付属資料 3-3

Lumi 川流域洪水管理計画案

ケニア共和国
洪水に脆弱な地域における効果的な
洪水管理のための能力開発プロジェクト

Lumi 川流域
洪水管理計画（案）

2013 年 7 月

株式会社ニュージェック

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1. 河川流域洪水管理計画の方針（案）

1.1 当該河川流域における洪水管理の方針（案）

Lumi 川流域はキリマンジャロ山の東斜面を源流とし、流域面積の 1/4 はタンザニア領内であり、東南方向に流下してケニア領内に入ったのち南流し、ジペ湖に流入する国際河川である。最上流部の地形勾配は急勾配である一方、最下流部は地形勾配が極めてゆるくなっており、下流域には氾濫原である低平地が広がっている。当該流域内で最も大きな町はタベタであり、主要な産業はメイズ、米、バナナなどの果物の栽培、プランテーションによるサイザル麻栽培などの農業と牧畜、ジペ湖などでの漁業、Tsavo West 国立公園周辺での観光業である。洪水管理を含む水資源管理全般については、WRMA Nolturesh-Lumi Sub Regional Office (SRO)の所管区域に含まれている。さらに、Lumi 川流域内には上流と下流に 2 つの WRUA が設立されており、WRMA と共同して草の根レベルの水資源管理を行っている。

主な洪水被害は、上流のキリマンジャロ山腹での豪雨が、国境を越えて Lumi 川下流部に伝搬し、Lumi 川本川下流部が溢水や破堤し低平地が長期湛水することによる家屋の倒壊や長期避難、農作物や家畜の被害、汚濁水の拡散による水源の汚染や衛生状態の悪化、道路の泥濘化などである。一方、Lumi 川の支川や小河川で生ずるフラッシュフラッドによって、道路・橋梁の破壊や家畜の被害などが生じている。2 ヶ月にもわたる長期湛水による被災者は毎年 2 千人以上と多く、その対策は重要である。しかし、Lumi 川そのものの改修は各種基礎資料が整備されていない現状では早期着手は困難である。したがって、当該河川における洪水管理の基本方針は、長期湛水による住民生活への影響をコミュニティ側での対応により軽減すること、及び、洪水被害からの生活の再建を早めるための工夫の普及・啓発に重点を置く。

洪水管理計画の策定に当たっては、構造物・非構造物対策の適切な組み合わせや、自助・共助・公助といった視点を考慮するとともに、WRUA をはじめとする利害関係者やコミュニティの参加を通して合意形成を図る。さらに、計画段階から WRUA やコミュニティが協働することにより、WRUA・コミュニティのオーナーシップの醸成を図り、構造物対策の当該流域内での普及・展開と維持・管理や非構造物対策において、WRUA・コミュニティが主体となって実施していく。

なお、本計画の対象期間は 2013～2018 年の 5 年間とし、必要に応じて適宜見直していくものとする。

1.2 WRMA の役割と責任

本計画の作成主体は WRMA である。WRMA は、WRUA が主体となって実施可能な事業を Sub-Catchment Management Plan (SCMP)に組み込めるよう WRUA の支援を行い、さらに、洪水

対策事業の実施に当たって技術的支援を行う。WRUA が主体とならない事業については、WRMA が関係ステークホルダーと調整を図りながら、事業の実施を促進する。

1.3 河川流域委員会

洪水管理は河川流域内の多様なステークホルダーが協力しなければ達成できないものである。また、今回の Lumi 川流域のように、一つの河川流域が上流・下流・左右岸などによって複数のサブ流域に分けられている場合もある。

以上を踏まえ、WRMA は、河川流域内のステークホルダーを一同に集め、河川流域単位で洪水管理に関する情報共有・調整を行うことを目的として、統合洪水管理河川流域委員会(Integrated Flood Management River Basin Committee)を設立する。

同委員会に参画を求める河川流域内のステークホルダーを以下に挙げる。

表 1.3.1 Lumi 川流域のステークホルダー

No	Organization	Remarks
1	Lower Lumi WRUA	
2	Upper Lumi WRUA	
3	Provincial Administration	Taveta District Commissioner
4	Ministry of 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	County Council	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	WRMA	HQ, RO, SRO

同委員会では、関係ステークホルダー間の意見交換、洪水管理計画の承認、コンセンサス構築、役割分担の議論、活動評価等を行う。委員会は、当面は数か月に 1 回程度の開催頻度で、次の

ような内容について討議する。

表 1.3.2 統合洪水管理委員会開催スケジュール（案）

回	討議内容	備考
第 1 回	・ 洪水の現状・問題点についての共有 ・ 考えられる洪水対策についての議論	2013 年 2 月 22 日に実施
第 2 回	・ 洪水管理計画（案）の提示と議論 ・ パイロット事業の合意形成（本プロジェクトのみ）	
第 3 回	・洪水管理計画（案）の議論 ・パイロット事業の進捗報告（本プロジェクトのみ）	
第 4 回	・洪水管理計画（案）の議論 ・パイロット事業の評価（本プロジェクトのみ）	

1.4 環境社会配慮

洪水対策事業を計画するに当たっては、ケニア国 Environmental Management and Coordination Act (EMCA) 1999 に基づき、適切な環境社会配慮を行う。

2. LUMI 川流域の概要

Lumi 川流域は、アフリカ東部のケニア共和国の南部のタンザニアとの国境地帯にあり、キリマンジャロ山の東南部に位置している。

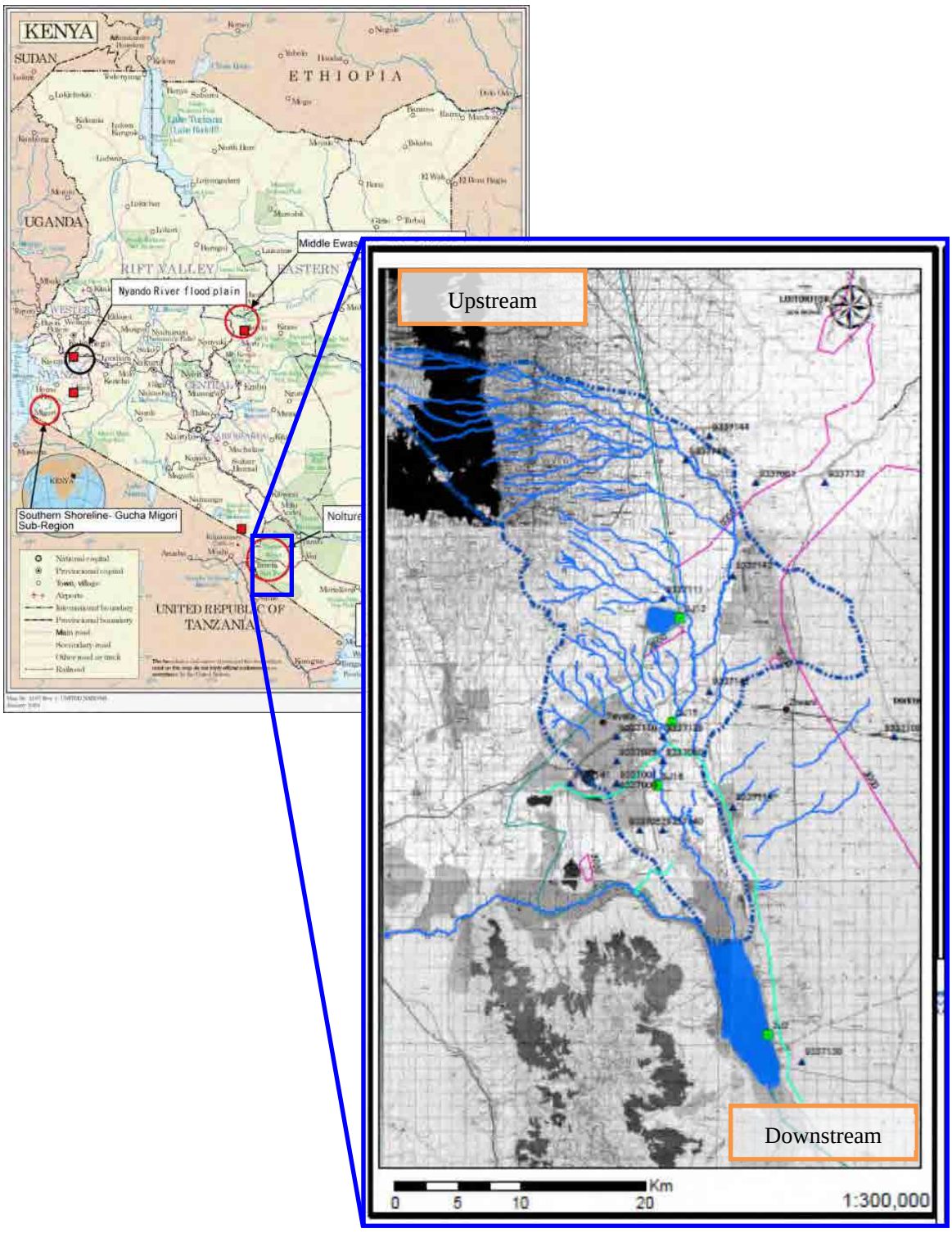


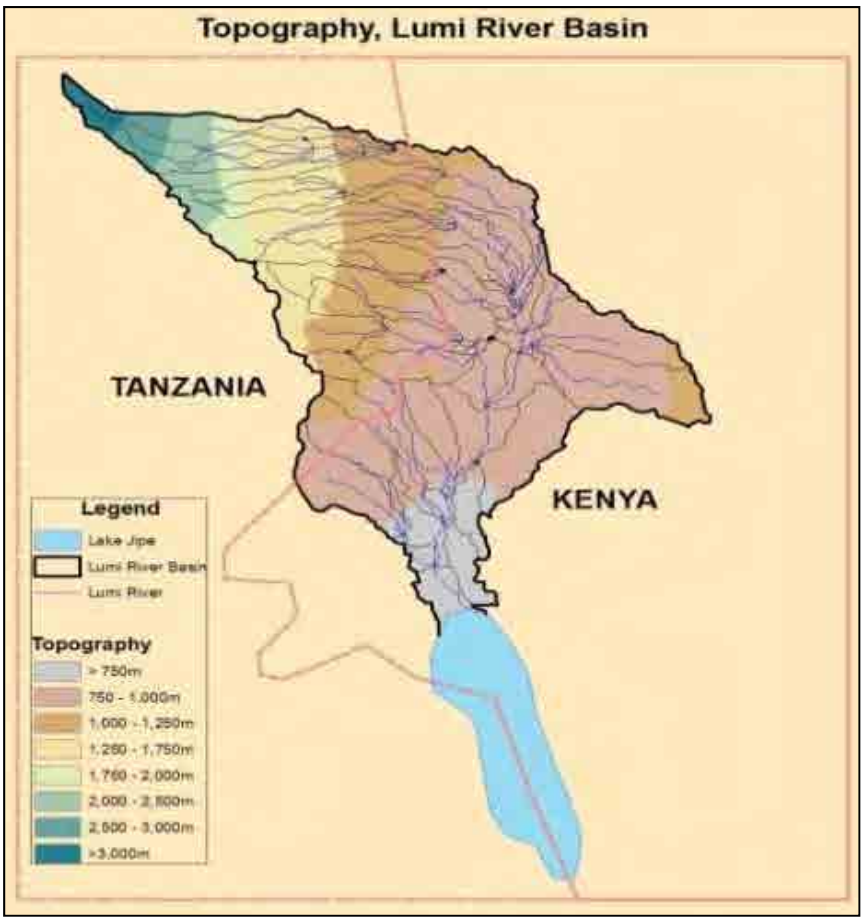
図 2.1 Lumi 川流域の位置

2.1 自然条件

2.1.1 地形・土壌

(1) 地　　形

Lumi 川流域の面積は約 590km^2（うち、ケニア内は 3/4 を占める）で、全長は南北に約 71km、幅は最も広いところで東西に約 20km となっている。Lumi 川はキリマンジャロ山を源流とし、そこから東のケニア領内の Taveta District を経て南へ向かって流れ、Jipe 湖と再びタンザニア領内の Luvu 川に流れ込んでいる。流域内には多くの泉があり、そこからも Lumi 川へ水が流入している。主な泉として、Kiboboto spring、Madala spring、Njoro spring、Sambeki spring がある[1]。

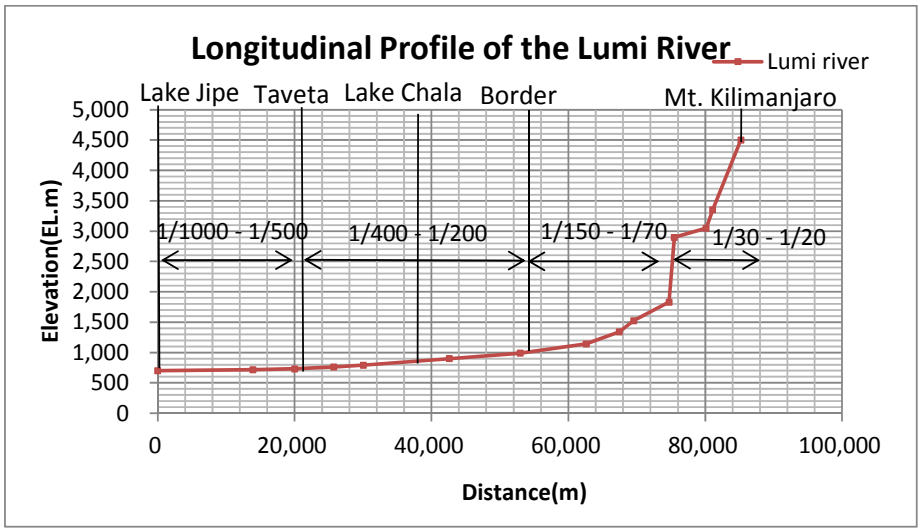


出典：WRMA, Action Plan on The Development and Implementation of a Flood Management Plan for Lumi River

図 2.1.1 Lumi 川流域標高区分図

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

Lumi 川流域においては、タンザニア国境内の上流域は約 4,500 m から 1,000 m の標高にあり、特に上図中に示される緑から黄緑色の部分にかけては急勾配の地形となっていることを読み取ることができる。ケニア領内に入ると、中流域が 1000m から 750m の標高にあり、下流域は標高 750m あたりで Jipe 湖に注ぎこんでいる。下流域は概ねフラットな地形である。



出典：1/50,000 地形図をもとに JICA Project Team が作成

図 2.1.2 河川流路断面図

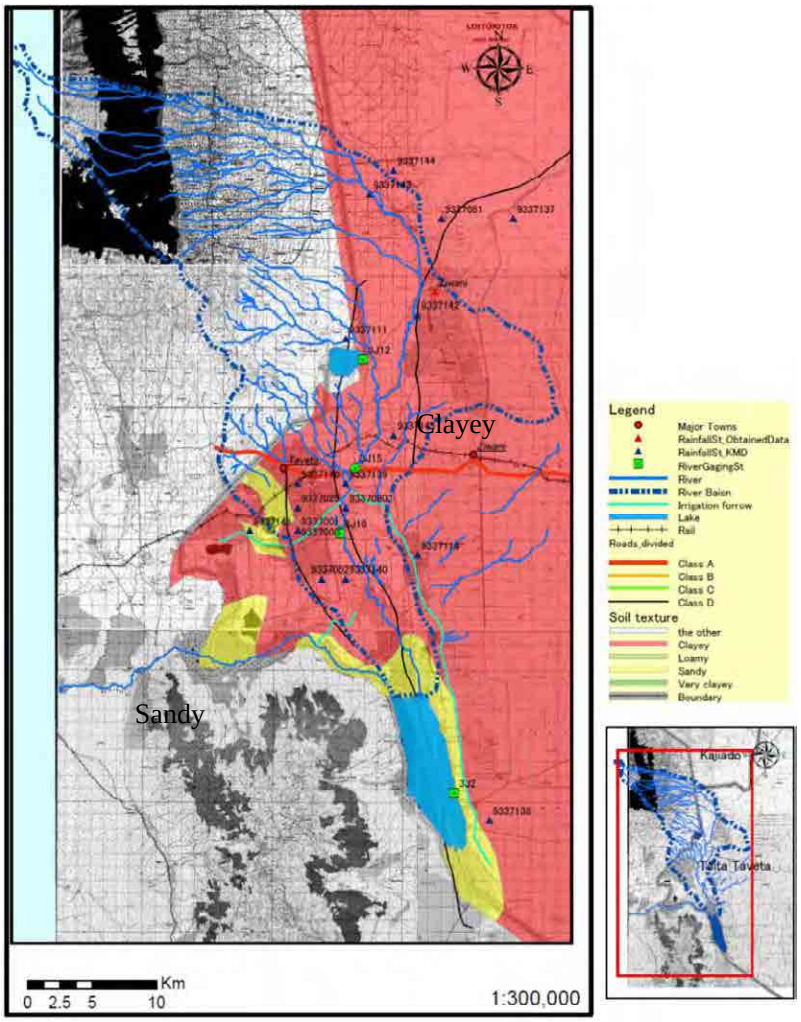
写真 2.1.1 キリマンジャロ山

写真 2.1.2 Challa 湖

写真 2.1.3 Jipe 湖

(2) 土　　壌

Lumi 川流域における土壌分布図を以下に示す。流域全般に土が覆っており、Jipe 湖流入部周辺及び Luvu 川周辺にかけて砂が分布している。



出典: Kenya soil survey (KSS) in 1982 and revised in 1997.をもとに JICA Project Team が作成

図 2.1.3 土壌分布図（Soil texture）

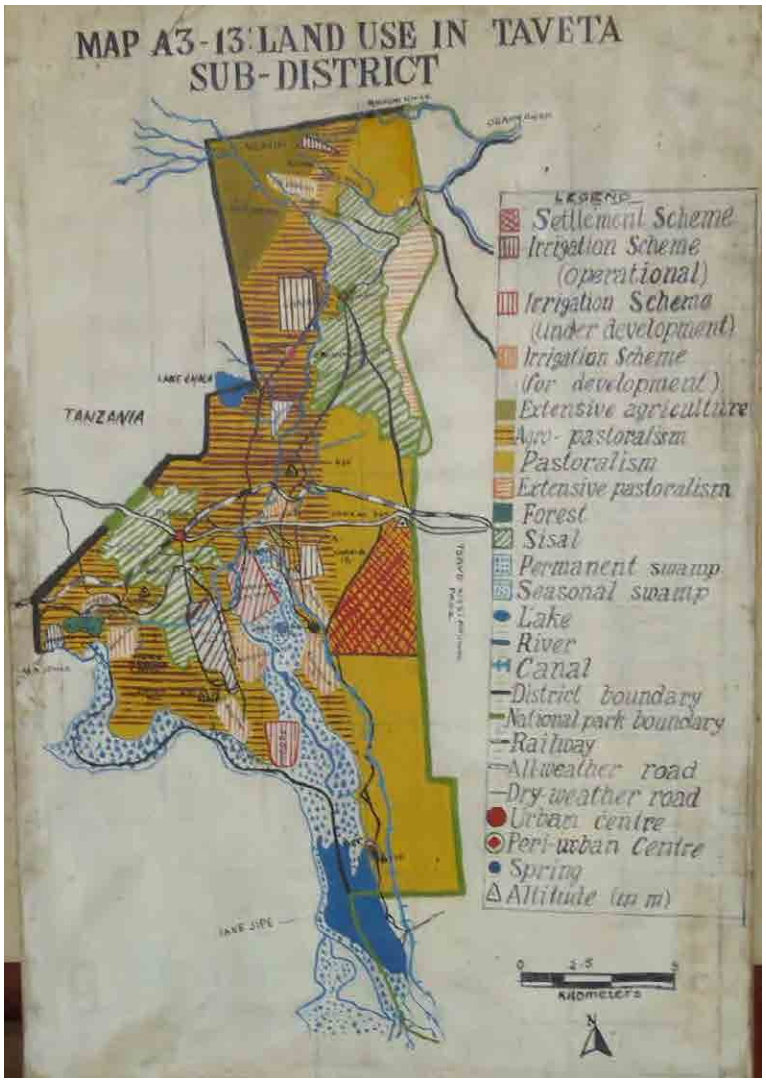
また、NWCPC の報告書[2]の表現はやや異なる面がある。Lumi 川流域の氾濫原は流水による土砂運搬によって堆積した粘土質の土砂と沈泥とされている。山岳部や丘のある地帯は埴壌土となっており、肥沃で水はけが良く、適度に深く、もろい性質であるため、農業に適した土地であるといえる。傾斜地や低地では砂質と粘土質の土壌となっているが、これらのエリアも農業に適している。氾濫原は塩分とナトリウムを含む粘土質の土壌の湿地となっている。

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)

2.1.2 植生・土地利用

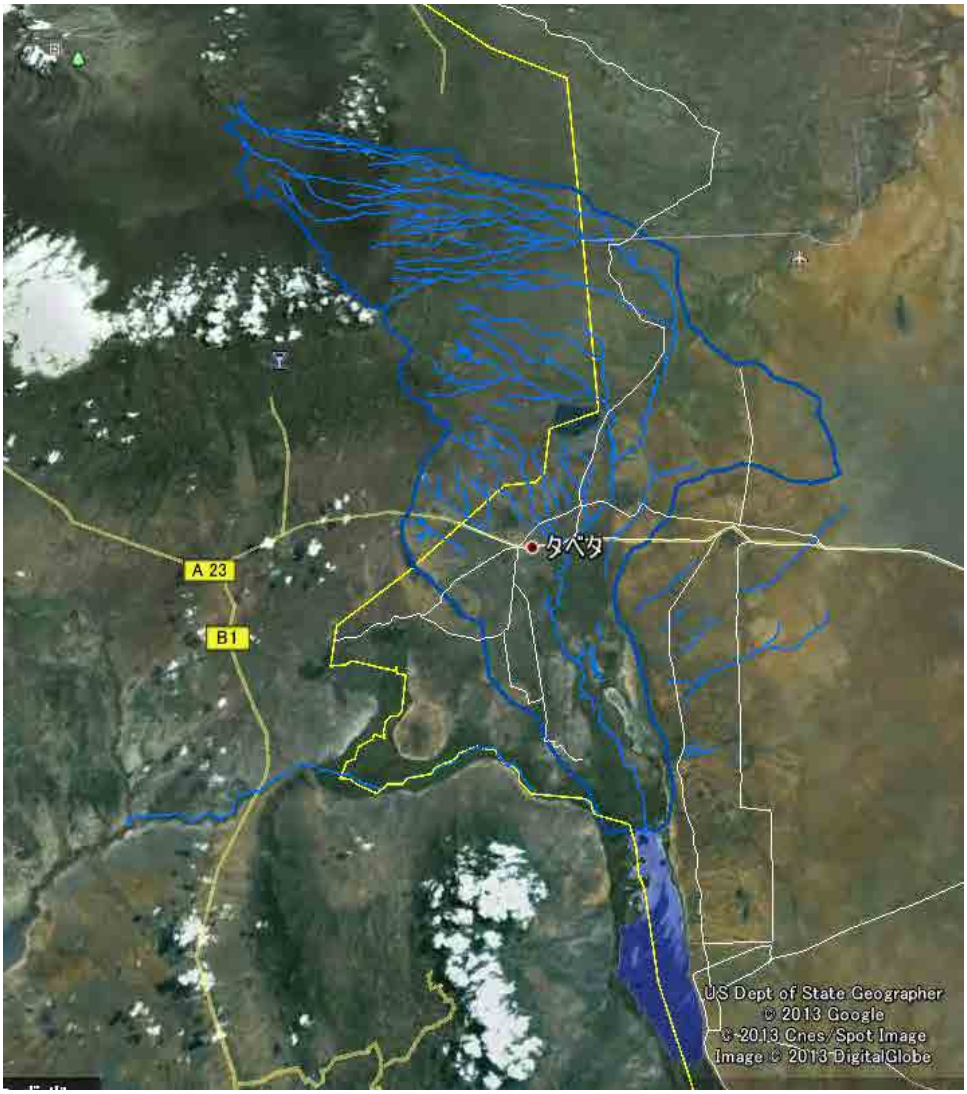
Lumi 川流域における土地利用特性を以下に示す。下記の図から読み取れるように、流域全般的に農業用地、放牧地としての利用が多い。Lumi 川中流域左岸周辺及び Taveta Town の南東側はサイザル麻の栽培地となっている。Jipe 湖付近の低地は湿地となっている。

下記の衛星写真からわかるとおり、中上流域及び西側は植生がほとんど確認できず、土壌が剥き出しとなっているエリアが多いことがわかる。そのため、降雨によって土砂が下流へ流出しやすいことが推察される。



出典：WRMA

図 2.1.4 Lumi 川流域における土地利用



出典： 衛星写真（2012 年 10 月 31 日）に JICA Project Team が加筆

図 2.1.5 Lumi 川流域の衛星写真

2.1.3 水文・気象

(1) 雨量及び水位観測の状況

(a) 観測地点

Lumi 川流域内及び近傍における KMD と WRMA の雨量観測所の一覧を表 2.1.1 と表 2.1.2 に示す。これらのうち、日雨量データを入手できた地点は着色した WRMA の雨量観測所 Ziwani 地点である。WRMA に雨量の入手を依頼したものの、他の雨量観測所のデータを入手することはできなかった。各観測所の位置を図 2.1.6 Lumi 川流域における雨量観測所及び水位観測所の位置図に示す。雨量観測所を三角形、水位観測所を四角形で示す。さらに、データ入手済み、WRMA 所管、

KMD 所管の雨量観測所地点をそれぞれ、赤、緑、青で識別している。水位観測所も同様にデータ入手済みを赤、流域内の水位観測所を緑で示している。

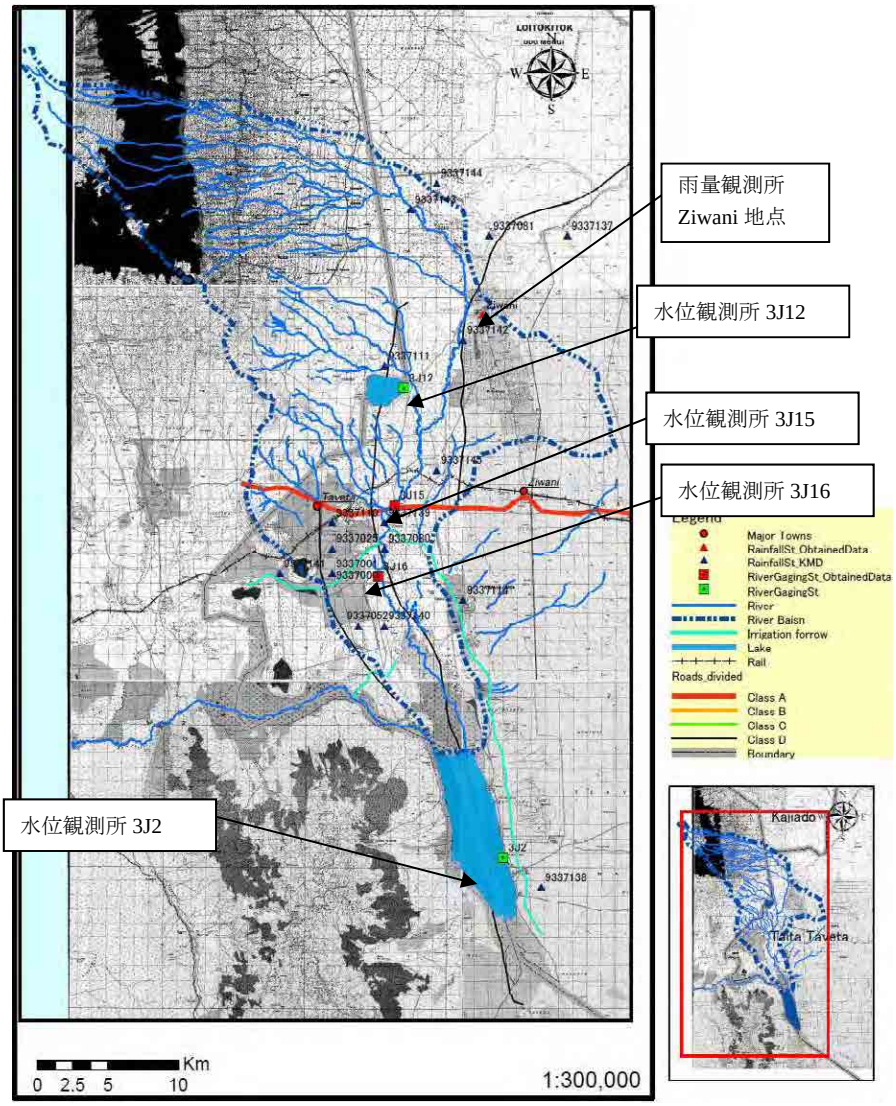


図 2.1.6 Lumi 川流域における雨量観測所及び水位観測所の位置図

(b) 雨量観測データ

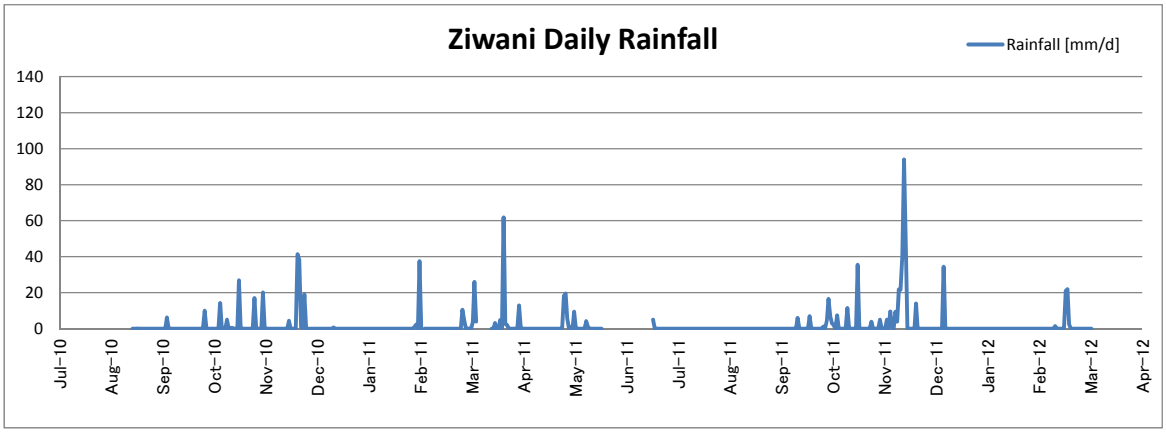
WRMA が所管する雨量観測所 Ziwani 地点における観測期間 2010 年 9 月 1 日 – 2012 年 3 月 12 日（欠測期間あり）の日雨量観測結果を図 2.1.7 に示す。WRMA 所管雨量観測所 Ziwani 地点の約 2 年間の観測期間（欠測期間あり）における既往最大日雨量は 2011 年 11 月 24 日に観測された 95 mm/day である。

表 2.1.1 Lumi 川流域内及び近傍の KMD 雨量観測所の一覧

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	_

表 2.1.2 Lumi 川流域内及び近傍の WRMA 雨量観測所の一覧

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



出典：2010 年 9 月 1 日–2012 年 3 月 12 日（欠測期間あり）の日雨量観測結果をもとに JICA Project Team が作成

図 2.1.7 Ziwani 地点の日雨量

(c) 水位観測データ

水位観測について、下記の表に示すとおり流域内に 4 ヵ所の水位観測所が整備されている。Lumi 川下流域に水位観測所 3J15、3J16 が位置しており、3J15 が Taveta Town の北側に位置しており、3J16 は南側に位置している。残りの 2 ヵ所は Challa 湖、Jipe 湖に位置している（図 2.1.6 参照）。

表 2.1.3 Lumi 川流域における水位観測所

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)

水位観測所番号：3J15
Lumi 川の水位を測定

水位観測所番号：3J16
Lumi 川の水位を測定。橋梁の下に設置

水位観測所番号：3J2
JIPE 湖の水位を観測するために、サファリキャンプ内に設置された水位観測地点

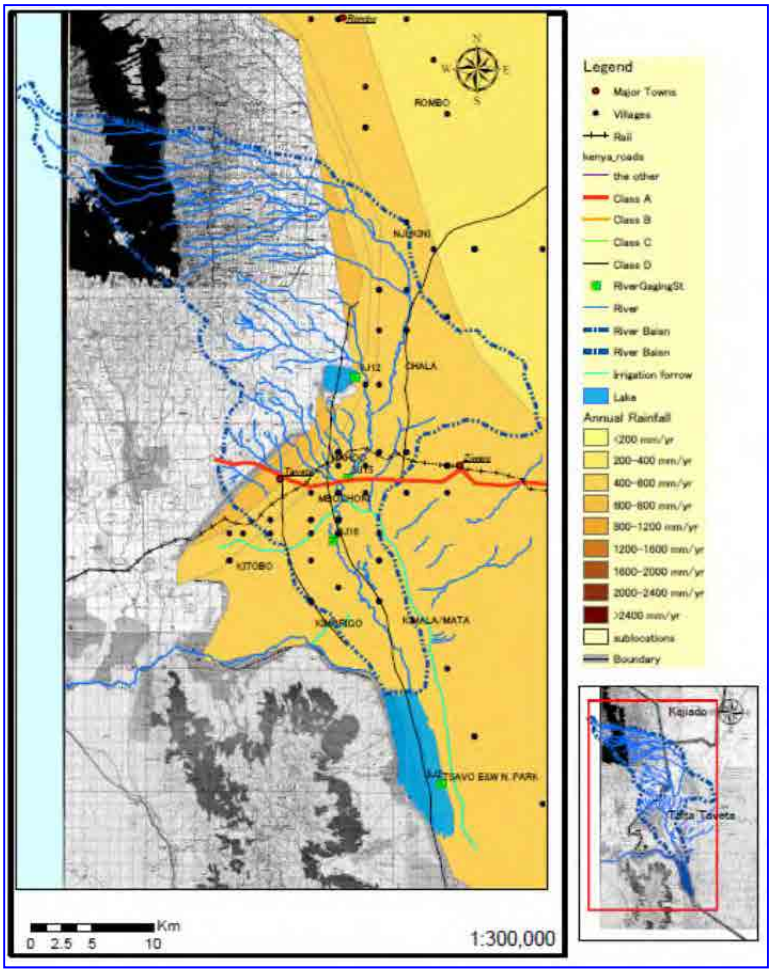
水位観測所番号：3J12
Challa 湖の水位を測定

各水位観測所とも、自動観測は実施されておらず、朝と夕方の 1 日 2 回の目視による水位観測を実施している。そのため、水位データから流量データへの変換が行われているが、洪水時の流量を適切に捉えているとはいえない。

(2) 降水量の特性

(a) 年間水量

Lumi 川流域における年間降雨量の分布状況を以下に示す。ケ国側流域面積の 7 割程度の地域において年間降雨量が 400 - 600mm である。この分布図からはタンザニア側の雨量が読み取れないため、源流に近い上流域の年間降雨量を確認することができないが、国境と接する上流側は年間降雨量が 600 - 800mm と値が高くなっていることが読み取れる。また、NWCPC の報告書（2006）[3]によれば、Lumi 川流域の年平均降水量は約 800 mm/yr、年平均蒸発散量は 1,930 mm/yr とされている。



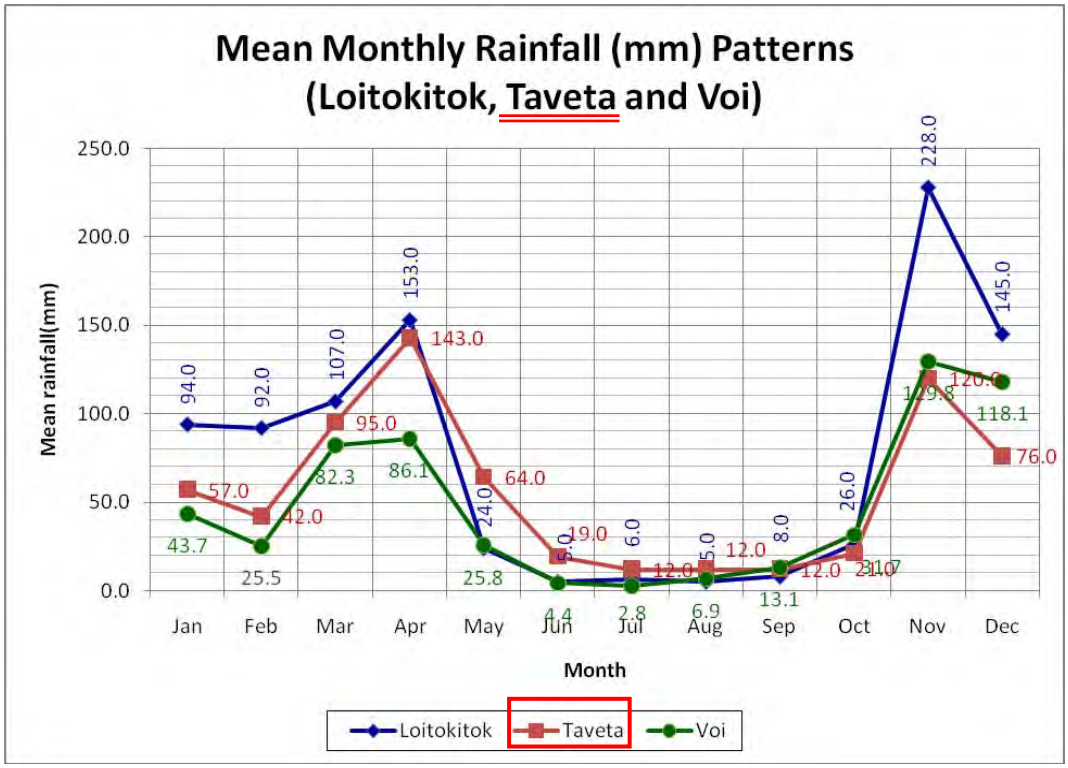
出典: JICA, National Water Master Plan のデータをもとに JICA Project team が作成

図 2.1.8 Lumi 川流域の年間降雨量分布図

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

(b) 月別降水量

Lumi 川流域では、年間に 2 度の雨季があり、3 月から 5 月の大雨期と 11 月から 12 月の小雨期に分かれる。以下に示す月別平均降水量のとおり、流域内の Taveta は 4 月と 11 月の降雨量が年間を通じて最も多くなっている。なお、最も降水量が大きい 4 月の降水量は 143 mm/month となっている。



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

図 2.1.9 月平均雨量（Taveta）

(3) 降雨と河川流量の関係

下記に Ziwani 地点の観測日雨量と 3J15、3J16 地点の観測水位を示す。3J15 で約 3 年間、3J16 で約 4 年間の観測記録あるが、欠測期間が多い。観測水位と観測日雨量の関連性について、データ数が少ないため検証が難しいが、下図中、赤丸で示す位置のように測定水位と降雨に関係が見られる部分が存在する。一方、青丸で示した降雨記録の既往最大値 95mm/日に対して、水位は高い値を示していない部分もある。これらのことから、観測精度については課題があるものと考えられる。

なお、NWCPC の報告書[4]によれば、Lumi 川の乾季の流量は 0.3m3/s である。

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

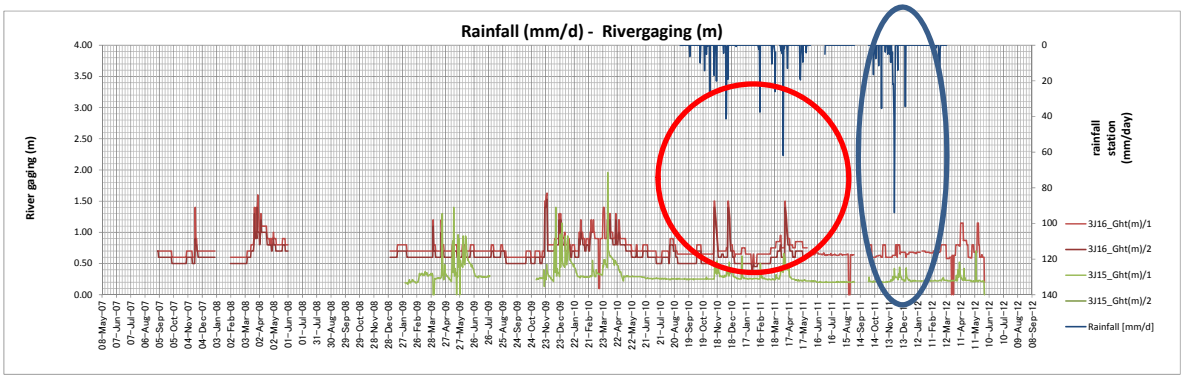


図 2.1.10 観測水位と観測日雨量の関連性

2.2 社会経済条件

2.2.1 行　　政

2013 年 3 月時点におけるケニア共和国の行政区分を以下に示す。

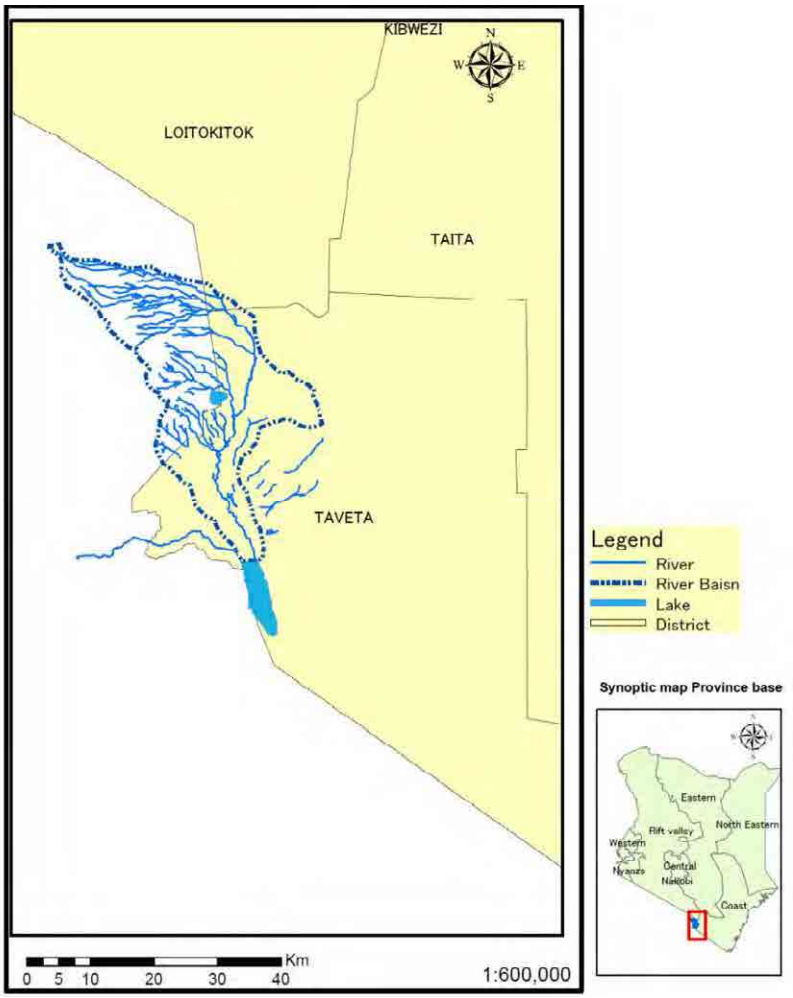
表 2.2.1 ケニア国における行政区分

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

ケニア共和国における行政システムは、大統領府の下に地方政府（Province – District – Division – Location – Sub-location）が位置づけられ組織構成されている。最も小さな行政単位は「Sub- location」となっている。また、行政機関ではないが、地域のコミュニティの単位として Village がある。各々の組織において首長は、Province は Province commissioner、District は District commissioner、Division 及び Location は Chief、Sub Location は Assistant Chief、 Village は Elder となっている。

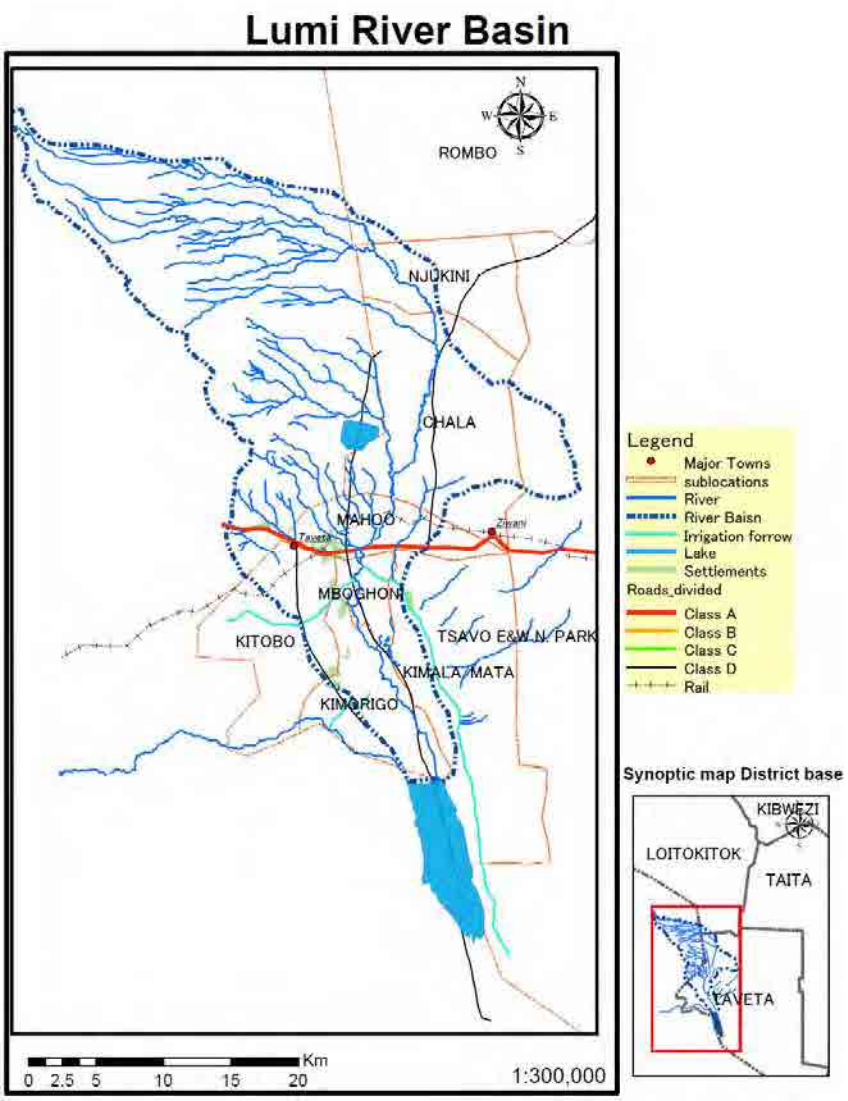
Lumi 川流域は、下記の図に示すとおり Coast Province、Taveta District に含まれている（2007 年までは Taita-Taveta Distrit と区分されており、同 District の旧 Taveta division が現在の Taveta District のエリアにほぼ該当する）。Taveta District はさらに、「Njukini」、「Chala」、「Mahoo」、「Kitobo」、「Mboghoni」、「Kimorigo」、「Kimala/Mata」の 7 つの Sub Location で構成されている。すなわち、ケニア領内で Lumi 川流域は、上記の 7 つの Sub Location と Tsavo National Park Division の 1 部に属している。Lumi 川流域と Sub

Location の位置関係を以下に示す。



出典：ILRI, GIS data をもとに JICA Project Team が作成。2007 年以降の District 区分。

図 2.2.1 Taveta District 及び Lumi 川流域の位置関係



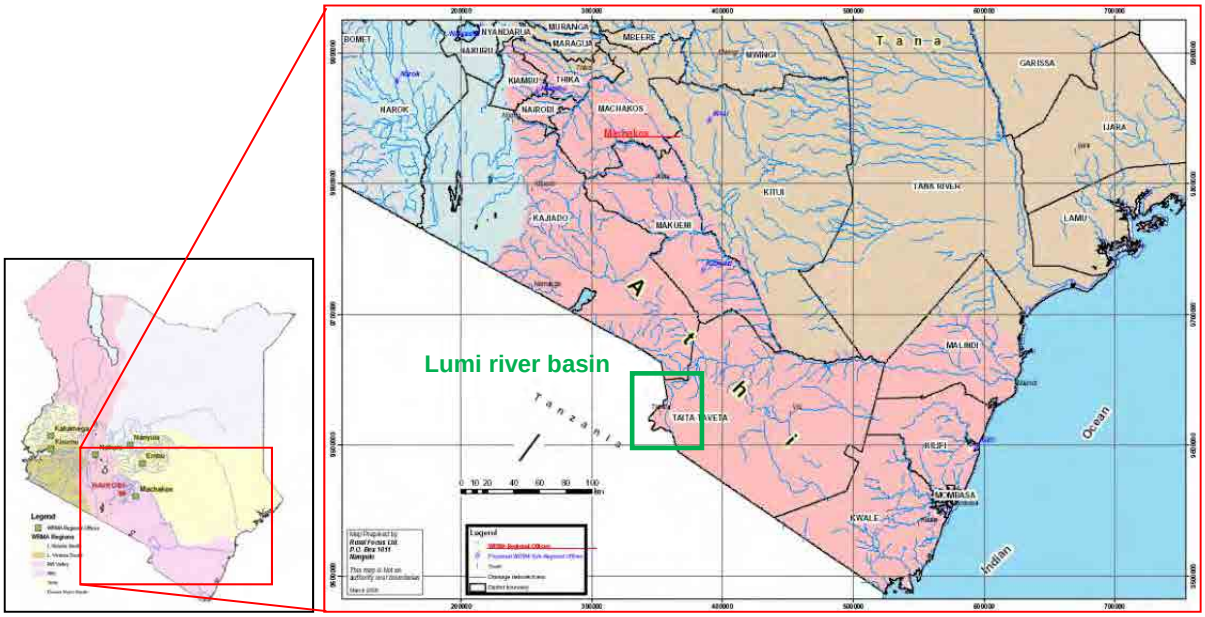
出典: JICA, National Water Master Plan のデータをもとに JICA Project Team が作成

図 2.2.2 Lumi 川流域と近隣 Sub location の位置関係

また、水資源に関連する行政を担う WRMA（Water Resource Management Authority）による管理区域と Lumi 川流域の関係を以下に示す。

WRMA は現行の水法（2002）で定められているとおり、全国を 6 つの Catchment に分割しておりそれぞれに地域事務所（Regional Office）を設置している。Lumi 川流域が含まれるのは「Athi Catchment Area」と呼ばれる Catchment である。Athi Catchment は「Upper Athi」、「Nairobi」、「Middle Athi」、「Nolturesh-Lumi」、「Coastal Athi」の 5 つのサブ地域事務所で構成されている。

Lumi 川流域は、「Nolturesh-Lumi サブ地域事務所」の管内に属している。



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

図 2.2.3 Athi Catchment

写真 2.2.1 WRMA Loitokitok Sub-regional Office

2.2.2 人　　口

Lumi 川流域が含まれる Taveta District における 2009 年の人口統計データを以下に示す。これによると、Lumi 川流域内で人口が集中している Taveta Town が含まれる Bomani Location のエリアで、人口密度が 1km^2 あたり 400 人弱から 600 人弱となっている。家屋数もこのエリアに多い。なお、Mjini Sub location では人口密度で 1km^2 あたり約 3,000 人と大変高い値を示しているが、Lumi 川流域外である。

表 2.2.2 Taveta District における 2009 年の人口統計データ

（Lumi 川流域に含まれる地域を着色で表示）

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

出典: Kenya National Bureau of Statistic, Census 2009

2.2.3 産　　業

Taveta District Development Plan（2008-2012）によると、Lumi 川流域で最も盛んな産業は農業となっている。Taveta District での作物の収穫状況を以下に示す。収穫量は、90kg のバッグ数、これに kg 単価（Sh：ケニアシリング）を乗じた金額（Sh）で示されている。

表 2.2.3 Taveta District における作物の収穫状況（重量、金額：2008 年）

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

出典: WRMA 収集資料（合計金額は JICA Project Team が算出）

Taveta District で生産されている作物は、Maize、Rice、Beans、Potato 類、Cotton　など

約 14 種類である。このうち、もっとも生産量が多いのは、重量、金額ともに主食の Maize となっている。続いて、Beans、Cowpeas、Rice、Sorghum、Cotton と続いている。

主な畜産物は、乳牛、肉牛、羊、山羊、家禽となっている。乾燥地帯では養蜂業が行われている。また、食料の確保と雇用の側面から魚の養殖が、Jipe 湖や Chala 湖で行われている。年間漁獲量は約 9 トンで、魚種はティラピアとナマズとなっている。

