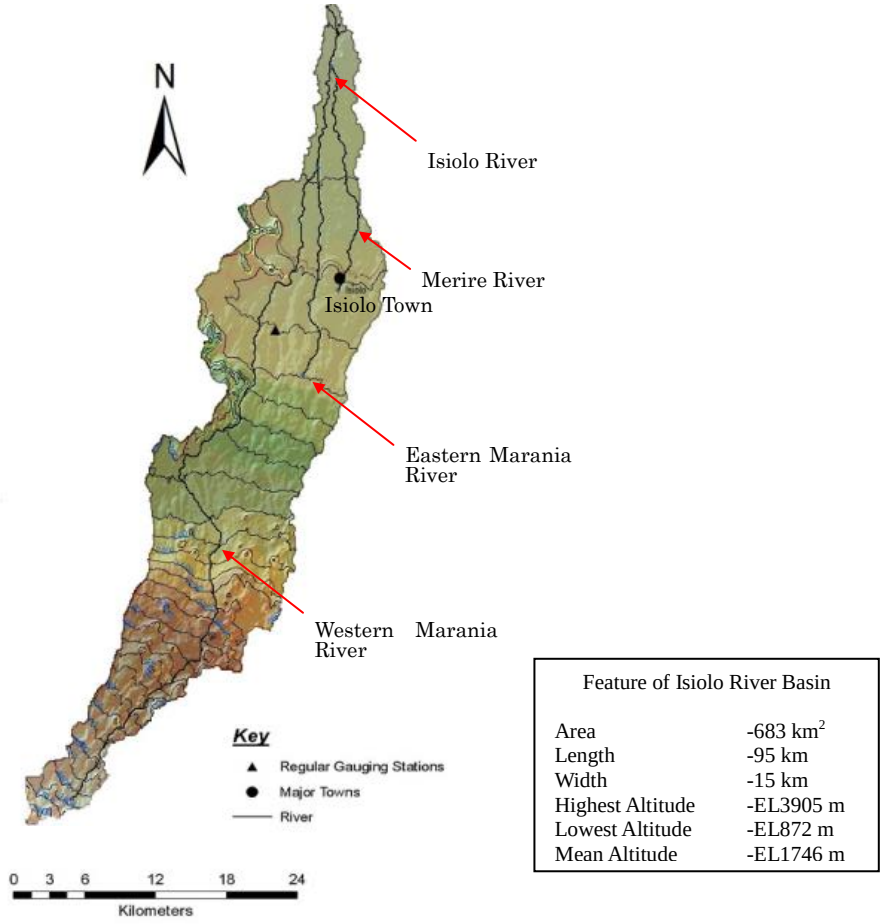
Location of Isiolo River Basin

2.1 NATURAL CONDITIONS

2.1.1 Topography and Soil

(1) Topography

Catchment area of Isiolo River is about 683km^2 and the total length of the river is approximately 95km flowing from south to north. The river width reaches about 15km (east to west) in the widest part. Isiolo River originates from Mr. Kenya and it flows towards the north via three districts of Meru Central, Imenti North and Isiolo. The river flows together with Ewaso Ng'iro North in the vicinity of Archer's Post. There are many tributaries in the upstream and these tributaries are confluent with Isiolo River at the downstream of the Isiolo Town. Major tributaries are Western Marania River, Eastern Marania River and Marire River.



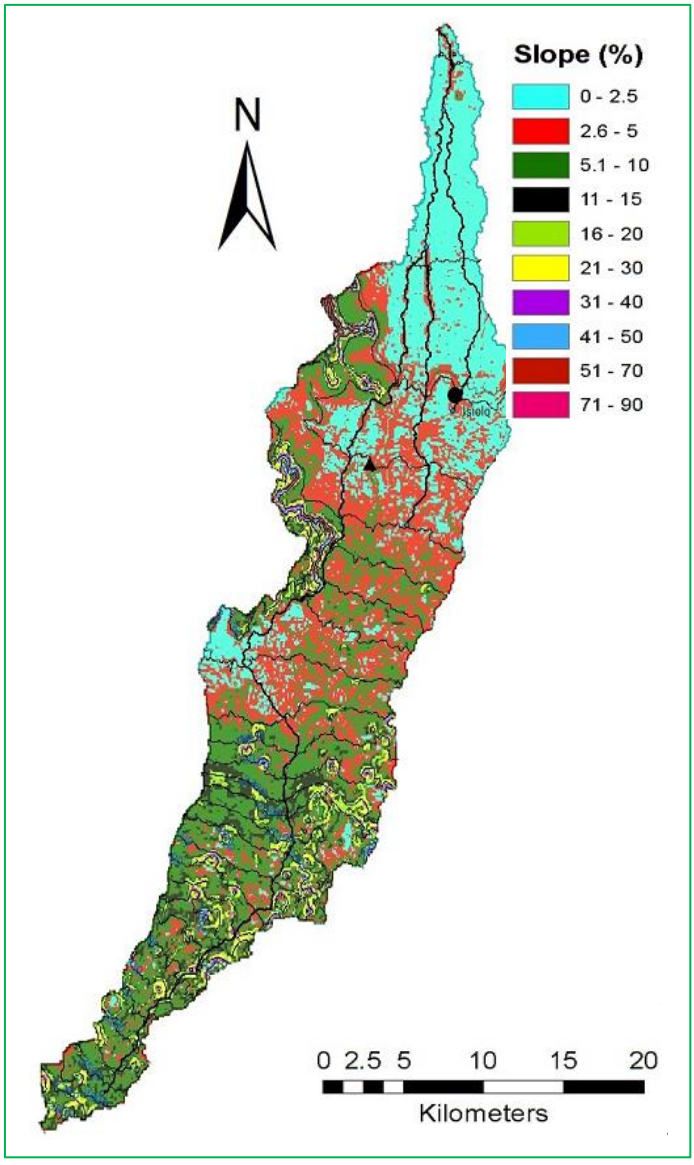
Source: Prepared by JICA Project Team based on WRMA's data

Figure 2.1.1 Map of Isiolo River Basin and Elevation Distribution

Topographic slope in the river basin is shown in Figure 1.1.2. There are some steep slopes of the river course varying from 10 to 70% in the vicinity of Mt. Kenya in the upstream to the

middle stream. In the middle stream, the river course is rapid with the slope of approximately 5 to 2.6%. On the other hand, in the downstream, the river course shows the characteristic of rather flat with the maximum slope of 2.5%.

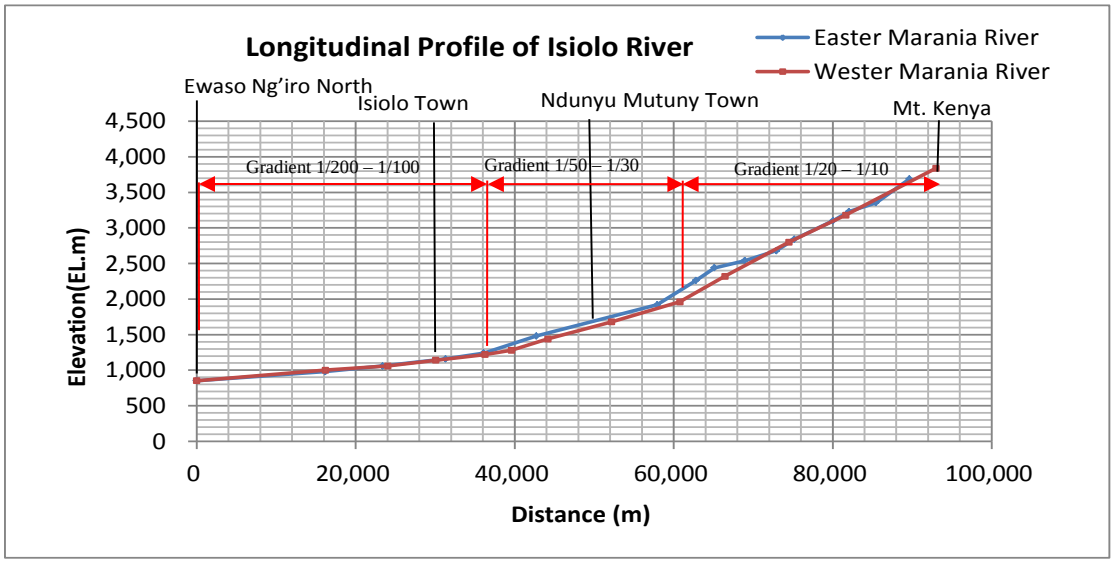
In Isiolo River Basin, the residential area is dominated on the transition area of the river course near Isiolo Town where the topographic slope of the river is turned from steep to flat. One of the reasons is that there is a spring in this vicinity and the groundwater level is shallow as this area is the transition point of topographic slope of the river. In the mountainous area where the river slope is steep, it tends to have regional heavy rain.



Source : Prepared by JICA Project Team based on WRMA's data

Figure 2.1.2 Distribution Map of Topographic Slope of Isiolo River Basin

Figure 2.1.3 shows longitudinal gradient of Isiolo River.

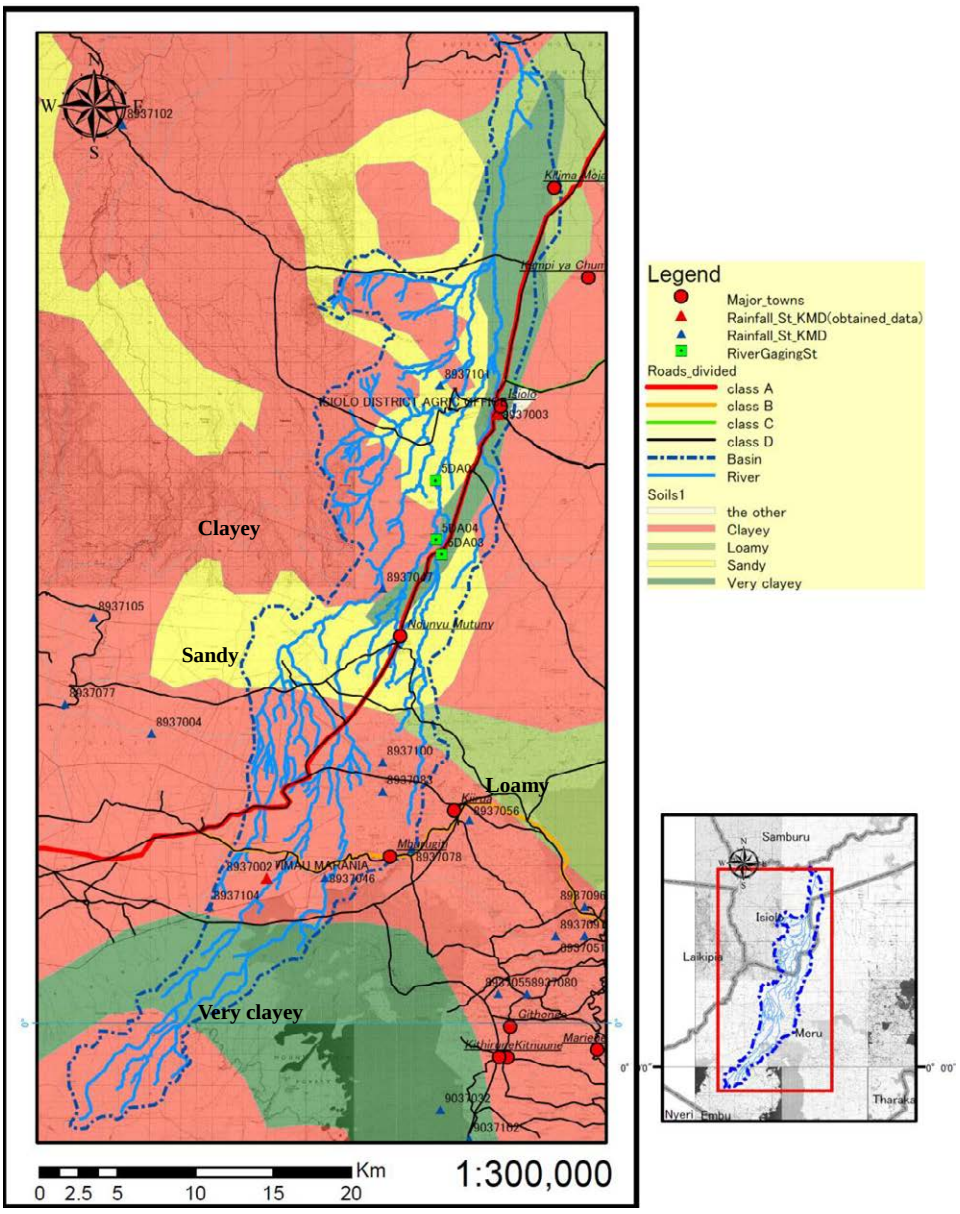


Source : Prepared by JICA Project Team based on 1/50,000Topo Map

Figure 2.1.3 Longitudinal Profile of Isiolo River

(2) Soil

Soil Distribution Map of Isiolo River Basin is as per Figure 1.1.4. Clayey soil covers all through the river basin, and sandy soil is distributed at the left bank of the river, from a part of the middle river basin and the middle stream to the downstream. High clayey content soil is deposited in the right bank of the downstream and the loam layer composed of silt and clay with the proportion of 25 to 40% is distributed. Isiolo Town is located on the strong clayey soil land.



Source: Prepared by JICA Project Team based on Kenya Soil Survey (KSS) in 1982 and revised in 1997.

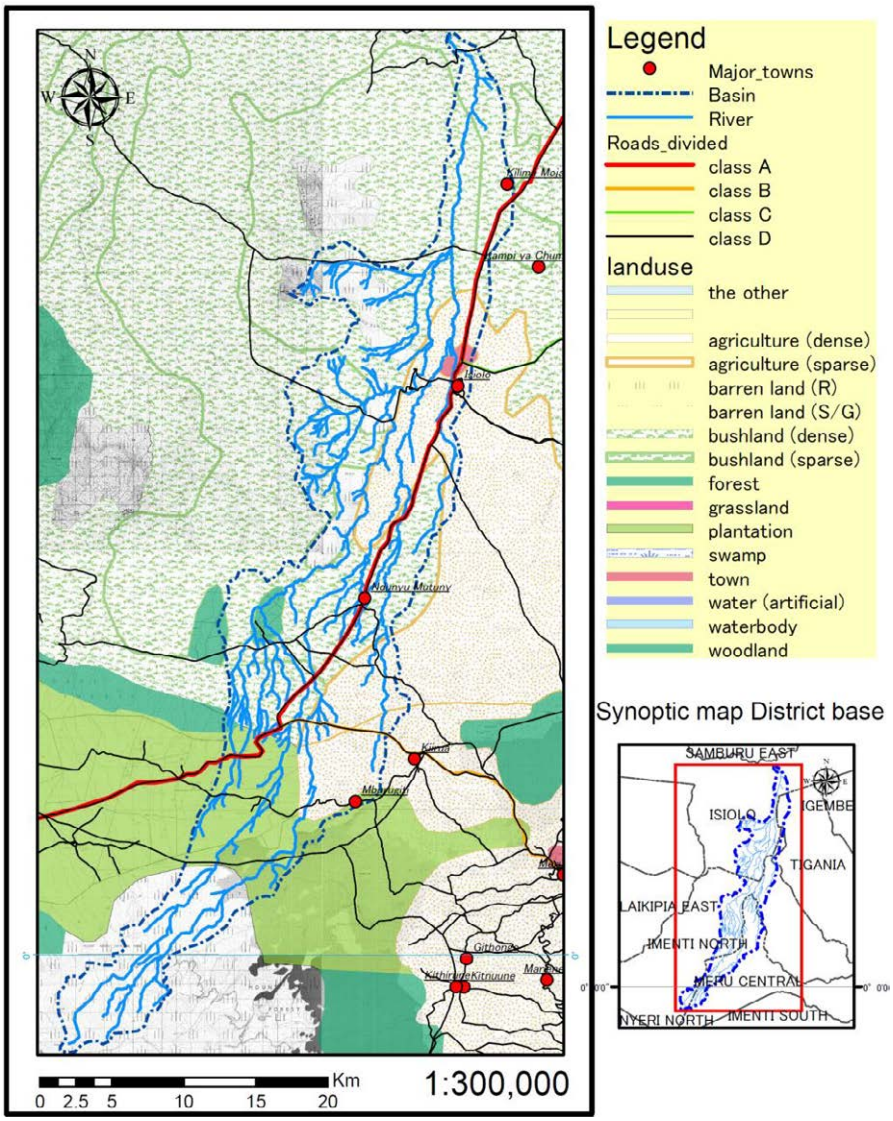
Figure 2.1.4 Soil Distribution Map (Soil texture)

2.1.2 Vegetation and Land Use

(1) Land Use

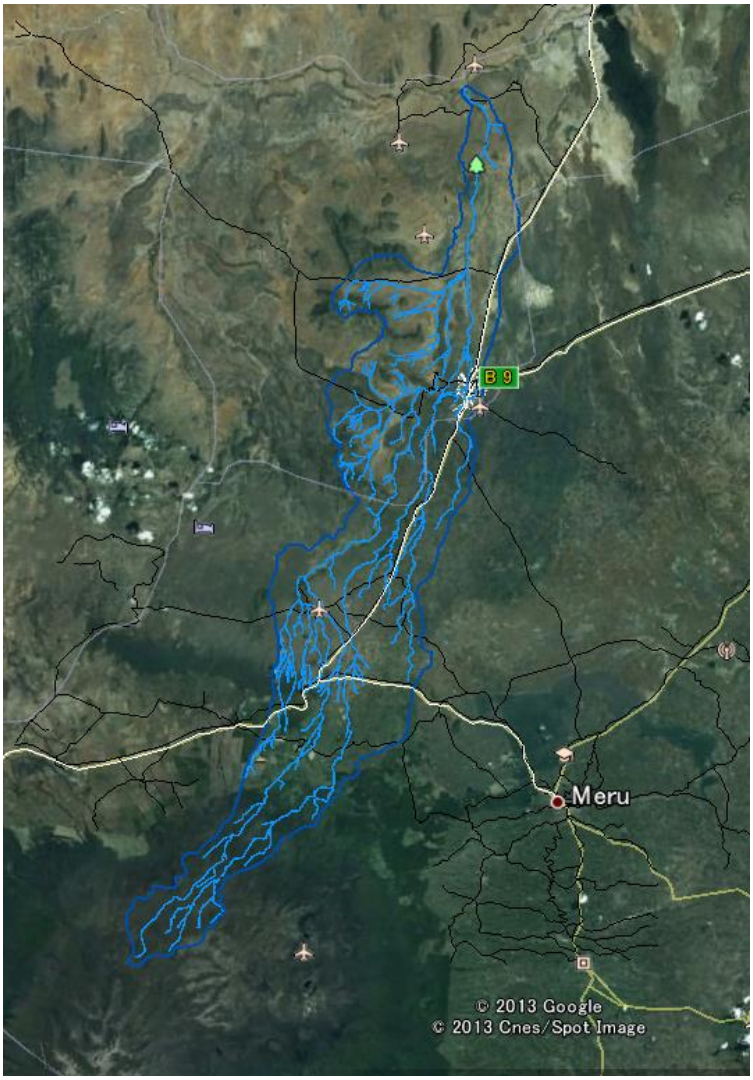
Land use characteristics of Isiolo River Basin are shown on Figure 2.1.5 and Figure 2.1.6. As seen in land use map, the mountainous area in the upstream river basin is a barren land, and from Google Earth Image Data it is known that the mountain is bare. In the middle river basin the plantation is extended. From the middle to downstream river basin the scrubland is extended, and there exists agricultural lands along the Western Marania River and Eastern Marania River of the middle river basin and in the suburb of downtown of Isiolo Town. In addition, as this river basin belongs to dry region and the xerophile vegetation is limited, forest

area is extremely few.



Source: Prepared by JICA Project Team based on the data of National Water Master Plan, JICA

Figure 2.1.5 Land Use in Isiolo River Basin



Source : Prepared by JICA Project Team based on Satellite Image of December 10, 2012

Figure 2.1.6 Satellite Image of Isiolo River Basin

According to the survey of NRM3 and CETRAD, 29.1km^2 of forest area in 1995 in Isiolo River Basin is decreased to 14.1km^2 in 2002. It is reported that 15km^2 of forest has been lost between 1995 to 2002. 2.1km^2 of forest loss has occurred in average every year. If the forest loss is continued at this rate, the forest in the river basin will totally be disappeared by 2018.

2.1.3 Hydrology and Meteorology

(1) Feature of Rainfall and Water Level Gauging Station

(a) Gauging Stations

Figure 2.1.7 shows locations of KMD rainfall and water level gauging stations. Rainfall gauging stations are indicated in triangle shape (▲), while the water level gauging stations are shown in box-shape (■). Rainfall gauging stations where the daily rainfall data have already been obtained by JICA project team are colored in red. The numbers given in the map mean the gauging station number.

Timau Marania Rainfall Gauging Station (No. 8937002) is located in the mountainous area of the upstream river basin, while Isiolo District Agric Office (hereinafter referred to DAO) is located in the suburb of downtown of Isiolo.

Kithima Water Level Gauging Station (No.5DA03) is located in the middle river basin, while Isiolo Gauging Station (No.5DA07) is located in the suburb of downtown of Isiolo.

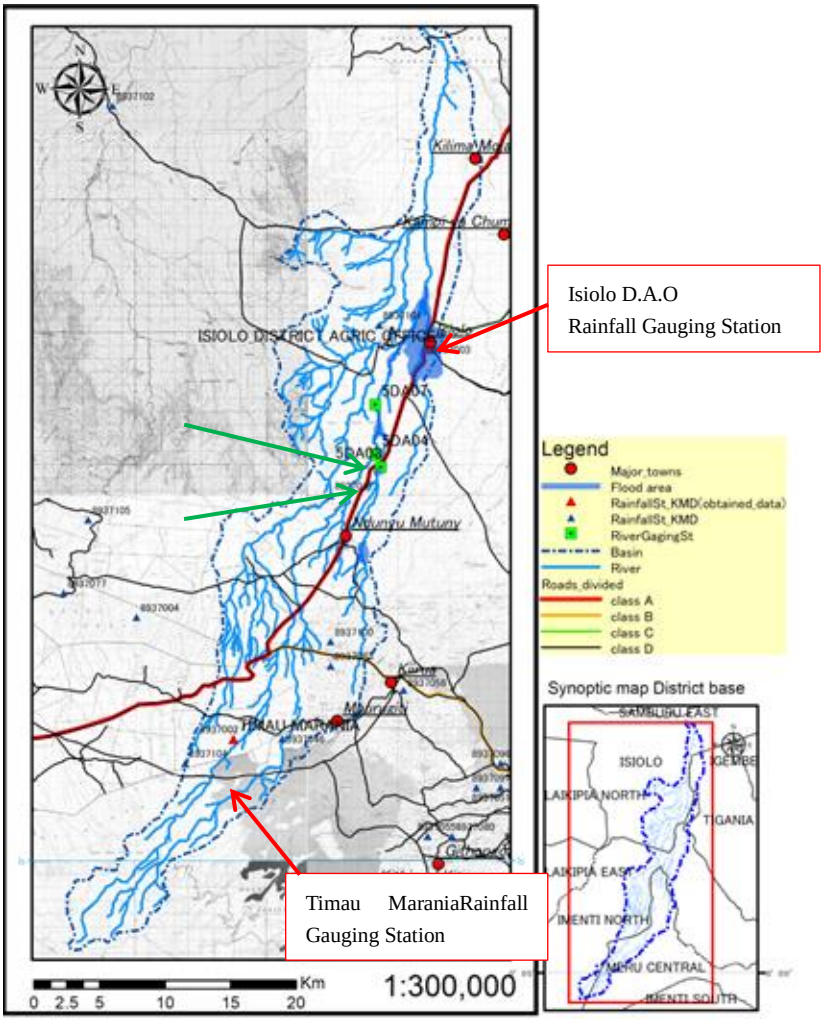


Figure 2.1.7 Location Map of Rainfall and Water Level Gauging Stations

Water Level Gauging Station No.:5DA07
Observation River：Eastern Marania River

Same as left.

Water Level Gauging Station No.:5DA04
Observation River：Eastern Marania River
Special Note：Water level gauge is broken off and damaged.

Water Level Gauging Station No.:5DA03
Observation River：Eastern Marania River

(b) Rainfall Observation Data

Table 2.1.1 shows a list of KMD Rainfall Gauging Station within Isiolo River Basin and its vicinity. Of the stations listed below, those stations obtained daily rainfall data are Gauging Station of Timau Marania and Isiolo DAO indicated by color. Observation periods of the daily rainfall obtained are 32 years from 1957 to 1989 (including missing period).

For Timau Marania Gauging Station No.8937002, the monthly rainfall data is obtained for 82 years from 1930 to 2011.

Table 2.1.1 List of KMD Rainfall Gauging Station within Isiolo River Basin and its Vicinity

STATION_NUMBER	stationname	Year_Opened	Year_Closed	Obtain
8937002	TIMAU_MARANIA	1925	_	obtain
8937003	ISIOLO_DISTRICT_AGRIC_OFFICE	1930	_	obtain
8937004	NGARE_UNGA_FARM	1930	1941	
8937046	MARANIA_FOREST__NANYUKI	1951	1953	
8937047	BIRDS_HILL_RANCH_ISIOLO	1951	1963	
8937078	MUCHENE_FOREST_STATION	1973	_	
8937083	NTUMBURI_PRIMARY_SCHOOL	1974	_	
8937100	MARURU_PRIMARY_SCHOOL	1979	_	
8937101	ISIOLO_L_M_D_HEADQUARTERS	1980	_	
9037155	SIRIMON_GATE__MT_KENYA_PARK	1970	_	

Source :KMD

(c) Water Level and River Discharge Observation Data

List of water gauging stations in Isiolo River Basin is shown on Table 2.1.2 of the stations listed below, those stations obtained water level observation data is only Gauging Station Nos. 5DA07 indicated by color. Automatic measurement is not done at each water level gauging stations, but the visual observation is carried out two times in a day, i.e. in the morning and in the evening. Therefore, the river discharge at the time of flood is said to be inaccurate.

Table 2.1.2 List of Water Level Gauging Station in Isiolo River Basin

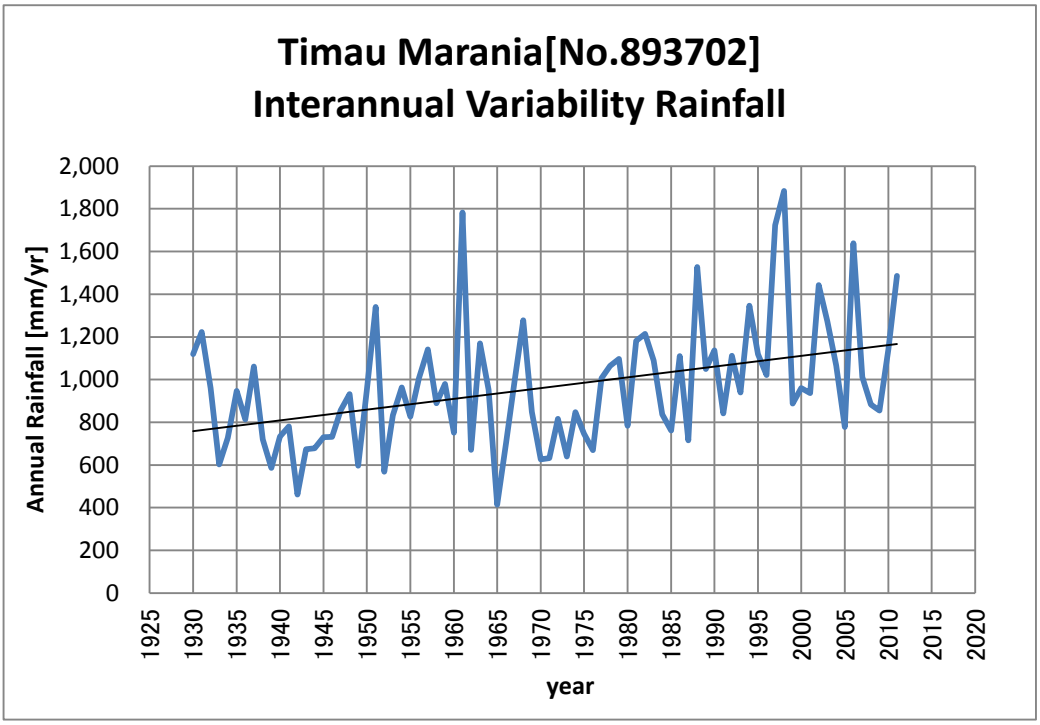
No.	ID	Name	River Name	Manual/ Auto/ Both	National/ MU/IMU/ Special	Daily/ Hourly/ Both	Operational	Start Year	End Year	SRO in charge
1	5DA07	Isiolo	Isiolo	Manual	MU	Daily	Yes	1976/1/1	N/A	MEN
2	5DA03	Kithima	Kithima	Manual	Intra-MU	Daily	Yes	2010/9/1	N/A	MEN
3	5DA04	Rugusu	Rugusu	Manual	Intra-MU	Daily	Yes	2010/10/1	N/A	MEN

Source : WRMA

(2) Feature of Annual Rainfall

(a) Long-Term Variability of Annual Rainfall

Figure 2.1.8 shows the variability of annual rainfall at Timau Marania Station in a period of 1930 to 2011. Out of the observation record from 1930 to 2011, the maximum annual rainfall, 1,883mm/year was recorded in 1998. The average annual rainfall during the same observation period is 959mm/year. The average annual rainfall tends to be increasing.



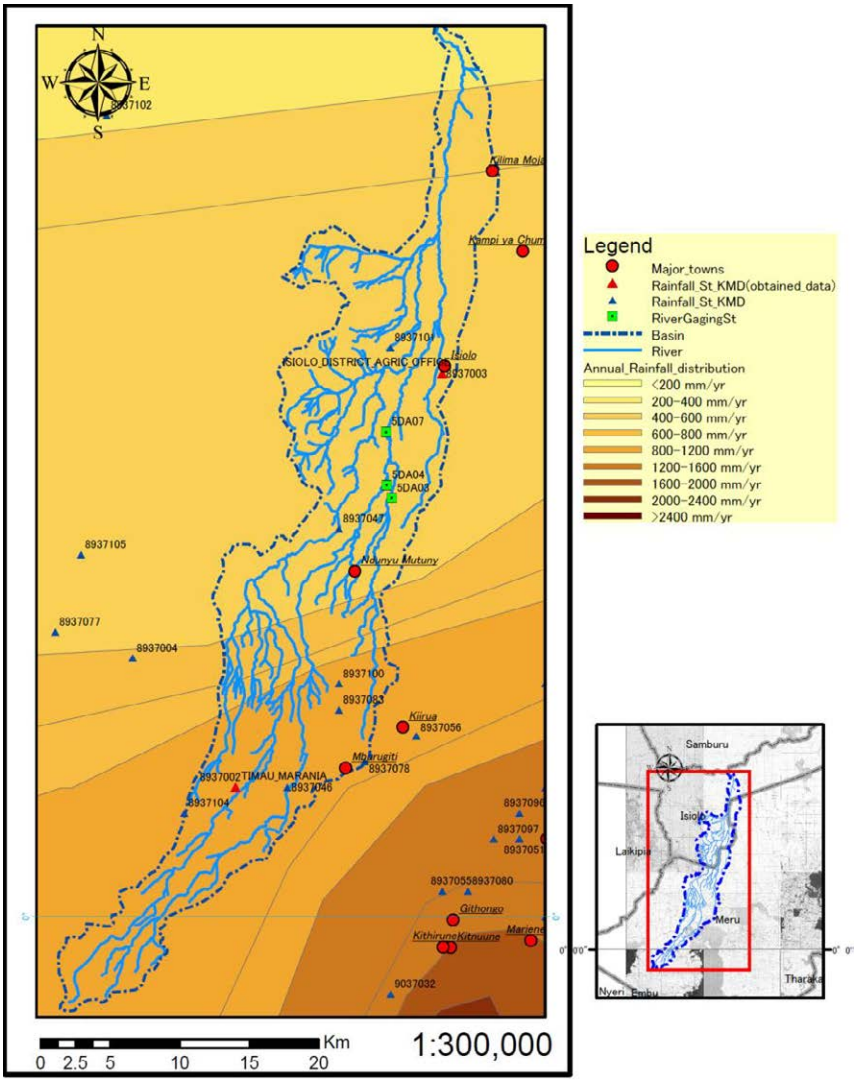
Source: Prepared by JICA Project Team based on WRMA's rainfall data of KMD gauging stations in the period between 1930 and 2011

Figure 2.1.8 Variability of Annual Rainfall at Timau Marania Station

(b) Distribution of Annual Rainfall

Monthly average temperatures vary from 7.6°C in highland to 32°C in low-lying area, and the low-lying area belongs to pindan.[1] Annual rainfall in the vicinity of Mt. Kenya, the headwaters of the river, goes beyond 1,200mm/year, and the average annual rainfall in the downtown of Isiolo which is the largest city in Isiolo River Basin, is approximately 600mm/year. Distribution of annual rainfall in Isiolo River Basin is shown below. From this distribution map, it is known that rainfall distribution is different between upstream and middle/downstream river basins. The annual rainfall in the upstream of EL.2,500m to EL.3,900m varies from 800 to 1,200mm/year, while those in the middle to downstream which occupies approximately 60% of the catchment area varies from 400 to 600mm/year.

[1] Isiolo WRUA and WRMA, SCMP (March 2009)



Source: Prepared by JICA Project Team based on National Water Master Plan, JICA

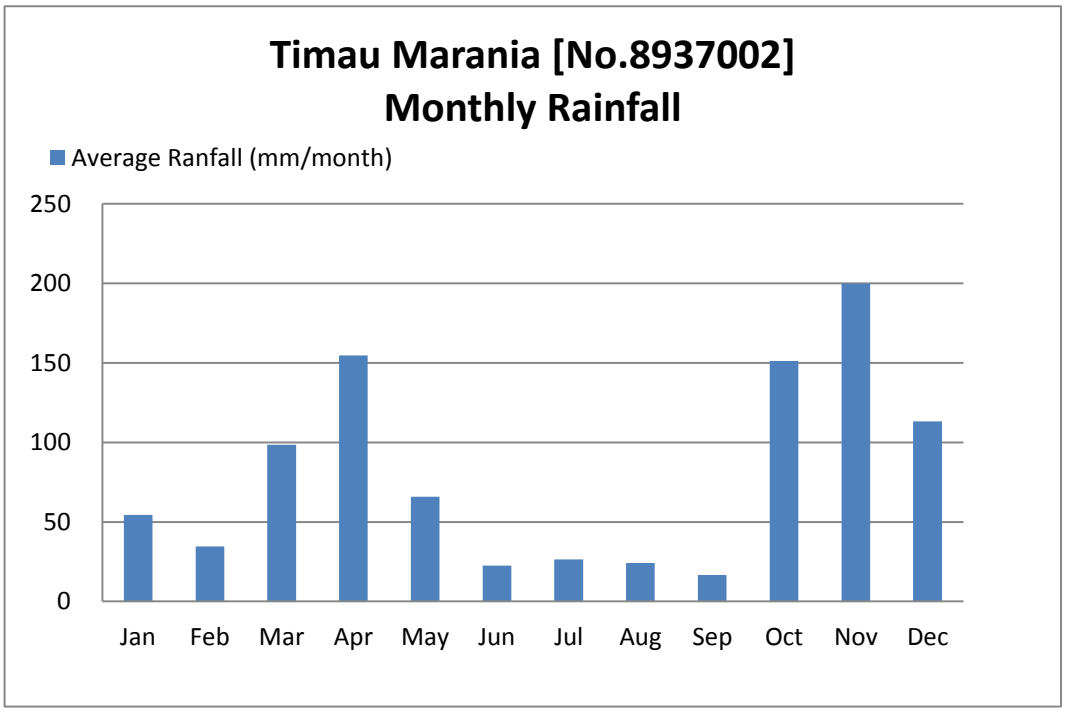
Figure 2.1.9 Distribution Map of Annual Rainfall of Isiolo River Basin

(c) Monthly Rainfall

There are two times of rainy seasons in Isiolo River Basin, i.e. March to May and October to December. Much rainfall is recorded during such a rainy season. Monthly rainfall at Timau Marania Rainfall Gauging Station in the upstream of Isiolo River Basin is shown on Figure 2.1.7. As shown in the following figure, it is understood that the maximum rainfall through the year can be observed in April and November. The heaviest monthly rainfall recorded in November is 200mm/month.

Besides, in recent years, it tends to have heavy rain in a short time. On the other hand, river flow is dried up during dry season of February, March, August and September.[2]

2 Isiolo SCMP



Source: Prepared by JICA Project Team based on WRMA's rainfall data of KMD gauging stations in the period between 1930 and 2011

Figure 2.1.10 Monthly Rainfall at Timau Marania Station

(d) Daily Rainfall

Timau Marania Station

Table 2.1.3 shows maximum daily rainfall, annual rainfall, number of missing data and period of missing data by the respective years from 1957 to 1989 at Timau Marania Station. Red numerical value indicates that there are missing data in the same year. And it means annual rain fall data of the year can be incorrect. The maximum daily rainfall recorded in the same period is 127.7mm/day observed in December 28, 1983. Those of the maximum annual rainfall are 1,737mm/year recorded in 1961. (Data set is different from data described above.)

Table 2.1.3 Observation Record at Timau Marania Station

Year	Date	Maximum Daily Rainfall [mm/day]	Annual Rainfall [mm/yr]	Number of missing data	Period of missing data
1957	1957/10/29	85.6	872	32	1/1-2/1
1958	1958/04/26	67.1	667	0	
1959	1959/12/11	114.3	823	90	1/2-4/1
1960	1960/10/25	51.8	751	0	
1961	1961/12/14	104.6	1,737	28	2/2-3/1
1962	1962/10/12	33.8	645	0	
1963	1963/05/29	63.0	1,161	0	
1964	1964/04/18	64.0	975	0	
1965	1965/03/25	26.4	414	0	
1966	1966/03/29	43.2	703	0	
1967	1967/11/26	52.1	985	0	
1968	1968/04/03	94.0	1,278	0	
1969	1969/05/02	84.3	865	0	
1970	1970/10/15	51.1	625	0	
1971	1971/04/27	61.7	631	0	
1972	1972/06/22	54.1	815	0	
1973	1973/04/15	32.9	640	0	
1974	1974/11/07	52.8	849	0	
1975	1975/11/17	42.6	740	0	
1976	1976/12/14	42.3	634	30	9/2-10/1
1977	1977/11/07	68.8	1,008	0	
1978	1978/11/26	49.4	1,052	0	
1979	1979/02/01	75.8	1,097	0	
1980	1980/10/19	62.5	775	30	9/2-10/1
1981	1981/11/07	65.3	1,173	0	
1982	1982/10/29	73.2	1,214	0	
1983	1983/12/28	127.7	1,093	0	
1984	1984/11/15	75.6	837	0	
1985	1985/11/12	65.1	775	0	
1986	1986/10/26	63.4	1,119	0	
1987	1987/06/04	64.7	723	0	
1988	1988/12/21	67.8	1,537	0	

Source : Prepared by JICA Project Team based on the observation data of the period of 1957 to 1989 at KMD owned Timau Marania Rainfall Gauging Station.

From October to December is short rainy season and from March to May is long rainy season in Kenya.

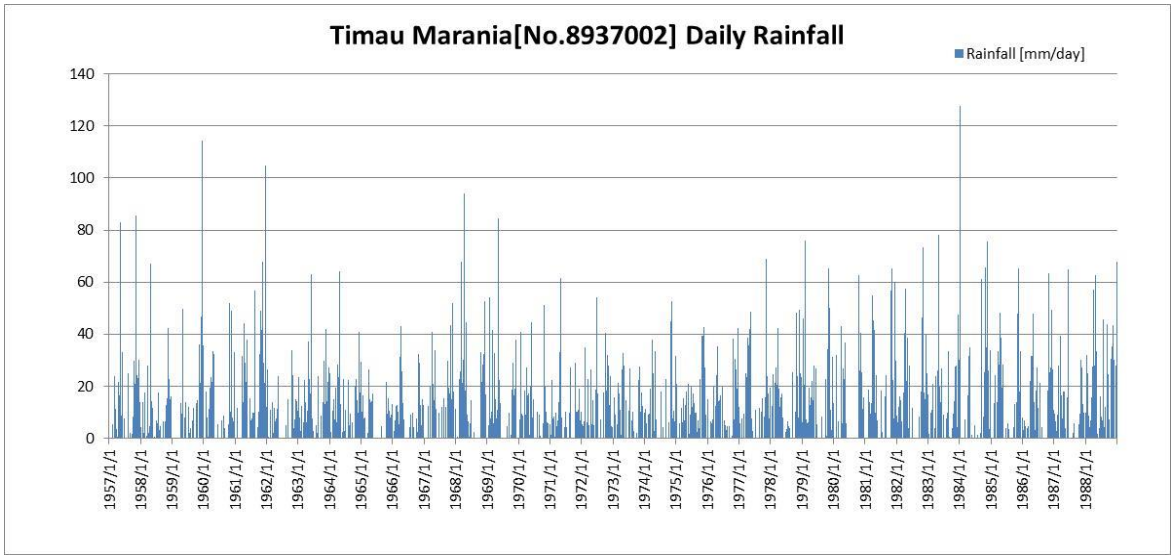
Concerning missing data (1957, 1959, 1961, 1976 and 1980), maximum daily rainfall of other 27 years is recorded 10 times in short rainy season, 9 times in long rainy season, 5 times in October, once in February and twice in June.

Missing period of 1957 is from 1/1 to 1/2. Frequency to occur maximum daily rainfall in this season is not high. Missing period of 1959 is from 1/1 to 1/4. The period includes long rainy season. However, maximum daily rainfall data recorded as 114.3mm in 11/12. This rainfall data is one of the highest records of the list and probability to exceed this rainfall is relatively low. Missing period of 1961 is from 2/2 to 1/3 that means just before

long rainy season. From same reason, the data 104.6mm of 14/12 is concluded as maximum rainfall of the year. Missing period of 1976 is from 2/9 to 1/10. There is no maximum daily rainfall recorded on the same season of other years. Possibility to record maximum rainfall is low. And also, missing period of 1980 is from 2/9 to 1/10. From same reason, the data is concluded as correct.

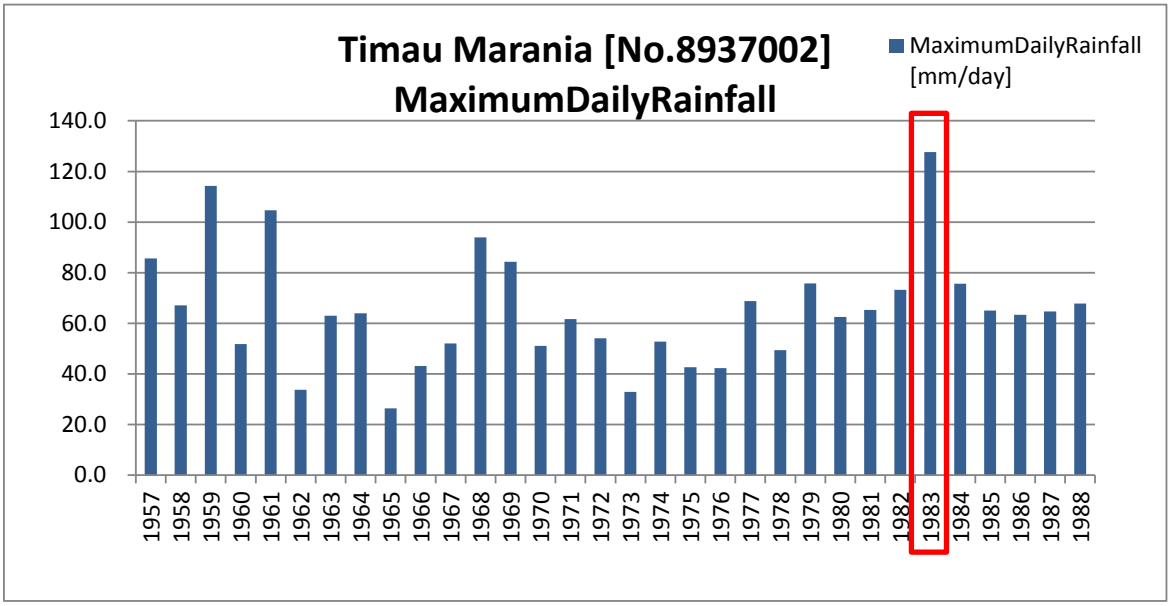
Therefore, probability to record maximum daily rainfall data in missing period is relatively low. JICA project team applies the data to analysis.

Variability of daily rainfall and maximum daily rainfall per year during the observation period of 1957 to 1989 at Timau Marania Station is shown on Figure 2.1.11



Source : Prepared by JICA Project Team based on the observation period of 1957 to 1989 at the KMD Timau Marania Rainfall Gauging Station that is offered by WRMA

Figure 2.1.11 Transition of Daily Rainfall at Timau Marania Station



Source : Prepared by JICA Project Team based on the observation data of the period of 1957 to 1989 at the KMD Timau Marania Rainfall Gauging Station that is offered by WRMA.

