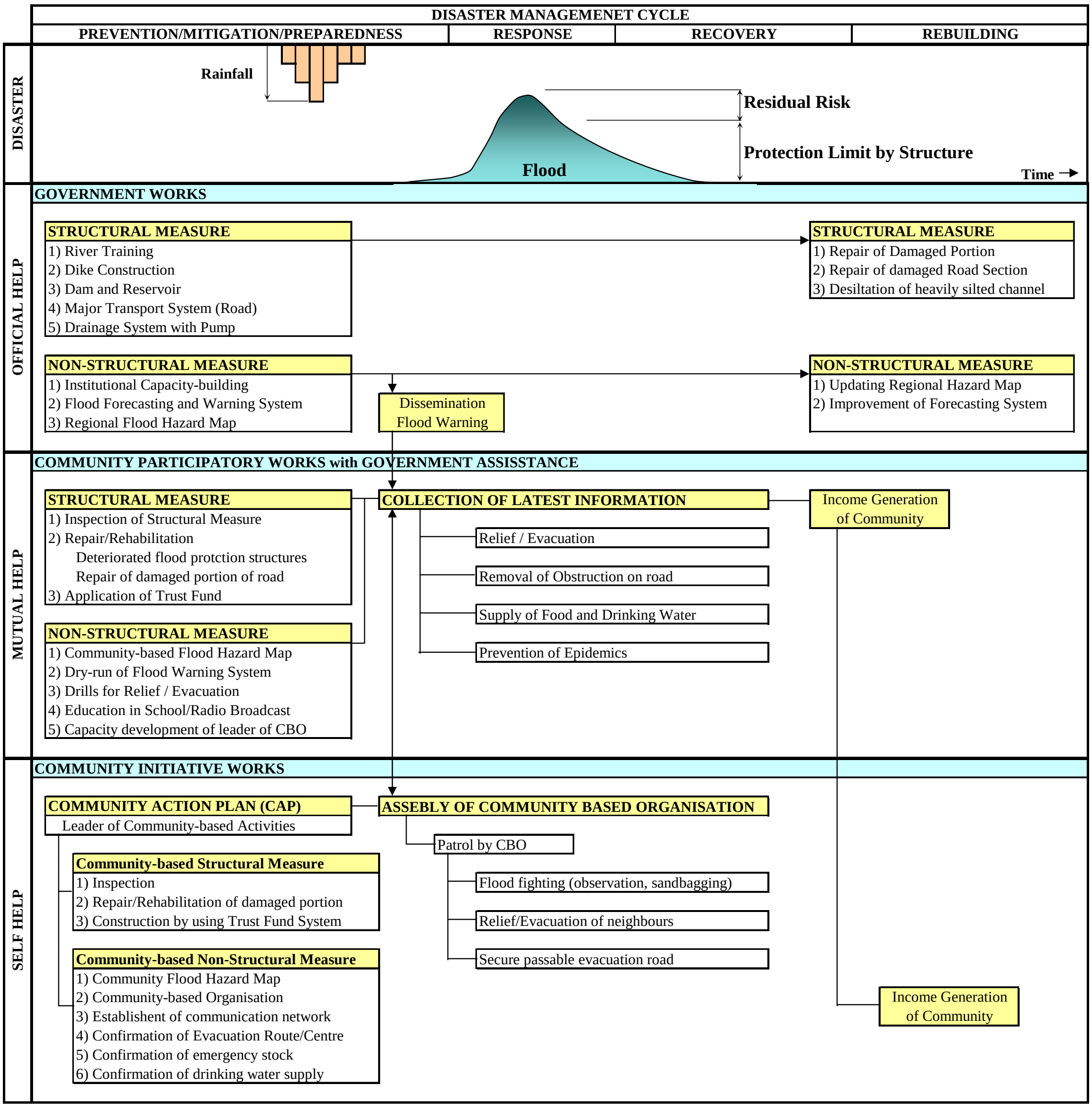
5.8 IMPLEMENTATION PROGRAMME

5.8.1 Overall Implementation Programme

All the schemes have to be implemented for the establishment of the integrated flood management to satisfy the national development goal as stated in the National Development Plan (2002-2008).

The implementation programme is also to be established under the categories of official, mutual and self helps taking into account the disaster management cycle under the concept of IFM as shown in Figure 5.8.1.



Source: JICA Study Team

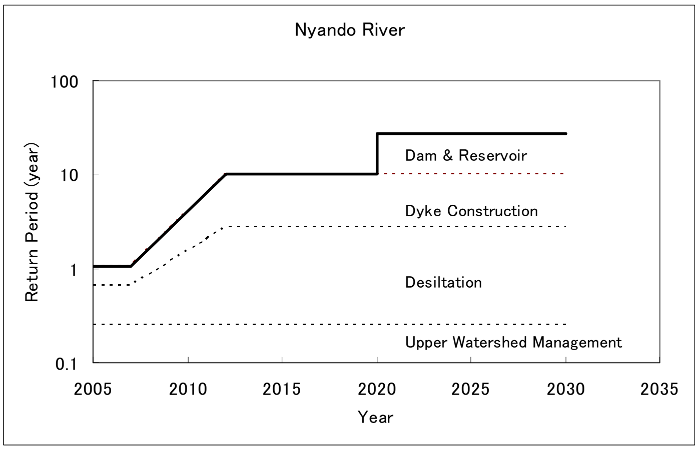
Figure 5.8.1 Relationship among Official, Mutual and Self Helps

The targets for the implementation by phases are as follows.