Taveta District はサイザル麻の産地ではあるが、原料の処理施設やこれを原料にした工芸品を作る施設が立地していない。
しかしながら、Lumi 川流域はバナナ等の果物や野菜の供給地であり、農産品加工のポテンシャルを有しているため将来成長が期待されている。

Tsavo West National Park を擁していること、Serengeti National Park の玄関口に位置しているため、Jipe 湖の周辺にロッジなどの観光施設が位置している。

写真 2.2.2　Lumi 川下流域の水田

写真 2.2.3　Jipe 湖周辺の漁業

2.3 開発計画

2.3.1 VISION 2030

「Vision2030」によると、以下のような開発計画がある。

「灌漑のための施設強化」

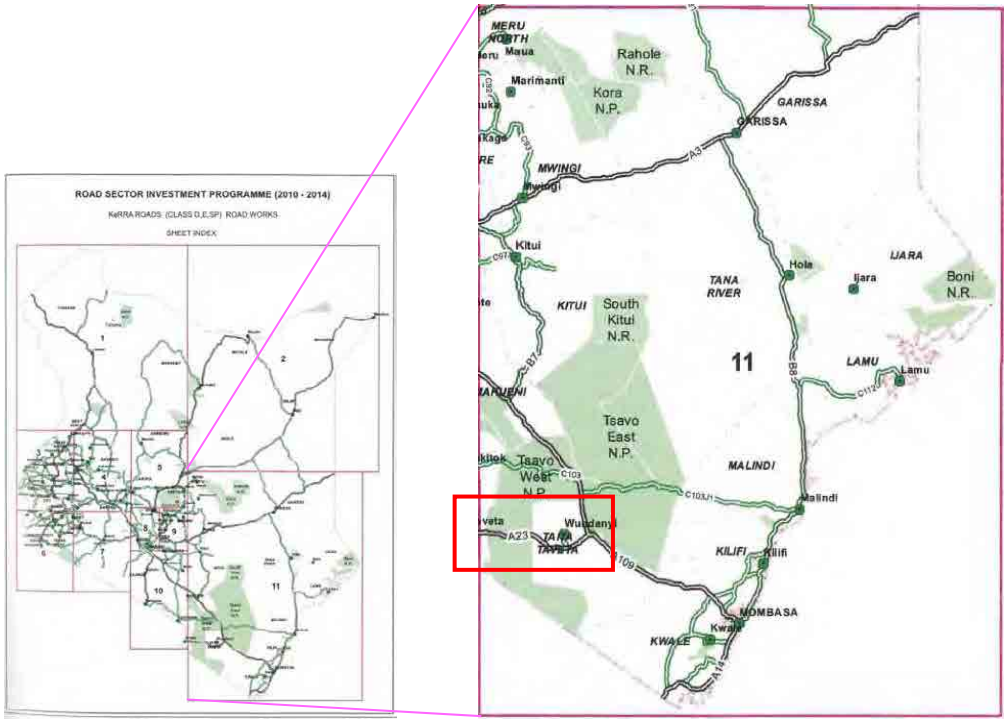
現在、主要な旗艦プロジェクトとして、Tana デルタにおける灌漑強化プロジェクトがあるが、このスキームを Taita-Taveta を含む他の地域にも展開することが示されている。

2.3.2 TAVETA DISTRICT DEVELOPMENT PLAN (2008-2012)

Taveta District の開発計画である「Taveta District Development Plan」によると、以下のような開発計画がある。

(1) 貧弱な道路および物流インフラの改善

現状、的確な予算充当がなされておらず、その結果メンテナンスが実施できていない。また、洪水による損傷も問題となっている。当面は管内のアクセスビリティを 65%にまで回復させる計画となっている。特に、以下の図に示す A23-Mwatate-Taveta Road のアクセスビリティを強化すること、Taveta 地区の洪水被害を軽減すること、空港の改修を行うことがあげられている。



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

図 2.3.1 道路計画図

2.3.3 ATHI WATER CATCHMENT AREA CATCHMENT MANAGEMENT STRATEGY (2009)

Athi Water Catchment において WRMA が掲げる管理計画である「Athi Water Catchment Area Catchment Management Strategy」によると、以下のような流域管理戦略がある。

(1) Surface Water/Flood Mitigation

以下の目的でミクロ（世帯レベル）とマクロ（州レベル）を結び付けた表流水の保持を進めていく。

・家庭用、灌漑用、畜産用、産業用ならびに発電用の水を増量することを目指し大規模貯水池ダムを建設する

・土砂が堆積したり破損した多数の中小規模のダムとため池の補修を推進し、地方での水供給や小規模灌漑のための水資源を確保する

・水供給や洪水の低減に絶大な効果が期待できるダムの建設に適した地点の詳細な調査や経済分析を推進する。

・地方部で雨水貯留タンクやため池による Rain Water Harvesting を推進する。

・Sabaki、Lumi、Voi 川流域での洪水管理につとめる。

(2) Enhancing Capacity to Regulate Storage Infrastructure Development

WRMA は独自に貯水池ダムを建設しないが、設計や建設には責任の一端を担う。Region のスタッフは、貯水用施設の設計や施工に関してキャパシティ・ビルディングのためのトレーニングが、災害の低減や救助をも含めて必要となる。

3. LUMI 川流域の洪水特性分析と洪水対策の検討

3.1 洪水被害実績

3.1.1 LUMI 川流域における洪水被害実績

Lumi 川流域における洪水による被害は下記の浸水実績図に示すとおり、特に Kimorigo sub-location, KImala Mata sub-location、Kitobo sub-location 等の下流域河口部の Lumi 川本川から浸水被害が大きい。下記の河川縦断図に示すとおり、タンザニア領内のキリマンジャロ山岳部は急勾配となっているが、ケニア領内にはいると、勾配がなだらかな地形となっている。特に、Taveta Town から Jipe 湖にそそぐ河口付近までの区間は河川勾配が 1/1000-1/500 とフラットな地形となっており、湛水現象を長期化させている。

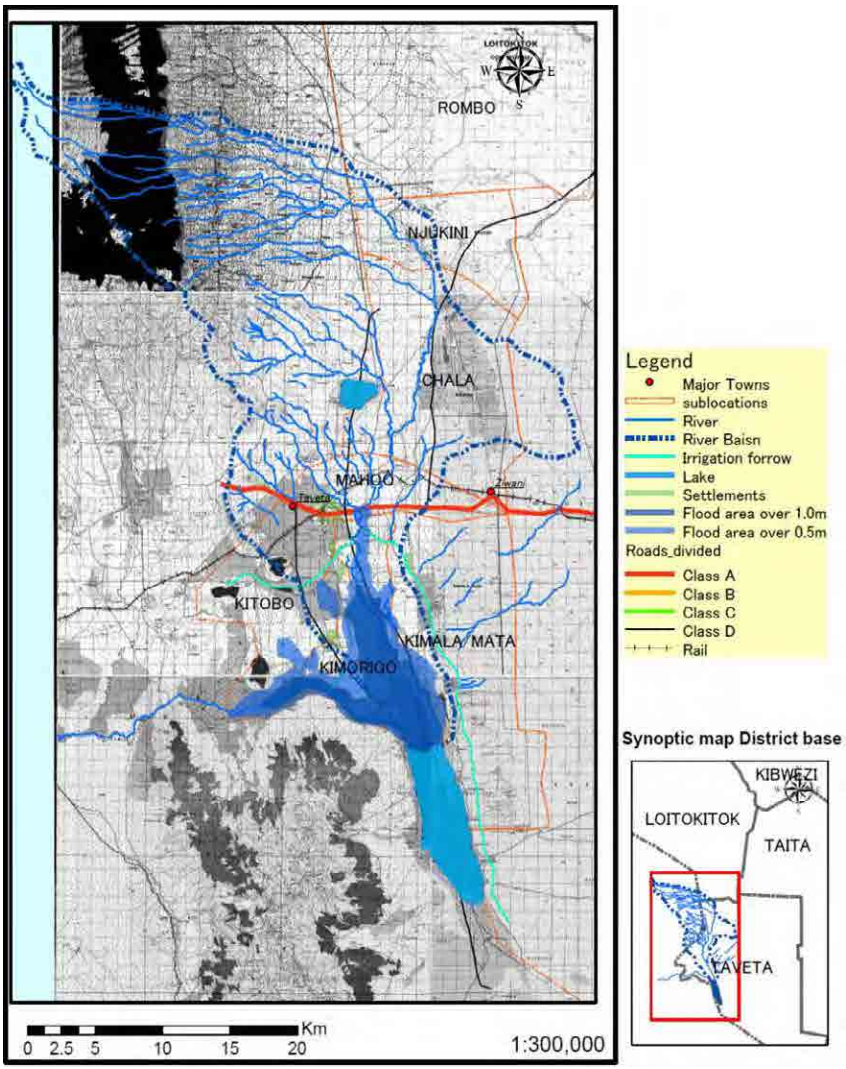


図 3.1.1 Lumi 川流域浸水実績図

Lumi 川下流域では洪水が頻発しており、農業作物への被害、インフラ、家屋への被害、洪水による死者、居住地区の制限、洪水に伴う開発の遅れ等の地域経済への悪影響が起きている。洪水による被害が住民にとって、極めて重要な問題であることから Lumi 川下流域の住民は Sub-Catchment Management Plan の中で洪水に関する問題を最優先課題として挙げている。

WRMA からの情報提供によれば、Lumi 川下流域において毎年発生している規模の洪水及び 2009 年に起きた洪水概況は以下のとおりである。2009 年時の洪水は浸水範囲が約 80km2 と例年の 4 倍程度の範囲が浸水し、避難民の人数及び避難期間も通常の 2 倍程度となっており、洪水被害の大きかった年であることがわかる。

表 3.1.1 Lumi 川下流域における通常及び大規模出水時（2009 年）の洪水概況

	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

出典：WRMA から 提供資料をもとに JICA プロジェクトチームが作成

Lumi 川流域における近年の洪水被害概況を以下の表に示す。前述したとおり、2009 年の洪水被害は下記の被害額で示す通り、例年に比べて 3000 万 Ksh と被害額が大きい。一方で、2009 年の洪水被害影響者数は低い数値を示しているため、洪水被害に関する情報を WRMA が正確に収集・把握できていない可能性がある。

表 3.1.2 Lumi 川流域における近年の洪水被害概況

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

出典： 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

Lumi 川流域の 2011 年から 2001 年における農業分野に関する被害推定を以下に示す。Kitobo の灌漑施設の被害額及び被害エリアともに大きいことがわかる。

表 3.1.3　Lumi 川流域の 2011 年から 2001 年における農業分野に関する被害推定

	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

出典: District Irrigation Office - Taveta

3.1.2　コミュニティから聴取した洪水の状況

Lumi 川下流域において、洪水被害が起きている主な地点は Kimorigo、Kiwalwa、Eldoro、Riata Marabani、Rekeke、Kimala、Ndilidau、Njoro、Bahati、Mata-Jipe、Kitobo 等である。これらの地点の洪水状況について、コミュニティへの聞き取り調査を行った結果を以下の表に示す。

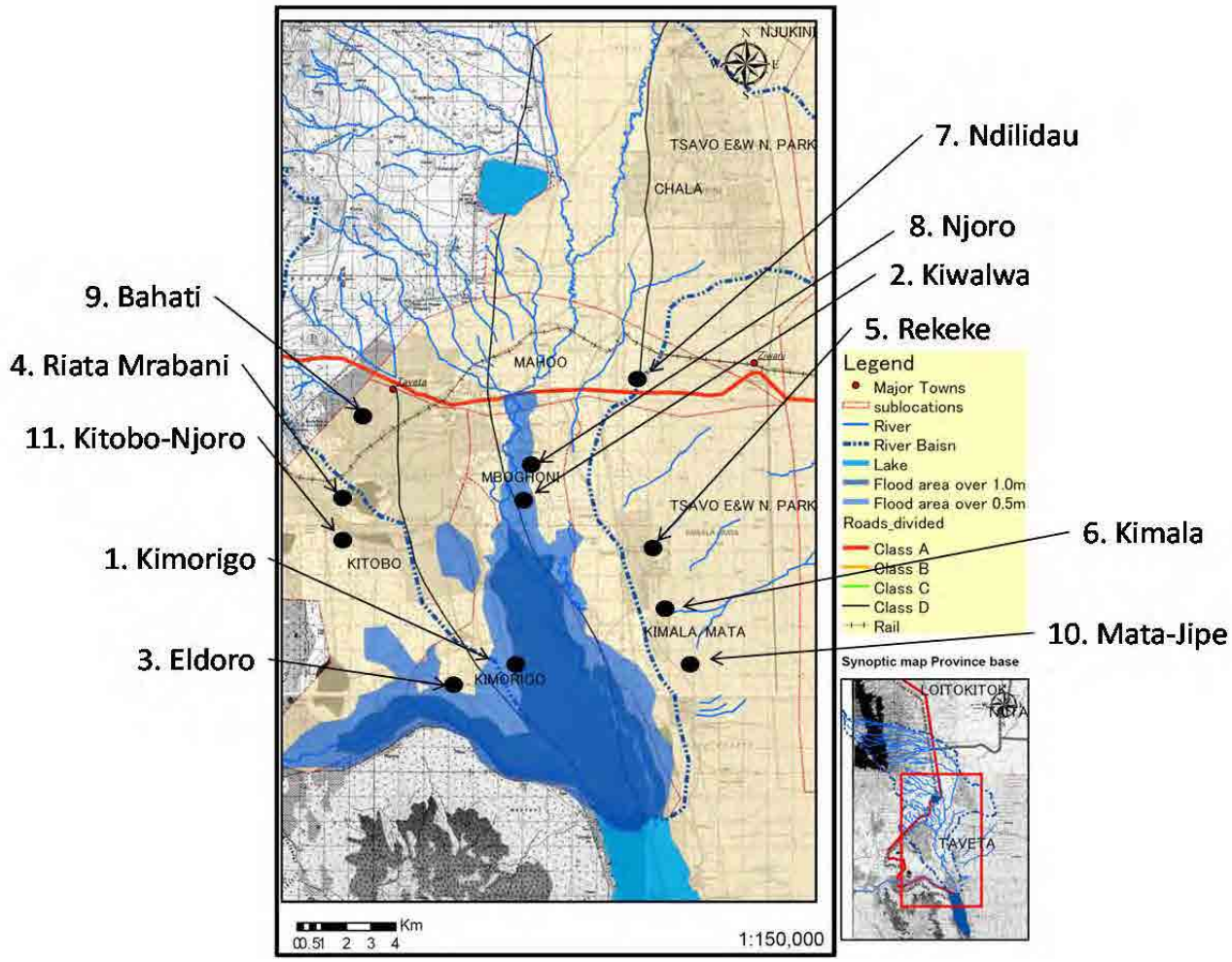


図 3.1.2　下流域における主要なコミュニティの位置図

表 3.1.4　Lumi 川下流域の主要コミュニティの洪水状況調査結果

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

出典：コミュニティへの聞き取り調査結果をもとに JICA プロジェクトチームが作成

河口付近における Lumi 本川からの溢水や破堤による広範囲かつ長期的な浸水は、特に Lumi 川の西側の氾濫区域に位置している Kimorigo 及び Eldoro での洪水被害が大きく、浸水深 120cm、浸水期間 2 ヶ月の長期的な浸水が起きている。
Rekeke、Kimala 等のコミュニティは上記の図からもわかるように、下流域の支川及び Jipe 湖に直接流入する小河川の周辺に位置しており、Lumi 川本川の洪水現象と大きく異なる。浸水時間は数時間程度と比較的短いことから流速が速いことが推測される。加えて、浸水深は 60cm 程度とされているが、流速が早いことから流れのエネルギーが大きく浸食・洗掘による氾濫の危険性が高く、水深が浅くても避難は困難となる。
また、地点毎にみられる特徴として、以下のことが読み取れる。

・ Kimorigo の Community 人口は Kiwala、Eldoro に比べて多くないが、Community 人口に被災者数が占める割合は極めて多い。

・ Kiwala、Mata-Jipe は Community 人口が多いことから被災者数も多い。

以上をふまえて、プロジェクトチームの聞き取り調査によって得られた各コミュニティにおける被害状況と洪水タイプを以下に示す。

1. Kimorigo
   - 浸水深 120cm、浸水期間 2 ヶ月の長期的な浸水が起きている..... (Lumi 本川からの溢水や破堤による浸水)
   - Kimorigo 地区で雨が降っていなくても上流からの流れにより出水があった .....(Lumi 本川からの溢水や破堤による浸水)
   - 家屋内への浸水と土砂の流入があった ..... (Lumi 本川からの溢水や破堤による浸水)
   - 山羊、羊、鶏および兎のような小さな家畜が洪水に流された ....(Lumi 本川からの溢水や破堤による浸水)
   - Murram Road が洪水により寸断され、村へのアクセスが不能になった ..... (Lumi 本川からの溢水や破堤による浸水)
   - 農地が洪水の直撃を受け、作物が流出した ..... (Lumi 本川からの溢水や破堤による浸水)
   - 洪水時、川の流れが激しい間 Abori 小学校が休校となった ....(Lumi 本川からの溢水や破堤による浸水)
   - 泥で作られた家の中には洪水で流されてしまったものもある ..... (Lumi 本川からの溢水や破堤による浸水)
   - 農地の中には沼地にかわってしまったところもある ..... (Lumi 本川からの溢水や破堤による浸水)
2. Kiwalwa
   - 氾濫水が耕作地に流れ込み作物が流失した .....

..... (Lumi 本川からの溢水や破堤による浸水)

・ 土砂流が家屋内に侵入し堆積した.....(LUMI 本川からの溢水や破堤による浸水)

・ 道路が洪水被害を受け、氾濫水によって作物を市場に運ぶのが妨げられた
.....(LUMI 本川からの溢水や破堤による浸水)

・ 洪水によって泉の水が汚染された.....(LUMI 本川からの溢水や破堤による浸水)

3. Elodro

・ 農地の中には沼地にかわってしまったところもある.....
.....(LUMI 本川からの溢水や破堤による浸水)

・ 厳しい洪水の間、Eldoro 小学校の機能が停止した.....
.....(LUMI 本川からの溢水や破堤による浸水)

・ 洪水によって食用作物が流失した ....(LUMI 本川からの溢水や破堤による浸水)

4. Riata-mrabani

・ キリマンジャロ山の山腹から洪水が到来した.....(フラッシュフラッド)

・ 鉄道や道路といったインフラが破壊された.....(フラッシュフラッド)

・ 氾濫水が土砂とともに家屋内へ流入した.....(フラッシュフラッド)

・ ガリーの浸食により農地が失われた.....(フラッシュフラッド)

5. Rekeke

・ Tsavo West 自然公園からの洪水が発生した .....(フラッシュフラッド)

・ 橋梁や道路といったインフラが破壊された.....(フラッシュフラッド)

・ 2009 年に村人が 1 人洪水で亡くなった.....(フラッシュフラッド)

・ 洪水流で家屋が破壊された.....(フラッシュフラッド)

・ 土砂流が家屋内に侵入した.....(フラッシュフラッド)

・ 山羊、羊、鶏および兎のような小さな家畜が洪水に流された.....
.....(フラッシュフラッド)

・ 浸食によりガリーのサイズが大きくなり、その分居住区、農地が減少した.....
.....(フラッシュフラッド)

6. Kimala

・ 主に Tsavo West 自然公園から洪水がやってくる .....(フラッシュフラッド)

・ 洪水が橋梁のようなインフラの破壊につながっている.....(フラッシュフラッド)

・ 氾濫水により家屋が浸水する.....(フラッシュフラッド)

・ ガリーの浸食により農地が喪失した.....(フラッシュフラッド)

7. Ndilau

・ Tsavo West 自然公園側からフラッシュフラッドが発生した.....
..... (フラッシュフラッド)

・ 激しい土壌浸食によって大きなガリーができ、それによって農地が減少した...
..... (土壌流出および土砂流出)

・ ガリーによって Voi や Jipe 湖へのアクセス道路が破壊されている .....
.....(土壌流出および土砂流出)

・ 洪水による流水で家屋が破壊されている.....(フラッシュフラッド)

・ 洪水によって農地が失われ作物が流出した.....(フラッシュフラッド)

・ 洪水発生時に大きなガリーを横断しようとして 1 名が命を失った.....
..... (フラッシュフラッド)

・

8. Njoro
・ 氾濫水によって泉が汚染された ..... (LUMI 本川からの溢水や破堤による浸水)
・ 洪水により農地から作物が流失した . (LUMI 本川からの溢水や破堤による浸水)
・ 洪水により家屋が破壊された ..... (LUMI 本川からの溢水や破堤による浸水)

9. Bahati
・ 山地からフラッシュフラッドが発生した ..... (フラッシュフラッド)
・ 洪水により家屋が破壊された ..... (フラッシュフラッド)
・ 洪水により家畜が流された ..... (フラッシュフラッド)

10. Mata-jipe
・ Tsavo West 自然公園側からフラッシュフラッドが発生した .....
..... (フラッシュフラッド)
・ 洪水により家屋が破壊された ..... (フラッシュフラッド)
・ 洪水により家畜が流された ..... (フラッシュフラッド)
・ 洪水により農地から作物が流失した ..... (フラッシュフラッド)
・ 激しいガリーの侵食により農地が減少した ..... (フラッシュフラッド)

11. Kitobo-Njoro
・ 上流側の山地からフラッシュフラッドが発生し Kitobo の泉付近に土砂が堆積した..... (フラッシュフラッド)
・ 洪水により泉の水が汚染された ..... (フラッシュフラッド)
・ 洪水によって Kitobo の泉のまわりに土砂が堆積し農業に支障をきたした .....
..... (フラッシュフラッド)
・ 激しいガリーの侵食により農地が減少した ..... (フラッシュフラッド)

3.1.3 既設構造物の現況

Lumi 川流域における主要な治水及び利水に関する構造物として、Canal-A、Canal-B、Canal-C 及び Grogan-canal がある。

下記の図に示すとおり、Lumi 川下流域の本川西側に平行して Canal-A（全長約 12km）、Canal-B、Canal-C（全長約 17km）があり、これら 3 つの用水路は Jipe 湖の手前で合流し、Jipe 湖から流出している Luvu River につながっている。これらの水路は植民地時代の 1930 年代に建設されたものであり、用水路と排水路の機能を有している。

また、NWCPC の報告書によれば、1973 年に Lumi 川下流域の西側の Canal-C の西側に沿って、堤高 1.5m、延長 10km に渡る堤防が建設された。堤防の建設に伴い 2 つの灌

漑排水の浚渫も行われている。この堤防は、洪水の拡散を防ぐことが目的であったが、出水時に一部区間が決壊し当初の機能を発揮できていない。特に 1987 年と 1997 年時の大規模出水と Lumi 川から農地への灌漑用水の取得を目的とした農民の故意による堤防開削があり、現況に至っている。

現時点においても、Canal-C の一部区間（約 700m）の堤防が破堤しているため、Lumi 川下流の氾濫水は Canal-C に沿って流下せず、Canal-B や Canal-A まで拡散している状況である。これらの水路システムが本来の機能を十分発揮できていないことが、Lumi 川下流域の西側の低平地で洪水被害が多発するようになった一因と推察される。

なお、2012 年には WRMA 主導で Grogan Canal の一部区間が改修され、利水上有効に機能していることや、WRUA によって適切に維持管理されていることもあり、Canal-A、Canal-B、Canal-C の改修とそれによる洪水被害の改善が MWI、WRMA、DC、WRUA などの重要な関心事となっている。

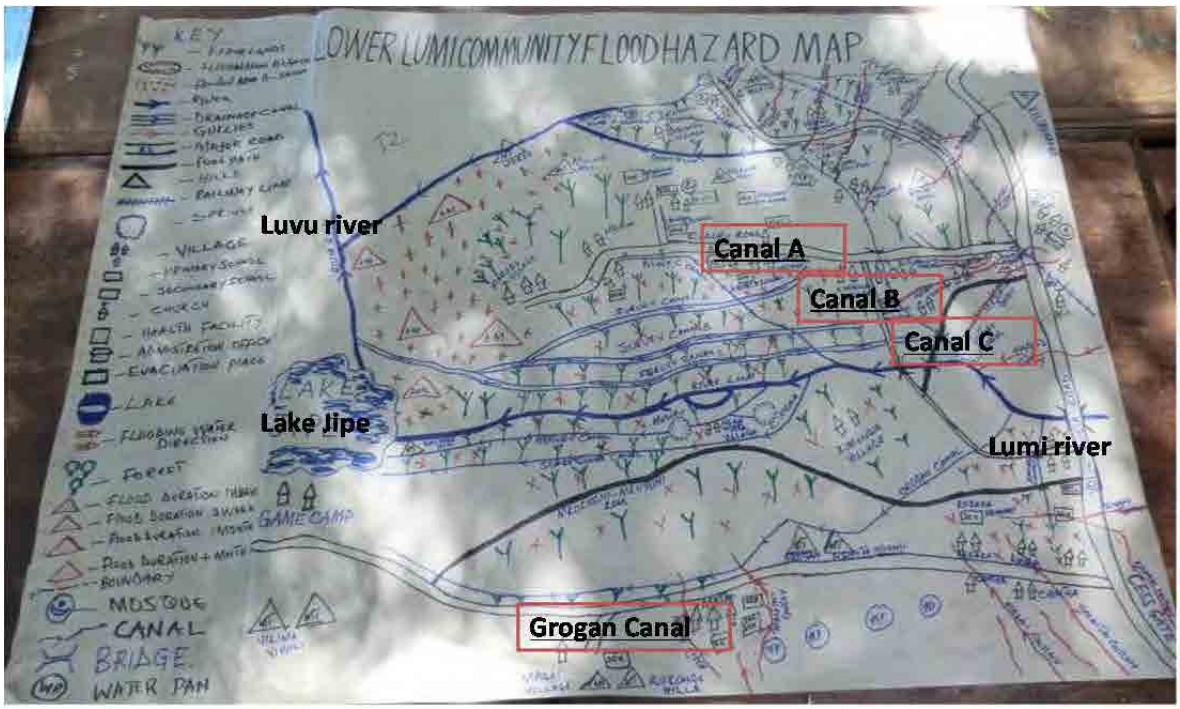


図 3.1.3　水路の位置関係

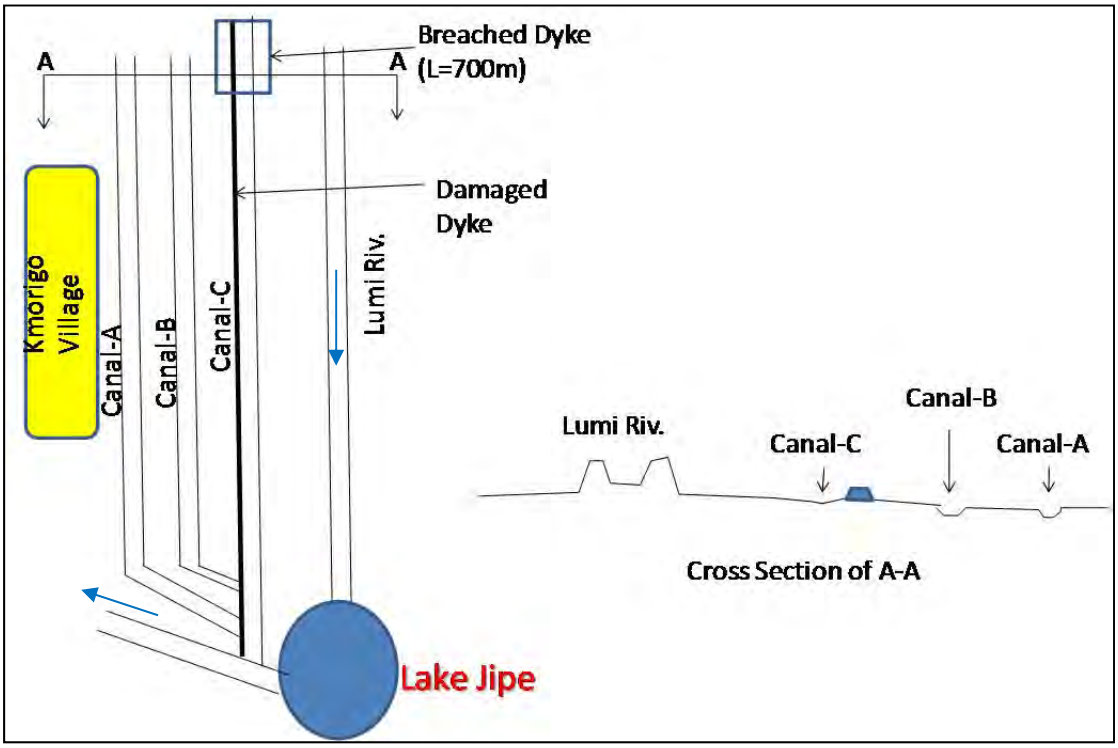


図 3.1.4　水路の断面状況

写真 3.1.1　Canal-C の堤防

写真 3.1.2　Canal-C の堤防が決壊した個所

写真 3.1.3　Kimorigo village 周辺の Canal-A

写真 3.1.4　Canal-C の堤防が人為的に破壊された地点
（左側の方に Lumi 川があり、堤防を切って、Lumi 川から右の方に農業用水を取水）

3.2 洪水特性分類と洪水被害メカニズム

3.2.1 洪水特性分類と被害発生メカニズムの概念

Lumi 川流域の洪水特性から分類すると、以下の 3 つに分類できる。

記号	洪水のタイプ	主な発生エリア
A	土壌流出および土砂流出	Lumi 川本川の中上流域
B	Lumi 本川からの溢水や破堤による浸水	Lumi 川下流の低平地
C	フラッシュフラッド	下流域の支川及び Jipe 湖に直接流入する小河川

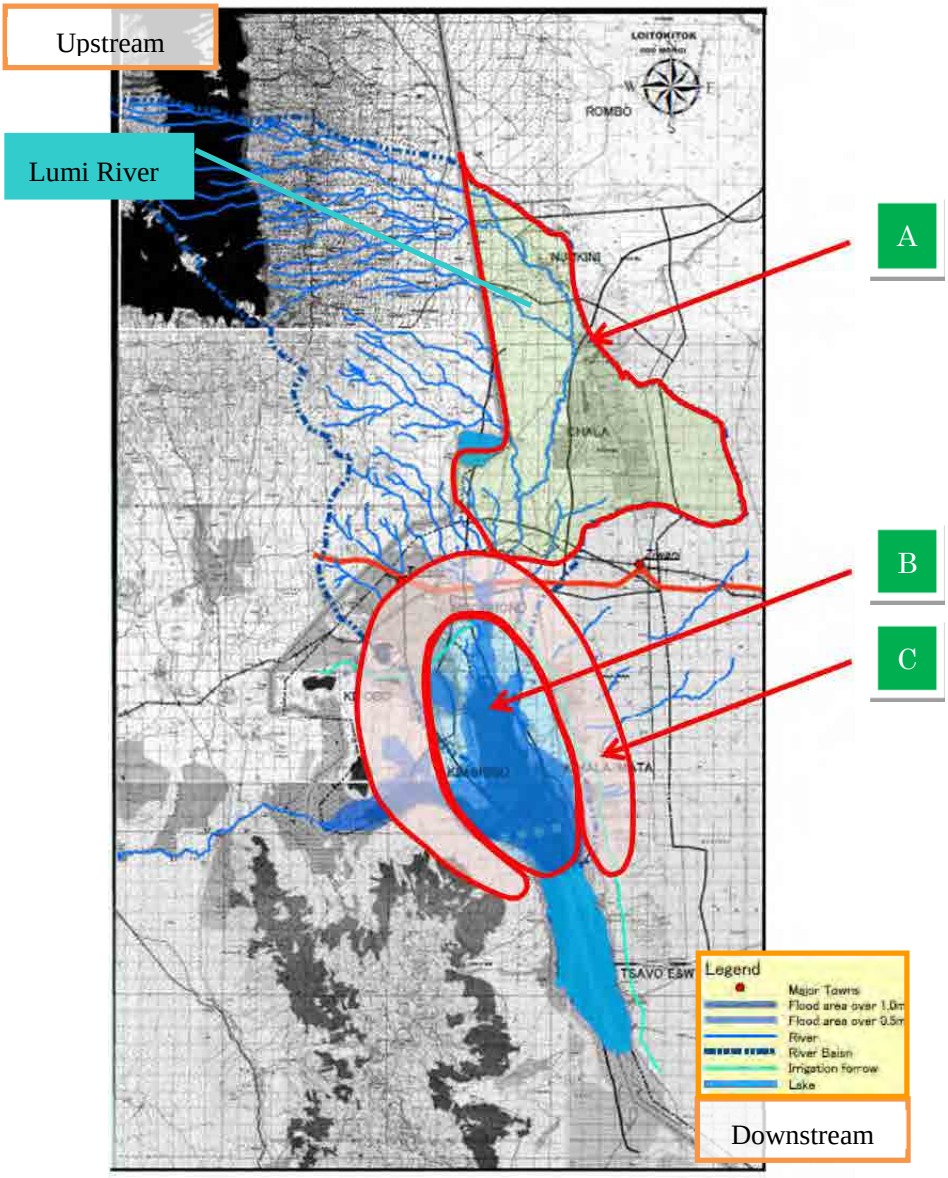
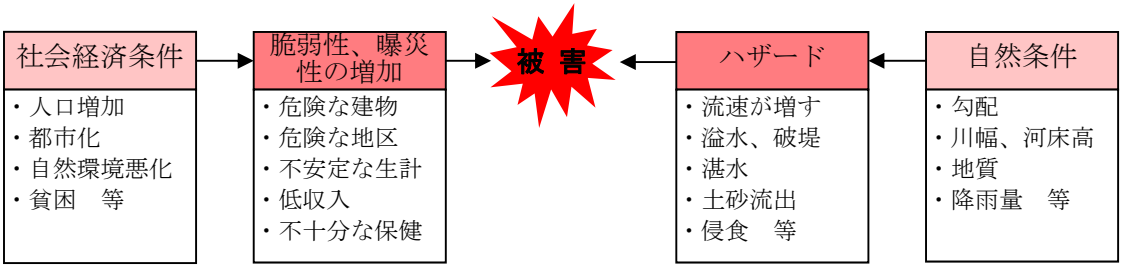


図 3.2.1 Lumi 川流域における洪水タイプとその大まかな発生エリアのイメージ図

洪水被害は以下に示すように、当該地域における自然条件、社会経済条件と密接な関係を持っており、自然条件によりハザードの増加、社会経済条件により脆弱性と曝災性（Exposure）の増加が規定され、洪水被害が決まってくるといえる。前述した A～C の洪水特性分類において、第 2 章で整理した各々の自然条件および社会経済条件をもとに洪水被害特性について分析する。



出典：石渡幹夫「コミュニティと防災援助(1997)」の資料を元に JICA Project Team が加筆

図 5.2 洪水被害の発生条件

3.2.2 LUMI 川中上流域の土壌流出および土砂流出（タイプ A）

Lumi 川中上流域での土壌流出および土砂流出を自然条件と社会条件から分析すると以下のとおりである。

(1) 自然条件からの洪水特性

キリマンジャロ山岳部の激しい降雨と地形勾配が 1/30-1/20 の急勾配となっているため流速が大きいことにより、森林等で被覆されていない表土が侵食されやすく、土砂流出量が多くなっている。流出土砂が運搬され、なだらかな地形勾配となっている下流域で流速が減少し、流出土砂が堆積することで下流域における河床上昇の原因となっている。さらに支川ではフラッシュフラッドが発生している。Lumi 川中上流域の大部分がタンザニア領内であり、タンザニア領内であるキリマンジャロ山岳部での降雨量が大きい。

前章で整理した Lumi 川流域の自然条件とそれに伴う当該地域におけるハザードを以下に示す。

表 3.2.1 Lumi 川中上流域の自然条件とハザード

自然条件	ハザード
山岳部での激しい降雨 急勾配な地形（1/30 -1/20）	表土の浸食、 流速が早く、掃流力が大きい ピーク流量が大きい
裸地が多い	土壌の浸食 土砂の流出

(2)社会条件からの洪水被害特性

牧畜業及び養殖業が盛んであり、洪水によって被害を受ける恐れがある。

Lumi 川の洪水特性分析には上流域の降雨量等の気象・水文データ及び、地質、土地利用データ等が必要である。しかし、Lumi 川中上流域の大部分がタンザニア領内であり、現在のところ、ケニアとタンザニア両国間でのデータ共有体制は未整備である。

表 3.2.2 Lumi 川中上流域の社会経済条件と脆弱性・曝災性

社会経済条件	脆弱性・曝災性
人口は約 1 万人で、人口密度は 50~150 人/km^2	人口密度は低いので、曝災性は小さい
牧畜業が盛ん	家畜の生命保護、飼育が困難になる
養魚業が盛ん（Chala 湖）	生計への被害
タンザニアに至る幹線道路がある コミュニティ道路は未舗装	道路構造や橋が脆弱
Lumi 川は上流域及び Chala 湖、Jipe がタンザニアとの国境をまたぐ国際河川である	タンザニア領内の水文・気象等のデータ収集が困難

図 3.2.3　Lumi 川中上流域での洪水特性

(3) 洪水被害のメカニズム

中上流域では、激しい降雨と流速の速い表面流により、農地の表土が浸食されることで土壌・土砂流出が生じている。しかし、この地域は、農業以外にも牧畜も盛んであるため土壌・土砂流出による影響度はそれほど大きくない。

3.2.3　LUMI 本川からの溢水や破堤による浸水（タイプ B）

Lumi 下流本川の低平地での洪水特性を自然条件と社会条件から分析すると以下のとおりである。

(1) 自然条件からの洪水特性

・Lumi 下流本川低平地では、Lumi 本川の流下能力不足に伴う Lumi 本川の溢水や破堤により低平地が浸水する

・Lumi 本川の流下能力不足の原因は、川幅が狭く、上流からの土砂供給により川床が上昇し天井川となっているため、河道面積が不足していることに加えて、地形勾配が 1/1000 から 1/500 となだらかになっているため、流速が小さいことに起因する（下記の Lumi 川河口付近の写真を参照）

・氾濫域における排水路（Canal A, B, C)の土砂堆積による排水能力の不足及び堤防の決壊等により既存施設の本来の機能を十分果たせていない。

・低平地の地形勾配は 1/1000 から 1/500 であるため、氾濫が長期にわたるという状況が発生している。

・加えて、Jipe 湖の水位上昇により氾濫水の行き場がなくなっている

写真 3.2.1　Lumi 川河口付近（川幅が狭く、天井川となっている）

前章で整理した Lumi 川流域の自然条件とそれに伴う当該地域におけるハザードを以下に示す。

表 3.2.3 Lumi 川下流域の自然条件とハザード

自然条件	ハザード
河川勾配が小さいフラットな地形	Lumi 川の流下が妨げられる 氾濫水が引きにくい
河床の土砂堆積が大きい 川幅が狭い	天井川となり、溢水の恐れあり 流下能力が小さい

(2) 社会条件からの洪水被害特性

・居住地が集中している地区の長期湛水のため、住民の居住不能状態、農地の浸水被害、飲料用の泉の汚染、インフラ被害（道路の寸断と通学不能、病院の水没）および家畜の死亡という被害が発生している。

・灌漑用水の取得を目的とした農民の故意による堤防の破壊によって、堤防の一部区間が機能していない。

・Kimorigho location では、洪水により 6,000 人が避難し、2,000 世帯の家屋が浸水している[5]。

・洪水時に 2 ヶ月以上の長期に渡る避難生活を余儀なくされる。

自然条件の場合と同様に、社会経済条件とそれに伴う当該地域における災害への脆弱性と曝災性を以下に示す。

表 3.2.4 Lumi 川下流域の社会経済条件と脆弱性･曝災性

社会経済条件	脆弱性・曝災性
居住区が集中している （人口密度高い 600 人／km^2） 下流域の総人口は約 17,000 人	・被災人口が多く、Kimorigho location では 6,000 人が避難、2,000 世帯が浸水している。 ・2 ヶ月以上の長期に渡る避難生活を余儀なくされる
農業、牧畜業がさかん	農業生産の停止、家畜の生命保護、飼育が困難になる。生計の悪化。
灌漑用水の取得を目的した農民による堤防の破壊	洪水時の周辺地域への影響が悪化
生活道路が未舗装	浸水により道路が寸断される
Jipe 湖周辺に観光施設が立地	浸水や道路の寸断に伴うサービス提供の停止

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図 3.2.4 Lumi 川下流本川の低平地での洪水特性

(3) 洪水被害のメカニズム

天井川となっている Lumi 川下流の本川から溢水・破堤することにより、洪水が低平地に拡散し、地形的に平坦であるため、排水されにくいことによって湛水が長期化している。湛水することにより土壁の家屋の損壊や、農作物の損失、生活用水用の泉の汚染、未舗装道路の軟弱化、病院等の社会インフラの水没、家畜・家禽類の死亡、さらには、地域全体が水没して家屋も居住不能となることにより長期的避難をせざるを得ないといった被害が生じている。

3.2.4 LUMI 下流支川エリアのフラッシュフラッド（タイプ C）

Lumi 下流支川エリアでの洪水特性を自然条件と社会条件から分析すると以下のとおりである。

(1) 自然条件からの洪水特性

Lumi 下流支川エリアでは、Tsavo West 公園を含む Lumi 川の周囲の丘陵部での短時間集中豪雨によってフラッシュフラッドが発生する。

前章で整理した Lumi 川流域の自然条件とそれに伴う当該地域におけるハザードを以下に示す。

表 3.2.5 Lumi 川下流支川の自然条件とハザード

自然条件	ハザード
丘陵部での短時間集中豪雨	洪水到達時間が早い ピーク流量が大きい 侵食の発生

(2) 社会条件からの洪水被害特性

村落が位置する平坦部をフラッシュフラッドが直撃することによって、道路や橋梁などのインフラの破壊や家屋、家財や家畜が流されるなどの被害が発生している。また、灌漑水路がフラッシュフラッドにより寸断される被害も発生している。

自然条件の場合と同様に、社会経済条件とそれに伴う当該地域における災害への脆弱性と曝災性を以下に示す。

表 3.2.6 Lumi 川下流支川エリアの社会経済条件と脆弱性・曝災性

社会経済条件	脆弱性・曝災性
平坦部に集落が立地 支川エリアの総人口は約 18,000 人	・丘陵部からのフラッシュフラッドが平坦部の集落に襲来 ・フラッシュフラッドによる総被災者数は約 7,000 人（ 地域別では Rekeke 200 人、Kimala 950 人、Mata-Jipe 3,000 人等。） ・長期的浸水はしない
灌漑農業が盛んである	灌漑水路の破壊により生計が困難となる
Taveta –Mwatate 間の幹線道路が物流に重要な役割を果たしている	浸水に伴う物流の停止、停滞
Jipe 湖の周辺に観光施設が立地している	浸水に伴うサービス提供の停止
診療所の前にガリーがある	洪水時に救護支援ができない
道路が未舗装である	土壌侵食及び降雨による影響をうけやすい

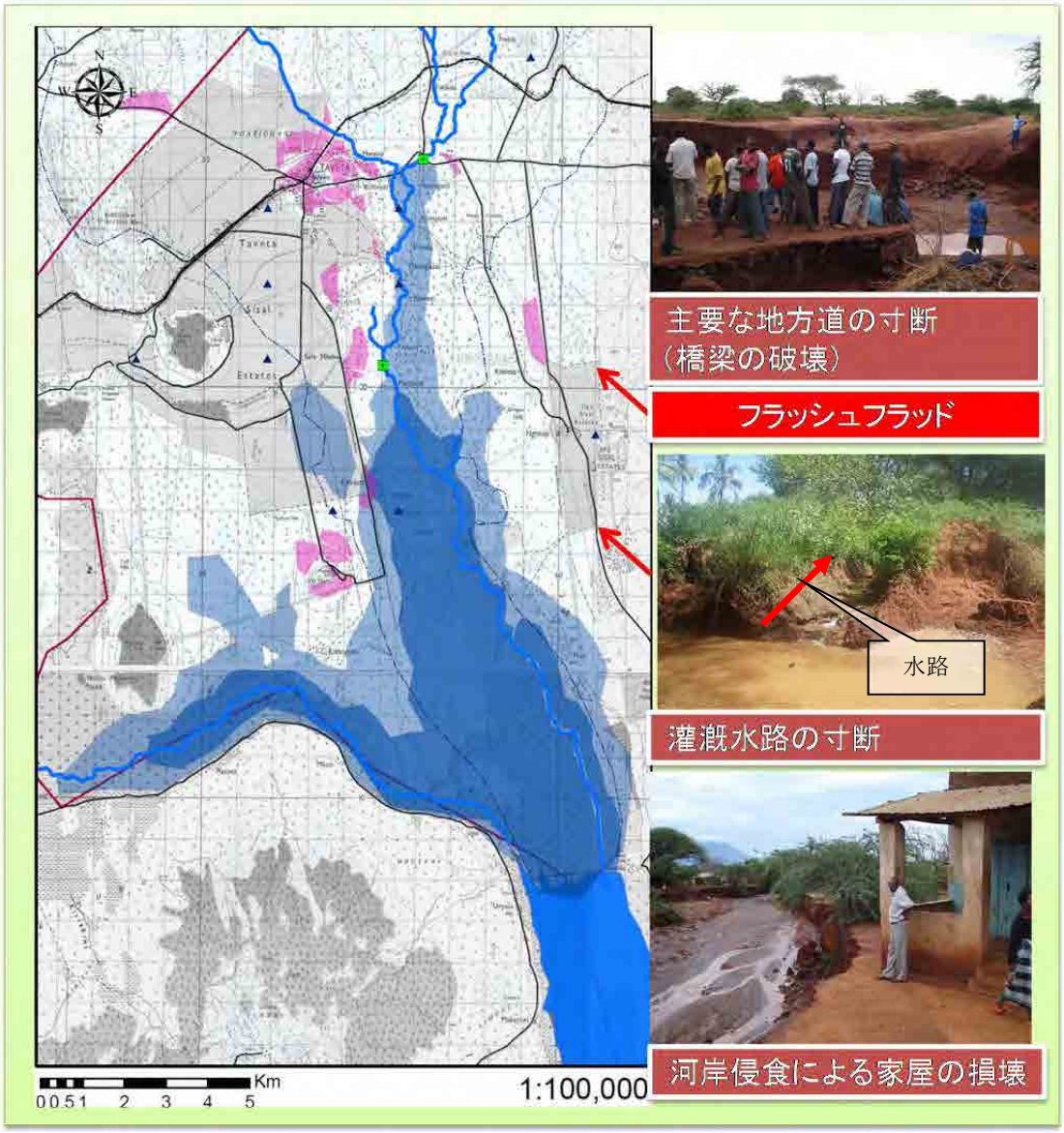


図 3.2.5 Lumi 川下流支川での洪水特性

(3) 洪水被害のメカニズム

下流域上中流域や支川部のフラッシュフラッドは、季節河川の小さい河道において、上流に集中豪雨が降って下流にピーク流量が大きい洪水が短時間で流出してくることにより発生する。流下する過程で、小さい河道を河岸浸食しながら流下してくるものと推察され、場合によっては、現在の河道から溢れて、新たな流路を形成して流下するため、川を横断する方向で走っている道路が損傷したり、橋が損傷したり、家屋や農地に被害を与えている。

3.3 洪水被害分析及び対策の検討

3.3.1 LUMI 川中上流域の土壌流出・土砂流出の洪水被害分析及び対策の検討

(1) 被害と対策の整理

これまでの現地調査をもとに、Lumi 川上流域での被害に関してロジックツリーによる分析を行った。

Lumi 川の中流から上流にかけては農業に関する被害が発生している。土石流や土壌浸食による農地被害が主なものである。

これらの解決策を導き出すため、オブジェクティブ・ツリー分析を行った。結果を次の図に示す。なお、左に解決すべき問題を置き、そこから対処方法を具体化している。

Lumi 川の中流から上流にかけては、降雨時にフラッシュフラッドが多く発生する。それにより、土石流が発生して多くの被害が発生する。土石流の流出防止には砂防ダムという対策が考えられる。また、一方で、土壌浸食被害も深刻となっている。土壌浸食による土砂流出は灌漑用のため池が土砂の堆積によって埋まってしまい、その本来の機能を喪失してしまうという問題も引き起こしている。これには樹木の伐採規制や植林活動等の植生の保護による土壌の強化が有効である。

側面からのフラッシュフラッドによって破壊された用水路

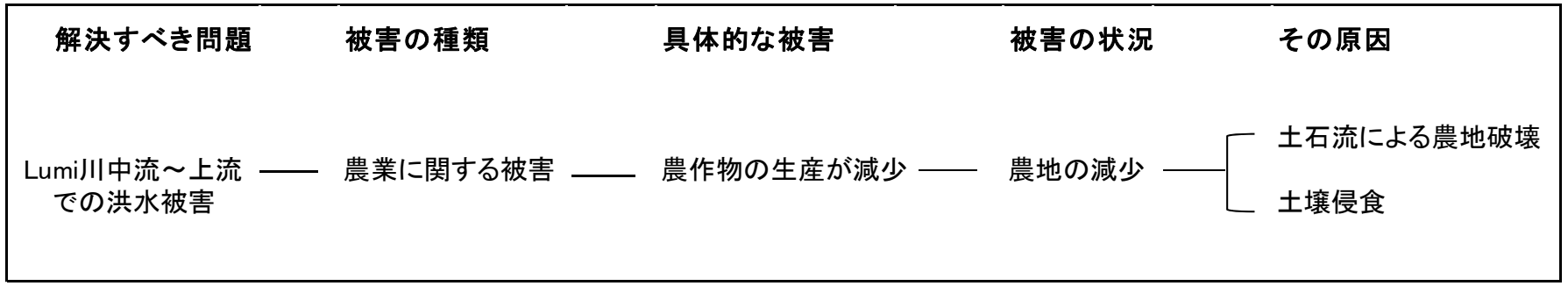


図 3.3.1　プロブレム・ツリー分析

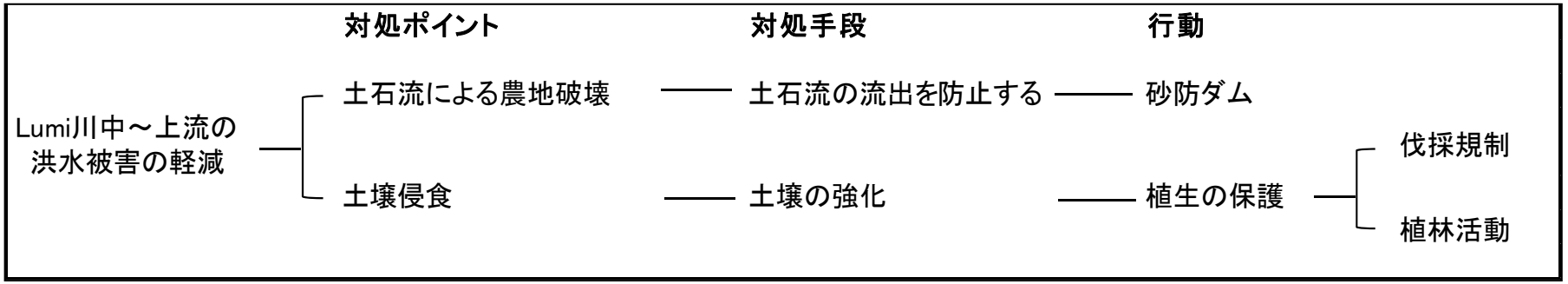


図 3.3.2　オブジェクティブ・ツリー分析

この地域で考えられる対策方法を以下に整理する。

表 3.3.1　LUMI 川中上流域の土壌流出・土砂流出エリアで考えられる対策方法

考えられる対策方法	対策の内容
砂防ダム	土砂流出の抑制
伐採規制	過剰伐採の抑制
植林活動	傾斜地における苗木の栽培及び植林

3.3.2　LUMI 本川からの溢水や破堤による浸水の洪水被害分析及び対策の検討

(1)被害と対策の整理

これまでの現地調査をもとに、Lumi 川下流の長期浸水による被害が発生するエリアに関してロジックツリーによる分析を行った。

この地域では、長期にわたる浸水による農地への被害や家畜の喪失が起こっている。また、家屋やインフラへの被害も大きく、家屋の水没や道路の冠水もあり、住民の生活や、生計にも影響を与えている。