Figure 2.1.12 Maximum Daily Rainfall in a Year at Timau Marania Station

Probability statistics analysis by each probable years (1/50, 1/30, 1/20, 1/10 and 1/5) was carried out based on the maximum daily rainfall in a year during the observation period for 30 years (There are some missing periods.) at Timau Marania Rainfall Gauging Station within the river basin.

Table 2.1.4 shows the result of hydrological statistics calculation and the planned daily rainfall.

Applied Provability Distribution Model "Gumbel distribution" is selected based on "guideline of high water planning" by Japan Institute of Country-ology and Engineering.

Table 2.1.4 Result of Rainfall Calculation by Provable Years at Timau Marania Station

Name of Rainfall Gauging Station : Timau Marania
Observation Period : 1957 to 1989
Applied Provability Distribution Model : Gumbel distribution

Provable year	Jack Knife Estimate Daily Rainfall (mm/day)	Planned Daily Rainfall (mm/day)
1/5	81.6	82
1/10	95.1	96
1/20	108	108
1/30	115.4	116
1/50	124.7	125

Isiolo DAO Station

Maximum daily rainfall and annual rainfall, number of missing data and period of missing data by each year in the observation period of 1957 to 1989 are shown on

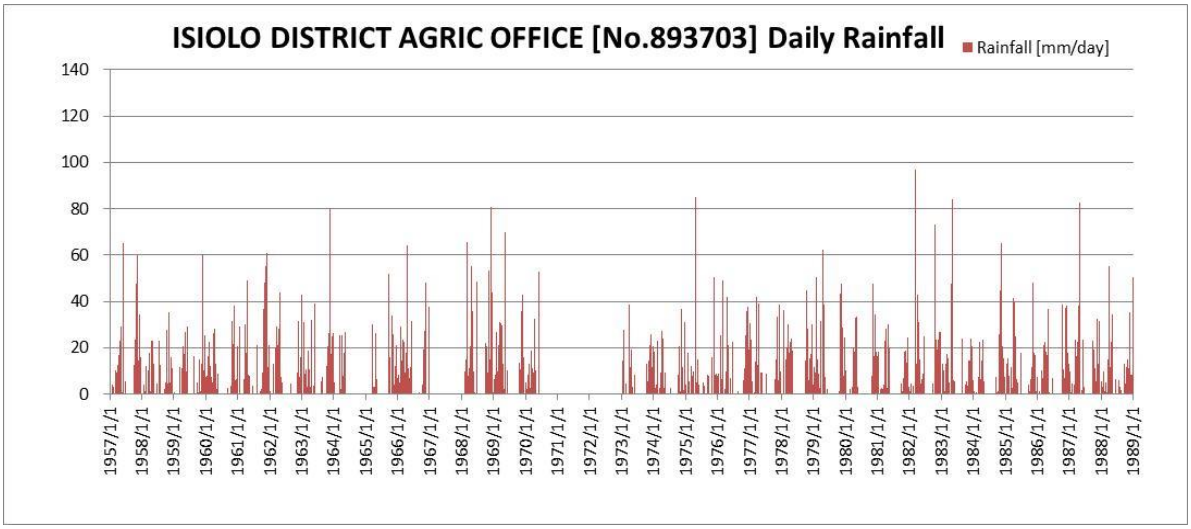
Table 2.1.5 below. The maximum daily rainfall in the observation period is 97mm/day recorded on March 10, 1982, and the maximum annual rainfall is 1,261mm/year recorded in 1961.

Table 2.1.5 Observation Record of Rainfall at Isiolo DAO Station

Year	Date	MaximumDailyRainfall [mm/day]	AnnualRainfall [mm/yr]	Number of missing data	Period of missing data
1957	1957/05/28	65.3	737	0	
1958	1958/11/06	35.6	455	0	
1959	1959/11/24	60.5	550	59	1/2-3/2
1960	1960/11/17	38.4	593	0	
1961	1961/11/25	61.0	1261	28	2/2-3/1
1962	1962/04/22	43.7	689	62	1/2-2/1, 10/2-11/1
1963	1963/11/15	79.7	859	0	
1964	1964/05/02	27.0	209	243	1/2-3/1, 6/2-9/1, 10/2-12/31
1965	1965/09/21	52.0	309	94	1/1-2/1, 5/2-6/1, 7/2-8/1
1966	1966/04/13	64.1	682	30	9/2-10/1
1967	-	0.0	0.0	183	3/2-6/1, 10/2-12/31
1968	1968/11/27	80.8	1243	1	1/1
1969	1969/05/03	70.0	906	0	
1970	1970/05/28	53.1	296	213	6/2-12/31
1971	-	0.0	-	-	No data
1972	-	0.0	-	-	No data
1973	1973/03/28	38.6	475	1	1/1
1974	1974/11/08	36.7	498	0	
1975	1975/04/18	85.2	475	0	
1976	1976/02/26	49.2	624	0	
1977	1977/03/23	42.1	646	0	
1978	1978/10/13	44.8	807	30	6/2-7/1
1979	1979/04/10	62.3	726	0	
1980	1980/11/10	47.7	528	0	
1981	1981/05/03	30.3	467	0	
1982	1982/03/10	97.0	763	0	
1983	1983/04/27	84.1	555	0	
1984	1984/11/08	65.4	535	0	
1985	1985/11/05	48.0	581	0	
1986	1986/10/10	38.8	694	0	
1987	1987/04/23	82.9	638	0	
1988	1988/03/25	55.2	717	0	

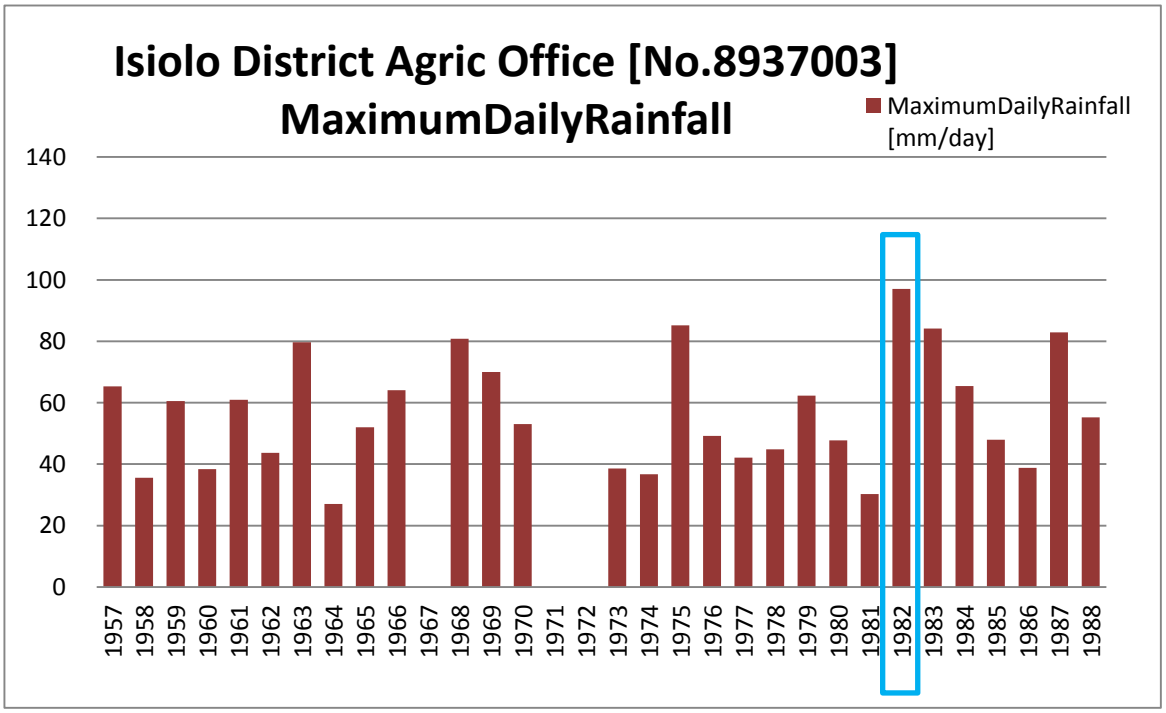
Source : Prepared by JICA Project Team based on the observation data for the period of 1957 to 1989 at KMD owned Isiolo DAO Rainfall Gauging Station

Variability of daily rainfall and maximum daily rainfall per year during the observation period of 1957 to 1989 at Isiolo DAO Station is shown on Figure 2.1.13



Source : Prepared by JICA Project Team based on the observation data for the period of 1957 to 1989 at KMD owned Isiolo DAO Rainfall Gauging Station

Figure 2.1.13 Transition of Daily Rainfall at Isiolo DAO Station



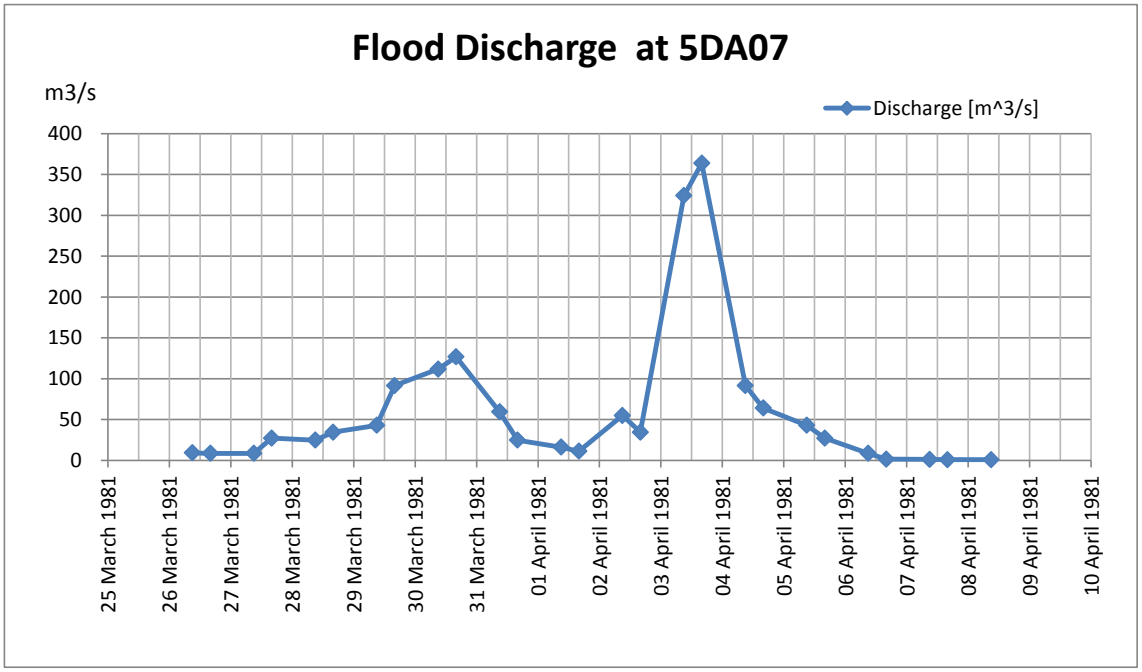
Source : Prepared by JICA Project Team based on the observation data for the period of 1957 to 1988 at KMD owned Isiolo DAO Rainfall Gauging Station

Figure 2.1.14 Maximum Daily Rainfall through the Year at Isiolo DAO Station

(3) Flood Peak Runoff Discharge

Peak flow on observation from 1971 to 2011 (There are missing data more than 12 years) at 5DA07 station that is located at upstream of Isiolo Town is 364 m^3/s on 16:00, 3/4/1981.

However, observation system works twice a day, 9:00 and 16:00. There is a possibility not to record correct flood peak runoff data. This data is offered by WRMA as converted data. Water level data is not offered.



Source : WRMA

Figure 2.1.15 Peak Flow of 5DA07station

Analysis from the view point of hydrology and hydraulics is studied. Specifically, daily rainfall data of each scale is calculated by stochastic method. In addition, rainfall intensity is estimated from the daily rainfall data. Flood peak runoff of each stochastic scale at main tributary stream and upstream of Isiolo Town is computed by rational formula. Generally, rational formula applies to basin area that is less than 100km2. However, rainfall and discharge measurement is not observed in this area and past flood flow data does not exist. There is no other choice. Dividing map of Isiolo River Basin is below.

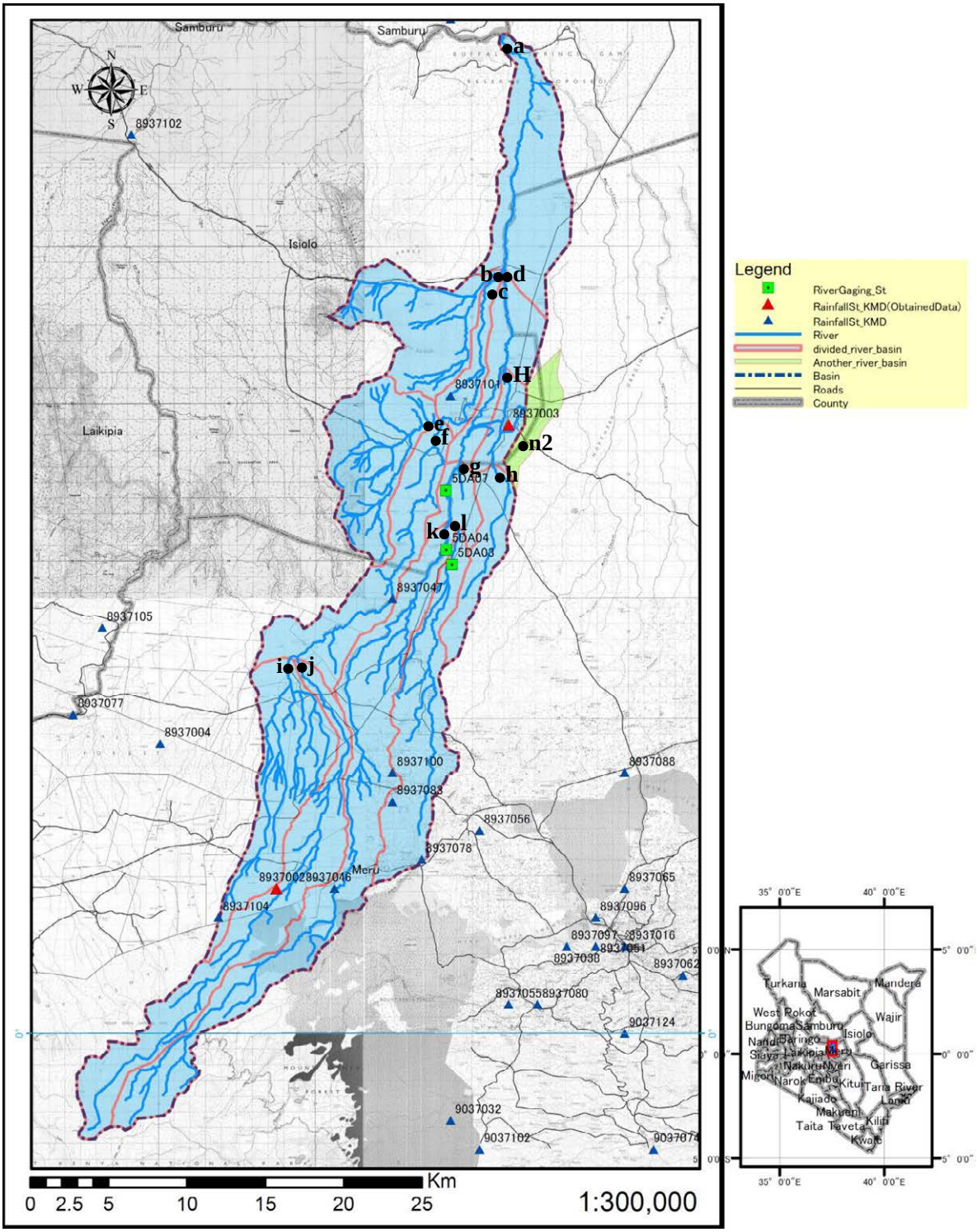


Figure 2.1.16 Dividing map of Isiolo River Basin (Sample spots are marked)

Rational formula

Rational formula and setting condition are below.

$$Q = 1/3.6 * f * r * A$$ ----------Rational formula

Q : flow discharge (m^3/s)

f : coefficient of discharge

r : average of rainfall intensity within arrival time of flood (mm/h)

A : dimension of river basin (km^2)

* Rational formula is a calculating formula to estimate flood peak runoff when rain water flows intensively from the most distant spots to sample spots. Considering canning condition of the surface, amount of flow is calculated by function as rainfall intensity and dimension of river basin.

[Condition of flood peak runoff calculation by rational formula]

- Calculating formula of arrival time of flood tc：Kraven-Rziha
- Planning daily rainfall of each scale：1/50 r24 =125 mm/d、1/30 r24 =116 mm/d、1/20 r24 =108 mm/d、1/10 r24 =96 mm/d、1/5 r24 =82 mm/d
- Formula of average rainfall intensity within arrival time of flood r：Monobe formula
- Coefficient of dischargef = 0.6（only n2 spot is applied f=0.45）
- Dimension of river basin：total dimension of river basin 474km^2

Table 2.1.6 shows the result of calculation of flood peak runoff by rational formula. The most inferior point of Isiolo River Basin to join in Ewaso Ng'iro North River is approximately 650m^3/s on 1/10. G and h spots of upstream of Isiolo Town (upstream of Eastern Marania River and Merire River) is 280 m^3/s、85 m^3/s on 1/10.

Table 2.1.6 Result of Calculation of Flood Peak Runoff by Rational Formula (Left to right : 1/50, 1/30, 1/20, 1/10, 1/5）

Point	Arrival time of flood t_c (min)	Riverbasin area A(km^2)	1/50 : r24 = 125mm/day Peak discharge Qp(m^3/s)	1/30 : r24 = 116mm/day Peak discharge Qp(m^3/s)	1/20 : r24 = 108mm/day Peak discharge Qp(m^3/s)	1/10 : r24 = 96mm/day Peak discharge Qp(m^3/s)	1/5 : r24 = 82mm/day Peak discharge Qp(m^3/s)	River	Name of the Point
i	96	45.0	238	221	206	183	156	-	
j	218	64.1	196	182	169	151	129	Western.M.R	
k	275	90.1	236	219	204	181	155	Eastern.M.R	
l	131	46.3	199	184	172	153	130	-	
e	71	40.4	260	242	225	200	171	-	
f	333	150.6	347	322	300	267	228	Western.M.R	
g	297	145.6	362	336	313	278	237	Eastern.M.R	Isiolo townの直上流地点
h	76	17.6	109	101	94	83	71	Merire.R	Isiolo townの直上流地点
b	76	11.4	70	65	61	54	46	-	
c	400	229.6	468	435	405	360	307	Western.M.R	
d	368	184.3	397	369	343	305	260	Eastern.M.R	Western.M.Rとの合流地点
H	104	27.1	136	126	117	104	89	Merire.R	Eastern.M.Rとの合流地点
a	489	473.6	844	783	729	648	554	Isiolo.R	Ewaso Ng'iro North river合流点
n2	31	2.4	21	19	18	16	13	-	隣接流域からの流路変更地点

Estimate arrival time can be utilized as lead time of early warning system.

2.2 SOCIO ECONOMIC CONDITIONS

2.2.1 Administration

(1) Local Administration

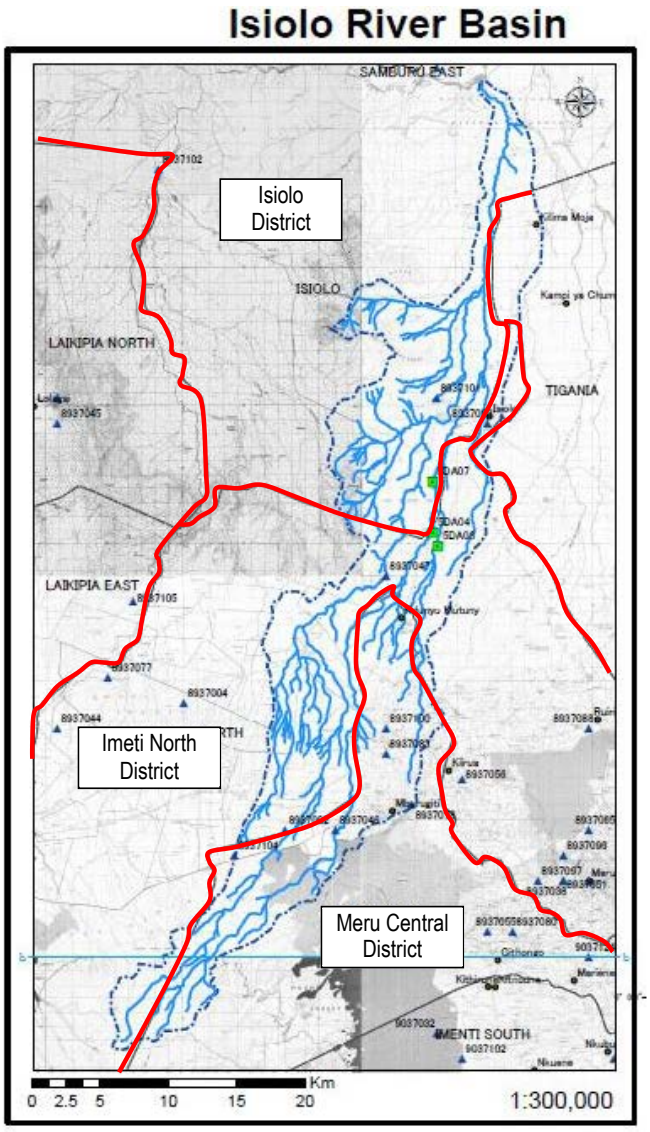
Administration division of the Republic of Kenya as of March 2013 is shown below.

Table 2.2.1 Administration Division in Republic of Kenya

Administration Unit	Ruler
Province	Province commissioner
District	District commissioner
Division	Chief
Location	Chief
Sub location	Assistant Chief
Community Unit	Leader
Village	Elder

In the administration system in Kenya, local governments (Province – District – Division – Location – Sub-location) are organized under President's office. The smallest administrative unit is Sub-location. Besides, although it is not an administrative organization, there is a village as a unit of rural community. Chieftains of the respective organizations are called "Province Commissioner" for Province, "District Commissioner" for District, "Chief" for Division and Location, "Assistant Chief" for Sub Location and "Elder" for Village.

Isiolo River Basin is mainly included in the three major districts of Meru Central, Imenti North and Isiolo. Locations of Isiolo River Basin and District and the administrative organizations included in Isiolo River Basin are shown in the following figure.



Source: International Livestock Research Institute GIS unit
Prepared by JICA Project Team based on the classified data in 1998

Figure 2.2.1 Locations of Isiolo River Basin and District

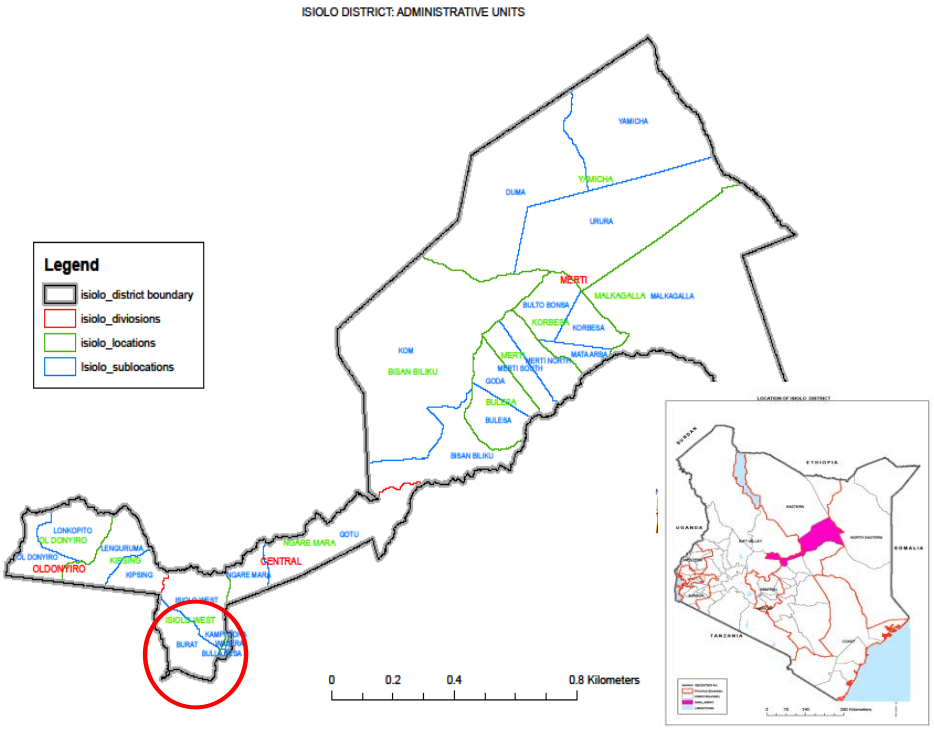
The detail of division of Division、Location, Sublocation in Isiolo River Basin is shown as below.

Table 2.2.2 Administrative division at Isiolo River Basin (June, 2004)

Districts	Divisions	Locations	Sublocations
Isiolo	Central	Central	Bulla Pesa
			Kampi Odha
		Isiolo East	Kiwanjani
			Wabera
		Isiolo West	Burat
			Isiolo West
		Ngare Mara	Ngare Mara
Meru Central	Abothuguchi West	Kiamiogo	Kiamiogo
		Kibirichia	Kimbo
		Ntugi	Mboroga
		Ntumburi	Kamarete
			Thiira
	Buuri	Kiirua	Kithima
			Nkando
		Kisima	Ntirimiti
		Rwarera	Kirwiro
			Mugae
	Timau	Kisima	Buuri
			Mutonyi
		Ngusishi	Mutarakwa
	Mt Kenya Forest	Mt Kenya Forest	Mt Kenya Forest
	National Park	National Park	National park
Meru North	Akithi	Akithi	Thinyaine
	Tigania North	Buuri	Nturingwi
	Tigania West	Mituntu	Mumui

Source : Center for Training and Integrated Research in ASAL Development February 2005 , Upper Ewaso Ngiro River Basin Sub Catchments Directory

Boundary of Isiolo District and Division、Location and Sub location in the district is shown as below. Red circle is the location of Isiolo River Basin.



Soruce : Isiolo District Development Plan (2008 - 2012)

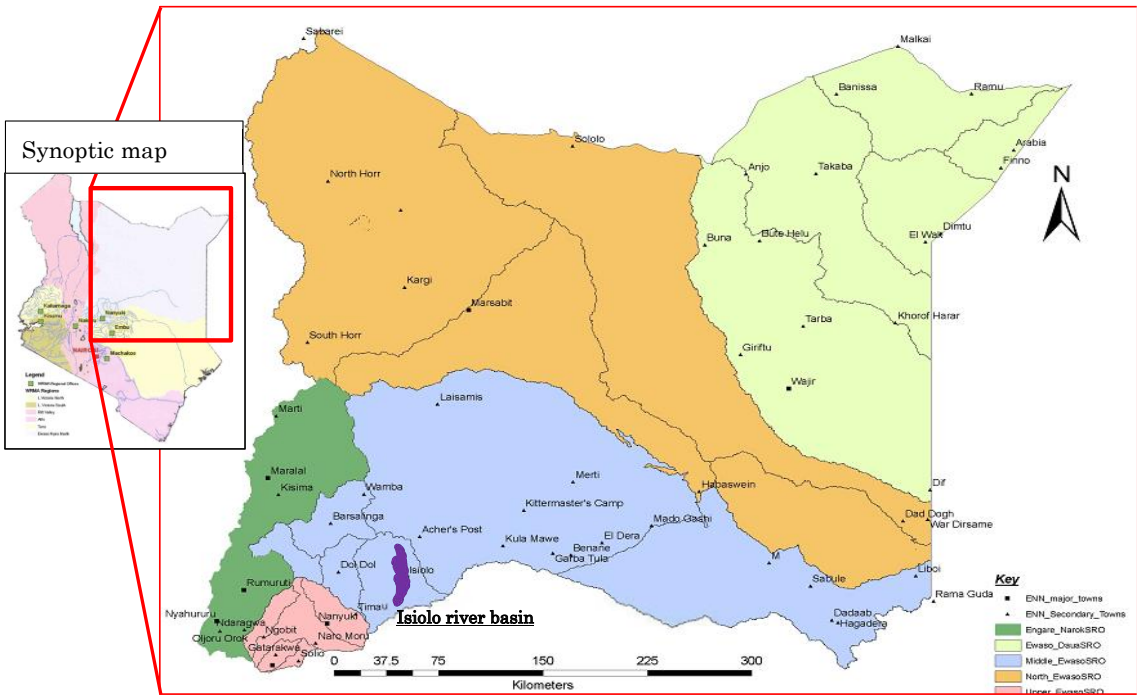
Figure 2.2.2 Location of Isiolo District

(2) Jurisdictional area of WRMA

Relation between the controlled area of WRMA (Water Resource Management Authority) responsible for the administration relating to the water resource and Isiolo River Basin is explained below.

WRMA divides the country in 6 catchment areas and Isiolo River Basin is included in the catchment called “Ewaso Ng’iro North Catchment Area (ENNCA)”.

Nanyuk Region Office in ENNCA have jurisdiction over the whole ENNCA. Besides, the catchment is divided into 5, i.e. Upper Ewaso Ng’iro, Middle Ewaso Ng’iro, Middle Ewaso Ng’iro, Engare-Narok Melphis, Morth Ewaso Laggas and Ewaso-Daua. There are Sub-Regional Offices in the respective regions. Isiolo River Basin is in Middle Ewaso Ng’iro indicated in blue color and belongs to Middle Ewaso Ng’iro Sub-Regional Office.



Source : Ewaso Ngi'ro North Catchment Area Catchment Management Strategy (June 2009)

Figure 2.2.3 Regional Division within the ENNCA Catchment and Location of Isiolo River Basin

Photo 2.2.1 WRMA Middle Ewaso Ng'iro (Isiolo) Sub-Regional Office

Table 2.2.3 Demarcation of Isiolo River Basin

	Regional Office Level	Sub regional Office Level	Sub Catchment Level
Area	Ewaso Ng'iro North Catchment Area(ENNCA)	Middle Ewaso Ng'iro Sub-Region	Isiolo Sub Catchment
WRMA / WRUA	WRMA ENNCA	WRMA Middle Ewaso Ng'iro (Isiolo) Sub-Regional Office	Isiolo WRUA

2.2.2 Population

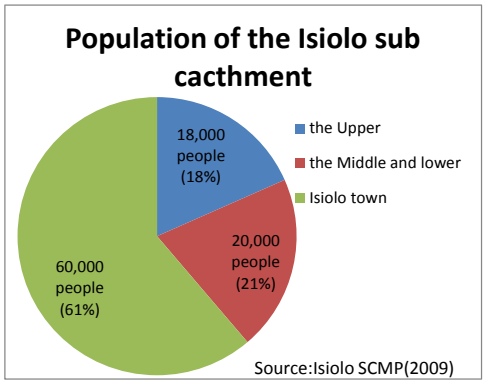
Population census data of 2009 in Isiolo District which includes Isiolo River Basin is presented in Table 2.2.4. The Central Division area including Isiolo Town is densely populated and the population reaches 40,000 persons occupying 40% of the total population of the whole district. No. of households is also concentrated in this area and occupies 45% of the whole district. Especially in Bulla Pesa and Odha of Central area, the population density is high, i.e. about 3,000 persons/km2 and about 1,000 persons/km^2, respectively.

Table 2.2.4 Population Census Data in Isiolo District (2009)

District	Division	Location	Sublocation	Male	Female	Total	Households	Area in Sq. Km.	Population Density
ISIOLO	CENTRAL	CENTRAL	BULLA PESA	11,148	11,574	22,722	6,190	7.66	2,965.93
			ODHA	2,860	3,062	5,922	1,236	5.67	1,044.57
		WEST	BURAT	4,580	4,010	8,590	1,640	345.51	24.86
			ISIOLO WEST	2,162	2,100	4,262	1,004	396.86	10.74
	CHERAB	KORBESA	BULTO BONSA	351	402	753	173	299.13	2.52
			KORBESA	871	939	1,810	361	247.40	7.32
			MATA ARBA	237	266	503	108	121.97	4.12
		MALKAGALLA	MALKAGALLA	1,105	1,071	2,176	443	2,812.81	0.77
		YAMICHA	DUMA	236	121	357	80	1,652.59	0.22
			URURA	587	470	1,057	243	1,621.58	0.65
			YAMICHA	807	764	1,571	307	1,552.10	1.01
	EAST	EAST	KIWANJANI	1,459	1,537	2,996	651	4.41	680.03
			WABERA	7,305	7,130	14,435	3,045	8.57	1,683.76
		NGARE MARA	GOTU	1,040	887	1,927	491	778.93	2.47
			NGARE MARA	2,071	1,522	3,593	759	184.96	19.43
	MERTI	BISAN BILIQU	BISAN BILIQU	663	686	1,349	285	636.46	2.12
			KOM	276	252	528	127	2,567.21	0.21
		BULESA	BULESA	851	888	1,739	384	316.65	5.49
			GODA	628	537	1,165	233	240.92	4.84
		MERTI	MERTI NORTH	2,375	2,448	4,823	998	312.92	15.41
			MERTI SOUTH	1,221	1,289	2,510	552	241.66	10.39
	OLDONYIRO	KIPSING	KIPSING	1,666	1,741	3,407	745	204.62	16.65
			LENGURUMA	1,031	1,122	2,153	473	335.74	6.41
		OLDONYIRO	LONKOPITO	1,406	1,450	2,856	587	365.81	7.81
			OLDONYIRO	3,444	3,528	6,972	1,348	255.06	27.34
Total				50,380	49,796	100,176	22,463	–	–

Source : Kenya National Bureau of Statistic, Census 2009

According to Isiolo Sub Catchment Management Plan, the population in Isiolo River Basin is approximately 98,000 persons. The breakdown by locations within the river basin is as per Figure 2.2.4, and the population by sub-catchment is about 18,000 persons in upstream, about 20,000 persons in middle/downstream and 60,000 persons in the downtown of Isiolo Town. This shows a trend of people to gather in the middle river basin where the water resource is abundant, and it also shows Isiolo, the largest town in the river basin is



Source : Prepared by JICA Project Team based on the population data of Isiolo SCMP

Figure 2.2.4 Population of Isiolo River Basin

the center of economy.

2.2.3 Industry

Agriculture is the most active industry in Isiolo River Basin. Production of honey and nursery tree is also done. Livestock farming for beef cattle and fur is carried out in the upstream basin. In addition, production of charcoal and running of hotel business are also done. The most popular agricultural crops are onion, potato, cabbage, banana, etc. Spring in the middle stream is utilized as irrigation water for agriculture.

2.3 DEVELOPMENT PLAN

2.3.1 Vision 2030

Downtown of isiolo is at present developed economically as the center of development in the northern part of Kenya. According to "Vision 2030" which is the development program of Kenyan government for 22 years from 2008 to 2030, major development programs are as follows.

(1) Development of Logistics Corridor

In Kenya, logistics corridor is planned to be developed connecting with South Sudan and Ethiopia via Isiolo. This project is passing through Garissa, Isiolo, Maralal, Lodwar and Lokichoggio from Lamu Port, and reaching to Ethiopia and South Sudan. Isiolo is scheduled to be developed as a strategic stop of transportation. This corridor will be composed of new road network, railway network, oil pipeline, Lamu Airport, port and harbor at Lamu, and it will connect the coastal area with the resort town to be developed in Isiolo.

Figure 2.3.1 Main Spot of Development Plan of Logistics Corridor

(2) Development of Resort Town

Isiolo is planned to be developed as resort town for a tourists to Mt. Kenya and Meru National Park. Further, Isiolo is expected to be a foothold of economical activitiesy in the northern part of the country.

(3) National water supply and sanitation

Mzima pipeline is planned to be expanded for the purpose of meeting to supply water demand in the proposed development sites of resort in the coastal town, Isiolo, etc.

2.3.2 Isiolo District Development Plan (2008-2012)

According to "Isiolo District Development Plan" which is the development plan of Isiolo District, there are the following programs.

(1) Water Harvesting

The project is to improve an access to the water for community. Community will present the site to be developed, and the community itself will construct the reservoir using the fund raised after appraisal.

(2) Opening of Northern Tourlist Circuit

Garbatua Road will be connected with Kuramawe district through development of the road, and the access to Iisiolo will be strengthened.

2.3.3 Imenti North District Development Plan (2008-2012)

According to "Imenti North District Development Plan" covering in detail the development plan of Imenti North District and Meru Central District in the upstream/middle stream of the Isiolo River Basin, there are the following programs.

(1) Mt. Kenya east pilot project

To improve mainly vegetation along the river, forestation project of nursery tree is planned. 100,000 pieces of nursery tree are planted in rainy season every year.

(2) Sirmon water project

7km of waterway pipe is planned to be constructed for supply of clean water to 2,000 households.

2.3.4 Ewaso Ngi'ro North Catchment Area Catchment Management Strategy (June 2009)

According to "Ewaso Ngi'ro North Catchment Area Catchment Management Strategy" which is the management plan of WRMA in Ewaso Ngi'ro North Catchment, the concept on storage of surface water and underground storage is presented in the Chapter of Water Storage Options in ENNCA as follows.

Table 2.3.1 Water Storage Options in ENNCA

Scale	Surface Storage Options	Ground Storage Options
Household and on-Farm	Roof catchment tanks, (< 50 m^3) Farm pond (< 500 m^3)	RWH Underground tanks (<500 m^3)
Farm/Community/WRUA	Runoff harvesting to pan or dam (< 50,000 m^3), typically offline (out-stream)	Sand dams or sub-surface dams
Sub-catchment	Small – medium sized dam (< 500,000 m^3), on-course or off-course	Artificial groundwater recharge
Catchment (State Schemes)	Large multi-purpose dam, (>500,000 m^3) typically in- stream	

3. ANALYSIS OF FLOOD CHARACTERISTICS AND COUNTERMEASURES

3.1 OVERALL CONDITION ON FLOODS IN THE ISIOLO RIVER BASIN

3.1.1 Records of Flood Damages

Following table presents that floods occur in the Isiolo River Basin year by year, recently. Floods have major adverse effects on agricultural products, livestock, houses, infrastructures such as road, electric cable and etc., lives and properties, bountiful surface soil runoff, sediment deposition in farming land, stockpiled food, pollution of water resources, health problems such as waterborne diseases, increasing of conflicts on water resources, poor nutrition which is caused by damage of stockpiled food and etc.

The flood in 2012 was caused by short but heavey rain and a flash flood and inundation occurred at urban area of Isiolo town. It disrupted transportation and economic activities in the area. Therefore, the flood and damage type is categorized as type A which is the inundation in urvban area. The flood in 2011 was caused by overflow of the Isiolo River. And it caused damage of farmlands, infrastructures and number of houses along the river. Therefore, the flood and damage type is categorized as type B which is the inundation caused by overflow and dyke break. The flood in 2006 was caused by dyke break of the Isiolo River. And it forced many people to evacuate and caused 8 people dead. Therefore, the flood and damage type is categorized as type B, too.

Table 3.1.1 Recent of Flood Damages

Time	Place	Outline of flood damage	Flood Type *
Sep. 25, 2012	Urban area of Isiolo Town, Kiwanjani Sublocation	The flood is caused by a 20-minute heavy rain with high wind. Flash flood occurred and inundated to a depth of below-knee at urban area of Isiolo town and it is detrimental to public transportation and economic activities. However, its adverse effect is limited about one hour. Residential district of Kiwanjani Sublocation where is located near the airport and high altitude, most of damages were that a number of houses were collapsed due to high wind.	Type A
2011	Neighboring area of the urban area of Isiolo Town	Long-term dysfunctional farming land due to inundation, occlusion of culverts, destroyed IWACO's water intake facility and washing away a number of houses	Type B
Oct. 2006	Kulamawe, Bullapesa, Bulla Arera, Juakali, Kambiodha, Kambibulle, Kampigabra and kabiwacho villages	Embankment of the Isiolo river was broken and number of affected people is approximately 500, number of death: 8. People who were affected by flood were forced to evacuate and camp out at the Isiolo Catholic Church.	Type B
2005		Number of deaths: 10	---

*: Flood types are shown in Figure 3.2.1.

Source: Data is created by JICA Project Team based on interview with WRMA and Isiolo WRUA

3.1.2 Flood Condition Inquiring From Relevant Communities

JICA Project team conducted interviews at the local communities in the Isiolo River Basin which were affected by flood damage. Figure 3.1.1 presents a location map of local communities where interview were conducted. Table 3.1.2 presents results of interviews on flood damages at the local communities.

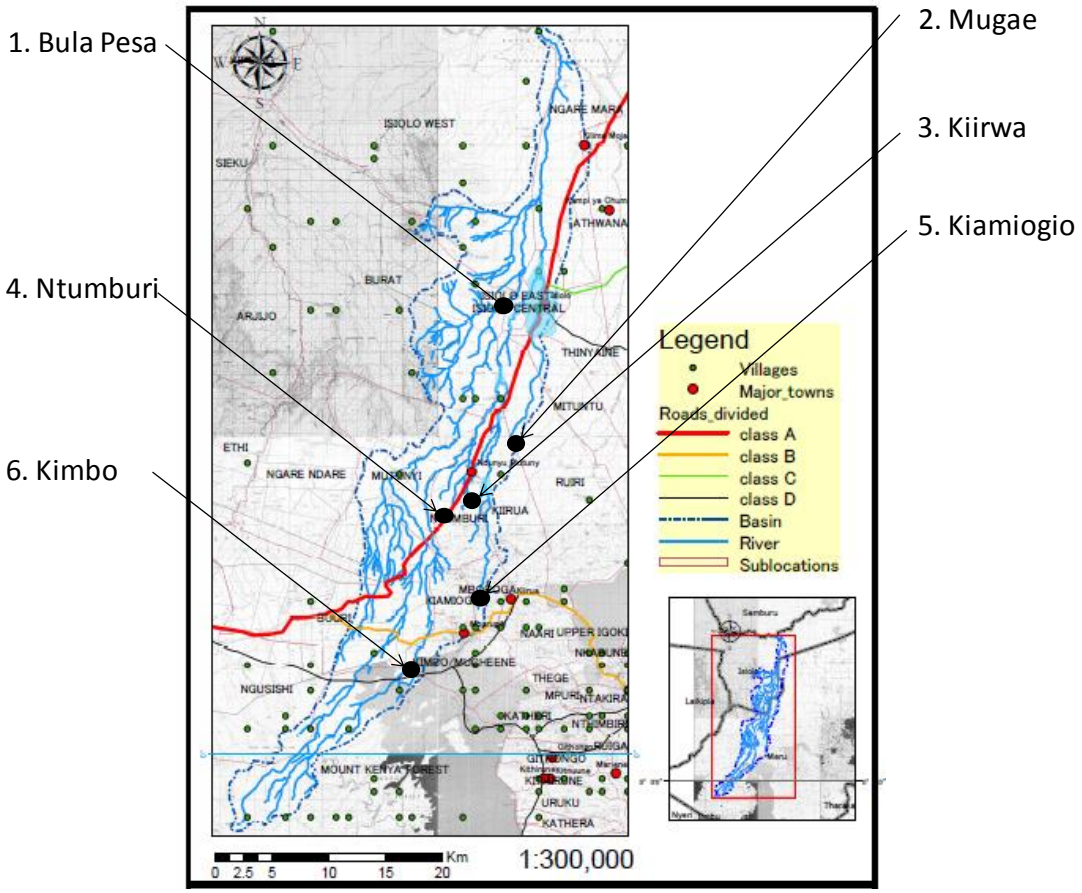


Figure 3.1.1 Map of IsioloRiver Basin and Location of Communities

Table 3.1.2 Communities in Isiolo River Basin and Each flood situation

No	Community	Population	Flood depth	Flood duration	Frequency	Flood type *
1	Bula Pesa	22, 722	Between 50 cm to 1.5 m	2-3 Hours	Erratic, but mostly expected between Oct.-Dec. every year	Inundation in urban area (A) Outflow from reivers (B)
2	Mugae	1,217	Approximately 50 cm	2-3 Hours	Erratic	Debris flow (C) Bank erosion (D)
3	Kiirwa	4,196	Between 50 cm to 1.5 m	2-3 Hours	Erratic	Debris flow (C) Bank erosion (D)

4	Ntumburi	2,847	Between 50 cm to 1.5 m	2-3 Hours	Erratic	Bank erosion (D) Outflow from reivers (B)
5	Kiamiogio	3,181	Approximately 50 cm	2-3 Hours	Erratic	Debris flow (C) Outflow from reivers (B)
6	Kimbo	4,149	Approximately 50 cm	2-3 Hours	Erratic	Bank erosion (D) Debris flow (C)

*: Flood types are shown in Figure 3.2.1.

The detailed damage situations and flood type in each community by project team's inquiring survey on the communities are shown below.