Short Term	(2007-2012)	:	By the target year 2012, the lower catchment of the Nyando River Basin will be secured against flood from the main river channel of the Nyando River, provided that the required financial resources are made available. In line with the concept of integrated flood management, the community participatory works with government assistance including non-structural measures will be carried out every year to manage residual risk for extraordinary floods beyond the flood magnitude of once in 10 years, while the community initiative works will be executed by the community based organisations.
Medium Term	(2013-2020)	:	By the target year 2020, the de-siltation work and embankments along the downstream stretches of adjacent rivers will be done to ensure the safety against floods of the magnitude of once in 5 years. Not only the development of dams and reservoirs on the Nyando and Kibos rivers, which increases the safety against the flood after the year 2021, but also the installation of telemetered flood forecasting and warning systems will be done. Both community participatory works with government assistance and community initiative works will be carried out continuously.
Long Term	(after 2021)	:	To maintain the condition accomplished by the target year 2020, the operation and maintenance works for structural and non-structural measures will be carried out. The community participatory works with government assistance will be carried out in line with the concept of the disaster management cycle with community initiative works.

The incremental levels of flood protection throughout the implementation of the phased development are illustrated in Figure 5.8.2 for Nyando River Basin and Figure 5.8.3 for other small river basins.

(i) Nyando River Basin

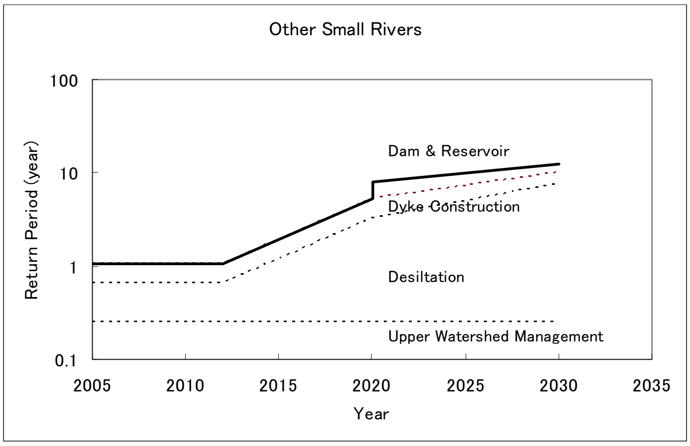


Source: JICA Study Team

Figure 5.8.2 Protection Level (Nyando River basin)

During the implementation of the short term plans, the strengthening of dikes and widening of low flow channels is to be executed to ensure the protection level for the flood magnitude of once in 10 years. By the target year 2012, the middle and lower stretches of Nyando River would be protected successfully with the ratio for raising flood protection level of 75% by dike construction and the remaining 25% by widening of low flow channels. The construction of storage dams will commence during the medium-term. The dams and reservoirs will be completed by the year of 2020. The flood protection level would be increased to the protection level for the flood magnitude of once in 25 years. The continuous de-siltation work of the low flow channels and maintenance work on the dikes for long-term period ensures the flood protection level accomplished for the short and medium-term period.

(ii) Other river basins



Source: JICA Study Team

Figure 5.8.3 Protection Level (Other River basins)

During the implementation of the short and medium-term plans, the de-silting of the river channels and construction of small-scale dikes is to be executed to ensure the protection level for the flood magnitude of once in 5 years. By the target year 2020, the lower stretches of other river basins would be protected. Approximately 60% of this increase in protection level will be due to de-silting of the river channels and the remaining 40% by construction of small-scale dikes. The construction of Kibos dam in the medium-term will be completed by the year of 2020 and will contribute to increasing the protection level up to a flood magnitude of once in 10 years. The continuous de-siltation work of low flow channels and heightening of dikes in the future will ensure further increase in the protection level.

(1) Short-Term Phase

1) To ensure the safety against flood from the main channel of Nyando River

Almost every year the heaviest flood damage occurs in the flood plain in the lower Nyando River Basin because of insufficient flow capacity of the river channel and deterioration of the existing dikes. The flood inundation occurs due to the breach of the dikes at the most seriously deteriorated portions. Hence, the first priority structural measure is given to the strengthening of the existing dikes along the lower and middle stretches of Nyando River.