浸水時の様子

これらの解決策を導き出すため、オブジェクティブ・ツリー分析を行った。結果を次の図に示す。なお、左に解決すべき問題を置き、そこから対処方法を具体化している。

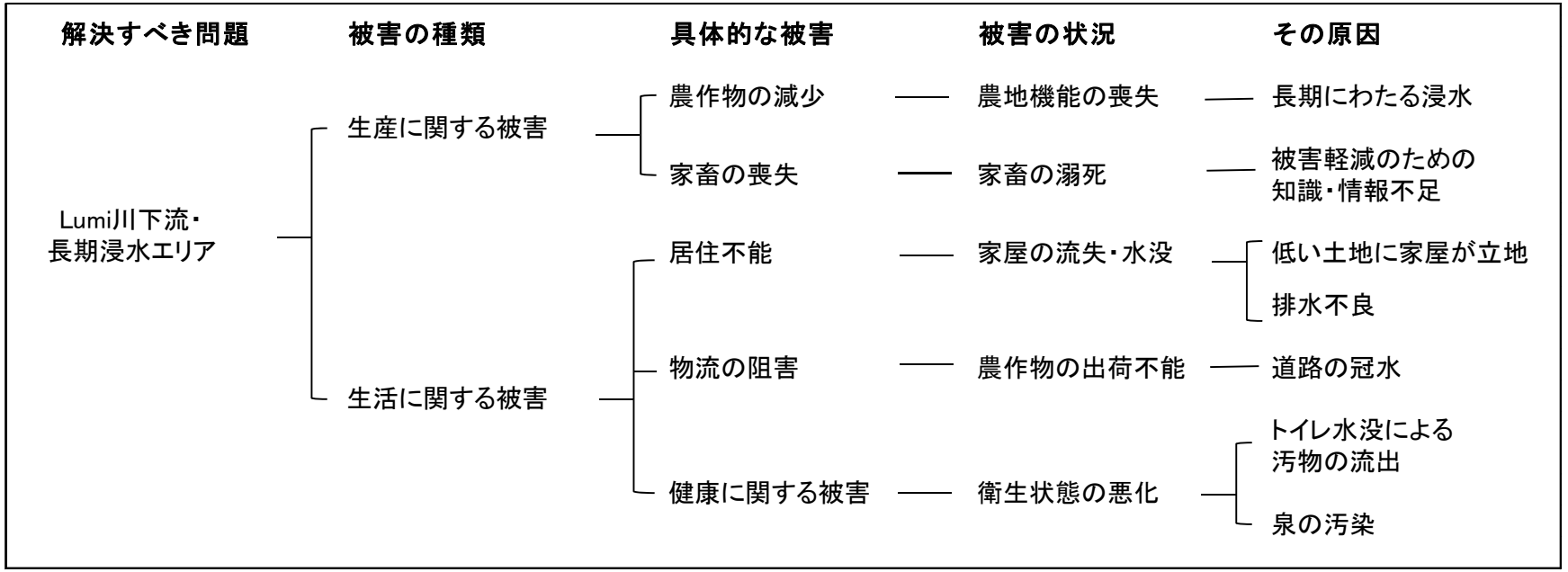


図 3.3.3　プロブレム・ツリー分析

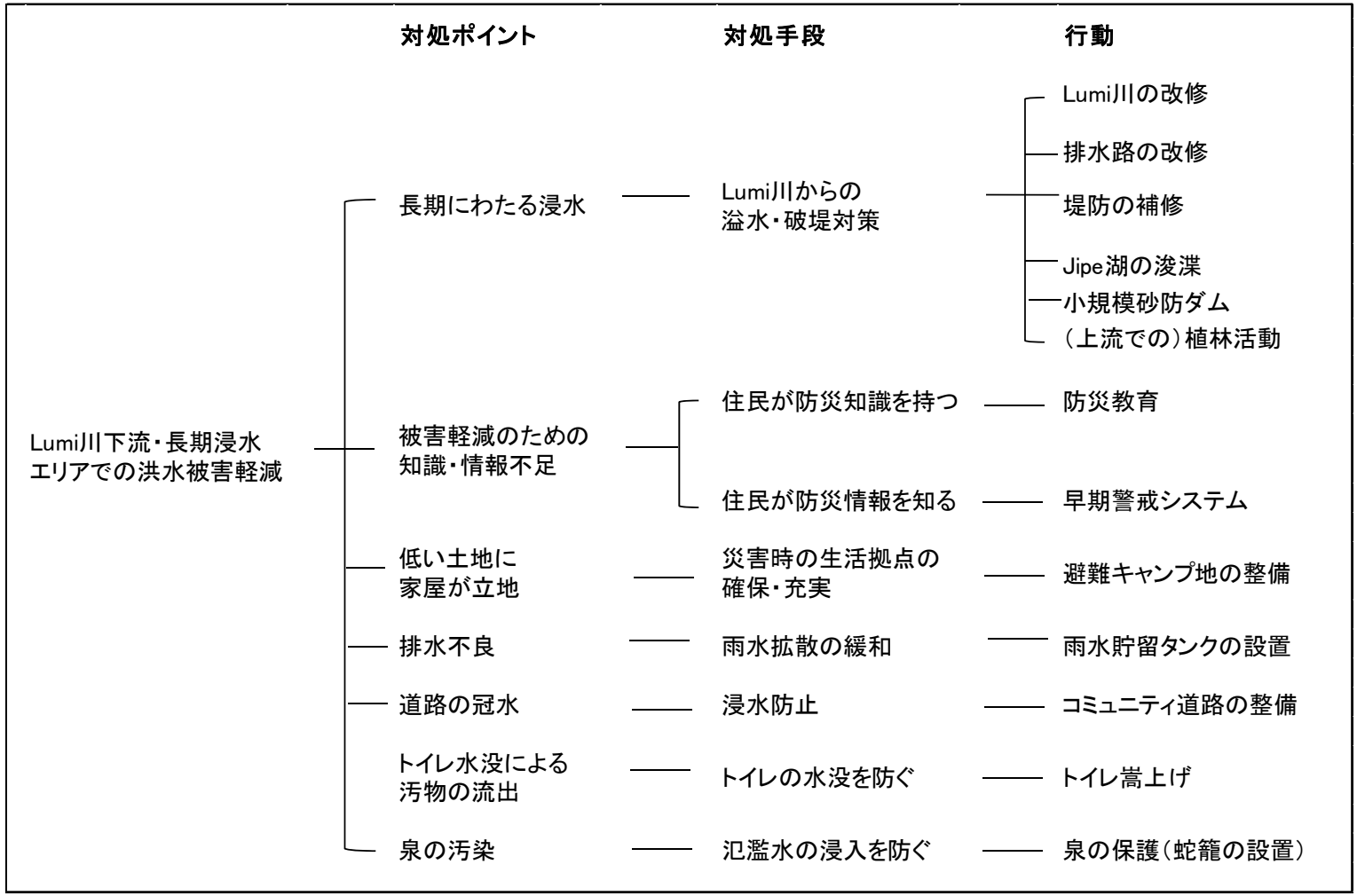


図 3.3.4　オブジェクティブ・ツリー分析

この地域の浸水は、道路や橋などの交通に関するインフラのほか、泉に氾濫水が混入することによる飲料水の汚染や家屋への影響など住民生活の様々なところに悪影響を及ぼす。
例えば浸水による道路の寸断は、通学や農作物の出荷を不可能にするほか、病院へのアクセスを不能にし、住民が医療サービスを受けられないという問題も引き起こす。
それに加えて、住民には被害軽減のための知識や情報がほとんどないことが、避けられるであろう被害の対策知らずに家畜を溺死させてしまうなど、被害を大きくしている。
これには住民自身が防災知識・情報を知り、対策を行っていくことが有効な手段であると考えられる。
対策としては学校での防災教育や早期警戒システムの導入等が考えられる。更に、Lumi 川からの浸水をくいとめるため、Lumi 川の拡幅や浚渫等の改修、低平地に作られた既存の排水路の改修、水深が浅くなり、貯留効果を回復させるための能力が低下している Jipe 湖の浚渫という対策がある。

道路橋が流失した様子
場所：Rengesa

家屋が浸水した後、土盛りした様子
場所：Rengesa

既存の排水路は主要なものとして、Canal A、Canal B、Canal C の 3 本がある。これら Canal A、Canal B、Canal C それぞれを浚渫し、改修を行ってその流下能力を高めることで、被害は大きく軽減されるものと考えられる。特に Canal C は現在は破堤しているが堤防部分があり、それを再構築するのも一つの方法である。

Canal-C の堤防が決壊した箇所の周辺の湿地

また、Lumi 川下流・長期浸水エリアでは、浸水が長引き、居住不能状態が続いたり、家が流されたりし、避難を余儀なくされる住民が多数存在する。これには、被災時の生活拠点を確保が重要であり、避難所の設置という対策が考えられる。この地域では既に避難キャンプ地として

避難キャンプ地
場所：Kimorigo

利用されている場所があるが、設備的には十分とは言えない部分もあるため、現在あるこの避難キャンプ地の整備が適当であると考えられる。この地域で考えられる対策方法を以下に整理する。

表 3.3.2　Lumi 川下流・長期浸水エリアで考えられる対策方法

考えられる対策方法	対策の内容
Lumi 川の改修	Lumi 川下流における溢水頻発地点で実施
排水路の改修	既存の Canal A/B/C の浚渫
堤防の補修	Canal C 始点の破堤部の補修
Jipe 湖の浚渫	Lumi 川が Jipe 湖に流入する部分に堆積した土砂を取り除き、流下能力を回復させる
小規模砂防ダム	沈殿化及び河床上昇の抑制
上流での植林活動	樹木及び植林を推進する活動
防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する
早期警戒システム	Lumi 川流域にて、上流で雨量など洪水に関係する情報を収集・分析し、下流の地域へ伝達する
避難キャンプ地の整備	Lumi 川下流に既にキャンプ地がある。その施設の拡充
雨水貯留タンク	雨どい、雨水貯留タンクの設置
コミュニティ道路の整備	Lumi 下流の長期浸水エリアでのコミュニティでの道路嵩上げ
トイレの嵩上げ	嵩上げの実施及び指導
泉の保護（蛇籠の設置）	泉の周辺に蛇籠を設置

3.3.3　LUMI 川下流支川エリアの洪水被害分析及び対策の検討

(1)被害と対策の整理

この地域に関しても、これまでの調査結果をもとにロジックツリー分析を行った。その結果を下図に示す。

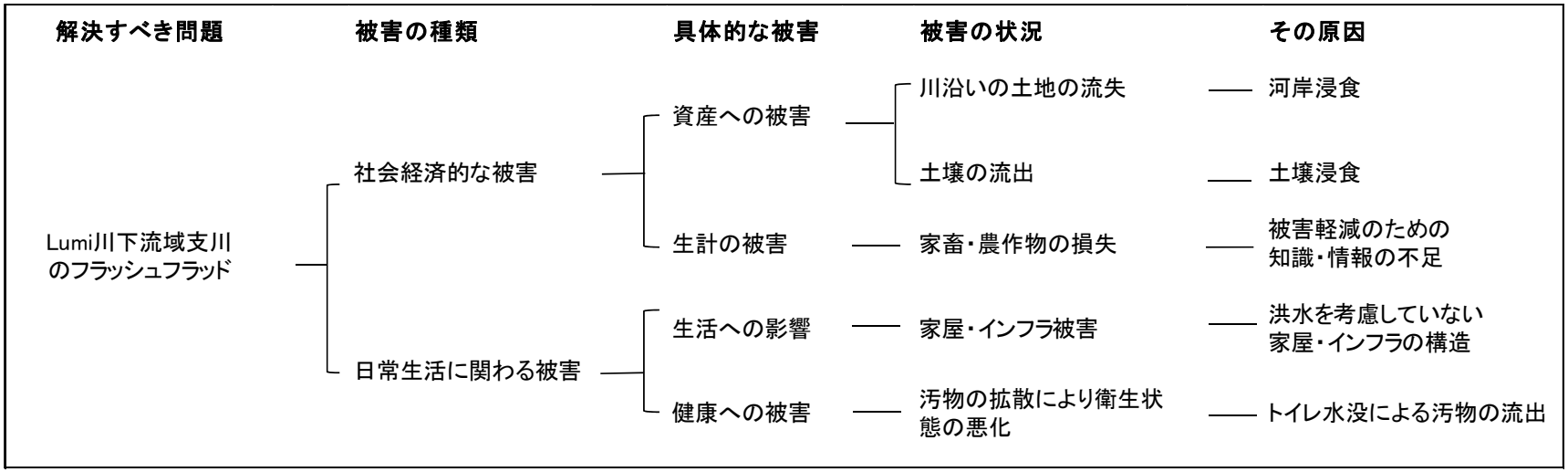


図 3.3.5　プロブレム・ツリー分析

Lumi 川下流域支川では、川沿いの土地の流失、土壌の流出、家畜・農産物の損失、家屋・インフラの損害、汚物拡散による衛生状態の悪化などの被害が生じている。それらの主な原因は、それぞれ、河岸浸食、土壌浸食、洪水被害軽減のための知識や情報の不足、洪水を考慮していない家屋やインフラの構造、トイレの水没等が考えられる。

季節河川によって河岸が浸食され
土地が流失

場所: Rekeke

Lumi 川下流域の支川や Jipe 湖へ直接流入する小河川では、フラッシュフラッドによって河岸が浸食され、農地や家屋用地が流失するといった被害が生じている。これは、普段は水のない枯れ川（季節河川）は河道の大きさが小さいにもかかわらず、上流で降雨が発生すると、一気に増水し、河岸を浸食しながら流下することが原因であると考えられる。また、かつては樹林に覆われていたが、薪炭材として樹木が伐採され、今では樹木はまばらに生えているだけとなっている。そのため、激しい雨が降ると、表土に降雨が直接当たり、土壌が流出してしまうことも問題とされている。

洪水によって表土が流出した農地

場所：Kimala Irrigation Scheme

生計に関する被害も大きく、洪水流がニワトリ小屋などの家畜小屋を直撃したり、水没させたりし、家畜が溺死するなどの損失が生じている。また、農作物も水没・流失による損害を受けている。この地域では、家屋やインフラ、特に道路や橋梁などの交通インフラの洪水による破損が顕著である。これは、家屋やインフラの計画・設計・施工・維持・管理の面で、洪水を考慮されていないことや、適切な材料や手法を知らないことが大きな原因と考えられる。

衛生面に関しては、トイレに関する被害が多く聞かれる。この地域のトイレは地面に穴を掘って、上に簡便な壁と屋根を付けただけの形式が主流である。こうしたトイレは、洪水時に水没し、中の汚物が流出することにより、衛生状態を悪化させ、コレラなどの各種水因性の疾患の原因となっている。

堆積土砂で埋まり、放置されたトイレ

場所: Rekeke

それらの解決策を分析するために左から解決すべき問題と対処方法を具体化する分析を行った。

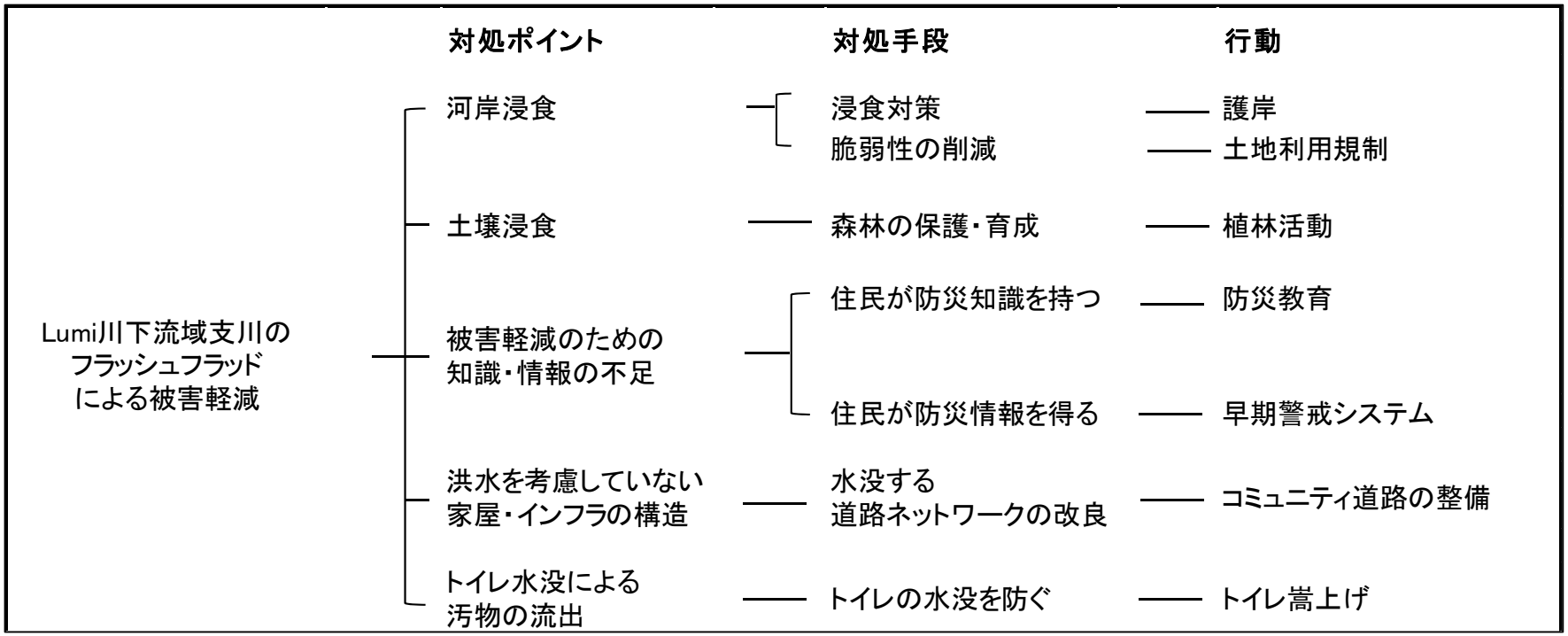


図 3.3.6　オブジェクティブ・ツリー分析

川沿いの土地の流失に関する対策としては、対処療法的には河岸浸食対策として護岸を設置することが考えられるが、洪水時の最大流量の推定は困難であることや、こうした枯れ川は、この近辺に数多くあることから、実際にこのような対策を講じることは、枯れ川の近隣に極めて重要な施設が隣接している場合に限定されると考えられる。

土壌の流出に関しては、一つの方法として森林・樹林の保護・育成としての植林が考えられる。実際、ケニア赤十字のボランティアグループによって、Lumi 川下流域では植林の取り組みが実施されているため、導入は難しくないと考えられる。植林は、効果の発現には時間がかかるが、環境への負荷が極めて小さいか、ほとんどないということや、コミュニティレベルでの取り組みも可能であるといった利点もあるため、可能な限り推進していくことが望ましい。

KRCS ボランティアグループによる植林
（苗木育成の様子）
場所：Rekeke

家畜・農作物の損失に関しては、住民レベルでの被害軽減の対策を行うための知識や情報が不足していることが挙げられる。例えば、ニワトリ小屋は、毎年洪水で水没するにもかかわらず、地面に直接建てており、洪水によって浸水すると、ニワトリは簡単に溺死してしまう。東南アジアの洪水常襲地帯のように、ニワトリ小屋の土台を嵩上げし、水没しないような工夫をすることにより、そうした被害を削減できる可能性がある。住民がそのような知識を持つことは被害軽減のために大変重要であり、それによって被害を最小化することは、洪水被害後の生活の再建にも大きく寄与すると考えられる。

ニワトリ小屋

道路を横断する枯れ川に設置された
パイプカルバート付きの橋梁

家屋・インフラの損害に関しては、洪水を考慮していない構造が問題であると考えられる。右の写真で示すコンクリート製の橋梁は、枯れ川を横断しており、パイプカルバートにより水を流下させるような構造となっているが、パイプの大きさや数は、洪水時の流量に対して小さすぎるものと考えられる。ケニアでは、洪水時の流量を推定する手法が確立されていないため、特に道路に付帯する橋梁の開口部は、洪水流を安全に流下させるだけの断面を確保していないことが多い。こうした被害に対する対策は、この地域における洪水

流量の算定手法を確立し、道路の設置者に対して、その手法を採用するように呼びかけることである。また、道路の路面の高さも、洪水による浸水位よりも低く設定されていることが多いため、適切な大きさと配置のカルバートの設置とともに、道路路面を高く嵩上げすることが必要と考えられる。

上記と同じ構造のコンクリートの橋梁がフラッシュフラッドにより流失
場所：Rengesa

トイレの溢れによる衛生状態の悪化に関しては、Nyando 川流域で実施されたような、トイレを嵩上げするようなことが推奨される。この地域の一部のトイレでは、既に実施されており、そうした事例を紹介して、住民の意識を啓発していくことも必要である。

以上のことを踏まえ、考えられる対策方法を以下に整理する。

表 3.3.3 Lumi 川下流域支川のフラッシュフラッド発生エリアで考えられる対策方法

考えられる対策方法	対策の内容
護岸	Rekeke 近傍ガリーの適所での実施
土地利用規制	河岸周辺等の土地利用の規制
植林活動	樹木及び植林を推進する活動
防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する
早期警戒システム	WRUA/WRMA で実施可能と考えられる簡易な計測器・伝達方法を使用したシステムを想定する
コミュニティ道路の整備	Lumi 下流の土壌浸食・河岸浸食エリアでのコミュニティでの道路嵩上げ
トイレ嵩上げ	嵩上げの実施及び指導

3.3.4 洪水対策の候補（ロングリスト）

洪水対策案の候補を以下に示す。

表 3.3.4 洪水対策候補全体の一覧

通し番号	考えられる対策方法	対策の内容	対象
1	Lumi 川の改修	Lumi 川下流における溢水頻発地点で実施	下流・長期浸水エリア
2	排水路の改修	既存の Canal A/B/C の浚渫	下流・長期浸水エリア
3	堤防の補修	Canal C 始点の破堤部の補修	下流・長期浸水エリア
4	Jipe 湖の浚渫	Lumi 川が Jipe 湖に流入する部分に堆積した土砂を取り除き、流下能力を回復させる	下流・長期浸水エリア
5	小規模砂防ダム	沈殿化及び河床上昇の抑制	下流・長期浸水エリア
6	上流での植林活動	樹木及び植林を推進する活動	下流・長期浸水エリア
7	防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する	下流・長期浸水エリア
8	早期警戒システム	Lumi 川流域にて、上流で雨量など洪水に関係する情報を収集・分析し、下流の地域へ伝達する	下流・長期浸水エリア
9	避難キャンプ地の整備	Lumi 川下流に既にキャンプ地がある。その施設の拡充	下流・長期浸水エリア
10	雨水貯留タンク	雨どい、雨水貯留タンクの設置	下流・長期浸水エリア
11	コミュニティ道路の整備	Lumi 下流の長期浸水エリアでのコミュニティでの道路嵩上げ	下流・長期浸水エリア
12	トイレの嵩上げ	嵩上げの実施及び指導	下流・長期浸水エリア
13	泉の保護（蛇籠の設置）	泉の周辺に蛇籠を設置	下流・長期浸水エリア
14	護岸	Rekeke 近傍ガリーの適所での実施	支川のフラッシュフラッド発生エリア
15	土地利用規制	河岸周辺等の土地利用の規制	支川のフラッシュフラッド発生エリア
16	植林活動	樹木及び植林を推進する活動	支川のフラッシュフラッド発生エリア
17	防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する	支川のフラッシュフラッド発生エリア
18	早期警戒システム	WRUA/WRMA で実施可能と考えられる簡易な計測器・伝達方法を使用したシステムを想定する	支川のフラッシュフラッド発生エリア
19	コミュニティ道路の整備	Lumi 下流の土壌浸食・河岸浸食エリアでのコミュニティでの道路嵩上げ	支川のフラッシュフラッド発生エリア
20	トイレ嵩上げ	嵩上げの実施及び指導	支川のフラッシュフラッド発生エリア
21	砂防ダム	土砂流出の抑制	上流域
22	伐採規制	過剰伐採の抑制	上流域
23	植林活動	傾斜地における苗木の栽培及び植林	上流域

3.4 優先的に対処すべき洪水被害の選定

3.4.1 コミュニティによる洪水被害分析ワークショップの結果

Lumi 川流域においては、2012 年 11 月 2 日及び 3 日に Lower Lumi サブ流域の問題分析を行うために WRUA メンバー、WRMA-SRO 職員及び JICA プロジェクトチームメンバーによってワークショップを開催した。

その結果、洪水の原因としては次のとおりの整理がなされた。

表 3.4.1 WRUA メンバーからの聞取りによる洪水の原因

テーマ	原　因	洪水による主な影響
洪水（上流）	キリマンジャロ山腹への降雨	フラッシュフラッド
	山腹からの土砂流出	
洪水（下流）	Lumi 川に入らない東側の枯川の増水	支川のフラッシュフラッド
	上流の土砂流出→天井川	長期湛水洪水
	河岸浸食→新たな河道の形成	河道の移動

また、被害については、次の通りの整理がなされ、WRUA メンバーによる優先順位の意見も示された。

表 3.4.2 WRUA メンバーによる被害認識と優先順位

WRUA メンバーによる優先順位付け	大項目	一次的被害	2 次的被害
①	土壌侵食（中流）	・下流への土砂排出	・河床の上昇（Lumi 川、Jipe 湖）
	土地侵食（下流）	・農地破壊 ・土地の損失	
②	浸水被害	・家屋浸水/破壊 ・農地被害	・住民の避難 ・教育活動の停止 ・収入減 ・食糧不足
③	水源汚染	・泉の汚染	・水不足 ・干ばつ
④	インフラ破壊	・道路寸断（Eldoro-Taveta 間/Taveta-Kitobo 間/Taveta-Jipe 間） ・学校	・物資が届かない ・人の移動ができない
⑤	生命	・家畜の死亡 ・人の死亡（稀）	

3.4.2 優先すべき洪水被害の選定

Lumi 川流域の洪水被害は、A)中上流域の土砂流出、B)下流域の本川からの溢水・破堤による氾濫と長期湛水、C)支川のフラッシュフラッドの 3 つに分類される。前節のコ

ミュニティにおける洪水被害の評価を踏まえ、それぞれの洪水被害の実情を社会的影響（被災者数、被災家屋数）と経済的影響（商業、農業、交通、観光への影響）に分けて評価するとの視点で整理しなおすと、下表のとおりであるとなった。

表 3.4.3 優先すべき洪水被害の選定

洪水のタイプ	社会的影響		経済的影響				優先度
	被災者数	被災家屋数	商業活動への影響	農業への影響	交通への影響	観光への影響	
A) 中上流域の土砂流出	小	小	小	**大**	中	中	低い
B) 下流域の本川からの溢水・破堤による氾濫・長期湛水	**大**	**大**	小	**大**	**大**	大	高い
C) 支川のフラッシュフラッド	中	中	中	中	**大**	**大**	やや高い

3 つの洪水被害のタイプのうち(B)下流域の本川からの溢水・破堤による氾濫・長期湛水という洪水被害が、社会的にも経済的に影響が大きく、優先度が高いと判断される。次いで優先度が高いのは、支川のフラッシュフラッドである。中上流域の土砂流出は、農業への影響があるもののそれ以外の社会・経済的影響は小さいため優先度は低いと言わざるを得ない。しかしながら、中上流域の土砂流出は、Lumi 川本川下流の河床上昇の原因になっている。中上流域の土壌浸食・土砂流出を抑制する対策は、効果の発現にも時間がかかるため、長期的な視点で取り組むべき課題であろう。

下流域の本川からの溢水・破堤による氾濫と長期湛水対策を最優先事項、支川のフラッシュフラッドを第二優先事項に位置づける。

選定されたロングリストを以下に示す。

表 3.4.4 優先すべき洪水対策の選定

通し番号	考えられる対策方法	対策の内容	対象
1	Lumi 川の改修	Lumi 川下流における溢水頻発地点で実施	下流・長期浸水エリア
2	排水路の改修	既存の Canal A/B/C の浚渫	下流・長期浸水エリア
3	堤防の補修	Canal C 始点の破堤部の補修	下流・長期浸水エリア
4	Jipe 湖の浚渫	Lumi 川が Jipe 湖に流入する部分に堆積した土砂を取り除き、流下能力を回復させる	下流・長期浸水エリア
5	小規模砂防ダム	沈殿化及び河床上昇の抑制	下流・長期浸水エリア
6	上流での植林活動	樹木及び植林を推進する活動	下流・長期浸水エリア
7	防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する	下流・長期浸水エリア
8	早期警戒システム	Lumi 川流域にて、上流で雨量など洪水に関係する情報を収集・分析し、下流の地域へ伝達する	下流・長期浸水エリア
9	避難キャンプ地の整備	Lumi 川下流に既にキャンプ地がある。その施設の拡充	下流・長期浸水エリア
10	雨水貯留タンク	雨どい、雨水貯留タンクの設置	下流・長期浸水エリア
11	コミュニティ道路の整備	Lumi 下流の長期浸水エリアでのコミュニティでの道路嵩上げ	下流・長期浸水エリア
12	トイレの嵩上げ	嵩上げの実施及び指導	下流・長期浸水エリア
13	泉の保護（蛇籠の設置）	泉の周辺に蛇籠を設置	下流・長期浸水エリア
14	護岸	Rekeke 近傍ガリーの適所での実施	支川のフラッシュフラッド発生エリア
15	土地利用規制	河岸周辺等の土地利用の規制	支川のフラッシュフラッド発生エリア
16	植林活動	樹木及び植林を推進する活動	支川のフラッシュフラッド発生エリア
17	防災教育	住民に対し、現状の洪水被害を自ら軽減する方法を教育する	支川のフラッシュフラッド発生エリア
18	早期警戒システム	WRUA/WRMA で実施可能と考えられる簡易な計測器・伝達方法を使用したシステムを想定する	支川のフラッシュフラッド発生エリア
19	コミュニティ道路の整備	Lumi 下流の土壌浸食・河岸浸食エリアでのコミュニティでの道路嵩上げ	支川のフラッシュフラッド発生エリア
20	トイレ嵩上げ	嵩上げの実施及び指導	支川のフラッシュフラッド発生エリア

4. 洪水管理事業の評価

4.1 五項目評価

4.1.1 評価の視点

この章では、前章で列挙された洪水対策案の中から、優先的に対処すべきである下流域の本川からの溢水・破堤による氾濫・長期湛水に対する対策案と支川のフラッシュフラッドに対する対策案の評価を行う。多角的な視点から評価を行うことを目的に、妥当性・有効性・効率性・インパクト・持続性の五項目を使用することとした。なお、五項目は今回の選定にあたって定義づけを行い、次の表に示す基準にて A、B、C の 3 段階で評価を行った。

表 4.1.1 事業選定に関しての五項目の定義

1	妥当性 (Relevance)	ステークホルダーの要望、対象地域のニーズと合致しているか 経済的被害・人的被害が大きいかどうか
2	有効性 (Effectiveness)	被害軽減の度合い （受益者数、軽減する冠水期間・面積・被害者数）
3	効率性 (Efficiency)	費用対効果 （想定される事業費の定性的大きさと上記の被害軽減度合いから判断）
4	インパクト (Impact)	同流域内又は他地域の波及効果（他地域での普及） 二次的効果
5	持続性 (Sustainability)	維持管理及び事業の効果継続性

＊DAC 評価五項目を参考に、今回の検討に合うよう定義付けした。

4.2 評価マトリクス

表 4.2.1 Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（1）

No.		1		
対象		Lumi 川下流		
対策		Lumi 川の改修		
概要		河川の拡幅ならびに上昇した河床の浚渫により流下能力を高める対策		
イメージ				
評価項目				
五項目評価	妥当性	浸水被害が多数発生しており、WRUA、住民、関係者からの要望が高い。河道断面積が少ないことから流下能力が不足しており、必要性が高い。	A	3
	有効性	長期湛水の軽減に大きく貢献する。	A	3
	効率性	効果は大きいが、費用も大きいため、費用対効果は中規模	B	2
	インパクト	他地域への波及効果は少ない。それぞれの地域の洪水特性や地形、気候等に応じ、個別の設計・計画が必要である。	C	1
	持続性	事業後も継続的な維持管理が必要である。WSTF で獲得した基金で設置した場合、維持管理の費用は別途必要となる。	C	1
五項目評価・合計			10	
メリット		対策効果が大きい		
デメリット		計画・設計・工事のそれぞれのプロセスである程度の時間が必要である。継続的な維持管理が必要である。建設費用が高い。		
環境への負の影響		上下流の河床変動への影響 生物多様性		
EIA の必要性		必要		
住民負担の有無		土砂運搬等の労働		
事業実施者（メインアクター）		NWCPC 、County		
事業関係機関		<許認可> County/District <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助		

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

表 4.2.2　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（2）

No.		2		
対象		Lumi 下流西側にある Cacal A/B/C		
対策		排水路の改修		
概要		堆積した土砂を取り除き、流下能力の回復を図る。		
イメージ				
評価項目				
五項目評価	妥当性	浸水被害が多数発生しており、WRUA、住民、関係者からの要望が高い。Lumi 川からの溢水を受け止め、下流に速やかに排出できるポテンシャルを持ち、灌漑にも寄与する。	A	3
	有効性	長期湛水の軽減に大きく貢献する。	A	3
	効率性	工事期間・費用は大きいが、劇的な被害軽減が見込める。	A	3
	インパクト	他地域への波及効果は少ない。(それぞれの地域の洪水特性や地形、気候等に応じ、個別の設計・計画が必要である。)	C	1
	持続性	事業後も継続的な維持管理が必要である。WSTF で獲得した基金で設置した場合、維持管理の費用は別途必要となる。	C	1
五項目評価・合計			11	
メリット		対策による効果は極めて大きい		
デメリット		対象となる Canal ABC 全ての改修は、大規模な工事であり、改修完了までに多大なコスト及び時間を要する。 また、その後の維持管理にも費用がかかる。		
環境への負の影響		上下流の河床変動への影響 生物多様性		
EIA の必要性		必要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		NWCPC 、County		
事業関係機関		<許認可> County/District <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.3　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（3）

No.		3		
対象		Lumi 下流西側にある Canal C		
対策		堤防の補修		
概要		Canal C の破堤部を補修し、Lumi 川本川からの溢水が拡散しないようにする対策工		
イメージ				
評価項目				
五項目評価	妥当性	浸水被害が多数発生しており、WRUA、住民、関係者からの要望が高い。Lumi 川からの溢水を Canal C に導流するのに効果的かつ不可欠である。	A	3
	有効性	長期湛水の軽減に大きく貢献する。	A	3
	効率性	効果は大きいが、費用も大きいため、費用対効果は中規模	B	2
	インパクト	構造物自体の他地域への波及は難しいが、下記に記述する WRUA による維持管理体制は周辺 WRUA にも波及効果が期待できる。	B	2
	持続性	事業後も継続的な維持管理が必要であるが、同 Canal 周辺の WRUA は活動が活発で灌漑用水の維持管理を自主的に行っており、持続性が見込める。	B	2
五項目評価・合計			12	
メリット		対象となる Canal C の破堤部のみの改修は比較的容易で短期間で実施可能であり、即効性もある。		
デメリット		計画、設計、施工のそれぞれのプロセスである程度の時間・コストがかかる		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		NWCPC 、County		
事業関係機関		<許認可> County/District <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.4　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（4）

No.		4		
対象		Lumi 川下流・長期浸水エリア		
対策		Jipe 湖の浚渫		
概要		Lumi 川が Jipe 湖に流入する部分に堆積した土砂を取り除き、流下能力を回復させるための対策工		
イメージ				
評価項目				
五項目評価	妥当性	流域関係者は Jipe 湖での土砂堆積の問題点を強く認識しており、要望がある。前述の Canal A, B, C 補修効果をより一層高める効果が期待される。	A	3
	有効性	長期湛水の軽減に大きく貢献する。	A	3
	効率性	効果を生むには多大な費用が必要である	B	2
	インパクト	他地域への波及効果は少ない。それぞれの地域の洪水特性や地形、気候等に応じ、個別の計画が必要である。	C	1
	持続性	事業後も継続的な浚渫が不可欠である。WSTF で獲得した基金で実施した場合、2 度目以降の費用は別途必要となる。	C	1
五項目評価・合計			10	
メリット		湛水軽減への効果は大きい		
デメリット		工事規模が大きく、かなり大規模な工事でなければ効果が期待しにくい。 中長期的に対策していく必要がある。 維持管理の負担が大きく、常に浚渫を行わなければ効果は出ない。		
環境への負の影響		生物多様性への影響		
EIA の必要性		必要		
住民負担の有無		なし		
事業実施者（メインアクター）		County、NWCPC		
事業関係機関		<許認可> County/District <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助		

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

表 4.2.5　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（5）

No.		5		
対象		Lumi 川下流・長期浸水エリア		
対策		小規模砂防ダム		
概要		土砂流出及び河床上昇の抑制		
イメージ				
評価項目				
五項目評価	妥当性	WRUA は lumi 川下流域の土砂堆積抑制のための小規模砂防ダムの建設を強く要望している。	A	3
	有効性	局所的な土砂堆積の抑制の効果は期待できる	B	2
	効率性	大規模な建設ではないが､効果は地域によって限定的である。	B	2
	インパクト	他地域への波及効果は少ない。	C	1
	持続性	効果は時間的に減衰していく	C	1
五項目評価・合計			9	
メリット		土砂流出及び河床上昇の抑制		
デメリット		計画、設計、施工の各プロセスにおいてある程度の時間を要する。 効果の持続性が低い。		
環境への負の影響		生物多様性		
EIA の必要性		必要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		County、MWI、NWCPC		
事業関係機関		<許認可> County/District、MWI, WRMA <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.6　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（6）

No.		6		
対象		Lumi 川下流・長期浸水エリア		
対策		上流域の植林活動		
概要		植林により、山腹の斜面の雨水による浸食・崩壊を防止すると同時に流域の貯留効果を増大し、洪水量を低減させる。		
イメージ				
評価項目				
五項目評価	妥当性	下流域で植林を行っているグループもあり、連携による相乗効果がある。 流域で必要性が認識されている。また WRUA、住民からの要望の声も高い。	A	3
	有効性	適切な規模で実施されれば、一定の浸食抑制効果がある。	B	2
	効率性	費用は安いが、効果が現れるまでかなりの時間を要する。	B	2
	インパクト	導入が比較的容易であり、活動が他地域でも応用できるが、実施場所には制限がある。	B	2
	持続性	事業者の意識に根付けば活動自体の継続性も高いが、苗が成長するまでの維持管理が必要である。	B	2
五項目評価・合計			11	
メリット		地球温暖化対策にもなる。 低コストかつ着手しやすい。 波及効果が高い。		
デメリット		効果が現れるまで時間を要する。効果はおだやかである。		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない（植林活動及び苗木の栽培）		
事業実施者（メインアクター）		ユースグループ/住民		
事業関係機関		<許認可> Kenya Forest Service <技術支援>MWI, WRMA <他の支援者>KRCS		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助		

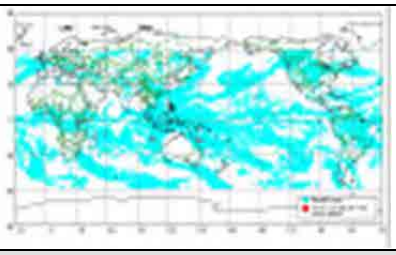
A(3 点): Excellent　/ B（2 点）: Good　/ C（1 点）: Poor

表 4.2.7　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（7）

No.		7		
対象		Lumi 川下流・長期浸水エリア		
対策		防災教育		
概要		防災に関する知識や情報を普及させ、防災意識を高めるための教育活動。意識啓発も含む。		
イメージ				
評価項目				
五項目評価	妥当性	WRMA からコミュニティ強化の要望が高く、住民も必要性を理解している。浸水にいかにうまく備えるかにより、被害を少なくし、回復を早くする効果が期待される。	A	3
	有効性	効果が一部の場所に限定されず、防災教育を受けた人間の数だけがそれぞれの場所で対策でき、その分の効果が出る。	B	2
	効率性	一度に大人数に知識を与えることができ、予算も少なくてすむ上、定着すれば効果は大きい。	A	3
	インパクト	受益者が家族に教える、友達に教えるなど方法さえわかれば効果の広がりがある。	A	3
	持続性	学校の先生、コミュニティリーダーなどのその土地の人間が講師になれば活動は持続していく。	A	3
五項目評価・合計			14	
メリット		短期間で準備可能であり、着手しやすい コミュニティへの防災意識及び能力の向上に直結 低コストかつ波及しやすい		
デメリット		住民行動に反映されるまでに時間を要する		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		関係資料の準備		
事業実施者（メインアクター）		学校、WRUA		
事業関係機関		<許認可> 教育省、County/District <技術支援>MWI, WRMA <他の支援者>KRCS、PTA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助・公助		

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

表 4.2.8　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（8）

No.		8		
対象		Lumi 川下流・長期浸水エリア		
対策		早期警戒システム（IFAS/GFAS）		
概要		衛星降雨情報を用いて洪水の発生の予見を補助するシステムの活用し、警戒情報の伝達を図る		
イメージ				
評価項目				
五項目評価	妥当性	IFAS/GFAS ケニアでは一般的でないが、防災情報の不足を訴える声は多く、期待は高い。浸水を事前に察知し備品を高いところへ置くなどの対策の普及効果が期待できる。	B	2
	有効性	警戒情報は広範囲に伝達することが可能である。警報があっても、洪水対策を知らなければ被害の軽減度合いは高くはないが、防災教育と同時に実施することで、その効果は高まる。	B	2
	効率性	低予算で大きな効果が得られることが期待される。	A	3
	インパクト	WRMA 内での体制が確立されれば、他流域への波及が期待されるが、IFAS/GFAS の機能上、効果が見込める地域が限定的である。	B	2
	持続性	一度システムが出来上がれば、維持管理も難しくないため、継続性はある。	A	3
五項目評価・合計			12	
メリット		IFAS 研修の受講者が WRMA HQ 内にいるため、短期間で準備可能であり、着手しやすい。 低コストである		
デメリット		効果が見込める地域が限定的である		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		なし		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>KMD/スペシャルプログラム省 <技術支援>MWI, WRMA <他の支援機関>KRCS		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

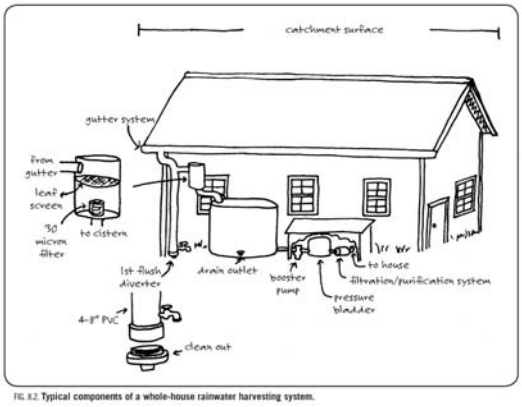
A(3 点): Excellent　/ B（2 点）: Good　/ C（1 点）: Poor

表 4.2.9　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（9）

No.		9		
対象		Lumi 川下流・長期浸水エリア		
対策		避難キャンプ地の整備		
概要		氾濫時に住民が一時退避し、当座の生活拠点となる施設の環境整備		
イメージ				
評価項目				
五項目評価	妥当性	浸水被害が多数発生しており、住民、関係者からの要望が高い。長期浸水に対して、遠くではなく近くに滞在でき、労働力等の喪失軽減が期待される。	A	3
	有効性	既に避難キャンプ地として活用されている場所があり、その施設の拡充は効果的である。	A	3
	効率性	多数の避難民に対応するのには大規模の事業となる。	B	2
	インパクト	それぞれの地域の洪水特性や地形、気候等に応じ、個別の設計・計画が必要である。	B	2
	持続性	事業後も継続的な維持管理が必要である。しかし、比較的小規模であるため維持管理はそれほど難しくはないものと考えられる。	B	2
五項目評価・合計				12
メリット		既に避難キャンプ地として利用されている場所の環境整備であるため、効果が見えやすい。		
デメリット		継続的な維持管理が必要 用地取得が必要		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>County/District、教育省 <技術支援>MWI, WRMA <他の支援機関>KRCS		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助		

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

表 4.2.10　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（10）

No.		10		
対象		Lumi 川下流・長期浸水エリア		
対策		雨水貯留タンク		
概要		雨水貯留システムの整備による流出抑制		
イメージ		 FIG. 8.2. Typical components of a whole-house rainwater harvesting system.		
評価項目				
五項目評価	妥当性	Town council は雨水活用できる設備を要望している。	C	1
	有効性	流出抑制効果を期待するには非常に多くの設置件数を必要とする	C	1
	効率性	1 基あたりのコストは比較的低コストであるが、流出抑制効果を得るためのコストは非常に大きい	B	2
	インパクト	コミュニティ、町内及び波及しやすい	B	2
	持続性	維持管理及び修繕を要する。	B	2
五項目評価・合計			8	
メリット		波及効果が高い オーナーシップが醸成しやすい 利水上の効果がある		
デメリット		維持管理、修繕に必要な材料が得られない可能性がある		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		Town Council/WRUA		
事業関係機関		<支援行政機関> Town Council <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助・自助		

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

表 4.2.11　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（11）

No.		11		
対象		Lumi 川下流・長期浸水エリア		
対策		コミュニティ道路の整備		
概要		道路の嵩上げやカルバートの設置などで道路が使用不能になることを防ぐ		
イメージ				
評価項目				
五項目評価	妥当性	この地域では洪水時に道路が浸水し、避難に困難が生じ、コミュニティ内での行き来や、子供たちの通学に影響するため、WRUA、住民の要望がある。嵩上げにより洪水時の移動の確保が期待される。	A	3
	有効性	避難経路が確保される	B	2
	効率性	広域での効果を得るためにはコストも大きい	B	2
	インパクト	小規模で簡易的な工事であれば、他地域への波及効果は難しくない。	B	2
	持続性	事業後も継続的な維持管理が必要であるが、比較的小規模であれば、維持管理は困難でない。	B	2
五項目評価・合計			11	
メリット		短期間で効果が出る		
デメリット		継続的な維持管理が必要。 計画・設計・工事のそれぞれのプロセスである程度の期間が必要である。		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>County/District、道路省、KeRRA <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.12　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（12）

No.		12		
対象		Lumi 川下流・長期浸水エリア		
対策		トイレ嵩上げ		
概要		トイレの高さを上げてトイレへの水の流入を防ぎ、汚物の流出を防止する。		
イメージ				
評価項目				
五項目評価	妥当性	浸水時に溢れた汚物による衛生状態の悪化、感染症の蔓延等の被害の報告があり、対策を求める声がある。嵩上げにより洪水時の衛生状態悪化の回避が期待される。	A	3
	有効性	トイレの汚物からの衛生悪化を防げれば、感染症が防げる	B	2
	効率性	嵩上げ自体は安価だが、地域中のトイレに対策を施さなければ、効果は出ないため、費用対効果は中程度。	B	2
	インパクト	比較的簡易的な工事であるため、他地域でも応用可能である。	A	3
	持続性	事業後も継続的な維持管理が必要である。しかし、小規模であるため維持管理はそれほど難しくはない。	B	2
五項目評価・合計			12	
メリット		短期間で準備可能 公衆衛生省と協働できれば、更なる効果を期待できる。 波及効果が高い		
デメリット		修繕補修等の継続的な維持管理が必要		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		WRUA、個人		
事業関係機関		<許認可>County/District、保健衛生省 <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助・自助		

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

表 4.2.13　Lumi 川下流・本川からの溢水・破堤による氾濫・長期湛水対策事業の評価検討（13）

No.		13		
対象		Lumi 川下流・長期浸水エリア		
対策		泉の保護（蛇籠の設置）		
概要		泉の周辺に蛇籠を設置し、川からの氾濫水や雨水の浸入を防ぐ		
イメージ				
評価項目				
五項目評価	妥当性	生活用水や飲料水に泉の水を利用しているため、対策を求める声があるが、一部の泉は既に他ドナーや WRUA 自身の WSTF への申請によって対策がなされている。	B	2
	有効性	泉の汚染を防ぐことができれば、周辺コミュニティの緊急時の生活用水が確保できる。	B	2
	効率性	大規模な工事ではないため費用は小さく、一定の効果を得ることができる。	B	2
	インパクト	小規模な蛇籠の設置であれば、他地域への波及は難しくないと考えられる。	A	3
	持続性	事業後も継続的な維持管理が必要である。しかし、比較的小規模であるため維持管理はそれほど難しくはない。	B	2
五項目評価・合計			11	
メリット		着手しやすく、高い効果が期待できる 泉の保護対策は Njoro Kubwa Springs で UNDP が、Kitobo 地区では WSTF 基金によって既に実施されている。		
デメリット		修繕補修等の維持管理が必要		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない。（石の確保・運搬、籠の組み立て等の設置作業）		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>County/District <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助		

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

表 4.2.14　支川のフラッシュフラッド対策事業の評価検討（14）

No.		14		
対象		Lumi 下流支川エリア		
対策		護岸		
概要		Lumi 川の川岸をかためる対策工。河岸の浸食を防ぐ		
イメージ				
評価項目				
五項目評価	妥当性	この地域での河川は季節河川であり、豪雨時における河岸浸食が深刻である。河岸浸食対策は手つかずの状態で被害は深刻であり、対策を求める WRUA や関係者の声は多い。	A	3
	有効性	Lumi 川周辺には多くの枯れ川があり、護岸一つの効果は限定的である。	C	1
	効率性	費用対効果は中規模である。	B	2
	インパクト	それぞれの地域の洪水特性や地形、気候等、に応じ、個別の設計・計画が必要である。	B	2
	持続性	事業後も継続的な維持管理が必要である。しかし、比較的小規模であるため維持管理はそれほど難しくはないものと考えられる。	B	2
五項目評価・合計			10	
メリット		短期間で効果を発揮、修繕しやすい		
デメリット		計画・設計・工事のそれぞれのプロセスである程度の時間が必要である。 既設の工法には改善が必要である。		
環境への負の影響		規模による		
EIA の必要性		規模による		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない（石の確保・運搬、籠の組み立て等の設置作業）		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>County/District、MWI, WRMA <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.15　支川のフラッシュフラッド対策事業の評価検討（15）

No.		15		
対象		Lumi 下流支川エリア		
対策		土地利用規制		
概要		川の近くでの建物を建設禁止及び土地の不法占拠禁止の法律・条例を制定		
イメージ		-		
評価項目				
五項目評価	妥当性	河岸近くに建設された家は不法であることが多く、そのために川の拡幅対策ができない等の問題がある。規制により、河川沿いの不法住居がなくなれば、洪水被害のリスク軽減の効果が高い	B	2
	有効性	施行までに長期間要する	B	2
	効率性	費用はほとんど発生しないが、直接的な減災効果は限定的である。	B	2
	インパクト	地域の広がりはあるが、波及効果はない	B	2
	持続性	規制制定後も継続的な取り締まり、監視が必要	B	2
五項目評価・合計			10	
メリット		不法占拠・占有等の規制取り締まりにより、被害リスクを軽減		
デメリット		住民移転が発生する可能性がある 規制と教育活動は同時に行う必要がある 政府レベルの対策であり、法律の制定までには時間がかかる		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		なし		
事業実施者（メインアクター）		Ministry of Lands/WRMA		
事業関係機関		<技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助		

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

表 4.2.16　支川のフラッシュフラッド対策事業の評価検討（16）

No.		16		
対象		Lumi 下流支川エリア		
対策		支川上流の植林活動		
概要		既に実施されている植林を促進し、土壌の固定を図る		
イメージ				
評価項目				
五項目評価	妥当性	土砂流出抑制にかかる WRUA の要望は高く、住民も必要性を認識しており､既にボランティアの手で実施されている。現状では零細事業にすぎず、支援による加速化が望まれている。	A	3
	有効性	適切な規模で実施されれば､一定の浸食抑制効果がある。	B	2
	効率性	費用・効果共に中規模	B	2
	インパクト	促進のための手法が他地域でも適用できる可能性がある	B	2
	持続性	事業者の意識に根付けば活動自体の継続性も高いが、苗が成長するまでの維持管理が必要である。	B	2
五項目評価・合計			11	
メリット		着手しやすく、波及効果が高い オーナーシップを醸成しやすい ボランティアにより既に実施されている活動であり、コミュニティの参画は困難でない。		
デメリット		効果が現れるまでに時間を要する。		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない（植林及び苗木の栽培）		
事業実施者（メインアクター）		ユースグループ/住民		
事業関係機関		<許認可> Kenya Forest Service <技術支援>MWI, WRMA <他の支援者>KRCS		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助		