(1) Bula Pesa

- Human settlements are affected when Merire river over flows..... (Inundation in urban area)
- Houses are knocked down by the debris carried by the flooding river.... (Outflow from rivers)
- Roads are badly eroded making access to social amenities like schools and hospitals inaccessible..... (Inundation in urban area)
- In some cases there is loss of human life as a result of flooding of Merire river ..... (Inundation in urban area)

(2) Mugae

- Debris flow damaging river structures like water intakes, and bridges.....(Debris flow)

-There is erosion carrying away arable top soil leaving the farmlands infertile hence decreased agricultural production ..... (Bank erosion)

(3) Kiirwa

-Sediments overflow into farm lands burying crops .....(Debris flow)

-Access roads are eroded by flood water making accessibility to market for agricultural products difficult ..... (Bank erosion)

(4) Ntumburi

- River bank erosion reducing the size of farmlands, hence less agricultural produce ..... (Bank erosion)
- Crops are washed away by flood waters ..... (Outflow from rivers)
- Makeshift bridges are washed away when the river overflows making accessibility to social amenities difficult. ..... (Outflow from rivers)

(5) Kiamiogio

- Sediments are deposited on farmlands submerging the crops .....(Debris flow)
- Makeshift bridges are washed away makinh accessibility to the market for farm products difficult ..... (Outflow from rivers)

(6) Kimbo

- Erosion on farmlands carry away top fertile soil leaving farmlands infertile..... (Bank erosion)
- Debris flow blocks access roads to market for farm products.....(Debris flow)

3.2 FLOOD CHARACTERISTICS AND SITUATION OF DAMAGES IN THE ISIOLO RIVER BASIN

3.2.1 Concept of Flood Characteristics and Situationl of Damages in the Isiolo River Basin

There are four types of flood characteristics in the Isiolo River Basin as described below;

Mark	Flood Type	Area
A	Inundation in urban area	Isiolo Town
B	Inundation which is caused by overflow and dyke break	Midstream and tributary stream
C	Debris flow	Upstream
D	Bank erosion	Entire basin

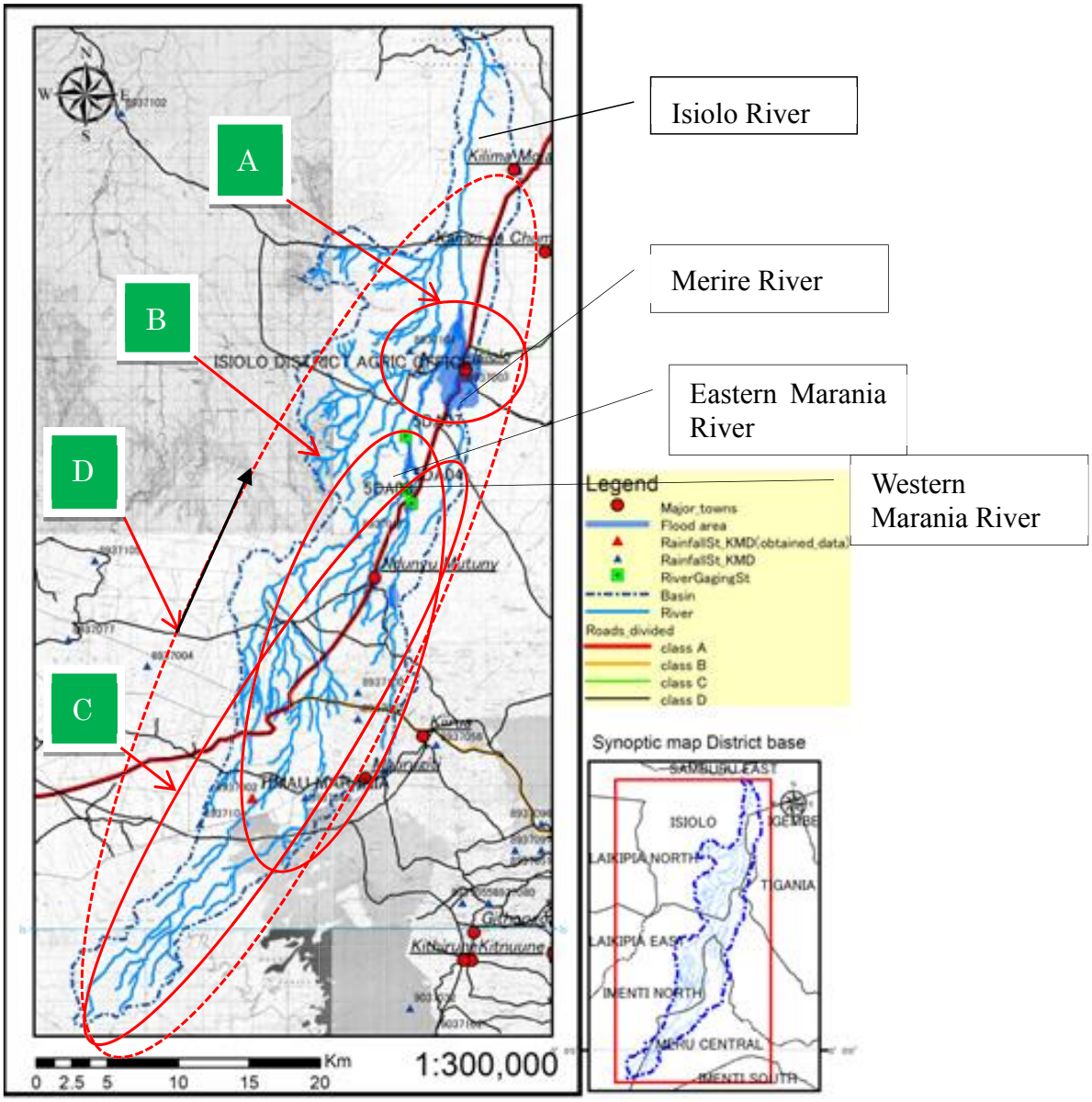
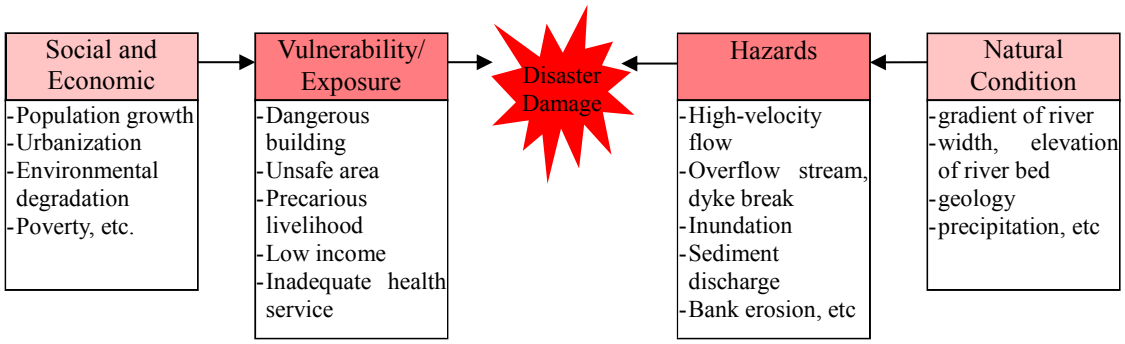


Figure 3.2.1 Flood Types and Areas in Lumi River Basin

Flood damage has a close relationship with between natural condition and social and economic condition in a local area. Natural condition defines types of Hazards in a river basin and social and economic condition defines vulnerabilities and exposures. Moreover, it could be said that disaster (flood) damage is defined from both aspects. Characteristics of flood damage are analyzed using information of last chaper (Natural condition and Socio-economic condition) about each flood characteristics of A), B), C) and D) as above-mentioned.



Source: Revised by JICA Project Team, based on material of "Community and Development assistant of Disaster Prevention, Mr. Mikio Ishiwatari (1997)

Figure 3.2.2 Mechanism of Flood Damage

3.2.2 Inundation in Urban Area of Isiolo Town (A)

Inundation near the Isiolo town area (Flood Characteristics (A)) is described in detail from the aspects of conditions on natural and socio-eco

(1) Flood Characteristics from Natural Conditions

Natural Conditions in the Isiolo River Basin that are described in the last chapter and Hazards in this area are shown as Table 3.2.1.

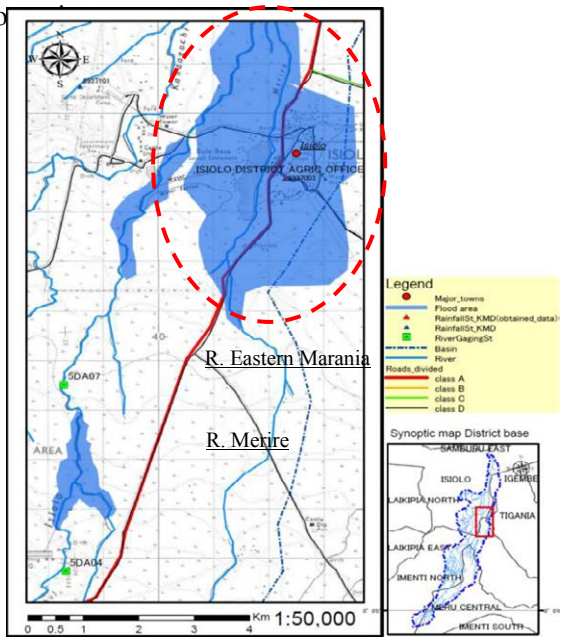


Table 3.2.1 Natural Conditions and Hazards in urban area of Isiolo town

Natural Conditions	Hazards

Approximately, geographical gradient is 1/50; gradient of river bed is 1/100	High velocity of surface and inundated water
Clayey soil	Since rain water doesn't seep underground, surface run-off occurs

- The Merire River flows in urban area and the Eastern Marania and Western Marania River flow in the western part of the town.
- As geography gradient is 1/50 and river bed gradient is 1/100, therefore, flood arrival time is short and surface and inundated water have high velocity.
- Rain water doesn't seep underground and surface run-off occurs in this basin, because surface soil is composed chiefly of clay.


Condition of inundation in the urban area of Isiolo town

- JICA Project team infers that urban area and its surroundings have high sediment runoff and high ratio of runoff. This area is located in semi-arid zone and its vegetation is shrub zone. Therefore interception of rainfall and water retention function can't be very effective.
- There is only data of daily precipitation and daily maximum rainfall of Isiolo DAO in the Isiolo town is 97mm. JICA Project team infers that characteristics of precipitation in this area are high and intensive rainfall within a few hours. Result of calculated 10-year rainfall intensity during flood arrival using rational method is 26.7mm per hour at the upstream point (h) of Isiolo town. Considering this factor, we think result of calculation is appropriate.
- 10-year probable peak flood runoff in the Merire River is calculated 80m3/s and 5-year runoff is 70m^3/s. Current capacity of flow is not enough to floods which might be occurred only once in few years and it is natural phenomenon that the Merrire River overflows.


Condition of inundation in the urban area of Isiolo town

(2) Characteristics of Flood Damage from Socio-economic Conditions

Relationship between conditions on Socio-economic and Vulnerability/ Exposure to Natural disasters in urban area of Isiolo town is shown in below.

Table 3.2.2 Conditions on Socio-economic and Vulnerability/ Exposure Urban Area of Isiolo

Socio-economic conditions	Vulnerability/ Exposure
Highly-populated residential area, (60% of population in the river basin, population density; 3,000 per square kilometer)	A large number of refugees who might be affected by flood
There are 45% of houses which stand all in this river basin	A large number of houses that might to be affected by flood
Commercial capital in the region	A temporary halt in economic activities due to inundation
Key junction of transportation network	A temporary halt and/or stagnation in logistics due to inundation
Resort area and facilities for tourists are placed	Stoppage and halt of service for tourists, due to inundation
Expansion of the airport	An increased risk of flood damage

- Population in the Isiolo town area is approximately 60,000. Even urban area inundates in a short time, flood damage gives a great impact to socio-economic in this region.
- Now infrastructure development projects such as expansion of the airport and construction of roads are in progress according to the higher regional master plan. In conjunction with these developments, housing land development is also promoting. However, impacts to flood management and municipal effluent are unconsidered in these development plans.

(3) Flood Damage Mechanism

Regarding to inundation in the urban area, three contributing factors are identified as described below;

1) Lack of flow capacity in the Merire River (River Water)

Lack of flow capacity of the Merire River which flows through the Isiolo Town is one of the causes of inundation in town area. There are some problems of natural conditions and problems of socio-economic conditions which increase it.


The Merire River runs in the Isiolo town

Regarding the problems of natural conditions, the Merire River doesn't have enough width and cross-sectional area.

Merire River has approximately 5m width and 0.5m height. Therefore, if we consider that the cross sectional shape is rectangular and gradient of riverbed is 1/100, flow capaciy of the river channel is approximately 4 m^3/s.

Based on the calcuration of rational formula mentioned before, 5 years return period flood discharge is approximately 75 m3/s and 10 years return period flood discharge is

approximately 85 m3/s. Not all the amount of flood discharge will run through into the town area. Even though, the flow capacity of the Merire River is obviously not sufficient.

Main riverbed material is sand. Height of river channel is approximately 0.5~1m. Sediment accumulates in the culvert. Sediment and disposed garbage are some of causes of culvert clogging.

Culvert along the Merire River in Isiolo town

Regarding the socio-economic problems, mainly in the downstream of the Merire River, houses are built in the riprian land illegally. Consequently, it is very difficult to widen the river channel. This issue should be encountered, too.

Many houses are built near the Merire River and the walls are encroaching river channel (upstream view)

Downstream of Merire River (upstream view) squatter's houses are on the left bank of the river channel

Sediment runoff occurs in the upstream of the Merire River and accumulates in the downstream. Not only the accumulation of sediment, but also the clogging of culberts by the illegally disposed garbage is one of the causes of reduction of flow capacity. A box-culvert located at the downstream end of the town area was clogged, and the upper side water of it was dammed up and water level became very high. For that reason, the inundated water depth became 2 to 3 meters.

A box culvert bridge at the downstream end of the town of the MerireRiver (Downstream view)

10 persons were dead in 2005, and 8 persons were dead in 2006. It is said that these persons were drowned by the highly dammed up flooded water or swept away by the flooded water.

2) Poor storm drainage system in whole Isiolo town (Inland Water)

Drainage system such as drainage channels, culverts, side ditches of road and etc. have not been developed to function as a network in Isiolo town. Therefore, drainage capacity in downtown is reduced and when rain in torrents in the urban area, inundation is occurred to stay on the surface of the road without being drained away. The depth is up to 50cm like around under knee deep of adult and there is the place that is around 2.5% or 1/40 of maximum inclines geographically and flood has a rapid current in the small alley of the urban area and it is dangerous for the vulnerable people to disaster such as children, women and the aged and the report that someone comes a gutzer is heard. In addition, by the short rain like 2-3 hours, commercial district of the city central is flooded depending on time of the flood outbreak, and it is said that influence on this local economy is extremely damaged to be suspended all economic activity.

Situation of inundation in the town center where shops stand side by side

Situation of inundated house

Summarizing the above, it is found that the flood in Isiolo city exist both inland and outside water damage. Inland flood with poor drainage of similar local city is to be heard well in Kenya, in discussion with MWI and WRMA, it is found that the need of the correspondence is recognized.

3) Changing water course due to construction of airport and roads

Recent years, due to construction of airport and road in the mountainside of Isiolo town, water course changed by influences of these new facilities.

In the past rain water ran from southern part of urban area didn't flow in a direction to the town area,it traveled down to the north in the eastern slope of the town. After the construction of those facilities, rain water from the south is blocked by embankment for the airport and roads and it is leading to the town area.

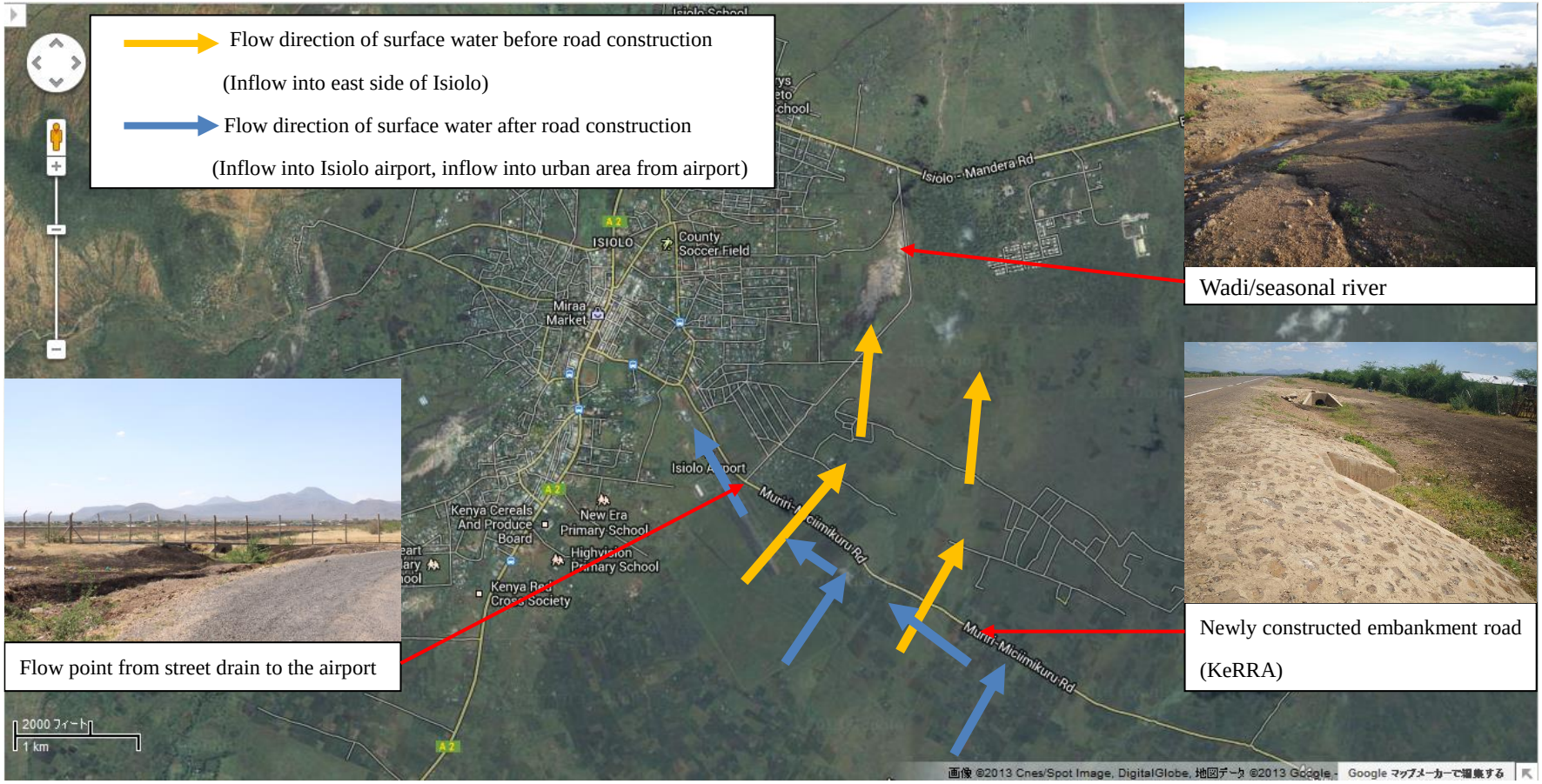
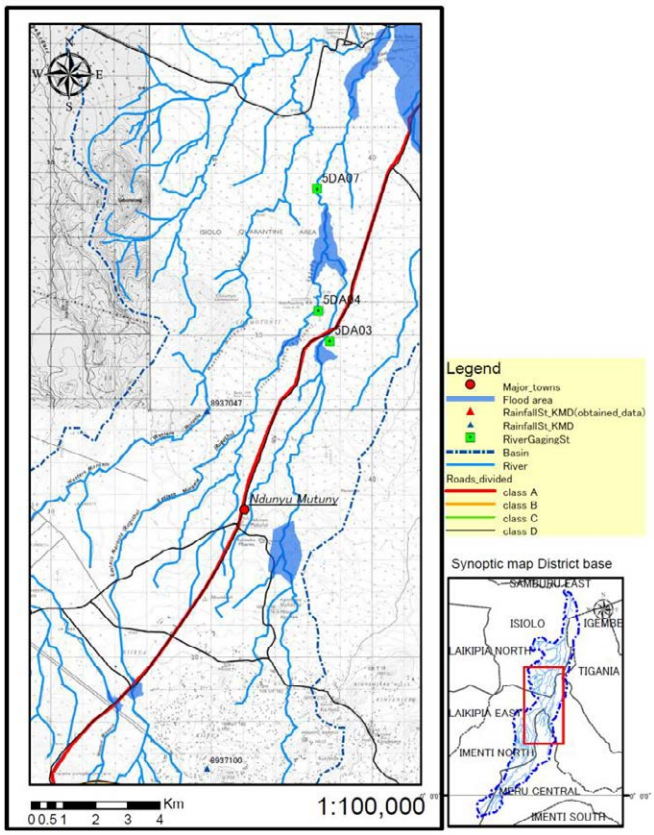


Figure 3.2.3 Direction of Rain Water from Airport Area

3.2.3 Inundation which is caused by overflow and dyke break in the middle river basin (B)

Flood Characteristics (B) in the middle of Isiolo River Basin is caused by overflow and dyke break. And it is described in detail from the aspects of natural, socio-economic conditions.



(1) Flood Characteristics from Natural Conditions

Natural Conditions in the Isiolo River Basin that are described in the Chapter-1 and Hazards in this area are shown as below table.

Table 3.2.3 Natural Conditions and Hazards in the Middle Isiolo River Basin

Natural Conditions	Hazards
Approximately, geographical gradient is 1/20; gradient of river bed is 1/50 – 1/30	High water velocity, unstable water course
Sandy soil	Vulnerable to erode

- Major rivers in the middle river basin are the Eastern Marania River and Western Marania River. In addition to these major water courses, there are many small tributaries and most of them are dry rivers normally.
- Geographical gradient is 1/20 and gradient of river bed is 1/50 - 1/30. The Isiolo River runs through the alluvial fan in the middle of its basin. The river has a sharp inclination; hence JICA Project team infers that the velocity flow is high and water course is unstable.
- Due to spreading clayey soil on surface layer in the upstream near Mt. Kenya, rain water doesn't seep underground and it accumulates in the middle river basin. Therefore JICA project team presumes that the river has much run off when floods occur.
- Calculated flood flow volume at the Eastern Marania River (g) is 260m^3/s (10-year flood) and 240m^3/s (5-year flood). Calculated flood flow volume is 250m^3/s (10-year flood) and 230m3/s (5-year flood).

(2) Characteristics of Flood Damage from Socio-economic Conditions

Relationship between conditions on Socio-economic and Vulnerability/ Exposure to Natural disasters in the middle Isiolo River Basin is shown in below.

Table 3.2.4 Conditions on Socio-economic and Vulnerability/ Exposure in the Middle of Isiolo River Basin

Socio-economic conditions	Vulnerability/ Exposure
Houses are dotted around dry rivers	When flood water comes through dry rivers, it leads to damage of houses along the rivers.
Plantation Farming land and scrub forest	Agricultural damages are occurred. Lose/ threaten former's livelihood
Highway and trunk route	A temporary halt and/or stagnation in logistics due to inundation
Development of Tourist resources	Stoppage and halt of service for tourists, due to inundation
Socio-economic conditions	Vulnerability/ Exposure

- Vegetation and land use in the middle of Isiolio River Basin is mainly farming land and scrub forest. When flood occurs, there is heavy agricultural damage in this area.
- Along with extension of urban area of Isiolo town, houses are built near water course of dry rivers. Once floods occur in dry rivers, flood flow hits and washes away those houses.

House was destroyed by flood

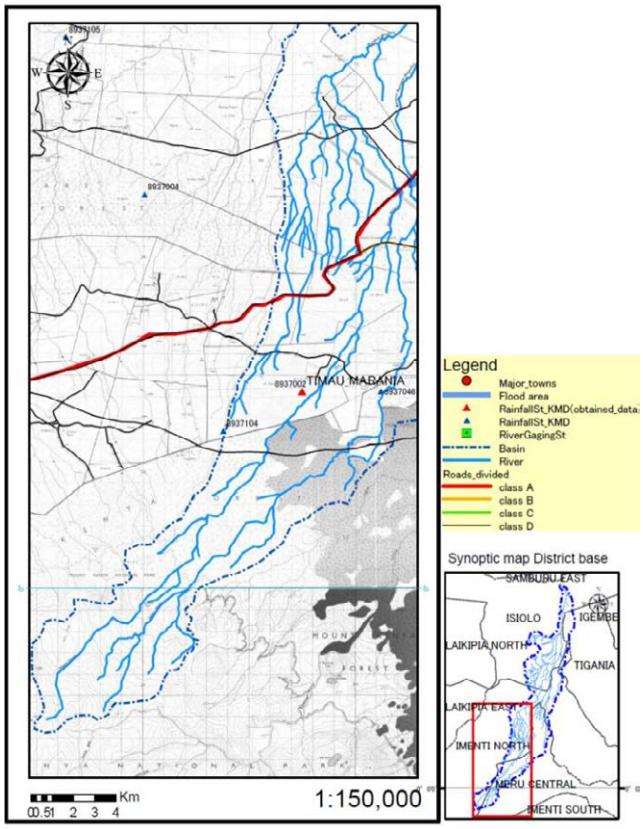
Houses were destroyed by flood

(3) Mechanism of the food damage with the overflow from the river in the middle basin

River channel is not clear because most of small branches flowing into Isiolo River midstream is dried up and ordinary flow is shallow. Flow at the time of flood is rapid and flow channel is unstable because of steep slope such as 5% (1/20) of topography inclines and 1/50-1/30 of river inclines. On the other hand, with the expansion of Isiolo urban area, house is built in the place that is dried up area and the neighborhood because river channel is not clear originally. As a result, flood streams overflow from the river channel at the time of a flood or duct changes, and damage hitting newly built house directly is occurred.

3.2.4 Debris flow in the Upstream (C)

Flood Characteristics (C) in the upstream of Isiolo River Basin is caused by debris flow. And it is described in detail from the aspects of natural, social and economic conditions.



(1) Flood Characteristics from Natural Conditions

Natural Conditions in the Isiolo River Basin that are described in the Chapter-1 and Hazards in this area are shown as following table.

Table 3.2.5 Natural Conditions and Hazards in the Upstream of Isiolo River Basin

Natural Conditions	Hazards
Approximately, gradient of river bed is 1/10	High water velocity
Clayey soil on surface layer, volcanic sediment is including	brittle geology

- Major rivers in the upstream area are the Eastern Marania River and Western Marania River.
- Gradient of river bed is 1/10 approximately. The river has an extremely sharp inclination; hence JICA Project team infers that the flood velocity flow is very high.
- Surface layer of this region is identified as clay, however there is volcanic sediment. Thus, geologically, surface soil layer is likely to be highly effective erosional agents.

(2) Characteristics of Flood Damage from Socio-economic Conditions

Relationship between conditions on Socio-economic and Vulnerability/ Exposure to Natural disasters in the upstream of Isiolo River Basin is shown in below.

Table 3.2.6 Conditions on Socio-economic and Vulnerability/ Exposure in the Upstream of Isiolo River Basin

Socio-economic conditions	Vulnerability/ Exposure
Villages are not concentrated in the same area. (Number of houses and population is small.)	Number of houses and population is small. Affected people and houses are few.
The area is straddled more than one local governments	Coordination between administrations of local governments is difficult.
Land use is limited to farming	Heavy damages suffer by agricultural products due to debris flood
Plantation proceeds a part of area	Heavy damages suffer by agricultural products due to debris flood. Lose/ threaten former's livelihood
Development of sightseeing resources	Delay of development suspension of service and due to debris (However, affected area is far from resort area. Influence is small.)

- Vegetation and land use in the upstream of Isiolio River Basin is mainly bare ground, plantation and farming. When debris flood occurs, there is heavy agricultural damage in this area.
- Although damages are caused by debris flood in this area, not many people and houses are affected due to a thinly populated.

Damages by not only floods but also river bank erosion and sediment runoff appear prominently in the upstream area. Farming land erosion is forced to reduce amount of agricultural crop and sediment runoff by bank erosion becomes a problem in lower area.

Status of water course after debris flow

(3) Mechanism of the food damage by debris flow in the upper basin

In the upper basin the river bed slope is very steep as 1/10, then the flow velocity is extremely high. Although the soil is easy to break because mainly it consists of volcanic sediment, then debris flow has occurred frequently. There are agricultural damages as principal flood damages because out flowed sediments cover farmlands. However, the actual situations of debris flow damages are not comprehend in detail because of low population density.

3.2.5 Bank Erosion in the Entire Basin (D)

Flood Characteristics (D) in the entire of Isiolo River Basin is caused by bank erosion. And it is described in detail from the aspects of natural, socio-economic conditions.

(1) Flood Characteristics from Natural Conditions

Natural Conditions in the Isiolo River Basin that are described in the Chapter-1 and Hazards in the entire river area are shown as following.

Table 3.2.7 Natural Conditions and Hazards in the entire Isiolo River Basin

Natural Conditions	Hazards
Most of basin is arid zone and streamflow is small normally, sometimes heavy rain occurs in a local area	Aggradation of river bed by runoff soil, short river width
Loss of forest	Soil erosion, Soil runoff

· Water courses in the entire river basin have a steep slope; there are many bank erosions at curved reach of the river.

(2) Characteristics of Flood Damage from Socio-economic Conditions

Relationship between conditions on Socio-economic and Vulnerability/ Exposure to Natural disasters in the entire Isiolo River Basin is shown in below.

Table 3.2.8 Conditions on Socio-economic and Vulnerability/ Exposure in the Entire Isiolo River Basin

Socio-economic conditions	Vulnerability/ Exposure
Villages are not concentrated in the same area, besides a part. (Number of houses and population is small.)	Number of houses and population is small. Affected people and houses are few.
The region has been prosperous in agriculture	Agricultural damages are occurred. Lose/ threaten former's livelihood
Highway and trunk road are developed	A temporary halt and/or stagnation in logistics due to inundation
Development of sightseeing resources	Delay of development suspension of service and due to debris (A part of the area includes resort area. Assumed damage is medium scale.)

· River banks are eroded in the upper and middle river basin, however population density is not high and houses are not concentrated. Therefore, mainly farming land and transportation infrastructure such as roads and bridges suffer damage from bank erosion.

· It is likely pointed out that residential area near Isiolo town in the lower river basin suffers damage from bank erosion. Though, landowners who have estate along the river have problems.

Bank erosion near urban area

Bank erosion at the Eastern Marania River

(3) Mechanism of the bank of river erosion damage in the whole area

Isiolo river tends that the riverbank is easy to be eroded unless river duct is steep slope and rock does outcrop in the river channel curved section. On the other hand, not only national highway A2is the highway which is demand for society, economic activities around Isiolo,but also is the most important highway to the northern part of Kenya. Therefore it is inferred that economical influence by bridge being damaged and suspended at the time of flood is extremely serious at the point of national highway A2 across the river.

3.3 ANALYSIS ON FLOOD DAMAGE AND COUNTERMEASURE

3.3.1 Analysis on Flood Damage and Countermeasure in the Urban Area of Isiolo

(1) Damage and its cause

Based on the field survey in this study, flood damage in the urban area of Isiolo was analyzed using logic tree. The following figure summarizes the specific causes of damage from the left side to the right side, i.e. kinds of damage, specific damage, condition of damage and its cause (see **Figure 3.3.1**).

In the urban area of Isiolo, damage is occurred caused by a short term inundation of the whole city. Specifically, these damages are human damage derived from the lack of mind, knowledge and information on disaster prevention, damages to logistics and people's movement due to disturbance by inundation and loss of houses and land caused by inflow of soil and flood discharge.

Inundated road in the urban area of Isiolo by flood (Place: Isiolo Town)

Road after flood (Place: Isiolo Town)

In addition to the lack of mind, knowledge and information on disaster prevention, the following three major causes are considered for the occurrence of large scale inundation as physical factors.

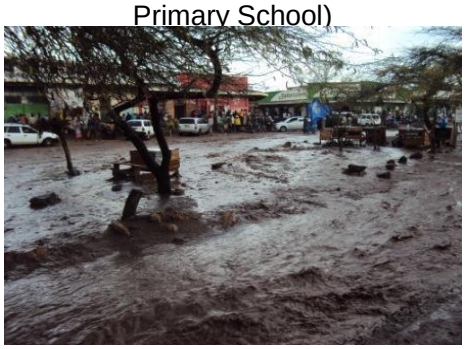
- Lack of discharge capacity of Merire River crossing the urban area
- Flow of rainfall has been changed by the airport and road newly constructed in the east side of the urban area and the flood hits the urban area directly, and
- Insufficient drainage system in the urban area of Isiolo.

(2) Countermeasures

To derive the countermeasures, the objective tree analysis was carried out. Issues to be solved are placed on the left side and the measures are specifically presented therefrom(see **Figure 3.3.2**).

Simple Rain Gauge (Place: Nkando Primary School)

In Isiolo River Basin, even if there is a heavy rain in the upstream by the effect of Mt. Kenya, there is a case having no rain in the middle and downstream. In such case, effective measure can be taken such as evacuation and activity to prevent flood by obtaining information on rainfall and water level in the upstream in advance. For this purpose, introduction of early flood warning system is effective. In the community too, rainfall in the upstream can be measured by simple hyetometer and the information transmitted to the downstream.



Flooded urban area due to vulnerable drainage system (Place: Isiolo Town)

As the mind on disaster prevention of the residents is very low, dangerous situations are happened such as the people suffered from injury by crossing the road overflown with the flooded discharge and/or washed away by crossing the bridge submerged under water. To avoid such a situation, it is considered effective to educate the residents on disaster prevention about how much the floods are dangerous.

Shop taking measure by sand bag (Place: Isiolo Town)

Insufficient drainage system in the urban area is one of the reasons why the flood damage spreads. Since the drainage infrastructure is not properly functioned or not well developed, inundation is occurred in the urban area with a little rainfall. Or the road is cut into pieces and the

commercial activity is suspended by the inflow of water into the shops. As countermeasures, it is considered to develop drainage network in the urban area and to protect the inflow of water by banking up sand bags in front of the shops.

Very few drain channel installed in the urban area (Place: Isiolo Town)

Besides, houses and buildings are damaged and lost by overflowing of Merire River. Countermeasure to prevent overflow is to improve the discharge capacity of Merire River by way of excavation and/or widening of the river course. In addition, the following countermeasures are considered.
Restriction on land use which sets a limit to reside in a place nearby the river bank, and Trash picking campaign to remove garbage which blocks the flow.

Further, inundation in the urban area is becoming serious as the outflow route of flood has been altered by the impact of construction of the new road and expansion of the airport in the eastern slope of the urban area. To improve such a situation, countermeasures are considered to restore the flood outflow route to the original by developing drainage channel and culvert, and to limit the outflow by flood basin.

Culvert installed near the airport (Place: Isiolo Town)

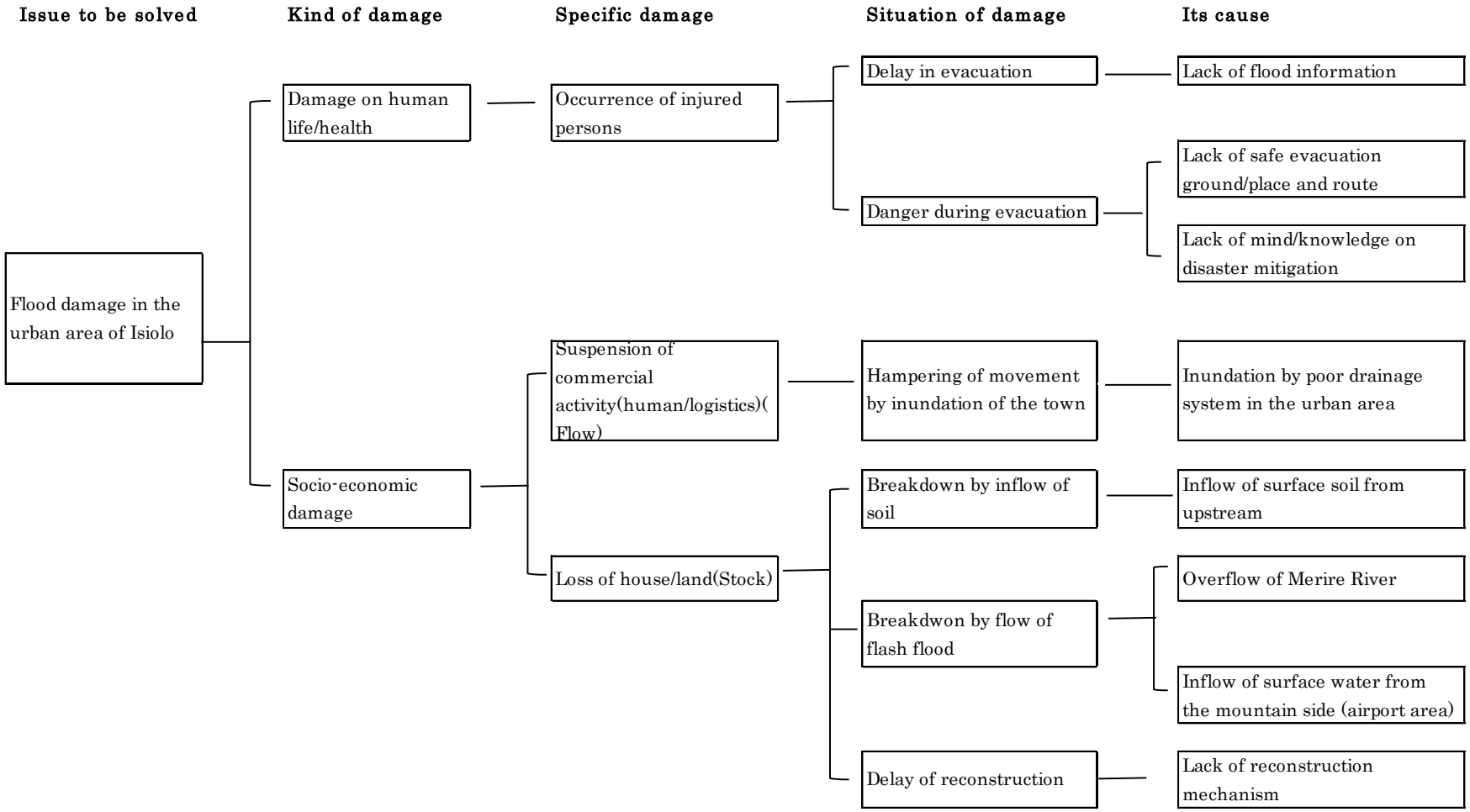


Figure 3.3.1 Analysis on Flood Damage and its Cause

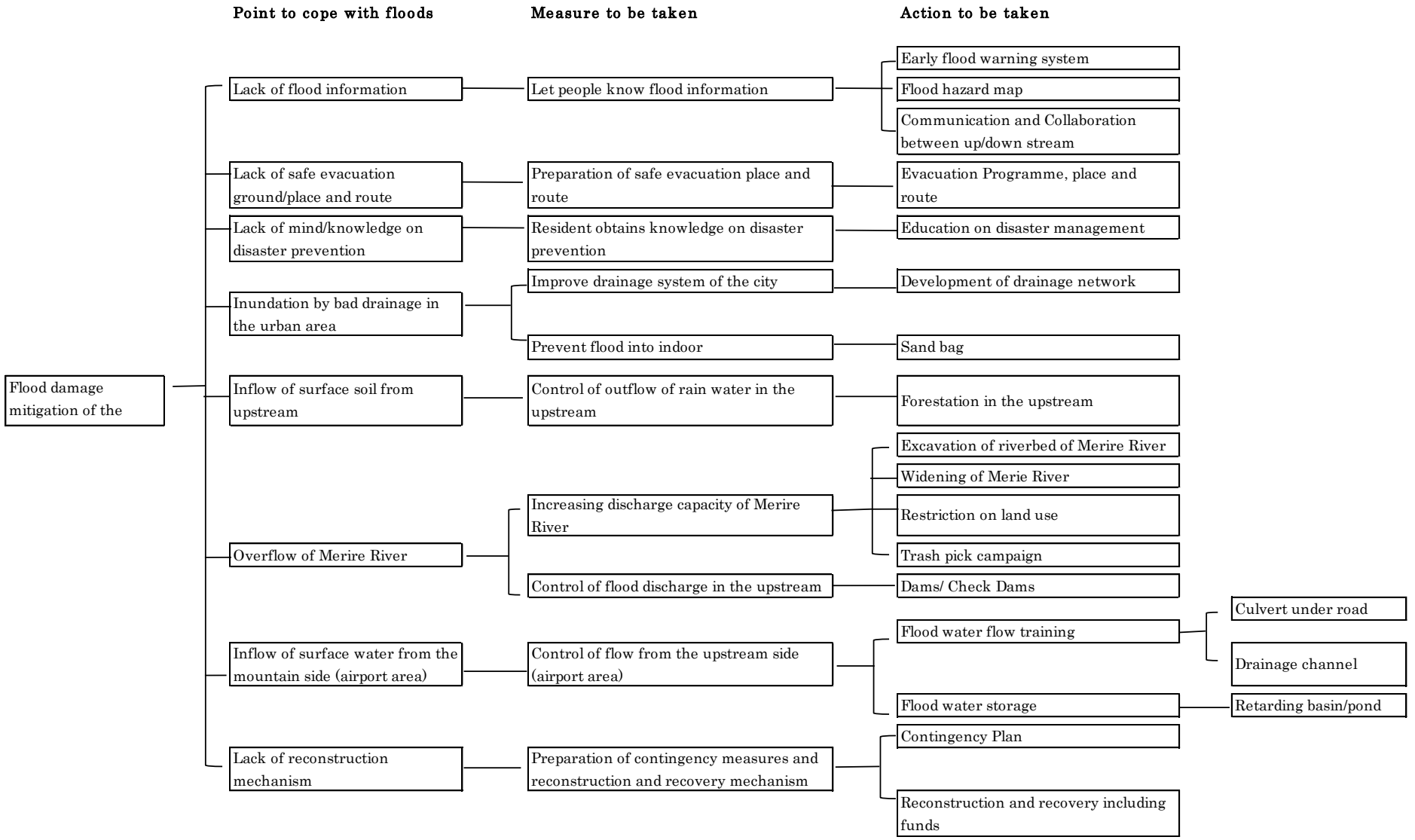


Figure 3.3.2 Analysis on Countermeasures

Considering the above, countermeasure method to be considered is summarized below.

Table 3.3.1 Countermeasure Method to be considered in the urban area of Isiolo

Countermeasure Method to be considered	Remarks	Target Area
Flood Early Warning	Collect and analyze information on flood such as rainfall and water level in the upstream of Isiolo River and transmit it to the urban area of Isiolo.	Isiolo Town
Flood Hazard Map	Flood hazard map is a tool for communicating the impact of a specific flood event in a particular community.	Isiolo Town
Communication and collaboration between up/down stream	Information sharing such as rainfall, water level, focal community members in both the upstream and downstream areas in the river basin allows for damage mitigation, evacuation, response and rescue operation	Isiolo Town
Flood evacuation programme	Establish evacuation programme including evacuation plan, safe evacuation places, route and evacuation drill	Isiolo Town
Education on disaster management	Educate the residents on how to reduce by themselves the present flood damage	Isiolo Town
Drainage network	Development in the whole urban area of Isiolo	Isiolo Town
Sand bag	Guidance on sand bag production and provision of materials	Isiolo Town
Forestation activity	Activity to promote plantation and forestation	Isiolo Town
Excavation of Merire River	Excavation of river bed of Merire River	Isiolo Town
Widening of Merire River	Widening of river width	Isiolo Town
Restriction on land use	Legislation on land use restriction	Isiolo Town
Trash picker campaign	Carrying out of trash picker campaign near Merire River	Isiolo Town
Dams/ Check Dams	Construction of dams and check dams in the upstream	Isiolo Town
Drainage canal	Development of drainage canal in the airport area	Isiolo Town
Culvert	Development of culvert in the airport area	Isiolo Town
Retarding basin/pond	Development of retarding basin/pond in the airport area	Isiolo Town
Contingency Plan	Contingency planning aims to prepare an organization to respond well to an emergency and its potential humanitarian impact.	Isiolo Town
Reconstruction and recovery including funds	A process of long-term reconstruction and economic recovery should begin while post-emergency actions aimed at restoring normality for the displaced populations returning home or settling in new places are being undertaken.	Isiolo Town

3.3.2 Analysis on Flood Damage and Countermeasure in the Outskirt excluding the Urban Area (Mainly in the upstream of urban area of Isiolo)

(1) Damage and its cause

Based on the result of field survey by this time, analysis was carried out, as the same as the urban area of Isiolo, on the damage at the outskirt area excluding the urban area, mainly in the

upstream of the urban area using logic tree (see **Figure 3.3.3**).