The river channel dikes are designed to protect against the magnitude of flood with the probability of once in 10 years. The dike height is equivalent to the highest portion of the existing dikes, and the widening of the low flow channels is proposed to ensure the flow capacity of the river channels. The downstream end of the dikes is set at around the confluence with a tributary of Awach Kano River, where further downstream a topographical depression is formed that extends down to Lake Victoria. Reconstruction of Ahero Bridge is also to be undertaken to ensure increased flow capacity of the main channel of Nyando River

2) To secure the transport system

The National Road A1 has a vital role for the purpose of relief and evacuation activities. However, a part of National Road A1 across the Awach Kano River is frequently submerged by flood water. This section is to be raised to ensure that it is capable of carrying traffic during flooding. Furthermore, major community roads linked with the National Road A1 are also to be raised to avoid the interruption of relief and evacuation activities.

3) To avoid the clogging of the river channel and to reduce bank erosion

River bank erosion along Awach Kano and Nyamasaria river basins triggers the riverbed aggradations and the clogging of the river channels in the downstream stretches. The reduction of flow capacity of the river channels in the downstream stretches causes prolonged flood inundation. The de-siltation work with low-height dikes is proposed to be carried out continuously throughout the short, medium and long-term. Sediment retention structures are also to be constructed for reducing bank erosion and sedimentation. These works will be done continuously throughout the short, medium and long term.

4) To establish Disaster Management Centre

For a comprehensive approach for disaster management, it is proposed to establish a Disaster Management Centre in the lower catchment catering to the existing disaster management committee with extended membership. In the current framework of disaster management, there is no presence of WRMA as a water resources regulator and it is, therefore, of necessity, that WRMA become a key member of the committee.

5) To initiate flood emergency management

Flood emergency management requires cooperation across sectors and administrative levels. In addition to resource mobilisation, continuous, timely and precise information flow is vital for handling emergency situations. So far, the government agencies including local government are executing the monitoring of the flood inundation situation individually in the Nyando River Basin. The relief and evacuation activities largely depend on the help of the Red Cross and NGOs. Government agencies related to flood management share the responsibility for flood emergency operation.

6) To install hydrological monitoring stations and wireless sirens

Several key stations will be replaced with automatic recording type stations in addition to the existing three stations (1GD03, 1GB03 and 1GB07) and stations to be upgraded in the coming dry season by WRMA. The services, 1) accumulation of rainfall and water level data, 2) clarification of the relationship between rainfall and water level, 3) simple forecasting of water levels at the lower key points through the above relationship, and 4) data accumulation for flood forecasting and warning systems, would be possible to achieve with the upgraded monitoring system.

7) To execute the guidance for upper watershed management

Guidance to the communities for restoring hydrological balance in the Nyando River Basin is to be conducted in order to reduce the rapid and intense water flow from the upper catchments. The guidance to the communities is required to restore the capacity of the land to hold rainwater through i) demonstration of interventions in land use in the slope areas, and ii) demonstration of interventions to recreate hydrological buffer zones. One of the effective methods is an experiment with a scale model to demonstrate the importance of slope protection works and hydrological buffer zones. In order to reduce sedimentation flow from the upper catchments, demonstrations to communities for mitigation of soil erosion is proposed. These works will be done continuously throughout the Short, Medium and Long term periods.

8) To encourage community initiative works

The activities related to self-help with external organisations for flood management should be done through community initiative, and external organisations should not only focus on creation of awareness of flood disaster mitigation measures but also assist activities through capacity development of community driven flood management organisations. Continuous effort will be expended throughout the Short, Medium and Long term periods.

(2) Medium-Term Phase

1) To improve the channels of other small rivers

After the implementation of the short-term plan, the downstream stretches of Nyando River will have been ensured of protection against floods with a probability of once in 10 years. However, there still remains the possibility of flooding from other small rivers and flood flow over the Nyamasaria, Oroba and Miriu river basins. Hence, river channel improvement will be done to ensure protection against the floods with a magnitude of once in 5 years. Additionally, the combination of ring dikes and secondary dikes is to be applied to lower stretch of Oroba River to gain flood retarding effects.

2) To construct dams

Three promising dams are identified to increase the safety level during extraordinary flood events in the whole basin. The detailed functions of the dams are either single purpose or multipurpose, and the dam dimensions need to be studied in a future stage.

3) To establish a branch of the Disaster Management Centre

For a comprehensive approach to disaster management, it is proposed to establish a branch of the Disaster Management Centre in the upper catchment catering to the existing disaster management committee with extended membership.

4) To install telemetered hydrological stations and wireless sirens

WRMA regional office will be the forecasting centre. Required data and information at the centre will be communicated through the sub regional offices. Notification of warnings and evacuation orders to the subject areas is to be made by the sub-regional office where the branch office is built in the Medium-Term.

(3) Long-Term Phase

The items which are to be carried out continuously throughout the Short, medium and Long term periods, are 1) De-siltation of small rivers including maintenance de-siltation of Nyando River, 2) Enhancement of flood emergency management, 3) Operation and maintenance of flood forecasting and warning systems, and 4) Guidance to communities for upper watershed management

Table 5.8.1 shows the overall implementation schedule for the Nyando River Basin, especially in the lower flood prone areas. Table 5.8.2 shows the work descriptions for the proposed items.