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

表 4.2.17　支川のフラッシュフラッド対策事業の評価検討（17）

No.		17		
対象		Lumi 下流支川エリア		
対策		防災教育		
概要		洪水による生計被害の損失を減らすため、また生活向上ための教育訓練活動。意識啓発も含む。		
イメージ				
評価項目				
五項目評価	妥当性	WRMA からコミュニティ強化の要望が高い。浸水にいかにうまく備えるかにより、被害を少なくし、回復を早くする効果が期待される。また洪水による生計被害軽減のための教育のニーズが高い。	A	3
	有効性	住民も必要性を理解している。	B	2
	効率性	効果が一部の場所に限定されず、トレーニングを受けた人間の数だけがそれぞれで実施でき、その分の効果が出る	A	3
	インパクト	一度に大人数に知識を与えることができ、予算も少なくてすむ上、定着すれば効果は大きい。	A	3
	持続性	受益者が家族に教える、友達に教える、など方法さえわかれば効果の広がりがある。	A	3
五項目評価・合計			14	
メリット		短期間で準備可能。 コミュニティの Resilience 向上が持続的に図られる。 既に KRCS がこの事業を行っており、彼らと連携できる可能性が大きい。 低コストかつ波及効果が高い		
デメリット		なし		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		関連資料の準備		
事業実施者（メインアクター）		学校、WRUA		
事業関係機関		<許認可> 教育省、County/District <技術支援>MWI, WRMA <他の支援者>KRCS、PTA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助・公助		

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

表 4.2.18　支川のフラッシュフラッド対策事業の評価検討（18）

No.		18		
対象		Lumi 下流支川エリア		
対策		早期警報システム		
概要		上流での水位や降雨状況をもとに居住区への警戒情報を伝達するシステム		
イメージ				
評価項目				
五項目評価	妥当性	早期警戒システム自体がケニアでは一般的でないため、設置を求める声は多くない。しかし、浸水を事前に察知し備品や家禽を高いところへ置くなどの対策の普及は期待されている。	B	2
	有効性	警戒情報は広範囲に伝達することが可能である。警報があっても、洪水対策を知らなければ被害軽減度合いは高くはないが、防災教育と同時に実施することで、その効果は高まる。	B	2
	効率性	比較的安価な予算で広範囲に効果を与えられる。	A	3
	インパクト	比較的容易に他地域でも導入でき、上・下流のコミュニティのコミュニケーションが活発になる、双方の防災意識が高まる、等の付加的効果もある。	A	3
	持続性	簡易的で安価な計測器・伝達システムであれば、維持管理が容易である。	A	3
五項目評価・合計			13	
メリット		比較的短時間で取りかかることができ、システムの運用、維持管理を実践することにより、防災意識の向上とオーナーシップの醸成が期待できる 修繕が容易な簡易的装置であるため、持続性が高い		
デメリット		継続的な維持管理が必要。 システムの確立するまでに時間がかかる		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		情報提供		
事業実施者（メインアクター）		WRUA/		
事業関係機関		<支援行政機関> KMD/スペシャルプログラム省 <技術支援>MWI, WRMA <他の支援機関>KRCS		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助		

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

表 4.2.19　支川のフラッシュフラッド対策事業の評価検討（19）

No.		19		
対象		Lumi 下流支川エリア		
対策		コミュニティ道路の整備		
概要		道路の嵩上げやカルバートの設置などで道路が使用不能になることを防ぐ		
イメージ				
評価項目				
五項目評価	妥当性	この地域では洪水時に道路が浸水し、避難に困難が生じ、コミュニティ内での行き来や、子供たちの通学に影響するため、WRUA や住民の要望がある。嵩上げにより洪水時の移動の確保が期待される。	A	3
	有効性	避難経路が確保される	B	2
	効率性	広域での効果を得るためにはコストも大きい	B	2
	インパクト	小規模で簡易的な工事であれば、他地域への波及効果は難しくない。	B	2
	持続性	事業後も継続的な維持管理が必要であるが、比較的小規模であれば、維持管理は困難でない。	B	2
五項目評価・合計			11	
メリット		洪水時の避難経路が確保される		
デメリット		継続的な維持管理が必要 計画・設計・工事のそれぞれのプロセスである程度の期間が必要である。		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		WRUA		
事業関係機関		<許認可>County/District、道路省、KeRRA <技術支援> KeRRA 、MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		公助・共助		

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

表 4.2.20　支川のフラッシュフラッド対策事業の評価検討（20）

No.		20		
対象		Lumi 下流支川エリア		
対策		トイレ嵩上げ		
概要		トイレの高さを上げてトイレへの水の流入を防ぎ、汚物の流出を防止する。		
イメージ				
評価項目				
五項目評価	妥当性	浸水時に溢れた汚物による衛生状態の悪化、感染症の蔓延等の被害の報告が住民から多数挙がっており、対策を求める声が高い。嵩上げにより洪水時の衛生状態悪化の回避が期待される。	A	3
	有効性	トイレの汚物からの衛生悪化を防げれば、感染症が防げる	B	2
	効率性	嵩上げ自体は安価だが、地域中のトイレに対策を施さなければ、効果は出ないため、費用対効果は中程度。	B	2
	インパクト	比較的簡易的な工事であるため、他地域でも応用可能である。	A	3
	持続性	事業後も継続的な維持管理が必要である。しかし、小規模であるため維持管理はそれほど難しくはない。	B	2
五項目評価・合計			12	
メリット		短期間で準備可能 公衆衛生省と協働できれば、更なる効果を期待できる。 波及効果が高い		
デメリット		継続的な維持管理が必要		
環境への負の影響		なし		
EIA の必要性		不要		
住民負担の有無		WDC マニュアルによると、地元住民は Alarm Status のサブ流域では 15%、Alert または Concern Status のサブ流域では 25%の負担をしなければいけないと定められている。それは、現金、労働、物品のいずれでも構わない		
事業実施者（メインアクター）		WRUA、個人		
事業関係機関		<許認可>County/District、保健衛生省 <技術支援>MWI, WRMA		
公助（行政レベル） 共助（コミュニティレベル） 自助（個人レベル）		共助・自助		

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

4.2.1 五項目評価における評価

評価対象となった全ての対策案の５項目評価の総合得点を下記の表で示す。点数の高いものからの着手が望ましいが、実際の実施には種々の前提条件がクリアーされる必要があり、それを考慮して事業実施計画を検討する。

表 4.2.21 ５項目評価・評価点

構造物・非構造物	No.	対策案	備考	点数
構造物	3	堤防の補修	事前調査･計画･調整が必要	12
	12	トイレの嵩上げ（長期湛水エリア）		12
	20	トイレの嵩上げ（支川エリア）		12
	9	避難キャンプ地の整備		12
	11	コミュニティ道路の整備（長期湛水エリア）		11
	2	排水路の改修	事前調査･計画･調整が必要	11
	19	コミュニティ道路の整備（支川エリア）		11
	13	泉の保護		11
	4	Jipe 湖の浚渫	事前調査･計画･調整が必要	10
	1	Lumi 川の改修	事前調査･計画･調整が必要	10
	14	護岸（支川エリア）		10
	5	小規模砂防ダム（上流域）	事前調査･計画･調整が必要	9
	10	雨水貯留タンクの設置		8
非構造物	7	防災教育（長期湛水エリア）		14
	17	防災教育（支川エリア）		14
	18	早期警戒システム（支川エリア）		13
	8	早期警戒システム（長期湛水エリア）		12
	6	植林活動（上流域）		11
	16	植林活動（支川エリア）		11
	15	土地利用規制（支川エリア）		10

5. 洪水対策の事業実施計画

5.1 今後実施すべき洪水対策

洪水管理計画では、下流域の本川からの溢水・破堤による氾濫・長期湛水という洪水被害を軽減すること、次に、支川のフラッシュフラッドによる被害を軽減することを優先的に実施する。

これらの対策については、CMS についても言及されるべきであり、Lower Lumi WRUA が 2012 年に予定していた SCMP を改定する際には、WRUA で実施すべき事業について記入されるべきである。

5.1.1 構造物対策

構造物対策については、優先度の順に次の順番で実施する。

- 避難キャンプ地の整備
- トイレ嵩上げ
- 排水路 / 堤防の補修の調査
- コミュニティ道路の整備の調査
- 泉の汚染及び保護の必要性に関する検討調査
- Lumi 川の改修の調査
- Jipe 湖の浚渫の調査
- 小規模砂防ダム建設の検討調査
- 支川の護岸の調査
- 雨水貯留タンクの設置検討調査

5.1.2 非構造物対策

非構造物対策については、優先度の順に次の順番で実施する。

- 防災教育の実施
- 早期警戒システム
- 植林活動
- 土地利用規制

5.2 洪水対策の実施スケジュール（案）

洪水対策の実施スケジュール（案）を次頁のとおり提案する。
ここで、

メインアクター： 実際に事業を実施する主体。規模によって複数の選択肢があり得る。

支援アクター

NGO： 事業実施を支援する NGO

行政官庁： 事業実施を支援あるいは、許可権限を有する官庁

技術官庁： 事業実施に当たって技術的支援を行う官庁

表 5.2.1　LUMI 川流域洪水対策の実施スケジュール（案）

	対策/活動内容	対策実施に必要な準備等	メインアクター（実施者）	支援アクター			WRMAの役割	WRUAの役割	1年次	2年次	3年次	4年次	5年次	6年次以降
				NGO	行政官庁	技術官庁								
構造物	避難キャンプ地の整備		WRUA	KRCS	County/District、教育省	MWI, WRMA	技術アドバイス	計画・建設への参画、避難所自主運営						
	トイレ嵩上げ		WRUA/コミュニティ/個人		County/District、保健衛生省	MWI, WRMA	技術アドバイス	計画・建設への参画、住民意識啓発						
	排水路 / 堤防の補修	調査・測量・協議	NWCPCか County		County/District	MWI, WRMA	関連省庁との連携	計画作成・維持管理での協働	調査・測量・協議					
	コミュニティ道路の整備	調査・測量・協議	WRUA		County/District、道路省、KeRRA	KeRRA, MWI, WRMA	技術アドバイス	計画・建設・維持管理への参画		調査・測量・協議				
	泉の保護	調査・測量・協議	WRUA		County/District	MWI, WRMA	技術アドバイス	計画・建設・維持管理への参画	調査・測量・協議					
	Lumi川の改修	調査・測量・協議	NWCPCか County		County/District	MWI, WRMA	関連省庁との連携	計画作成・維持管理での協働				調査・測量・協議		
	Jipe湖の浚渫	調査・測量・協議	NWCPCか County		County/District	MWI, WRMA	関連省庁との連携	計画作成・維持管理での協働				調査・測量・協議		
	小規模砂防ダム	調査・測量・協議	NWCPC、MWIか County		County/District、MWI, WRMA	MWI, WRMA	技術アドバイス	計画・建設・維持管理への参画		調査・測量・協議				
	護岸	調査・測量・協議	WRUA		County/District、MWI, WRMA	MWI, WRMA	技術アドバイス	計画・建設・維持管理への参画				調査・測量・協議		
	雨水貯留タンク	調査・測量・協議	Town Council/WRUA		Town Council	MWI, WRMA	技術アドバイス	計画・建設・維持管理への参画		調査・測量・協議				
非構造物	防災教育		学校, WRUA	KRCS	教育省, County/District	MWI, WRMA	関連省庁との連携	連携・参画・住民啓発						
	コミュニティによるフラッシュフラッドへの早期警報システム		WRUA	KRCS	KMD/スペシャルプログラム省	MWI, WRMA	技術アドバイス	計画・構築・運営管理への参画	構築					
	下流域への早期警報システム(IFAS/GFAS)		WRUA/コミュニティ	KRCS	KMD/スペシャルプログラム省	MWI, WRMA	関連省庁との連携	連携・参画・住民啓発	検討					
	植林活動		ユースグループ/住民	KRCS	Kenya Forest Service	MWI, WRMA	関連省庁との連携	連携・参画・住民啓発						
	土地利用規制		KFS		Kenya Forest Service	MWI, WRMA	関連省庁との連携	連携・参画・住民啓発	検討					

6. 提言事項

・ 長期的には Lumi 川本川下流からの洪水氾濫を制御するような抜本的な洪水対策が検討されるべきである。
・ 洪水に対するレジリエンスを強化する事業を実施するためには、既存の District Disaster Management Committee（DDMC）などの組織と連携するべきである。

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)	

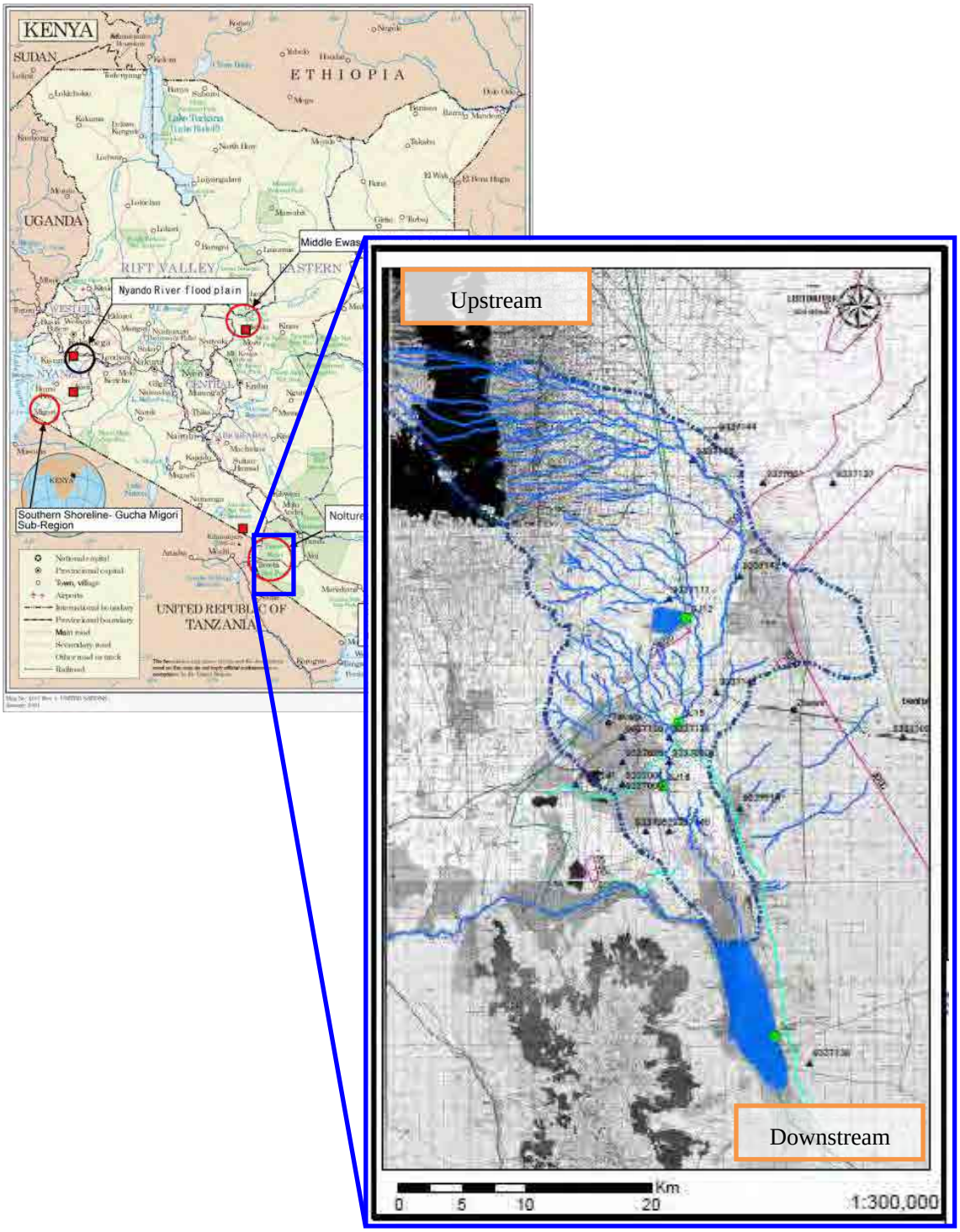
1.4 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

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.



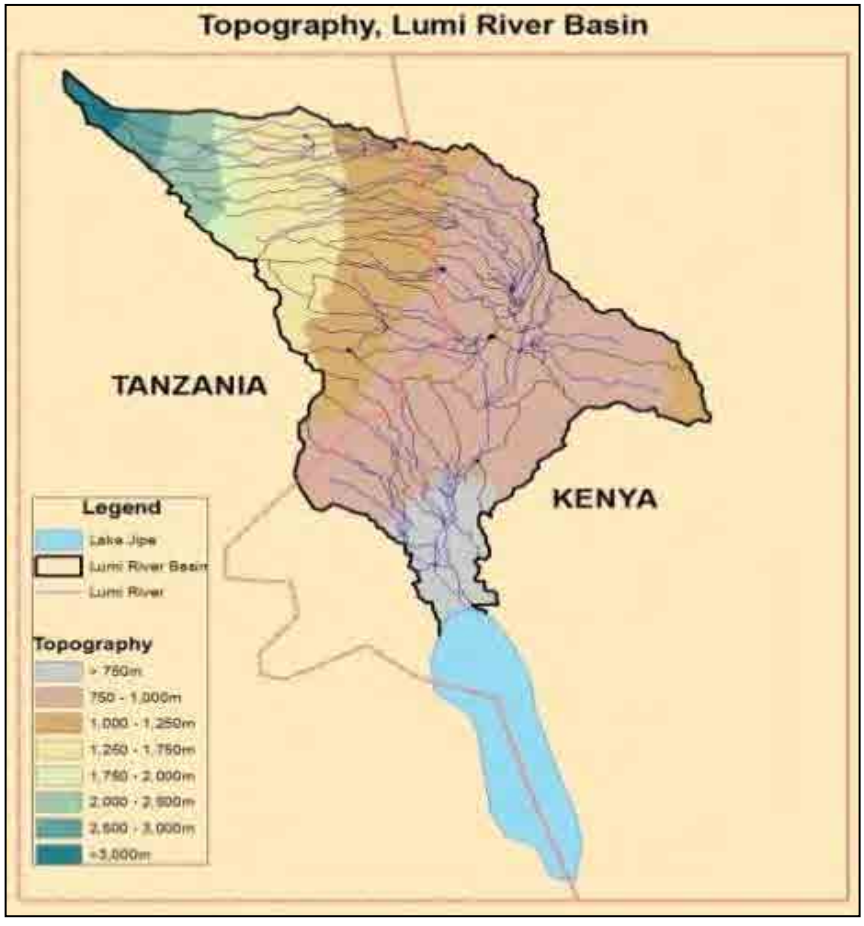
Location of Lumi River Basin

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].

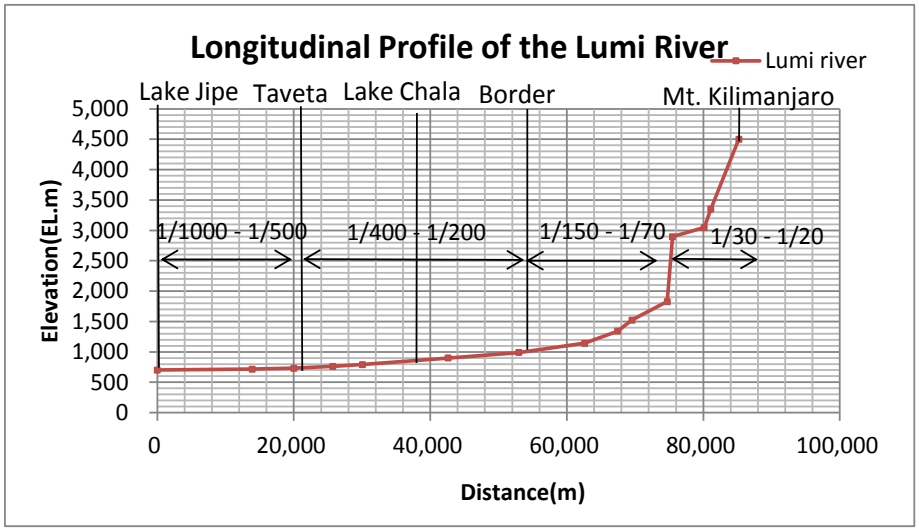


Source：WRMA, Action Plan on The Development and Implementation of a Flood Management Plan for Lumi River

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

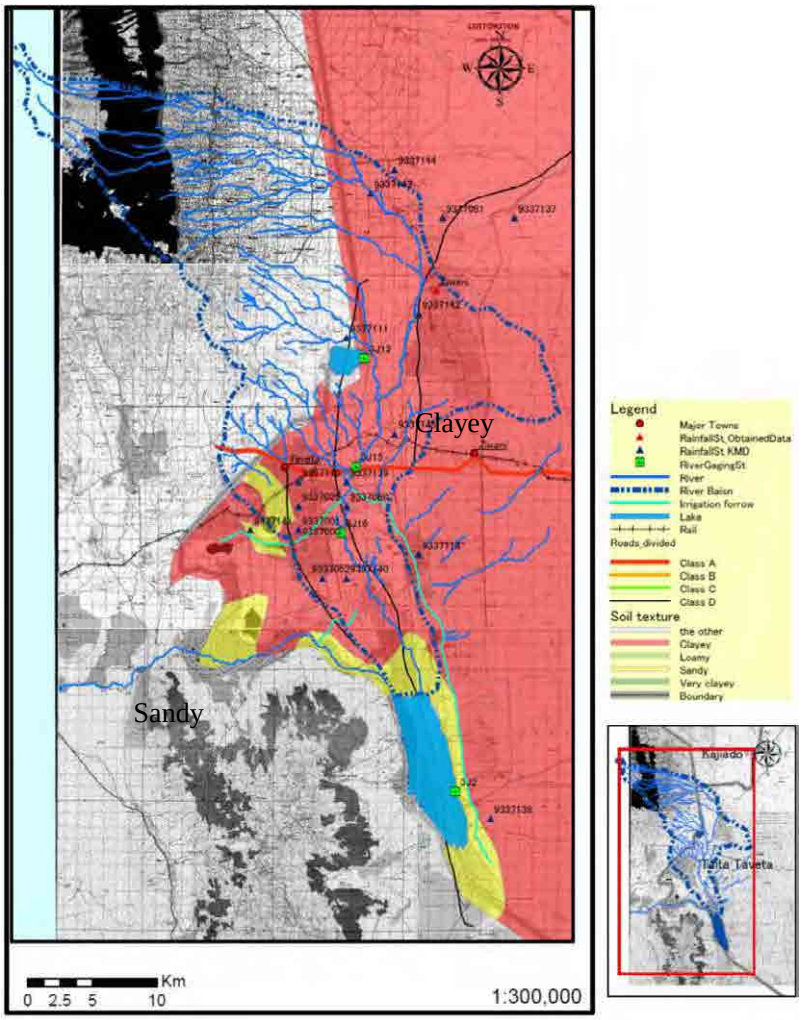
Photo 2.1.1 Mt. Kilimanjaro

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.

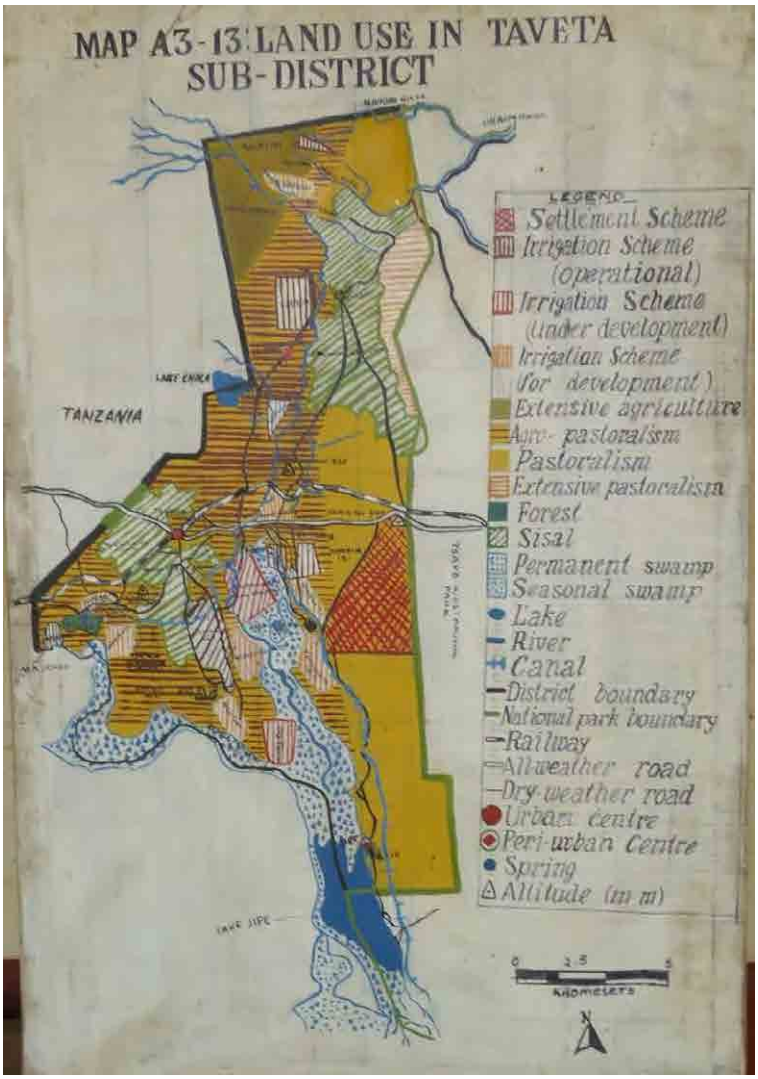
Figure 2.1.3 Soil Distribution Map(Soil texture)

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.

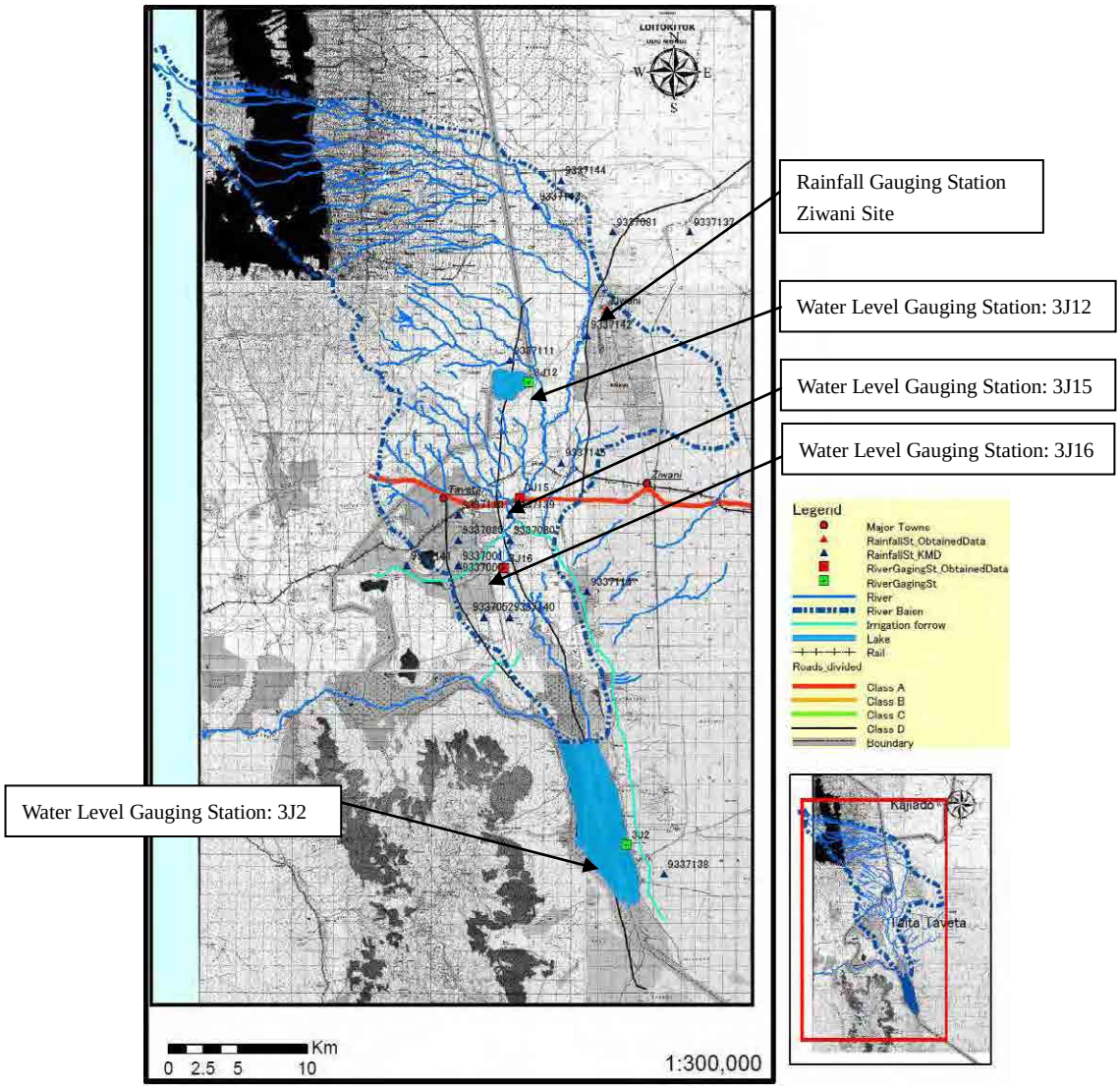


Figure 2.1.6 Location Map of Rainfall and Water Level Gauging Stations in Lumi River Basin

(b) Daily Rainfall Data

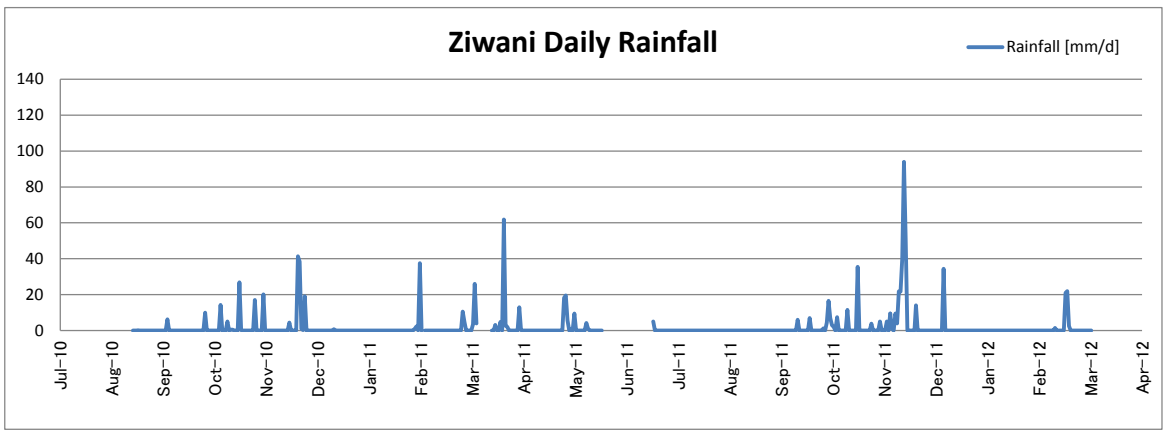
Figure 2.1.7 shows the result of daily rainfall measurement at the rainfall gauging station of Ziwani which is under jurisdiction of WRMA from September 1, 2010 to March 12, 2012. (There are some missing data.) The maximum daily rainfall recorded at Ziwani rainfall gauging station during about two years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

Y	X	AltitudeMeter	FullMet_Auto_Manual		Daily/Hourly/Both	Operational	Start_Year	End_Year	SROin
-3.398	37.677		Manual	3.398	37.677	Daily	Manual	Yes	Daily	N_A	Yes
-3.389	37.672	794	Manual	3.389	37.672	Daily	794 Manual	Yes	Daily	2011	N_A	Yes
-3.474	37.755	748	Manual	3.474	37.755	Daily	748 Manual	Yes	Daily	2008	N_A	Yes
-3.296	37.733	911	Manual	3.296	37.733	Daily	911 Manual	Yes	Daily	2008	N_A	Yes
-3.351	37.754	851	Manual	3.351	37.754	Daily	851 Manual	Yes	Daily	2009	N_A	Yes
-3.187	37.724	1014	Manual	3.187	37.724	Daily	1014 Manual	Yes	Daily	2008	N_A	Yes
-3.629	37.776	728	Manual	3.629	37.776	Daily	728 Manual	Yes	Daily	2008	N_A	Yes
-3.437	37.639	739	Manual	3.437	37.639	Daily	739 Manual	Yes	Daily	2008	N_A	Yes
-3.472	37.699	736	Manual	3.472	37.699	Daily	736 Manual	Yes	Daily	2008	N_A	Yes
-3.267	37.762		Manual			Daily		Yes	2010	N_A	NL_Lo



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

Catchment Area	River Basin/ Sub Catchment	River Name	Manual/ Auto/ Both	National/ MU/IMU/ Special	Daily/ Hourly/ Both	Start Year	End Year	SRO in charge	End Year	SRO in charge
Lumi ACA 3J15	ACA Lumi Taveta	Lumi [illegible]	Manual [illegible]	[illegible]	Daily [illegible]	2009	N/A	NL (Loitokitok) [illegible]	N/A	2009 [illegible]
Lumi ACA 3J16	ACA Lumi Taveta	Lumi [illegible]	Manual [illegible]	[illegible]	IMU [illegible]	2007	N/A	NL (Loitokitok) [illegible]	N/A	2007 [illegible]
Lake Challa ACA 3J12	ACA Lake Challa	Lake Challa [illegible]	Manual [illegible]	National [illegible]	Daily [illegible]	2008	N/A	NL (Loitokitok) [illegible]	N/A	2008 [illegible]
Lake Jipe ACA 3J2	ACA Lake Jipe	Lake Jipe [illegible]	Manual [illegible]	National [illegible]	Daily [illegible]	2007	N/A	NL (Loitokitok) [illegible]	N/A	2007 [illegible]

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.

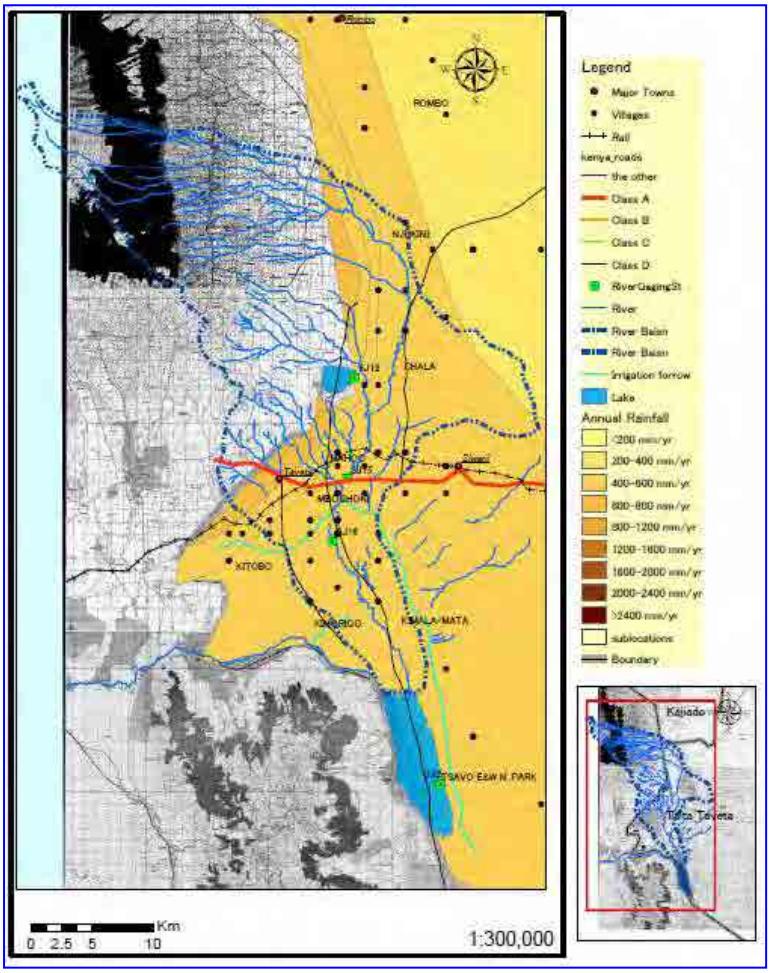
Automatic measurement is not done at each water level gauging station, but the visual observation is carried out twice a day, i.e. in the morning and in the evening. Therefore, the river discharge at the time of flood is said to be inaccurate although the conversion is done from water level data to river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

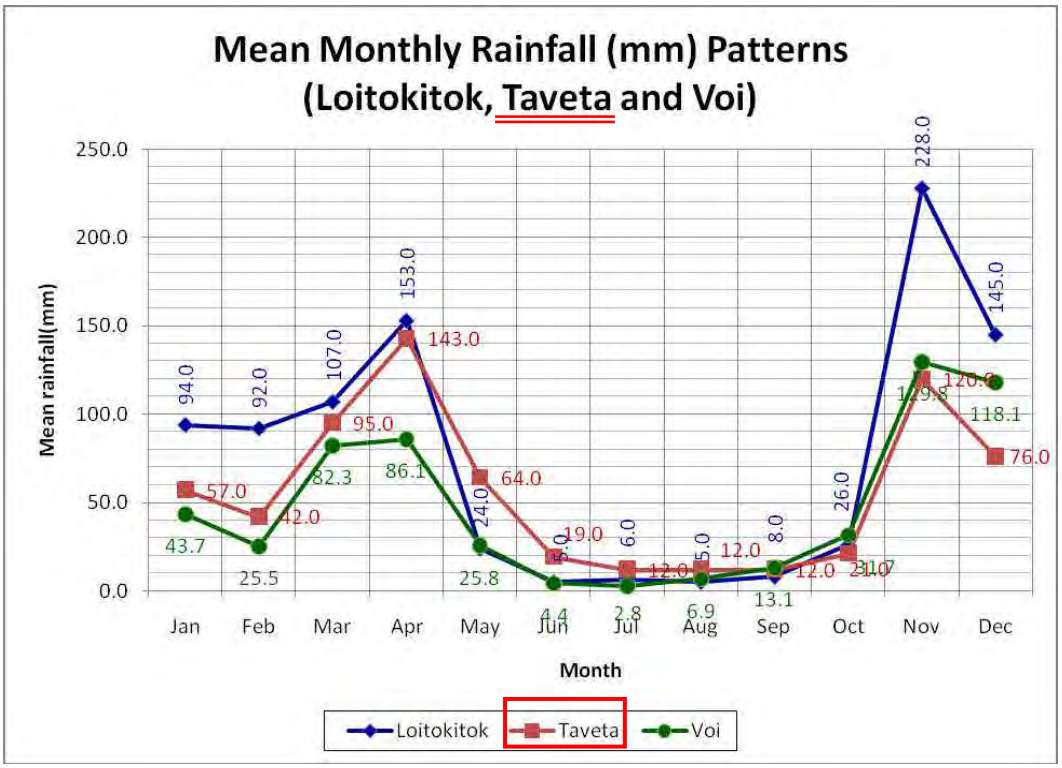


Source: Prepared by JICA Project Team based on the data of National Water Master Plan, JICA

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)

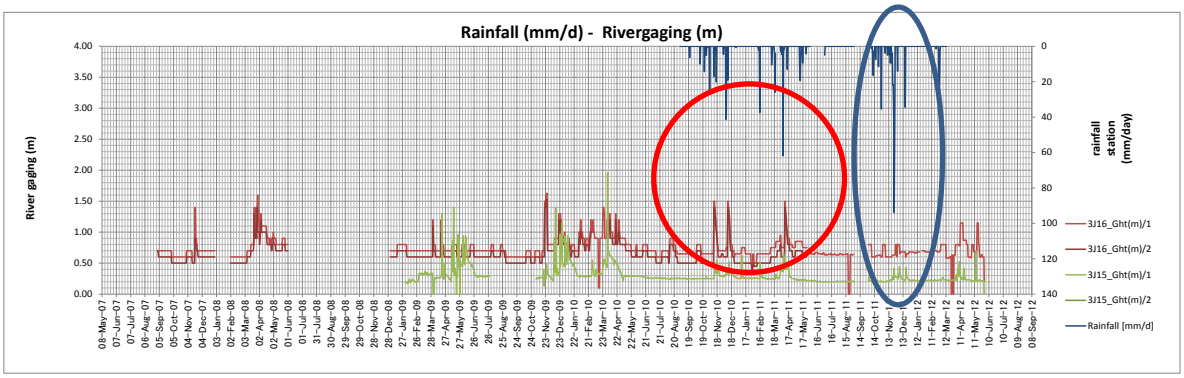


Figure 2.1.10 Correlation between Observed Water Level and Daily Rainfall

2.2 SOCIO-ECONOMIC CONDITIONS

2.2.1 Administration

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

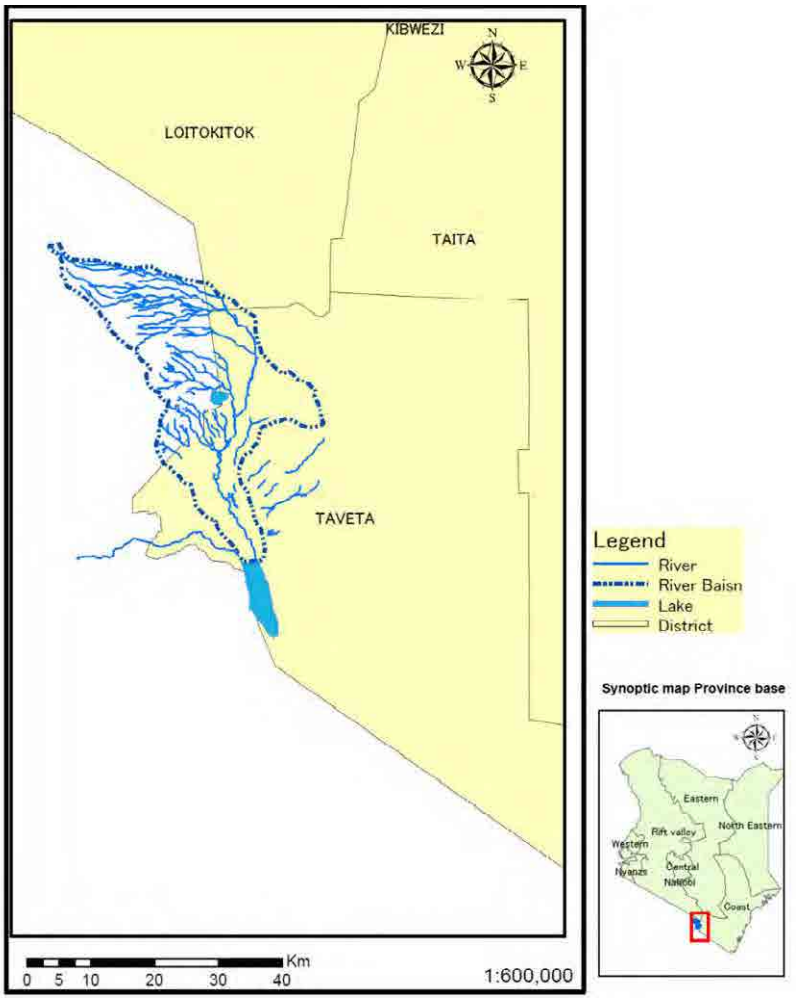
Table 2.2.1 Administrative Division in Republic of Kenya

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.

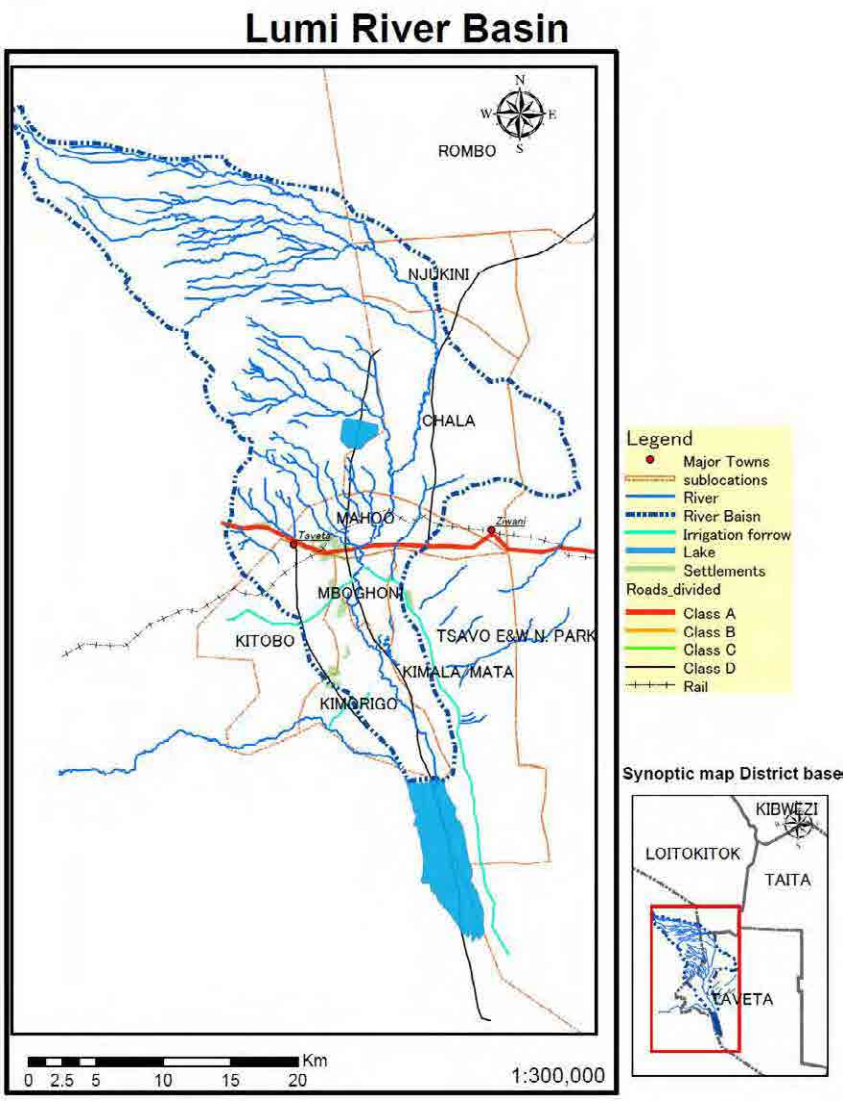
Lumi River Basin is included in Taveta District, Coast Province as shown in the following figure. (Until 2007, the area was a part of Taita-Taveta District, and the present Taveta District corresponds nearly to the former Taveta division of Taita-Taveta District. Taveta District is composed of 7 Sub 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



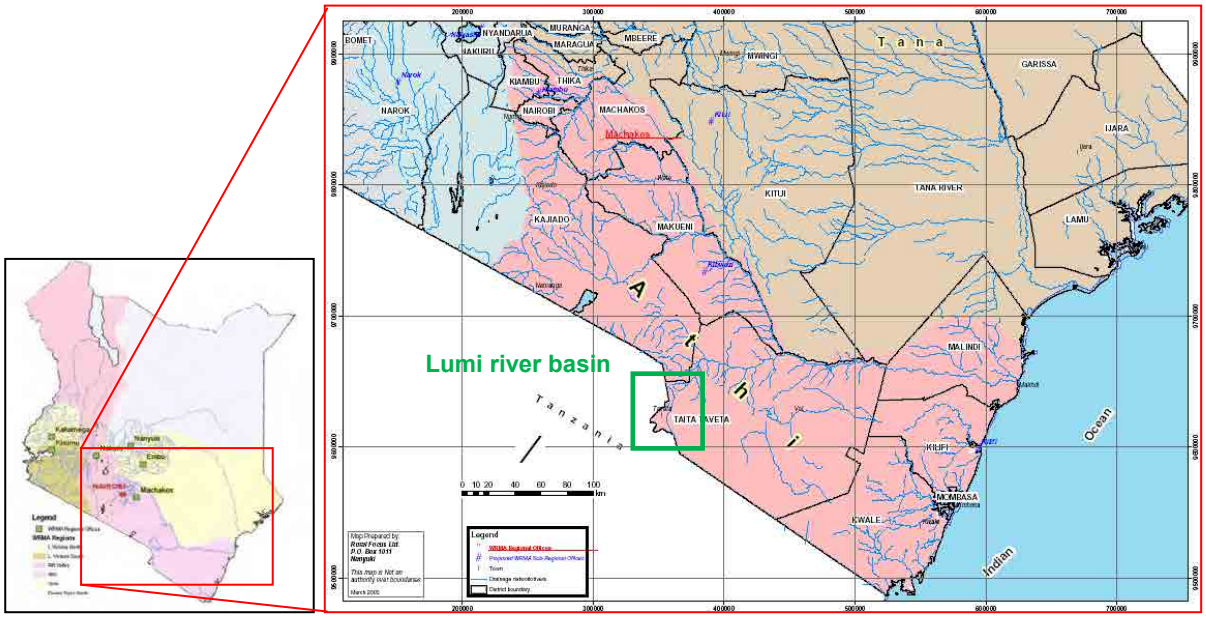
Source: Prepared by JICA Project Team based on National Water Master Plan, JICA

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":

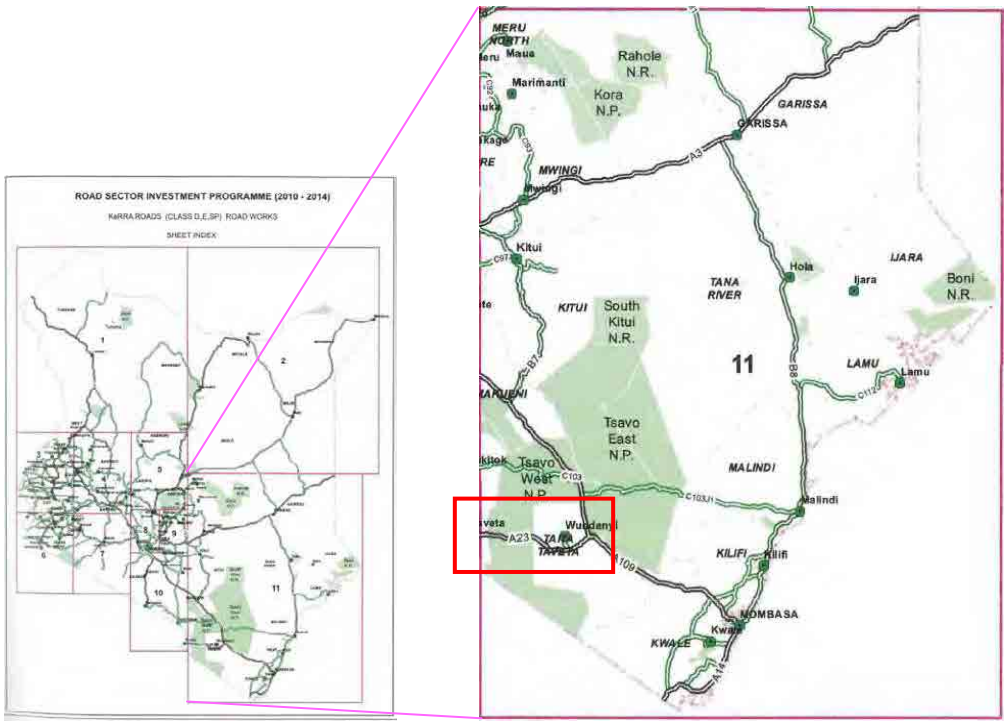
Currently, there is an irrigation strengthening project in Tana Delta as the flagship project. This project is proposed to be disseminated to the other regions including Taita-Taveta.

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.