Damages in the outskirt area excluding the urban area are mainly caused by, as mentioned in last chapter, displacement of river course in the middle stream, occurrence of debris flow, erosions of river bank and soil. There are a lot of agricultural lands in the outskirt of Isiolo, therefore, the damage to agriculture is remarkable and destruction of agricultural land by debris flow and washout of land by river bank erosion are occurred. In addition, infrastructures such as houses and bridges are also damaged by inundation, and it gives a great impact to the living of the residents.

Flood water went up to the elbow of the man (Place: Middle of the Isiolo River)

River bank erosion along Eastern Marania River (Place: Upstream of Isiolo River)

Bridge in the outside of Isiolo Town (Place: Upstream of Isiolo River)

(2) Countermeasures

To derive the countermeasures, the objective tree analysis was carried out. Issues to be solved are placed on the left side and the measures are specifically presented therefrom(see **Figure 3.3.4**).

Production of agricultural crops is affected by the destruction of agricultural land by debris flow in this area. To prevent the outflow of debris flow, construction of check dam is considered effective. In addition, as a measure for river bank erosion, bank protection works are also effective to prevent washout of land.

Regarding the damage giving an impact to the living of residents by destruction of houses and infrastructures, there is a measure to prevent overflow by improvement of river course. If possible, upgrade or improvement of bridge is another option.

Example of check dam in Nzoia River

Example of river bank protection in Nzoia River

Countermeasures to be considered are summarized below.

Table 3.3.2 Countermeasures to be considered in the Outskirt Area excluding the Rrban Area (mainly in the upstream of the urban area of Isiolo)

Countermeasure Method to be considered	Remarks	Target Area
Check Dam	Construction of sabo dam at Isiolo River	Upstream
Bank protection and spur dike	Construction at Isiolo River	Entire basin
Improvement of river course	Improvement of river course of Isiolo River	Midstream and tributary stream
Improvement of bridge	Improvement of bridge of Isiolo River	Midstream and tributary stream

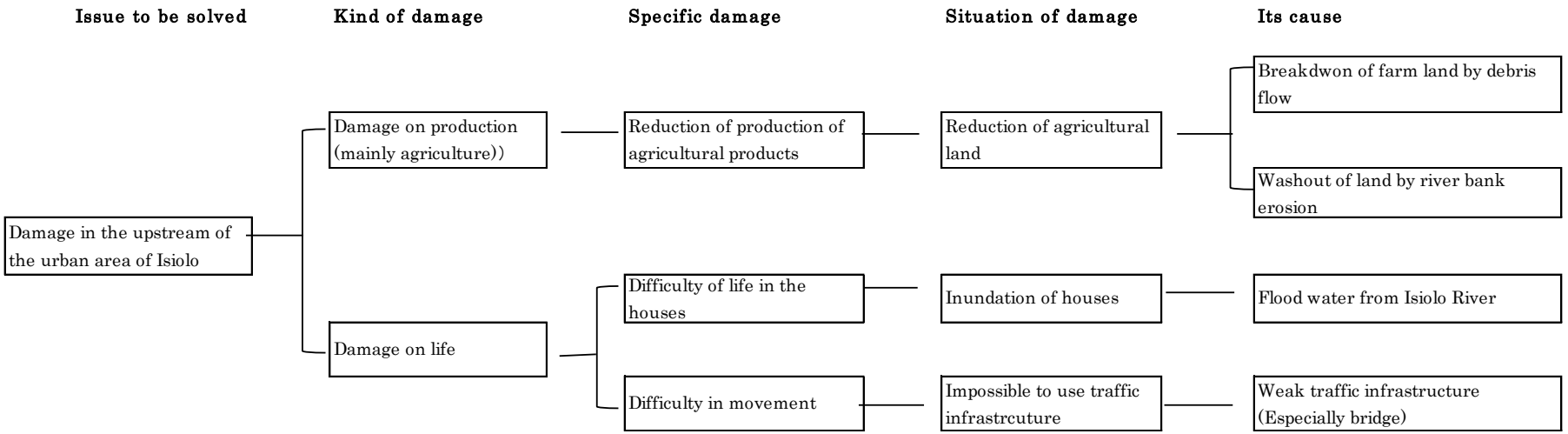


Figure 3.3.3 Analysis on Flood Damage and its Couse

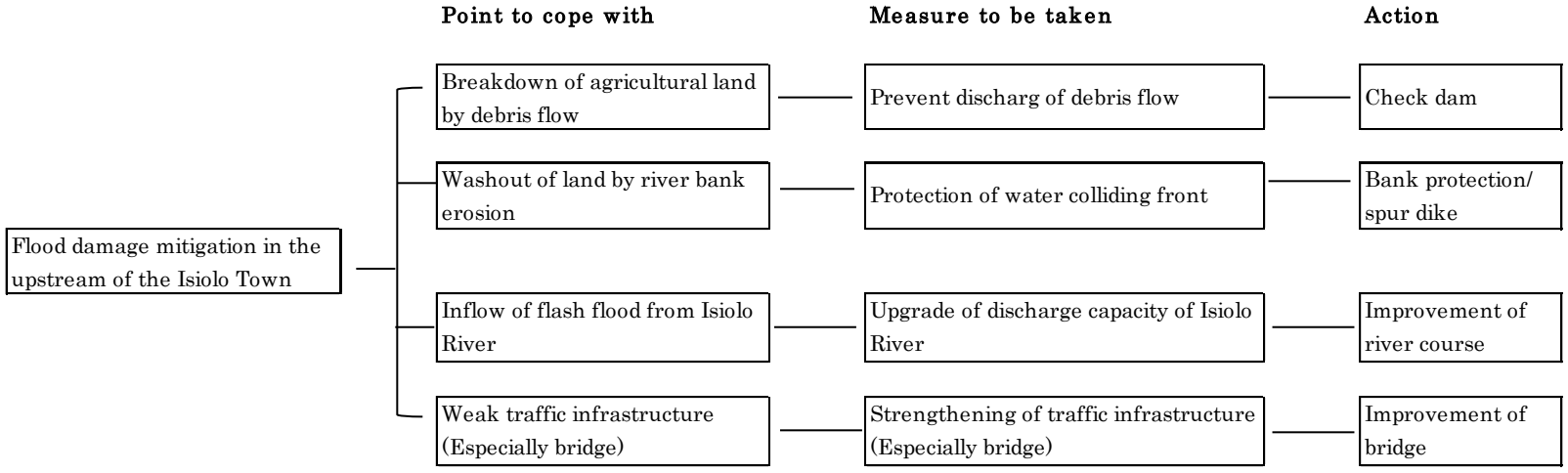


Figure 3.3.4 Analysis on the Countermeasures

3.3.3 Longlist/candidates of Countermeasures to the Flood

Longlis/candidates of countermeasures to the flood are presented as below.

Table 3.3.3 Longlist of the Countermeasures to the Flood in Isiolo River Basin

No.	Countermeasure Method to be considered	Remarks	Target Area
1	Flood Early Warning	Collect and analyze information on flood such as rainfall and water level in the upstream of Isiolo River and transmit it to the urban area of Isiolo.	Isiolo Town
2	Flood Hazard Map	Flood hazard map is a tool for communicating the impact of a specific flood event in a particular community.	Isiolo Town
3	Communication and collaboration between up/down stream	Information sharing such as rainfall, water level, focal community members in both the upstream and downstream areas in the river basin allows for damage mitigation, evacuation, response and rescue operation	Isiolo Town
4	Flood evacuation programme	Establish evacuation programme including evacuation plan, safe evacuation places, route and evacuation drill	Isiolo Town
5	Education on disaster management	Educate the residents on how to reduce by themselves the present flood damage	Isiolo Town
6	Drainage network	Development in the whole urban area of Isiolo	Isiolo Town
7	Sand bag	Guidance on sand bag production and provision of materials	Isiolo Town
8	Forestation activity	Activity to promote plantation and forestation	Isiolo Town
9	Excavation of Merire River	Excavation of river bed of Merire River	Isiolo Town
10	Widening of Merire River	Widening of river width	Isiolo Town
11	Restriction on land use	Legislation on land use restriction	Isiolo Town
12	Trash picker campaign	Carrying out of trash picker campaign near Merire River	Isiolo Town
13	Dams/ Check Dams	Construction of dams and check dams in the upstream	Isiolo Town
14	Drainage canal	Development of drainage canal in the airport area	Isiolo Town
15	Culvert under the road	Development of culvert in the airport area	Isiolo Town
16	Retarding basin/pond	Development of retarding basin/pond in the airport area	Isiolo Town
17	Contingency Plan	Contingency planning aims to prepare an organization to respond well to an emergency and its potential humanitarian impact.	Isiolo Town
18	Reconstruction and recovery including funds	A process of long-term reconstruction and economic recovery should begin while post-emergency actions aimed at restoring normality for the displaced populations returning home or settling in new places are being undertaken.	Isiolo Town
19	Check Dam	Construction of check dam at Isiolo River	Upstream
20	Bank protection and spur dike	Construction of river bank protection works at Isiolo River	Entire basin
21	Improvement of river course	Improvement of river course of Isiolo River	Midstream and tributary stream
22	Improvement of bridge	Improvement of bridge of Isiolo River	Midstream and tributary stream

3.4 SELECTION OF FLOOD DAMAGE TO BE MANAGED PREFERENTIALLY

3.4.1 The Result of Workshop for Flood Damage Analysis by Community

In Isiolo river basin, the workshop was held to analyze the problems in Isiolo sub catchment with WRUA members, WRMA-SRO staff and JICA project team members on Nov. 7th, 2012

As a result of analysis, the causes of flood are pointed out as bellow.

Table 3.4.1 Analysis for the Causes of Flood by Interviewing to WRUA Members

Theme	Causes	Principal Influence from Flooding
Floods	Rainfall around the Mt. Kenya slope	Flash flood from immediate rising in "wadi"
	Sediment flow around upstream	
	Lack of capacity for drainage	City area inundation caused by poor drainage
	Developed condition of poundage in the airport	

Concerning flood damages, following analysis was done and was indicated the priority order lead by WRUA members.

Table 3.4.2 Damage Analysis and Priority Order Determined by WRUA Members

Priority order determined by WRUA members	Item	Primary Damage	Secondary Damage
①	Sediment erosion	-Soil outflow from farmland -Loss of agricultural products -Sediment outflow	-Lack of farmlands -Inefficiency of harvest -Lack of lands -Obstruction of culverts
②	Damage of infrastructures	-Transmission wire -Roads -Bridges -Water intakes -Culverts	-Black out -Beyond reach of goods to markets -Unable to go to hospital or school -Insufficient water, conflicts over water, drought -Water spilling
③	Water pollution	-An epidemic of diseases -Growing worse of sanitation	-Epidemic of Cholera, Dysentery and Typhoid fever
④	Damage in daily life or livelihood	-Trash scattering -Overflowing from toilet -Destruction of houses	-Obstruction of culverts, water leaking -Sanitary conditions -Moving enforcement
⑤	Human life	-Lost of Human life by sweeping away -Drowned livestock	

3.4.2 Selection of the Prioritized Flood Damage to be Managed

As a description in previous chapter, the flood damages along Isiolo river is principally classified 4 types such as A) Inundation in urban area of Isiolo town , B) Inundation which is

caused by overflow and dyke break, C) Debris flow in the upstream and D) Bank erosion in the entire basin .

Based on the evaluation of flood damages by communities previously described, each impact from flood damages are evaluated from the viewpoints of social impacts as "Number of affected people and houses" or economic impacts as "Losses of merchandise, agriculture, transportation and sightseeing industry", and are shown in the following table.

Table 3.4.3 Selection of The Flood Damages should be Corresponding Preferentially

Flood type	Social impacts		Economic impact				Priority order
	Number of affected people	Number of affected houses	Merchandise	Agriculture	Transportation	Sight seeing industry	
A. Inundation in urban area of Isiolo town	**High**	**High**	**High**	Low	**High**	Mid	Extremely High
B. Inundation which is caused by overflow and dyke break	Low	Low	Low	Mid	Low	Low	Slightly low
C. Debris flow in the upstream	Low	Low	Low	Mid	Low	Mid	Slightly low
D. Bank erosion in the entire basin	Low	Low	Low	Mid	**High**	Mid	Partially high in transportation

In the 4 types of flood damages, it shows that the damage by "Inundation in urban area of Isiolo town" has strongest impacts socio-economically, and the impact of damage in the point concerned to transportation by dyke brake.

According to these review, in Isiolo river basin, "Inundation in urban area of Isiolo town" is selected as the damage should be corresponding extreme preferentially, and subsequently the dyke break in the point concerned to transportation.

Therefore, selected longlist is shown in the next page.

Table 3.4.4 Selected Long List of the Countermeasures to the Flood in Isiolo River Basin

No.	Countermeasure Method to be considered	Remarks	Target Area
1	Flood Early Warning	Collect and analyze information on flood such as rainfall and water level in the upstream of Isiolo River and transmit it to the urban area of Isiolo.	Isiolo Town
2	Flood Hazard Map	Flood hazard map is a tool for communicating the impact of a specific flood event in a particular community.	Isiolo Town
3	Communication and collaboration between up/down stream	Information sharing such as rainfall, water level, focal community members in both the upstream and downstream areas in the river basin allows for damage mitigation, evacuation, response and rescue operation	Isiolo Town
4	Flood evacuation programme	Establish evacuation programme including evacuation plan, safe evacuation places, route and evacuation drill	Isiolo Town
5	Education on disaster management	Educate the residents on how to reduce by themselves the present flood damage	Isiolo Town
6	Drainage network	Development in the whole urban area of Isiolo	Isiolo Town
7	Sand bag	Guidance on sand bag production and provision of materials	Isiolo Town
8	Forestation activity	Activity to promote plantation and forestation	Isiolo Town
9	Excavation of Merire River	Excavation of river bed of Merire River	Isiolo Town
10	Widening of Merire River	Widening of river width	Isiolo Town
11	Restriction on land use	Legislation on land use restriction	Isiolo Town
12	Trash picker campaign	Carrying out of trash picker campaign near Merire River	Isiolo Town
13	Dams/ Check Dams	Construction of dams and check dams in the upstream	Isiolo Town
14	Drainage canal	Development of drainage canal in the airport area	Isiolo Town
15	Culvert under the road	Development of culvert in the airport area	Isiolo Town
16	Retarding basin/pond	Development of retarding basin/pond in the airport area	Isiolo Town
17	Contingency Plan	Contingency planning aims to prepare an organization to respond well to an emergency and its potential humanitarian impact.	Isiolo Town
18	Reconstruction and recovery including funds	A process of long-term reconstruction and economic recovery should begin while post-emergency actions aimed at restoring normality for the displaced populations returning home or settling in new places are being undertaken.	Isiolo Town
19	Bank protection and spur dike	Construction of river bank protection works at Isiolo River	Entire basin

4. EVALUATION OF COUNTERMEASURES TO THE FLOOD

4.1 VIEW POINT OF EVALUATION

Candidate countermeasures that are extracted in last chapter are studied in detail. On the basis of the result of last chapter, 5 criteria; relevance, effectiveness, efficiency, impact and sustainability is considered.

The project team defined 5 criteria as the description on following table, and then evaluated the countermeasures by marking "A", "B" and "C" according to these 5 Items.

Table 4.1.1 Definition of 5 Items for Project Evaluation

1	Relevance	Requirements from the stakeholders, Needs of target area Dimension of economic damage and human suffering.
2	Effectiveness	Degree of damage mitigation (Number of beneficiary, Reduction of submergence period, area and number of affected people)
3	Efficiency	Cost effectiveness (It is evaluated by estimated qualitative dimension and degree of damage mitigation)
4	Impact	Spreading effect within a same basin or to other areas Indirect effects
5	Sustainability	Sustainability of maintenance and project effects (On the assumption of pilot project completion according to the design.)

*The project team defined these 5 items for the purpose of this study according to "DAC's evaluation 5 items"

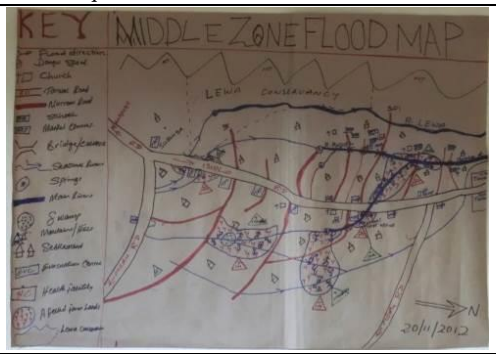
4.2 EVALUATION RESULT FOR EACH COUNTERMEASURE

Table4.2.1 Evaluation on Countermeasure against Inundation in Isiolo Town (1)

No.		**I-T1**		
Target Area		**Isiolo Town (Overflow from Merire River)**		
Countermeasure		**Flood Early Warning System (FEWS)**		
Outline		It is a system to transmit flood information based on hydrological data from upstream to downstream. People can prepare for the flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	FEWS is not common yet in Kenya, but lack of information on disaster prevention is recognized. It's beneficial that residents know the information as soon as possible during flood, because flow speed is fast and damage is huge.	B	2
	Effectiveness	Warning information can be transmitted extensively. However, if people don't know how to react against flood, this countermeasure doesn't make sense. Its effect becomes higher when it implement with education on disaster prevention.	B	2
	Efficiency	This can give good effect extensively with low cost.	A	3
	Impact	Application in other area is relatively easy. Supplemental effect such as activation of communication between upstream and downstream community is considered.	A	3
	Sustainability	If it is low cost equipment and simple communication system, maintenance is not difficult.	A	3
Total			13	
Merit		・ Community based FEWS can be introdueced at the low cost.		
Demerit		・ Accuracy is not so high. ・ It needs cooperation between upstream and downstream. ・ Collaboration with County Government is necessary for implementation.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Collaboration between residents living in the upstream and residents living in the downstream and flood affected area is necessary.		
Main Actor		WRUA/County/District		
Supporting Actor: NGO		KRCS		
Supporting Actor: Administrative Authority		KMD, Ministry of State for Special Programmes		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.2 Evaluation on Countermeasure against Inundation in Isiolo Town (2)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Flood Hazard Map**		
Outline		Flood hazard map, in general, is a tool for the presentation and dissemination of information on flood hazard (intensity, spatial range, inundation depth, duration time, frequency, etc.) and evacuation options (location of evacuation centers, evacuation routes, dangerous spots, etc.) in aid of quick and safe evacuation in the event of flooding.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Requiirement from the residents is very high. Need of the target area is very high. Economic damage is high and human damage is also high.	A	3
	Effectiveness	Number of beneficiay is equal to the people living in the Isiolo Town. It means quite large.	A	3
	Efficiency	Cost of formulation of the flood hazard map is very low. Cost of printing of brochures is not high. Cost of signboards is not high. Effectiveness is high and cost is low, therefore, efficiency is high.	A	3
	Impact	It is easy to spread and promote the same method. Therefore, the secondary impact is high.	A	3
	Sustainability	If flood hazard map formulation will be done with disaster management education, the sustainability of it might be high.	A	3
Total			15	
Merit		・ It is easy for the residents to understand flood hazard and evacuation option.		
Demerit		・ Some particular technic and methods should be learned by the community members.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Participation in the process of formulation of the map		
Main Actor		WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.3 Evaluation on Countermeasure against Inundation in Isiolo Town (3)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Communication and collaboration between up/down stream**		
Outline		Information sharing such as rainfall, water level, focal community members in both the upstream and downstream areas in the river basin allows for damage mitigation, evacuation, response and rescue operation.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Requirement from the communities in the upstream and the downstream is high.	A	3
	Effectiveness	Number of beneficiary is large. It is almost equal to the number of Isiolo Town residents. Therefore, effectiveness is high.	A	3
	Efficiency	・ Cost of communication and collaboration is low. ・ Therefore, efficiency is is high.	A	3
	Impact	It is easy to spread and promote the same method. Therefore, the secondary impact is high.	A	3
	Sustainability	If both upstream and downstream residents get merit, collaboration might be sustainable.	B	2
Total			14	
Merit		If there is good communication and collaboration between upstream and downstream, flood management in the entire river basin might be effective in the cost and the quality.		
Demerit		Usually main beneficiary might be the downstream residents only.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Participation to the actural communication and collaboration		
Main Actor		WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		MWI, WRMA		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.4 Evaluation on Countermeasure against Inundation in Isiolo Town (4)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Flood Evacuation Programme**		
Outline		Evacuation plan should be developed and evacuation drills and mock experience and evacuation centre management should be prepared and implemented.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	· Requirement from the residents especially from school pupils is high because they might suffer from the flood water on the way to and back from the school. · Not only school pupils, but also women and elder people migh suffer from the flood water.	A	3
	Effectiveness	Number of beneficiary is large. It is almost equal to the number of Isiolo Town residents. Therefore, effectiveness is high.	A	3
	Efficiency	· Cost of preparing evacuation plan is low. · Therefore, efficiency is is high.	A	3
	Impact	It is easy to spread and promote the same method. Therefore, the secondary impact is high.	A	3
	Sustainability	If flood evacuation programme will be done with disaster management education, the sustainability of it might be high.	B	2
Total			14	
Merit		· Structural measures are not perfectly to be able to prevent flood holistically, therefore non-structural measures are also applied as important part of the flood management. · Evacuation is an important part of saving lives and minimizes property damage from the flood. · Evacuation drill helps communities envisage the different stages of flood disaster cycle, preparation, mitigation plan, early warning, and evacuation plan of flood through activities.		
Demerit		Evacuation drill should be done repeatedly.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Participation		
Main Actor		WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support/ Self-help		

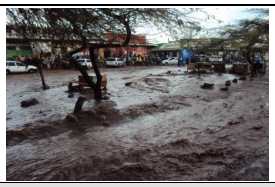
A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.5 Evaluation on Countermeasure against Inundation in Isiolo Town(5)

No.		**I-T2**		
Target Area		**Isiolo Town (General)**		
Countermeasure		**Education on Disaster Management**		
Outline		It is educational activity to give information to reduce damage from flood and raise awareness of disaster management.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	WRMA has a high request of enforcement of community. In addition, some damage can prevent if people have knowledge on flood management. So it importance is high.	A	3
	Effectiveness	It is expected certain effect against number of educated people. Their knowledge on disaster prevention can implement wherever and whenever they need. Its effect can be spread.	B	2
	Efficiency	It can give knowledge on disaster prevention to a large number of people at the same time. Cost is low. Effectiveness is high when the knowledge is rooted.	A	3
	Impact	Knowledge can hand down from beneficiary to their family and friends. It can expand widely.	A	3
	Sustainability	Local people such as school teacher and community leader can be a lecturer. So educational activity sustain. In addition, integration into curriculum is important.	A	3
Total			14	
Merit		・ Cost is low. ・ Knowledge learned in childhood will last long until the child will become adult. ・ Knowledge learned by the school pupils will be disseminated to the parents and other related adults.		
Demerit		・ Cooperation and coordination with education sector is necessary. ・ It is need to train school teachers at the first.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Support of school teachers		
Main Actor		School (Teachers)/ WRUA		
Supporting Actor: NGO		KRCS/ PTA (Pareents Teachers Association)		
Supporting Actor: Administrative Authority		Ministry of Education/ County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance/ Mutual support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.6 Evaluation on Countermeasure against Inundation in Isiolo Town (6)

No.		**I-T3**		
Target Area		**Isiolo Town (Inland Water)**		
Countermeasure		**Development of Drainage Network in the Whole Town**		
Outline		It is improvement project to develop drainage system in whole Isiolo town.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Commercial area of Isiolo concentrates in urban area of Isiolo Town. There is a lot of economic loss by flood damage. In addition, debris flow makes it more serious. The necessity of development of drainage network is urgent.	A	3
	Effectiveness	If the development proceeds in the whole Town, its effect is extensively high.	A	3
	Efficiency	Cost is extensive, but effectiveness is higher than that. It is a fundamental countermeasure against inundation at Isiolo Town.	A	3
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous maintenance is inevitable.	C	1
Total			11	
Merit		・ Bad sanitation condition after flood is related to the insufficient drainage network. If the drainage network will be improved,damage to the sanitary condition may be reduced.		
Demerit		・ Preparation before actual construction work such as discussion with stakeholders, survey, planning, design needs long term.		
Environmental Negative Impact		・ If the storm water and seweage water will be drained together, and if there is no sewage water treatment, there is a possibility of concentration of water quality contamination at the discharging point from the drainage network to the river. ・ However, sewage water is not treated at the present. Therefore, development of drainage network doesn't have negative impact to the water quality in total.		
Necessity of EIA		Yes		
Contribution by the residents		None, but the maintenance can be supported by the residents		
Main Actor		County/ District		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		Ministry of Planning		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.7 Evaluation on Countermeasure against Inundation in Isiolo Town (7)

No.		**I-T4**		
Target Area		**Isiolo Town (General)**		
Countermeasure		**Sandbag**		
Outline		It is obstruction to flow water and sand. People put sand in bags and bank up.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Residents recognize its importance and effect. Some people already implements to sandbag. It is a simple measure against lack of infrastructure that is one of a main factors of inundation in Isiolo Town.	A	3
	Effectiveness	A large amount of sandbag is necessary to obtain a good result from this countermeasure.	B	2
	Efficiency	Cost is small and effectiveness is limited.	B	2
	Impact	It is relatively simplified measure. So application in other area is not difficult.	A	3
	Sustainability	Once people learn how to sandbag they can continue the activity. Maintenance is simple.	A	3
Total			13	
Merit		· Preparation period is short. · Cost is low.		
Demerit		· It is a temporary countermeasure. · It is impossible to prevent flood water from entering houses and buildings completely.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		The local contribution for the WDC has been set at a minimum of 15% of budget for sub-catchments in Alarm Status and 25% for sub-catchments in Alert or Concern Status. The local contribution may be in the form of cash, labour and materials/services.		
Main Actor		Individual/ WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Self-Help/Mutual support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.8 Evaluation on Countermeasure against Inundation in Isiolo Town (8)

No.		**I-T5**		
Target Area		**Upstream of Isiolo River**		
Countermeasure		**Forestation Activity**		
Outline		It is to protect and recover vegetation in the upstream of the mountain. Its storage effect will rise.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Residents are affected by soil erosion. Also, in "Imenti North District Development Plan" shows forestation at same area. It corresponds with higher plan.	A	3
	Effectiveness	If this countermeasure implement at appropriate scale, sedimentation from upstream would reduce.	B	2
	Efficiency	Large scale forestation is required to obtain certain effectiveness.	B	2
	Impact	Application in other area is not difficult. In addition, it contributes environmental conservation.	B	2
	Sustainability	Once main actor is aware the importance, activity can continue. Maintenance is complicate. It takes time to grow up.	B	2
Total			11	
Merit		・ Preparation period is short. ・ Cost is low. ・ There are many environmental positive impacts. ・ It contributes to reduce global warming.		
Demerit		・ It takes long term to show the effect. ・ Climate in Isiolo require some certain kinds of trees for forestation.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		The local contribution for the WDC has been set at a minimum of 15% of budget for sub-catchments in Alarm Status and 25% for sub-catchments in Alert or Concern Status. The local contribution may be in the form of cash, labour and materials/services.		
Main Actor		WRUA		
Supporting Actor: NGO		KRCS		
Supporting Actor: Administrative Authority		Kenya Forest Service		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.9 Evaluation on Countermeasure against Inundation in Isiolo Town (9)

No.		**I-T6**		
Target Area		**Isiolo Town (Overflow from Merire River)**		
Countermeasure		**Excavation of River bed of Merire River**		
Outline		It is a countermeasure to excavate river bed and increase flow capacity		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Inundation by Merire River is reported frequently. Lack of cross section of river channel is a main cause, so demand is high.	A	3
	Effectiveness	Overflow from Merire River reduces drastically. Damage reduction of overflow from Merire River can be expected.	A	3
	Efficiency	Both cost and effectiveness are extensive.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous excavation is necessary. Additional cost is high.	C	1
Total			10	
Merit		・ It is certain that the excavation of riverbed improves flow capacity of Merire River.		
Demerit		・ Preparation before actual construction work such as discussion with stakeholders, survey, planning, design needs long term. ・ Excavation might be implemented continuously, because sediment from upstream might come and deposite in the river channel.		
Environmental Negative Impact		・ There might be no natural environmental negative impact. because the current status of Merire River is like a sewage channel. There is no ecological environment. ・ Involuntary resettlement might be occurred.		
Necessity of EIA		Yes		
Contribution by the residents		None, but the maintenance can be supported by the residents.		
Main Actor		NWCPC (National Water Conservation and Pipeline Cooperation)		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.10 Evaluation on Countermeasure against Inundation in Isiolo Town (10)

No.		**I-T7**		
Target Area		**Isiolo Town (Overflow from Merire River)**		
Countermeasure		**Widening of Merire River**		
Outline		It is a countermeasure to widen river width and increase flow section.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	WRMA has expectation. The importance of high, because lack of cross section of river channel is the cause of overflow from Merire river. However, there are some illegal constructions around river edge. Resettlement can be occurred.	B	2
	Effectiveness	Expected damage reduction is high. Overflow from Merire River can become less drastically.	A	3
	Efficiency	Both cost and effectiveness are extensive.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	The cost can be lower than excavation. However, continuous maintenance is necessary.	C	1
Total			9	
Merit		・ It is certain that the widening of river channel improves flow capacity of Merire River.		
Demerit		・ Preparation before actual construction work such as discussion with stakeholders, survey, planning, design needs long term. ・ There are some houses around the river bank. Resettlement can occur. Coordination with stakeholder is difficult.		
Environmental Negative Impact		・ There might be no natural environmental negative impact. because the current status of Merire River is like a sewage channel. There is no ecological environment. ・ Involuntary resettlement might be occurred.		
Necessity of EIA		Yes		
Contribution by the residents		None, but the maintenance can be supported by the residents.		
Main Actor		NWCPC (National Water Conservation and Pipeline Cooperation)		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.11 Evaluation on Countermeasure against Inundation in Isiolo Town (11)

No.		**I-T8**		
Target Area		**Whole Country (Overflow from Merire River)**		
Countermeasure		**Restriction on land use**		
Outline		It is to establish a law to prohibit people from illegal construction and illegal occupation of lands near the river.		
Image		-		
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Its importance is recognized by stakeholders. Illegal constructions are existed around river edge. So, government can't implement widening of the river. And also, people who live in illegal houses can affect directly by overflow water.	B	2
	Effectiveness	This is not a direct measure against flood. Crackdown and educational activity is required at the same time.	C	1
	Efficiency	Legislation is almost no cost to implement. However, direct effectiveness for disaster reduction is small.	B	2
	Impact	Legislation itself is nationwide.	A	1
	Sustainability	Once the law is established, validity can continue. However, certain regulation and educational activity should be implemented the same time.	B	2
Total			8	
Merit		・ Illegal occupation of riparian land can be reduced. ・ Cost is low.		
Demerit		・ Involuntary resettlement can occur. ・ Regulation and educational activity should be implemented. ・ It is government level and takes long time to establish a law.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		None		
Main Actor		WRMA / Ministry of Lands		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		Ministry of Lands		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.12 Evaluation on Countermeasure against Inundation in Isiolo Town (12)

No.		**I-T9**		
Target Area		**Surrounding of Merire River (Overflow from Merire River)**		
Countermeasure		**Trash picker Campaign**		
Outline		It is an activity to remove garbage that can be obstacle to water flow.		
Image		 (Source: City of Kurume)		
Evaluation items				
Evaluation by Five Criteria	**Relevance**	A lot of residents complain about illegal dumping. This problem makes cross section smaller. In addition, illegal dumping is a cause of blockage of culvert. Its necessity is high.	A	3
	Effectiveness	Garbage removal from river bed and culvert can make its function back. Overflow from Merire River and from clogged culvert can reduce.	B	2
	Efficiency	Effectiveness is bigger than cost.	A	3
	Impact	Introduction is simple, so activity can spread in other area. And also, it contributes environmental conservation and improvement of sanitation.	A	3
	Sustainability	If people recognize the effectiveness, they became to have a keen awareness of disaster prevention. Continuity is high.	A	3
Total			14	
Merit		・ Overflow from Merire River reduces. ・ Cost is low. ・ It is community based activity. ・ The method is simple. ・ Preparation period is short.		
Demerit		・ Disposal of trash should be considered.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Participation		
Main Actor		WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.13 Evaluation on Countermeasure against Inundation in Isiolo Town (13)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Dam/Check Dam**		
Outline		Check dams are relatively small, temporary structures constructed across a swale or channel.		
Image		 (Source: WRMA, NALEPO Project in Athi CA)		
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Both upstream and downstream have damage by sediment deposition. Geology at upstream is fragile and grate is sudden, Its necessity is relatively high. However, one small scale check dam is not sufficient to reduce damage drastically. It should be large scale or small scale dam in a lot of sites.	B	2
	Effectiveness	Damage of debris flow around the check dam can reduce, but the effect of one check dam is limited.	B	2
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous maintenance is inevitable. In case WRUA implement with WSTF fund, maintenance cost is additional.	C	1
Total			8	
Merit		・ They are used to slow the velocity of concentrated water flows, a practice that helps reduce erosion. ・ As stormwater runoff flows through the structure, the check dam catches sediment from the channel itself or from the contributing drainage area.		
Demerit		・ Preparation before actual construction work such as discussion with stakeholders, survey, planning, design needs long term.		
Environmental Negative Impact		・ There might be an impact to the downstream river channel caused by stopping the sediment movement and an impact to living things caused by blocking of water flow.		
Necessity of EIA		Yes		
Contribution by the residents		The local contribution for the WDC has been set at a minimum of 15% of budget for sub-catchments in Alarm Status and 25% for sub-catchments in Alert or Concern Status. The local contribution may be in the form of cash, labour and materials/services.		
Main Actor		WRUA/ NWCPC (If the scale is large, main actor might be NWCPC.)		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual support/ Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.14 Evaluation on Countermeasure against Inundation in Isiolo Town (14)

No.		**I-T10**		
Target Area		**Mountainside/Airport area (Inland Water)**		
Countermeasure		**Drainage channel**		
Outline		It is a structure to gather rain water and flow toward adequate and secure direction.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage in Isiolo Town is extensive. Local government has a strong request. This is a countermeasure for inland water from airport area that is one of 3 biggest factors of flood damage in Isiolo Town. Necessity is high.	A	3
	Effectiveness	When the problem of rain water flow from airport area is resolved, inundation in Isiolo Town reduces.	A	3
	Efficiency	Cost is medium scale, but drastic improvement is expected.	A	3
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Maintenance cost is not so expensive. Maintenance system should be established.	B	2
Total			12	
Merit		・ Flow volume from airport area is drastically reduced.		
Demerit		・ Cost is high. ・ Planning, design and construction take long time.		
Environmental Negative Impact		・ Excavation of land is necessary. ・ Heavy machinery is required for construction.		
Necessity of EIA		Yes		
Contribution by the residents		The local contribution for the WDC has been set at a minimum of 15% of budget for sub-catchments in Alarm Status and 25% for sub-catchments in Alert or Concern Status. The local contribution may be in the form of cash, labour and materials/services.		
Main Actor		WRUA/ County/ District		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		KeRRA		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutural Support/ Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.15 Evaluation on Countermeasure against Inundation in Isiolo Town (15)

No.		**I-T11**		
Target Area		**Mountainside/Airport area (Inland Water)**		
Countermeasure		**Culvert under the road**		
Outline		It is a structure to flow rain water safely.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage in Isiolo Town is extensive. Local government has a strong request. This is a countermeasure for inland water from airport area that is one of 3 biggest factors of flood damage in Isiolo Town. Necessity is high.	A	3
	Effectiveness	When the problem of rain water flow from airport area is resolved, inundation in Isiolo Town reduces.	A	3
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Maintenance cost is not so expensive. Maintenance system should be established.	B	2
Total			11	
Merit		・ Flow volume from airport area is drastically reduced.		
Demerit		・ Cost is high. ・ Planning, design and construction take long time. ・ Coordination with stakeholders could be difficult.		
Environmental Negative Impact		・ The candidate site is boundary between Isiolo town and Meru town. Coordination with them can take long time. ・ Excavation of land is necessary. ・ Heavy machinery is required for construction.		
Necessity of EIA		Yes (It depends on the scale of the construction work.)		
Contribution by the residents		None. But, the maintenance can be supported by the residents.		
Main Actor		KeRRA (Kenya Rural Road Authority)		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.16 Evaluation on Countermeasure against Inundation in Isiolo Town (16)

No.		**I-T12**		
Target Area		**Mountainside/Airport area (Inland Water)**		
Countermeasure		**Retarding Basin/Pond**		
Outline		It is to impound water rain temporary and reduce peak discharge.		
Image		 (Source: Mie Prefecture)		
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage in Isiolo Town is extensive. Local government has a strong request. This is a countermeasure for inland water from airport area that is one of 3 biggest factors of flood damage in Isiolo Town. Necessity is high.	A	3
	Effectiveness	When the problem of rain water flow from airport area is resolved, inundation in Isiolo Town reduces.	A	3
	Efficiency	Both cost and effectiveness are high.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Maintenance cost is not so expensive. Maintenance system should be established.	B	2
Total			11	
Merit		· Flow volume from airport area can be reduced.		
Demerit		· Coordination with Kenya Airport Authority can take long time. · Cost is high. · Planning, design and construction take long time. · Large-scale ground is necessary for retarding basin/pond. The most effective site is in the airport.		
Environmental Negative Impact		· Excavation of land is necessary. · Heavy machinery is required for construction.		
Necessity of EIA		Yes		
Contribution by the residents		None		
Main Actor		Kenya Airport Authority		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		County/ District		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.17 Evaluation on Countermeasure against Inundation in Isiolo Town (17)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Contingency Plan**		
Outline		Contingency planning aims to prepare an organization to respond well to an emergency and its potential humanitarian impact. Developing a contingency plan involves making decisions in advance about the management of human and financial resources, coordination and communications procedures, and being aware of a range of technical and logistical responses.(Source: Contingency Planning Guide 2012, International Federation of Red Cross and Red Crescent Societies, 2012)		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Currently, preparadness to mitigate the flood disaster damage is is not sufficient. Therefore, post flood disaster management including contingency plan is required by the County Government and residents.	A	3
	Effectiveness	Effective contingency planning should lead to timely and effective disaster-relief operations. Therefore, degree of damage mitigation shall be high.	A	3
	Efficiency	Cost of contingency planning is low. Therefore, efficiency is high.	A	3
	Impact	It is easy to spread and promote the same method. Therefore, the secondary impact is high.	A	3
	Sustainability	County Government has the responsibilty of formulation of contingency plan. Therefore, sustainability is high.	A	3
Total			15	
Merit		・ Contingency planning is a management tool, involving all sectors, which can help ensure timely and effective provision of humanitarian aid to those most in need when a disaster occurs.		
Demerit		・ It needs certain period to develop the contingency plan.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		Provision of information to the County Government		
Responsible Institution/Agency		County Government		
Main Actor		County/ District		
Supporting Actor: NGO		KRCS/ World Vision		
Supporting Actor: Administrative Authority		Ministry of State for Special Programmes		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Publich assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.18 Evaluation on Countermeasure against Inundation in Isiolo Town (18)

No.				
Target Area		**Isiolo Town (General)**		
Countermeasure		**Reconstruction and Recovery including Funds**		
Outline		A process of long-term reconstruction and economic recovery should begin while post-emergency actions aimed at restoring normality for the displaced populations returning home or settling in new places are being undertaken.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	People affected by floods require the assistance of reconstruction and recovery process.	A	3
	Effectiveness	Number of beneficiary depends on the amount of the fund.	B	2
	Efficiency	If fund will be large, the cost also becomes large. Therefore, efficiency is medium.	B	2
	Impact	Spreading the fund depends on the amount of the budget of County Government or National Government. Therefore, impact is medium.	B	2
	Sustainability	Sustainability depends on the continuous budget of County Government or National Government. Therefore, sustainability is medium.	B	2
Total			11	
Merit		Recovery and reconstruction from flood disaster damage might be enhanced.		
Demerit		There is a need of county governmental or national governmental budget for the fund.		
Environmental Negative Impact		None		
Necessity of EIA		No		
Contribution by the residents		None.		
Main Actor		County/ District		
Supporting Actor: NGO		KRCS		
Supporting Actor: Administrative Authority		Ministry of State for Special Programmes		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Public Assistance		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

Table4.2.19 Evaluation on Countermeasure against River Bank Erosion at Entire River Basin

No.		**I-U2**		
Target Area		**Upstream of Isiolo River**		
Countermeasure		**Bank Protection**		
Outline		It is a structure to prevent riverbank erosion.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Population and number of houses are few at upstream. However, damage to farmland and plantation is extensive. There is a main highway near by upstream of Isiolo River. Prevention for road erosion is necessary. Stakeholder has strong request.	A	3
	Effectiveness	It also functions as protection of highway. In addition, it contributes to reduce flood damage to physical distribution and human movement. However, the effect of one construction is limited.	B	2
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	If it is simple design, application in other area is not difficult.	B	2
	Sustainability	Continuous maintenance is inevitable. However, if it is simple design, maintenance is not difficult.	B	2
Total			11	
Merit		・ Bank erosion of the construction site will be prevented.		
Demerit		・ Influence for downstream and other side of bank should be considered.		
Environmental Negative Impact		・ Heavy machinery is required for construction. It can affect environment.		
Necessity of EIA		If the size of construction work is large, EIA is need. But, if the size is small, EIA is not necessary.		
Contribution by the residents		The local contribution for the WDC has been set at a minimum of 15% of budget for sub-catchments in Alarm Status and 25% for sub-catchments in Alert or Concern Status. The local contribution may be in the form of cash, labour and materials/services.		
Main Actor		WRUA		
Supporting Actor: NGO				
Supporting Actor: Administrative Authority		WRMA / County/ District/ Ministry of Roads and KeNHA		
Supporting Actor: Technical Authority		MWI, WRMA		
Public assistance/ Mutual support /Self-help		Mutual Support		

A (3 point) : Excellent / B (2 point) : Good / C (1 point) : Poor

4.2.1 Result of the Evaluation on 5 Criteria

Following figure shows the result of evaluation on 5 criteria of all candidate countermeasures. It is preferable to implement from high scored to low scored measures. However, schedule some of them require long term coordination and negotiation. JICA project team studies

Table 4.2.20 Evaluation List of 5 Criteria

Structural/ Non-structural	Countermeasure and Target Area	Score	Remarks
Structural Measure	Drainage Canal / Isiolo Town (Airport Area)	12	Study/Survey/ Discussions
	Development of Drainage Network / Isiolo Town	11	Survey and discussions
	Culvert / Isiolo Town (Airport Area)	11	Study/Survey/ Discussions
	Flood Basin / Isiolo Town(Airport Area)	11	Study/Survey/ Discussions
	Bank Protection / Entire Basin	11	
	Excavation of River bed /Isiolo Town (Merire River)	10	Study/Survey/ Discussions
	Widening of River / Isiolo Town (Merire River)	9	Study/Survey/ Discussions
	Dam/ Check Dam in the upstream /Isiolo Town	8	Study/Survey/ Discussions
Non-structural Measure	Flood Hazard Map /Isiolo Town	15	
	Contingency Plan	15	Study/Discussion
	Communication and Collaboration between up/down stream /Isiolo Town	14	Already started in the committee
	Flood Evacuation Programme /Isiolo Town	14	Study/Discussion
	Education on Disaster Management / Isiolo Town	14	
	Trash picker Campaign /Isiolo Town	14	
	Early Warning System / Isiolo Town	13	Study/Discussion
	Sandbag / Isiolo Town	13	
	Reconstruction and Recovery including Funds	11	
	Forestation Activity	10	
	Restriction on land use	8	

5. PROJECT IMPLEMENTATION PLAN OF FLOOD COUNTERMEAURES

5.1 FLOOD COUNTERMEASRES IN THE FLOOD MANAGEMENT PLAN

The Flood Management Plan defines the most prioritized flood event as inundation in urban area of Isiolo Town and the second as bank erosion at places where affects traffic facilities.

Among those countermeasures, WRUA scale project should be incorporated in the SCMP.

(1) Structural Countermeasures

Structural countermeasures should be implemented as following order.

- Study, survey and discussion on drainage network in urban area of Isiolo Town
- Study, survey and discussion on countermeasures against water inflow from airport area (drainage channel, culvert, flood basin and etc.)
- Bank protection at the transportation and farmland affetected area
- Study, survey and discussion on improvement of Merire River (excavation of river bed and widening of river)
- Study, survey and discussion on dam/check dam in the upstream of Merire River

(2) Non-structural Countermeasures

Non-structural countermeasures should be implemented as following order.

- Flood hazard map
- Contingency Plan
- Communication and collaboration between up/down stream
- Education on disaster management
- Trash picker Campaign at Merire River
- Early warning system
- Sandbag
- Reconstruction and Recovery including Funds
- Forestation activity
- Restriction on land use

5.2 DRAFT IMPLEMENTETION SCHEDULE OF FLOOD COUNTERMESUREAS

JICA project team proposes draft implementation schedule of flood countermeasures as the following page.

In this schedule, actors are defined as follows:

Main actor: A group or organization to implement the measures in practice. However, there may be multiple choices depending on the size of the measures.