Table 5.8.1 Implementation Schedule and Construction Cost

DESCRIPTION	Government Agency			Impelmentation Schedule			Cost
	Coordi-nation	Executing	O&M	Short	Medium	Long	(M.K.Shs)
STRUCTURAL MEASURES							**7,532.3**
A. NYANDO RIVER IMPROVEMENT	WRMA	NWCPC	WRMA				
a.1 Dike system in lower/middle reach				●			1,363.0
a.2 Desiltation/Channelling in swamp area in downstream end					●		192.0
B. AWACH KANO RIVER BASIN IMPROVEMENT	WRMA	NWCPC	WRMA				
b.1 Desiltation in Awach Kano river				●	●		173.1
b.2 Desiltation in Tributary of Awach Kano				●	●		176.4
b.3 Desiltation in Nyaidho river					●		50.0
C. DRAINAGE IMPROVEMENT IN AWACH KANO BASIN							
c.1 Drainage improvement along A1 National Road	WRMA	NWCPC	WRMA		●		33.5
c.2 Raising of A1 National Road (Ahero - Katito Section)	WRMA	MOPW	MOPW	●			660.0
D. NYAMASARIA RIVER BASIN IMPROVEMENT	WRMA	NWCPC	WRMA				
d.1 Desiltation in Nyamasaria river and ditch					●		70.4
d.2 Desiltation in Luando river					●		276.7
d.3 Desiltation in Ombeyi river and ditch					●		186.9
d.4 Desiltation in Miriu river and ditch					●		224.2
d.5 Dyke construction in Oroba river					●		173.2
E. DRAINAGE IMPROVEMENT IN NYAMASARIA BASIN	WRMA	NWCPC	WRMA				
e.1 Construction of drainage channel along A1 road					●		52.4
F. RAISING SECONDARY ROAD	WRMA	MOPW	WRMA				
f.1 Raising secondary road as evacuation road				●			273.0
G. DAM AND RESERVOIR	WRMA	LBDA	LBDA				
g.1 Two dams, (Nyando and Kibos)					●		3,300.0
H. SEDIMENT RETENTION AND EROSION PROTECTION	WRMA	NWCPC	WRMA				
h.1 Middle/Upstream catchment of small rivers					●	●	327.5
NON-STRUCTURAL MEASURE/COMMUNITY PARTICIPATORY WORKS WITH GOVERNMENT ASSISSTANCE							**1,590.5**
A. DISASTER MANAGEMENT CENTRE							
a.1 Main Building and Branch Office	OP/LA	OP	OP/LA	●	●		95.0
B. FLOOD EMERGENCY MANAGEMENT							
b.1 Updating of Flood Preparedness	DMC	WRMA	WRMA	●	●	●	16.9
b.2 Inspection/Spread of Knowledge for Disaster Prevention	DMC	Cty/LA	Cty/LA	●	●	●	478.2
b.3 Relief/Evacuation	DMC	OP/LA	Cty/LA	●	●	●	64.1
b.4 Restoration	DMC	Cty/LA	Cty/LA	●	●	●	55.0
b.5 Review/Improvement	DMC	WRMA	WRMA	●	●	●	35.5
C. FLOOD FORECASTING AND WARNING SYSTEM							
c.1 Installation of Monitoring Station	WRMA	WRMA	WRMA	●			9.4
c.2 Installation of Telemetering Station/Warning Station	WRMA	WRMA	WRMA	●	●		216.0
c.3 Installation of Additional Station	WRMA	WRMA	WRMA	●	●	●	474.3
c.4 Operation and Maintenance	WRMA	WRMA	WRMA	●	●	●	84.2
D. UPPER WATERSHED MANAGEMENT							
d.1 Guidance for Restoring Hydrological Balance	WRMA	MOA	Cty	●	●	●	18.3
d.2 Guidance for Protection of Soil Erosion	WRMA	MOA	Cty	●	●	●	43.7
COMMUNITY INITIATIVE WORKS							**2,688.0**
A. COMMUNITY SURVEY	WRMA	WRMA	Cty	●	●		220.0
B. FLOOD MANAGEMENT TRAINING	WRMA	WRMA	Cty	●	●		535.0
C. COMMUNITY-DRIVEN STRUCTURAL MEASURE (Including retarding basin)	WRMA	Cty	Cty	●	●		1,605.0
D. O&M OF COMMUNITY-DRIVEN STRUCTURAL MEASURE	WRMA	Cty	Cty	●	●	●	104.0
E. MONITORING AND EVALUATION	WRMA	WRMA	Cty	●	●	●	224.0
TOTAL							**11,811**

Note : Short-term : 2007-2012, Medium-Term : 2013-2020, Long Term : after 2021

Legend: Cty: Communities; MOPW: Ministry of Public Works; OP: Office of the President; MOA : Ministry of Agriculture
LA: Local Authority; NWCPC: National Water Conservation and Pipeline Corporation
WRMA: Water Resources Management Authority; DMC : Disaster Management Committee
LBDA: Lake Basin Development Authotiry