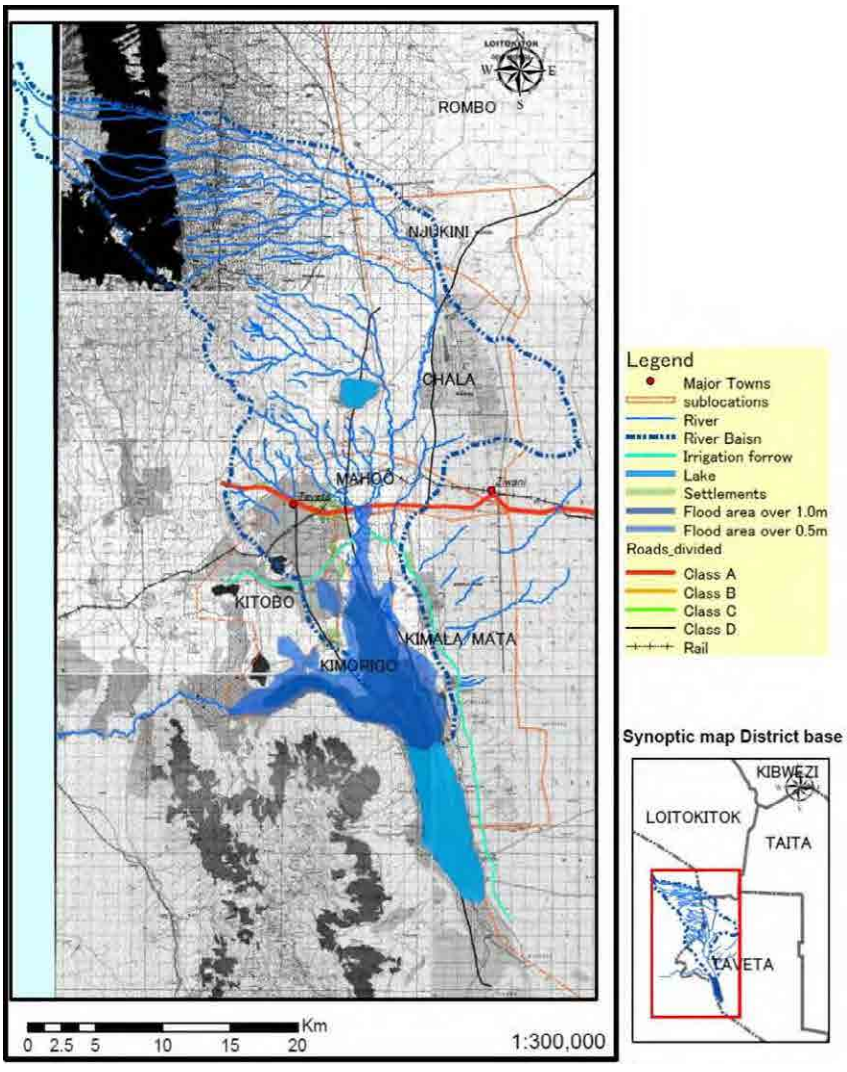


Figure 3.1.1 Records of Flood Damage in the Lumi River Basin

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.

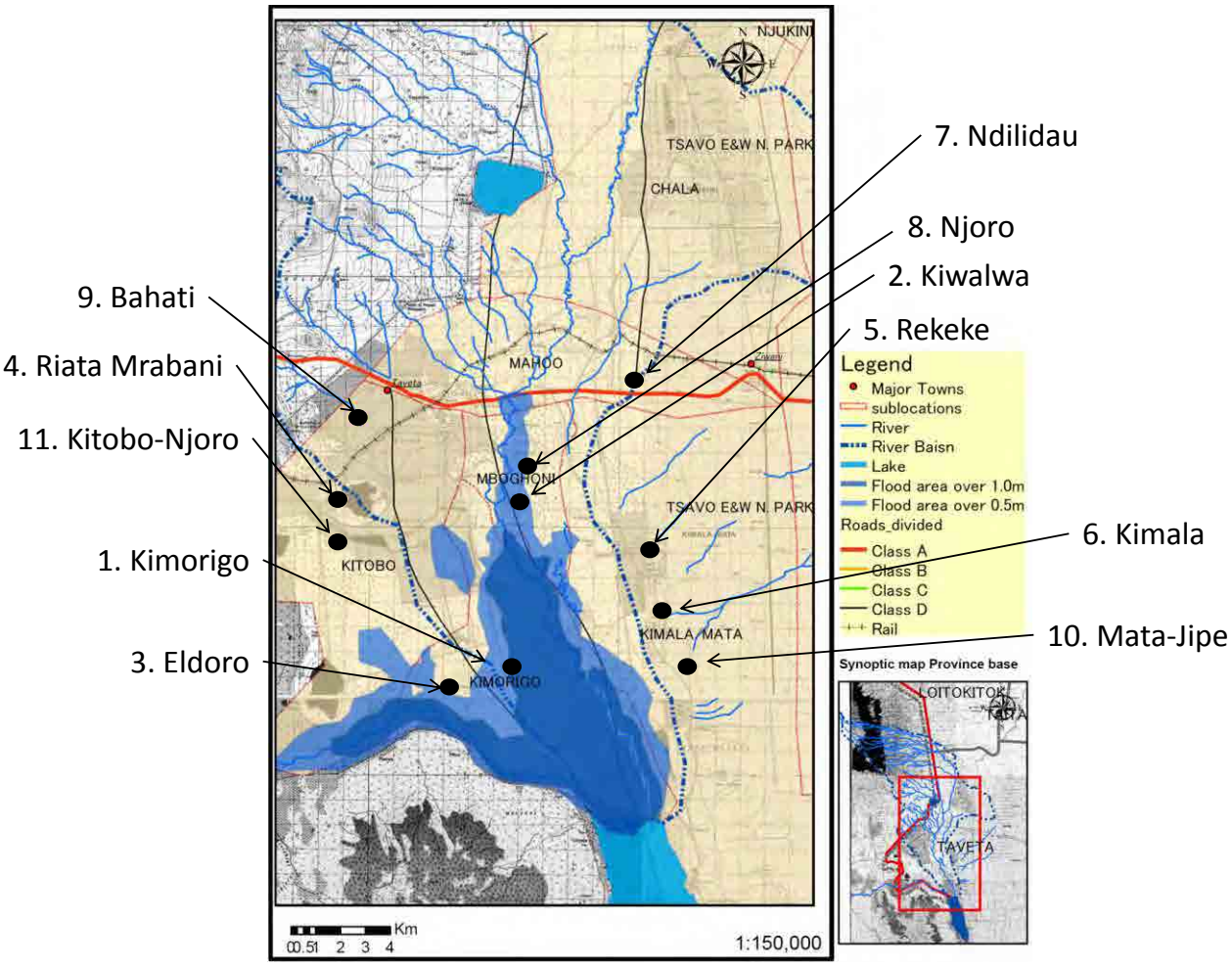


Figure 3.1.2 Location Map of Principal Community in Downstream Area

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,

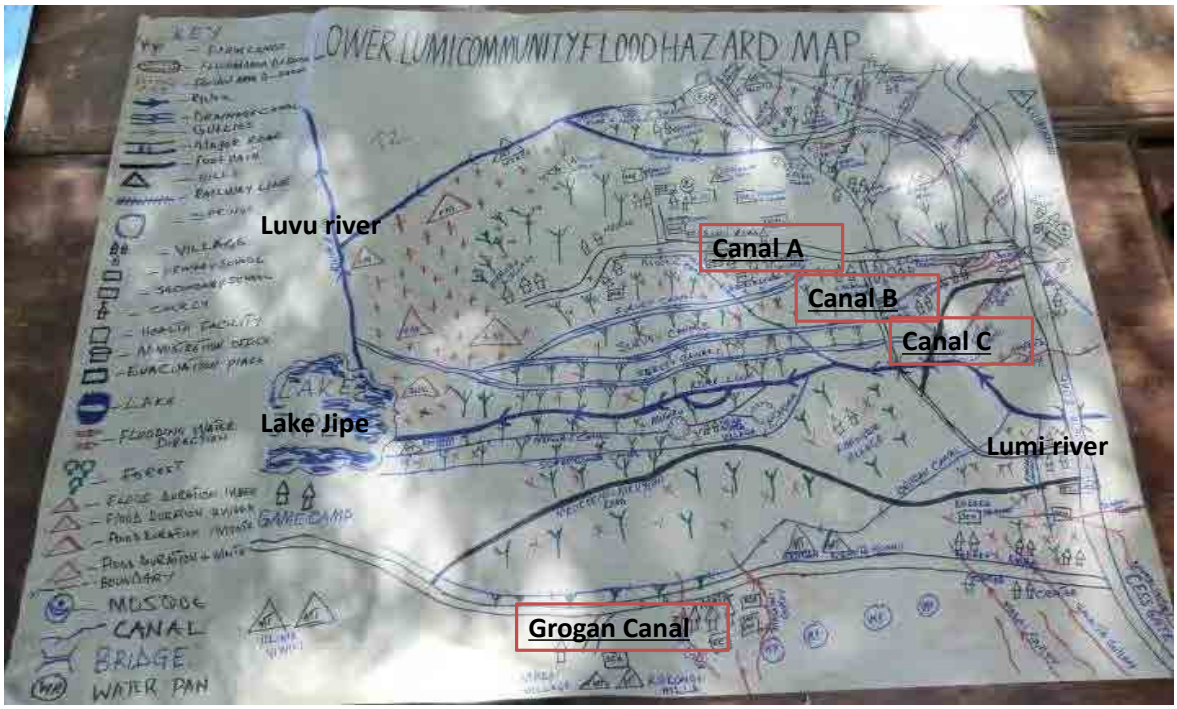


Figure 3.1.3 Location of Canals

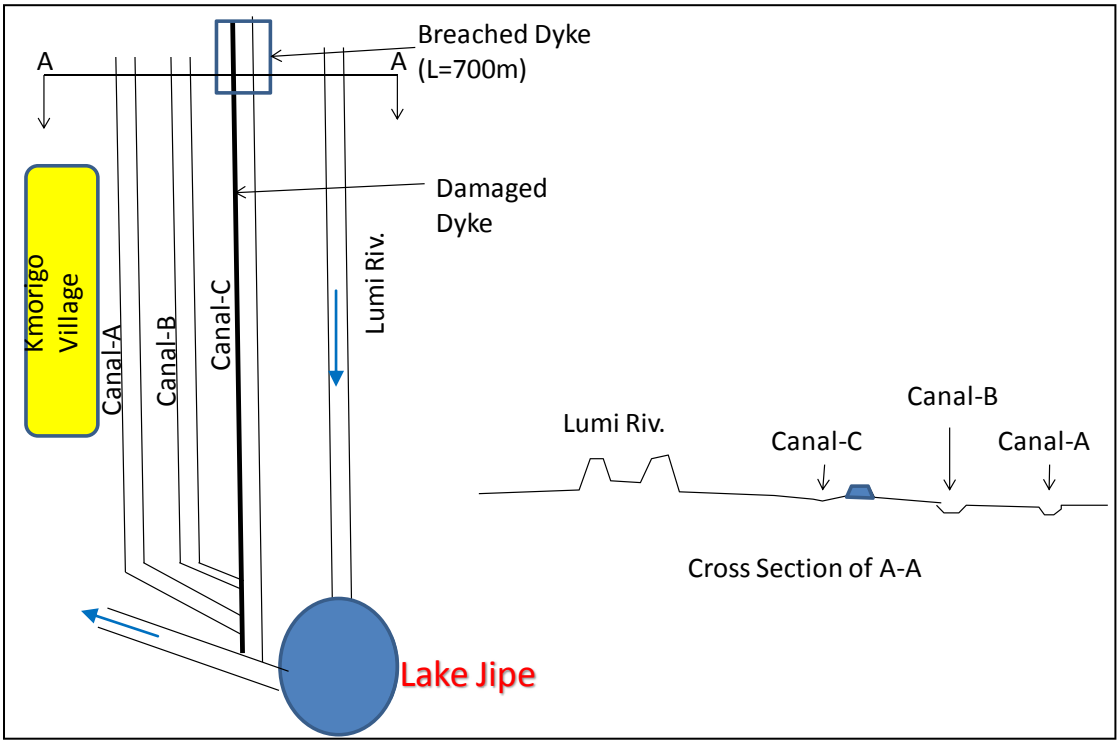


Figure 3.1.4 Cross-section Diagram of the Lumi River and Canals

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

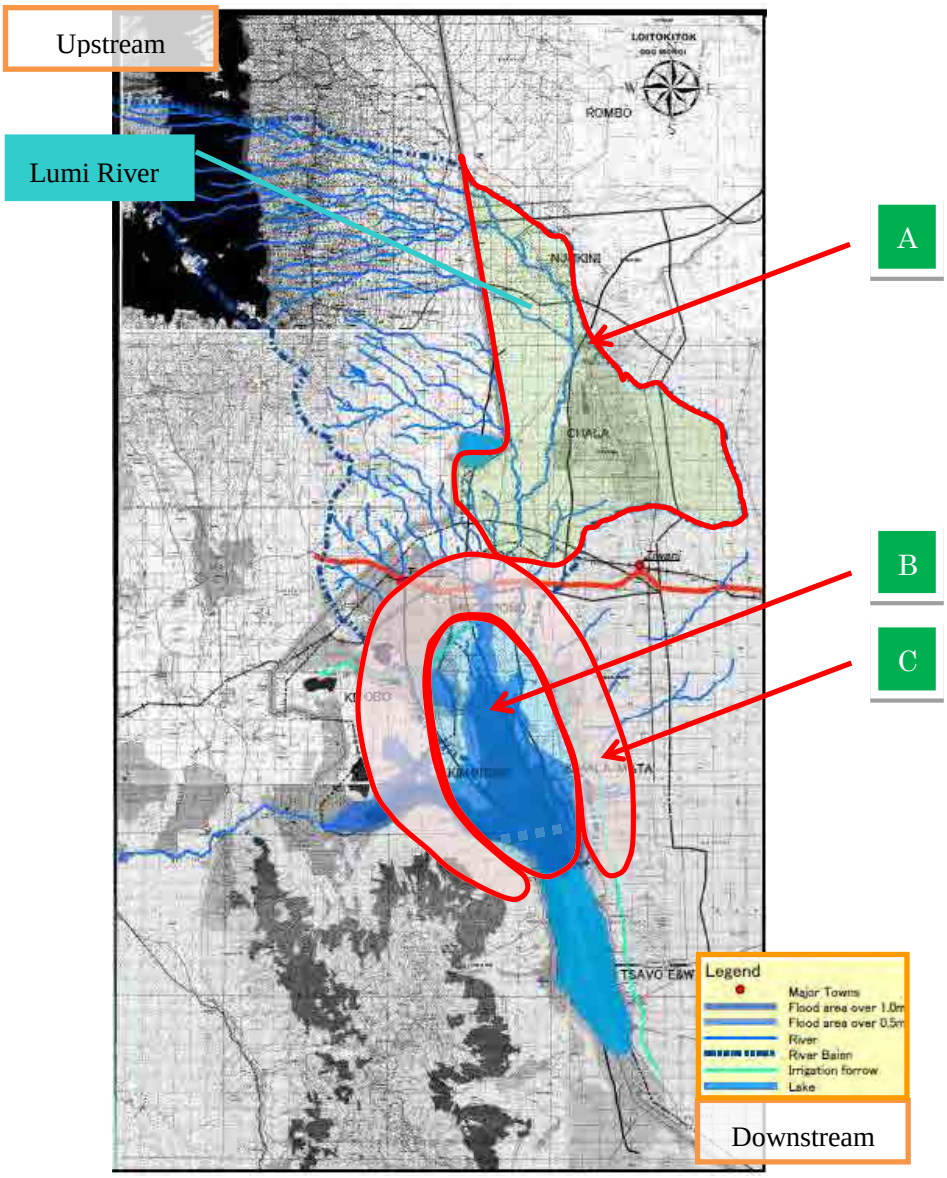
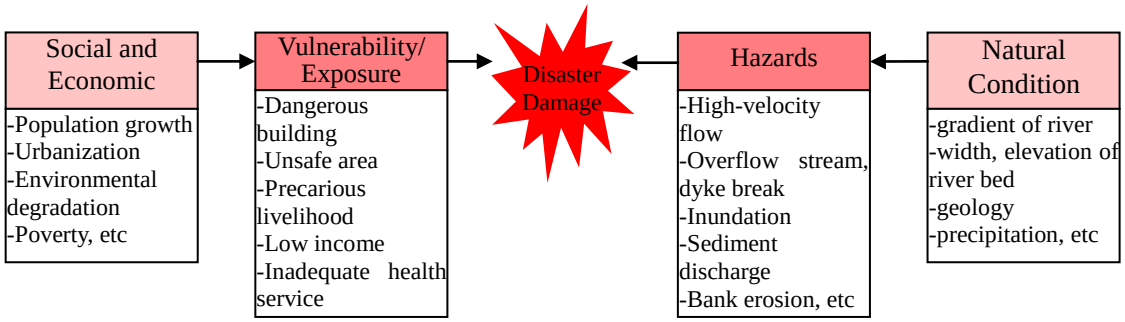


Figure 3.2.1 Records of Flood Damage and Classification of Flood Characteristics in the Lumi River Basin

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

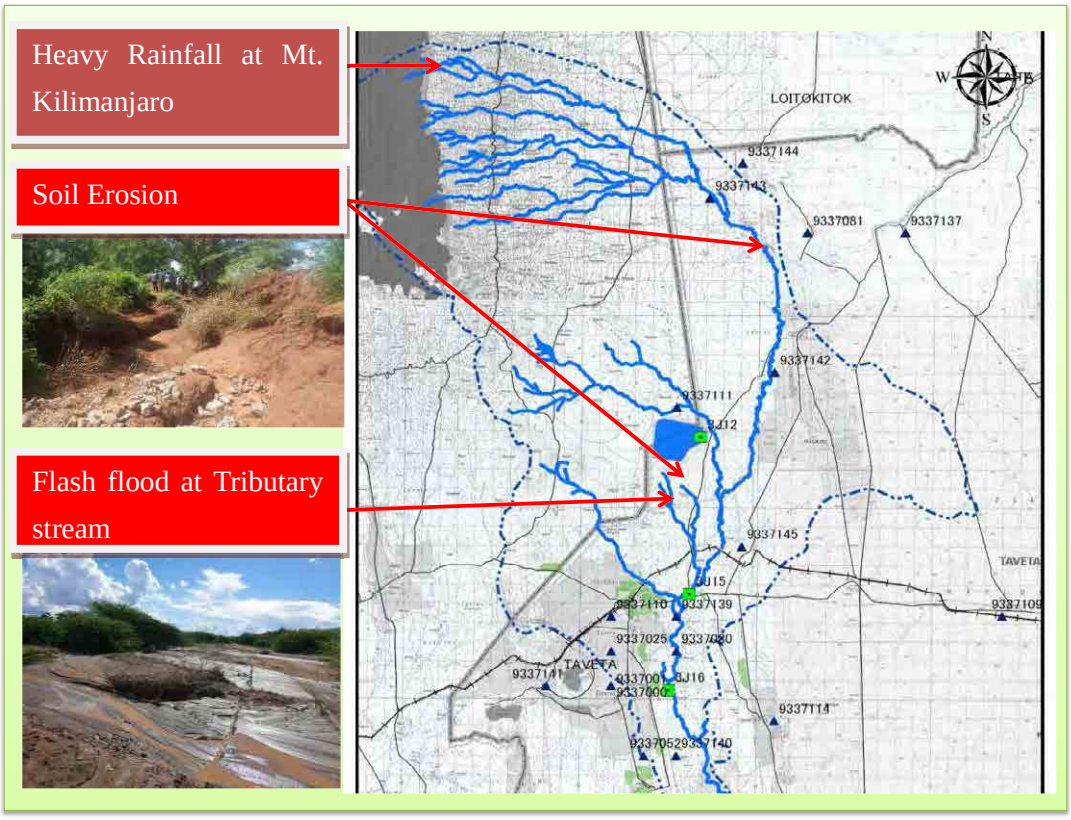


Figure 3.2.3 Flood Characteristics in upstream and middle stream

(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

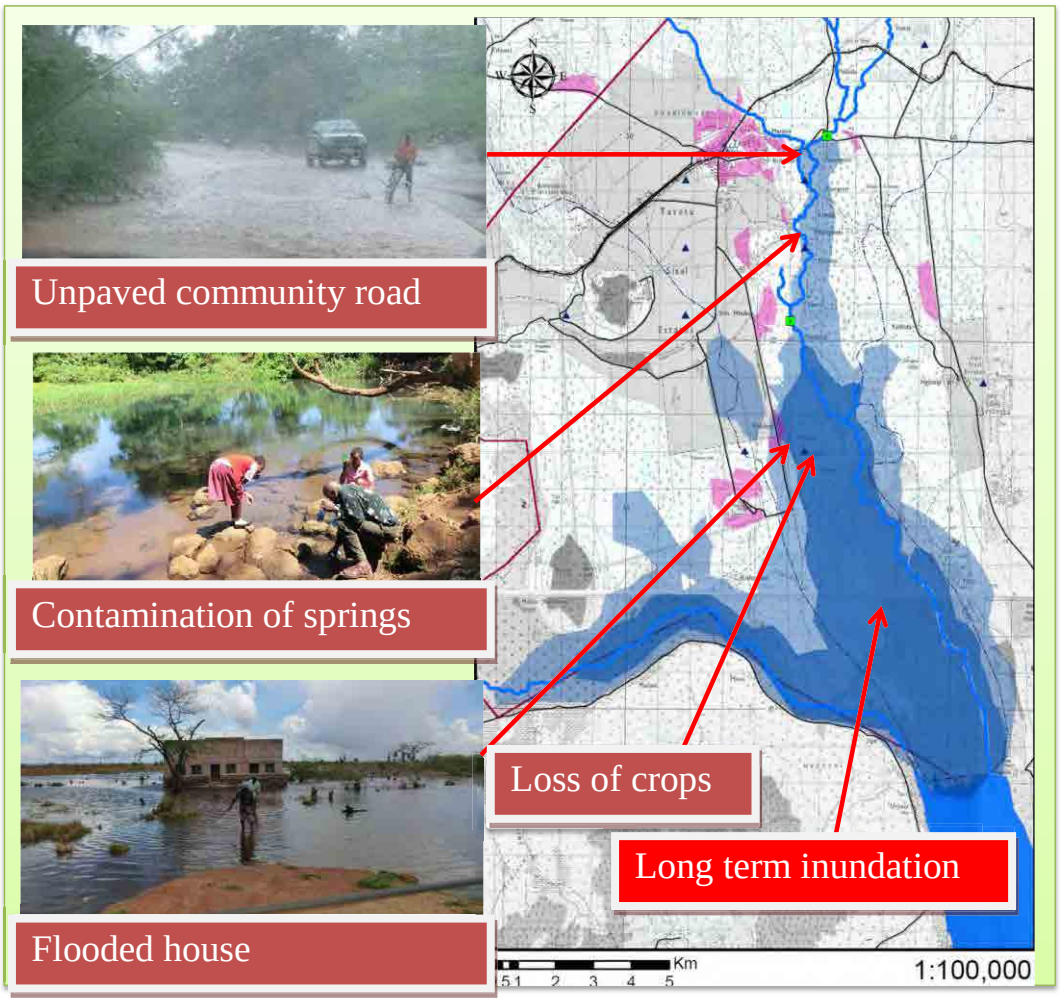


Figure 3.2.4 Flood Characteristics in the Low-lying area of Lower Lumi River

(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

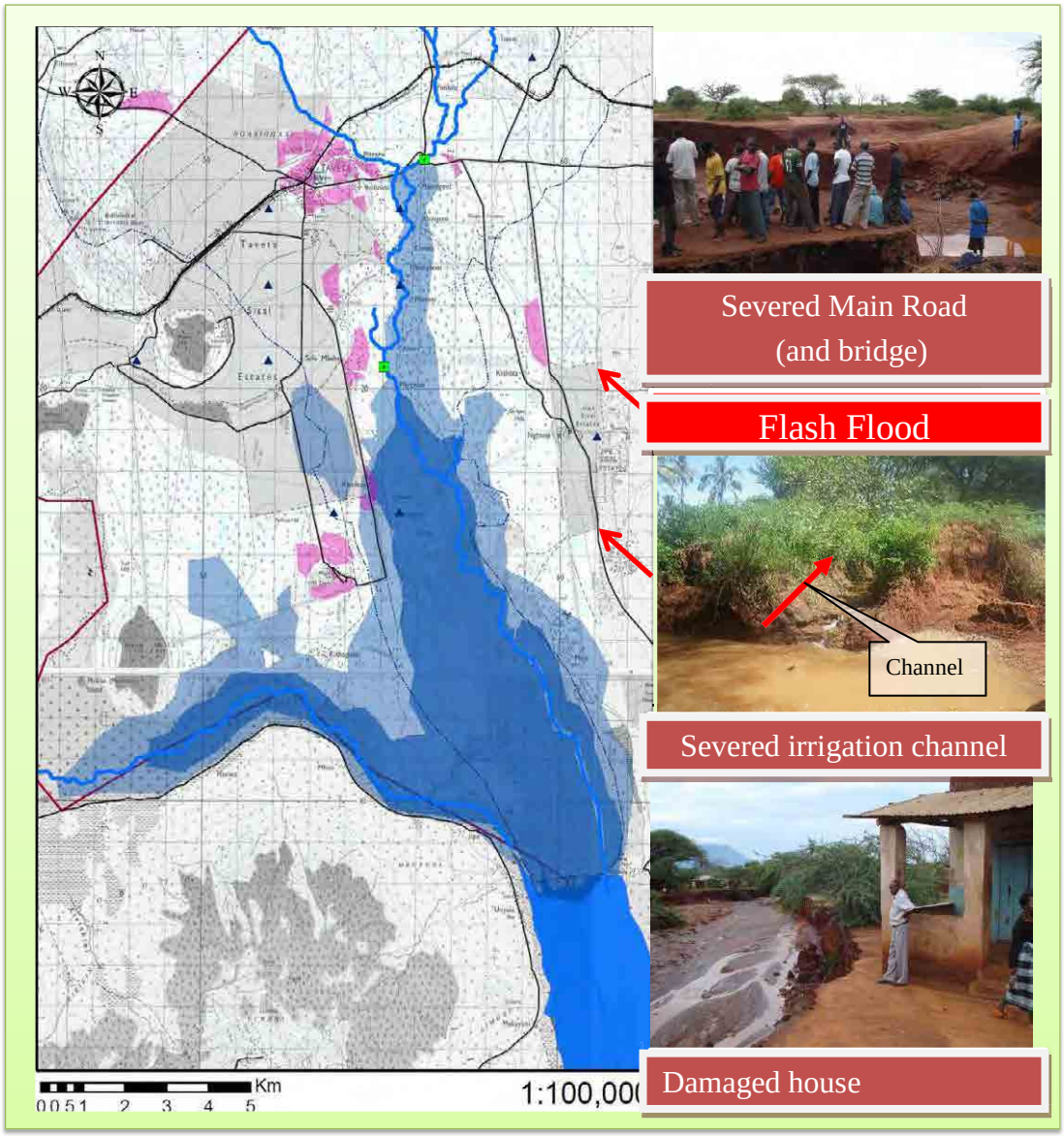


Figure 3.2.5 Flood Characteristics near the Lumi River's Tributaries

(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)

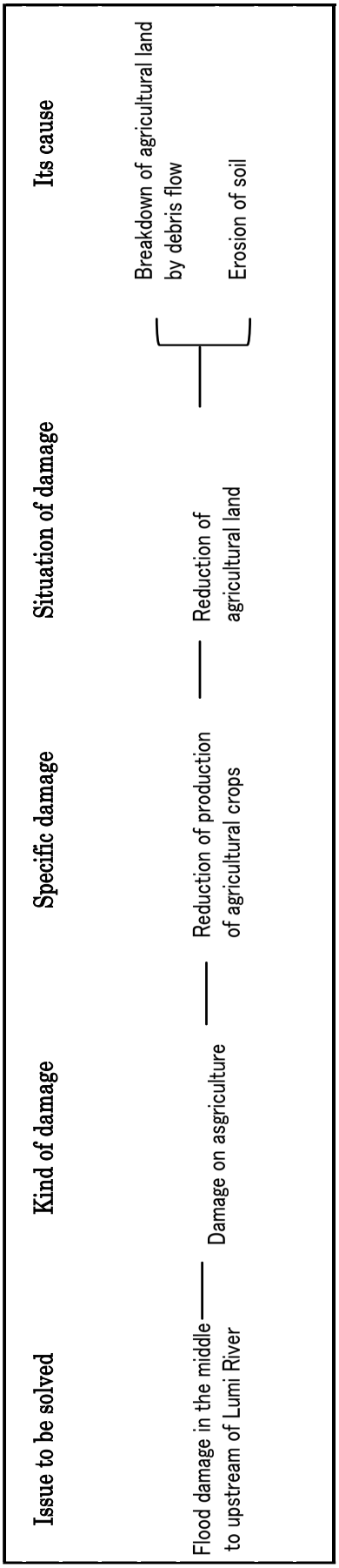


Figure 3.3.1 Analysis on Problem Tree

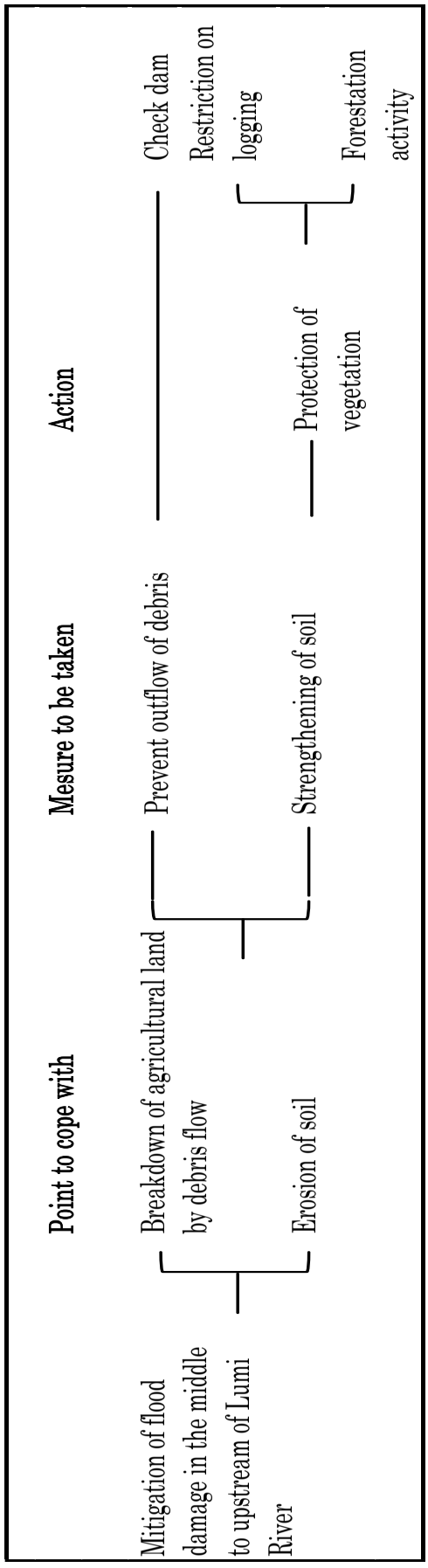


Figure 3.3.2 Analysis on Objective Tree

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.

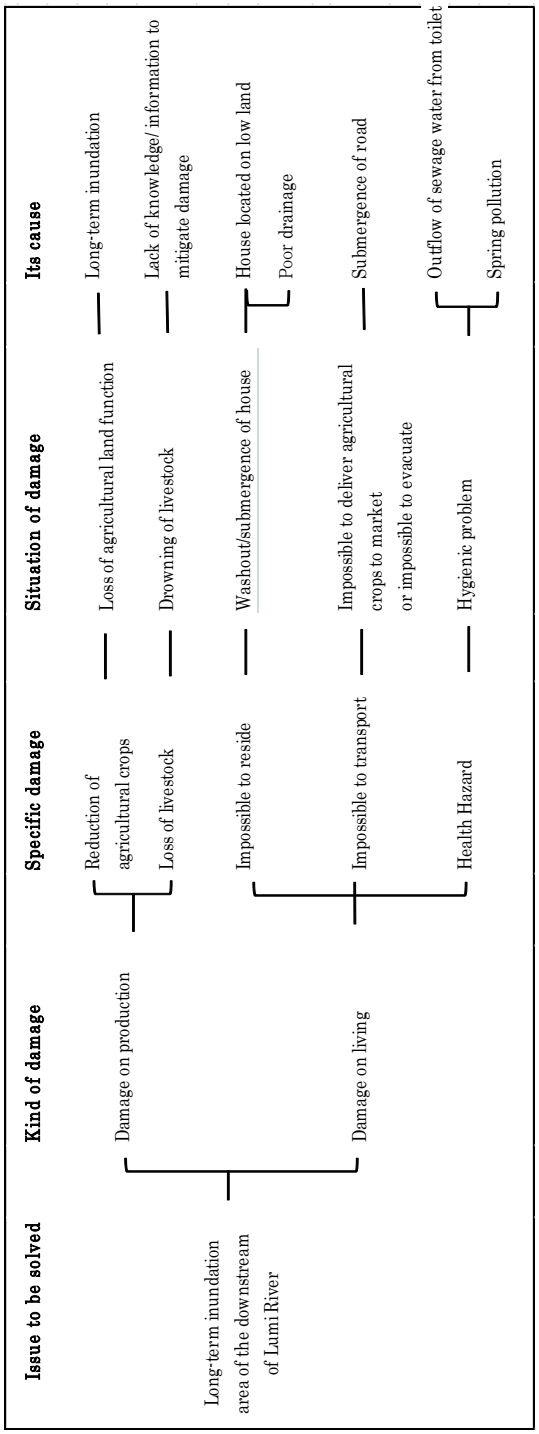


Figure 3.3.3 Analysis on Problem Tree

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.

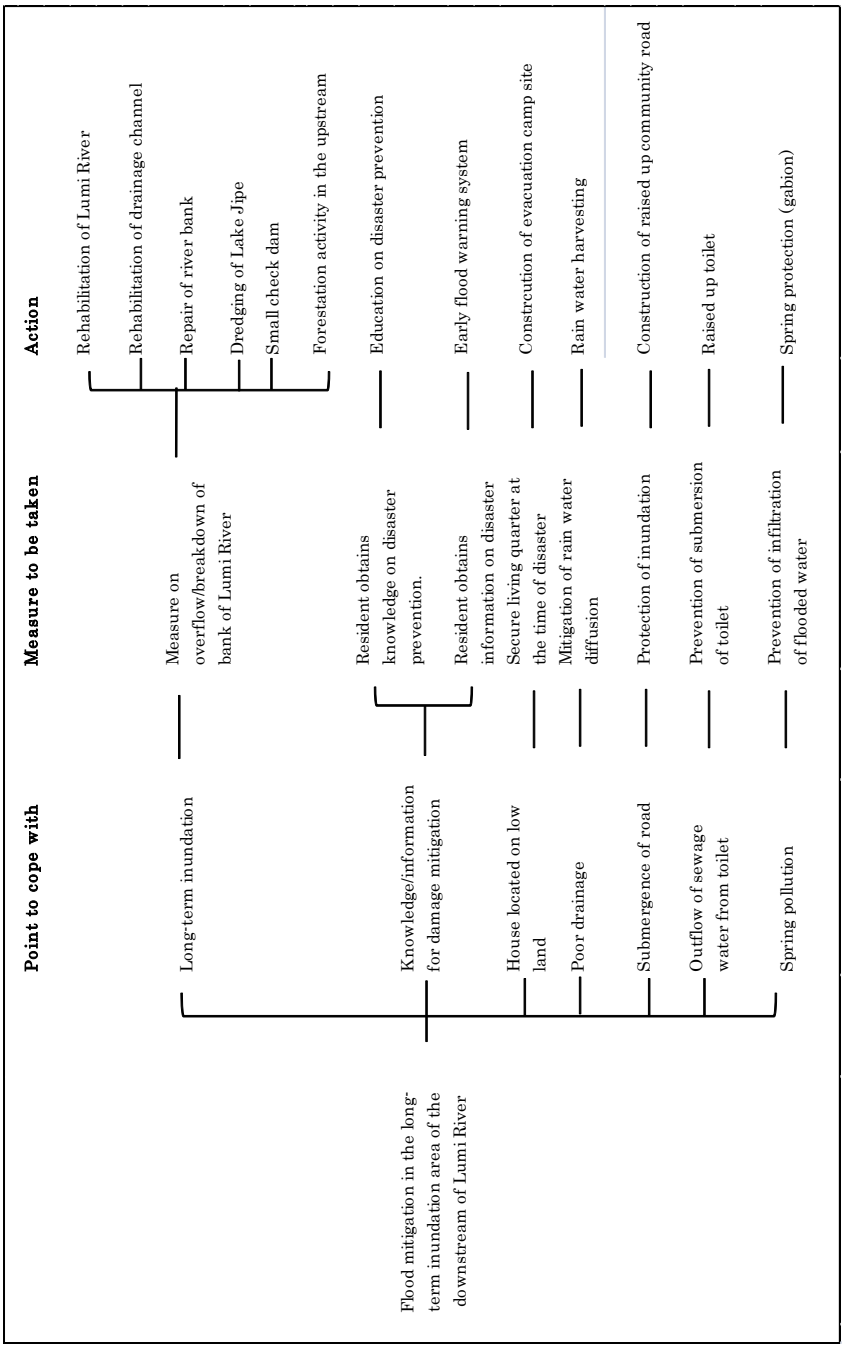


Figure 3.3.4 Analysis on Objective Tree

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.

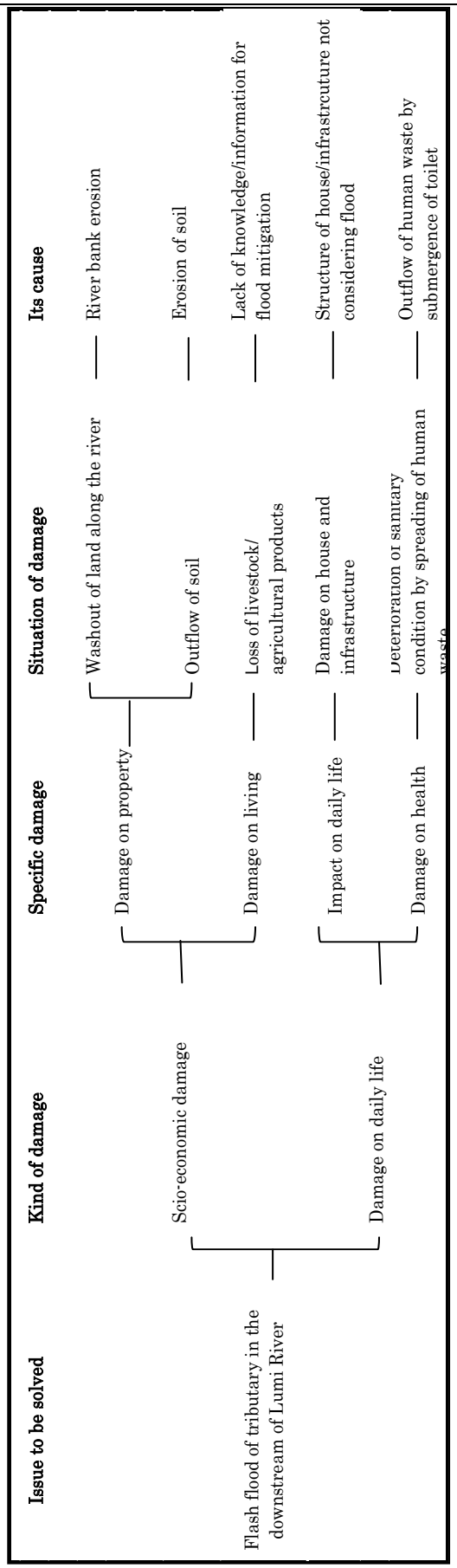


Figure 3.3.5 Analysis on Problem Tree

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.

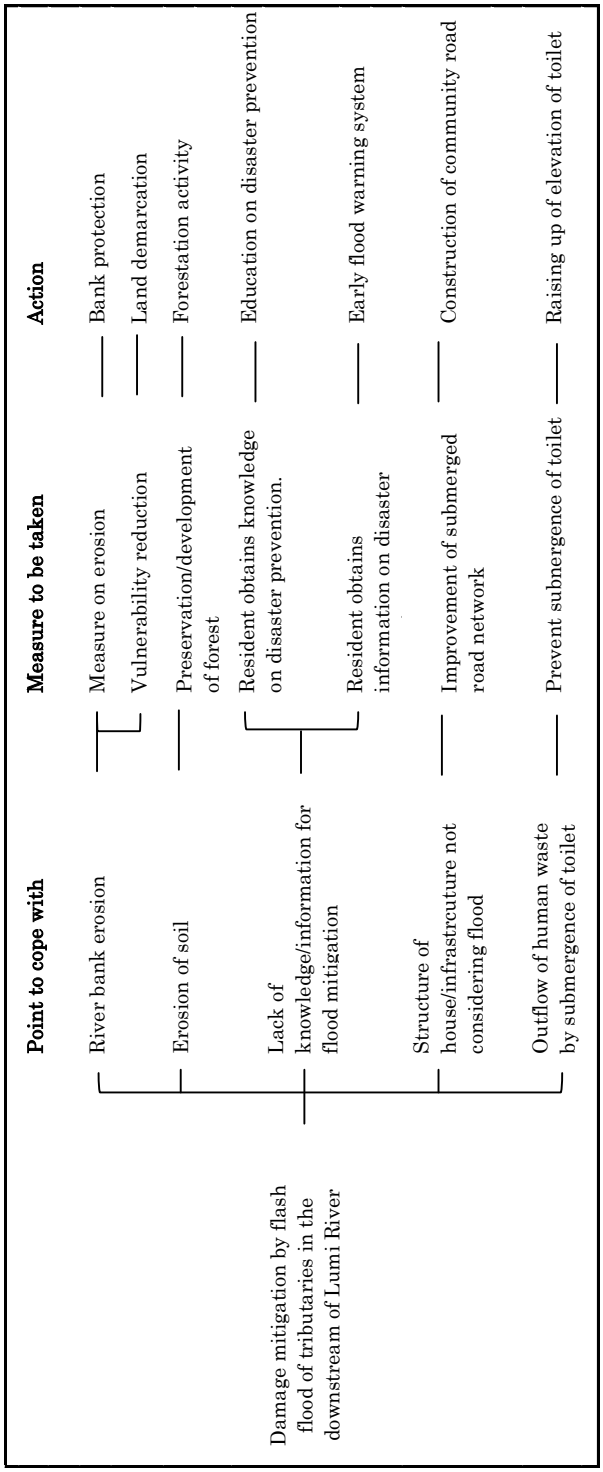


Figure 3.3.6 Analysis on Objective Tree

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		

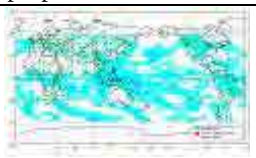
A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

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		

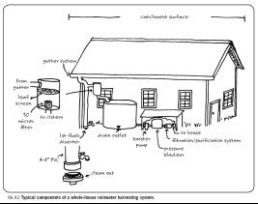
A (3 point): Excellent / B (2 point) : Good / C (1 point) : Poor

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/enlightenment 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.

付属資料 3-4

Gucha Migori 川洪水管理計画案

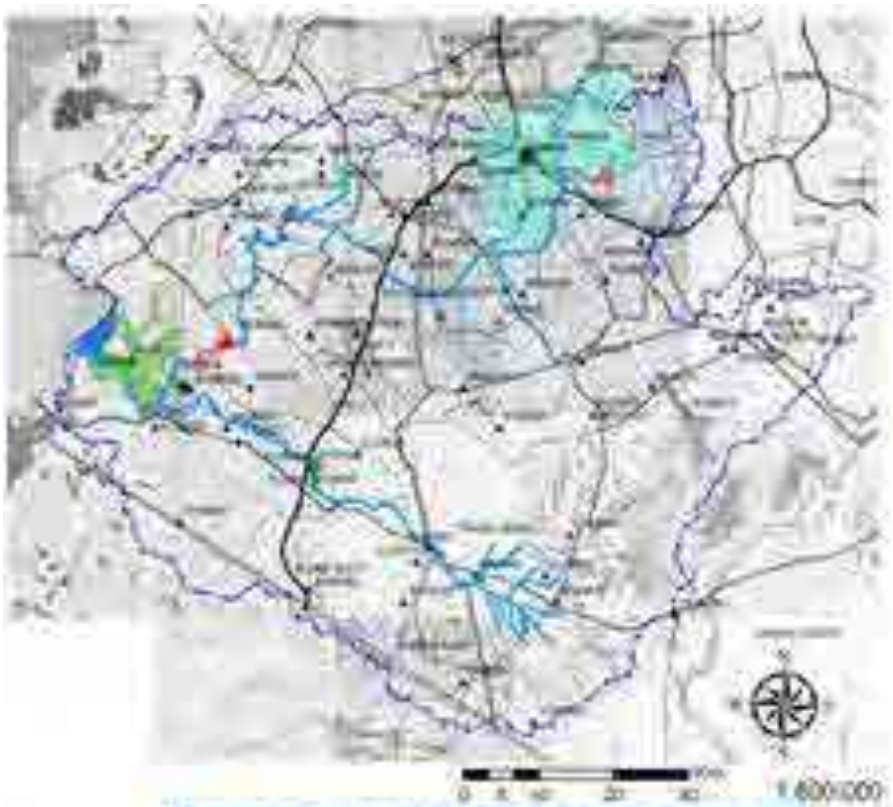
REPUBLIC OF KENYA
PROJECT ON CAPACITY DEVELOPMENT
FOR
EFFECTIVE FLOOD MANAGEMENT IN FLOOD PRONE AREA

GUCHA MIGORI RIVER BASIN INTEGRATED FLOOD MANAGEMENT PLAN -ZERO DRAFT-

JULY 2014
WRMA and JICA

NEWJEC

Name of the River	The Gucha Migori River
River system	The Gucha River and the Migori River
River length	149 km
Catchment Area	6,900 Km2
Annual discharge	58 m3/s
Location	South- western corner of the Lake Victoria basin in westem Kenya
Head Waters	The Gucha river: In the highlands around Keroka in Nyamira county, which rise up to nearly 3,000 m.amsl at Kiatonyora peak. The Migori River: In Chepalungu forest, at altitudes around 2,000 m.asml.



The Gucha Migori River Basin

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

Gucha Migori River Basin Integrated Flood Management Plan
- Draft -

Table of Contents

POLICY OF RIVER BASIN FLOOD MANAGEMENT PLAN (DRAFT)

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

The Gucha Migori river basin is a vast expansive river basin that consist of two river system i.e. River Gucha system and R. Migori System. These two rivers merge at a confluence in Sango area in Central Kadem Location in Nyatike district to become the wide R. Gucha Migori. The river thereafter flows and pours its water in Lake Victoria. R. Gucha has its source in Nyamira County in the Kisii highlands while R. Migori has its source in Narok County specifically in Emuria Dikiri district.

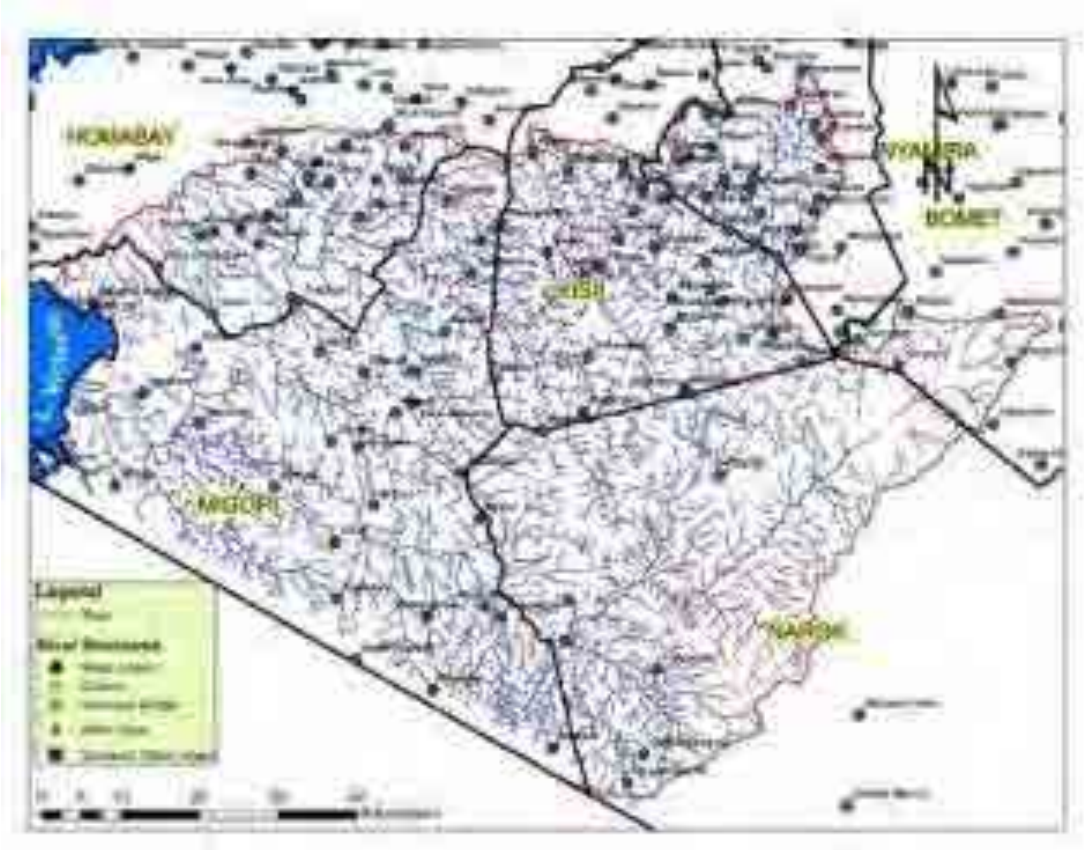


Figure 0.1 Counties wherein Gucha Migori River Basin lies

The Gucha Migori river basin belongings to the jurisdiction of WRMA-LVSC Southern Shoreline Sub Regional Office (SRO) concerning the general water resource management flood management inclusive flood management. Then, LOGUMI WRUA, Ongoche WRUA (Nyatike district), Nyangweta WRUA (Kenyenya district), Middile Gucha WRUA (Gucha district), Nyarwaba WRUA (Nyamarambe district), Chirichiro WRUA (Masaba district), Nyamache WRUA (Nyamache district), Kenyamware WRUA (Nyamira district) Upper Magor WRUA (Emuria Dikiri district) are established within the Gucha Migori river basin. In the flood plane of R. Gucha Migori there is the LOGUMI WRUA that is located within the Lower Gucha Migori Sub-catchment and implements grass-roots water management in

collarroboration with WRMA.

The principal flood damages are destruction of houses, enforcement of longterm evacuation, heavy losses of crops in the farmlands, contamination of water resources by polluted water diffusion, growing worse sanitary conditions and impassable roads and longer period of flood waater inundation of the villages within the flood prone areas etc.

The reason why floods occur is a result of heavy rains in the upstream that leads to heavy surface run-off water to flow into both R. Gucha and R. Migori systems. The surface run-off water erodes soil as it flows into the river leading to heavy sedimentation of the river channel as the water flows downstream. The heavy sediments are deposited downstream leading to shallow river channel in the downstream and with heavy and at a high spead river flows downstream the water overflows its banks leading to floods. On the other hand the flood plain area also experience flash floods from the neighbouring hills within the Lower Gucha Migori Sub-catchment. The flash floods lead to damage of houses and losses of properties, crops and livestock. The measures against floods will be important because the numbers of affected by floods with flood inundation of more than two months are more than three thousand (3000) every year.

Therefore the important point of the flood management policy in relevant river basin shall be mitigation against the impacts of flood damage which include disruption of the daily livelihood and lack of a hospitable and safe evacuation place moreover enlightment schemes that will make it easier,quicker and faster life-skills in recovery from the flood damages.

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.

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.

RIVER BASIN COMMITTEE

Flood management cannot achieve the objectives without the cooperation of various stakeholders within 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 The Stakeholders in Gucha Migori River Basin

No	Organization	Remarks
1	WRUAs within Gucha Migori River Basin	One representative from each of the nine WRUAs
2	Provincial Administration	District Commissioner, Nyatike district
3	Ministry of State for Special Programmes	Active in providing humanitarian assistance to disaster victims in Lower Gucha Migori area
4	CFMOs within LOGUMI SC	One representative from each CFMO
5	Ministry of Water and Irrigation	Migori County Director for Water
6	Heads of Evacuation Places (Nyora and Kabuto Primary Schools)	One representatives from the two schools that act as evacuation places
7	Ministry of Agriculture	Nyamira County Director and District Agricultural Officer Nyatike
8	Ministry of Forestry	Narok County Director
9	Ministry Of Education	District Education Officer Nyatike
10	Kenya Meteorological Department	Contact Person at National Level
11	Lake Basin Development Authority (LBDA)	Representative from Kerian Sub-regional Office
12	National Environmental Management Authority	Migori County Director
13	Blue Cross	One representative
14	Kenya Red Cross	Representative from Migori Branch
15	World Vision	Representative from Regional Office
16	CAAC	CAAC member
17	Fishermen	One representative
18	Farmers	One representative
19	Environment/Natural Resources Management CBOs	Environment representative
20	Religious Group	One each from downstream, midstream and upstream
21	Kenya Forest Service	CAAC member
22	Department of Social Services	Registers WRUAs and other social welfare groups
22	Kenya National Chamber of Commerce and Industry	Gucha Migori chapter
23	Catholic Diocese of Gucha Migori	One representative
24	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 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	Held on 18th Dec. 2013
2nd Meeting	Cause & Effect of floods in Gucha Migori	Held on 27th Feb. 2014
3rd Meeting	Draft IFMP and building consensus on the draft IFMP	Tentative date 10th April 2014
4th Meeting	Methods of incorporating the IFMP into the SCMP, CMS, county government strategic plans	Tentative date 22nd May 2014
5th Meeting	Prioritization of countermeasures and identifying avenues for funding the implementation	Tentative date 26th June 2014

ENVIRONMENTAL AND SOCIAL CONSIDERATIONSONS

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”.