Supporting Actor

NGO: NGO to support the main actor to implement the measures

Administrative Authority: A government agency to support or to provide an approval for implementation of the measures

Technical Authority: A government agency to support for implementation of the measures technically

Draft Implementation Schedule of Flood Countermeasures in Isiolo River Basin

	Countermeasures	Required Preparation	Main Actor	Support Actor: NGO	Support Actor: Administrative Authority	Support Actor: Techinical Authority	WRMA's role	WRUA's role	1st year	2nd year	3rd year	4th year	5th year	6th year or later
Structural Measure	Development of Drainage Canal at Airport Area	Study/Survey/Discussion	County/District/WRUA		KeRRA	MWI, WRMA	coordination with related ministries	planning/construction/maintenance	Study and Discussion ↔	↔	■			
	Development of Drainage Network in Whole Urban Area of Isiolo Town	Study/Survey/Discussion	County/District		Ministry of Planning	MWI, WRMA	coordination with related ministries	maintenance	↔	↔	Study and Discussion ↔	↔	↔	■
	Culvert under road at airport area	Study/Survey/Discussion	KeRRA		County/District	MWI, WRMA	coordination with related ministries	maintenance	Study and Discussion ↔	↔	■	■	■	
	Retarding Basin/Pond at airport area	Study/Survey/Discussion	Airport Authority		County/District	MWI, WRMA	coordination with related ministries		Study and Discussion ↔	↔	■	■	■	
	Bank Protection (affected area to the transportation and farmlands)		WRUA		WRMA/County/District, Ministry of Road/ KeNHA	MWI, WRMA	approval of construction, coordination with related ministries, techinical advice	planning/construction/maintenance	■	■	■	■	■	
	Improvement of Merire River (widening, etc)	Study/Survey/Discussion	NWCPC		County/District	MWI, WRMA	coordination with related ministries	maintenance			Survey and Discussion ↔	↔	↔	■
	Dam/Check Dam in the upstream of Merire River	Study/Survey/Discussion	WRUA/NWCPC		County/District	MWI, WRMA	coordination with related ministries	planning/construction/maintenance			Survey and Discussion ↔	↔	↔	■
Non-structural Measure	Flood Hazard Map		WRUA		County/District	MWI, WRMA	coordination with related ministries/techinical advice	cooperation/participation/enlightenment activity	■	■				
	Contingency Plan	Study and Discussion	County/District	KRCS/World Vision	Min. of Special Programmes	MWI, WRMA	coordination with related ministries/techinical advice	cooperation/participation/enlightenment activity	Study and Discussion ↔	↔	■	■	■	■
	Communication and collaboration between up/down stream	Already started in the committee	WRUA		MWI, WRMA	MWI, WRMA	coordination with related ministries/techinical advice	cooperation/participation/enlightenment activity	■	■	■	■	■	■
	Flood Evacuation Programme	Study and Discussion	WRUA		County/District	MWI, WRMA	coordination with related ministries/techinical advice	cooperation/participation/enlightenment activity	Study and Discussion ↔	↔	■	■	■	■
	Education on Disaster Prevention		Schools, WRUA	KRCS/ PTA	Ministry of Education/County/District	MWI, WRMA	coordination with related ministries/techinical advice	cooperation/participation/enlightenment activity	■	■	■	■	■	■
	Trash picker Campaign		WRUA		County/District	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity			■	■	■	
	Flood Early Warning System	Study and Discussion	WRUA/County/District	KRCS	KMD/Ministry of Special Programs	MWI, WRMA	techinical advice	planning/formulation/operation/maintenance	Study ↔	↔	■	■	■	■
	Sandbag		WRUA		County/District	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity			■	■	■	
	Reconstruction and Recovery including Funds		County/District	KRCS	Min. of Special Programmes	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity				■	■	■
	Forestation Activity		WRUA	KRCS	Kenya Forest Service	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity				■	■	■
	Restriction on land use		WRMA MOL		MOL	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity				■	■	■

6. RECOMMENDATION

- Observation data of rainfall and flow discharge that is utilized for detail design of works is lacking. WRMA should observe rainfall and flow discharge data steadily. In addition, they should improve the accuracy and accelerate accumulation.

- Countermeasures against inundation of whole urban area of Isiolo Town (inland water) and flood from Merire River (river water) should be considered from long term perspective.

Appendix 3-3

Lumi River Basin Integrated Flood Management Plan

As of 4 August 2013

REPUBLIC OF KENYA
PROJECT ON CAPACITY DEVELOPMENT
FOR
EFFECTIVE FLOOD MANAGEMENT IN FLOOD PRONE AREA

LUMI RIVER BASIN
INTEGRATED FLOOD MANAGEMENT PLAN
- DRAFT -

August 2013

NEWJEC

Republic of Kenya
Project on Capacity Development for Effective Flood Management in Flood Prone Area

Lumi River Basin Integrated Flood Management Plan
- Draft -

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1. POLYCY OF RIVER BASIN FLOOD MMANAGEMENT PLAN (DRAFT)

1.1 POLICY OF FLOOD MANAGEMENT IN THE RELEVANT RIVER BASIN (DRAFT)

The source of Lumi River is the eastern slope of Mt. Kilimanjaro, and 1/4 of river basin size belongs to Tanzania territory. The Lumi River flows down toward south east and Kenyan territory, then flows down to south and flows into Lake Jipe. Thus the Lumi river is an international river.

Around uppermost stream area in this basin, the slope is steep. On the other hand, around most downstream area, the topographic slope is pretty gentle, and then low level ground spreads out as flood plain.

The biggest town in this river basin is "Taveta". In this river basin, the main industries are agricultural producing such as Maize, Rice and fruits like Bananas, plantation of sisal hemp, livestock farming, fishery at lakes such as Jipe and tourism around Tsavo West national park.

The Lumi river basin is belonging to the jurisdiction of WRMA Nolturesh-Lumi Sub Regional Office (SRO) concerning the general water resource management inclusive flood management.

In addition, 2 WRUAs such as "Upper Lumi WRUA" and "Lower Lumi WRUA" are established in the Lumi river basin, and both WRUAs implement grass-roots water management in corroboration with WRMA.

Principal flood damages are destruction of houses, enforcement of long term evacuation, agricultural product including livestock loss, contamination of water resource by polluted water diffusion, growing worse sanitary conditions and muddy road condition etc.

The reason why the floods occurred are long term inundation depending on overflow from the Lumi river downstream or dyke break by reaching storm water from the heavy rain in Mt. Kilimanjaro mountainside of upstream area.

On the other hand, destruction of roads or bridges and loss of livestock have been occurred by the effect of flash flood in the tributaries or small channel of the Lumi river. The measures against floods will be important because the number of affected people by long term inundation for 2 months was large more than 2,000 every year.

However it is difficult to start training of the Lumi river in this period under the circumstance of undeveloped various supporting data.

Therefore the important point of the flood management policy in relevant river basin shall be mitigation of influence to resident daily life by long term inundation and distribution and enlightenment schemes to make it faster in life recovery from flood damage.

In the course of drawing up the flood management plan, the appropriate combination of structural and non-structural measures or the view point of "Self-help", "Mutual support" and "Public assistance" should be considered. And also consensus building among the stakeholders

through the participation of WRUA or communities should be implemented.

WRUA and communities implement the distribution, evolution, maintenance of structural measures and non-structural measures with initiative.

WRUA and communities shall work together from the period of project planning so that incubate their ownership

The scoping period of this plan is 5 years from 2013 to 2018, the contents of plan will be revised properly in necessity.

1.2 THE ROLE AND RESPONSIBILITY OF WRMA

Main actor of this plan is WRMA. WRMA should assist WRUA to make it can build realizable tasks in to the Sub-Catchment Management Plan (SCMP) by itself. In addition, WRMA provide the technical assistance to implement the countermeasures against flooding matters.

Concerning the tasks that WRUA has no initiative, WRMA shall precede the implementation of tasks while coordinating it with relevant stakeholders.

1.3 RIVER BASIN COMMITTEE

Flood management cannot achieve the objectives without the cooperation with various stakeholders in the river basin.

Some river basins are divided by plural sub catchment such as upper stream, lower stream, left bank and right bank.

According to this condition, WRMA shall establish “Integrated Flood Management River Basin Committee” in order to share the information concerning flood management and coordinate in river basin unit.

The stakeholders in the relevant river basin preferable to be participated in the committee are listed below.

Table 1.3.1 The Stakeholders in Lumi River Basin (as of February 2013)

No	Organization	Remarks
1	Lower Lumi WRUA	
2	Upper Lumi WRUA	
3	Provincial Administration	Taveta District Commissioner
4	Ministry of Devolution/ State for Special Programmes	Active in providing humanitarian assistance to disaster victims
5	Kenya National Highways Authority/Kenya Rural Roads Authority – Representative	One representative
6	Ministry of Water and Irrigation	Irrigation Department representative
7	Ministry of Lands	District Physical planner
8	Ministry of Agriculture	District Agricultural Officer
9	Ministry of Livestock	District Livestock Officer
10	Ministry Of Education	District Education Officer
11	Kenya Meteorological Department	Contact Person at National Level
12	National Environmental Management Authority (NEMA)	District Officer
13	Taita Taveta County Government	One representative
14	Kenya Red Cross Society	Representative from Regional Office
15	World Vision	Representative from Regional Office
16	Religious Group	One each from Christian and Muslim
17	Kenya Forest Service	
18	Department of Social Services	Registers WRUAs and other social welfare groups
19	Kenya National Chamber of Commerce and Industry	
20	National Water Conservation and Pipeline Corporation (NWCPC)	
21	WRMA	HQ, RO, SRO

In the committee, exchanging of opinions between the relevant stakeholders, approval of flood management plan, consensus building, discussion of role sharing and activity evaluation etc. shall be done.Committee members shall be discussing about the following themes once in every some months for the time being.

Table 1.3.2 The Schedule of Integrated Flood Management Committee Meeting (Draft)

	Discussion Themes	Remarks
1st Meeting	・ Information sharing on current situation and problems in flooding ・ Discussion on conceivable flood measures	Already done in Feb. 22nd, 2013
2nd Meeting	・ Suggestion of flood management plan(draft) ・ Discussion on flood management plan(draft) ・ Consensus building on pilot project(This project only)	
3rd Meeting	・ Discussion on flood management plan(draft) ・ Progress reporting of pilot project(This project only)	
4th Meeting	・ Evaluation of pilot project(This project only)	

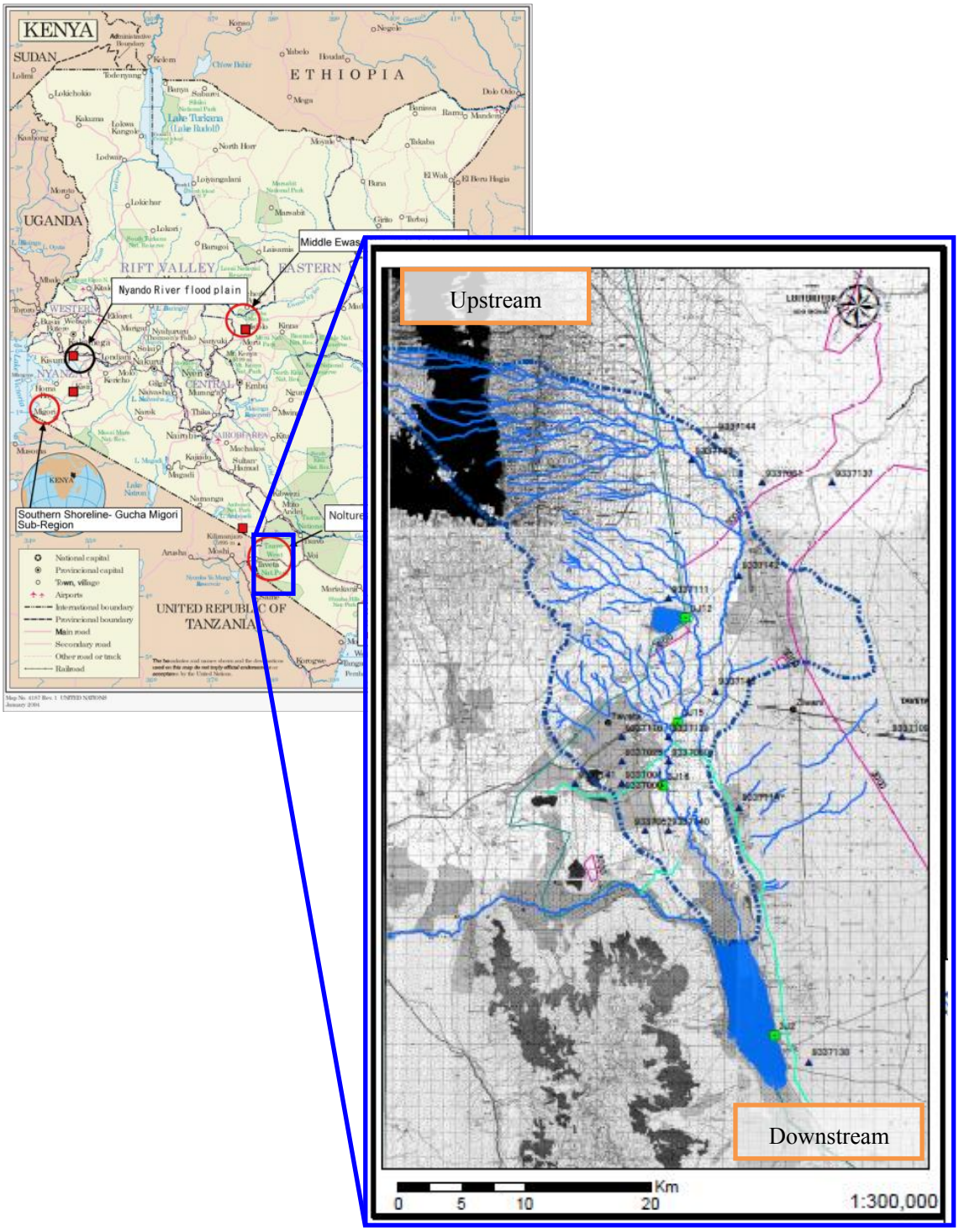
1.4 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

On planning the flood measures project, the appropriate environmental and social consideration shall be done based on Kenyan regal code “Environmental Management and

Coordination Act (EMCA) 1999".

2. OUTLINE OF LUMI RIVER BASIN

Lumi River Basin is within the border of Kenya and Tanzania in the southern part of the Republic of Kenya and it is located in the south-east part of Mt. Kilimanjaro.



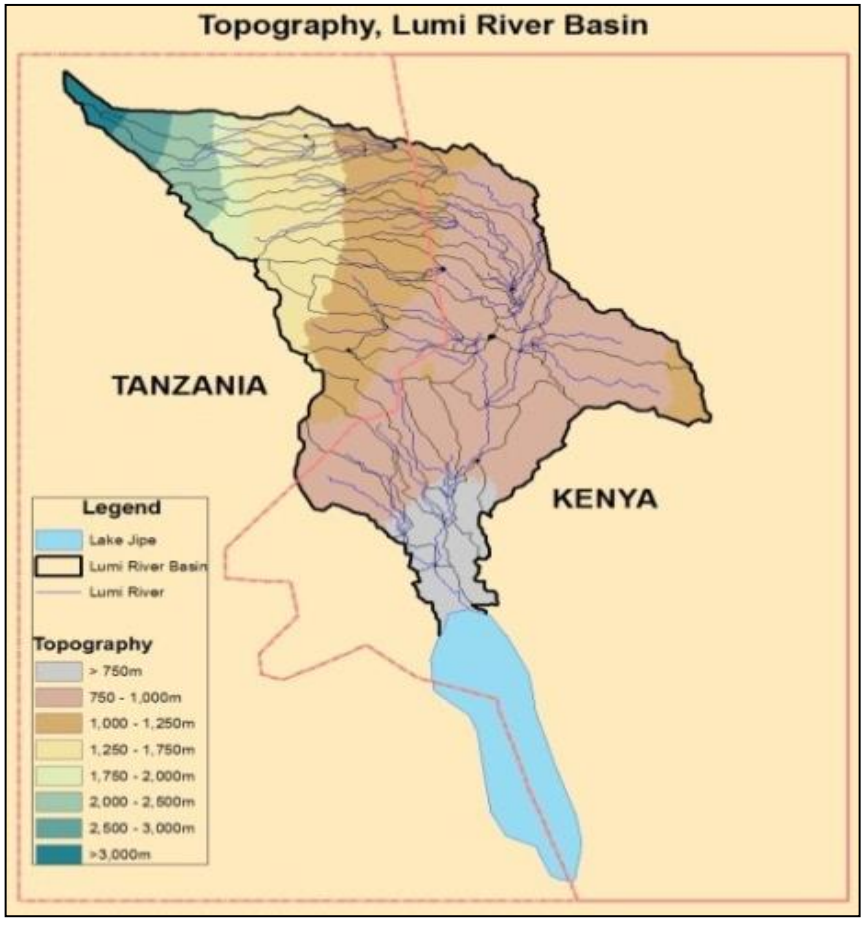
Location of Lumi River Basin

2.1 NATURAL CONDITIONS

2.1.1 Topography and Soil

(1) Topography

Catchment area of Lumi River is about 590km^2 (of which 75% of the area is in Kenya), and the total length of the river is approximately 71km flowing from north to south. The width of the river is about 20km (east to west) in the widest place. Lumi River originates from Mt. Kilimanjaro and it flows towards south direction via Taveta District in the easten part of Kenya. Then, Lumi River flows into Lake Jipe and again flows into Luvu River within the territory of Tanzania. There are many springs within the river basin and the water flows into Lumi River from those springs. Major springs are Kiboboto spring, Madala spring, Njoro spring and Sambekispring[1].

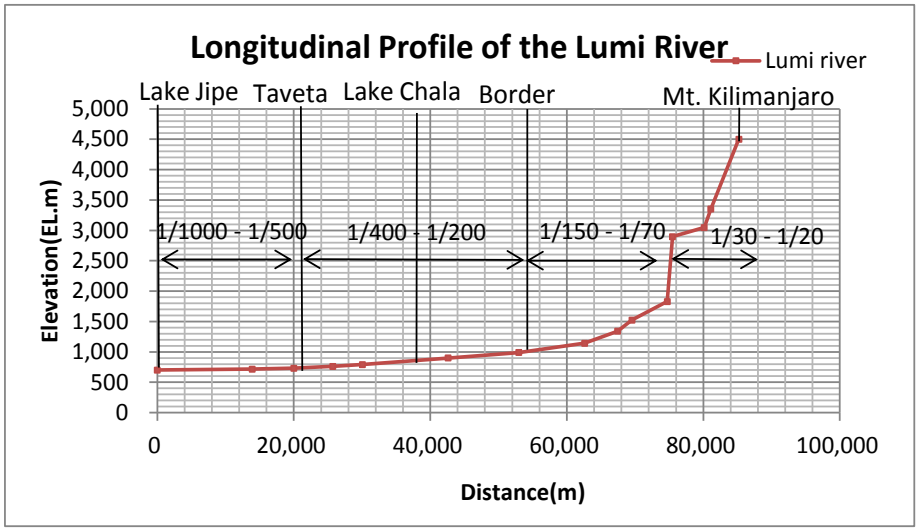


Source：WRMA, Action Plan on The Development and Implementation of a Flood Management Plan for Lumi River

Figure 2.1.1 Elevation Distribution of Lumi River Basin

[1] NWCPC, Study on Causes and Effects of Floods in Nyanza and Western provinces Tana basin and Taita Taveta District, Draft study Report (May 2006)

In the Lumi River Basin, the elevation of the upstream area within the border in Tanzania varies approximately from 4,500m to 1,000m, especially in the area colored in green to greenish yellow, the river stream shows a steep slope topography. After flowing into the Kenyan territory, the elevation of middle stream varies from 1,000m to 750m. In the downstream, the river flows into Lake Jipe at the elevation of 750m. It is known from the spread of the river basin that the topography of these areas seems to be generally flat.



Prepared by JICA Project Team based on 1/50,000 Topo Map

Figure 2.1.2 Cross Section of River Stream

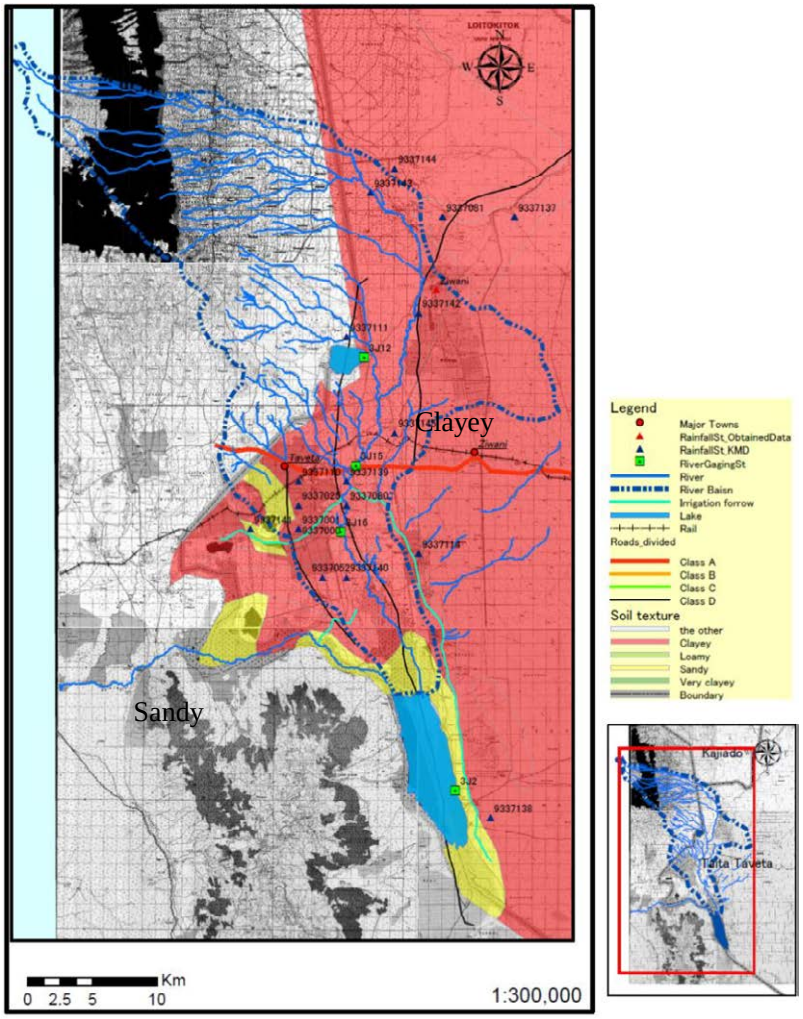
Photo 2.1.1 Mt. Kilimanjaro

Photo 2.1.2 Lake Challa

Photo 2.1.3 Lake Jipe

(2) Soil

Soil Distribution Map of the Lumi River Basin is as per Figure 2.1.3 soil covers all through the river basin, and sandy soil is distributed around the inflow areas of Lake Jipe and Luvu River.



Source: Prepared by JICA Project Team based on Kenya Soil Survey (KSS) in 1982 and revised in 1997.

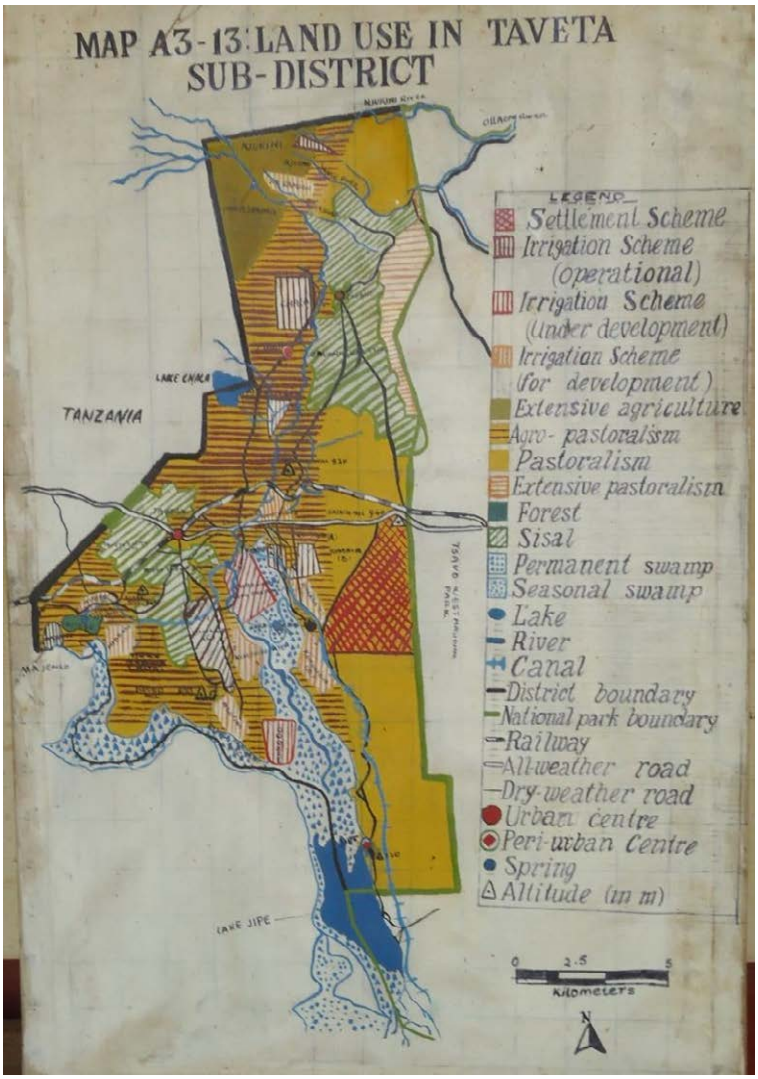
Figure 2.1.3 Soil Distribution Map(Soil texture)

Besides, according to the NWCPC report, description of the situation is different, The flood of Lumi River Basin is reported to be caused by the clayey sediment and silt deposited in the course of transportation of earth and sand by flowing water. Mountainous and hilly areas are covered with moderately thick and breakable clayey loam and the land is fertile and well drained. Therefore, the area is suitable for agriculture. In the inclined or low land, soil is composed of sandy and clayey soil. However, these areas are also suitable for agriculture. Floodplain is wetland of clayey soil containing sodium and natrium.

2.1.2 Vegetation and Land Use

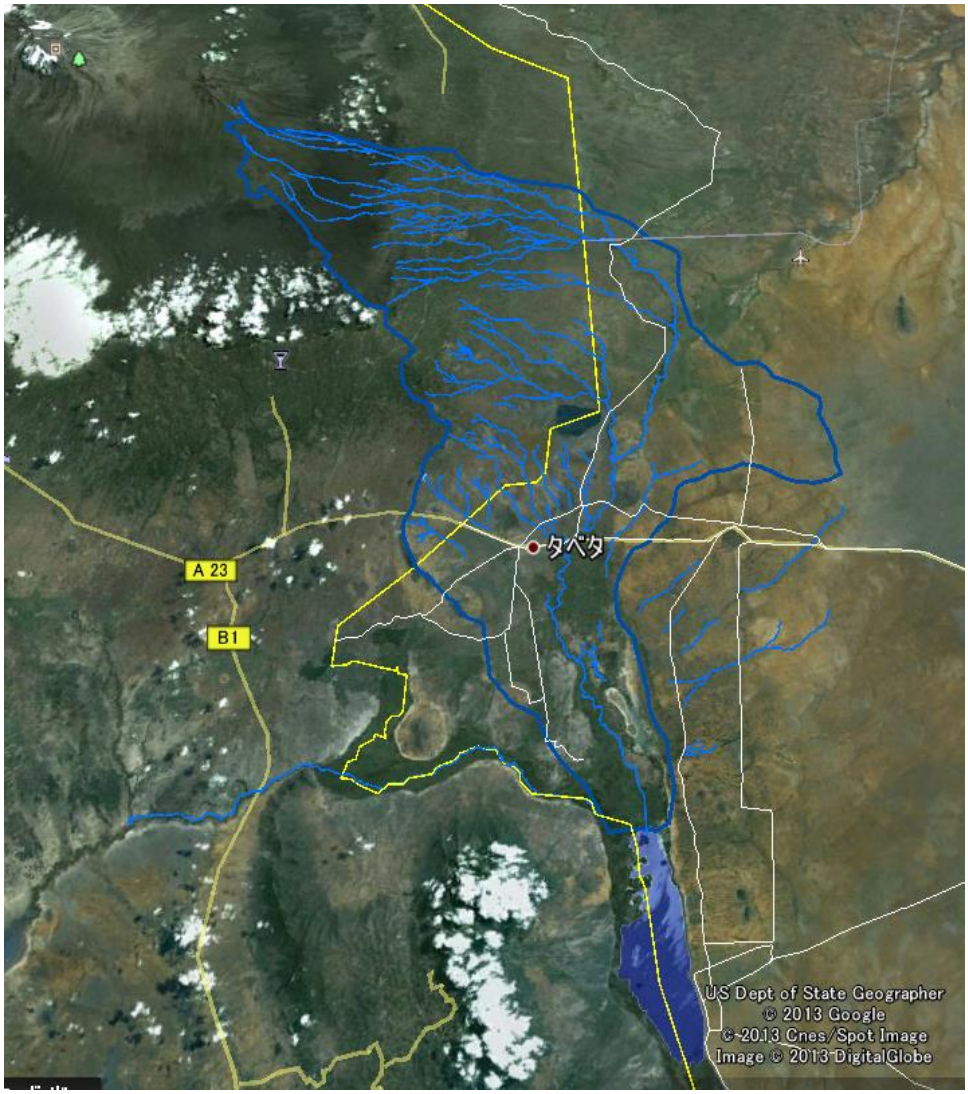
Land use characteristic in Lumi River Basin is shown in Figure 2.1.4. As shown in Figure 2.1.4, the river basin is generally utilized as agricultural land and cattle camp. In the vicinity of left bank of middle stream of Lumi River and at the east-south side of Taveta Town, sisal is grown. Low land nearby Lake Jipe is a wetland.

Judging from Figure 2.1.5 satellite Image, there is few vegetation area confirmed in the middle stream and west side, and it is understood that these areas are clayey soil exposed land. Therefore, it is inferred that the flowing out of earth and sand are caused by rainfall.



Source：WRMA

Figure 2.1.4 Land Use in Lumi River Basin



Source：Prepared by JICA Project Team based on Google Earth Image Data of October 31, 2012

Figure 2.1.5 Satellite Image of Lumi River Basin

2.1.3 Hydrology and Meteorology

(1) Rainfall and Water Level Measurement

(a) Observation Station

Lists of the rainfall gauging stations of KMD and WRMA within Lumi River basin and its vicinity are shown in Table 2.1.1 and Table 2.1.2. Of the data in these tables, the daily rainfall data obtained at Ziwani gauging station of WRMA is shown by color. Locations of each gauging station are shown in Figure 2.1.6. Rainfall gauging stations are indicated in triangle shape (▲), while the water level gauging stations are shown in box-shape(■). Further, those rainfall gauging stations which have already obtained the data and the gauging stations under jurisdiction of WRMA and KMD are colored in red, green and

blue, respectively. Similarly, for water level gauging stations, red color means the data obtained, and the water level gauging stations in the river basin are shown in green color.

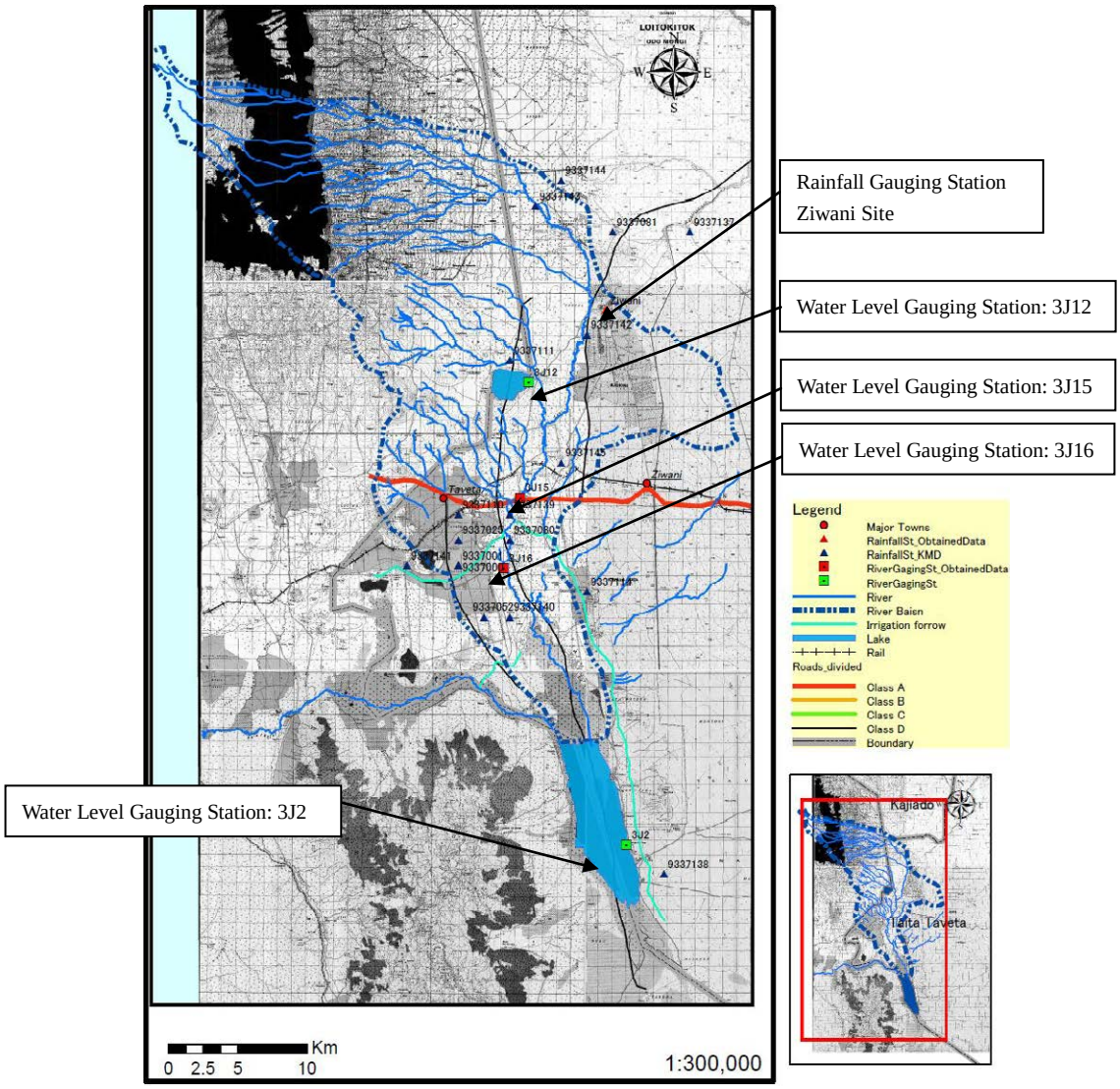


Figure 2.1.6 Location Map of Rainfall and Water Level Gauging Stations in Lumi River Basin

(b) Daily Rainfall Data

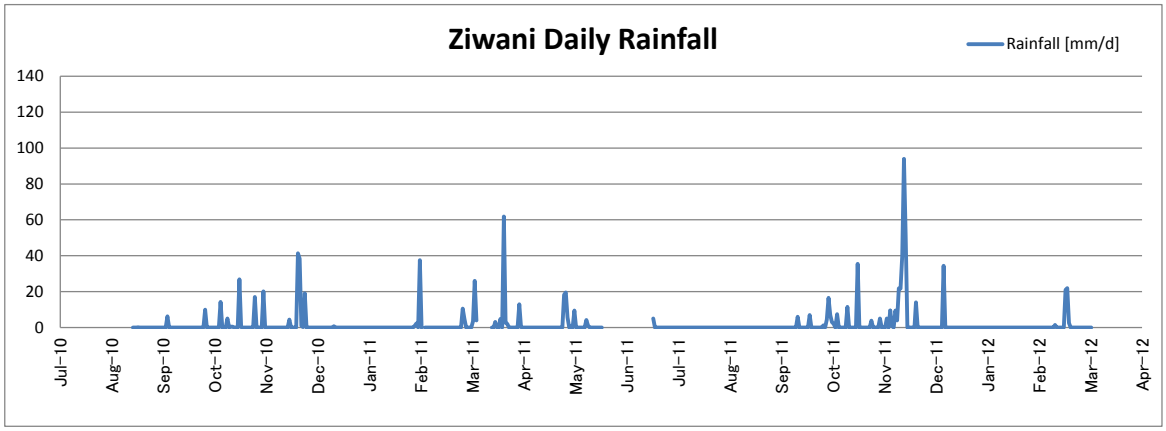
Figure 2.1.7 shows the result of daily rainfall measurement at the rainfall gauging station of Ziwani which is under jurisdiction of WRMA from September 1, 2010 to March 12, 2012. (There are some missing data.) The maximum daily rainfall recorded at Ziwani rainfall gauging station during about two years was 95mm/day recorded on November 24, 2011.

Table 2.1.1 List of KMD Rainfall Gauging Station within Lumi River Basin and its Vicinity

Station Number	Station Name	Year_Opened	Year_Closed
9337000	TAVETA_DISTRICT_OFFICE	1905	1971
9337001	TAVETA_HOMER_BROS_LTD	1926	1945
9337025	TAVETA_SISAL_ESTATE_LTD_	1938	1963
9337052	AGRICULTURAL_SECTION_TAVETA	1946	1949
9337080	TAVETA_NJORO_KUBWA	1954	1969
9337081	TAVETA_ZIWANI_SISAL_ESTATE	1941	_
9337109	TSAVO_NAT__PARK_MBUYUNI_GATE	1971	_
9337110	TAVETA_WATER_DEVELOPMENT_STATION	1968	_
9337111	TAVETA__LAKE_CHALA	1970	_
9337114	JIPE_SISAL_ESTATE	1971	_
9337137	ZIWANI_GAME_POST	1975	_
9337138	LAKE_JIPE_GAME_S_CAMP	1975	_
9337139	KIMALA_NGUI_S_FARM	1980	_
9337140	KIWALWA_MALARIA_FIELD_STATION	1980	_
9337141	KITOBO_IRRIGATION_SCHEME	1980	_
9337142	CHALA_FARMER_S_CO_OP__SOCIETY	1980	_
9337143	CHUMUINI_CHOKAA_PRI__SCHOOL	1980	_
9337144	NJUKINI_FARMER_S_CO_OP__SOCIETY	1980	_
9337145	TIMBILA_PRIMARY_SCHOOL	1981	_

Table 2.1.2 List of WRMA Rainfall Gauging Station within Lumi River Basin and its Vicinity

Station Name	FullMet_Auto_Manual	Daily/Hourly/Both	Operational	Start_Year
KWS_Office	Manual	Daily	Yes__	
Zoweni_pri	Manual	Daily	Yes__	2011
Mata_Chiefs_camp	Manual	Daily	Yes__	2008
Challa_chief's_camp	Manual	Daily	Yes__	2008
Kedong_pri	Manual	Daily	Yes__	2009
Njukini_chief's_camp	Manual	Daily	Yes__	2008
L._Jipe_KWS_Office	Manual	Daily	Yes__	2008
Kitobo	Manual	Daily	Yes__	2008
Kimirigo_chiefs_camp	Manual	Daily	Yes__	2008
Ziwani	Manual	Daily	Yes__	2010



Source：Prepared by JICA Project Team based on the record of daily rainfall from September 1, 2010 to March 12, 2012

(There are some missing data.)

Figure 2.1.7 Daily Rainfall at Ziwani Site

(c) Water Level Observation Data

There are four water level gauging stations within the river basin as shown in the following table. Water level gauging stations 3J15 and 3J16 are located in the downstream of Lumi River, and 3J15 is located at the northern part of Taveta Town, while 3J16 is located at the southern part. The remaining two stations are located at Lake Challa and Lake Jipe. (Refer to Figure 2.1.6.)

Table 2.1.3 Water Level Gauging Stations in Lumi River Basin

ID	Name	Manual/ Auto/ Both	National/ MU/IMU/ Special	Daily/ Hourly/ Both	Start Year	End Year	SRO in charge
3J15	Lumi	Manual	MU	Daily	2009	N/A	NL(Loitokitok)
3J16	Lumi	Manual	IMU	Daily	2007	N/A	NL(Loitokitok)
3J12	Lake Chala	Manual	National	Daily	2008	N/A	NL(Loitokitok)
3J2	Lake Jipe	Manual	National	Daily	2007	N/A	NL(Loitokitok)

Water Level Gauging Station No.:3J15
Measure water level of Lumi River.

Water Level Gauging Station No.:3J16
Measure water level of Lumi River. Install device under the pier.

Water Level Gauging Station No.:3J2
Water level gauging station inside Safari Camp for measurement of water level of Lake Jipe

Water Level Gauging Station No.:3J12
Measure water level of Lake Challa.

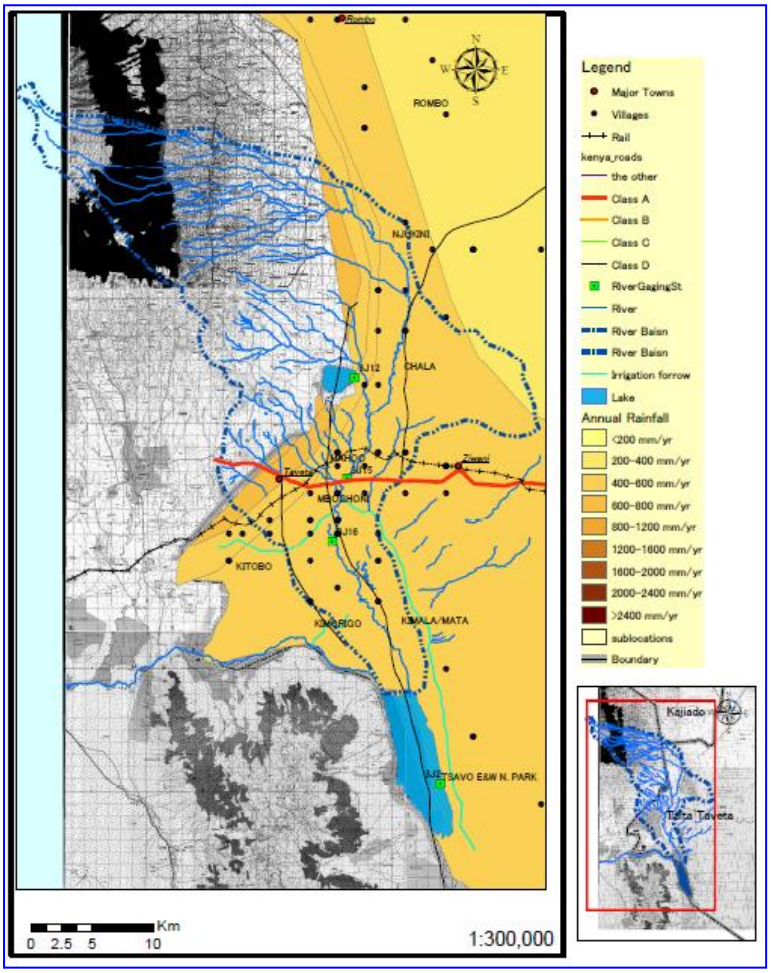
Automatic measurement is not done at each water level gauging station, but the visual observation is carried out twice a day, i.e. in the morning and in the evening. Therefore, the river discharge at the time of flood is said to be inaccurate although the conversion is done from water level data to river discharge data.

(2) Feature of Rainfall

(a) Annual Rainfall

Figure 2.1.8 shows the distribution map of the annual rainfall in Lumi River Basin. The annual rainfall ranges from 400 to 600mm in approximately 70% of the catchment area within the territory of Kenya. As the rainfall in Tanzanian side is hard to be known from this rainfall distribution map, the annual rainfall in the upstream near the headstream can't be confirmed. However, it is understood that the annual rainfall in the upstream side along the border is rather high, i.e. 600 to 800mm.

According to the NWCPC report (2006), the average annual rainfall in Lumi River Basin is reported to be about 800mm/year, while the average annual evaporation volume is 1,930mm/year.