Source: JICA Study Team

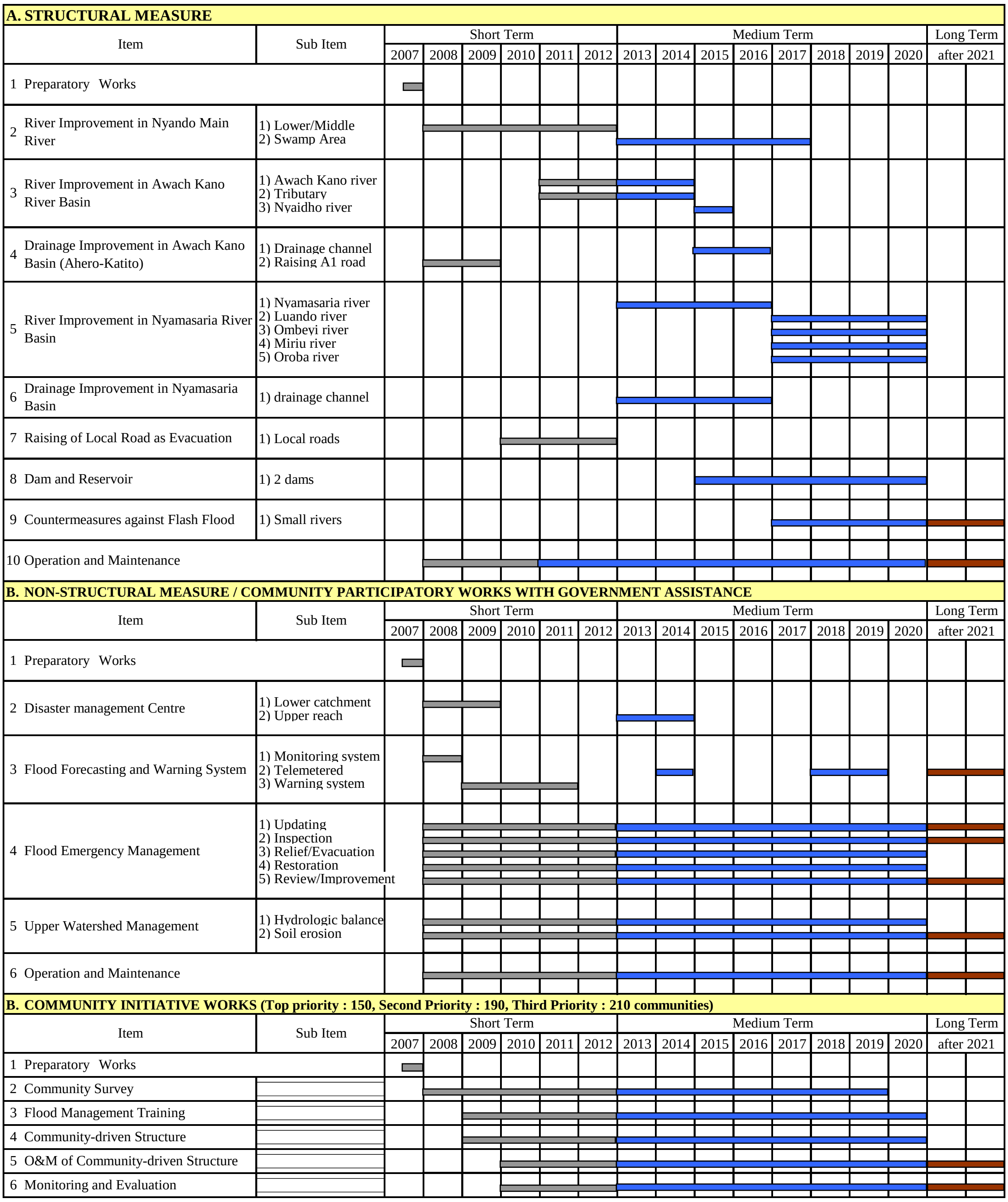
Table 5.8.2 Work Descriptions of Structural and Non-Structural Measures