OUTLINE OF GUCHA MIGORI RIVER BASIN

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

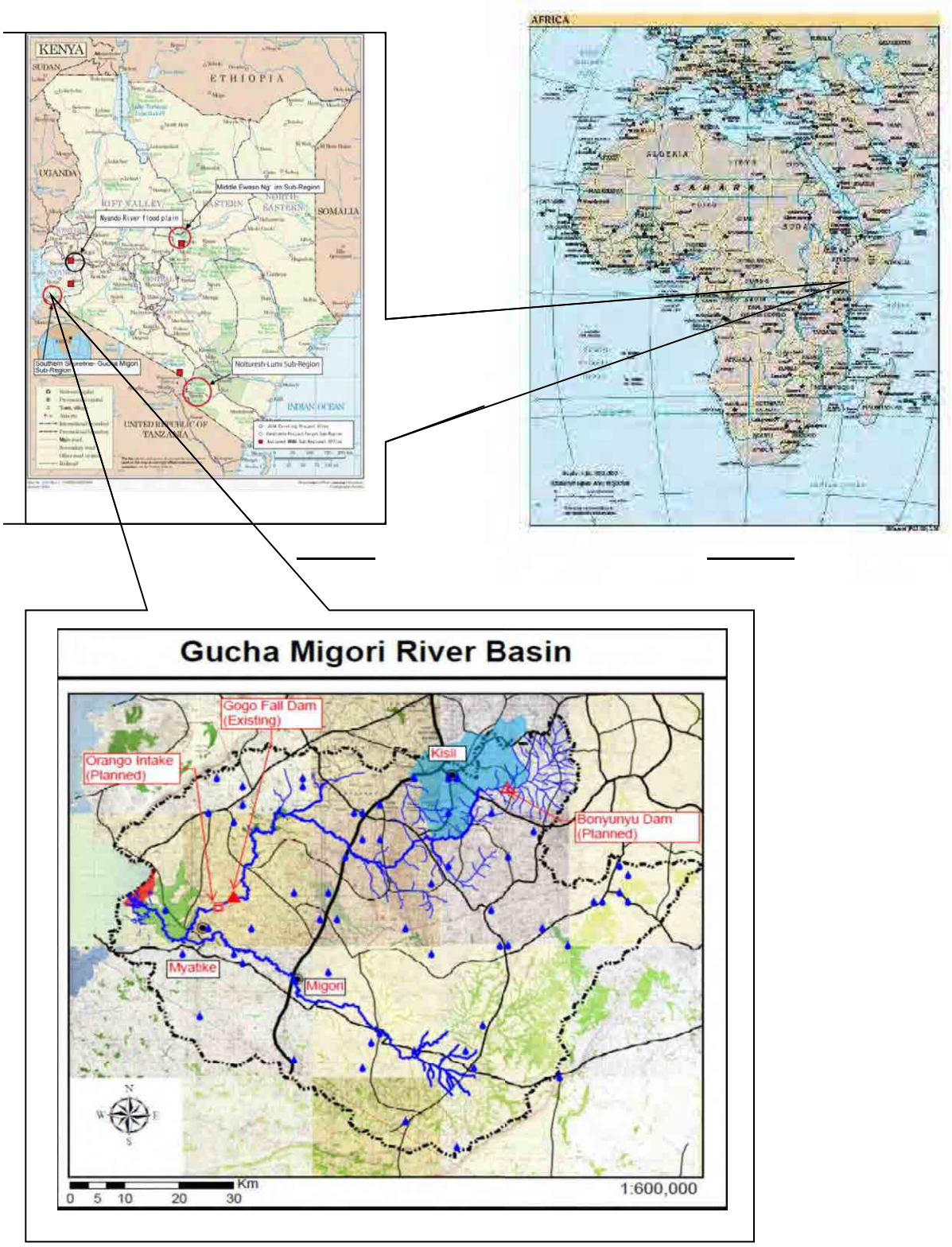


Figure 0.1 Records of Flood Damage in the Gucha Migori River Basin

Natural Conditions

1.1.1 Background

Wikipedei the Free Encyclopedia explains concerning R. Gucha as follows: Gucha River, referred to River Kuja by Luo community starts from the highlands of Kiabonyoru in Nyamira county passing through the heart of Gucha District running west through Migori Town where its Joined by other smaller rivers then into Lake Victoria. Streams, as it runs across the Gusii Land come together and one of them being Mogonga River, known by every Kisii of its deadly effects it leaves behind when it floods. Mogonga and Gucha are almost equal in size and they meet just 1 mile before entering into Ogembo Town Center.

It further explains concerning Migori town as follows: Its elevation is roughly 1500 meters above sea level (asl.) at Kakrao descending by 100 m asl. into the Migori river. The different peaks near the town are a little over 1550 m asl.

The graphic description of the Gucha Migori based on a study carried out in 1976 is as indicated in the figure 2.2 below:

Source: Preliminary Report No. 14 Agricultural University Wageningen Netherlands
Training Project in Pedology Kisii, Kenya

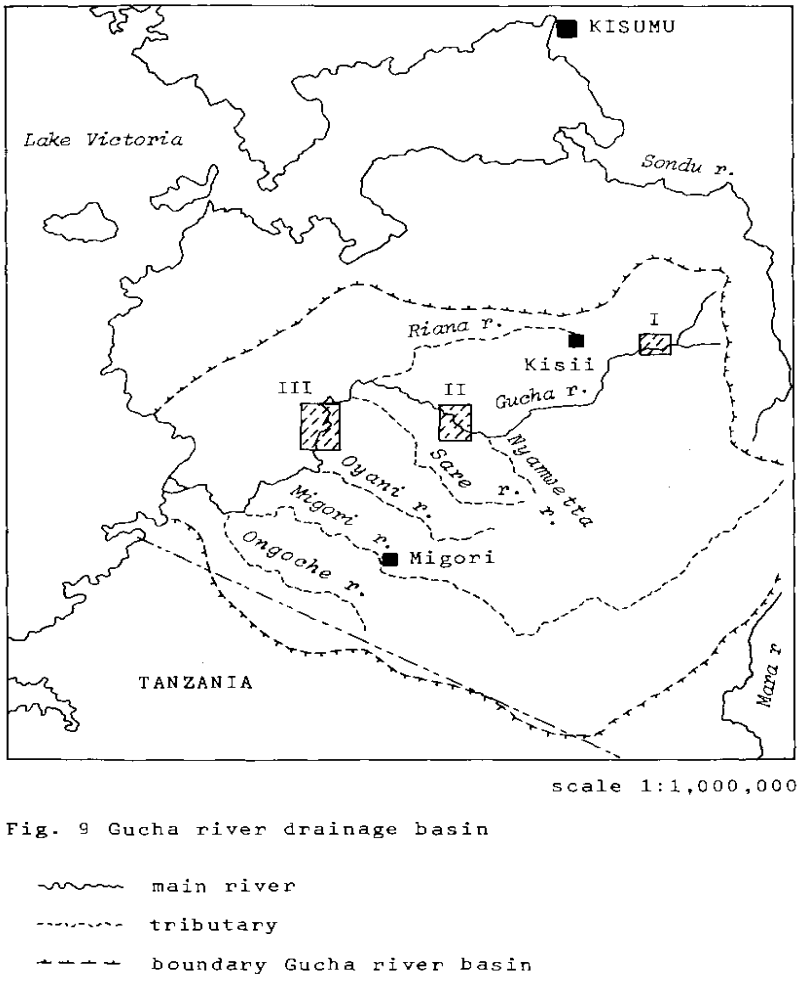


Figure 0.2 Gucha Migori River Basin Map as at 1976

1.1.2 Topography , Vegetation and Soil

(1) Topography, Geology and Vegetation

Gucha-Migori River Basin cuts across five counties i.e. Nyamira County, Kisii County, Narok County, Homa Bay County and Migori County. The Gucha-Migori River Basin is therefore located on the south-western corner of the Lake Victoria Basin in western Kenya. The R. Gucha has its source in the of Nyamira county, which rise up to nearly 3,000 m.amsl at Kiabonyoro peak GPS location Altitude1653M South 00034'07.6" East 034058'50.3".

The Migori River has its source in Chepalungu forest, at altitudes of around 2,000 m.amsl, and drains a large area west of the Sirian Escarpment which shields the Maasai Mara to the east. The two rivers together have a catchment area which spans over 6,900 km² in Nyamira, Kisii, Migori and a section in the western-most Narok counties. At the confluence of R. Gucha and R. Migori near Macalder Mines, about 30 km from their mouth on Lake Victoria the mean annual runoffs (MAR) of the Gucha and Migori rivers are estimated at 1,083 and 609 Mm^3/year respectively. At the outflow to Lake Victoria the MAR is estimated at 1,884 Mm^3/year. Figure 1.2.[1]

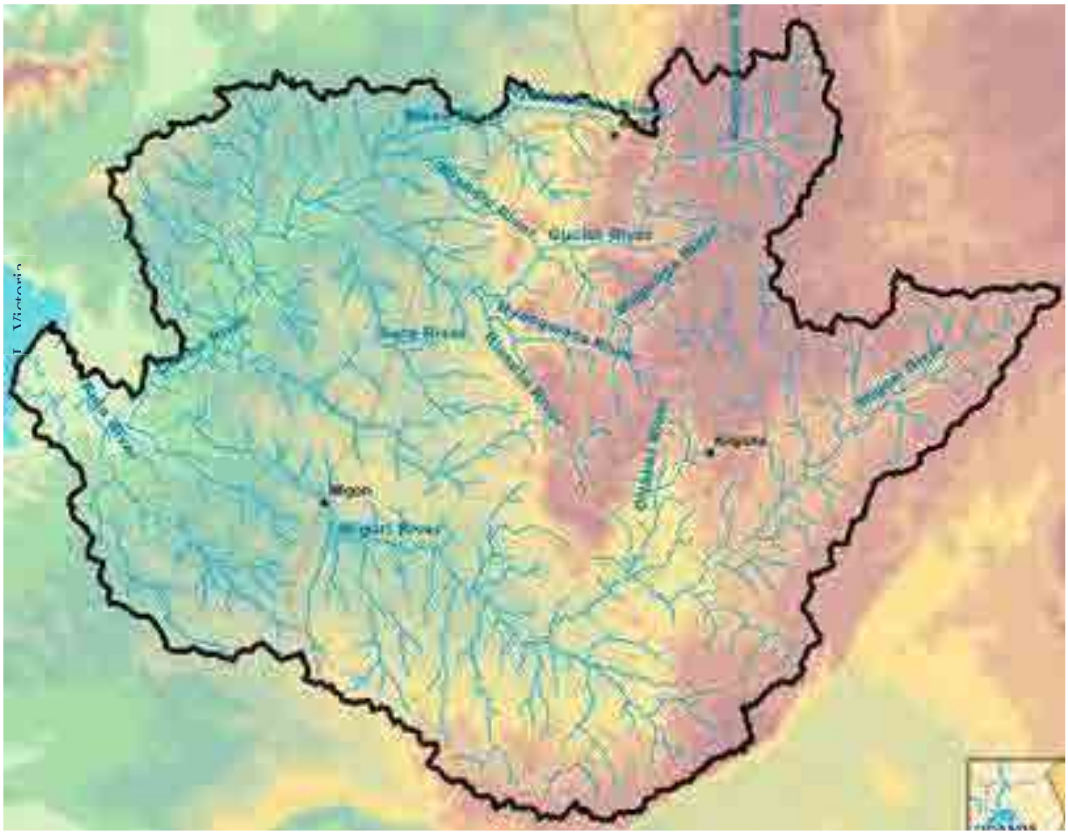


Figure 0.3 Gucha Migori River Basin Map

Source: Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin In Kenya: Final Strategy Report

[1] Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin in Kenya: Final Strategy Report

The geology of the Gucha catchment consists mainly of old Bukoban system rocks which are of Palaeozoic age. Those within the catchment are represented by the Kisii series. A narrow belt of Precambrian and Kavirondian systems of rock occur in the lower western parts of the catchment. The Bukoban system consists of a broad north-south belt of acidic volcanics with a narrow belt of quartzite and escarpments. On the far western andsoutheastern parts of the catchment is found a quartzitic belt which is sandwiched by a broad belt of basalt. Kisii soapstones within the central parts of of the catchment are derived from the basalt by hydrothermal activity. Post-Kavirondian conglomerates, grits and sandstones are predominant in some parts of the catchment such as Wanjare-South Mugirango. Most of the western parts lie within the rhyolite and tuff belt. Western parts that border the South Nyanza district are predominantly covered by porphyritic and non-porphyritic felsite and andésite.

The Gucha River rises from an elevation of 1500M at its confluence with Gucha-Migori to 1800M in the Kisii uplands which in some parts rise up to an altitude of 3000M. The main watershed of the Gucha River occurs within the Kisii uplands which are above the sub-Miocene erosion surface (Pulfrey, 1960).[2]

To understand the slope in the river basin, the basin has been divided into three slope units as follows: a) upstream slope unit, mistream slope unit and downstream slope units. These slope units have different slope gradient and slope form depending on the location. The slope gradient is in percentage (%) while the slope form is the profile curvecature. The slope gradient in Gucha Migori varies from 0-5% to 5%-10% in the downstream with slope form of concave, 10-15% to 20-25% in the midstream with slope form of convex but irregular and 25% to over 40% in the upstream with slope form of convex in most parts.

Land use characteristics of Gucha Migori River Basin are shown on Figure 0.4. In the upstream areas there are extensive agricultural activities. The land in the upstream is arable leading to deforestation. In Kisii highlands the population is huge compared to the available land. In the upstream especially in the Kisii highlands Eucalyptus trees have been extensively been planted. There is heavy brick-making in Nyamira district due to the nature of the soil in the area. In Transmara there has been a shift from livestock keeping to commercial agriculture that has led to heavy deforestation. Most of the forests in Transmara are owned by individuals who engage in charcoal production. The forest cover in Transmara district is mainly indigeneous trees. In the midstream of Gucha Migori River Basin, the land is arable and there is heavy investment in sugarcane and tobacco farming. In the midstream the trees are conserved in the hilltops. In the downstream the land is fertile and arable but the climate is semi-arid and vegetation cover is mainly savanna grasslands.

2) Soil Erosion in Gucha Migori River Basin

Soil erosion is a serious problem in the Gucha catchment, bank and channel erosion are partly

[2] Impact of hydrological and land use processes on the quality of water in the Gucha catchment, southwestern Kenya

responsible for the sediments transported by the river. In addition cultivation in areas adjacent the river also contributes to the observed sediment transport rates. Other factors in sediment production are untarmacked and feeder access roads (Omari, 1986). The average suspended sediment concentration is 325.5 ppm while the total sediment transport rate is 0.4 x 106 t year"1 (Ongwenyi, 1979).[3]

The following figures indicate:

i) The Longitudinal Profile for the R. Gucha Migori is as indicated in the Figure 2.3

ii) Landuse map in the river basin is indicated in Figure 2.4.

[3] Impact of hydrological and land use processes on the quality of water in the Gucha catchment, southwestern Kenya

Source: Preliminary Report No. 14 Agricultural University Wageningen Netherlands Training Project in Pedology Kisii, Kenya

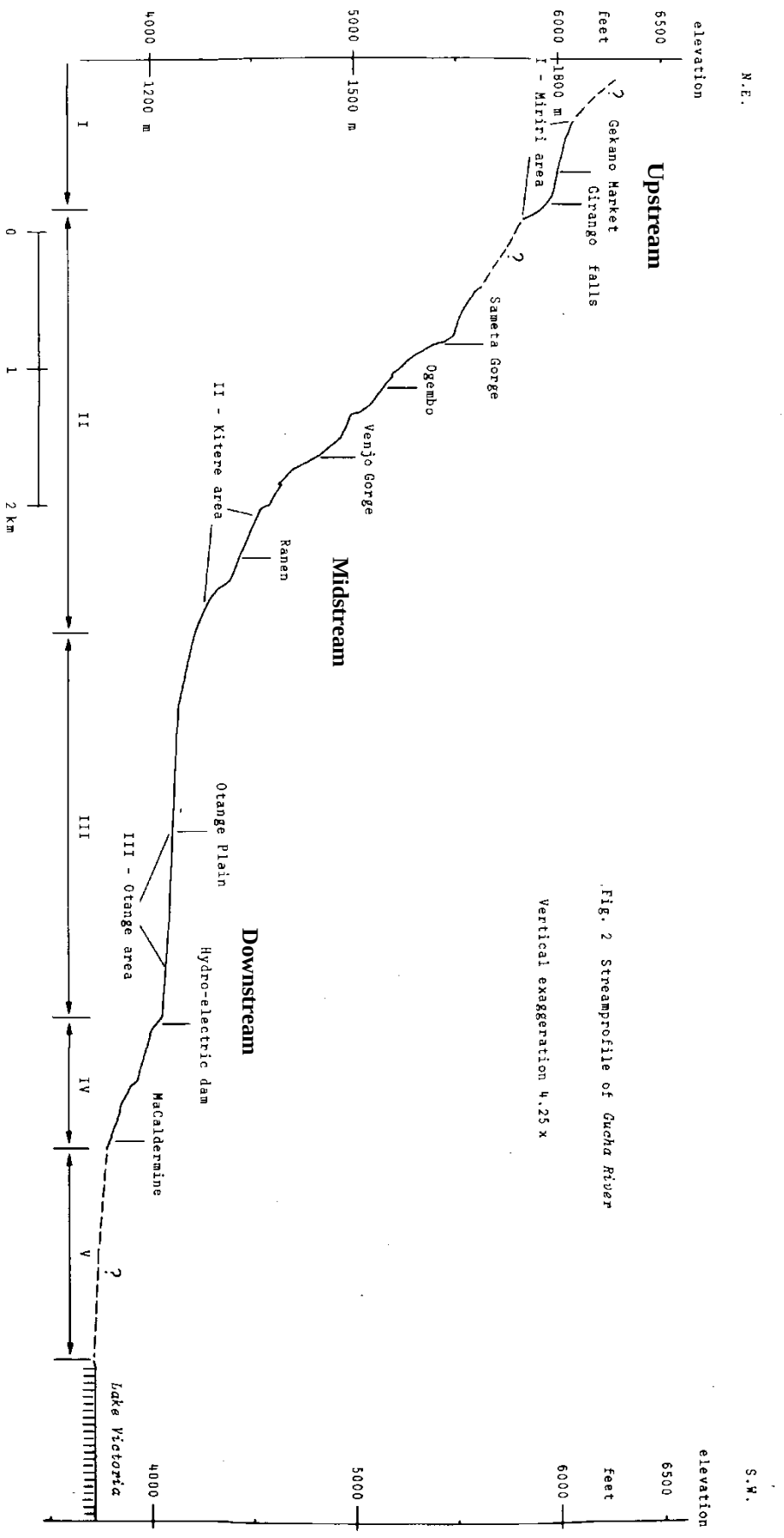


Figure 0.4 Longitidunal Profile for Gucha Migori River

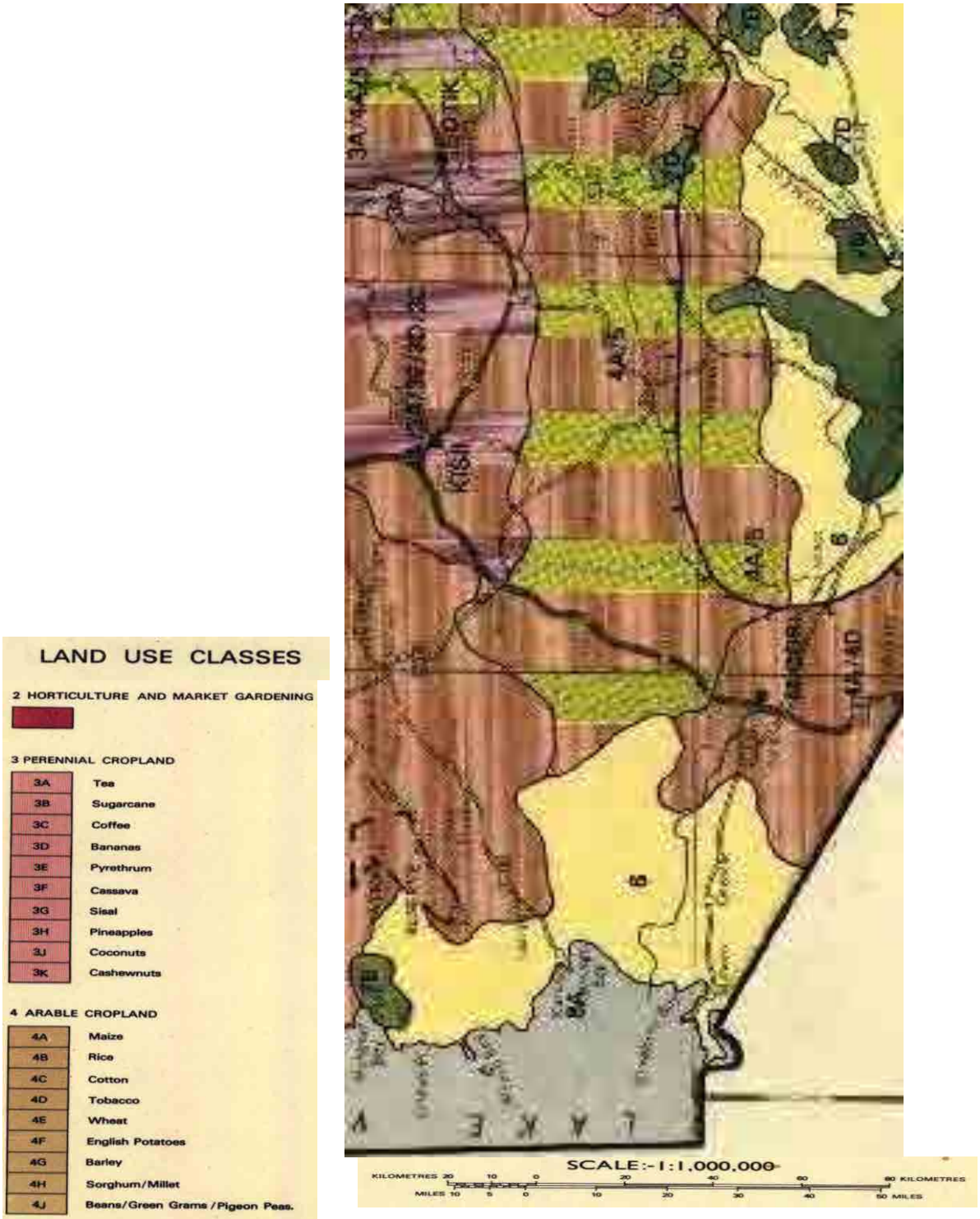


Figure 0.5 Distribution Map of Topographic Slope of Gucha Migori River Basin

(2) Soil

Soil Distribution Map of Gucha Migori River Basin is as per Figure 2.5. The upstream of Gucha system consist of the fertile reddish volcanic loamy soils that cover most parts of Kisii and Nyamira highlands. The upstream of Migori system consist of fertile alluvial grayish clay soil. The midstream area is mainly covered by fertile grayish clay soil and some areas area sandy. The downstream is covered by grayish clay soil in some parts, while other parts are covered by black cotton soil and near the river it is characterized by clay soil and sandy soil.

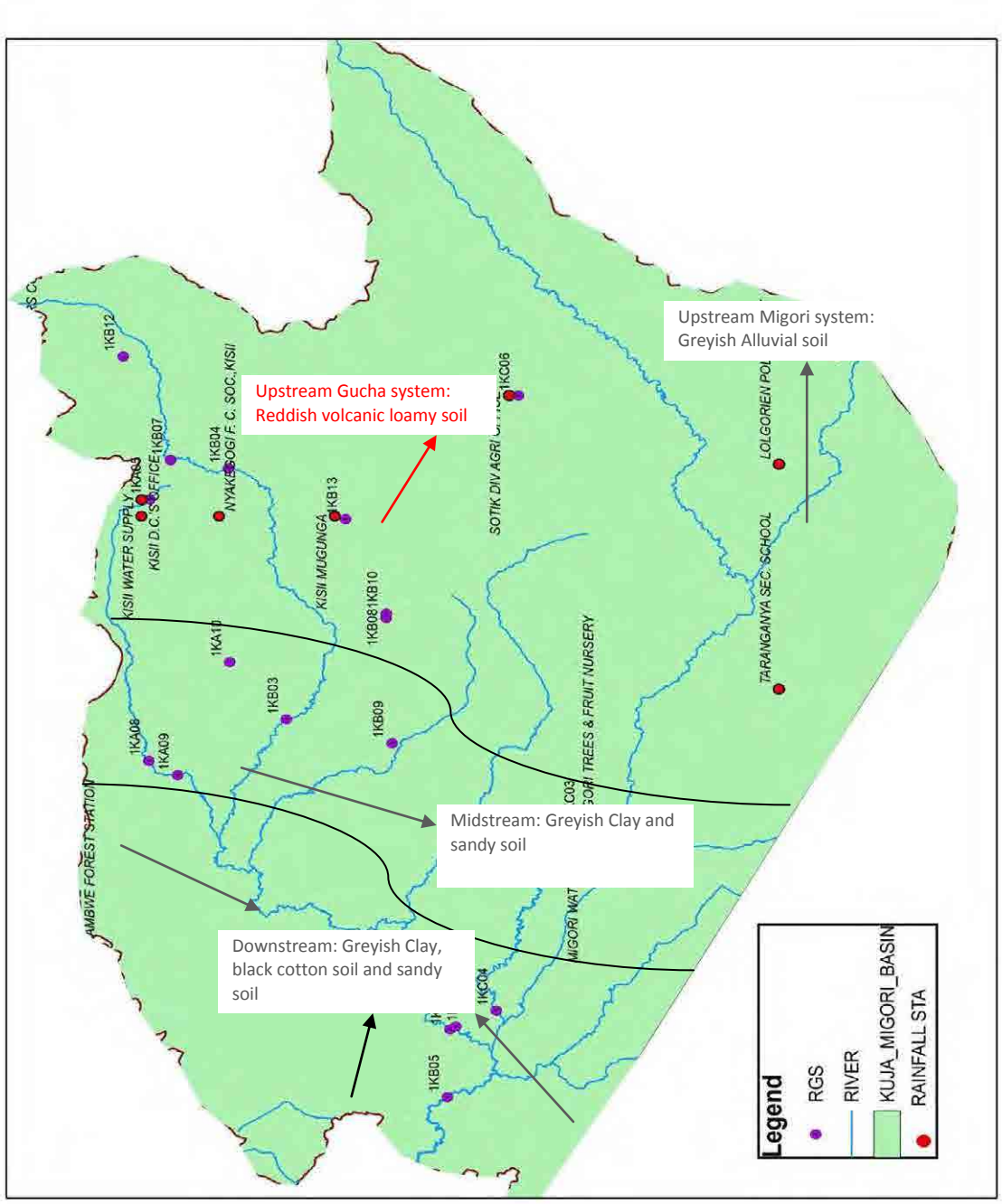


Figure 0.6 Soil Distribution Map (Soil texture)

1.1.3 River Characteristics

(1) Riverbed Materials

The R. Gucha Migori is a river that forms after two big rivers join together to drain its water into Lake Victoria. It is wide with some places like Sango having a width of approximately one hundred and twenty metres (120M). It is imperative therefore to highlight the river bed materials from the source to the Lake. The table 2.1 below therefore indicate the riverbed materials for both R. Gucha and R. Migoriand R. Gucha Migori after the confluence.

Table 2.1 Location and Riverbed Materials in R. Gucha Migori

SN	Place	River Name and features	Riverbed Material
1	Getengerine in Kiabonyoru, Nyamira District (This area is where the source of R. Gucha is located)	R.Gucha (at the source)	Pebbles and water is very clean
2	Magombo in Kenyerere in Nyamira District	R. Gucha	Rocks and water is very clean
3	Rigwero in Nyamira District	R. Kanyamware a tributary of R. Gucha	Rocky riverbed, water not clean and cattle treads noted on the riverbanks
4	Gekano-Kanyamwere boundary. (There is a confluence of R. Gekano; R. Kanyamware and R. Gucha)	Confluence of R. Gekano and R. Kanyamware all joining into R. Gucha	Pebbles, soil sediments riverbed, water is brown in colour and riverbank erosion noted
5	Kianwarimu-Gekano bridge	R. Gucha	Pebbles, soil sediments riverbed, water is brown in colour and riverbank erosion noted
6	Gekano area in Nyamira district	R. Gucha	Soil sediment with few pebbles riverbed, water is brown in colour and the riverbank erosion is pronounced
7	Esani bridge in Esani area boundary of Manga and Boribari District. The place experiences floods during rainy season	R. Gucha	Soil sediment (sandy) and pebbles riverbed, water is brown in colour and the riverbank erosion is pronounced
8	Kegati Water plant in Kisii Town (Water suppy plant for Kisii)	R. Gucha	Rocky and soil sedimentation riverbed and water is brown in colour after the intake
9	Ogembo Bridge in Gucha District	R. Gucha	Rocky and soil sedimentation riverbed and water is not clean
10	Sare Bridge in Awendo Town	R. Sare a tributary of R. Gucha	Rocky and sandy riverbed; overgrown vegetation on some parts of the river channel water is brown in colour
11	Oyani Bridge in Awendo town	R. Oyani a tributary of R. Gucha	Rocky and sandy riverbed; run-off surface water from surrounding hill flow into river channel and water in the river is brown in colour
12	Gogo Kengen, Nyatike District. (A hydroelectric generation planted established during colonial era)	R. Gucha	Rocky and sandy riverbed
13	Daraja Aego, Nyatike District	R. Gucha	Rocky and sandy riverbed and wooden logs in the river channel

14	Sango area in Nyatike district. (This is where the confluence of R. Gucha and R. Migori is located)	R. Gucha Migori	Rocky and sandy riverbed; Sediment deposits that has led to gold mining when the water levels of the river reduces
15	Wath Onger (This is Lower Gucha Migori Area)	R. Gucha Migori	Rocky and sandy riverbed and wooden logs in the river channel
16	Onyinjo Area	R. Onyinjo a seasonal river that flows into R. Gucha	Rocky riverbed with overgrown vegetation in some parts of the river channels
17	Mirogi	R. Mirogi that flows into R. Gucha	Rocky riverbed water is dirty and in some places the water seems stagnant
18	Oljoposei Area in Transmara District	R. Oljoposei draining into R. Migori	Rocky and pebble riverbed and the river channel is narrow
19	Kaposorwa in Transmara District	R. Moiguiet	Soil sedimentation riverbed, narrow channel and watering point for livestock
20	Kapng'eno area in Transmara District (this is where the confluence of R. Moiguiet and R. Migori is located)	R. Moiguiet joining R. Migori	Confluence of two rivers and velocity of both rivers is high, natural indigenous trees noticeable and soil sedimentation riverbed
21	Magor bridge in Transmara East district	R. Migori	Soil sedimentation riverbed, water levels low during dry season and very high during rainy season
22	Esoit-Naibor area	R. Migori	Rocky riverbed and wooden logs noticeable in the river channel
23	Mikei area in Nyatike District	R. Migori	Rocky and sandy riverbed and community people use different points for gold ore washing
24	Enoosaen area in Keyian division Transmara District	R. Enoosaen a tributary of R. Migori	Rocky and sandy materials. Lots of car washing activities within the river channel
25	Enoosaen area in Keyian division Transmara District	R. Enoosaen a tributary of R. Migori	Pebbles and sand alluvial materials
26	ASTU, Indiyano Sub-location Transmara District	R. Remo a tributary of R. Migori	Rocky, pebbles and sand alluvial materials.
27	Ndiri area Transmara District	R. Ndiri a seasonal river and tributary of R. Migori	Rocky, pebbles and alluvial soil sediments materials. Water at some points the flow is very slow almost stagnant
28	Transmara-Kuria boundary bridge	R. Migori	Rocky and sand alluvial materials.
29	Nyeikute village, Komanga Sub-location in Kuria-Kihancha District	R. Nyogoto a tributary of R. Migori	Rocky and sand alluvial materials.
30	Daraja ya Masaba area boundary of Nthiange and Masaba sub-locations in Kuria District	R. Bungenech a tributary of R. Migori	Rocky and sand alluvial materials.
31	Hibwa Area in Kuria District. (This is where a conluence of R. Bosara and R. Nyandara is and thus forming R. Hibwaa)	R. Hibwaa a tributary of R. Migori and starts at the confluence of R. Bosara and R. Nyandara (both sources are in Tanzania)	Rocky, pebbles and sand alluvial materials.
32	Ragane Area near the boundary of Kuria and Migori districts	R. Ragena a tributary of R. Migori	Rocky and pebbles materials.

33	Migori Bridge in Migori Town	R. Migori	Rocky and sand alluvial materials.
34	Nyasare Estate in Migori town	R. Nyasare a tributary of R. Migori	Rocky, pebbles and sand alluvial materials.
35	R. Migori at Nyasare area in Migori town	R. Migori	Rocky and sand alluvial materials.
36	Nyamure in Magina area in Migori town	R. Nyagugo also known as R. Nyamure about 100M to R. Migori	Rocky, pebbles and sand alluvial materials.
37	Kakrao area	R. Nyasarara that drains into R. Migori	Rocky, pebbles and sand alluvial materials and is crystal in colour.
38	Othatcho location near othatcho hills	R. Othatcho (spring) that drains into R. Migori	Pebbles and soil sediment materials and is crystal clear
39	Eko area, Ajego Sub-location, Othatcho location	R. Eko a tributary of R. Migori	Rocky and soil sediment materials
40	Nyarogi Sub-location, Othatcho location	R. Nyakonya a tributary of R. Migori	Rocky and soil sediment materials
41	Kadem south - Othatcho locations boundary	R. Owich a seasonal river and a tributary of R. Migori	Rocky and soil sediment materials
42	Mikei area in Nyatike District here after the R. Migori moves towards confluence with R. Gucha at Sango area in Lower Gucha Migori SC	R. Migori	Rocky and sandy riverbed and community people use different points for gold ore washing

Source JICA Project Team

(2) River Structures

River Gucha Migori has two river systems i.e. River Gucha system and R. Migori system. Along these two systems there are various river structures constructed therein along the river or besides the river in the two river system.

The pictures in table 2.2 below are divided in the respective river system and indicate the river structures and riverbed materials along R. Gucha Migori from the upstream, midstream and downstream.

Table 2.2 Pictures of the River Structures along R. Gucha Migori

River Gucha System: Upstream	
	
Description : R. Gucha at its source in Getengerine village in Kiabonyoru and community members use it for domestic use	Description : R. Gucha at its source in Getengerine village in Kiabonyoru,Nyamira District the river channel is narrow
	
Description : Magombo in Kenyerere in Nyamira District the water in the river channel is colourless and clean with rocky riverbed	Description : Magombo in Kenyerere in Nyamira District the river structure is a culvert constructed for purposes of road transport
	
Description : R. Kanyamwere a tributary of R. Gucha located in Rigwero area in Nyamira District, the river water starts changing colour and the riverbed material is rocky	Description : R. Kanyamwere a tributary of R. Gucha located in Rigwero area in Nyamira District, the river acts as watering point for livestock and thereis a vehicular bridge

	
Description : Confluence point at Gekano-Kanyamware boundary where R. Gekano and R. Kanyamware join and both drain into R. Gucha. Riverbed material is pebbles and soil sediments and there is riverbank erosion	Description : Gekano-Kanyamware boundary the river structure is a seventeen metre (17M) concrete vehicular bridge that links two sub-locations and there are brick making works by community members just 20M from the river
	
Description : Kianwarimu-Gekano area where the water is light brown greyish in colour and the riverbed material is pebbles and soil sediments and there is riverbank erosion	Description : Kianwarimu-Gekano area here there is a twenty metre (20M) steel footbridge constructed and blue gum trees are planted in the riparian areas
	
Description : R. Gucha widens at Gekano area in Nyamira district as it flows downstream riverbed material is soil sediments with few traces of pebbles	Description :Gekano area in Nyamira district where there is a river structure a drainage canal dug by community members to channel water from their nearby hills into the river channel

	
Description : Esani area boundary of Manga and Boribari Districtriver structure includes a vehicular bridge constructed on the murram road that links Manga and Boribari	Description : Community member from Esani explains how the drainage canal was dug and now it protects the bridge from being flooded but the nearby school still get affected by floods during rainy seasons
	
Description: Kegati area in Kisii Town the river water is brown in colour and riverbed material is rocky and soil sediment there is minimal riverbank erosion	Description : Kegati area in Kisii Town the river structure includes water intake that supplies Kisii town
	
Description : Kegati area in Kisii Town the river structure includes vehicular bridge that KisiiNarok road passes over the R. Gucha	Description : Kegati area in Kisii Town the water flows downstream and there is vegetation cover in the riparian areas

	
Description :Ogembo town in Gucha District the river water is brown in colour and riverbed material is rocky and soil sediment there is minimal riverbank erosion	Description :Ogembo town in Gucha District the river structure includes vehicular bridge that KisiiKilgorisroad passes over the R. Gucha
	
Description : Ogembo town in Gucha District the river structure includes the gabion works used to reinforce the vehicular bridge that KisiiKilgoris road passes over the R. Gucha	Description : Ogembo town in Gucha District the river structure includes the under construction footbridge that will give pedestrian easy access to the market stalls

River Gucha System: Midstream

	
Description : Sare bridge in Awendo town R. Sare a tributary of R. Gucha. The river water is brown in colour and riverbed material is rocky and sandy there is minimal riverbank erosion	Description :Sare bridge in Awendo town the river structure includes the gabion works used to reinforce the vehicular bridge that KisiiMigori road passes over the R. Sare

	
Description : Oyani bridge where R. Oyani a tributary of R. Gucha passes under. The river water is brown in colour and riverbed material is rocky and sandy there is minimal riverbank erosion	Description : Oyani bridge inear Awendo town the river structure includes the gabion works used to reinforce the vehicular bridge that KisiiMigori road passes over the R. Oyani and their debris in river channel
	
Description : Onyinjo bridge where seasonal R. Onyinjo a tributary of R. Gucha passes under. There are overgrown vegetation within the river channel and the riverbed material is rocky	Description : Mirogi bridge the river structure includes the vehicular bridge that Sori-Rongo road passes over the R. Mirogi in which the water is greyish in colour and some point stagnant and riverbed material is rocky

River Gucha System: Downstream

	
Description : GogoKenGenGogoin Nyatike district R. Gucha flows downstream and the water colour is brownish and the riverbed material is rocky and soil sediments	Description : GogoKenGenGogo Hydroelectric plant on R. Gucha. River Structures include dam, water intake and footbridge. The dam is silted

	
Description : GogoKenGenGogo Hydroelectric plant on R. Gucha. The water flows at high velocity	Description : GogoKenGenGogo Hydroelectric plant on R. Gucha. The dam is silted leading to vegetation growth in some parts of the dam
	
Description : DarajaAego in Nyatike District, R. Gucha flows downstream and the water colour is brownish and the riverbed material is rocky and soil sediments. The river structure is the vehicular bridge on Migori-WathOnger road	Description : DarajaAego in Nyatike District, R. Gucha flows downstream and the water abstractors using pumps to pump into their lorry thereafter use the water to wash gold ore in the mines
	
Description : Sango area in Nyatike District, the confluence of R. Gucha and R. Migori the water colour is brownish and the riverbed material is rocky, sandy and soil sediments.	Description : Sango area in Nyatike District, the confluence of R. Gucha and R. Migori there is a huge deposit of soil sediments within the river channel which during rainy season is covered by water

	
Description : Sango area in Nyatike District, the confluence of R. Gucha and R. Migori the community members mine gold from the soil sediments deposited within the river channel during low rain seasons	Description : R. Gucha at the downstream where there is riparian encroachment with agricultural activities undertaken almost at the brick of the riverbanks
	
Description : WathOnger R. GuchaMigori flows downstream the water is brownish in colour and the riverbed material is rocky, sandy and soil sediments and in the river structure includes vehicular bridge on WathOnger-Muhuru Bay road	Description : WathOnger R. GuchaMigori flows downstream the water is brownish in colour and the river structure includes WRMA's river gauge station and in the river channel there are wooden logs debris
River Migori System: Upstream	
	
Description : Oljoposei Area in Transmara District, where R. Oljoposei which drains into R. Migori has riverbed material as rocky and pebble riverbed and the river channel is narrow	Description : Oljoposei Area in Transmara District, where R. Oljoposei which drains into R. Migori has river structure of a box culvert and community members use the river for washing their motorcycle

	
Description : Kaposorwa in Transmara District, R. Moiguiet that drains into R. Migori flows through. The riverbed material soil sedimentation	Description : Kaposorwa in Transmara District, R. Moiguiet which drains into R. Migori has river structure of a vehicular bridge and the river is a watering point for livestock
	
Description : Kapng'eno area in Transmara District, R. Moiguiet joins with R. Migori the area is the confluence of two rivers and riverbed material is soil sedimentation rand natural indigenous trees are noticeable	Description : Kapng'eno area in Transmara District, R. Moiguiet joins with R. Migori at this confluence there are no river structures and community members wade through water to cross the river
	
Description : Magor bridge in Transmara East district R. Migori flows through. The riverbed material soil sedimentation water levels are low during dry season and very high during rainy season	Description : Magor bridge in Transmara East district R. Migori flows under this bridge . The river structure is a vehicular steel bridge, there vegetation noted in the river channels

	
Description : Esoit-Naibor area in Transmara District, R. Migori flows downstream riverbed material is rocky riverbed and wooden logs noticeable in the river channel	Description : Esoit-Naibor area in Transmara District, R. Migori flows downstream river structure is a vehicular two compartment bridge
	
Description : Enoosaen area in Keyian in Transmara District, R. Enoosaen that drains into R. Migori flows downstream riverbed material is rocky and sandy	Description : Enoosaen area in Keyian in Transmara District, R. Enoosaen that drains into R. Migori flows downstream river structure is wooden footbridge and there are car washing activities
	
Description : Enoosaen area in Keyian in Transmara District, R. Enoosaen that drains into R. Migori flows downstream riverbed material is rocky and sand alluvial	Description : Enoosaen area in Keyian in Transmara District, R. Enoosaen that drains into R. Migori flows downstream river structure is eight cylindrical culvert of which 2 are blocked

	
Description : ASTU, Indiyano Sub-location Transmara District R. Remo that drains into R. Migori flows downstream riverbed material is rocky, pebbles and sand alluvial	Description : ASTU, Indiyano Sub-location Transmara District R. Remo flows through a river structure a box 3 compartment bridge for vehicular use and 2 cylindrical culvert compartments constructed as one unit
	
Description : Ndiri area in Transmara District, R. Ndiri that drains into R. Migori flows downstream riverbed material is rocky pebbles and alluvial soil	Description : Ndiri area in Transmara District, river structure is a vehicular Bridge; and parts of old structures of the decommissioned bridge and also a watering point for livestock

River Migori System: Midstream

	
Description : Transmara-Kuria boundary bridge R. Migori flows downstream riverbed material is rocky and sand alluvial and the point acts as a watering point for livestock	Description : Transmara-Kuria boundary bridge R. Migori flows downstream river structure 5 compartments vehicular bridge

	
Description : Nyeikute village, Komanga Sub-location in Kuria-Kihancha District R. Nyogoto a tributary of R. Migori has riverbed material of rocky and sand alluvial	Description : R. Nyogoto a tributary of R. Migori has river structure box culvert for vehicular use; River overflows the bridge and affects the farms nearby
	
Description : Daraja ya Masaba area boundary of Nthiange and Masaba sub-locations in Kuria District R. Bungenech a tributary of R. Migori has riverbed material of rocky and sand alluvial. River catchment is intact with minimal human activities observed	Description : R. Bungenech a tributary of R. Migori has river structure of box culvert on the road that links the two locations i.e. Nthiange and Masaba sub-locations in Kuria District
	
Description : At the confluence of R. Bosara and R. Nyandara is where R. Hibwaa a tributary of R. Migori starts. Riverbed material are rocky, pebbles and sand Rocky, pebbles and sand alluvial	Description : R. Hibwaa has river structure a vehicular bridge and gabions. There are debris blockages on the bridge compartments

	
Description : Ragane Area near the boundary of Kuria and Migori districts. R. Ragane a tributary of R. Migori flows and riverbed material is rocky and pebbles and one of the river structure is the vehicular bridge	Description : R. Ragane a tributary of R. Migori flows and the river structure includes gabion works that reinforces the bridge and drainage canal that drains run-off water into the river channel
	
Description : Migori Bridge in Migori where R. Migori flows and riverbed material is rocky and sandy	Description : R. Migori flows downstream and there is a river structure i.e. bridge constructed above the river channel on an A1 road
	
Description : Nyasare estate in Migori Town: R. Nyasare a tributary of R. Migori and the rriverbed material is rocky, pebbles and sandy	Description : R. Nyasare as it flows downstream it has river structure which is 5 compartment cylindrical culvert and a house is constructed just beside the river

	
Description : On R. Nyasare there is also a run-off water drainage that drains into the river channel	Description : R. Nyasare drains into R. Migori which is about 100 M apart at this point. There are no river structures on R. Migori at this point but there are vegetation growing in the river channel
	
Description : Nyamure in Magina area in Migori Town: R. Nyagugoalso known as R. Nyamure a tributary of R. Migori and the rriverbed material is rocky, pebbles and sandy has river structure a 3 compartment cylindrical culvert and gabions	Description : R. Nyagogo drains into R. Migori which is about 200 M apart at this point. There are no river structures on R. Migori at this point but there are sand harvesting activities and the point acts as a watering point for the livestock
	
Description : Kakrao area in Migori district R. Nyasarara a tributary of R. Migori and the rriverbed material is soil sediments, rocky and pebbles	Description : R. Nyasarara that drains into R. Migori flows downstream river structure is 4 compartment cylindrical culvert of which some are blocked

	
Description : Othatcho location in Migori district R. Othatcho a tributary of R. Migori and the rriverbed material is soil sediments, rocky and pebbles	Description : R. Othatcho drains into R. Migori and has river structure a 1 compartment cylindrical culvert and on its channel there is a natural indentation on the river channel that acts as a reservoir for water during dry season
	
Description : Eko area, Ajego sub-location in Migori district R. Eko a tributary of R. Migori and the rriverbed material is soil sediments and rocky	Description : R. Eko has river structure is a vehicular bridge

River Migori System: Downstream

	
Description : Nyarogi sub-location in Othatcho location R. Nyakonya a tributary of R. Migori and the riverbed material is soil sediments and rocky	Description : R. Nyakonya that drains into R. Migori flows downstream through a river structure a vehicular bridge and on both side of the river there is riparian land encroachment

	
Description : Kadem south - Othatcho locations boundary R. Owich though a seasonal river is a tributary of R. Migori and the rriverbed material is soil sediments and rocky	Description : R. Owich drains into R. Migori aand has river structure which is a 2 compartment cylindrical culvert and water pollution is negligible by evidence of breeding of tadpoles and other marine life
	tadpoles and other marine life  
Description : Mikei area in Nyatike district R. Migori flows downstream to join with R. Gucha at Sango. The rriverbed material of R. Migori at this point is rocky and sandy and river structure is the vehicular bridge	Description : Wath Onger R. Gucha Migori flows downstream into the L. Victoria the riverbed material at this point is rocky and sandy and the water is brownish in colour. The river structure is a vehicular bridge and there is a WRMA automated and manual river gauge station

Source JICA Project Team

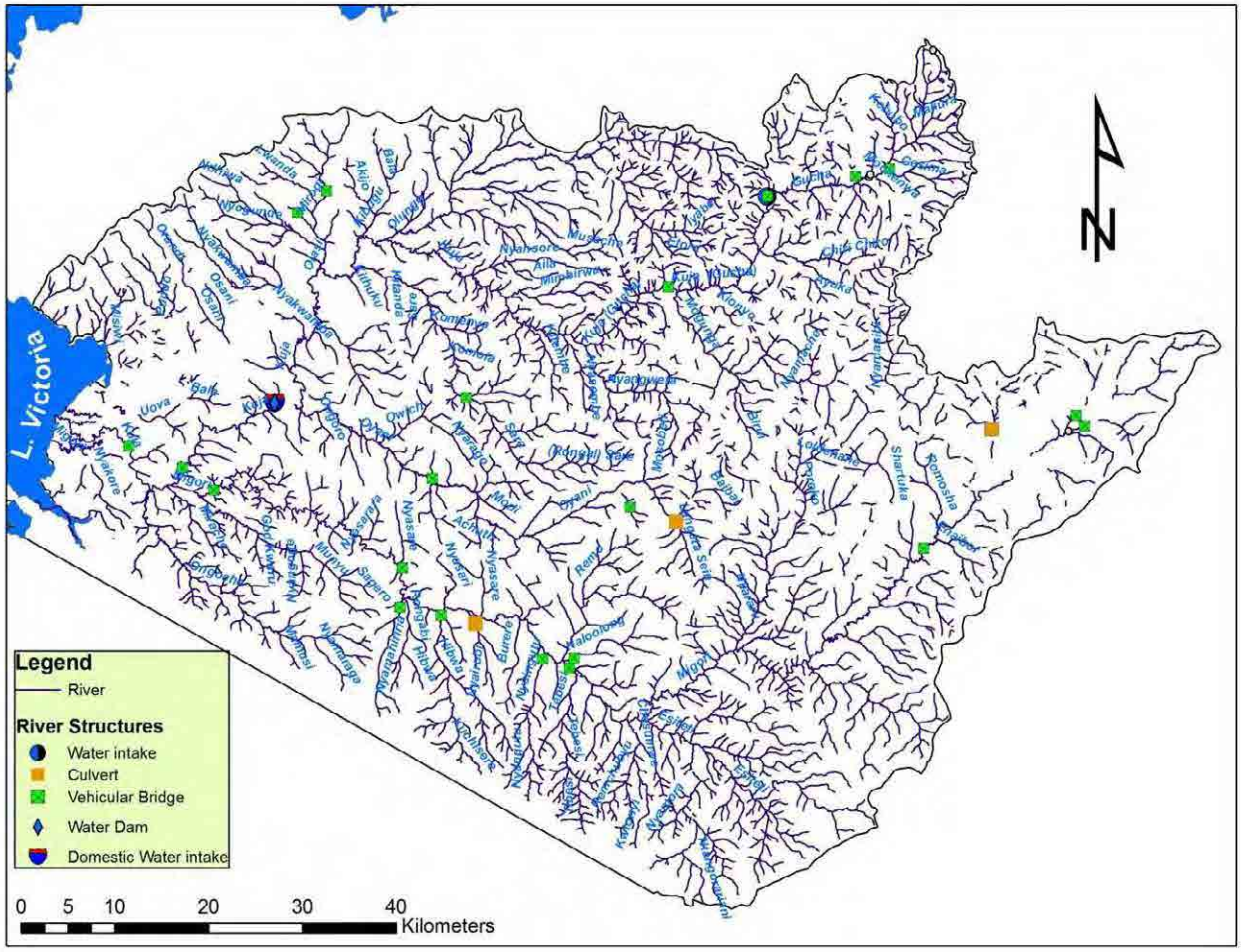


Figure 2.7 Gucha Migori River structures Map

(3) Changing of River Course

River Gucha Migori drains its water into Lake Victoria. The river changed its course in the year 2001-2002 to establish its current channel that flows through Kabuto Nyora villages in Lower Central Kadem. The initial channel was through Aneko village in Aneko location (previously known as West Kadem).

Interviews with community members revealed that before the river changed its course it had changed at least four times eastwards within Aneko bay.

The figure 2.6 shows the river channel on its old course, while figure 2.7 shows google map that indicates the new channel and figure 2.8 shows an updated map that indicates the new channel.