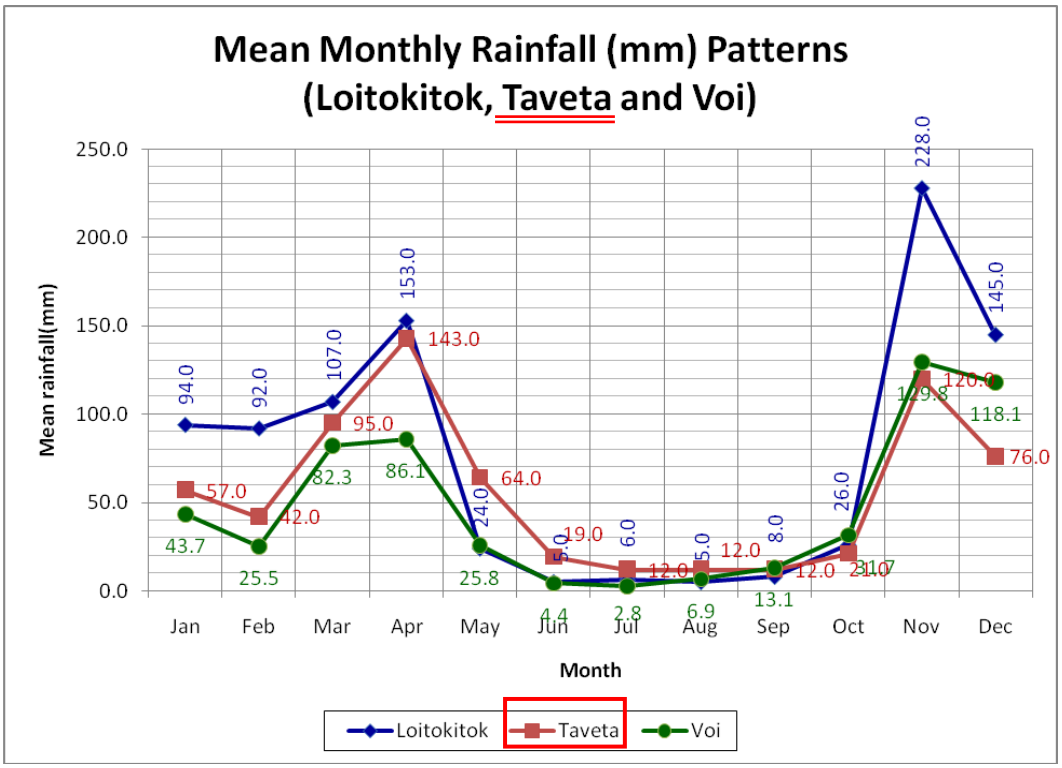


Source: Prepared by JICA Project Team based on the data of National Water Master Plan, JICA

Figure 2.1.8 Distribution Map of Annual Rainfall in Lumi River Basin

(b) Monthly Rainfall

There are two rainy seasons in Lumi River Basin, i.e. the heavy rainy season from March to May and the light rainy season from November to December. As shown in Figure 2.1.9. Average Monthly Rainfall, Taveta within the river basin records the highest rainfall in April and November through the year. In the Month of April rainfall is recorded to be the highest, it is 143mm/month.



Source : WRMA, Action Plan on The Development and Implementation of a Flood Management Plan for Lumi River

Figure 2.1.9 Average Monthly Rainfall (Taveta)

(3) Correlation between Rainfall and River Flow

The daily rainfall at Zawani station and the water level observed at 3J15 and 3J16 stations are presented in Figure 2.1.7. There are observation records for about 3 years at 3J15 and for about 4 years at 3J16, however, there are many missing periods. Verification of correlation between observed water level and daily rainfall is rather difficult as the observation records are so limited. However, as it is shown in the following figure, it seems that there is a correlation between observed water level and rainfall. As the water level shows not a high value against the maximum rainfall of 95mm/day indicated in blue circle, there seems to be a problem on the observation accuracy.

In addition, according to the NWCPC report[2], the discharge in dry season of Lumi River is $0.3m^3/s$.

[2] NWCPC, Study on Causes and Effects on Floods in Nyanza and Western provinces Tana basin and Taita Taveta District, Draft study Report (May 2006)

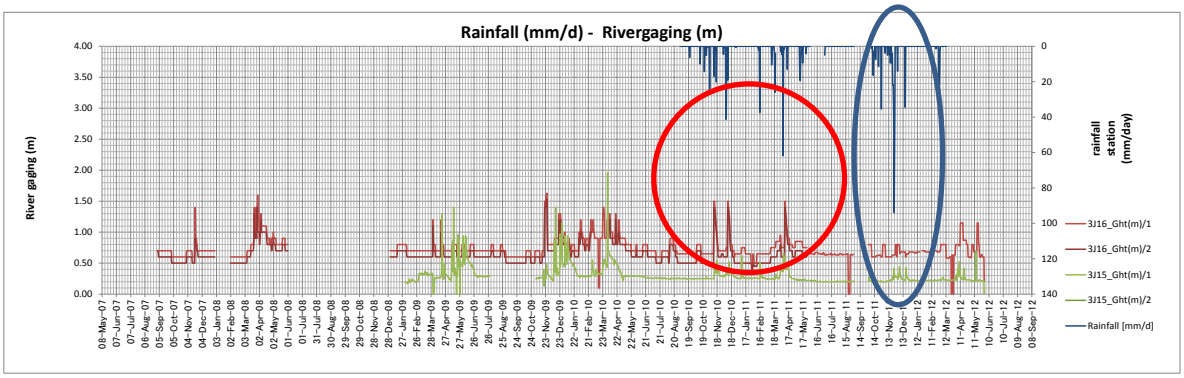


Figure 2.1.10 Correlation between Observed Water Level and Daily Rainfall

2.2 SOCIO-ECONOMIC CONDITIONS

2.2.1 Administration

Administration division of the Republic of Kenya as of March 2013 is shown below.

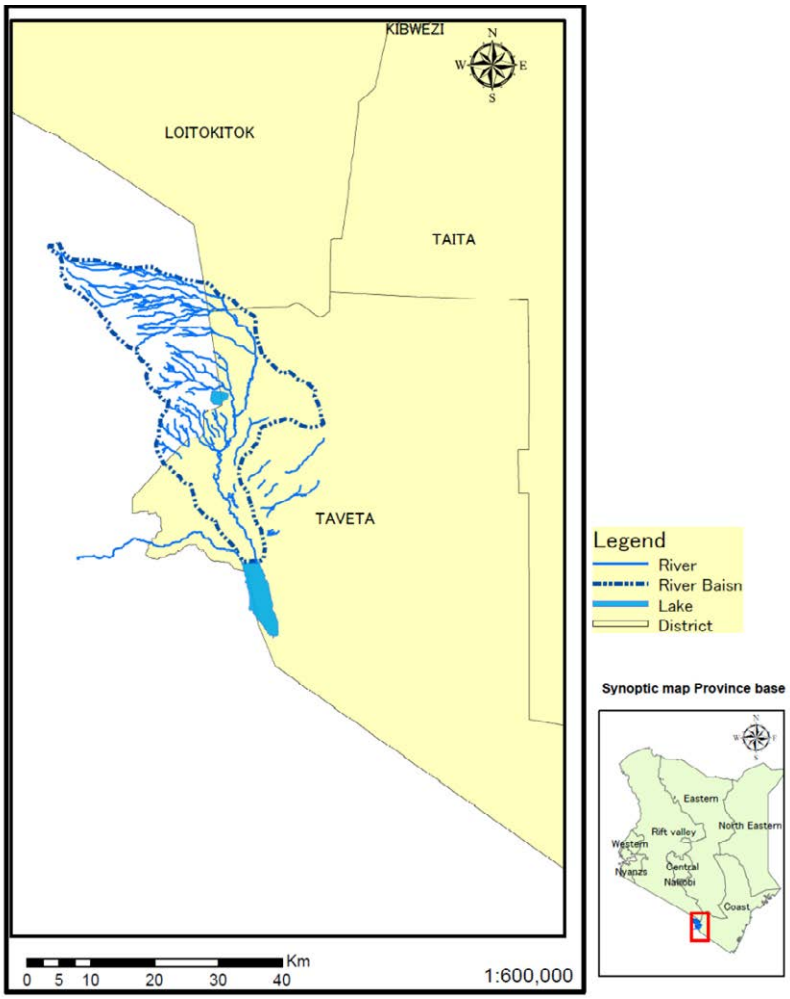
Table 2.2.1 Administrative Division in Republic of Kenya

Administration Unit	Ruler
Province	Province commissioner
District	District commissioner
Division	Chief
Location	Chief
Sub location	Assistant Chief
Community Unit	Leader
Village	Elder

In the administration system in Kenya, local governments (Province – District – Division – Location – Sub-location) are organized under President's office. The smallest administrative unit is Sub-location. Besides, although it is not an administrative organization, there is a village as a unit of rural community. Head of the respective organizations are called "Province Commissioner" for Province, "District Commissioner" for District, "Chief" for Division and Location, "Assistant Chief" for Sub Location and "Elder" for Village.

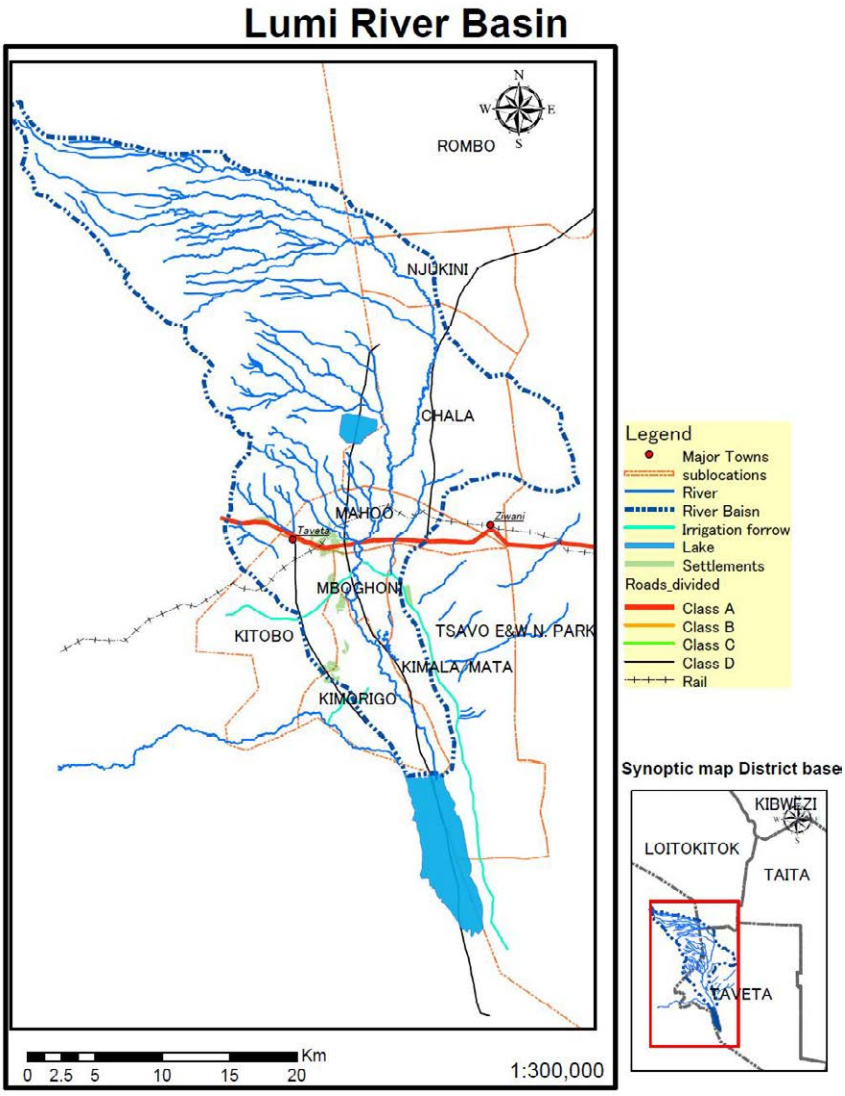
Lumi River Basin is included in Taveta District, Coast Province as shown in the following figure. (Until 2007, the area was a part of Taita-Taveta District, and the present Taveta District corresponds nearly to the former Taveta division of Taita-Taveta District. Taveta District is composed of 7 Sub Locations such as Njukini, Chala, Mahoo, Kitobo, Mboghoni, Kimorigo and Kimala/Mata. That is to say Lumi River Basin is belonging to 7 Sub Locations and a part of Tsavo National Park Division. Locations of Lumi River Basin and Sub Locations are

referred to the following figure.



Source：Prepared by JICA Project Team based on ILRI and GIS data.(District division after 2007)

Figure 2.2.1 Relation of Locations of Taveta District and Lumi River Basin



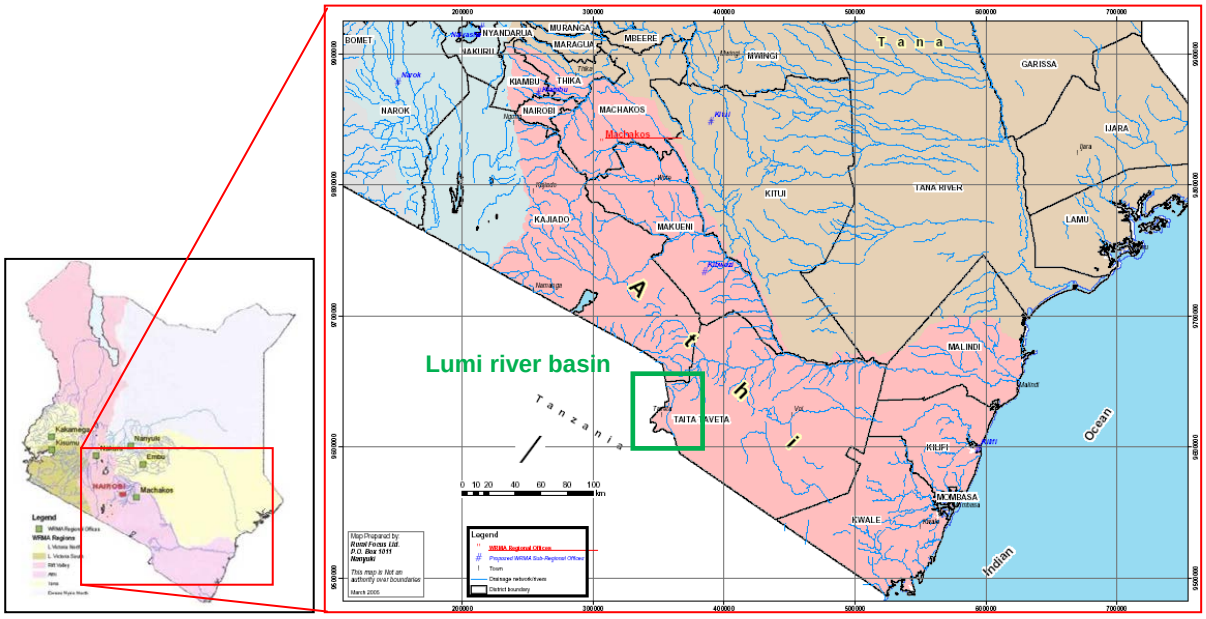
Source: Prepared by JICA Project Team based on National Water Master Plan, JICA

Figure 2.2.2 Locations of Lumi River Basin and nearby Sub Locations

Relation between the controlled area by WRMA (Water Resource Management Authority) in charge of water resource related administration and Lumi River Basin is shown below.

As set forth in the present Water Act (2002), WRMA divides the country in 6 catchment areas and the regional offices are established at each area. Catchment called “Athi Catchment Area” includes Lumi River Basin. Athi Catchment Area is composed of five sub-regional offices, such as “Upper Athi”, “Nairobi”, “Middle Athi”, “Nolturesh-Lumi” and “Coastal Athi”.

Lumi River Basin belongs to the control area of “Nolturesh-Lumi Sub-Regional Office”.



Source: Athi Water Catchment Area Catchment Management Strategy (June, 2009)

Figure 2.2.3 Athi Catchment

Photo 2.2.1 WRMA Loitokitok Sub-regional Office

2.2.2 Population

Table 2.2.2 shows the population census data of 2009 which includes the data of densely populated Taveta District within Lumi River Basin. According to this data, the population density in Bomani Location in Taveta District is 400 persons or little less per km^2 to 600 persons or little less per km^2. Number of households records high in this area. In Mjimi Sub location, the population density per km^2 is quite high, i.e. approximately 3,000. However, this location is outside of Lumi River Basin.

Table 2.2.2 Population Census Data of 2009 in Taveta District

Province	District	Division	Location	Sublocation	Male	Female	Total	Households	Area in Sq.	Population Density
COAST	TAVETA	BOMENI	BOMANI	MAHOO	1578	1618	3196	813	7.28	438.75
				MALUKILORITI	753	785	1538	358	12.3	125.03
				MBOGHONI	4241	4141	8382	2384	14.25	588.36
				NJORO	1254	1146	2400	609	6.62	362.79
			KIMORIGO	ELDORO	2212	2111	4323	967	26.46	163.36
				KIMORIGO	1055	884	1939	418	37.41	51.83
			KITOBO	KITOBO	1994	1807	3801	839	33.81	112.42
				MRABANI	1234	969	2203	510	57.27	38.46
			NGARASHI	LESESIA	591	564	1155	217	9.31	124.01
				MJINI	4613	4369	8982	2544	2.89	3108.5
		CHALLA	CHALLA	CHALLA	2661	2345	5006	1243	106.9	46.83
				MAHANDAKINI	1550	1416	2966	567	28.35	104.64
				NAKRUTO	628	633	1261	263	14.51	86.89
			NJUKINI	CHUMVINI	1483	1397	2880	543	11.92	241.66
				LUMI	1260	1183	2443	510	26.25	93.06
				NJUKINI	2477	2293	4770	989	33.94	140.52
		JIPE	JIPE	KIMALA	1855	1753	3608	911	12.61	286.16
				MATA	2413	2136	4549	1088	166.81	27.27
			TIMBILA	MSENGONI	555	594	1149	288	8.04	142.83
				NDILINDAU	498	456	954	213	9.19	103.78
		NATIONAL PARK	NATIONAL PARK	TSAVO WEST	114	46	160	84	2875.74	0.06

Source: Kenya National Bureau of Statistic, Census 2009

2.2.3 Industry

According to Taveta District Development Plan (2008-2012), the most active industry in Lumi River Basin is the agriculture. The following table shows the production of crops in Taveta District. The production weight is shown by the number of 90kg bags and the amount (Sh) is shown calculated by multiplying the unit price per kg to the total production weight.

Table 2.2.3 Status of Harvest of Crops in Taveta District (Weight, Amount: Year 2008)

Crop	Total Achieved Production 90 Kg Bags	Farmgate price Sh/ Kg	Sh
Maize	27,297	20	545,940
Rice	1,184	70	82,880
Sorghum	1,135	40	45,400
Millet	599	70	41,895
Beans	3,384	70	236,880
Cowpeas	1,185	70	82,964
Pegion Peas	329	70	23,016
Green Grams	870	70	60,900
Cassava	376	40	15,024
Sweet Potatoes	318	50	15,883
Arrow Roots	178	50	8,880
Cotton	1,026	26	26,676
Sunflower	738	18	13,284
Ground nuts	217	80	17,344

Source: WRMA (Total amount is calculated by JICA Project Team)

About 14 kinds of crops are produced in Taveta District such as Maize, Rice, Beans, Potatoes, Cotton, etc. Out of these crops, the most productive one is the principal food, Maize in terms

of weight and amount. Following Maize, Beans、Cowpeas、Rice、Sorghum、Cotton are actively produced.

Major stock farm products are milking cow, cow for meet, woolly, goat and poultry. Apiary business is run at the dry region. Besides, fishery is active at Lake Jipe and Lake Challa from the view point of food security and job creation. Annual fish catch reaches approximately 9 tons, and tilapia and fresh-water catfish are the major fish kinds.

Taveta District is also an area of production of sisal. However, there are no treatment facility of material and the factory processing the sisal into craft products.

Lumi River Basin is a supply area of fruits like banana, etc. and vegetables, too. Therefore, as there is a potential for processing agricultural products, the economic growth in future is expected.

Within the river basin, there is Tsavo West National Park and it is located at the gateway of Serengeti National Park. Therefore, there are tourist facilities such as lodge around Lake Jipe.

Photo 2.2.2 Rice Field in the Downstream Area of Lumi River

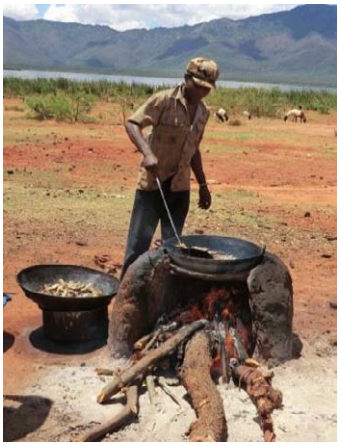


Photo 2.2.3 Fisherman nearby Lake Jipe

2.3 DEVELOPMENT PLAN

2.3.1 Vision 2030

According to "Vision 2030", there is the following development plan.

"Strengthening of Irrigation Facility":

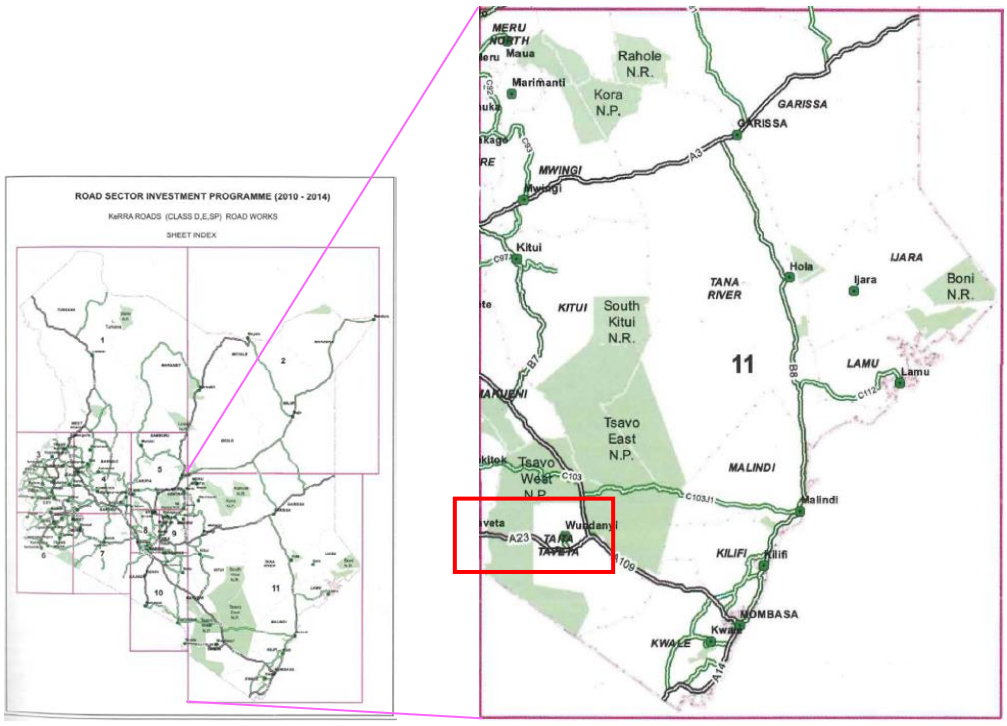
Currently, there is an irrigation strengthening project in Tana Delta as the flagship project. This project is proposed to be disseminated to the other regions including Taita-Taveta.

2.3.2 Taveta District Development Plan (2008-2012)

According to the Taveta District Development Plan which is the development plan in Taveta District, there is the following development plan.

(1) Improvement of Weak Road and Logistics Infrastructure

Under the present circumstances, appropriate budget is not secured. Accordingly, maintenance is not properly done. Damages caused by flood are also problematic. For the meantime, accessibility is planned to be improved up to 65%. Especially the accessibility of A23-Mwatate-Taveta Road shown in the following figure shall be strengthened, the flood damage of Taveta District shall be reduced, and the airport shall be rehabilitated.



Source：Ministry of Roads, Road Sector Investment Programme 2010 – 2024 (May 2011)

Figure 2.3.1 Road Plan Map

2.3.3 Athi Water Catchment Area Catchment Management Strategy (2009)

According to the "Athi Water catchment Area Catchment Management Strategy" which is the management plan prepared by WRMA for Athi Water Catchment, there is the following river basin management strategy.

(1) Surface Water/Flood Mitigation

To achieve the objective, the conservation of surface water is promoted in conjunction of micro (household level) with macro (province level).

- Construct a large reservoir type dam to store water for the household use, irrigation, livestock farming, industry and power generation,
- Secure water resource for water supply and small scale irrigation in the rural area by rehabilitating middle to small scale dams and ponds having sedimentation and/or damage,
- Promote detailed investigation and economic analysis for the site suitable for constructing dam which would contribute largely to the water supply and the reduction of flood,
- Promote rain water harvesting by storage tank of rain water and pond in the rural area, and
- Make effort for flood management in the river basins of Sabaki, Lumi and Voi.

(2) Enhancing Capacity to Regulate Storage Infrastructure Development

WRMA will not construct reservoir dam by itself, however, WRMA is partly responsible for design and construction. Training of the regional office staff is required for capacity building on design and construction management of reservoir facility including reduction of disaster and rescue.

3. ANALYSIS OF FLOOD CHARACTERISTICS AND COUNTERMEASURES

3.1 OVERALL CONDITION ON FLOODS IN THE LUMI RIVER BASIN

3.1.1 Records of Flood Damages

Records of flood damages in the Lumi River Basin are shown in Figure 3.1.1. Especially, near river mouth area such as Kimorigo sub-location, KImala Mata sub-location and Kitobo sub-location suffered heavy damages from flood from the Lumi River. The longitudinal slope of the Lumi River is steep in the mountainous area of Mt. Kilimanjaro within the border of the United Republic of Tanzania. When the river flows into the territory of the Republic of Kenya, the stream has gentle gradient. (Figure 3.1.1). The section from the Lake Jipe to Taveta Town is about 1/1000 to 1/500 and the velocity in the section is low so that flood water is extended for a long period of time at the lower basin.

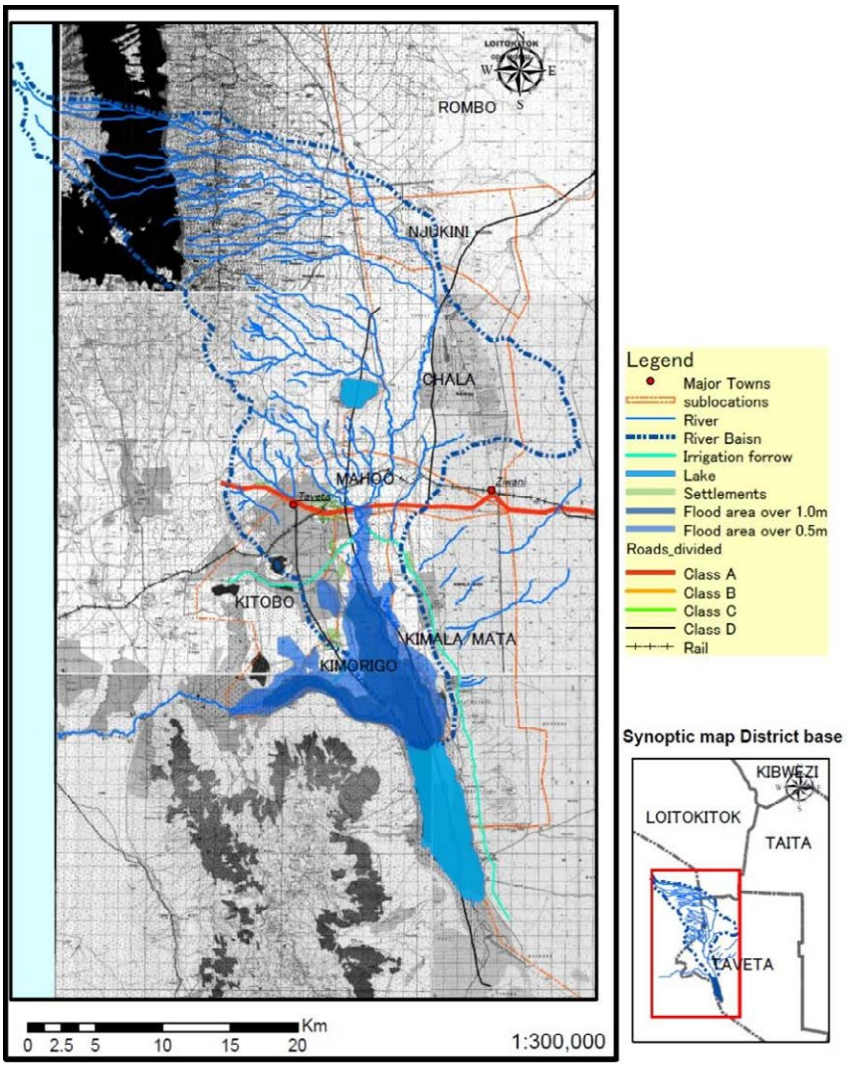


Figure 3.1.1 Records of Flood Damage in the Lumi River Basin

In the lower Lumi River Basin suffers damage from flood frequently and it has major adverse effects on agricultural products, infrastructures, houses, lives and properties, land use, local economy and etc. Moreover it is caused a delay of development. Since flood damage is extremely important problem for people who live in the lower Lumi River Basin, they put priority on issues of flood management in the Sub-Catchment Management Plan.

According to information that is provided by WRMA, numeric character data of floods which was occurred in an ordinary year and 2009 in the lower Lumi River Basin is shown in the Table 3.1.1. It indicates that approximately 80km^2 was inundated in 2009 that was four times larger area and the number of victims and duration of the evacuation was two times larger and longer than an ordinary year.

Table 3.1.1 Overview of Flood in the Lower Lumi River Basin (Ordinary year and 2009)

	The flooding situation in an ordinary year	The flooding situation In an extreme year (2009)
Flood area	22.5 km^2	79.8 km^2
Depth of water	0.3 m	0.9 m
No of evacuee	700	1600
Evacuation duration	1 month	2 month
No of floods in a year	1	2

Source : The table is created by JICA Project Team based on information provided by WRMA

Overview of recent flood damages in the lower Lumi River Basin is shown in Table 3.1.2. As described above, estimated flood damage in 2009 is approximately 30,000,000 Ksh and it is larger than an ordinary year. On the other hand, number of people who were affected by flood in 2009 is shown to be lower than an ordinary year. Thus there is a possibility that WRMA could not collect and understand actual data and information of flood damage in the basin.

Table 3.1.2 Overview of Annual Flood Damage in the Lumi River Basin

Year	No of People affected	No of People dead	Estimated Damages cost (Kshs)
2012	464	0	5,530,000
2011	105	1	1,350,000
2010	110	0	1,700,000
2009	29	4	30,300,000
TOTAL	708	5	38,880,000

Source: ACTION PLAN ON THE DEVELOPMENT AND IMPLEMENTATION OF A FLOOD MANAGEMENT PLAN FOR LUMI RIVER Training Program: Capacity Development for Flood Risk Management with IFAS (A)July 9th to August 8th 2012

Table 3.1.3 presents estimated flood damage cost and inundated area of agriculture sector in the Lumi River Basin from the year of 2001 to 2011. Irrigation facilities of Kitobo suffered a

great deal of damage on cost and area of farming land

Table 3.1.3 Agricultural Estimated Damage in the Lumi River Basin (2001-2011)

	Name of Irrigation scheme	Area (HA)	Damage Cost
1	Kasokoni	5.3	430,000
2	Block C	12	235,000
3	Ngutini	4.9	780,000
4	Marondo	1.8	3,000,000
5	Msengoni	6.2	230,000
6	Kamleza	6.1	1,200,000
7	Kitobo	21	13,900,000
8	Rekeke/Lumi (Grogan canal)	8.9	2,100,000
9	Kimondia	8.1	730,000
10	Kimala	3.5	650,000
	Total		23,255,000

Source: District Irrigation Office - Taveta

3.1.2 Flood Condition Inquiring From Relevant Communities

The principal points having flood damages in the Lumi river basin are Kimorigo, Kiwalwa, Eldoro, Riata Marabani, Rekeke, Kimala, Ndilidau, Njoro, Bahati, Mata-Jipe and Kitobo etc. The results of inquiring survey on the communities concerning the flooding situations in these points are shown in the following table.

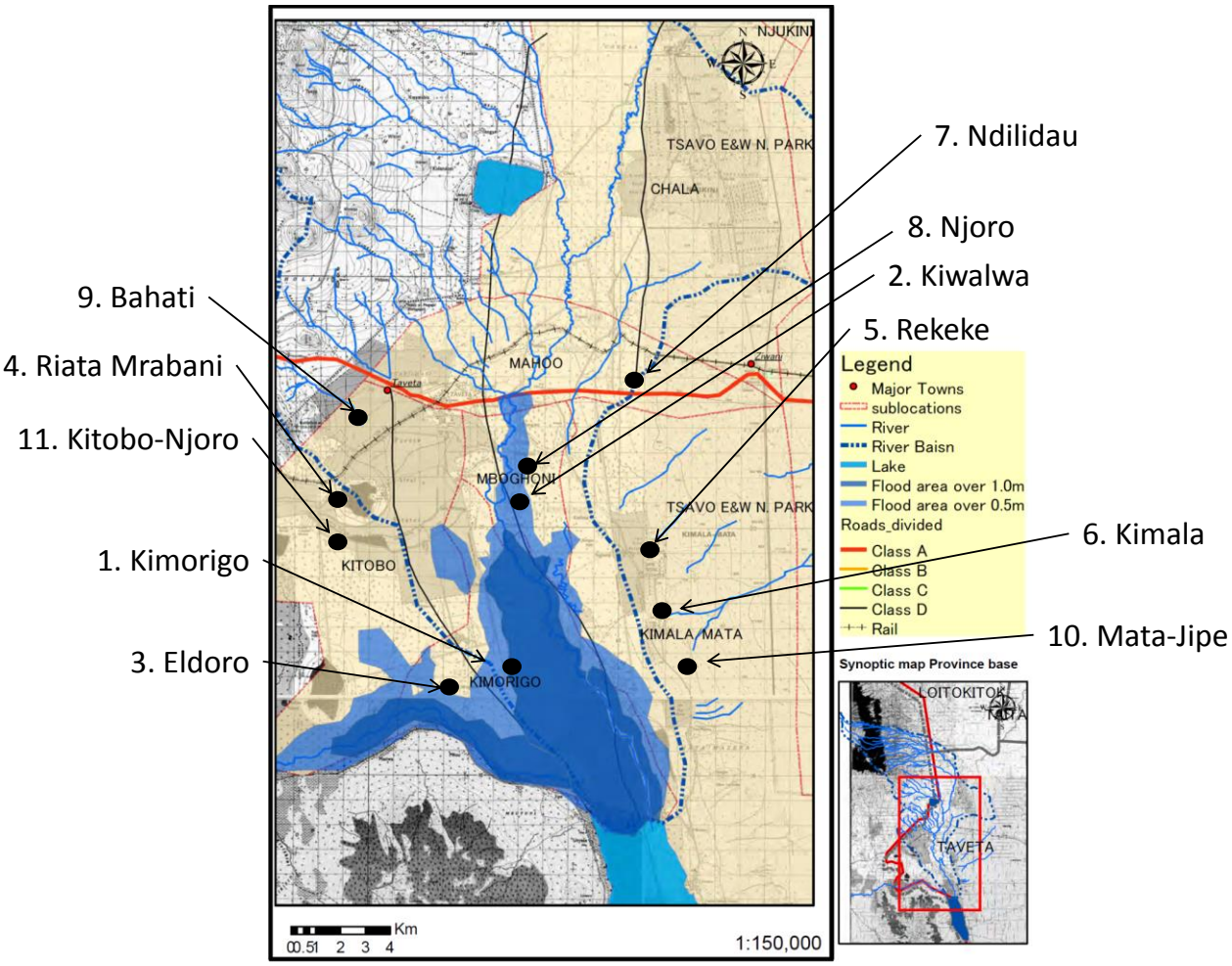


Figure 3.1.2 Location Map of Principal Community in Downstream Area

Table 3.1.4 Communities in Lumi River Basin and Each flood situation

No	Community	Water depth (cm)	Duration Time	Frequency	Direct Affected Population by Flood	Population	Direct Affected Population by Flood /Population
1	Kimorigo	120	2 months	2 times in a year	1939	1,939	1.00
2	Kiwalwa	40	3 week	2 times in a year	4500	7,082	0.64
3	Elodro	120	2 months	2 times in a year	300	4,323	0.07
4	Riata-mrabani	60	8 hours	2 times in a year	200	2,203	0.09
5	Rekeke	60	5-6 hours	2 times in a year	200	1300	0.15
6	Kimala	60	5 hours	2 times in a year	950	1,608	0.59
7	Ndilau	60	8 hours	2 times in a year	500	954	0.52
8	Njoro	45	2 hours	2 times in a year	1000	2,400	0.42
9	Bahati	40	3 hours	2 times in a year	800	1,550	0.52
10	Mata-Jipe	60	6 hours	2 times in a year	3000	4,549	0.66
11	Kitobo-Njoro	60	8 hours	2 times in a year	500	3,801	0.13

Source: JICA project team survey by inquiring to communities

Widespread and long term inundation around the river mouse caused by outflow from the Lumi River or dyke break bring the severe damages to especially “Kimorigo” or “Eldoro”

communities located in inundation area western side of the Lumi River, and there occurred the inundation with 120cm depth and 2 months duration.

According to the figure described above, “Rekeke” or “Kimala” communities are located around the downstream tributaries and small streams towards Lake Jipe directly and they are absolutely different with the phenomenon of flooding around the Lumi River.

It can be speculated that the flow velocity is high because the duration of inundation is comparatively short as around several hours.

In addition, although the depth is 60cm around, the dangerousness of inundation caused by erosion or corrosion is high because of high energy of flow led by high velocity. And then, the evacuation will be difficult even the water depth is shallow.

Also, following features can be pointed out by inundation points.

- Although the population of Kimorigo community is smaller than Kiwala or Eldoro, the number of affected people ratio in community population is very high.
- The number of affected people of Kiwala or Mata-Jipe is numerous because their population is large.

According to this, the damage situations and flood type in each community by project team’s inquiring survey on the communities are shown below.

(1) Kimorigo

- Water depth is 120cm, duration is 2 month when floods occurs.
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- Flow from river water and from upstream even when there is no rainfall in Kimorigo area
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- Waters and sediments flow into the houses
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- Small livestock such as goats, sheep, chicken and rabbits swept away
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- The murram roads are inundated with flood water cutting off the villages from travelling.
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- The farms are flooded sweeping away the food crops
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- During very heavy flows Abori Primary School is closed
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- Some mud houses are swept away
  ..... (Inundation caused by overflow and dyke break from the Lumi River)
- Some of the farmlands have been turned into permanent swamps
  ..... (Inundation caused by overflow and dyke break from the Lumi River)

(2) Kiwalwa

- Flood waters flows into the farmlands and sweeps the crops away
  .....(Inundation caused by overflow and dyke break from the Lumi River)
- Sediment flows into the houses and deposited inside
  .....(Inundation caused by overflow and dyke break from the Lumi River)
- Access roads are affected by the flood water interfering with transportation of produce to the market.....(Inundation caused by overflow and dyke break from the Lumi River)
- Pollution of spring water
  .....(Inundation caused by overflow and dyke break from the Lumi River)

(3) Elodro

- Some of the farmlands have been turned into permanent swamps
  .....(Inundation caused by overflow and dyke break from the Lumi River)
- During periods of very heavy flooding school work is interfered with at Eldoro Primary School.....(Inundation caused by overflow and dyke break from the Lumi River)
- The flood waters sweep away the food crops
  .....(Inundation caused by overflow and dyke break from the Lumi River)

(4) Riata-mrabani

- Flooding from the slopes of Mt. Kilimanjaro..... (Flash flood)
- Destruction of infrastructure like roads and the railway..... (Flash flood)
- Flood water gets into the houses with sediments..... (Flash flood)
- Very serious gulley erosion leading to loss of farmlands ..... (Flash flood)

(5) Rekeke

- Flood waters from Tsavo West ..... (Flash flood)
- Destruction of infrastructure such as the bridge on the road ..... (Flash flood)
- Death of one villager in 2009 ..... (Flash flood)
- Destruction of houses in Rekeke .....(Flash flood)
- Sediment flow inside the houses .....(Flash flood)
- Small livestock such as goats, sheep, chicken and rabbits swept away (Flash flood)
- Very serious erosion that increases the sizes of the gulleys and reduces the size of the residents farmlands at the same time..... (Flash flood)

(6) Kimala

- Flood waters mainly from the Tsavo West National Park..... (Flash flood)
- Leads to destruction of infrastructure like bridges ..... (Flash flood)
- Houses are inundated with flood water..... (Flash flood)
- Loss of lands by gully erosion..... (Flash flood)

(7) Ndilau

- Flash flooding from the side of Tsavo West National Parks .....(Flash flood)
- Heavy soil erosion has led to the formation of very big gulleys hence loss of farmlands .....(Soil and sediment run off)
- It has caused the destruction of the road to Voi and Lake Jipe.....(Soil and sediment run off)
- The flood flows also cause the destruction of houses .....(Flash flood)
- Destruction of farmland and the sweeping away of crops .....(Flash flood)
- 1 person was killed while trying to cross the big gulleys during the flood.....(Flash flood)

(8) Njoro

- Flood waters cause the pollution of the springs .....(Inundation caused by overflow and dyke break from the Lumi River)
- Sweeping away the crops in the farmlands .....(Inundation caused by overflow and dyke break from the Lumi River)
- Destruction of the house .....(Inundation caused by overflow and dyke break from the Lumi River)

(9) Bahati

- Flash flooding from the side of Tsavo National Park.....(Flash flood)
- Destruction of the houses.....(Flash flood)
- Sweeping away of the livestock..... (Flash flood)

(10) Mata-jipe

- Flash flooding from the side of Tsavo West National Park.....(Flash flood)
- Destruction of houses.....(Flash flood)
- Sweeping away of Livestock and other domestic animals.....(Flash flood)
- Sweeping away of the crops in the farms.....(Flash flood)
- Serious gulley erosion leading to the loss of farmland .....(Flash flood)

(11) Kitobo-Njoro

- Flash flooding from the mountain on the upper side but then the flood water settle near the Kitobo spring .....(Flash flood)
- Leads to the pollution of the spring waters .....(Flash flood)
- Land surrounding the Kitobo springs made unsuitable for agriculture.....(Flash flood)
- Serious gulley erosion leading to the loss of farmlands.....(Flash flood)

3.1.3 Existing Structures along the River

There are flood control and water use facilities in the Lumi River Basin such as Canal-A, Canal-B, Canal-C and Grogan-canal.

As shown in following figures, Canal-A (approx. 12km), Canal-B and Canal-C (approx. 17km) flow parallel on the western side of the Lower Lumi River and these three canal merge into one at the north side of the Lake Jipe and then the canal connects the Ruvu River which flow from the Lake Jipe. These canals were constructed in 1930's during the colonial period and they have functions of drainage and irrigation.

According to the report of NWCPC, embankments (Height: 1.5m, Length: 10km) along the Canal-C were built in 1973. In conjunction with construction of embankments, two irrigation canals were dredged. However, due to sediment discharge and inappropriate maintenance of the channels, capacity of flow has been reduced and part of embankment got collapsed when flood had occurred. Since then canals doesn't fulfill a function. Especially flood in 1987 and 1997, farmers destroyed dykes in order to intake agricultural water for farmland between the Lumi River and dyke and currently part of embankment is dysfunctional.

Part of embankment of Canal-C (approx. 700m) is broken at this moment, flooding water in the Lower Lumi River can't run through the Canal-C and spread across area of the Canal-B and the Canal-A. We infer that these canals which can't fulfill a function may have caused frequent flood damage in the western low-lying area of the Lower Lumi River Basin.