WORK ITEM	DESCRIPTION		
	SHORT (2007 - 2012)	MEDIUM (2013 - 2020)	LONG (after 2021)
STRUCTURAL MEASURES			
A. NYANDO RIVER IMPROVEMENT			
A.1 Dike system in lower/middle reach	Dyke construction including reconstruction of Ahero Bridge.		
A.2 Desiltation/channeling in swamp area		Desiltation of river channel in swamp area at downstream end	
B. AWACH KANO RIVER BASIN IMPROVEMENT			
B.1 Awach Kano river	Protection works for gully and lateral erosion of river bank	Desiltation of river channel and river channel training	
B.2 Tributary of Awach Kano			
B.3 Nyaidho river			
C. DRAINAGE IMPROVEMENT IN AWACH KANO BASIN			
C.1 Construction of drainage channel along A1 road		Construction of drainage channel with water pans along A1road	
C.2 Raising A1 road surface	Raising A1 road for submerged section during flood.		
D. NYAMASARIA RIVER BASIN IMPROVEMENT			
D.1 Nyamasaria river and ditch	Desiltation of clogged river stretch due to siltation. Construction of water pans.	Desiltation of river channel	
D.2 Luando river			
D.3 Ombeyi river and ditch			
D.4 Miriu river and ditch			
D.5 Oroba river		Construction of open and ring dike system	
E. DRAINAGE IMPROVEMENT IN NYAMASARIA BASIN			
E.1 Construction of drainage channel along A1 road		Construction of drainage channel with water pans at upstream side of A1 road	
F. RAISING SECONDARY ROAD			
F.1 Raising secondary road as evacuation road	Raising of inter-community road for relief and evacuation.		
G. DAM AND RESERVOIR			
G.1 Two dams (Nyando and Kibos)		F/S, D/D and construction of dams	
H. PROTECTION WORKS FOR SOIL EROSION			
H.1 Upstream stretch of small rivers		Installation of sand pocket and river bank protection works.	
COMMUNITY PARTICIPATORY WORKS WITH GOVERNMENT ASSISTANCE (including NON-STRUCTURAL MEASURE)			
A. DISASTER MANAGEMENT CENTRE			
A.1 Main Building and Storage House	Construction of Main building	Construction of branch office	
B. FLOOD EMERGENCY MANAGEMENT			
B.1 Updating of Flood Preparedness	Updating of flood hazard map and collection of latest status of structural measure		
B.2 Inspection /Education for Disaster Prevention	Inspection, dry-run of flood forecasting and warning system, Education of disaster prevention		
B.3 Relief / Evacuation	Relief and evacuation activities during flood		
B.4 Restoration	Urgent restoration of infrastructures and securing of transportation system		
B.5 Review / Improvement	Review of flood disaster map and parametres of flood forecasting model		
C. FLOOD FORECASTING AND WARNING SYSTEM			
C.1 Installation of monitoring stations	Rehabilitation of gauging station and installation of new automatic recorders		
C.2 Installation of Telemetering Station/Warning Station	Installation of warning stations	Installation of telemetred water level and rainfall gauges	
C.3 Installation of Additional Station		Installation of additional telemetred water level and rainfall gauges	
C.4 Operation and Maintenance	Operation and maintenance of flood forecasting and warning system		
D. EDUCATION OF DISASTER PREVENTION			
D.1 Restoration of Hydrological Balance	Guidance to intervention to land use in slope area and hydrological buffer zone		
D.2 Mitigation of Soil Erosion	Guidance to communities for water pans/woody vegetation/proper land use		
COMMUNITY INITIATIVE WORKS			
A. Community Survey	Community hazard mapping and identification of priority schemes for flood management		
B. Flood Management Training	Establishment of organisation and execution of community-driven flood management		
C. Community-driven Structural Measure	Construction of priority schemes of community-driven structural measures including retarding basin		
D. O&M of Community-driven Structural Measure	Operation and maintenance of priority schemes of community-driven structural measure		
E. Monitoring and Evaluation	Monitoring and evaluation of community-driven flood management organisation		

Source: JICA Study Team

(4) Cost for Structural and Non-Structural Measures by Term

The costs are broken down in accordance with the implementation schedule (Figure 5.8.4).



Source: JICA Study Team

Figure 5.8.4 Construction Schedule by Term

Table 5.8.3 shows the preliminary cost estimates by term for structural measures, community participatory works and community initiative works.

Table 5.8.3 Preliminary Cost Estimates by Term

(Million Ksh)

	DESCRIPTION	SHORT (2007-2012)	MEDIUM (2013-2020)	LONG (after 2021)	TOTAL
A.	**STRUCTURAL MEASURE**				
1	Nyando River Improvement	1,362.94			1,362.94
2	Nyando River Improvement (Swamp Area)		192.00		192.00
3	Awach Kano River Improvement	33.06	140.08		173.14
4	Tributary of Awach Kano Improvement	24.40	152.03		176.43
5	Nyaido River Improvement		50.04		50.04
6	Drainage Improvement along A1 (Ahero-Katito)		33.54		33.54
7	Raising of A1 National Road	660.00			660.00
8	Nyamasaria River Improvement		70.35		70.35
9	Luando River Improvement		276.68		276.68
10	Ombeyi River Improvement		186.91		186.91
11	Miriu River Improvement		224.18		224.18
12	Oroba River Improvement		173.21		173.21
13	Drainage Improvement along A1 (Kisumu-Ahero)		52.38		52.38
14	Raising of Secondary Road	273.00			273.00
15	Dam Development (Nyando, Kibos)		3,300.00		3,300.00
16	Sediment retention/Flush flood countermeasure		93.56	233.93	327.49
	Sub-total of Item A	2,353.40	4,944.96	233.93	7,532.29
B.	**COMMUNITY PARTICIPATORY WORKS WITH GOVERNMENT ASSISTANCE**				
1	Disaster management centre	60.00	35.00		95.00
2	Flood emergency management	122.12	120.56	407.00	649.68
3	Flood forecasting and warning system	180.94	167.95	435.01	783.90
4	Upper watershed management	21.36	18.00	22.50	61.86
	Sub-total of Item B	384.42	341.51	864.51	1,590.44
C.	**COMMUNITY INITIATIVE WORKS**				
1	Community Survey	54.00	166.00		220.00
2	Flood Management Training	98.00	437.00		535.00
3	Community Structure (Including retarding pond)	294.00	1,311.00		1,605.00
4	O&M of Community Structure	7.00	42.00	55.00	104.00
5	Monitoring and Evaluation	27.00	173.00	24.00	224.00
	Sub-total of Item C	480.00	2,129.00	79.00	2,688.00
	TOTAL	3,217.82	7,415.47	1,177.44	11,810.73

Source : JICA Study Team

Remarks : Structural measures includes land acquisition cost of 60 million Ksh.
Dam cost in item A.15: from 2004 MWRMD Final Report.