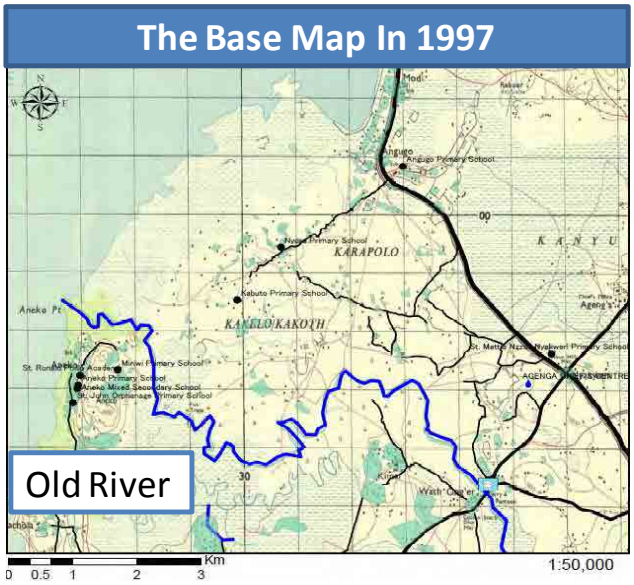


Figure 2.8 Old Map indicating old river channel

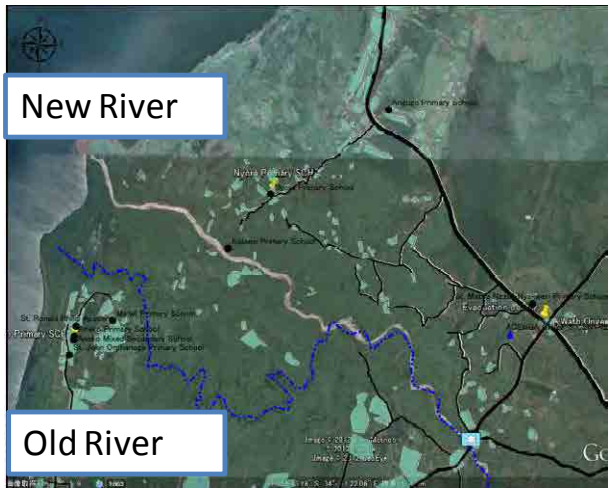


Figure 2.9 Satellite data on google Map indicating the new river channel

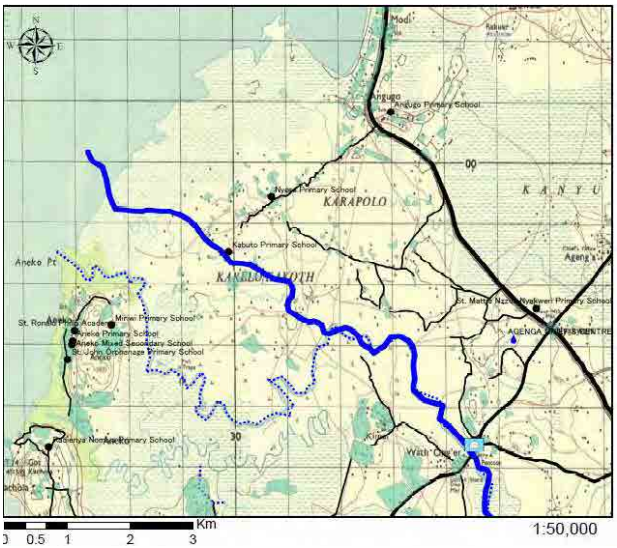


Figure 2.10 New updated Map indicating the new river channel

1.1.4 Hydrology and Meteorology

(1) Feature of Rainfall and Water Level Gauging Station

(a) Gauging Stations

Figure 2.9 shows locations of WRMA rainfall and water level gauging stations. Rainfall gauging stations are indicated in red colour, ● while the water level gauging stations are shown in purple ● colour.

Wath Onger River Gauging Station ID 1KB05 is located in the downstream of R. Gucha Migori i.e. after the two rivers R. Gucha and R. Migori having joined together and becoming a wide R. Gucha Migori.

Gucha Migori River Basin is endowed with river gauging stations strategically placed both on R. Gucha system and R. Migori System.

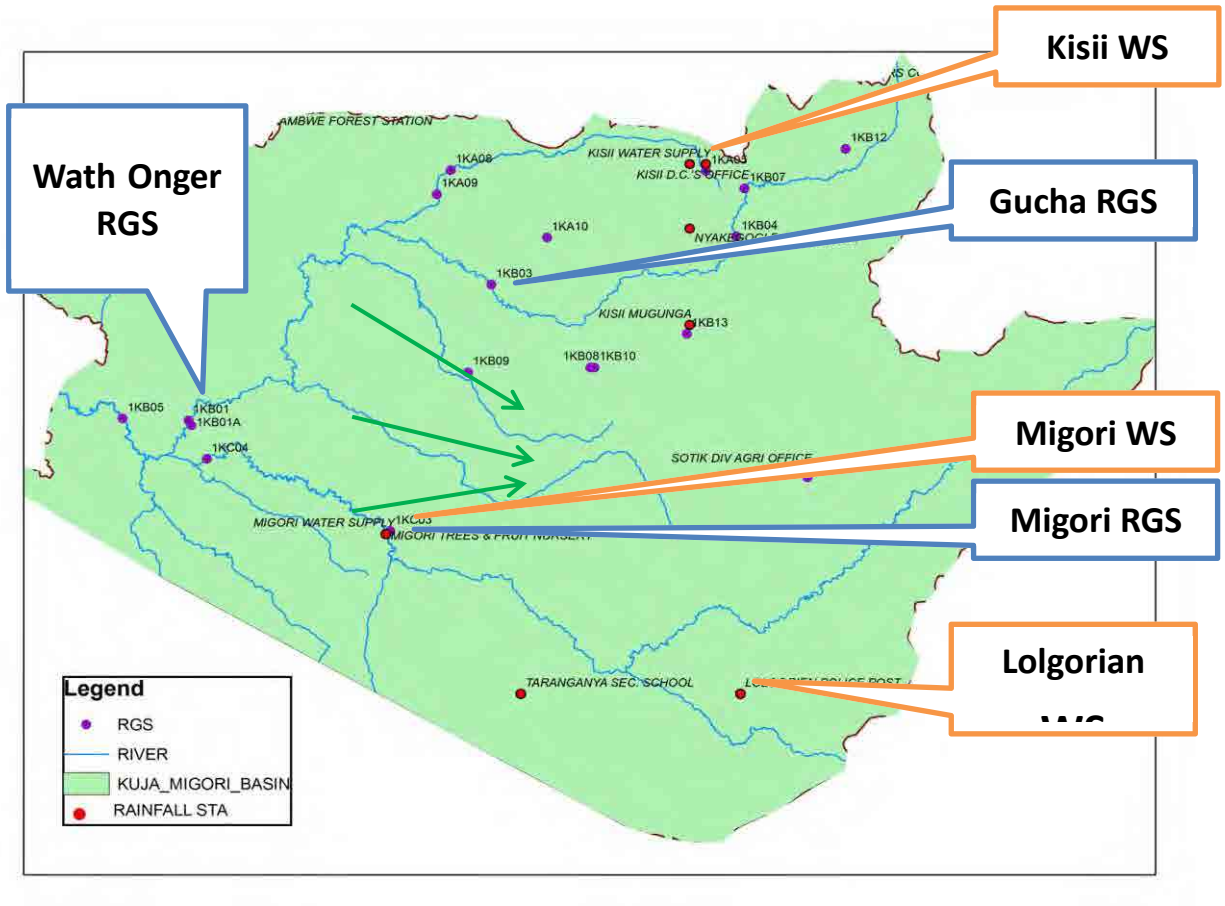


Figure 0.7 Location Map of Rainfall and Water Level Gauging Stations

Water Level Gauging Station No.:1KB11
Observation River：Oyani River

Water Level Gauging Station No.:1KC03
Observation River：Migori River
Special Note：Water level gauge is broken off and damaged.

Water Level Gauging Station No.:1KB05
Observation River：Gucha Migori River

Water Level Gauging Station No.:1KB05
Observation River：Gucha Migori River
Special Note：This is an automated gauge station that transmit data to WRMA Regional Office

(b) River Gucha Migori Discharge Data

The National Water Master Plan 1992 indicates the annual discharge for R. Gucha Migori as indicated in the Figure 2.10 below

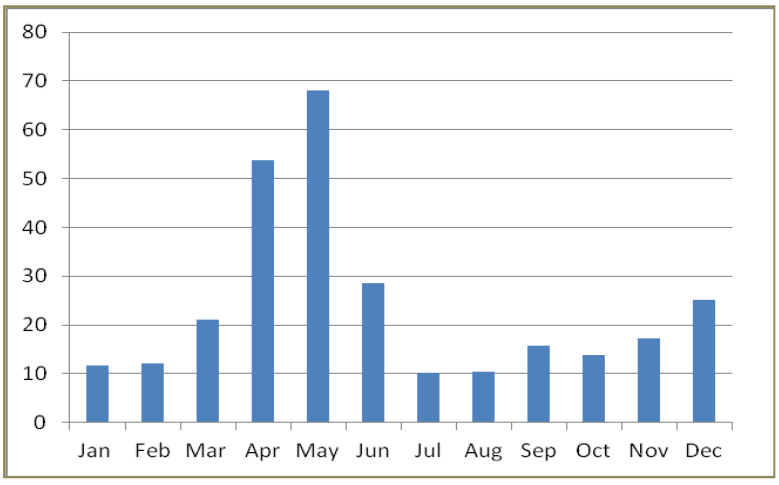


Figure 0.8 Annual Discharge R. Gucha Migori

Table 2.3 List of WRMA Rainfall Gauging Station within Gucha Migori River Basin

Station ID	Name	Status	Start Year
640	Keroka	Operational	
New	Nyamache tea factory	Not operational	
New	TDP-Kilgoris	Operational	
New	Lolgorian	Operational	
New	Nkararo	Operational	
9134025	Migori	Operational	
9134009	Muhuru bay	Operational	
9034093	Homabay	Operational	

Source: WRMA

(c) Water Level and River Discharge Observation Data

List of water gauging stations in Gucha Migori River Basin is shown on Table 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,

Table 2.4 List of Water Level Gauging Station in Gucha Migori River Basin

Station ID	Name	Status	Start Year
1KB12	Kenyamware	Operational	1970
1KB03	Gucha	Operational	1993
1KB05	Wath Onger	Operational	1980s
1KB11	Oyani	Operational	1970s
1KC03	Migori	Operational	1970s
1KC07	Enkaregituak	Operational	1970s

Source: WRMA

(2) Meteorology

Rainfall is in two seasons like in most of Kenya and the highest rainfall is between March and May. Average rainfall is approximately 1200 mm and above, but the rainfall patterns are unique, as the small town has three patterns of rainfall according to the neighborhood. It could rain in Kakrao but around Onyalo school would be very dry and Namba would have a slight drizzle.

There are several sub-counties (formerly known as districts) within the Gucha Migori River Basin. The climatic information of these districts is as follows:

a) Gucha Sub-county

i) Rainfall

The district experiences a highland equatorial climate. It receives an average of 1800 mm of rainfall annually with the long rains between March and June while the shortest rains are received from September to November. Hailstones are common occurrence during the short rains. July and January are relatively dry months. (Source: Gucha District Development Plan 2008-2012)

ii) Temperatures

The maximum temperatures in the district range between 21^{o}C to 30^{o}C while the minimu temperatures range between 15^{o}C to 20^{o}C. An average relative humidity of 80% is experienced in the district. (Source: Gucha District Development Plan 2008-2012)

b) Kisii Central District

i) Rainfall

The district has a highland equatorial climate resulting into bimodal rainfall pattern with an average annual rainfall of 2000 mm which is highly reliable. It has two rainy seasons the long rains occurring between February and June and the short rains occurring between September to early December. Dry spells however occur sometimes towards the ends of the short rains in some part of the district. (Source: Kisii Central District Development Plan 2008-2012)

ii) Temperatures

The high altitude of the district is expected to lower temperatures. However the proximity of the equator raises the temperatures to a mean annual maximum of 27^{o}C in the lowlands and minimum of 16^{o}C. The maximum temperatures of the highlands are 24^{o}C with a mean minimum of 14^{o}C. The coldest seasons are experienced in late June, July and August. (Source: Kisii Central District Development Plan 2008-2012)

c) Migori District

i) Rainfall

The district has a mild inland equatorial climate modified by relief altitude and proximity to the lake. Rainfall pattern ranges from 700 mm to 1800 mm annually, with short rains occurring between March and May while long rains fall during October to December. The lakeshore divisions experience unreliable and poorly distributed rainfall. (Source: Migori District Development Plan 2008-2012)

ii) Temperatures

The temperatures show a mean minimum of 17°C and maximum temperatures of 20°C with a high humidity and a potential evaporation of 1800 to 2000 mm per year. (Source: Migori District Development Plan 2008-2012)

The data on rainfall for the year 2009 provided by Nyatike District Agricultural Office is shown in the figure 2.11 below

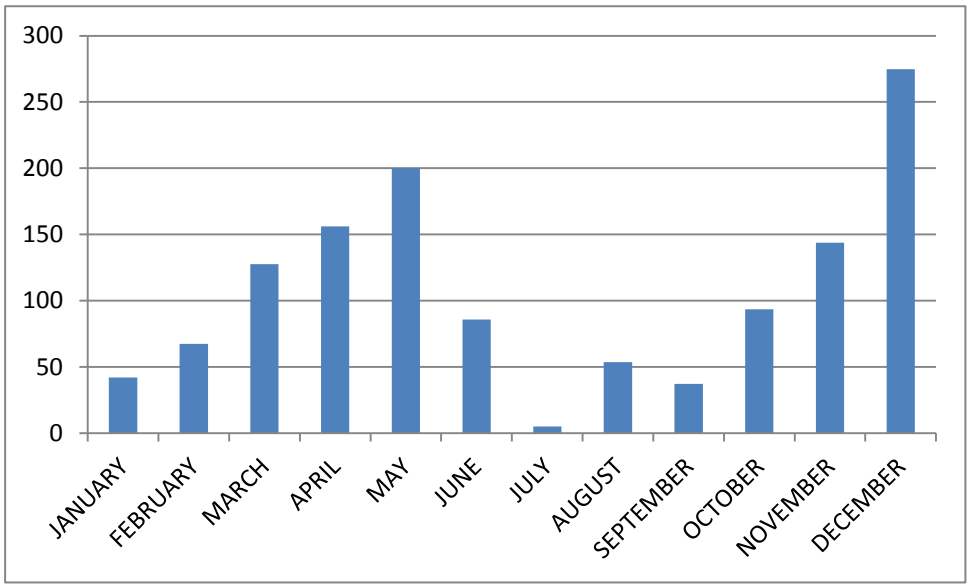


Figure 0.9 Annual Rainfall in Nyatike downstream of R. Gucha Migori

1.1.5 Lower Gucha Migori River Basin Floods

(1) Secondary Data

a) Background

The secondary data collected from Lake Basin Authority "RIVER PROFILE STUDIES VOLUME IV, LOWER KUJA, IRRIGATION DEVELOPMENT ANNEX II HYDROLOGY OCT 1985" reports that: The Kuja flow record at1KB05 provides an annual series of 15 years. Although this record is short it has the benefit of the station being reasonably calibrated up to 5.78M (534M^3/S). the highest level at which flows have been gauged by current meter; with the highesr observed level in 15 years being at 6.70M, under 1M higher than the maximum gauged by current meter. By contrast, records at 1KB1, 1KB1A and 1KC3 are longer but have less certain flood flow ratings. The highest gauged flow of the Kuja at 1KB1/1KB1A is only 139M3/S, although the 1KC03Migori has been gauged at 477 M^3/S.[4] (Page A2-17)

b) Flood Series at 1KB5

[4] Lake Basin Authority "River Profile Studies iv, Lower Kuja, Irrigation Development Annex II Hydrology Oct. 1985

The secondary data collected from Lake Basin Authority "RIVER PROFILE STUDIES VOLUME IV, LOWER KUJA, IRRIGATION DEVELOPMENT ANNEX II HYDROLOGY OCT 1985" reports that: The mean annual flood derived from this series is 407 M^3/S. Extreme Value (Type 1) analysis with Gringorten plotting positions gives the following estimates:[5] (Page A2-17)

Return Period, T (Years)	Flood Flow Q (m^3/s)	$QT/Q_{2.33}$
2.33	407	1.0
10	690	1.7
20	810	2.0
50	965	2.4
100	1082	2.7

(Page A2-18)

SOCIO ECONOMIC CONDITIONS

1.1.6 General Profile

There are three predominant tribes within the basin i.e. the Luo tribe located in the downstream and part of the midstream and call R. Gucha as R. Kuja. The Luo are mainly farmers and fishermen; the Kisii tribe is located in the upstream of R. Gucha and is mainly farmers; the Massai tribe is located in the upstream of R. Migori which they call R. Magor. The Massai are pastoralist but are quickly adapting to farming especially in Transmara East district; and Kuria tribe that are in the midstream of R. Migori. The Kuria are farmers. All these tribes keep livestock.

1.1.7 Administration

(1) Local Administration

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

Table 2.5 Administration Division in Republic of Kenya

Administration Unit	Officer in charge
County	County commissioner
District	District commissioner
Division	District officer
Location	Chief
Sub location	Assistant Chief
Village	Village Elder
Community Unit	Respective Opinion Leader

In the administration system in Kenya, Central Government Administrative Organ (County –

[5] Lake Basin Authority "River Profile Studies iv, Lower Kuja, Irrigation Development Annex II Hydrology Oct. 1985

District – Division – Location – Sub-location) is managed under the Office of the President. The smallest administrative unit is the Sub-location. For purposes of better and grassroot oriented management the administrative organ engages village elders to manage respective village within a sub-location. The Officer in charge at respective level is as "County Commissioner" for County, "District Commissioner (DC)" for District, "District Officer (DO)" for Division and Location, "Chief", for Sub Location (Assistant Chief) and for Village "Elder".

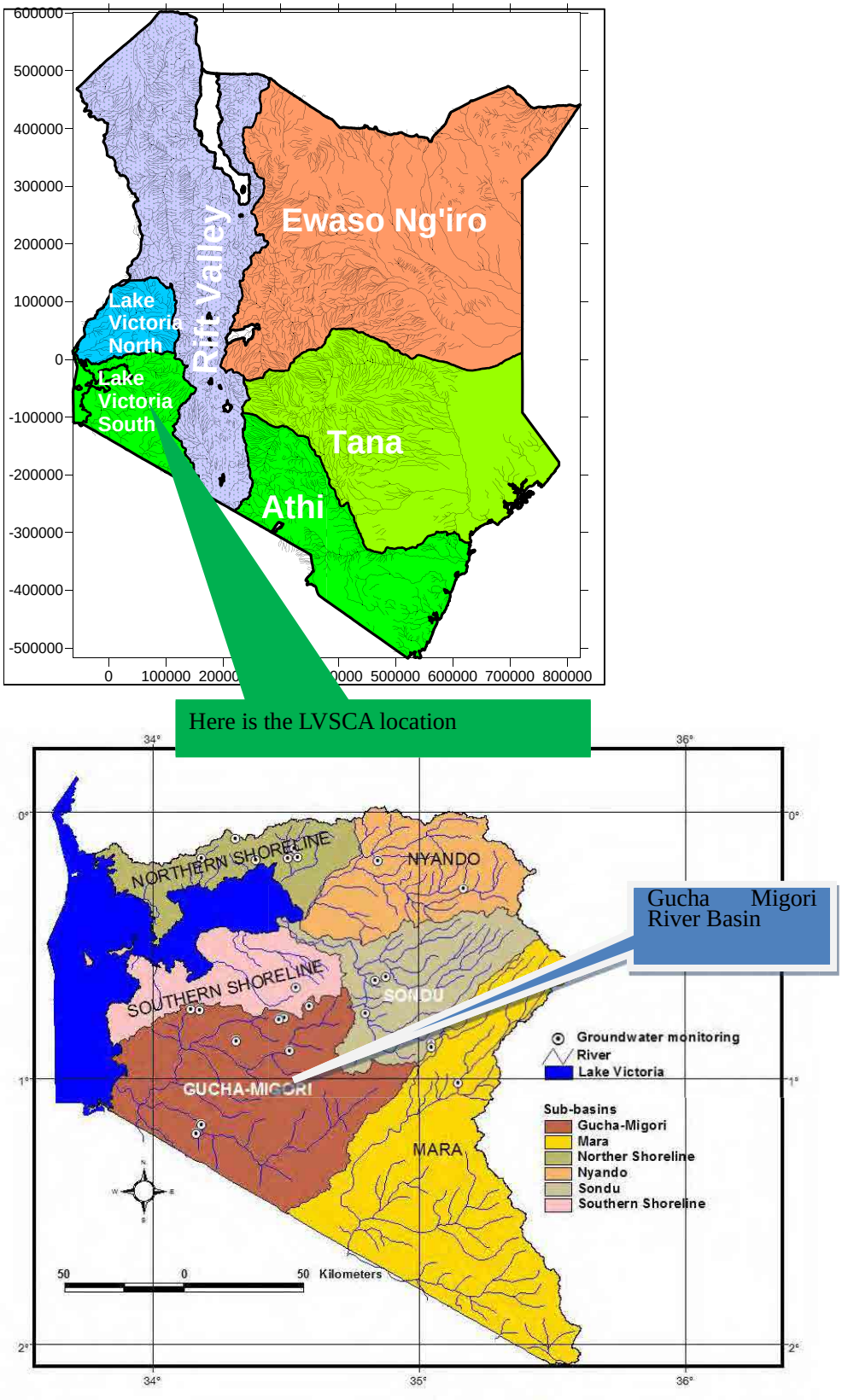
Gucha Migori River Basin consists of Nyamira County under which Nyamira and Manga districts belong to, Kisii County under which Gucha, Kisii Central, Semeta and Kenyenya districts belong to, Narok County under which Transmara East district belongs to, Migori County wherein Migori, Kuria, Uriri and Nyatike districts belong to and Homabay County wherein Ndhiwa district belongs to.

(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 Gucha Migori River Basin is explained below. WRMA divides the country in 6 catchment areas and Gucha Migori River Basin is included in the catchment called "Lake Victoria South Catchment (LVSCA)".

Kisumu Regional Office in LVSCA have jurisdiction over the whole LVSCA. Besides, the catchment is divided into three (3), i.e. Kisumu sub-region, Kericho sub-region, and Southern Shoreline (Gucha Migori) sub-region. There are Sub-Regional Offices in the respective sub-regions.

Figure 0.10 WRMA Southern Shoreline (Gucha Migori) Sub-Regional Office



Source : Lake Victoria South Catchment Area Catchment Management Strategy (June 2009)

Figure 0.11 LVSCA Catchment within the Kenya Map indicating the six regions

(3) 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 Gucha Migori River Basin is explained below.

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1.1.8 Population

Approximately 2.5 million people live within the Gucha-Migori basin (or 360 cap/km²) and it is estimated that 4.9 million people will live within the basin in 2030 (or 710 cap/km²), with the large majority of the population dependant on subsistence farming. Rural population densities in the upper half of the Gucha River basin and around Migori are (and will be) therefore very high. This is a significant issue that poses challenges for land use, ownership, and subsistence,especially in areas that already have a high urban population density (like Kisii and Migori), and areas that have a high dependence on land. [6]

The population census data of 2009 per districts in Gucha Migori River Basin is presented in Table 2.6.

Table 2.6 Population Census Data in Gucha Migori River Basin (2009)

District	Male	Female	Total
HOMA BAY	145981	161346	307327
MIGORI	121181	132228	253409
RONGO	65240	68914	134154
KURIA WEST	66766	69496	136262
KURIA EAST	40248	41585	81833
KISII CENTRAL	133883	149234	283117
KISII SOUTH	25973	28996	54969
MASABA	67399	75588	142987
GUCHA	173472	190988	364460
GUCHA SOUTH	70458	75849	146307
NYAMIRA	125744	137457	263201
MANGA	41678	46181	87859
BORABU	34151	33461	67612
TRANS MARA	130323	130493	260816
Total	**1242497**	**1341816**	**2584313**

Source : Kenya National Bureau of Statistic, Census 2009

It is imperative to note that some of the districts lie on the boundary between Southern shoreline (Gucha Migori) and Kericho sub-regional jurisdiction for example Masaba and

[6] Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin in Kenya: Final Strategy Report

Borabu districts. It is also important to note that some of the district lie on the boundary of Gucha Migori River Basin and Awach Tende and Awach Kibwon river basins.

1.1.4 Industrial, Agricultural Products and Commercial Activities

Agricultural products in the river basin are derived from farming, animal husbandry, fishing, brick-making, sand harvesting, small scale business, carpentry and handicraft (stone carvings) making.

There are industrial factories within the Gucha Migori River Basin which are mainly involved in processing the agricultural products. The following are some of the example of industrial factories within the river basin: 1) There is sugar processing company in Awendo, Transmara and Ndhiwa, Migori county and 2) Tea factories in Nyamira and Kisii counties.

DEVELOPMENT PLAN

1.1.5 Vision 2030

Under the flagship projects on Water and Sanitation Vision 2030 envisages to rehabilitate the hydro-metrological network andm rehabilitate 600 stations and this includes the stations in Gucha Migori River Basin and in particular 1KB05 Wath Onger.Vision 2013 also envisages Constructing twenty two (22) medium-sized multi-purpose dams with a total capacity of two (2) billion M^3 to supply water for domestic, livestock and irrigation use in the arid and semi-arid areas in Kenya wherein the downstream of Gucha Migori River Basin shall be a beneficiary of one of the dams.

Gucha Migori River Basin is also the hub of agricultural, livestock and fisheries activities in Sourthern part of Western part of Kenya. In the Vision 2030 it envisages that Kenya will raise incomes in agriculture, livestock and fisheries even as industrial production and the service sector expand. This will be done by processing and thereby adding value to her products before they reach the market. She will do so in a manner that enables her producers to compete with the best in other parts of the world. This will be accomplished through an innovative, commercially oriented and modern agriculture, livestock and fisheries sector.

These interventions are expected to generate an additional KSh.80-90 billion increase in GDP, mainly through better yields in key crops, increased smallholder specialisationin the cash crop sector (2-3cropsper plot),utilisation of a million hectares of currently uncultivated land, and new cultivation of upto 1.2 million hectares of newly-opened lands.

Specific strategies will involve the following: (i) transforming key institutions in agriculture

and livestock to promote household and private sector agricultural growth; and (ii) increasing productivity of crops and livestock. Kenya will also introduce new land use policies through: better utilisation of high and medium. (Source: Kenya Vision 2030 Popular Version)

1.1.6 County Development Plan (2013-2018)

Currently the five counties in their respective jurisdiction are developing County Strategic Development Plan. The strategic plan should include integrated water resource management.

1.1.7 Lake Victoria Catchment Area Catchment Management Strategy (June 2009)

According to "Lake Victoria South Catchment Area Catchment Management Strategy" which is the management plan of WRMA in Lake Victoria South Catchment, the concept on Integrated Flood Management in LVSCA is captured in Chapter 9 Flood and Drought Management. This Chapter explains an overview of floods and drought in Lake Victoria South Catchment, Flood and Drought Early Warning, vulnerabilities to floods and drought, vulnerabilities of people to floods, priorities in floods protection, and achivement of floods. Floods occur regularly in the catchment with devastating effects causing havoc to the human population, crops and livestock and grossly undermining the socio-economic status of the local population. The total area of flood risk will be surveyed and data made available for implementation of control measures. Information and data obtained from the River Nyando Integrated Flood Management Project by JICA will be adopted for replication in areas that were not piloted. Flood mitigation measures will then be undertaken through structural measures such as the construction of dykes and dams and non-structural measures such as the development of flood early warning systems and capacity building in disaster management skills and the implementation of flood warning system. Further action will be taken to construct emergency evacuation centres and to train local communities on disaster preparedness and management strategies on flood prevention and mitigation.

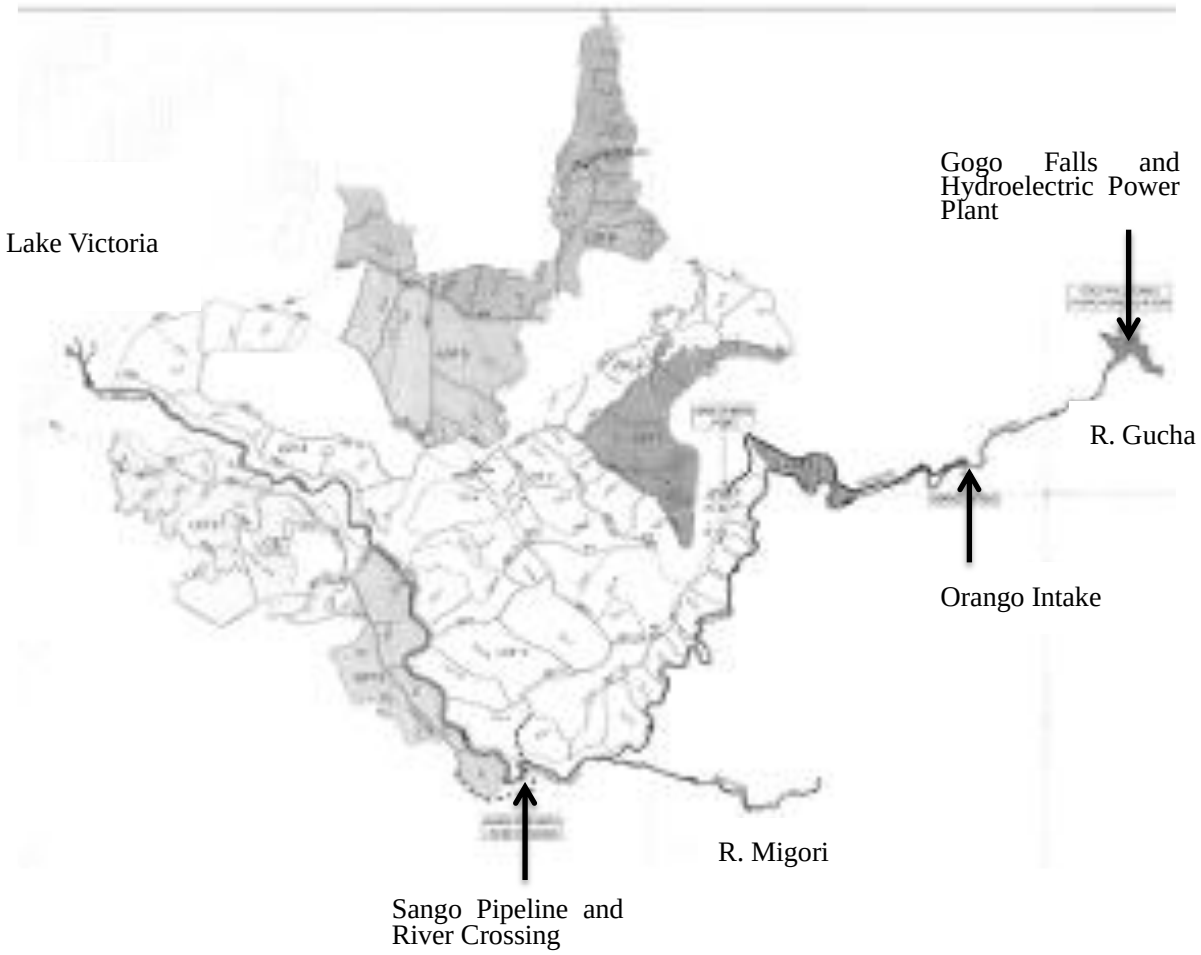
1.1.8 Bonyunyu Dam in the Upstream

Bonyunyu Dam Water and Sanitation Project aims at constructing a 7Million cubic meter capacity dam on Gucha River, construction of 55,000m^3/day Treatment works, Distribution system, tanks and sanitation.

1.1.9 National irrigation Board (NIB) Irrigation Project

The National Irrigation Board is currently undertaking and irrigation project in the downstream of R. Gucha Migori. There is an intake at Orango that will be constructed just after Gogo Dam on R. Gucha system. There is another intake and water piping works at Sango area which is at

the confluence point of R. Gucha and R. Migori. It is imperative to note that the success of this project will play an important role in the mitigation of floods in Lower Gucha Migori



Sub-catchment.

Source: National Irrigation Board Irrigation Project Planned Map

Figure 0.12 Planned NIB Irrigation Project Map

ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

The catchment is faced with major issues which undermine the sustainable utilization of its resources. These include among others: deforestation; wetland degradation; overutilization of ecologically fragile areas including hill slopes, wetlands and river banks; land fragmentation; water pollution; and loss of bio-diversity. With exploding population, shrinking land holdings, stagnant farming practices and declining yield levels, changing rainfall regime due to global climate change, and hardly any prospects for industrialization, there is a palpable stress in the environmental conditions in the basin as manifested in poverty levels of the population and environmental degradation. It is very clear that most of the environmental and social issues are

interdependent and cannot be treated separately.[7]

1.1.10 Environmental issues

The uppermost part of the Gucha-Migori basin was originally covered by a dense, tropical highland forest similar to that currently in the undisturbed sections of the Mau water tower. Over the past five decades, human settlement activities have completely cleared this from the area, and no primary vegetation is to be found in most of the upper parts of the basin, with the exception of the highly degraded Chepalungu forest in the upper Migori basin and of some isolated areas on the valley floors although this is threatened by wetland/swamp reclamation.

The middle reaches of the Gucha-Migori basin were covered in thick bushlands and patches of light forests but this has now also given way to cultivation and pastures. In particular, the Migori River passes through large stretches of pasturelands used quite extensively by the Maasai pastoralists. The original bushlands of the lower Gucha-Migori basin are progressively being replaced by cultivation and are impacted by charcoal burning and logging as sources of income and construction materials. The riverine and mountain wetlands, once numerous in the upper parts of the Gucha basin, have been practically wiped out. The Kuja River enters Lake Victoria through a small delta that has no major swamp. There are a number of environmental issues in the Gucha-Migori basin. Most are interrelated and have become increasingly serious due mainly to high population growth and related anthropogenic reasons in many parts of the basin.[8]

1.1.11 Socio-economic issues

The catchment is notably characterized by high population density and growth rates Approximately 2.5 million people live within the Gucha-Migori basin (or 360 cap/km²) and it is estimated that 4.9 million people will live within the basin in 2030 (or 710 cap/km²), with the large majority of the population dependant on subsistence farming. Rural population densities in the upper half of the Gucha River basin and around Migori are (and will be) therefore very high. This is a significant issue that poses challenges for land use, ownership, and subsistence, especially in areas that already have a high urban population density (like Kisii and Migori), and areas that have a high dependence on land. High poverty levels Around 40% of Kenyans lived below the national poverty line In the Gucha-Migori basin, around 53%, with Gucha (67%), Kuria (59%), Bomet (58%), Kisii (54%) districts over 50% of the population below the poverty line. In addition, some of the areas within the basin had some of the highest poverty densities in the country with more than 200 people below the poverty line per km² (Gucha, Bomet, Kisii and Nyamira).

High disease prevalence rates it is recorded that the infant mortality rate is high – 95 per 1,000

[7] Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin in Kenya: Final Strategy Report
[8] Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin in Kenya: Final Strategy Report

– and the under-five mortality rate is also high –149 per 1,000 (these figures are for Nyanza province but are similar for all the Gucha-Migori districts). The most prevalent diseases are malaria, meningitis, HIV/AIDS, diarrhoea diseases, respiratory diseases, pneumonia, skin diseases, eye infections and intestinal worms. Malaria is the leading cause of morbidity across all the districts in the basin, representing an average of 52.5% of all cases. HIV prevalence varies throughout the basin from 4.3% in Manga district to 22.3% in Homa Bay district.

Land Tenure Kenya's recent history has been dotted with several intense episodes of land-ownership conflict. The post-colonial land tenure management has led to a sectorization with certain repercussions on the distribution of the different communities which populate the country. This situation has become a source of inter-ethnic tensions which are exacerbated by the high/growing population density. Subsitence agriculture with low prodctivity. Over 80% of people depend upon agriculture (farming, livestock production and fishing) in the Gucha-Migori sub-basin. Most of the agriculture in the basin is for subsistence. The main food crops produced include maize, beans, finger millet, cassava, sweet potatoes and bananas. Subsistence agriculture is characterised by productivity levels which have remained low for decades despite technical advances which could support a major increase in productivity. This leads to food insecurity and poverty. The impact of low per ha productivity is compounded by diminishing land holdings. Frequent flooding and drought has been on increase in the Gucha Migori River Basin. By reducing agricultural productivity, destroying crops and properties, droughts and floods are major causes of food insecurity and poverty and a real obstacle to development.[9]

[9] Identification of Multipurpose Water Resources Development Project in Gucha Migori River Basin in Kenya: Final Strategy Report

ANALYSIS OF FLOOD CHARACTERISTICS

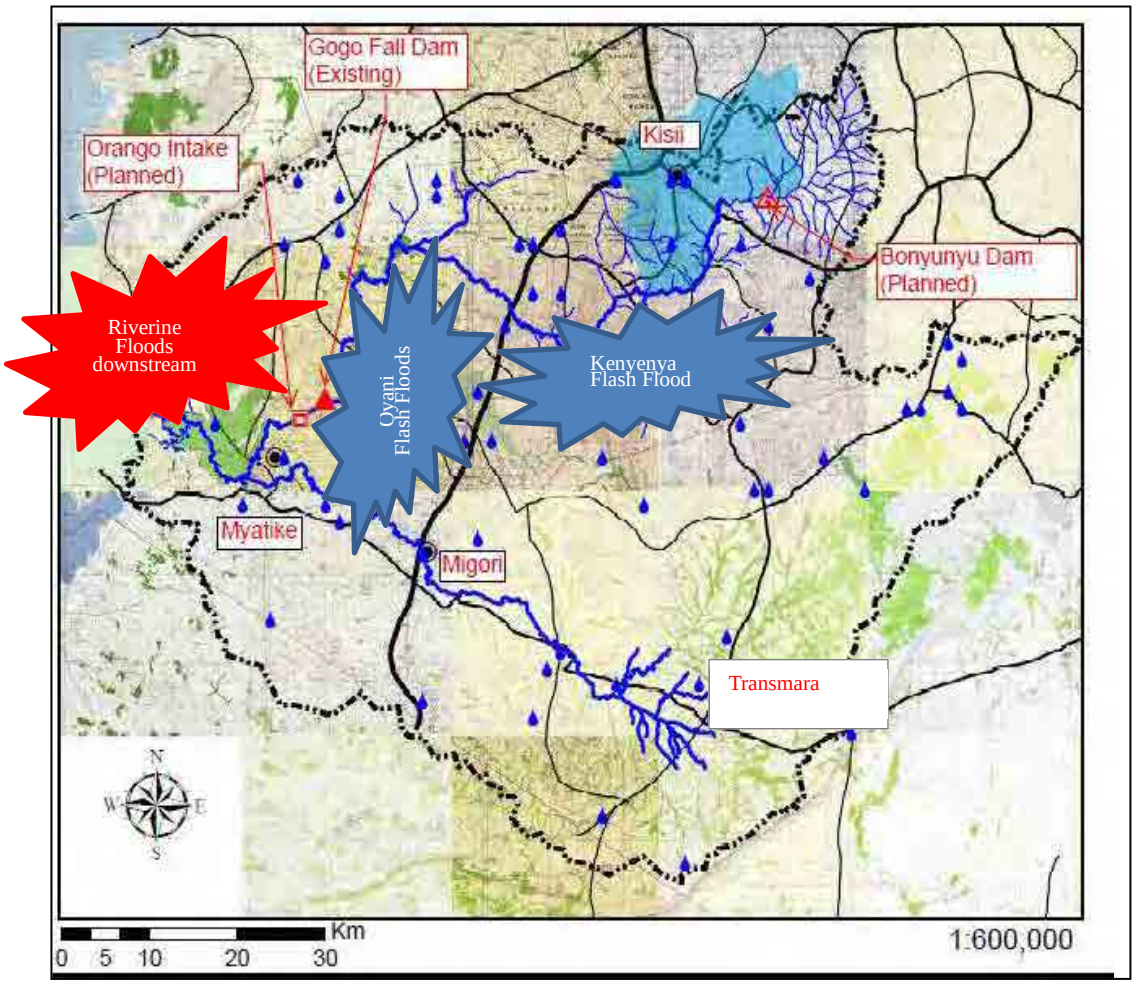
3.1 OVERALL CONDITION ON FLOODS IN THE GUCHA MIGORI RIVER BASIN

3.1.1 Records of Flood Damages

Flood damage is enormous in Gucha Migori River Basin. In the upstream Kenyenya Sub-counties the area encounters flash floods that mainly damages the farmlands and disrupts traffic. In the mid-stream the area of Oyani encounters flash floods and riverine floods that destroys farmlands and disrupts transport networks. In the downstream area suffers from both flash floods in the area surrounded by hills like Lwanda, Tito and Misiwi areas, while places in the flood plains like Nyora, Kabuto, Kimai, Sere, Aeko and Aneko suffers from riverine floods with inundation period of three weeks to two months. The Figure 3.1.1 below shows the records of flood damage in Gucha Migori River Basin.

Figure 3.1.1 Records of Flood Damage in the Gucha Migori River Basin

The longitudinal slope of the River Gucha and River Migori is steep in the Kisii Highlands and Transmara Highlands. The two rivers merge at Sango area to form one vast wide river that flows downstream at high velocity and due to heavy sedimentation the riverbed is shallow and therefore the river bursts its banks and some of the water flow along the former river channel that is silted leading



to floods along the former channel and the new channel. The soil in the area is black cotton soil that has high water retention rate that leads to longer period of inundation in the downstream areas especially around Kabuto and Nyora villages in Lower Central Kadem Location, Nyatike Sub-county. Initially before the new channel the flood occurrence was heavy in Tulu and Aneko villages in West Kadem Location, Nyatike Sub-county. But currently West Kadem location is affected when there is an

overflow into the old river channel, the overflow of the streams that used to flow into the old channel and the baskflow from the Lake Victoria.

(1) Upstream of Gucha Migori River Basin

In the upstream of R. Gucha Migori are mainly affected by flash floods. The flash floods mainly affect farmlands and disrupt traffic. In 2012 in Kenyenya Sub-county it was reported that three people drown and died as a result of the flash floods. The flash floods are as a result of the heavy rainfall leading to heavy surface run-off water on the feeder roads that flow into the streams and rivers that are tributaries of either R. Gucha in the Kisii Highlands or R. Migori in the Transmara Highlands. During site investigation the following were noted:

a) Kiabonyoru area in Nyamira

The source of River Gucha is located in this area and it was observed that there were soil erosion on the feeder roads was noted. This eroded soils forms part of sediments in the river.

b) Esani Area in Nyamira

River Gucha flow through this area it was observed that Nyantaro primary school.primary school is built on a wetland. There is a road next to school that initially used to get flooded leading to difficulties in accessing the school and this led to the community members through CDF assistance to divert the river to prevent flooding of school and neighbouring homes and prevent damage to the road.

c) Ogembo in Gucha

River Gucha flow through this area and it was observed that the river water was muddy yet the site investigation was done during the dry spell which is an indication that soil erosion is rampant in this area. In this area there are many feeder murram roads in the area that the surface run-off water flows on into the river.

d) Kebabe Area in Gucha and Kenyenya

R. Riasucha a tributary of R. Nyangweta which also acts as a tributary of river Gucha flow through this area and it was observed that a road in Kebabe has culverts constructed on it that causes havoc to the neighbouring homes when it rains heavily because the rain water flow through the culverts and have no place to flow to therefore the water inundates the farmlands, homes and has led to community members to dig a trench that enhances soil erosion that flows into R. Nyangweta. As a result of heavy surface run-off water that leads to flash floods that inundates the farmlands leading to loss of crops in the area.

(2) Mid-stream of Gucha Migori River Basin

In the midstream of R. Gucha Migori the area experiences heavy rainfall during the long and short rain seasons. The major towns in the midstream area are Migori Town, Awendo Town and Rongo Town. In Awendo there is a sugar factory. The following observations were noted:

a) Masaa area under Oyani WRUA jurisdiction
R. Oyani a tributary of river Gucha flow through this area and it was observed that there were extensive agricultural activities including human activities around the hills that surround Oyani area. The farmlands in Oyani area gets flooded during heavy rains. The floods are as a result of the R. Oyani breaking its banks but also the flood water comes from the surface run-off water from the neighboring hills.
The main cash crop grown in the area is sugarcane and during the floods in the area the farmers lose millions to the floods when their sugarcane is washed away.

There is a bridge at Masaa area that was constructed by Ministry of Roads and during the construction the contractor constructed a gabion within the water channel and after the works the decommissioned gabion remained under the bridge. The community members pointed out that during high flows the gabions blocks the river water leading to water overflowing to the nearby farms.

(3) Downstream of Gucha Migori River Basin

In the lower parts of Gucha Migori Basin which forms the downstream of R. Gucha Migori experience perennial floods and suffers damage from flood frequently. The floods cause adverse effects on agriculture and agricutural products, infrastructures, houses, lives and properties, land use, local economy and etc.

The effects and impacts of flood directly cause a stagnated economic growth. In the Sub-Catchment Management Plan developed by LOGUMI WRUA activities aimed at management of floods are prioritized.

According to information of data collected for lower parts of Gucha Migori River Basin which is shown in the Table 3.1.1. It indicates that approximately 100 km^2 was inundated in 1997 and 2002 and 2006 that was three 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 Gucha Migori River Basin (Ordinary year and extraordinary years)

	The flooding situation in an ordinary year	The flooding situation In an extreme year (1997, 2002 and 2006)
Flood area	25 km^2	100 km^2
Depth of water	1 m	1.5 m
No of evacuee	900	1800
Evacuation duration	1 month	3 month
No of floods in a year	2	2

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

Overview of recent flood damages in the downstream of Gucha Migori River Basin is shown in

Table 3.1.2 presents estimated flood damage cost and inundated area of agriculture sector in the downstream of Gucha Migori River Basin in the year 2012. It is imperative to note that the floods in the year 2012 waere ordinary floods yet the river level rose to 7.2M and the flood damage was enormous.

The floods affected severely Kabuto and Nyora villages and washed away most of their farmlands, inundated homesteads and made the area very difficult to access. As a result of two months inundation in the homesteads most houses sunk 1M down.

Table 3.1.2 Agricultural Damage in the Lower Gucha Migori River Basin in 2012

S/No	Villages	Crops Damaged	No. Of Affected Farmers	Affected acreage	Value In Millions (M) Kshs Lost.
1. Karungu Division in Nyatike District	i. Sito valley ii. Upper Okayo iii. Alara. iv. Okero v. Ojawa vi. Riat vii. Osiri viii. Agulu ix. Wakine. x. Atonge. xi. Lower Okayo xii. Obware valley xiii. Along L. Victoria Shore.	Young Sorghum, Kales, Maize, Young Cassava, Beans, Tomatoes, Sweet Potatoes, Watermelon. Tree nurseries and tree seedlings, Local vegetables (e.g. Mrenda,. Black night shade and Spider plant)	88	120	2.4 M
2. Nyatike Division in Nyatike District	i. Kabuto ii. Angugo iii. Modi iv. Luanda v. Kimai vi. Lower Magungu vii. Nyora	Young Sorghum, Kales, Maize, Young Cassava, Beans, Tomatoes, Sweet Potatoes, Watermelon. Tree nurseries and tree seedlings, Local vegetables (e.g. Mrenda,. Black night shade and Spider plant)	390	415	10.3M
3. Muhuru Division in Nyatike District	i. Ratieny Valley ii. Tagache/Kiambu iii. Lower Tito iv. Upper Tito. v. Lisori vi. Nyakumu	Young Sorghum, Kales, Maize, Young Cassava, Beans, Tomatoes, Sweet Potatoes, Watermelon. Tree nurseries and tree seedlings, Local vegetables (e.g. Mrenda,. Black night shade and Spider plant)	52	92	2.3M
Total			**530**	**627 Acres**	**15.0M**

Source: District Agriculture Office-Nyatike

3.1.2 Flood Condition Inquiring From Relevant Communities

The focal points having flood damages in the downstream of Gucha Migori river basin are Nyora, Kabuto, Kimai, Aneko, Aeko, Lwanda, Misiwi, Tulu, Ratieny and Tito etc.

During the community inquiry survey on these communities on the flooding situations during ordinary floods, the community members were able to reveal as shown in the following

Table 3.1.24 while figure 3.1.2 is the map that shows these areas.

Table 3.1.3 Floods impact on communities in the downstream during an ordinary year

Village name	Population				Flood Damages	Remarks
	Popn.	HH	Affected popn.	HH		
1. Nyora	2620	262	924	184	Homes, farms and transport networks	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
2. Kabuto	2678	270	844	152	Homes, farms and transport networks	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
3. Kimai	2200	220	230	20	Homes, grazing land and transport networks	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
4. Aneko	3600	360	-	-	Affects mainly farmlands	Community members are involved in drainage improvement
5. Aeko	8700	870	190	15	Few homes and farmlands	Farmland destruction that leads to heavy food shortages
6. Lwanda	1526	254	520	50	Disrupts transport and damage homes	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
7. Misiwi	2623	262	230	35	Disrupts transport and damage homes	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
8. Tulu	1010	134	468	78	Disrupts transport and damage homes	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation
9. Ratieny	1300	170	200	20	Disrupts transport and damage homes	Farmland destruction that leads to heavy food shortages
10. Tito	2511	252	147	25	Disrupts transport and damage few vhomes	Toilets collapse leading to sanitation and hygiene problems. Community assist each other in evacuation

Source: JICA project team survey by inquiring to communities

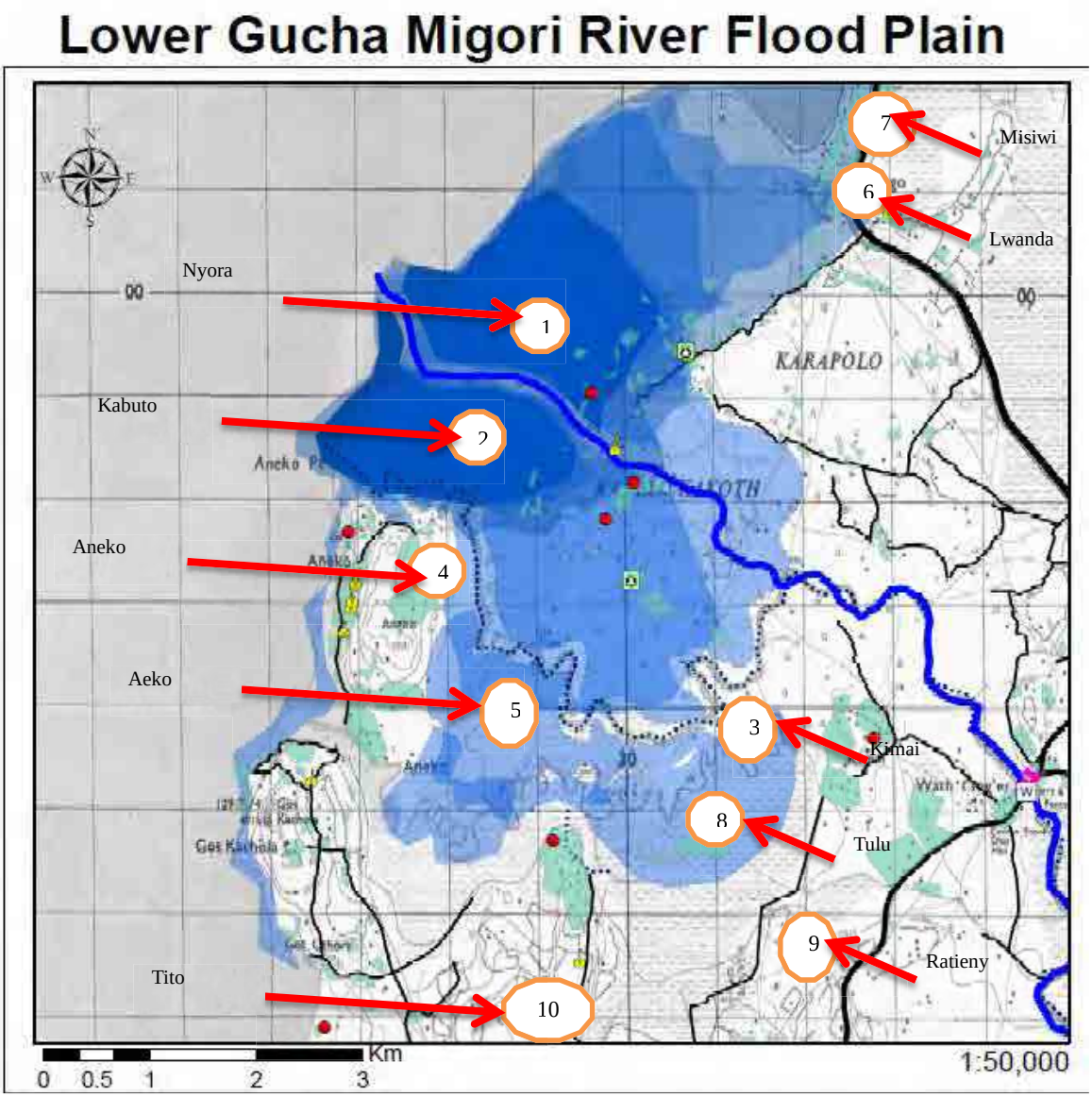


Figure 3.1.2 Location Map of Principal Community in Downstream Area

Widespread and long term inundation around the river caused by overflow from the R. Gucha Migori causes severe damages to especially "Nyora" and "Kabuto" villages located in inundation area on the either side of the river with flood depth ranging from 100cm to 150cm depth and 1 to 3 months duration period.
According to the figure described above, "Nyora" or "Kabuto" villages are located in the downstream of R. Gucha Migori approximately 3KM from Lake Victoria. The river bursts its banks and overflow into the farmlands thereafter into the homesteads, schools etc. The inundated area becomes one big like basin full of water that looks like a lake.
Both Kabuto and Nyora are densely populated and the crops in the farmlands in the area and poultry especially chickens being washed away into Lake Victoria.