On the other hand, part of the Grogan Canal was renovated at the initiative of WRMA in 2012, it is function effectively on irrigation purpose and WRUA is maintaining the canal and its facilities properly. Hence, MWI, WRMA, DC, WRUA and etc. become their primary focus on projects of renovation on the Canal-A, Canal-B and Canal-C and mitigation of flood damages,

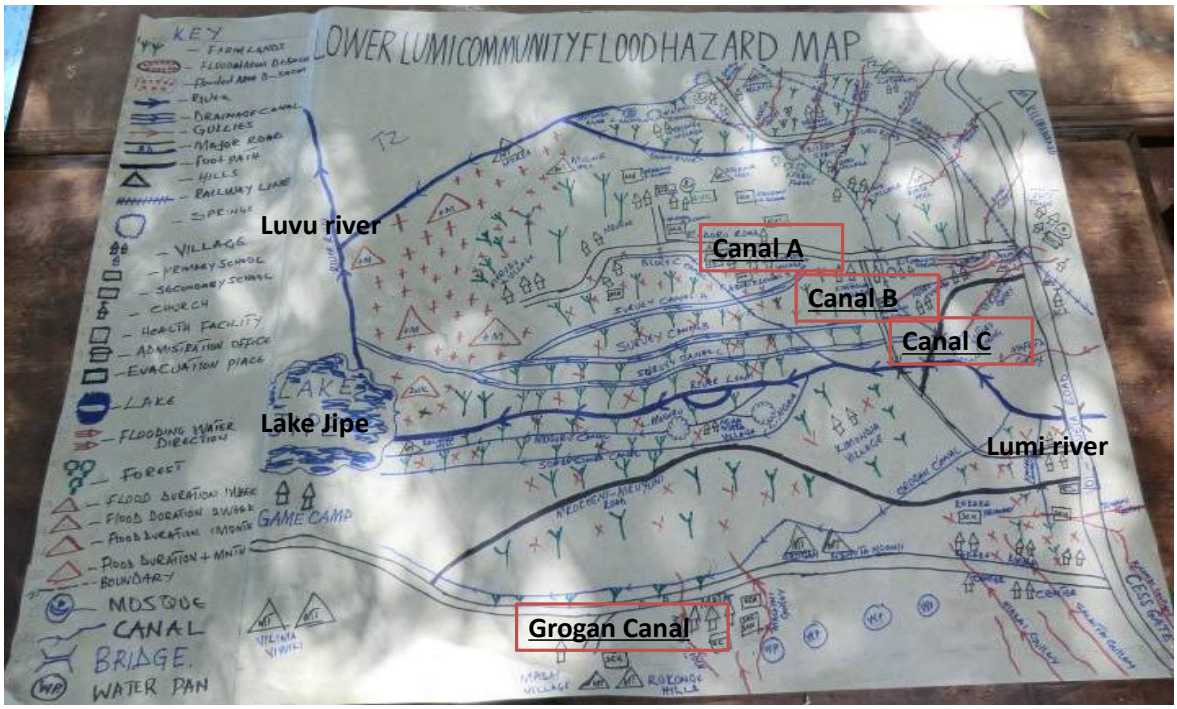


Figure 3.1.3 Location of Canals

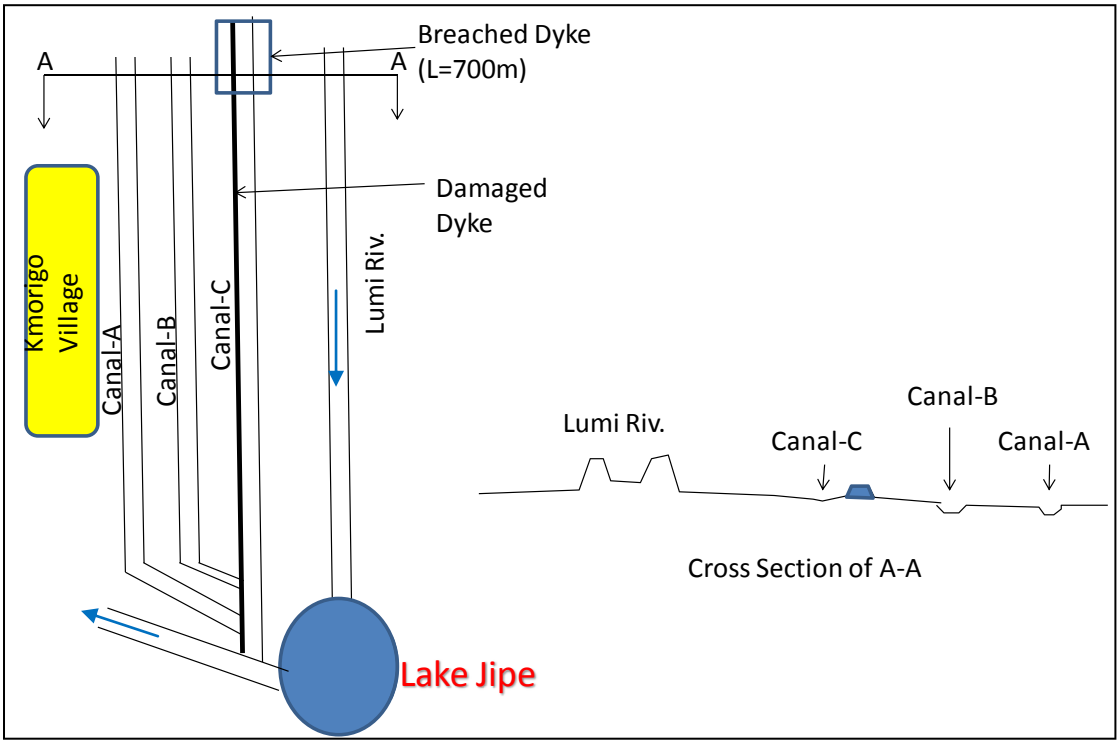


Figure 3.1.4 Cross-section Diagram of the Lumi River and Canals

Photo 3.1.1 Embankment of the Canal-C

Photo 3.1.2 Broken point of the embankment Canal-C

Photo 3.1.3 Canal-A around Kimorigo village

Photo 3.1.4 A point of artificially-destroyed embankment
(take agricultural water from Lumi R. of the left side on the photo and supply to the right side)

3.2 FLOOD CHARACTERISTICS AND SITUATION OF DAMAGES IN THE LUMI RIVER BASIN

3.2.1 Concept of Flood Characteristics and Situation of Damages in the Lumi River Basin

There are three types of flood characteristics in the Lumi River Basin as described below;

Mark	Flood Type	Area
A	Soil and sediment run off	Upper and middle river basin
B	Widespread and long-running inundation which is caused by overflow and dyke break from the Lumi River	Low-lying area at the lower river basin)
C	Flash flood	Branches of the Lower Lumi River and small streams flow in the Lake Jipe

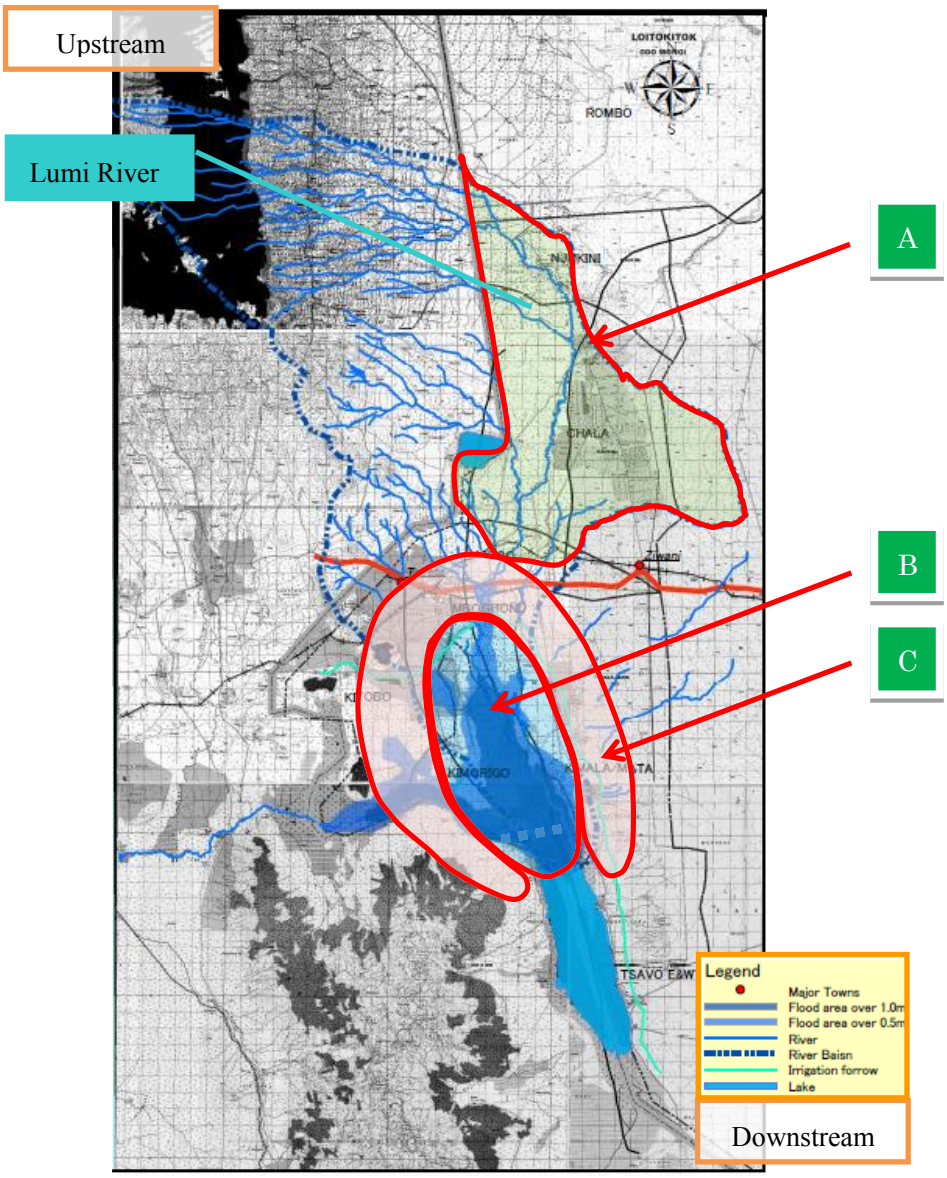
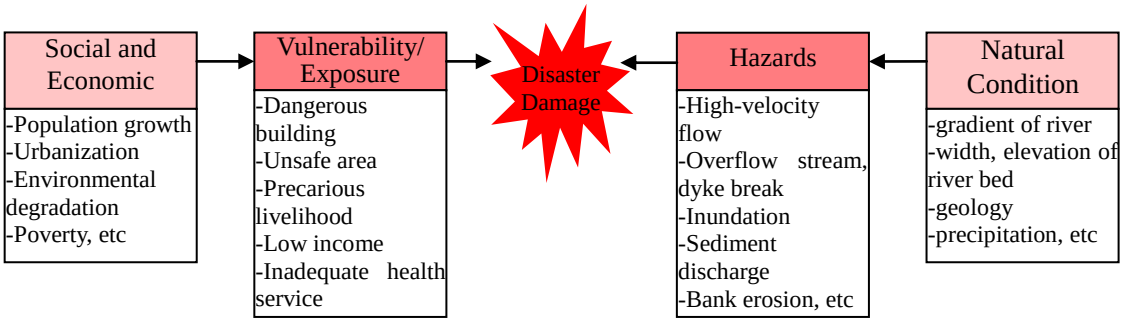


Figure 3.2.1 Records of Flood Damage and Classification of Flood Characteristics in the Lumi River Basin

Flood damage has a close relationship with natural condition and Socio-economic condition in a local area. Natural condition defines types of Hazards in a river basin and Socio-economic condition defines vulnerabilities and exposures. Moreover, it could be said that disaster (flood) damage is defined from both aspects. Characteristics of flood damage are analyzed using information of last chapter (Natural condition and Socio-economic condition) about each flood characteristics of A), B) and C) as above-mentioned.



Source: Revised by JICA Project Team, based on material of "Community and Development assistant of Disaster Prevention, Mr. Mikio Ishiwatari(1997)

Figure 3.2.2 Mechanism of Flood Damage

3.2.2 Soil and sediment run off in upstream and middle stream (A)

Flood characteristics in the upstream and middle stream which are analyzed from the aspects of natural, Socio-economic conditions are shown below.

(1) Flood Characteristics from Natural Conditions

There is heavy rainfall around the mountain-side of Mt. Kilimanjaro and those areas have a sharp inclination of 1/30 – 1/20. Because of high flow velocity and most of area doesn't cover with forest and vegetation, it is more likely to erode clay soil and a large amount of soil is supplied to the downstream.

- Sediment discharge is causing aggradation of river bed levels in the downstream that is gentle slope and low flow velocity.
- In addition, flash floods occur at the Lumi River's Tributaries.
- Most of upper and middle of the Lumi River Basin is located in the territory of the United Republic of Tanzania and mountain area of Kilimanjaro and the area has a high precipitation.

Natural Conditions that are described in the last chapter and Hazards in this area are shown as Table 3.2.1.

Table 3.2.1 Natural Conditions and Hazards in Upstream and Middle Stream

Natural Conditions	Hazards
Heavy rains in the mountain area Geography: A sharp inclination (1/30 -1/20)	Soil Erosion High velocity and tractive force High peak discharge
Large area of bare lands	Soil erosion Sediment run-off

(2) Characteristics of Flood Damage from Socio-economic conditions

Relationship between conditions on Social and Economic and Vulnerability/ Exposure to Natural disasters in the upstream and middle stream are shown below.

There are stockbreeders and fish farmers in the area. The area extends across border of Kenya and Tanzania. In order to analyze flood characteristics of the Lumi River Basin, data of metrological, hydrological, geological and land use in the upstream area are required. However, most of upper and middle river basin is located in the territory of the Tanzania, sharing information between the government of Kenya and Tanzania is not established at this moment.

Table 3.2.2 Conditions on Social and Economic and Vulnerability / Exposure in Upstream and Middle Stream

Socio-economic conditions	Vulnerability/ Exposure
Population is 10,000. Density of population 50~150 person/km	Density of population is low. Vulnerability is small.
Stockbreeding	Make it difficult to protect livestock and breed
Culture fishery in the Lake Chala	Lose/ threaten fish former's livelihood
Highway and trunk route	Structural vulnerability of roads and bridges
The basin is located in International River Basin (Kenya and Tanzania)	Difficult to collect data of metrological, hydrological and etc. from the Tanzania

Figure 3.2.3 Flood Characteristics in upstream and middle stream

(3) Flood Damage Mechanism

Around upstream to middle stream, sediment outflow has occurred with farmland erosion caused by furious rainfall and high velocity sheet flow. However, in this area, raising livestock is also prosperous, and then the impact from sediment outflow is not so severe.

3.2.3 Flood Characteristics of Low-lying Area in the Lower Lumi River Basin (B)

Flood Characteristics of low-lying area in the lower Lumi River Basin which are analyzed from the aspects of natural, Socio-economic conditions are shown below.

(1) Flood Characteristics from Natural Conditions

- Low-lying area is inundated by flood water of over flow and dyke break from the Lumi River due to lack of flow capacity.
- The lack of flow capacity is caused by narrowness, high bedded and gentle slope of the Lumi River. Aggradation of river bed levels is generated by discharged sediment. Moreover gentle slope (1/1000 – 1/500) of river profile is causing low flow velocity. (Reference on Photo which was taken near the mouth of the Lumi River)
- Drainage canals (Canal-A, -B and –C) which are located in the inundation area don't have enough flow capacity and part of embankment along the canals is broken; hence these canals don't fulfill their function of existed facilities.
- Inundation is prolonged at the low-lying area because gradient of land features is gentle (1/1000 – 1/500).
- In addition, due to rising water level of the Lake Jipe, flooding water has nowhere to go

Photo 3.2.1 Near the mouth of the Lumi River
(the River is narrow and water level is higher than farming land)

Natural Conditions that are described in the Chapter-1 and Natural Risks (Hazards) in this area are shown in Table 3.2.3.

Table 3.2.3 Natural Conditions and Hazards in the Lower Lumi River Basin

Natural Conditions	Hazards
Gentle river bed slope and flat landscape	Interrupt the flow of water through the downstream
Discharge large amounts of sediment Narrow river	Aggradation of river bed, there is the threat of levee breach. Small capacity of river flow

(2) Characteristics of Flood Damage from Socio-economic conditions

Due to long term inundation, highly-populated area has impacts of flooding including damages to properties and farmlands, destruction of crops, no-access of springs water (muddy after flooding), non-functioning of infrastructures facilities (severed road, physically impossible to commute to school, flooding in hospitals and etc.) and loss of livestock.

- Part of bank along the canals is broken by local farmers in order to take agricultural water.
- 20,000 households were inundated and 60,000 residents were evacuated in Kimorigho location at the floods of year 2007 -2008 .
- Refugees who are evacuated from floods are forced to displace for two months.

Relationship between “Socio-economic conditions” and “vulnerability/ exposure” in this area are shown in Table 3.2.4.

Table 3.2.4 Conditions on Social and Economic and Vulnerability/ Exposure in the Lower Lumi River Basin

Socio-economic conditions	Vulnerability/ Exposure
Highly-populated residential area (population density of 600 people per square kilometer)	A number of refugees who might be affected by flood
Agriculture and stockbreeding have been prosperous in this area	Agricultural production stoppage, Protection of livestock, difficulty of breeding, affect the residents' livelihood
Part of bank is broken by local farmers in order to take agricultural water.	Creation an adverse impact on surrounding area
Unpaved community road	Roads are severed by floods
Tourist facilities locate near the Lake Jipe	Due to inundation and severed roads, stoppage of a service for tourists

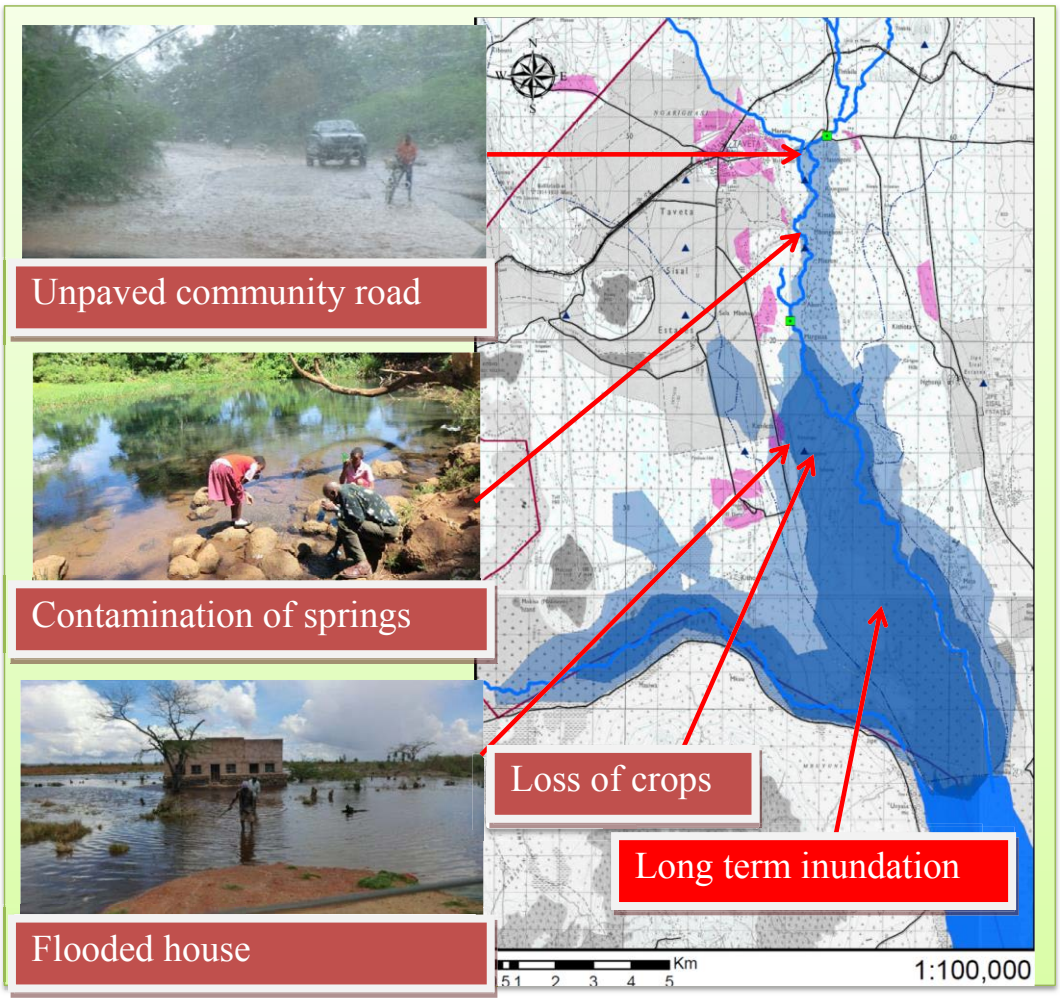


Figure 3.2.4 Flood Characteristics in the Low-lying area of Lower Lumi River

(3) Flood Damage Mechanism

The Lumi River is a raised up river, and then flood water diffuse to low lying drainage basin by outflow or dyke break from lower Lumi main stream. Submersion is prolonged because relevant area is a flat plain and hard to drain.

There are various damages such as destruction of houses made from mud, loss of agricultural products, pollution of spring for daily life, weakening of unpaved roads and submersion of social infrastructures like a hospital and death of livestock. In addition, there is a damage forced residents to evacuate long term because the area is wholly submerged and unavailability of houses to stay.

3.2.4 Flashflood in Tributary stream of downstream area(C)

Flood Characteristics near the Lumi River's Tributaries which are analyzed from the aspects of natural, Socio-economic conditions are shown below.

(1) Flood Characteristics from Natural Conditions

Due to short-term torrential rainfall, flash floods sometimes occur near Lumi River's Tributaries including the area of Tsavo West National Park and hilly district. In addition, Due to clay soil, rain water doesn't seep underground and surface run-off occurs

Natural Conditions that are described in the Chapter-1 and Natural Risks (Hazards) in this area are shown in Table 3.2.5

Table 3.2.5 Natural Conditions and Hazards near the Lumi River's Tributaries

Natural Conditions	Hazards
Short-term torrential rainfall at hilly district	Arrival time of flood is short. High peak discharge Steam erosion occurs

(2) Characteristics of Flood Damage from Socio-economic Conditions

Infrastructures such as roads and bridges, houses, household goods and livestock suffer damage from flash flood that hit rural communities in flat area. Additionally, flash floods lead to damage that irrigation channels are severed.

"Socio-economic conditions" and "vulnerability and exposure" in this area are shown in Table 3.2.6.

Table 3.2.6 Conditions on Social and Economic and Vulnerability/ Exposure near the Lumi River's Tributaries

Socio-economic conditions	Vulnerability/ Exposure
Village is on flat land Population is approximately 18,000	- Flash food from hill attack villages - Affected people by flash flood is approximately 7,000. (Rekeke 200, Kimala 950, Mata-Jipe 3,000) - Long term inundation does not occur
Irrigated agriculture has been prosperous in this area	Damage on irrigation channel has an influence on farmers' livelihood
The highway between Taveta and Mwatate serve an important function of logistics.	A temporary halt and/or stagnation in logistics due to inundation
Tourist facilities locate near the Lake Jipe	Stoppage and halt of service for tourists, due to inundation and severed road network
There is a gully erosion in front of the health clinic	Emergency rescue is not able to be provided during flooding
Unpaved road	Vulnerable by soil erosion and precipitation

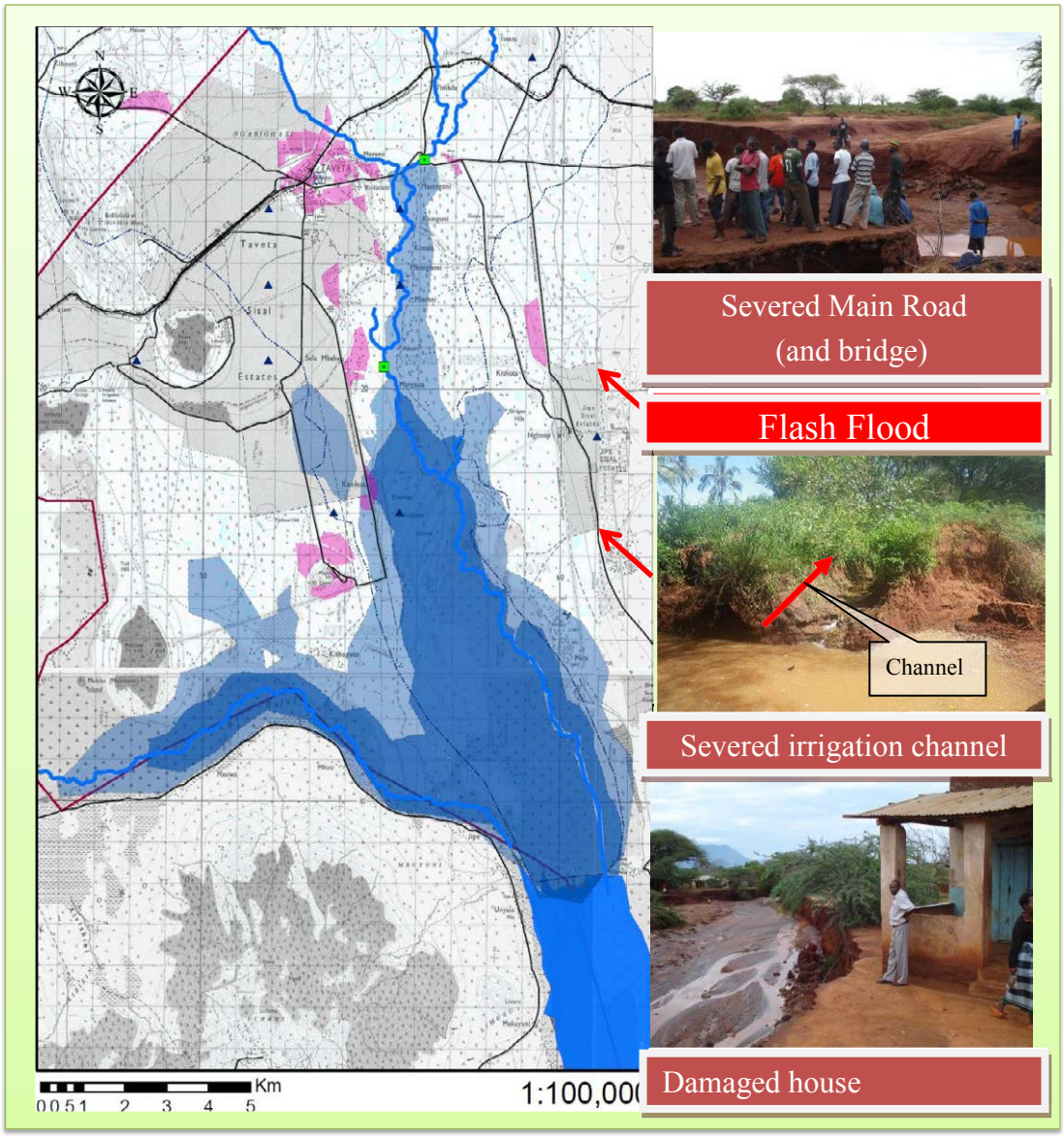


Figure 3.2.5 Flood Characteristics near the Lumi River's Tributaries

(3) Flood Damage Mechanism

Flash flood around downstream, upper to middle stream and tributary is caused by concentrated rainfall and occurrence of flood with large peak flow in short term in a small river course of seasonal stream.

In the course of down flow, flood water flow down with bank erosion. There are some cases that flood water makes a new river course by overflowing from current river course, and then some roads or bridges crossing the river are broken, and also houses or farmlands have damages.

3.3 ANALYSIS ON FLOOD DAMAGE AND COUNTERMEASURE

3.3.1 Analysis on Flood Damage and Countermeasure for Earth and Soil Flown Out Area in the Upstream of Lumi River Basin

(1) Summary of Damage and Measures

Based on the field survey done by this time, flood damage in the upstream of Lumi River was analyzed using by logic tree.

Damage on agriculture is occurred in the middle to upstream of Lumi River. Damage on agriculture is mainly caused by debris flow and soil erosion.

To derive the countermeasures, objective tree analysis was carried out. The result is shown on the following figure. Issues to be solved are placed on the left side and the measures are specifically presented therefrom.

Irrigation canal broken down by flash flood from lateral face

Many flash floods occur during rainy season in the middle to upstream of Lumi River. Flash flood brings about a lot of damages inducing debris flow. To prevent flowing out of debris flow, Check dam is considered as a countermeasure. On the other hand, damage on soil erosion becomes a serious issue. Flowing out of earth and soil causes irrigation pond to be buried by soil erosion, and this induces another issue to lose the primary function of the irrigation pond. To cope with this issue, strengthening of soil by restriction of logging, forestation activity, etc. is considered effective.

Check Dam
(Example of Nzoia River)

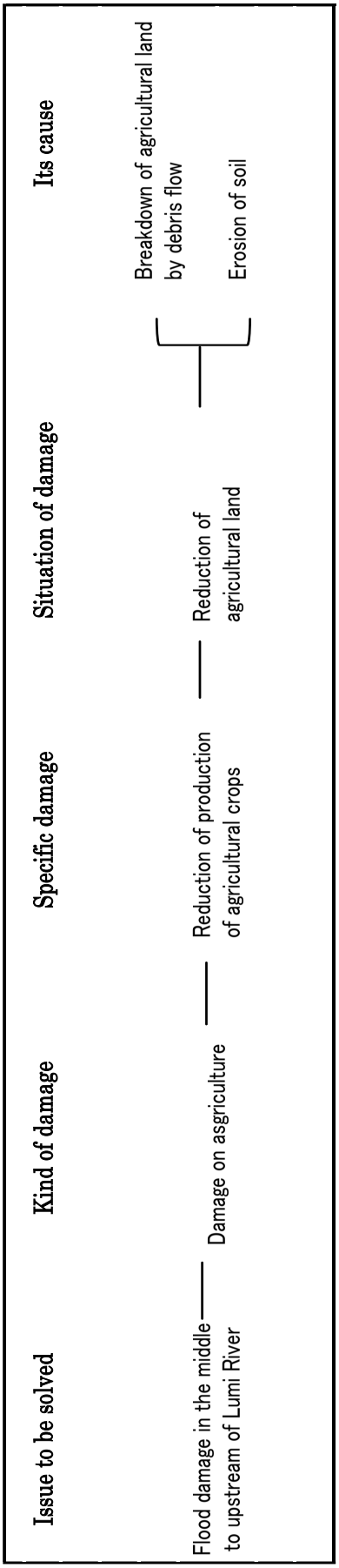


Figure 3.3.1 Analysis on Problem Tree

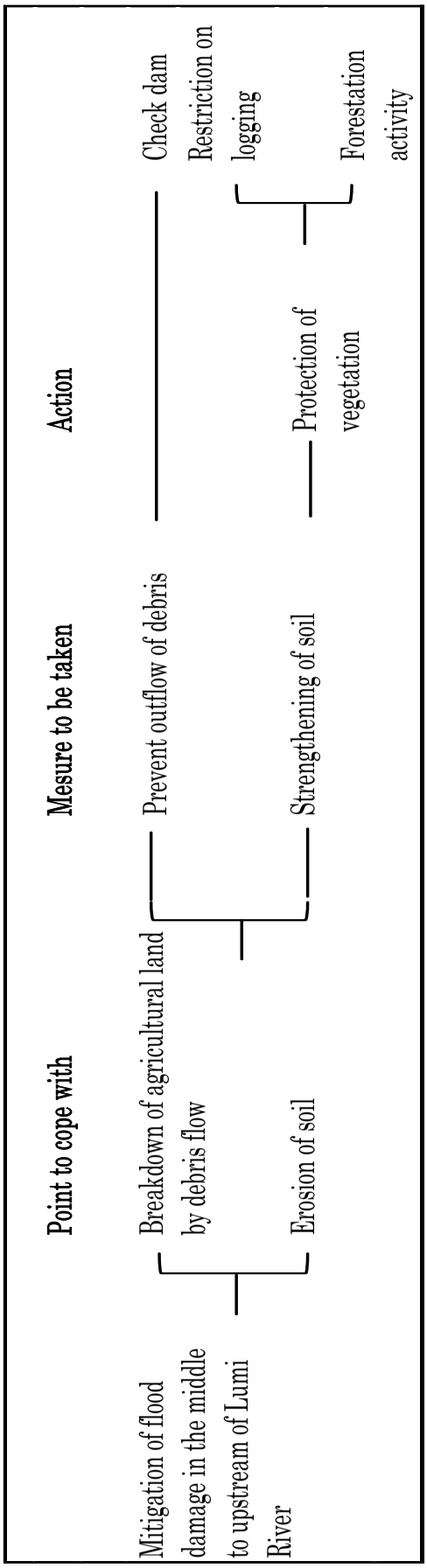


Figure 3.3.2 Analysis on Objective Tree

Countermeasure method to be considered for this area is summarized below.

Table 3.3.1 Countermeasure Method to be considered in the Earth and Soil Flown Out Area in the Upstream of Lumi River Basin

Serial No.	Countermeasure Method to be considered	Remarks
L-U1	Check dam	Preventing the outflow of debris
L-U2	Restriction on logging	Preventing the excess tree cutting.
L-U3	Forestation activities	Raising nursery trees and planting on slope.

3.3.2 Analysis on Flood Damage and Countermeasure in the Long-term Inundated Area of the Downstream of Lumi River

(1) Summary of Damage and Measures

Based on the result of field survey by this time, analysis was carried out on the area where damage occurred by the long-term inundation of the downstream of Lumi River using by logic tree.

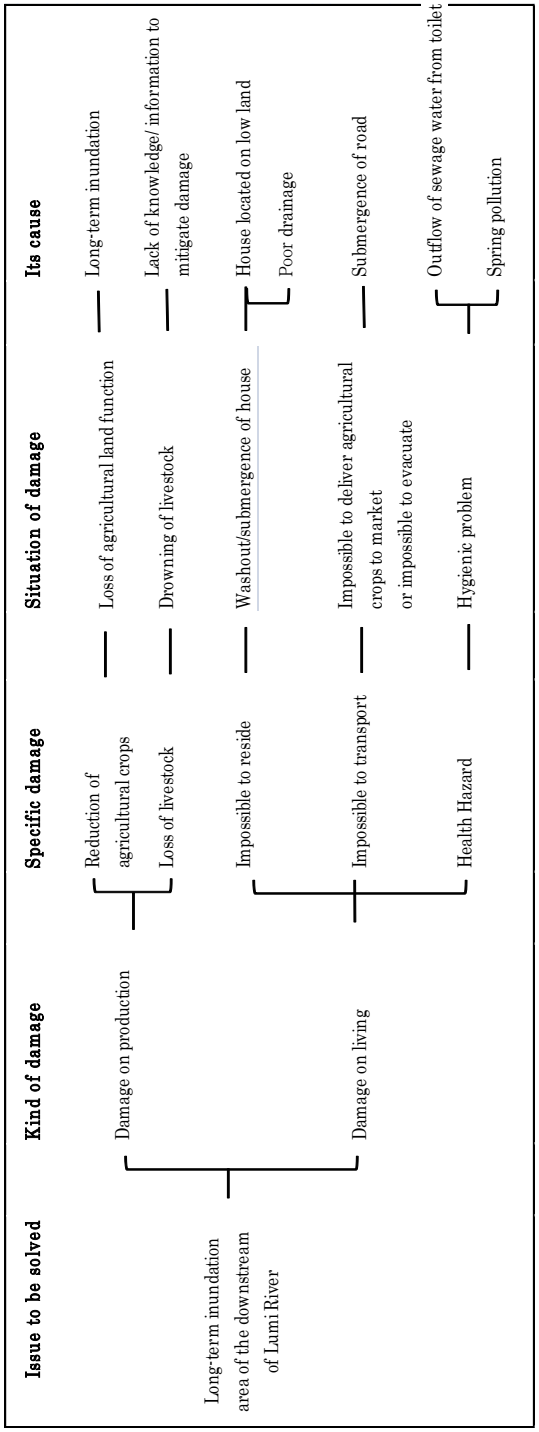


Figure 3.3.3 Analysis on Problem Tree

Long-term inundation brings about damage and loss of agricultural land and livestock in this area. Besides, houses and infrastructures are largely damaged and submersion of houses and road under water also occurred. This gives an impact to the life and living of the residents.

Condition at the time of flooding

To derive the countermeasure, objective tree analysis was carried out. The result of analysis is shown on the following figure. Issues to be solved are placed on the left side and the measures are specifically presented therefore.

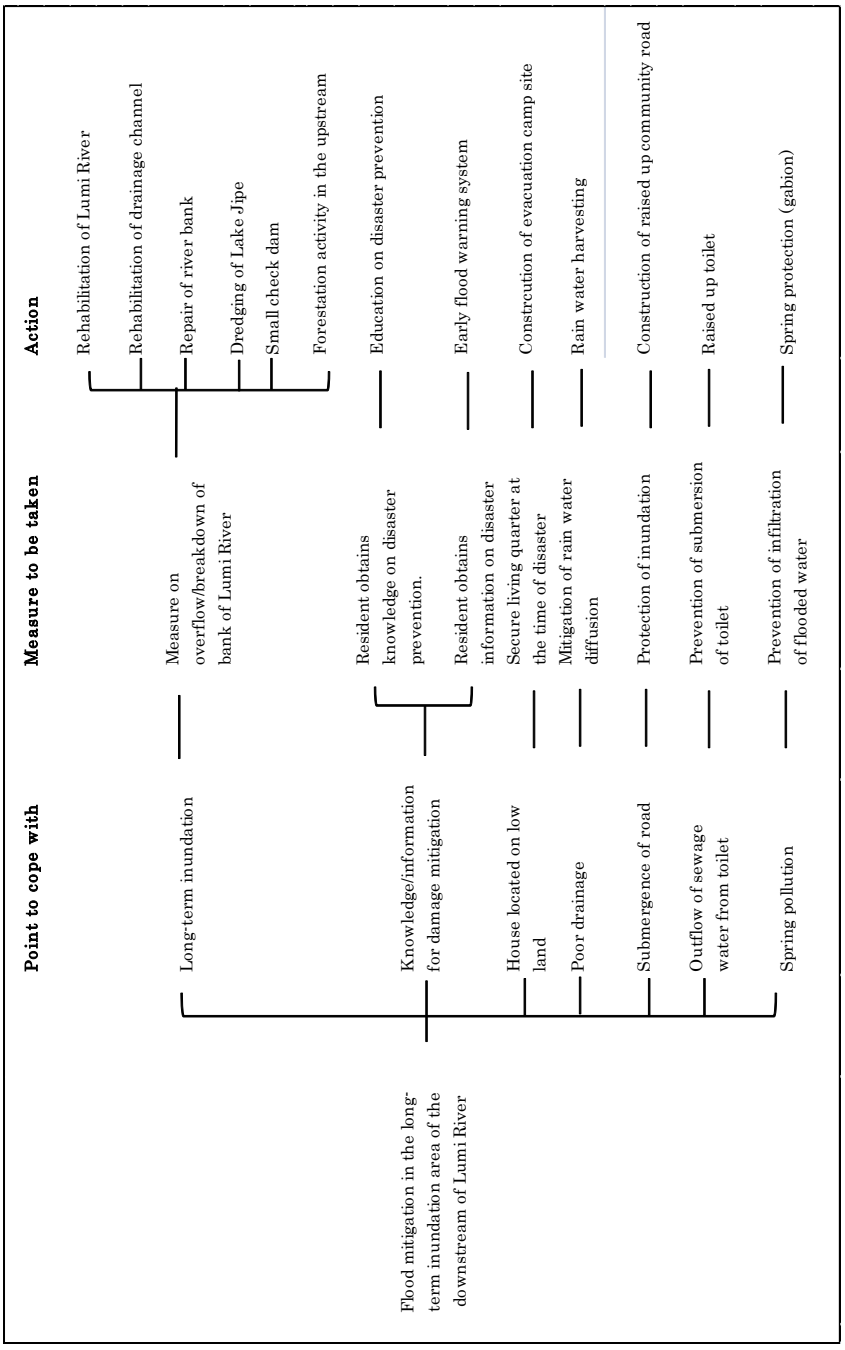


Figure 3.3.4 Analysis on Objective Tree

Inundation in this area has various impacts such as pollution of drinking water by interfusion of flooded water to the spring, damage to houses and living of the residents. For instance, severed road by inundation will make students go to school and agricultural products to deliver to the market impossible. In addition, as the access to the hospital becomes impossible, another issue will occur where by the resident cannot have medical service. Furthermore, as the residents have little knowledge and information to reduce damages, the damages becomes larger such as to drown livestock. To reduce the flood damage, it is considered an effective mean that the residents acquire knowledge and information on disaster prevention and devise countermeasure by themselves. As countermeasures, education on disaster prevention at school, early flood warning system, etc. are considered. Further, to force an end of inundation from Lumi River, the countermeasures such as widening of and improvement by dredging, etc. of Lumi River, improvement of the existing drainage canal in low-lying area and dredging of Lake Jipe to improve the storage capacity are considered. There are three major existing drainage canals of Canal A, Canal B and Canal C. It is considered to reduce the flood damages largely by heighten the flow capacity of these Canal A, Canal B and Canal C by way of dredging and improvement. Especially, though the bank of Canal C is partly broken down at present, it is one of the options to rehabilitate the bank.

Road Bridge rushed out
Place : Rengesa

Besides, there are many residents forced to evacuate in the long-term inundation area of the downstream of Lumi River because the inundation is prolonged, the houses are

Damp ground where the bank of Canal-C has been washed out

Land elevation after inundation of house
Place : Rengesa

Evacuation camp site
Place : Kimorigo

impossible to reside and the houses are washed out. Assurance of living quarter is important for victims of flood, therefore, construction of evaluation camp is considered as a countermeasure. There is an existing place being utilized as evacuation camp site, however, the facility is not well constructed. Therefore, it is considered appropriate to improve the existing evacuation camp. Countermeasure method to be considered for this area is summarized below.

Table 3.3.2 Countermeasure Method to be considered in the Downstream of Lumi River and Long Term Inundation Area

Serial No.	Countermeasure Method to be considered	Remarks
L-W1	Improvement of Lumi River	Implement at the place where the overflow occurs frequently in the downstream of Lumi River.
L-W2	Improvement of Drainage	Dredging of the existing Canal A/B/C.
L-W3	Repair of Bank	Repair the bank of gateway of Canal C which is broken down.
L-W4	Dredging of Lake Jipe	Remove earth and soil deposited to increase the reservoir capacity of Lake Jipe.
L-W5	Small check dam	Restrain silting and rising of riverbed.
L-W6	Forestation Activity in upstream	Activity to promote plantation and forestation.
L-W7	Education on Disaster prevention	Educate the residents on how to reduce the current flood damage by themselves
L-W8	Early Flood Warning System	Deliver information to the downstream area after gathering and analyzing information on flood such as rainfall, etc. in the upstream of Lumi River Basin.
L-W9	Construction of Evacuation Camp	There is an existing camp site in the downstream of Lumi River. Expand the evacuation camp facility.
L-W10	Rain water harvesting	Distributing the rain water storing by using roof, gutters and tank.
L-W11	Development of Raised Up Community Road	Raising elevation of Community Road in the long term inundation area of the downstream of Lumi River.
L-W12	Raised up toilet	Implementation of raising elevation and guidance.
L-W13	Spring protection (gabion)	Installation of gabion nearby spring

3.3.3 Tributary Area in the Downstream of Lumi River

(1) Summary of Damage and Measures

Based on the result of field survey by this time, analysis was carried out on this area using by logic tree, too. Its result is shown in the following figure.

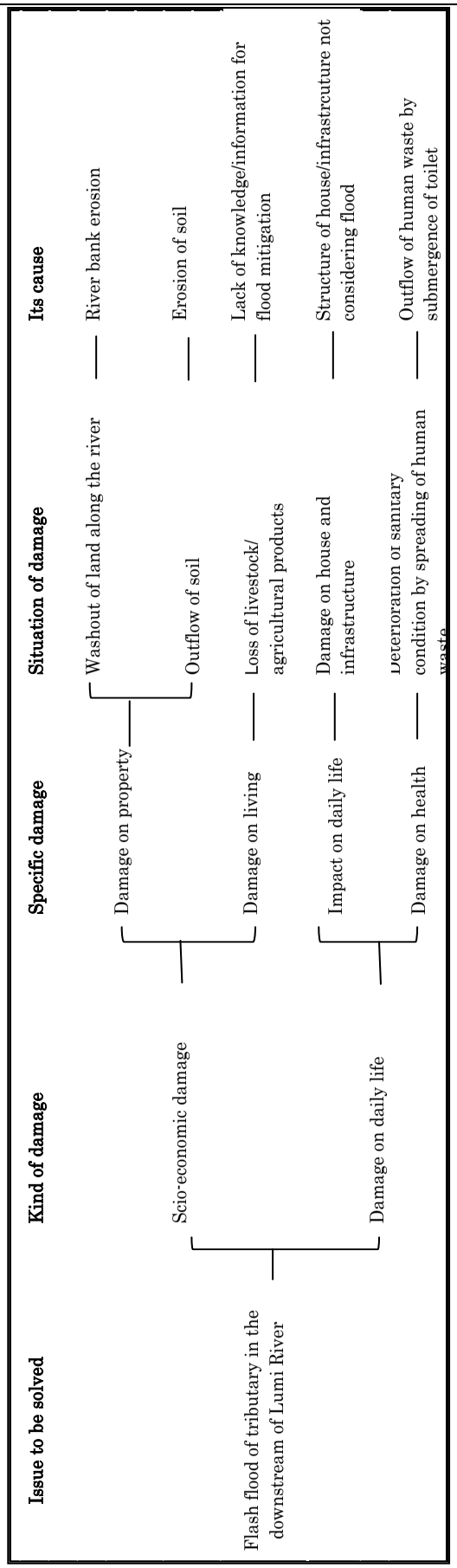


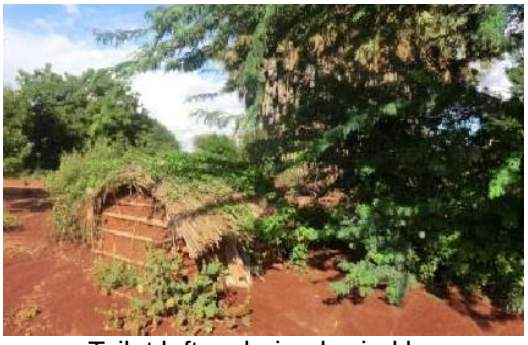
Figure 3.3.5 Analysis on Problem Tree

In the tributary of downstream of Lumi River, flood damages occur such as washout of land along the river, flowing out of soil, loss of livestock and agricultural products, damages on houses and infrastructures, deterioration of sanitary environment by spreading of human waste, etc. Major reasons of those are considered to be erosions of river bank and soil, lack of knowledge and information to reduce flood damages, structure of houses and infrastructure not considering floods, submersion of toilet, etc.