The total cost is estimated at 11,811 million KShs and is broken down into 7,532 million KShs for structural measures, 1,590 million KShs for community participatory works and 2,688 million KShs for community initiative works. The required costs by stages will be as shown below in Table 5.8.4.

Table 5.8.4 Summary of Preliminary Cost Estimates by Term

Category	Total Cost (million KShs)	Cost by Term (million KShs)		
		Short Term	Medium Term	Long Term
Structural measures	7,532.3	2,353	4,945	234
Community Participatory Works	1,590.4	384	342	864
Community Initiative Works	2,688.0	480	2,129	79
Total	11,811	3,217	7,416	1,177

Source: JICA Study Team

5.9 CLIMATE CHANGE DUE TO GLOBAL WARMING

5.9.1 Assessment by the Intergovernmental Panel on Climate Change (IPCC)

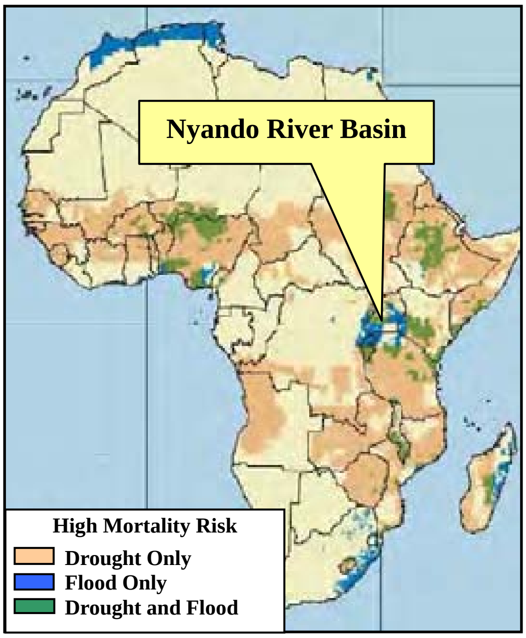
The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report[3], states for the first time that the scientific evidence of human-induced global warming is obvious and that the latest predictions are much worse than previous estimates. The last 100 years have been the warmest, and warming during the last 50 years has a clear human signature.

Global temperatures will increase by 1.4-5.8^{o}C by 2100; sea levels are rising and are expected to reach 14-88 cm by 2100, flooding low-lying areas and displacing hundreds of million people. Rainfall patterns are changing, El Nino events are increasing in frequency and intensity, and tropical mountain glaciers, such as Mt. Kilimanjaro and Mt. Kenya, are retreating.

One region of the world where the effects of climate change are being felt particularly hard is Africa. Because of the lack of economic, development, and institutional capacity, African countries are likely among the most vulnerable to the impacts of climate change.

Climate change impacts have the potential to undermine and even, undo progress made in improving the socio-economic well-being of East Africans. The negative impacts associated with climate change are also compounded by many factors, including widespread poverty, human diseases, and high population density, which is estimated to double the demand for food, water, and livestock forage within the next 30 years.

The consequences of these changes assuming concerted global efforts are also dire. According to IPCC report, agricultural productivity in Africa could decrease by 30% in this century.



Source: Natural Disaster Hotspots: A Global Risk Analysis Synthesis Report, Columbia University and World Bank, March 2005

Figure 5.9.1 High Mortality Risk Area in Africa

Severe droughts will occur, while wetter climates and more floods are predicted for parts of East Africa. Among all, Nyando river basin is nominated as hotspot for high mortality risk[4] due to drought and flood as shown in Figure 5.9.1.

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3 "Technical Paper on Climate Change and Water", Intergovernmental Panel on Climate Change (IPCC), April 2008

4 "Natural Disaster Hotspots : A Global Risk Analysis", International Bank for Reconstruction and Development (UNDP), The World Bank and Columbia University, March 2005