Lwanda, Misiwi, Tito and Ratieny are affected by flash floods as a result of heavy rains in the neighboring hills in the downstream. While Tulu, Aeko, Aneko areas are affected by both flash floods and riverine floods. The flash floods are caused by the numerous streams (both permanent and seasonal) that flow through these areas. In Tulu area the water overflows the stream and inundates the area for more than two weeks with extensive damage in the farmlands.

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) Nyora Village

- Water depth is 150cm in the farmlands and 120-100cm in the homesteads, duration is 1 to 2 month when floods occur.
  .....(Inundation caused by overflow of River Gucha Migori)
- Flow from river water and from upstream even when there is no rainfall in Nyora area
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- Waters and sediments flow into the houses make homesteads inhabitable
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- Small livestock such as goats, sheep, chicken and ducks swept away
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- The murram roads are inundated with flood water cutting off the villages from travelling and community members use canoes from one place to the other.
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- The farms are flooded sweeping away the food crops
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- During very heavy flows Nyora Primary School is closed and used as evacuation centre
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- Some mud houses are swept away and others sink in case inundation is more than 2 months
  ..... (Inundation caused by R. Gucha Migori breaking its banks)

(2) Kabuto

- Water depth is 150cm in the farmlands and 120-100cm in the homesteads, duration is 1 to 2 month when floods occur.
  .....(Inundation caused by overflow of River Gucha Migori)
- Flood water flows from the R. Gucha Migori old and new channel and a seasonal stream that transverse through the village.
  .....(Inundation caused by overflow of River Gucha Migori old and new channel)
- Flood waters flows into the farmlands and sweeps the crops away
  .....(Inundation caused by overflow of River Gucha Migori new channel)
- Sediment flows into the houses and deposited inside
  .....(Inundation caused by overflow of River Gucha Migori new channel)
- Access roads are affected by the flood water making Kabuto Health Centre inaccessible and give affected families difficulties to access Kabuto Primary which acts as evacuation centre(Inundation caused by overflow of River Gucha Migori old and new channel)
- Small livestock such as goats, sheep, chicken and ducks swept away
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- The murram roads are inundated with flood water cutting off the villages from travelling and community members use canoes from one place to the other.
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- The farms are flooded sweeping away the food crops
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- During very heavy flows Kabuto Primary School is closed and used as evacuation centre
  ..... (Inundation caused by R. Gucha Migori breaking its banks)
- Some mud houses are swept away and others sink in case inundation is more than 2 months
  ..... (Inundation caused by R. Gucha Migori breaking its banks)

(3) Kimai

- Water depth is 100cm in the farmlands and 50-100cm in the homesteads, duration is 2 weeks to 1 month when floods occur.
  .....(Inundation caused by overflow of Onyongo and Nyakori streams)
- Some of the grazing lands like Olumbe have permanent depression that makes the area be like a water-pan during floods and even after
  (Inundation caused by overflow of Onyongo and Nyakori streams and surface run-off from Otho area)
- The flood waters sweep away the food crops

.....(Inundation caused by overflow of Onyongo and Nyakori streams)

- The murram roads are inundated with flood water cutting off the villages from travelling. (Inundation caused by overflow of Onyongo and Nyakori streams and surface run-off from Otho area)

(4) Aneko

- Water depth is 100cm in the farmlands and 50cm in the homesteads, duration is 1 to 3 weeks when floods occur. (Inundation caused by overflow of River Gucha Migori old channel and backflow from the L. Victoria)
- Flood water flows from the R. Gucha Migori old channel, backflow from the lake, Kanga and Nyakore and surface water from Othora hills. ...(Inundation caused by overflow of River Gucha Migori old and backflow from L. Victoria)
- The farms are flooded sweeping away the food crops ...(Inundation caused by overflow of River Gucha Migori old and backflow from L. Victoria)

(5) Aeko

- Water depth is 80-100cm in the farmlands and 50cm in the homesteads, duration is 1 to 3 weeks when floods occur. .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)
- Flood water flows from the R. Gucha Migori old channel, backflow from the lake, Kanga and Nyakore and surface water from Othora hills. .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)
- The farms are flooded sweeping away the food crops .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)
- The grazing grounds are inundated making it difficult for livestock to graze .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)
- The murram roads are inundated with flood water cutting off the villages from travelling. .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)
- Some of the homes are inundated leading damages of the houses especially mud thatched huts. .....(Inundation caused by backflow L. Victoria and run-off water from Othora hills)

(6) Lwanda

- Flood waters mainly from the neighbouring Magungu and Obware hills ..... (Flash flood)
- Leads to disruption of transport Lwanda Karungu Road..... (Flash flood)
- Disruption of Education Programme .....(Flash floods)
- Leads to disruption of economic activity at the busy Lwanda trade centre..... (Flash flood)
- Houses are inundated with flood water..... (Flash flood)
- Destruction of toilets. ..... (Flash flood)

(7) Misiwi

- Flood waters mainly from the Aora Chudho stream and Got Bim hills ..... (Flash flood)
- Leads to disruption of transport..... (Flash flood)
- Houses are inundated with flood water..... (Flash flood)
- Destruction of toilets. ..... (Flash flood)

(8) Tulu

- Water depth is 80-100cm in the farmlands and 50cm in the homesteads, duration is 1 to 4 weeks when floods occur. (Inundation caused by Nyokore stream and run-off water from Suna hills) .....(Inundation caused by Nyokore stream and run-off water from Suna hills)
- Flood water flows from run-off water from Suna hills and Nyakore stream). .....(Inundation caused by Nyokore stream and run-off water from Suna hills)
- The farms are flooded sweeping away the food crops .....(Inundation caused by Nyokore stream and run-off water from Suna hills)
- The grazing grounds are inundated making it difficult for livestock to graze .....(Inundation caused by Nyokore stream and run-off water from Suna hills)
- The murram roads are inundated with flood water cutting off the villages from travelling.

.....(Inundation caused by Nyokore stream and run-off water from Suna hills)
- Tulu Siko village becomes an island as the flood water surrounds the village make it in accessible .....(Inundation caused by Nyokore stream and run-off water from Suna hills)

(9) Ratieny
- Flood waters mainly from the Ratieny stream that is fed by run-off water from the neighbouring hills ..... (Flash flood)
- Leads to disruption of transport..... (Flash flood)
- Few houses are inundated with flood water..... (Flash flood)
- Farmlands and grazinglands are seriously affected .....(Flash floods)

(10) Tito
- Water depth 60-100cm with a duration of 3 weeks .....(Flash floods)
- Flood waters mainly from the Kamegeta hills in Tanzania and flows into the R. Tito that eventually over flow its banks..... (Flash flood)
- Leads to disruption of transport feeder roads and road that links Kenya and Tanzania (Flash flood)
- Houses near R. Tito are inundated with flood water..... (Flash flood)
- Schools like Nyakondo are seriously affected ..... (Flash flood)

3.1.3 Existing Structures along the River

a) Water Plant at Kigati in Kisii central Sub-county
The Water Plant at Kigati was established in 1976 and water intake at plant is 6000M^3/day and the water is supplied to Kisii town and its environ. The plant is currently under upgrading and it targets an intake of 18000M^3/day.
Based on interview with staff at the Water Plant it is estimated that sediment sieved during intake is 1 tonne in 3 months i.e. one tonne in three months of sediment is removed by the water plant from the river channel during intake. They dump this sediment within the farms within the water plant compound. The sediment charecteristics is fine sand and soil (reddish-brownish in colour) granules.

b) Water Plant at Ogembo in Gucha Sub-county
The Water Plant at Ogembo was established in 2005 and water intake at plant is 200M^3/day and the water is supplied to Ogembo town and its environ.
Based on interview with staff at the Water Plant it is estimated that sediment sieved during intake is 1/4 tonne in 6 months i.e. a quarter tonne in six months of sediment is removed by the water plant from the river channel during intake. They dump this sediment within the farms within the water plant compound. The sediment charecteristics is fine sand and soil (reddish-brownish in colour) granules.

c) Water Plant at Keroka in Gucha Sub-county
The Water Plant at Keroka was established in 1980 and water intake at plant is 500M^3/day and the water is supplied to Keroka town and its environ.
Based on interview with staff at the Water Plant it is estimated that sediment sieved during intake is 1/2 tonne in 3 months i.e. a half tonne in three months of sediment is removed by the water plant from the river channel during intake. They dump this sediment within the farms within the water plant compound. The sediment charecteristics is fine sand and soil (reddish-brownish in colour) granules.

d) Water Plant at Oyani in Uriri Sub-county
Targets water supply to Migori Town and its environ and the plant is currently construction.

e) Gogo falls dam
The secondary data collected from Lake Basin Authority "RIVER PROFILE STUDIES VOLUME IV, LOWER KUJA, IRRIGATION DEVELOPMENT ANNEX II HYDROLOGY OCT 1985" reports that: Gogo Falls dam was completed in 1957. In 1961 a severe flood caused the dam to be overtopped and resulted in failure of the right abutment wingwall and the formation of 8M deep erosion gully around the right end of the dam. Grundy estimated a discharge of 30,000Ft^3/S (850M^3/S) for the same flood a few KM downstream at KB1…
Following this failure a roughly built cofferdam was constructed at the upstream end of the gully.

The cofferdam blocked off a section of the secondary spillway, reducing the level of security of the main dam, and by 1979 had developed serious leaks. In order to restore the dam to its pre 1961 level of security a fuse plug spillway was constructed in 1981 in the erosion gully on the right bank; it is designed to fail by overtopping and subsequent erosion.
The dam now has three distinct spillways. The first spillway is typicaly in use, except periods of low flows. The second spillway comes into operation at a discharge of approximately 220 M^3/S. The third, fuse plug, spillway is designed to breach at a discharge of 390 M^3/S, corresponding to a 1 in 5 year flood. On failing, the initial outflow will be of the order of 300-400 M^3/S. Combined with flow already in the river this will result in a surge downstream of 700-300 M^3/S.
It may be noted therefore that in 1 in 5 year flood at Gogo could result in a flood discharge of similar magnitude to that estimated for 1961. Attention is drawn to this because flood estimates provided for 1KB05 and the Project do not allow for failure of Gogo Falls fuse plug spillway. Careful consideration needs to be given to this aspect in relation to safety of staff engaged in hydrological monitoring at Gogo Falls, 1KB1A and 1KB05… [10] (Page A2-19)

f) Drainage Canals
In Gekano area in Nyamira Sub-county there is a drainage canal that is dug by community through CDF funding. The canal flows into R. Gucha, its water comes from the hilly areas near Gekano Secondary. In Esani area in Nyamira Sub-county there is also a drainage canal that was dug by community through CDF funding and it is the current channel of R. Gucha. The purpose of canal was to reduce the impact of flash floods in the area during rainy seasons especially the can now protects the vehicular bridge, the road and it reduces inundation of the nearby school compound.

g) Bridges and Culverts along R. Gucha Migori System
There are at least twenty seven (27) civil works structures constructed along the R. Gucha and R.Migori as they join to form R. Gucha Migori. These structures include culverts, footbridges and vehicular bridges. It was noted during site visit survey that some culverts were blocked by debris. In R. Oyani a tributary of R. Gucha for example at Masaa Bridge there is decommissioned gabion that was left within and in the middle of the river channel by the contractor who constructed the bridge. At Daraja Aego in Nyatike Sub-county the river channel is rocky with sandy riverbed and there are wooden logs in the river channel. These two place lie within R. Gucha system. While in the Migori system at Esoit-Naibor area it was noted during survey that the river had rocky riverbed and wooden logs were observed in the river channel. And in R. Gucha Migori in many places wooden logs were observed in the river channel for example at Wath Onger Bridge.

3.2 FLOOD CHARACTERISTICS AND SITUATIONAL DAMAGES IN GUCHA MIGORI RIVER BASIN

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

There are three types of flood characteristics in the Gucha Migori River Basin as described in table 3.2.1 below:

[10] Lake Basin Authority "River Profile Studies iv, Lower Kuja, Irrigation Development Annex II Hydrology Oct. 1985

Table 3.22.1 Floods impact on communities in the downstream during an ordinary year

Mark	Flood Type	Area
A	Soil and sediment run off	Upstream and mid-stream of the river basin
B	Widespread and long-running inundation which is caused by overflow leading to breaking of the R. Gucha Migori riverbanks and heavy backflow from Lake Victoria	Low-lying area at the lower river basin)
C	Flash floods from the neighbouring hills, overflow of small tributaries of R. Gucha Migori and permanent and seasonal streams overflow	Upstream, Mid-stream and downstream

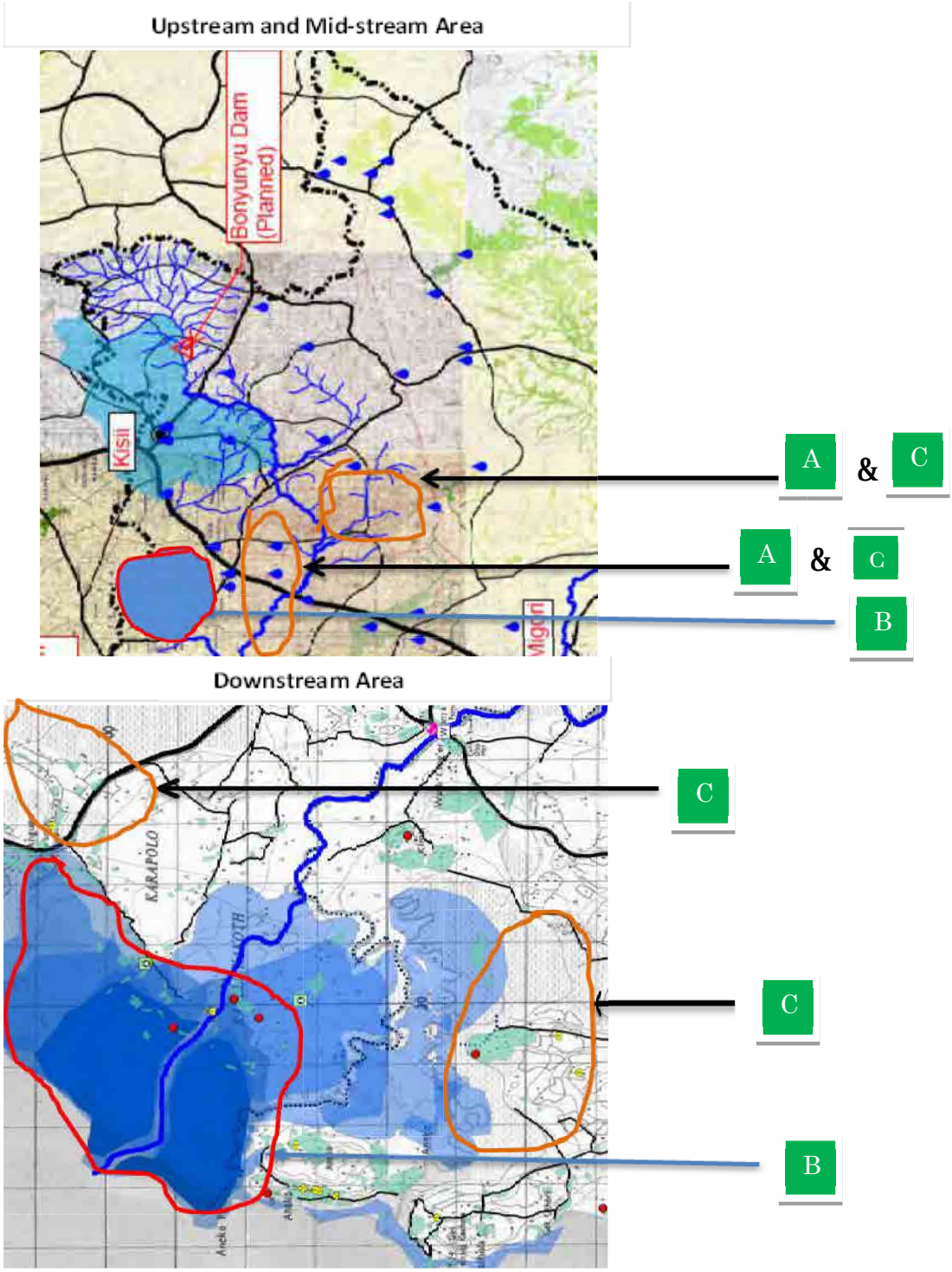
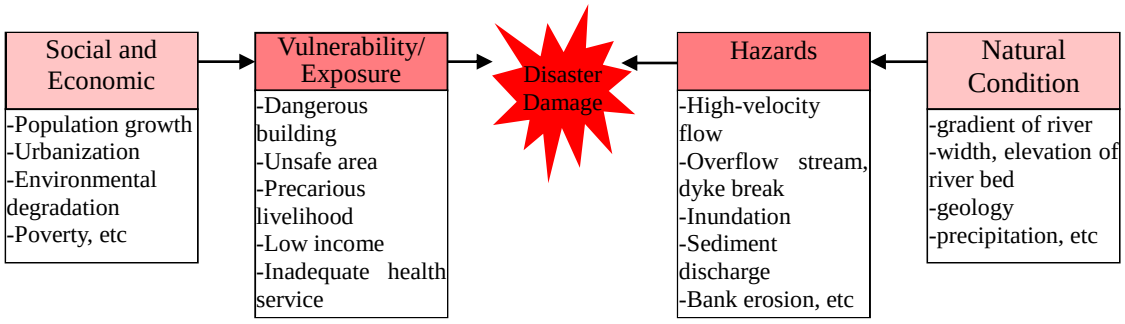


Figure 3.2.1 Records of Flood Damage and Classification of Flood Characteristics in the Gucha Migori River Basin

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 middle stream and downstream

(1) Flood Characteristics from Natural Conditions

During the rainy seasons of March to May and September to November there is heavy rainfall in the upstream area of Kisii and Transmara highlands. In both areas in the upstream there are heavy agricultural activities and many feeder murram roads, and therefore during rainy season a large amount of volcanic alluvial soil is washed away from the farms and the murram road that flows downstream at high velocity. The feature is as follows:

- Sediment discharge in the upstream is causing aggradation of river bed levels in the downstream that is gentle slope and low flow velocity.
- In addition, flash floods occur in the upstream areas on the tributaries of R. Gucha and R. Migori.

Natural Conditions that are described in the last chapter and Hazards in this area are shown as Table 3.2..

Table 3.2.2 Natural Conditions and Hazards in Upstream and Middle Stream

Natural Conditions	Hazards
Heavy rains in the Kisii and Transmara highlands Geography: A sharp inclination (High Altitude of 1867m in Kisii Highlands and 1808m in Transmara highlands and lowlands of less than 1151 at Wath Onger downstream)	Soil Erosion High velocity and tractive force High peak discharge
Many earthen (murram) feeder roads	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:

The upstream area is an agricultural rich area with farmers engaged in cash crop farming especially of tea and sugarcane plantations. There farmers also grow food crops like maize and beans. There is heavy infestation of eucalyptus tree in the upstream of Kisii highlands. In Transmara the forest cover is drastically reducing as many community members in the area adapt agricultural farming lifestyle at the expense of pastoralist lifestyle. This has enhanced soil erosion in the upstream..

Table 3.2.3 Conditions on Social and Economic and Vulnerability / Exposure in Upstream, Middle Stream and downstream

Socio-economic conditions	Vulnerability/ Exposure
Population is 1,671,328 . Density of population 1500~2200 person/km^2	Density of population is high. Vulnerability is high.
Cash Crop Farmers in the upstream and midstream	Access roads to the farms and market are many. Exposure to surface water run-off is high
Riparian land owners in the downstream	Farms are close to the rivers. Vulnerability is high
Feeder roads and trunk route	Structural vulnerability of roads and bridges
The basin is vast cutting across five counties	Difficult to coordinate, integrate or collect and analysis data of metrological, hydrological

(3) Flood Damage Mechanism

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

(1) Flood Characteristics from Natural Conditions

Downstream area is inundated by flood water that over flow R. Gucha Migori and backflow from the Lake Victoria. The overflow is a result of the river lack of flow capacity due to heavy sedimentation of the river channel. The sedimentation is also heavy at the mouth of the lake leading to the backflow.

- The lack of flow capacity is caused by heavy sedimentation of Gucha Migori River. Aggradation of river bed levels is generated by discharged sediment.
- Meandering nature of the river at a sharp bends leading to the river changing its course and continuous breaking of the riverbanks.
- Continuous widening of the river due to sedimentation.
- In addition, due to rising water level of the Lake Victoria, flooding water has nowhere to go

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

Due to long term inundation, the floods have heavy impacts including damages to properties and farmlands, destruction of crops, no-access to drinking water (the only borehole with good drining water is located in a high depth inundated area), non-functioning of infrastructures facilities (severed road, physically impossible to commute to school, flooding in hospitals and etc.) and loss of livestock and poultry.

- River Gucha Migori breaks its banks and inundated more than two villages with Kabuto and Nyora villages being heavily affected. During floods community members use canoes to access various points of the affected areas.
- Five hundred and seventy nine (579) households were inundated (KRCS calculation puts six persons per one household) and 3,474 residents were affected in the year 2012.
- Evacuees who are evacuated during floods are displaced for over one month. The evacuees move to schools for temporary shelter but because of the damage to school facility during evacuation sometimes the evacuees are denied a place to evacuate to and they have to stay in the cold or at the raised places in their relatives' homes.

l p b w “S - m d ” d “ l b l y/ xp ”
are shown in

Table 3.2.4.

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

Socio-economic conditions	Vulnerability/ Exposure
Highly-populated villages (population density of 400 people per square kilometer)	A big number of community members are affected by flood
Fishing, agriculture and livestock rearing are the major source of livelihood in this area	Agricultural activities are affected, lack of grazing land for livestock, canoes are used for evacuation and transport hampering fishing activities all this affects the residents' livelihood
Encroachment of the riparian land by farmers.	Riverbanks are weaken and easy to be breached
Unpaved community road	Roads are severely damaged by floods
Education activities in the area	Schools are occupied as evacuation places. Long period of education programmes being suspended enhances school dropout rate in the area.

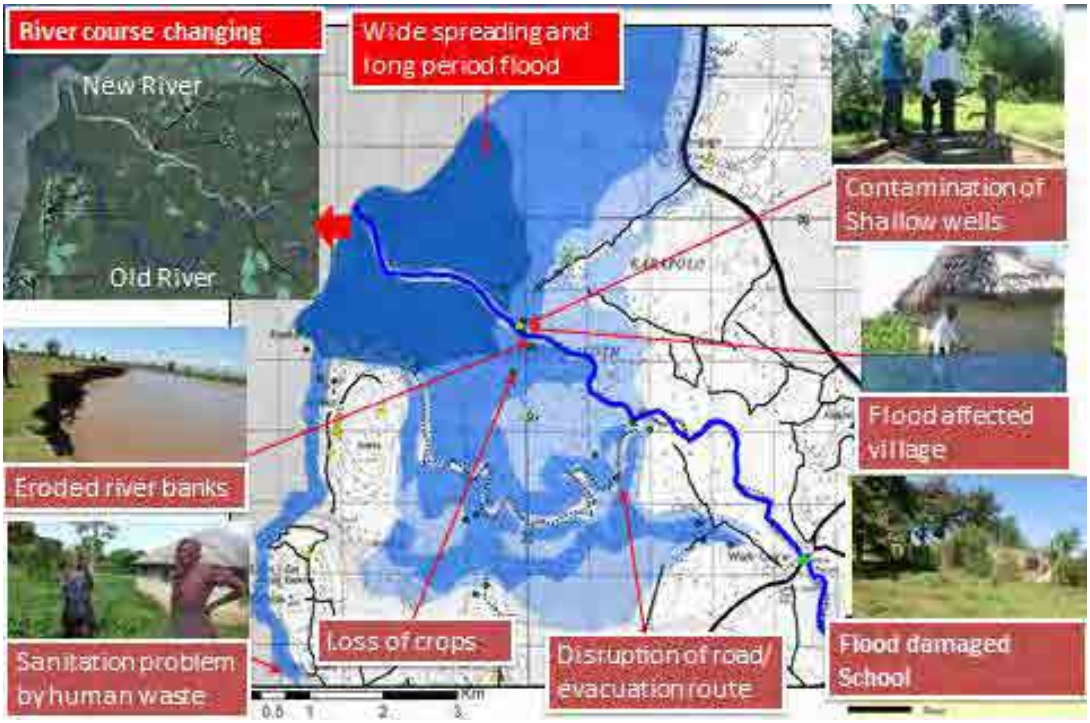


Figure 3.2.3 Flood Characteristics in the Low-lying area of Lower Gucha Migori River

(2) Flood Damage Mechanism

Around upstream to middle stream, sediment outflow occurs heavily with farmland erosion caused by furious rainfall and high velocity sheet flow. Interviews with Agricultural Officers in the upstream revealed that there is heavy erosion during heavy rains and that the storm water flows through the many murram feeder roads into the river channel.

In the upstream and midstream agriculture is the main economic activity with much of their fertilizer being deposited in the downstream as silt that makes the community members in the downstream consider floods as having some good effects to their agricultural land by providing good silt that add value to agriculture in the area.

Figure 3.2.4 Flood Characteristics near the Gucha Migori River's Tributaries

Figure 3.2.5 Flood Characteristics: Damaged riverbank after floods by R. Gucha Migori

3.2.4 Flash flood from the neighbouring hills, overflow of small tributaries of R. Gucha Migori and permanent and seasonal streams overflow(C)

(1) Flood Characteristics from Natural Conditions

Table 3.2.1 Natural Conditions and Hazards near the Gucha Migori ' T b

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

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

Table 3.2.2 Conditions on Social and Economic and Vulnerability/ Exposure near the Gucha Migori ' T b

Socio-economic conditions	Vulnerability/ Exposure
Highly-populated villages (population density of 600 people per square kilometer)	A big number of community members living at the Lwanda township are affected by flash flood

Agriculture, motorcycle transport and livestock rearing are the major source of livelihood in this area	Agricultural activities are affected, lack of grazing land for livestock, and transport by motorcycle is dirupted
Unpaved community road	The tarmac roads becomes the channel through which the strom water flow on and aftermath of flash floods the roads are severely damaged by floods

Figure 3.2.6 Flood Characteristics: Run-off water from nearby hills flow downstream

Figure 3.2.7 Flood Characteristics: The road through which the run-off water flow on

Figure 3.2.8 Flood Characteristics: The rain run-off water flow into the township

(2) Flood Damage Mechanism

Flash flood in the area is caused by concentrated rainfall around the hilly areas and occurrence of flood with large peak flow in short term into the Lwanda Township. In Tito and Ratieny area the concentrated heavy rains flow at high peak into the small seasonal river course and the nearby streams and thereby leading to floods in the area.

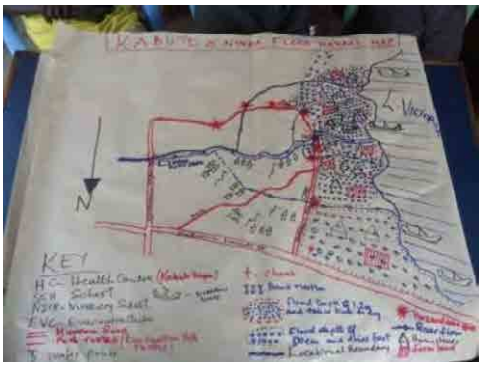
3.2.5 Flood Hazard Map in the downstream of Gucha Migori river basin

Community members in Lower Gucha Migori Sub-catchment have developed four (4) community-driven flood hazard maps. The maps are for the following areas:

i) Kabuto-Nyora (areas mainly affected by overflow of R. Gucha Migori);
ii) Lwanda Misiwi (areas that are affected by heavy rainfall run-off steming from the neaibouring hills);
iii) Ratieny Tito (areas that are affected by heavy rainfall run-off steming from the neaibouring hills that flows into the seasonal rivers and streams); and
iv) Aneko, Aeko Tulu (areas affected by the old channel that overflows during the high flow peaks and the backflow from the lake).

Example of the community driven flood hazard map is shown in the figure 3.2.8 below.

Drawing the map on the ground



Drawn map is transferred to manila paper

Figure 3.2.9 Flood Characteristics: The Community-driven Flood Hazard Map

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 Gucha Migori River Basin

(1) Summary of Damage and Measures

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

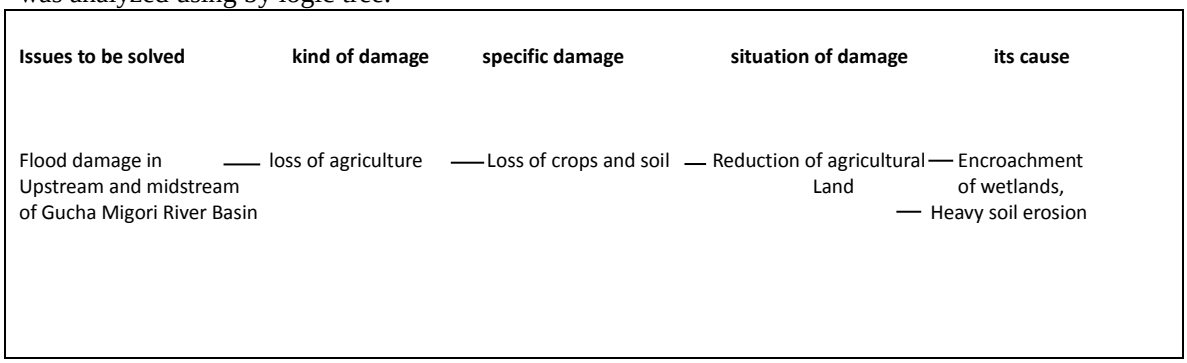


Figure 3.3.1 Analysis on Problem Tree

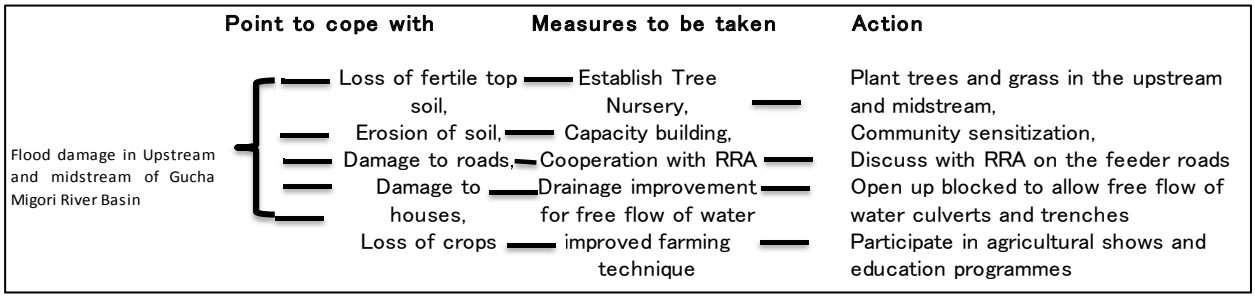


Figure 3.3.2 Analysis on Objective Tree

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

(1) Summary of Damage and Measures

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

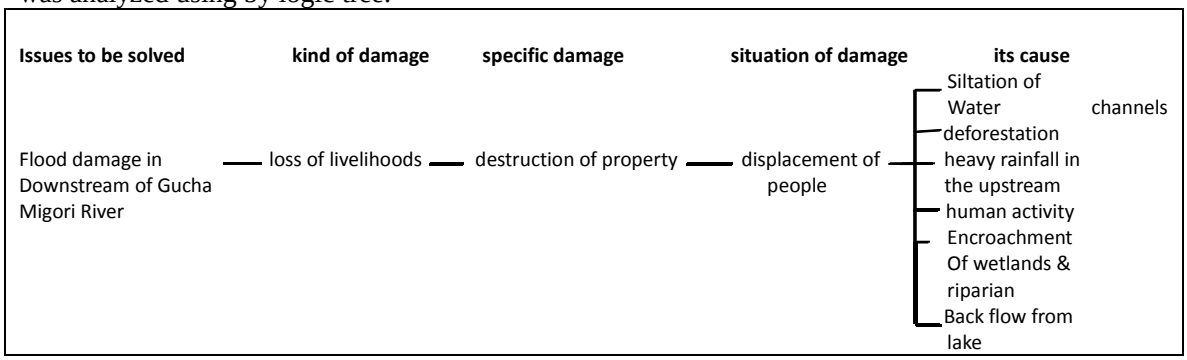


Figure 3.3.3 Analysis on Problem Tree

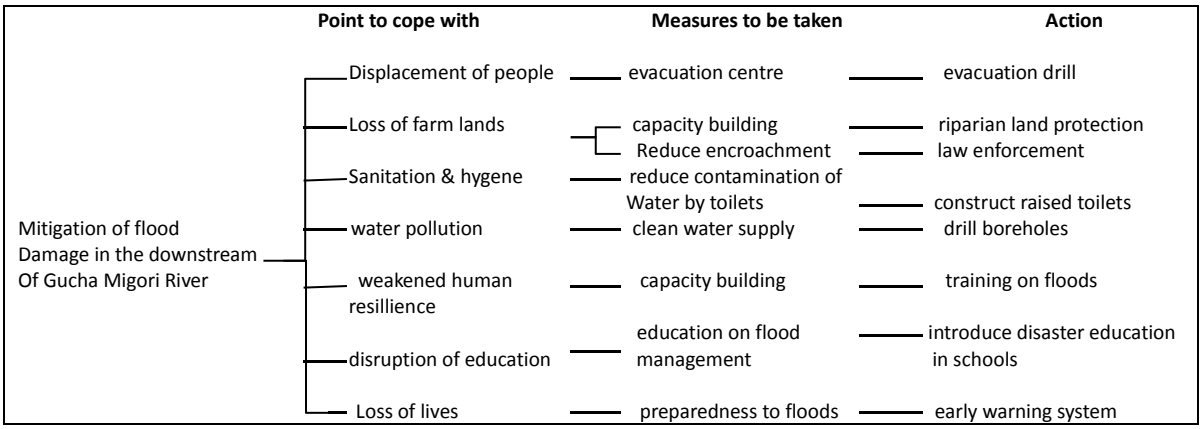


Figure 3.3.4 Analysis on Objective Tree

Table 3.3.1 Countermeasure Method to be considered in Gucha Migori River

	Short Term (1 year)	Medium Term (2 – 5 years) (SCMP)	Long Term (5 -10 years)
Structural and non-structural measures by the government (Large scale)	1. Mainstreaming Flood Management concepts into school curriculum 2. Construction of mobilets or provision of mobilets to every homestead	1. Improvement of evacuation route by constructing footbridges, culverts and bridges; 2. Construction of check-dams in the upstream and mid-stream 3. Improvement of drainages including the storm run-off water on the feeder road	1. Construction of dykes along R. Gucha Migori; 2. Desilting of R. Gucha Migori and its tributary; 3. River training of R. Gucha Migori; 4. Gabion works at breached riverbank ; 5. Improvement of Gogo falls dam
Community participatory works/activities with government assistance including structural and non-structural measures (Medium scale)	1. Improvement of agricultural practices; 2. Drilling of borehole and installing water tanks at evacuation places 3. Conducting evacuation drills (bi-annually); 4. Construction of Retarding basins; 5. Construction of raised toilets in evacuation places	1. Construction of an evacuation centre; 2. Construction of water pans 3. Establishing an integrated flood management forum (Umbrella WRUA) 4. Construction of a storage facility that can store food and household properties of the evacuees; 5. Improved Irrigation-based agriculture	1. Construction of health facility with an admission wing with capacity of at least 50 and maternity wing;
Community initiative works/activities including structural and non-structural measures (Small scale)	1. Construction of well maintained flood resistant toilets; 2. Developing flood sensitization posters; 3. Promotion of low-cost water treatment; 4. Advocacy on sanitation and hygiene	1. Establishing community based early warning system; 2. Capacity building on use of eco-san toilets	1. Raising of houses in the flood affected areas;

3.4 SELECTION OF FLOOD DAMAGE TO BE PREVENT PREFERENTIALLY

3.4.1 The Result of Workshop for Flood Damage Analysis by Community

In Gucha Migori River Basin, the workshop was held to analyze the problems in Lower Gucha Migori sub-catchment with WRUA members, WRMA-SRO staff and JICA project team members on 30th and 31st October 2012.

As a result of analysis, the causes of flood are pointed out as below:

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

Area	Causes	Characteristics of flood
Downstream of Gucha Migori River	Delta and lowland; Lack of flow capacity of river channel in the downstream; Heavy rainfall in the upstream; Deforestation by cultivation; Large volume of sediment discharge	Wide spreading and long period inundation in lowland of the downstream
	River meandering; Bank erosion	Shifting of river channel in the downstream
Small rivers in hilly area	Heavy rainfall; Lack of flow capacity	Flash flood from small rivers in hilly area

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 by WRMA-Kisii	Theme	Direct impact	Secondary impact
1	Evacuation problem	-Disruption of evacuation route -People have to evacuate	- Death of people - Doctor and medical service doesn't reach the area - Closure of school for evacuation use
2	Destruction of infrastructure	-Road -Communication networks	- Public transportation system does not work - Community is divided - People can't transfer - Supplies don't reach the market - Delayed response from out side
3	Destruction of farm land (livelihood)	-Loss of crops -Loss of livestock	-Lack of food -Income decrease
4	Water contamination	-Contamination of well-water -Overflow of sewer from toilet	-Outbreak of disease

During the workshop that was held in Gucha Migori River Basin, on 30th and 31st October 2012 the community members were able to discuss the flood problem in Lower Gucha Migori Sub-catchment vis-à-vis hazard, risks, vulnerability and capacity.

The result of the discussion is indicated below:

Table 3.4.3 Discussion on flood problem vis-à-vis hazard, risks, vulnerability and community capacity to cope

Hazards

- Flood hazards includes: Heavy sedimentation of the river channels; Encroachment of the riparian areas and wetlands and heavy rains at the hilltops (rapid speed for onset leads to delayed warning on possible flooding scenario)
- Poor farming techniques leading to soil erosion in the upstream;
- Lack of ability to control sedimentation through trapping the sediments in the upstream;
- Lack of capacity for community in desiliting the river channels

- Lack of machinery for desiltation;
- Soil infertility in the area leading to cultivation of riparian land that are assumed to be fertile;
- Lack of knowledge on small scale irrigation methods leading to assumption that cultivating near the river leads to easy irrigation;
- Uncontrolled gold mining activities ; and
- Destruction of reeds in the wetlands. Reeds are harvested to be used for house construction.

Risks

- Cultivation of riparian land leading to breaching of riverbanks;
- Lack of security of the homes disserted as affected families evacuate;
- Poor evacuation routes that lack facilities like bridges that lead to hazardous evacuation;
- Lack of education programmes on issues of flood management and also interference of education programmes leading to poor performances of people therefore reduced capacity on management of floods;
- Contaminated water sources;
- Invasion of the villages and farmlands by aquatic animals like hippopotamus, crocodile etc
- Poor farming practices which includes riparian land cultivations;
- Poverty: This lead to destruction of forests through charcoal burning etc;
- Lack of capacity in flood management; and

Poor construction techniques whereby community people lay low foundations for houses that are below the flood depth.

Vulnerability

- Farms: The farmlands are located near the rivers or near the water sources are vulnerable;
- Children: Mainly children aged between 2 years and 6 years are the most vulnerable because during flooding disaster there is panic confusion that makes this children more vulnerable because of inability to make informed decision;
- The aged: Senior citizens in the community majorly sixty five and above years are most vulnerable. There is lack of caring for the elderly system;
- Settlements: There are no alternative places for resettlement and most community members do not prefer evacuating to the schools or evacuation places because there is lack of established evacuation place or centre and evacuation to raised places makes evacuees be at the mercy of those in charge of the raised place whether school or any other facility;
- Water points: Contamination of water bodies leading to epidermis and quick spread of diseases; and

Sick persons: The sick who are being treated while at home also vulnerable. This is because they are few trained community health workers

Capacity

- Lack of collective responsibility in addressing flooding disaster;
- Poor communication skills: One major way of communicating is through barazas that some people do not attend and others though they attended they disseminate wrong information to others. Communication through mobile phones is often hampered due to lack of providers' network;
- Lack of technical know how in the community on preparedness;
- Destructive cultural practices and believes;
- Lack of community mobilization skills;
- Lack of knowledge on proper management of evacuation place which includes how to live at the evacuation places; and

Lack of institutionalized flood early warning system

3.4.2 Selection of Flood Damage to be prioritized

The flood damages in Gucha Migori River Basin is principally classified 3 types such as A) Soil and sediment run off (Upstream and midstream of the river basin), B) Widespread and long-running inundation which is caused by overflow leading to breaking of the R. Gucha Migori riverbanks and heavy backflow from Lake Victoria and C) Flash floods from the neighbouring hills, overflow of small tributaries of R. Gucha Migori and permanent/seasonal streams overflow.

Based on the evaluation of flood damages by communities as elaborated above, 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	Small Scale business	
A) Soil and sediment run off	Low	Low	Low	**High**	Mid	Mid	Low
B) Widespread and long-running inundation which is caused by overflow leading to breaking of the R. Gucha Migori riverbanks and heavy backflow from Lake Victoria	**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 "B) Widespread and long-running inundation which is caused by overflow leading to breaking of the R. Gucha Migori riverbanks and heavy backflow from Lake Victoria" has strongest impacts socio-economically, and next is the damage by flash flood. The damage by "Soil and sediment run off" in upstream and midstream to midstream has impacts to agriculture but the impacts to socio-economic matters is not so high, and then the priority is low. The countermeasure to reduce the soil erosion and sediment outflow should implement in long term perspective because it takes long time to be given the effects.

(3) Selecting Process FOR POSSIBLE Projects

4.1 Evaluation on 5 Criteria

4.1.1 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 3.41.4 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"

The Integrated Flood Management Committee (IFMC) Gucha Migori River Basin Meeting that was held on 24th July 2014 was tasked with the responsibility of keenly reviewing the proposed countermeasures based on the above elaborated evaluation criteria thereafter rank the countermeasures based on the priority as perceived by the IFMC members.

Through the group discusssions wherein groups were divided into three and each group was tasked with evaluation of the countermeasures. Group one was tasked with evaluation of the shortterm countermeasures, while group two was tasked with evaluation of mid-term countermeasures and group three was tasked with evaluation of the longterm countermeasures. The groups thereafter presented to the plenary on their findings including prioritization of the countermeasures and the implementation period of such countermeasures. The group presentations based on the evaluation, prioritization of the possible countermeasures is herein captured in the table below:

Table 3.4.2 Proposed Activities in Community-driven Flood Management Action Plan

Activity	Relevancy	Effectiveness	Efficiency	Impact	Sustainability	Ranking	Implementation period
Proposed countermeasures for Shortterm implementation							
1) Developing flood sensitization posters	High	High	High	High	High	(1)	Jan 2015 to Dec 2017
2) Conducting evacuation drills (bi-annually);	High	High	High	High	High	(2)	Jan 2015 to Dec 2017
3) Drilling of borehole and installing water tanks at evacuation places	High	High	High	High	High	(3)	Jan 2015 to Dec 2017
4) Construction of raised toilets in evacuation places	High	High	High	High	High	(4)	Sept. 2014 to Sept. 20167
5) Advocacy on sanitation and hygiene	High	High	High	High	High	(5)	Jan 2015 to Dec 2017
6) Promotion of low-cost water treatment;	High	High	High	High	High	(6)	Jan 2015 to Dec 2017
7) Construction of mobilets or provision of mobilets to every homestead	High	High	High	High	High	(7)	Jan 2015 to Dec 2017
8) Improvement of agricultural practices;	High	High	High	High	Fair	(8)	Jan 2015 to Dec 2017
9) Mainstreaming Flood Management concepts into school curriculum	High	High	High	High	Fair	(9)	Jan 2015 to Dec 2017
10) Construction of well maintained flood resistant toilets;	High	High	High	Fair	High	(10)	June 2015 to June 2016
11) Construction of Retarding basins;	High	High	Fair	High	Fair	(11)	Jan 2016 to Dec 2017
12) Check dams in the up-streams	High	High	Fair	Fair	Fair	(12)	Jan 2016 to Dec 2017
Proposed countermeasures for Mid-term implementation							
1) Construction of an evacuation centre	High	High	High	High	High	(1)	Jan 2015 to Dec 2017
2) Construction of water pans	High	High	High	High	High	(2)	Jan 2015 to Dec 2020
3) Establishing an integrated flood management forum (Umbrella WRUA)	High	High	High	High	High	(3)	Jan 2015 to Dec 2015
4) Construction of a storage facility that can store food and household properties of the evacuees	High	High	High	High	High	(4)	Jan 2015 to Dec 2017
5) Improved Irrigation-based agriculture	High	High	High	High	High	(5)	Jan 2015 and conitinuous
6) Capacity building on use of eco-san toilets	High	High	High	High	High	(6)	Jan 2015 to Dec 2015
7) Improvement of evacuation route by	High	High	High	High	Fair	(7)	Jan 2015 to Dec 2018

constructing footbridges, culverts and bridges;							
8) Construction of check-dams in the upstream and mid-stream	High	High	High	High	Fair	(8)	Jan 2015 to Dec 2019
9) Establishing community based early warning system;	High	High	High	High	Fair	(9)	Jan 2015 to Dec 2017
10) Capacity development in proper farming methods in the upstream;	High	High	High	High	Fair	(10)	Jan 2015 to Dec 2020
11) Improvement of drainages including the storm run-off water on the feeder road	High	High	High	High	Low	(11)	Jan 2015 to Dec 2019
Activities targeted for long-term implementation							
1) Construction of health facility (dispensary)	High	High	High	High	High	(1)	Jan 2015 to Dec 2020
2) Raising of houses in the flood affected areas;(Through capacity building)	High	High	High	High	High	(2)	Jan 2015 to Dec 2020
3) Construction of dykes along R. Gucha Migori	High	High	High	Fair	Fair	(3)	Jan 2015 to Dec 2020
4) Gabion works at breached riverbank	High	Fair	Fair	High	High	(4)	Jan 2015 to Dec 2020
5) Improvement of Gogo falls dam 6)	High	High	High	Fair	Fair	(5)	Jan 2015 to Dec 2025
7) Construction of the dams in the upstream	Fair	Fair	Fair	Fair	Fair	(6)	Jan 2015 to Dec 2025
8) River training of R. Gucha Migori	Fair	Fair	Fair	Fair	Low	(7)	Jan 2015 to Dec 2023
9) Desilting of R. Gucha Migori and its tributary	Fair	Low	Fair	Fair	Low	(8)	Jan 2015 to Dec 2020

PROJECT IMPLEMENTATION PLAN OF FLOOD COUNTERMEASURES

5.1 FLOOD COUNTERMEASURES IN THE FLOOD MANAGEMENT PLAN

The Flood Management Plan defines the most prioritized flood damage as a result of the long term inundation after the confluence of R.Gucha and R. Migori and hence R. Gucha Migori and that is the downstream areaof the both R. Gucha and R. Migori and also experience the backflow of the L. Victoria and the second prioritized flood damage as result of the Flash Flood from Tributary River, heavy runoff from the neighbouring hills and this is in the upstream, midstream and downstream areas.

The countermeasures against the above mentioned flood damage should be incorporated in the CMS. In addition, planning of small scale projects that can be implemented at the WRUA scale should be incorporated in the Lower Gucha Migori WRUA SCMP and in the SCMPs of the WRUAs' in the midstream and upstream.

5.1.1 Structural Countermeasures

1) Short-term Structural countermeasures should be implemented in the following order:

· Drilling of borehole and installing water tanks at evacuation places
· Construction of raised toilets in evacuation places
· Construction of mobilets or provision of mobilets to every homestead
· Construction of Retarding basins;
· Check dams in the up-streams

2) Mid-term Structural countermeasures should be implemented in the following order:

· Construction of an evacuation centre
· Construction of water pans
· Construction of a storage facility that can store food and household properties of the evacuees
· Improvement of evacuation route by constructing footbridges, culverts and bridges;
· Construction of check-dams in the upstream and mid-stream
· Improvement of drainages including the storm run-off water on the feeder road

3) Long-term Structural countermeasures should be implemented in the following order:

· Construction of health facility (dispensary)
· Construction of dykes along R. Gucha Migori
· Gabion works at breached riverbank
· Improvement of Gogo falls dam
· Construction of the dams in the upstream
· River training of R. Gucha Migori
· Desilting of R. Gucha Migori and its tributary

5.1.2 Non-structural Countermeasures

1) Short-term Structural countermeasures should be implemented in the following order:

· Developing flood sensitization posters
· Conducting evacuation drills (bi-annually);
· Drilling of borehole and installing water tanks at evacuation places
· Advocacy on sanitation and hygiene
· Promotion of low-cost water treatment;

· Improvement of agricultural practices;
· Mainstreaming Flood Management concepts into school curriculum

2) Mid-term Structural countermeasures should be implemented in the following order:

· Establishing an integrated flood management forum (Umbrella WRUA)
· Improved Irrigation-based agriculture
· Capacity building on use of eco-san toilets
· Establishing community based early warning system;
· Capacity development in proper farming methods in the upstream;

3) Long-term Structural countermeasures should be implemented in the following order:

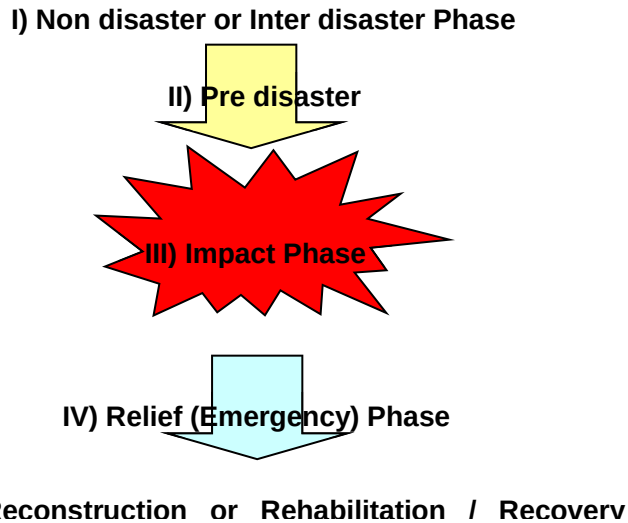
· Raising of houses in the flood affected areas;(Through capacity building)

5.2 DRAFT IMPLEMENTATION SCHEDULE OF FLOOD COUNTERMEASURES

WRMA, LOGUMI WRUA, stakeholders and members of the IFMC and JICA Project Team proposes draft implementation schedule of flood countermeasures as following.

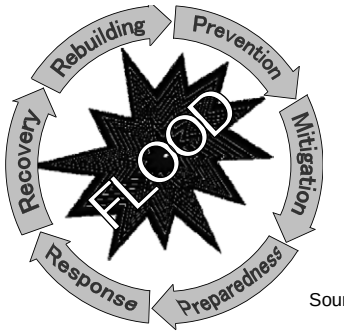
RECOMMENDATION

- ✓ Fundamental countermeasure against long term inundation in the downstream of Gucha Migori River on a long term basis should be considered.
- ✓ Collaboration with existing organization such as Sub-county Disaster Management Committee and County Disaster Management Committe is necessary to implement a project that can enforce resilience of community against flood.
- ✓ Integrated approach in flood management is important and should be the driving force. The integrated apprpach gives room for cooperation between upstream. Midstream and downstream. It also encompasses the idea of stakeholder cooperation and collaboration which includes sharing of knowledge, data and information.
- ✓ When undertaking flood management activities it is important to consider age, sex, human physical vulnerabilities etc. It is important that when structures are constructed there must be consideration of the physically challenged persons within the community (persons with disabilities).
- ✓ Flood management is not based on one phase of floods alone i.e. response but effective flood management considers all the phases of floods. The pre-flood phase that entails preparedness, flooding phase that entails response and post-flood phase that entails rehabilitation, reconstruction and developing plan for the next flood occurrence.



Source: Trainers Training Manual on Flood Disaster Management developed under the Nyando Project

Figure 5.1 ***Phases of Disaster***



Source: Flood Management Textbook for school pupils

Figure 5.2 ***Phases of Disaster***