Wash out of land by bank erosion of seasonal river
Place: Rekeke

In the tributaries of the downstream of Lumi River and the small rivers directly flowing into Lake Jipe, the river bank is eroded by flash flood, and damages on agricultural land and housing lot are occurred by washout of land. It is supposed to be that the rainfall in the upstream swells the dry up river (seasonal river), where normally there is no water in the narrow river course, into flash flood with erosion of river bank. Besides, the area was covered by trees once. However, as the trees were logged as fuel wood materials, there are only scattered trees in the area at present. Therefore, if there is a heavy rain, the rainfall directly hits the surface soil, and it results in washout of soil.

Agricultural land of which the surface soil has been washed out by flood
Place : Kimala Irrigation Scheme



Toilet left as being buried by sedimentation by flood
Place: Rekeke

Damage to living is also large, for example, cribs such as chicken house, etc. are hit and submerged by flash flood, and livestock is drowned. Agricultural products are also lost by inundation. Breakage of houses and infrastructures, especially, transportation infrastructure such as roads and bridges by flood is remarkable in this area. This is largely because, in planning, design, construction, operation and maintenance of houses and infrastructures, floods are not considered and the people do not know the proper material and method.

Damages on toilet often induce sanitary issues. Toilet in this area is mainly constructed by digging a hole on the ground and surrounded by wall and roof. These toilets are submerged under water at the time of flood and the human waste is flown out. Sanitary environment is deteriorated and this causes various waterborne diseases like Cholera, etc.

To derive the countermeasures, issues to be solved are placed from the left side and the measures are specifically presented.

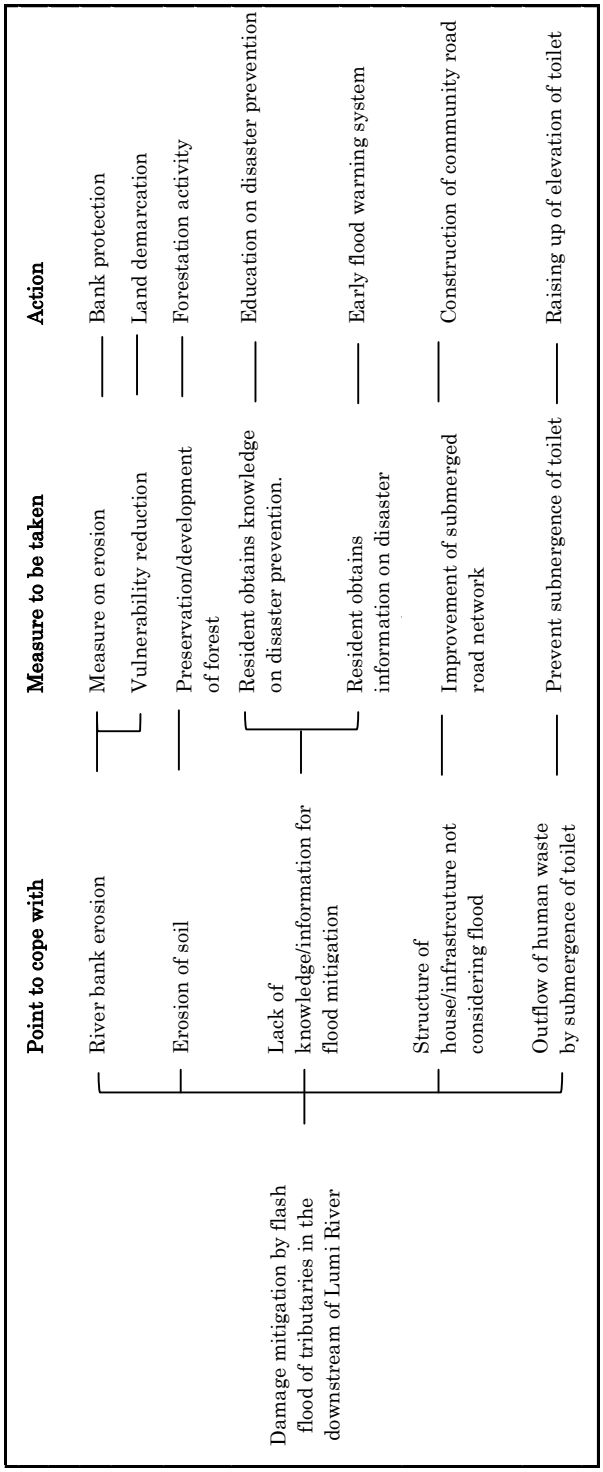


Figure 3.3.6 Analysis on Objective Tree

For countermeasure on washout of land along the river, construction of bank for protection from river bank erosion is considered as a short-term measure. However, since the maximum discharge at the time of flood is impossible to be estimated, adoption of these measures shall be limited to the area where very important facility is built nearby the dry river.

Forestation by KRCS Volunteer Group
(Planting nursery tree)
Place : Rekeke

For washout of soil, it is considered, as one of the methods, to reforest for the purpose of protection and development of forest and trees. In fact, it may not be difficult as the forestation activity is carried out in the downstream of Lumi River by the volunteer group organized by Red Cross of Kenya. Forestation requires time to heighten an effect, however, as an impact to the environment is quite small or few, it is ideal to promote as much as possible as a countermeasure to be adopted by the community level.

Chicken House

Regarding loss of livestocks and agricultural products, lack of knowledge and information to reduce damage by resident level becomes obstacles. For instance, chicken house is constructed directly on the ground though it is submerged every year by flood. Accordingly, chickens are easily drown by the inundation caused by flood. There is a possibility to reduce damages by raising elevation of chicken house not to be submerged under water like the south east Asian countries where many floods hit every year. It is quite important that the residents shall have such a knowledge for reduction of damage, and minimizing the flood damage will largely contribute to the recovery of living after flood damage.

Washout of the concrete bridge of the same structure to the above by flash flood
Place : Rengesa

Bridge with pipe culvert installed at the dry up river crossing the road

Regarding damage on house and infrastrcucture, the structure not considereing the flood is

considered problematic. Concrete bridge shown on the right photo crossess over the dry river and the water passess through the pipe culvert. However, the diameter and the number of pipe culvert seem to be rather small to cope with the discharge during flood. Method to estimate the discharge during flood is not established in Kenya. Therefore, especially the open channel of the bridge often does not secure enough cross section to discharge flood safely to the downstream. Countermeasure for these damages is to establish a calculation method of flood discharge in this area and to recommend the adoption of method to the parties concerned who construct the road and bridge. Further, the elevation of road surface is also often determined lower than the inundation level by the flood, therefore, it is considered necessary to install proper size of culvert and to raise the elevation of surface of the road.

Regarding deterioration of sanitary environment by overflowing of toilet, it is recommended to raise the elevation of toilet as implemented in Nyando River Basin. To raise the elevation of toilet has already been implemented in part of this area. Therefore, it is necessary to enlighten the resident's mind by introducing such an example.

Considering the above, countermeasure method to be considered is summarized below.

Table 3.3.3 Countermeasure Method to be considered in the Flash Flood Occurrence Area of Tributary in the Downstream of Lumi River

Serial No.	Countermeasure Method to be considered	Remarks
L-E1	Bank Protection	Implementation of gully at the right place near Rekeke.
L-E2	Restriction on landuse	Clarification on riverbank regulation
L-E3	Forestation Activity	Activity to promote plantation and forestation.
L-E4	Education on Disaster Prevention	Educate the residents on how to reduce by themselves the present flood damage.
L-E5	Early Flood Warning System	Supposing a system utilizing the simple measurement and communication method which is considered to be adopted by WRUA and WRMA.
L-E6	Construction of Community Road	Raising elevation of community road in the soil and river bank erosion areas of the downstream of Lumi River.
L-E7	Raised up Toilet	Implementation of raising elevation and guidance.

3.3.4 Long list/candidates of Countermeasures to the Flood

Long list/candidates of countermeasures to the flood are presented as below

Table 3.3.4 Countermeasure Long List

No.	Countermeasure	Structural/ Non-structural
L-U1	Check dam / Earth and Soil Flown Out Area in the Upstream of Lumi River Basin	S
L-U2	Restriction on logging / Earth and Soil Flown Out Area in the Upstream of Lumi River Basin	N
L-U3	Forestation activities / Earth and Soil Flown Out Area in the Upstream of Lumi River Basin	N
L-W1	Channel Improvement of Lumi River / Long term inundation area	S
L-W2	Drainage Channel Improvement / Long term inundation area	S
L-W3	Repair of existing embankment / Long term inundation area	S
L-W4	Dredging of Lake Jipe / Long term inundation area	S
L-W5	Small check dam	S
L-W6	Forestation Activity (upstream) / Long term inundation area	N
L-W7	Education on Disaster Prevention / Long term inundation area	N
L-W8	Early Warning System (IFAS/GFAS) / Long term inundation area	S
L-W9	Environmental Improvement of Evacuation Camp / Long term inundation area	S
L-W10	Rain water harvesting	S
L-W11	Development of Community Road/ Long term inundation area	S
L-W12	Raised-up Toilet / Long term inundation area	N
L-W13	Spring protection (gabion)	N
L-E1	Bank Protection / Tributary Stream Area	S
L-E2	Restriction on land use	N
L-E3	Forestation Activity / Tributary Stream Area	N
L-E4	Education on Disaster Prevention / Tributary Stream Area	N
L-E5	Early Warning System / Tributary Stream Area	S
L-E6	Development of Community Road / Tributary Stream Area	S
L-E7	Raised-up Toilet / Tributary Stream Area	N

S: Structural, N: Non-Structural

3.4 SELECTION OF FLOOD DAMAGE TO BE PREVENT PREFERENTIALLY

3.4.1 Priority by WRUA Members

In Lumi River Basin, the workshop was held to analyze the problems in Lower Lumi sub catchment with WRUA members, WRMA-SRO staff and JICA project team members on Nov.

2nd, 2012

As a result of analysis, the causes of flood are pointed out as bellow.

Table 3.4.1 Analysis for the causes of flood by interviewing to WRUA Members

Theme	Causes	Principal Influence from Flooding
Floods (Upstream)	Rainfall around the Mt. Kilimanjaro slope	Flash Floods
	Sediment flow from Mountain slope	
Floods (Downstream)	Rise of east side Wadi river apart from the Lumi river	Flash Floods around tributary
	Sediment flow around upstream →Raised bed river	Flooding by long term inundation
	Bank erosion →Newly generation of river course	River course diversion

Concerning flood damages, following analysis was done and was indicated the priority order lead by WRUA members

Table 3.4.2 Damage Analysis and Priority by WRUA Members

Priority by WRUA members	Type of Damage	Primary Damage	Secondary Damage
①	Soil erosion (Middle stream)	- Sediment outflow to downstream	- Raised up the river bed (Lumi river,Lane Jipe)
	Soil erosion (Downstream)	- Destruction of farmland	
②	Submersion	- Submersion and destruction of houses - Farmland damage	- Evacuation - Suspending educational activities - Income decreasing - Food shortage
③	Polluted water resource	- Pollution of springs	- Water shortage - Drought
④	Damage of infrastructures	- Cutting roads between (Eldoro and Taveta / Taveta and Kitobo / Taveta and Jipe) - School	- Unable to get commodities - Unable to transport
⑤	Lives	- Livestock - Human (Rare case)	

3.4.2 Selection of Flood Damage to be prioritized

The flood damages in Lumi river basin is principally classified 3 types such as A) Soil and sediment run off (Upper and middle river basin), B) Widespread and long-running inundation which is caused by overflow and dyke break from the Lumi River (Low-lying area at the lower river basin) and C) Flash flood (Branches of the Lower Lumi River and small streams flow in the Lake Jipe).

Based on the evaluation of flood damages by communities previously described, each impact from flood damages are evaluated from the viewpoints of social impacts as "Number of affected people and houses" or economic impacts as "Losses of merchandise, agriculture, transportation and sightseeing industry", and are shown in the following table.

Table 3.4.3 Selection of The Flood Damages Should Be Corresponding Preferentially

Flood type	Social impacts		Economic impact				Priority order
	Number of affected people	Number of affected houses	Merchandise	Agriculture	Transportation	Sight-seeing industry	
A) Soil and sediment run off	Low	Low	Low	**High**	Mid	Mid	Low
B) Widespread and long-running inundation which is caused by overflow and dyke break from the Lumi River	**High**	**High**	Low	**High**	**High**	**High**	High
C) Flash flood	Mid	Mid	Mid	Mid	**High**	**High**	Slightly high

In the 3 types of flood damages, it shows that the damage by "A) Soil and sediment run off" has strongest impacts socio-economically, and next is the damage by flash flood along tributaries. The damage by "Soil and sediment run off" in upstream to midstream has impacts to agriculture but the impacts to socio-economic matters is not so high, and then the priority is low. The measure to reduce the soil erosion and sediment outflow should implement in long term perspective because it takes long time to be given the effects.

According to these review, in Lumi river basin, "Widespread and long-running inundation which is caused by overflow and dyke break from the Lumi River" is selected as the damage should be corresponding preferentially, and subsequently the flash flood.

Therefore, selected long list is shown in the next page.

Table 3.4.4 Selected Long list of the Countermeasures to the Flood in Lumi River Basin

No.	Countermeasure	Structural/ Non-structural
L-W1	Channel Improvement of Lumi River / Long term inundation area	S
L-W2	Drainage Channel Improvement / Long term inundation area	S
L-W3	Repair of existing embankment / Long term inundation area	S
L-W4	Dredging of Lake Jipe / Long term inundation area	S
L-W5	Small check dam	S
L-W6	Forestation Activity (upstream) / Long term inundation area	N
L-W7	Education on Disaster Prevention / Long term inundation area	N
L-W8	Early Warning System (IFAS/GFAS) / Long term inundation area	S
L-W9	Environmental Improvement of Evacuation Camp / Long term inundation area	S
L-W10	Rain water harvesting	S
L-W11	Development of Community Road/ Long term inundation area	S
L-W12	Raised-up Toilet / Long term inundation area	N
L-W13	Spring protection (gabion)	N
L-E1	Bank Protection / Tributary Stream Area	S
L-E2	Restriction on land use	N
L-E3	Forestation Activity / Tributary Stream Area	N
L-E4	Education on Disaster Prevention / Tributary Stream Area	N
L-E5	Early Warning System / Tributary Stream Area	S
L-E6	Development of Community Road / Tributary Stream Area	S
L-E7	Raised-up Toilet / Tributary Stream Area	N

S: Structural, N: Non-Structural

4. EVALUATION OF COUNTERMEASURES TO THE FLOOD

4.1 VIEW POINT OF EVALUATION

Candidate countermeasures that are extracted in last chapter are studied in detail. On the basis of the result of last chapter, 5 criteria; relevance, effectiveness, efficiency, impact and sustainability is considered.

The project team defined 5 criteria as the description on following table, and then evaluated the countermeasures by marking "A", "B" and "C" according to these 5 Items.

Table 4.1.1 Definition of 5 Items for Pilot Project Selection

1	Relevance	Requirements from the stakeholders, Needs of target area Dimension of economic damage and human suffering.
2	Effectiveness	Degree of damage mitigation (Number of beneficiary, Reduction of submergence period, area and number of affected people)
3	Efficiency	Cost effectiveness (It is evaluated by estimated qualitative dimension and degree of damage mitigation)
4	Impact	Spreading effect within a same basin or to other areas Indirect effects
5	Sustainability	Sustainability of maintenance and project effects (On the assumption of pilot project completion according to the design.)

*The project team defined these 5 items for the purpose of this study according to "DAC's evaluation 5 items"

4.2 EVALUATION RESULT FOR EACH COUNTERMEASURE

Table 4.2.1 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（1）

No.		**L-W1**		
Target Area		**Downstream of Lumi River**		
Countermeasure		**Channel Improvement of Lumi River**		
Outline		It is a work to widen of the river and to dredge raised river bed.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage is huge in this area. Residents and stakeholder highly request to improve the actual situation. Lack of flow capacity of Lumi river is the main factor. Excavation and widening of the river channel is effective and necessary.	A	3
	Effectiveness	It contributes considerably to reduction of long term inundation from Lumi River.	A	3
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous maintenance is necessary. If WRUA implements this project with WSTF fund, additional maintenance cost should be considered.	C	1
Total			10	
Merit		Easy appearance of effects		
Demerit		Relevance with PCDEFM project is low. Each stage such as planning, design, and construction need long term. Continuous maintenance, High costs.		
Environmental Negative Impact		Silting at downstream, Bio diversity		
Necessity of EIA		Necessary		
Contribution by the residents		Soil carriage		
Responsible Institution/Agency		WRMA		
Main Actor		Taveta County/MWI/NWCPC		
Public assistance/Mutual support /Self-help		Public Assistance		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.2 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（2）

No.		**L-W2**		
Target Area		**West side of downstream of Lumi River (Canal A/B/C)**		
Countermeasure		**Drainage Channel Improvement**		
Outline		It is to remove accumulated sedimentation. Flow capacity can be recovered.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage is huge in this area. Residents and stakeholder highly request to improve the actual situation. Sediment deposition is one of main factors. To recover flow capacity of the drainage channel is effective and necessary.	A	3
	Effectiveness	It contributes considerably to reduction of long term inundation from Lumi River.	A	3
	Efficiency	Cost is extensive, and damage reduction is also huge.	A	3
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous maintenance is necessary. If WRUA implements this project with WSTF fund, additional maintenance cost should be considered.	C	1
Total			11	
Merit		Expectable drastic effects		
Demerit		Each stage such as planning, design, and construction need long term. Total construction cost is more expensive than other countermeasures. Relevance with PCDEFM project is low. Continuous maintenance, High costs.		
Environmental Negative Impact		Silting at upstream and downstream Bio diversity		
Necessity of EIA		Nnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		MWI, WRMA		
Main Actor		Taveta County/MWI/NWCPC		
Public assistance/Mutual support /Self-help		Public Assistance, Mutual support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.3 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（3）

No.		**L-W3**		
Target Area		**West side of downstream of Lumi River (Canal C)**		
Countermeasure		**Repair of existing embankment**		
Outline		It is repair work of existing embankment (canal C). Overflow stream from Lumi River can be minimized.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Flood damage is huge in this area. Residents and stakeholder highly request to improve the actual situation. To bank up overflow from Lumi river and to lead to Canal C is effective and necessary.	A	3
	Effectiveness	It contributes considerably to reduction of long term inundation from Lumi River.	A	3
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	It is difficult to spread structural works itself. However, maintenance system that is already operated by WRUA in this community can be spread.	B	2
	Sustainability	Continuous maintenance is necessary. Fortunately, WRUA members at this community already operate maintenance system of irrigation facilities voluntary. Sustainability is highly expected.	B	2
Total			12	
Merit		Repair of broken part of Canal C is relatively simple and short term. Easy appearance of effects.		
Demerit		Securing stabilities, High costs		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		MWI, WRMA		
Main Actor		Taveta County/MWI/NWCPC		
Public assistance/Mutual support /Self-help		Public Assistance, Mutual support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.4 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（4）

No.		**L-W4**		
Target Area		**Long term inundated area / Downstream of Lumi River**		
Countermeasure		**Dredging of Lake Jipe**		
Outline		It is a work to recover flow capacity. It is effective to remove sedimentation at the area between Lumi River and Lake Jipe.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Stakeholders also recognize the issue of sediment deposition at Lake Jipe. This can be more effective if L-W2 and W3 are implemented at the same time.	A	3
	Effectiveness	It contributes considerably to reduction of long term inundation.	A	3
	Efficiency	Large scale construction is necessary, but effect is extensive.	B	2
	Impact	Spreading effect is small. (The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.)	C	1
	Sustainability	Continuous dredging is necessary. Additional cost is high.	C	1
Total			10	
Merit		Continuous effects Strong effect for mitigation of inundation.		
Demerit		Large scale dredging is required for extensive effect. Dredging should be continued semi-permanently. Sustainability is low. High costs, Requirement long term to be effected.		
Environmental Negative Impact		Bio diversity		
Necessity of EIA		Necessary		
Contribution by the residents		Nil		
Responsible Institution/Agency		MWI		
Main Actor		Taveta County/MWI/NWCPC		
Public assistance Mutual support Self-help		Public Assistance		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.5 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（5）

No.		**L-W5**		
Target Area		**Long term inundated area / Downstream of Lumi River**		
Countermeasure		**Small check dam**		
Outline		Restrain silting and rising of riverbed		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Stakeholders require small check dams strongly to restrain silting at lower Lumi.	A	3
	Effectiveness	It contributes considerably to reduction of silting partly.	B	2
	Efficiency	Large scale construction is not necessary, but effect is limited in local point.	B	2
	Impact	Spreading effect is small.	C	1
	Sustainability	Continuous dredging is necessary. Effects fade out with time passing. Cost is not low.	C	1
Total			9	
Merit		Easy to distribute		
Demerit		Each process such as planning, design, and construction need long term. Large scale dredging is required for extensive effect. Dredging should be continued semi-permanently. Sustainability is low.		
Environmental Negative Impact		Bio diversity.		
Necessity of EIA		Nnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		MWI, WRMA		
Main Actor		Taveta County/MWI/NWCPC		
Public assistance Mutual support Self-help		Public Assistance, Mutual support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.6 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（6）

No.		**L-W6**		
Target Area		**Long term inundated area / Downstream of Lumi River**		
Countermeasure		**Forestation Activity at Upstream**		
Outline		It is to protect and recover vegetation in the upstream of the mountain. Its storage effect will rise.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Volunteer groups already practice forestation activity at downstream. Collaboration with them is expected.	A	3
	Effectiveness	If this countermeasure implement at appropriate scale, sedimentation from upstream would reduce. Effects of determinate erosion restraint will be expected	B	2
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Application in other area is not difficult. In addition, it contributes environmental conservation. There is a limitation for appropriate places to be implemented.	B	2
	Sustainability	Once main actor is aware the importance, activity can continue. Maintenance is complicate. It takes time to grow up.	B	2
Total			11	
Merit		Evaluation is high on all items. It contributes to reduce global warming. Easy to start, Low costs, Easy to distribute.		
Demerit		Requirement long term to be effected		
Environmental Negative Impact		Bio diversity		
Necessity of EIA		Necessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.（Planting assistance, Raising nursery trees）		
Responsible Institution/Agency		WRUA, KRCS		
Main Actor		WRUA etc.		
Public assistance Mutual support Self-help		Mutual Support		

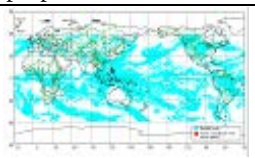
A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.7 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（7）

No.		**L-W7**		
Target Area		**Long term inundated area / Downstream of Lumi River**		
Countermeasure		**Education on Disaster prevention**		
Outline		It is educational activity to give information to reduce damage from flood and raise awareness of disaster prevention.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	WRMA has a high request of enforcement of community. In addition, some damage can prevent if people have knowledge on flood management. So it importance is high.	A	3
	Effectiveness	It is expected certain effect against number of educated people. Their knowledge on disaster prevention can implement wherever and whenever they need. Its effect can be spread.	B	2
	Efficiency	It can give knowledge on disaster prevention to a large number of people at the same time. Cost is low. Effectiveness is high when the knowledge is rooted.	A	3
	Impact	Knowledge can hand down from beneficiary to their family and friends. It can expand widely.	A	3
	Sustainability	Local people such as school teacher and community leader can be a lecturer. So educational activity sustain. In addition, integration into curriculum is important.	A	3
Total			14	
Merit		Preparation can be short term. Community based activity relates with concept of PCDEFM project. Easy to distribute, Low costs.		
Demerit		Requirement long term to be effective		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		Preparing the relevant materials		
Responsible Institution/Agency		WRUA, KRCS		
Main Actor		Ministry of Education/ Taveta County Educational Officer/ Teachers / WRUA		
Public assistance Mutual support Self-help		Mutual Support･Public Assistance		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.8 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（8）

No.		L-W8		
Target Area		Long term inundation area / Downstream of Lumi River		
Countermeasure		Early Warning System（IFAS/GFAS）		
Outline		It is a system to transmit flood information based on satellite information (IFAS/GFAS). People can prepare for the flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	Relevance	IFAS/GFAS is not common yet in Kenya, but lack of information on disaster prevention is recognized. It's beneficial that residents know the information as soon as possible during flood.	B	2
	Effectiveness	Warning information can be transmitted extensively. However, if people don't know how to react against flood, this countermeasure doesn't make sense. Its effect becomes higher when it implement with education on disaster prevention.	B	2
	Efficiency	This can give good effect extensively with low cost.	A	3
	Impact	Once observation system is established in WRUA, application at other river basin is not difficult. However, in the viewpoint of IFAS/GFAS function, effective area is limited.	B	2
	Sustainability	Once the system is established, sustainability is high.	A	3
Total			12	
Merit		Preparation can be short time. In addition, there is a staff who participated IFAS/GFAS training in WRMA HQ. His knowledge can utilize for this project. Low costs, Easy to distribute		
Demerit		Requirement long term to be effective		
Environmental Negative Impact		Bio diversity		
Necessity of EIA		Necessary		
Contribution by the residents		Planting assistance, Raising nursery trees		
Responsible Institution/Agency		WRUA, KRCS		
Main Actor		WRMA/KMD/Kenya National Disaster Operation Center/Ministry of Special Program		
Public assistance Mutual support Self-help		Public Assistance, Mutual support		

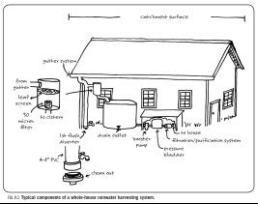
A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.9 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（9）

No.		L-W9		
Target Area		Long term inundation area / Downstream of Lumi River		
Countermeasure		Environmental Improvement of Evacuation Camp		
Outline		It is to enhance and improve existing evacuation Camp during flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	Relevance	Flood damage is huge in this area. Residents and stakeholder highly request to improve the actual situation.	A	3
	Effectiveness	There are existing evacuation centers in this area. Application is effective and in demand.	A	3
	Efficiency	Both cost and effectiveness are medium scale if this attempt will be for numerous number of evacuees.	B	2
	Impact	The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.	B	2
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			12	
Merit		Since this matter is an improvement of existing evacuation camp, It will be easy to implement.		
Demerit		Continuous maintenance Necessary for land acquisition.		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		WRUA		
Main Actor		Taveta County/ Kenya National Disaster Operation Center/Ministry of Special Program		
Public assistance Mutual support Self-help		Mutual support,		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.10 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（10）

No.		L-W10		
Target Area		**Long term inundation area / Downstream of Lumi River**		
Countermeasure		**Rain water harvesting**		
Outline		Distributing the rain water storing by using roof, gutters and tank		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Town council required equipping the tank for rain water reuse.	C	1
	Effectiveness	If tank equipped house are increased, it will be effective. Numerous number of tank will be required to expect the effect for flow restraint.	C	1
	Efficiency	Cost and effectiveness are medium scale. Cost is high to get effects for flow restraint.	B	2
	Impact	Distribution within the town and to other towns is easy.	B	2
	Sustainability	Maintenance against deterioration is required some years later.	B	2
Total			8	
Merit		Easy to distribute, Raising ownerships Effectiveness in the irrigation		
Demerit		Maintenance and replacement against deterioration		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		Town council		
Main Actor		Taveta County/KeRRA/WRUA		
Public assistance Mutual support Self-help		Mutual Support, elf-help		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.11 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（11）

No.		**L-W11**		
Target Area		**Long term inundation area / Downstream of Lumi River**		
Countermeasure		**Development of Community Road**		
Outline		It means to construct a culvert or rise up community road in order to prevent its incapability by flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Community road is inundated during flood. It disturbs evacuation, communication in the community and communing to school. Residents request highly, Raised up road is required.	A	3
	Effectiveness	Flood damage in this community is surely reduced. Restraint of evacuation root.	B	2
	Efficiency	Both cost and effectiveness are medium scale. High costs will be required to get effects in wide areas.	B	2
	Impact	Almost all community have small scale road. Construction of such kind of road is not difficult. Application at other area is expected.	B	2
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			11	
Merit		Short term to be effective		
Demerit		Continuous maintenance, Each process of planning, design and construction could take long time.		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		KeRRA, WRUA		
Main Actor		Taveta County/KeRRA/WRUA		
Public assistance Mutual support Self-help		Public assistance, Mutual Support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.12 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（12）

No.		L-W12		
Target Area		**Long term inundation area / Downstream of Lumi River**		
Countermeasure		**Raised of toilet**		
Outline		It is to rise up toilet to prevent water flow from come into the toilet and drain sewage.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Overflowed sewage from toilet cause expansion of infectious disease. Raised up toilet prevents to overflow. People's demand is high.	A	3
	Effectiveness	It is assumed to reduce infectious disease.	B	2
	Efficiency	One raised up toilet is moderate price. However, a large number of toilets should be developed for reduction of infectious disease.	B	2
	Impact	It is relatively simplified measure. So application in other area is not difficult.	A	3
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			12	
Merit		Preparation is short term. Easy to distribute, Collaboration with Ministry of Public health is effective.		
Demerit		Maintenance against deterioration		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		WRUA		
Main Actor		WRUA, etc		
Public assistance Mutual support Self-help		Mutual support, Self help		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.13 Evaluation Study on countermeasure against long term inundation from Lumi River / downstream area（13）

No.		**L-W13**		
Target Area		**Long term inundation area / Downstream of Lumi River**		
Countermeasure		**Spring protection (gabion)**		
Outline		It is to install gabion to protect springs for prevention of infiltration of flooded water.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Residents use spring water for daily life water and drinking water. Demand exists, but other donor and WRUA already implement the projects.	B	2
	Effectiveness	Spring protection contributes towards securing drinking water in emergency.	B	2
	Efficiency	It is not large scale construction and certain effect is expected.	B	2
	Impact	Installation of small gabion is not difficult to implement and spread to other areas.	B	2
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			10	
Merit		High effectiveness, Easy to start ‘cause spring protection project is already implemented in Kubwa Springs by UNDP and in Kitobo area by WSTF.		
Demerit		Maintenance against deterioration		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials. (Collecting stones, Gabion assembling)		
Responsible Institution/Agency		WRMA, WRUA		
Main Actor		WRMA/WRUA		
Public assistance Mutual support Self-help		Mutual Support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.14 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（14）

No.		**L-E1**		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Bank Protection**		
Outline		It is a structure to prevent riverbank erosion.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	There are tributary and seasonal river in this area. Bank erosion is remarkable during rainy season, Any countermeasure is implemented. Stakeholders highly request provision. Bank protection works as bridge and road protection. It is effective and necessary..	A	3
	Effectiveness	There are a lot of tributary and seasonal river in this area. The effect of one bank protection is limited.	B	2
	Efficiency	Construction cost is not expensive, but effectiveness is low. (Existing bank protection in this area is broken.) Cost performance is mid level.	B	1
	Impact	The construction requires respective design and plan according to flood characteristics, climate and geological formation of the site.	C	1
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			9	
Merit		Short term to be effective, Easy to repair		
Demerit		Determinate term will be required to implement in each process such as “Planning”, “design” and “construction” Improvement of existing construction method will be required. General construction of bank protection is not suitable to characteristics of Lumi river. , Continuous maintenance, Easy to breach (Bank protection that is constructed by KeRRA is already broken.)		
Environmental Negative Impact		Depending on scale.		
Necessity of EIA		Depending on scale.		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials. (Collecting stones, Gabion assembling)		
Responsible Institution/Agency		MWI		
Main Actor		Taveta County/MWI		
Public assistance Mutual support Self-help		Public Assistance Mutual support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.15 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（15）

No.		L-E2		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Restriction on land use**		
Outline		It is to establish a low to prohibit people from illegal construction and illegal occupation of lands near the river		
Image		-		
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Its importance is recognized by stakeholders. Illegal construction are existed around river edge. So, government can't implement widening of the river. And also, people who live in illegal houses can affect directly by flood.	A	3
	Effectiveness	This is not a direct measure against flood. Crackdown and education activity is required at the same time.	B	2
	Efficiency	Legislation is almost no cost to implement. However, direct effectiveness for disaster reduction is small.	B	2
	Impact	Legislation itself is nationwide.	B	2
	Sustainability	Once the law is established, validity can continue. However, certain regulation and educational activity should be implemented the same time.	B	2
Total			11	
Merit		Illegal occupation of riparian land can be reduced. Cost is low.		
Demerit		Requirement long term to be effective. Involuntary resettlement can occur. Regulation and educational activity should be implemented. It is government level and takes long time to establish a law.		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		NIl		
Responsible Institution/Agency		WRUA, KRCS, KFS		
Main Actor		WRUA/KRCS etc.		
Public assistance Mutual support Self-help		Public assistance		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.16 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（16）

No.		**L-E3**		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Forestation Activity at Upstream of Tributary River**		
Outline		It is to protect and recover vegetation in the upstream of the mountain. Its storage effect will rise.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Volunteer groups already practice forestation activity at downstream. Collaboration with them is expected.	A	3
	Effectiveness	If this countermeasure implement at appropriate scale, sedimentation from upstream would be reduced. Effects of determinate erosion restraint will be expected	B	2
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Application in other area is not difficult. In addition, it contributes environmental conservation.	B	2
	Sustainability	Once main actor is aware the importance, activity can continue. Maintenance is complicate. It takes time to grow up.	B	2
Total			11	
Merit		Easy to start, Easy to distribution, Raising ownerships (Volunteer group in this area is already practiced this activity. Community participation is not difficult in this case. Sustainability is expected.)		
Demerit		Requirement long term to be effective		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials. (Planting assistance, Raising nursery trees)		
Responsible Institution/Agency		WRUA, KRCS, KFS		
Main Actor		WRUA/KRCS etc.		
Public assistance Mutual support Self-help		Mutual Support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.17 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（17）

No.		**L-E4**		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Education on Disaster prevention**		
Outline		It is educational training to mitigate the impact of flood and to improve livelihood. It can reduce damage from flood and raise awareness of disaster prevention.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	WRMA has a high request of enforcement of community. In addition, some damage can prevent if people have knowledge on flood management. So it importance is high.	A	3
	Effectiveness	It is expected certain effect against number of educated people. Their knowledge on disaster prevention can implement wherever and whenever they need. Its effect can be spread.	B	2
	Efficiency	It can give knowledge on disaster prevention to a large number of people at the same time. Cost is low. Effectiveness is high when the knowledge is rooted.	A	3
	Impact	Knowledge can hand down from beneficiary to their family and friends. It can expand widely.	A	3
	Sustainability	Local people such as school teacher and community leader can be a lecturer. So educational activity sustain. In addition, integration into curriculum is important.	A	3
Total			14	
Merit		Preparation takes short time. Community's resilience can be improved. KRCS volunteers already practiced training on livelihood improvement. Collaboration with them is effective. Easy to distribute, Low costs.		
Demerit		Requirement definite term to be effective		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		Preparation of relevant materials		
Responsible Institution/Agency		WRUA, KRCS		
Main Actor		Ministry of Education/Taveta County Educational Officer/ Teachers/WRUA		
Public assistance Mutual support Self-help		Mutual Support・Public Assistance		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.18 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（18）

No.		**L-E5**		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Early Warning System**		
Outline		It is a system to transmit flood information based on hydrological data from upstream to downstream. People can prepare for the flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	EWS is not common yet in Kenya, but lack of information on disaster prevention is recognized. It's beneficial that residents know the information as soon as possible during flood, because flow speed is fast and damage is huge.	B	2
	Effectiveness	Warning information can be transmitted extensively. However, if people don't know how to react against flood, this countermeasure doesn't make sense. Its effect becomes higher when it implement with education on disaster prevention.	B	2
	Efficiency	This can give good effect extensively with low cost.	A	3
	Impact	Application in other area is relatively easy. Supplemental effect such as activation of communication between upstream and downstream community is considered.	A	3
	Sustainability	If it is low cost equipment and simple communication system, maintenance is not difficult.	A	3
Total			13	
Merit		Raising ownerships by being expected from system operation and maintenance. Public awareness for evacuation activities. Observation by simple equipment is effective in this area. Sustainability is high because of easy to repair.		
Demerit		Continuous maintenance, Difficulty in operational taking over to next generation		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		Distribution of information		
Responsible Institution/Agency		WRUA		
Main Actor		WRUA etc.		
Public assistance Mutual support Self-help		Mutual Support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.19 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（19）

No.		L-E6		
Target Area		Tributary Stream Area / Downstream of Lumi River		
Countermeasure		Development of Community Road		
Outline		It means to construct a culvert or rise up community road in order to prevent its incapability by flood.		
Image				
Evaluation items				
Evaluation by Five Criteria	Relevance	Community road is inundated during flood. It disturbs evacuation, communication in the community and communing to school. Residents request highly, Raised up road is required.	A	3
	Effectiveness	Ensure of evacuation root	B	2
	Efficiency	Both cost and effectiveness are medium scale.	B	2
	Impact	Almost all community have small scale road. Construction of such kind of road is not difficult. Application at other area is expected.	B	2
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			11	
Merit		Short term to be effective		
Demerit		Continuous maintenance Each stage such as planning, design, and construction need long term. Relevance with PCDEFM project is low.		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		KeRRA, WRUA		
Main Actor		WRUA/ Taveta County etc.		
Public assistance Mutual support Self-help		Public Assistance, Mutual support		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

Table 4.2.20 Evaluation Study on countermeasure against Flash Flood from Tributary River / downstream area（20）

No.		**L-E7**		
Target Area		**Tributary Stream Area / Downstream of Lumi River**		
Countermeasure		**Rised-up Toilet**		
Outline		It is to rise up toilet to prevent water flow from come into the toilet and drain sewage.		
Image				
Evaluation items				
Evaluation by Five Criteria	**Relevance**	Overflowed sewage from toilet cause expansion of infectious disease. Raised up toilet prevents to overflow. People's demand is high.	A	3
	Effectiveness	It is assumed to reduce infectious disease.	B	2
	Efficiency	One raised up toilet is moderate price. However, a large number of toilets should be developed for reduction of infectious disease.	B	2
	Impact	It is relatively simplified measure. So application in other area is not difficult.	A	3
	Sustainability	Maintenance cost is not so expensive. However, maintenance system should be established.	B	2
Total			12	
Merit		Preparation is short term. Collaboration with Ministry of Public health is effective. Easy to distribute		
Demerit		Maintenance against deterioration		
Environmental Negative Impact		Nil		
Necessity of EIA		Unnecessary		
Contribution by the residents		According to WDC Manual, Residents should provide contribution. In Alarm Status sub catchment, it should be 15%. On the other hand, in Alert or Concern Status sub catchment, it shou be 25%. The contribution will be provided by cash, laybour or materials.		
Responsible Institution/Agency		WRUA		
Main Actor		WRUA etc.		
Public assistance Mutual support Self-help		Mutual support, Self-Help		

A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

4.2.1 Result of the Evaluation on 5 Criteria

Following figure shows evaluation on 5 criteria of all candidate measures. It is preferable to implement from high scored to low scored measures. However, schedule some of them require long term coordination and negotiation. JICA project team studies.

Table 4.2.21 Evaluation List of 5 criteria

Structural/ Non-structural	No.	Countermeasure	Score
Structural Measure	L-W3	Repair of existing embankment / Long term inundation area	12
	L-W12	Raised-up Toilet / Long term inundation area	12
	L-E7	Raised-up Toilet / Tributary Stream Area	12
	L-W9	Environmental Improvement of Evacuation Camp / Long term inundation area	12
	L-W11	Development of Community Road / Long term inundation area	11
	L-W2	Drainage Channel Improvement / Long term inundation area	11
	L-E6	Development of Community Road / Tributary Stream Area	11
	L-W13	Spring protection (Gabion) / Long term inundation area	10
	L-W4	Dredging of Lake Jipe / Long term inundation area	10
	L-W1	Channel Improvement of Lumi River / Long term inundation area	10
	L-E1	Bank Protection / Tributary Stream Area	9
	L-W5	Small check dam / Long term inundation area	9
	L-W10	Rain water harvesting / Long term inundation area	8
Non-structural Measure	L-W7	Education on Disaster Prevention / Long term inundation area	14
	L-E4	Education on Disaster Prevention / Tributary Stream Area	14
	L-E5	Early Warning System / Tributary Stream Area	13
	L-W8	Early Warning System / Long term inundation area	13
	L-W6	Forestation Activity (upstream) / Long term inundation area	11
	L-E3	Forestation Activity / Tributary Stream Area	11
	L-E2	Restriction on land use / Tributary Stream Area	11

5. PROJECT IMPLEMENTATION PLAN OF FLOOD COUNTERMAURES

5.1 FLOOD COUNTERMEASURES IN THE FLOOD MANAGEMENT PLAN

The Flood Management Plan defines the most prioritized flood event as long term inundation from Lumi River (downstream area) and the second as Flash Flood from Tributary River (downstream area)

Countermeasures against those events should be mentioned in CMS. In addition, planning of WRUA scale project should be incorporated in the Lower Lumi WRUA SCMP.

5.1.1 Structural Countermeasures

Structural countermeasures should be implemented in the following order.

- Environmental improvement of evacuation camp
- Raised-up toilet
- Study on repair of existing embankment
- Study on development of community road
- Study on spring protection (Gabion)
- Study on channel improvement of Lumi River
- Study on dredging of Lake Jipe
- Study on building small check dam
- Study on bank protection at Tributary Stream Area
- Study on rain water harvesting

5.1.2 Non-structural Countermeasures

Non-structural countermeasures should be implemented in the following order.

- Education on disaster prevention
- Early warning system
- Forestation activity
- Restriction on landuse

5.2 DRAFT IMPLEMENTATION SCHEDULE OF FLOOD COUNTERMEASURES

JICA project team proposes draft implementation schedule of flood countermeasures as following.

Draft Implementation Schedule of Flood Countermeasures in Lumi River Basin

	Countermeasures	Required Preparation	Main Actor	Support Actor			WRMA's role	WRUA's role	1st year	2nd year	3rd year	4th year	5th year	6th year or later
				NGO	Administrative Authority	Techinical Authority								
Structural Measure	Environmental Improvement of Evacuation Camp		WRUA	KRCS	County/District/Ministry of Education	MWI, WRMA	techinical advice	planning/construction/operation/maintenance	■	■	■			
	Raised-up Toilet		WRUA/Community/Individual		County/District/Ministry of Public Health	MWI, WRMA	techinical advice	planning/construction/enlighten ment activity	■	■	■			
	Repair of existing embankment	Study/Survey/Discussion	NWCPC or County		County/District	MWI, WRMA	coordination with related ministries	planning/maintenance	Study/Survey/Discussion ←	→	→	→	→	■
	Development of Community Road	Study/Survey/Discussion	WRUA		County/District/Ministry of Road/KeRRA	KeRRA, MWI, WRMA	techinical advice	planning/construction/maintenance		Study/Survey/Discussion ←	→	■	■	
	Spring protection (Gabion)	Study/Survey/Discussion	WRUA		County/District、MWI, WRMA	WRMA	techinical advice	planning/construction/maintenance	Study/Survey/Discussion ←	→		■	■	
	Channel Improvement of Lumi River	Study/Survey/Discussion	NWCPC or County		County/District	MWI, WRMA	coordination with related ministries	planning/maintenance				Study/Survey/Discussion		←→
	Dredging of Lake Jipe	Study/Survey/Discussion	NWCPC or County		County/District	MWI, WRMA	coordination with related ministries	planning/maintenance				Study/Survey/Discussion		←→
	Building small check dam	Study/Survey/Discussion	NWCPC,MWI or County		County/District、MWI, WRMA	MWI, WRMA	techinical advice	planning/construction/maintenance		Study/Survey/Discussion ←	→	■	■	
	Bank Protection	Study/Survey/Discussion	WRUA		County/District、MWI, WRMA	MWI, WRMA	techinical advice	planning/construction/maintenance				Study/Survey/Discussion		←→
	Rain water harvesting	Study/Survey/Discussion	Town council,/WRUA		Town council	MWI, WRMA	techinical advice	planning/construction/maintenance		Study/Survey/Discussion ←	→	■	■	
Non-structural Measure	Education on Disaster Prevention		Schools, WRUA	KRCS	Ministry of Education/County/District	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity	■	■	■	■	■	■
	Community based Early Warning System against Flash Flood		WRUA	KRCS	KMD/Ministry of Special Programs	MWI, WRMA	techinical advice	planning/establishment/operation/mainenance	Formulation ←	→	■	■	■	■
	Early Warning System for downstream (IFAS/GFAS)		WRUA/Community	KRCS	KMD/Ministry of Special Programs	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity	Consideration ←	→	■	■	■	■
	Forestation Activity		Youth group/Residents	KRCS	Kenya Forest Service	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity	■	■	■	■	■	■
	Restriction on landuse		KFS		Kenya Forest Service	MWI, WRMA	coordination with related ministries	cooperation/participation/enlightenment activity	Consideration ←	→	■	■	■	■

6. RECOMMENDATION

- ♦Fundamental countermeasure against long term inundation from downstream of Lumi River on a long term basis should be considered.

- ♦Collaboration with existing organization such as District Disaster Management Committee (DDMC) is necessary to implement a project that can enforce resilience of community against flood.