5.9.2 Impacts due to Climate Change

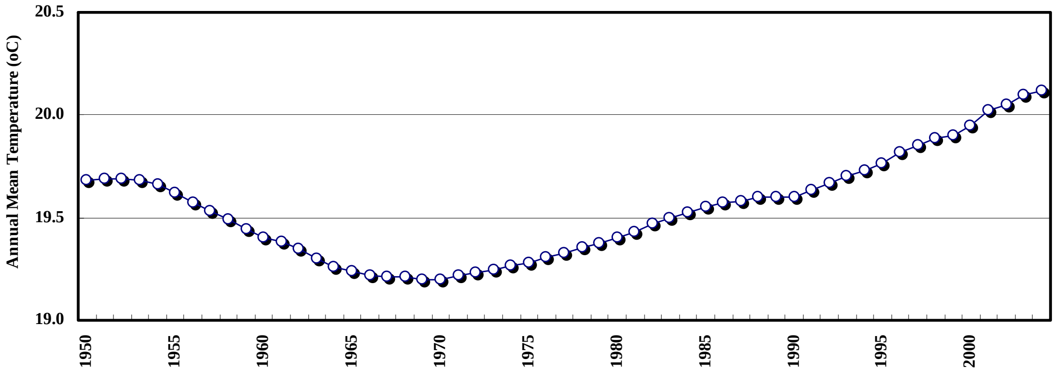
(1) Temperature Increase

Kenya's National Malaria Control Programme[5] reported that there is a clear correlation between climatic variations and malaria epidemics based on the 1998 investigation of the epidemic breakout in Kericho, a district in the south-western highlands known for its tea production and cool climate in Nyando river basin.

The report determined that the El Nino effect had raised temperatures by 2.2-4.5°C between January and March 1997 and by 1.8-3.0°C between February and April 1998, leading to the sudden occurrence of epidemics.

The monthly temperature time series were extracted from the database of Kenya Meteorological Department (KMD). Kericho (latitude, 0.30 S; longitude, 35.37 E) in the highland of Nyando river basin was chosen as the location of interest.

The reconstructed time series of annual mean temperature is plotted in Figure 5.9.2. It consists of a nonlinear trend, with an inflection point in the 1970s followed by an increase in the 1980s and 1990s of +0.5°C and in the 2000s of almost 1.0°C.[6]



Source: Database, KMD

Figure 5.9.2 Long-term Variation of Annual Mean Temperature at Kericho

In the tea-producing regions of Kenya as Kericho, the world's second largest exporter of tea, a small increase in temperature (1.2 °C from now) and the resulting changes in precipitation, soil moisture and water irrigation could cause large areas of unusable[7]land, which is currently supporting tea cultivation to be largely.

Economically, this would have far-reaching impacts because tea exports account for roughly 25% of Kenya's export earnings and employs about three million Kenyans (10% of its

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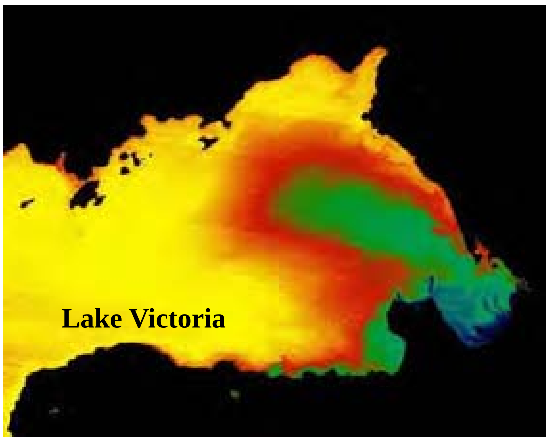
5 "Health-Kenya: Malaria Rises to Highland Areas", Najum Mushtaq, June 2008

6 "Malaria resurgence in the East African highland: Temperature trends revisited", M.Pascual, J.A.Ahumade, L.F.Chaves, X.Rodo, and M.Bouma, April 2006

7 "Improved land management in the Lake Victoria Basin: Final report on the TransVic project" ,World Agroforestry Centre, 2006

population).

(2) Catchment Degradation



Source: ICRAF's 1999 annual report and in Science Online. 2000

Figure 5.9.3 Sediment Plume in Lake Victoria

The historical records show the occurrence of an extraordinarily pluvial period from 1961 to 1964 in the eastern portion of the Lake Victoria basin. During this time, the water level of Lake Victoria rose by approximately 2.5 m[8]. For the Nyando river basin, interviews with local people suggest that many of the major soil erosion problems either started or were dramatically accelerated during the early 1960's. It is speculated that rapid land use changes, deforestation, infrastructure development and over-grazing structurally altered the landscape during the first half of the 20th century[9]. Prevailing conditions during the early 1960's may then have been such that the basin was essentially primed for massive erosion/sedimentation during a period of extraordinarily heavy rainfall in the region.

The Nyando river basin is particularly vulnerable to the large rainfall events occurred in the early 1960's. Such an event would have resulted in unprecedented mass soil movement from the lake plain into the lake[10] as shown in Figure 5.9.3.

(3) Long-term Trend of Annual Rainfall and Heavy Rainy Days

Many of the impacts of climate change will materialise through changes in extreme events such as droughts, floods, and storms. The meteorological models[11] show a high degree of agreement in simulating an increase in the extreme high rainfall over East Africa. An increase of more than 20% in the very extreme (one-in-100-years) high rainfall events was simulated for around the year of 2100. This indicates that an increase in extreme rainfall events during the long-rains season could have long-term implications on flood impacts.

Among the rainfall stations in Nyando river basin, the fluctuation of annual rainfall was evaluated at three rainfall gauging stations; Kisumu at downstream, Kericho at mid-stream and

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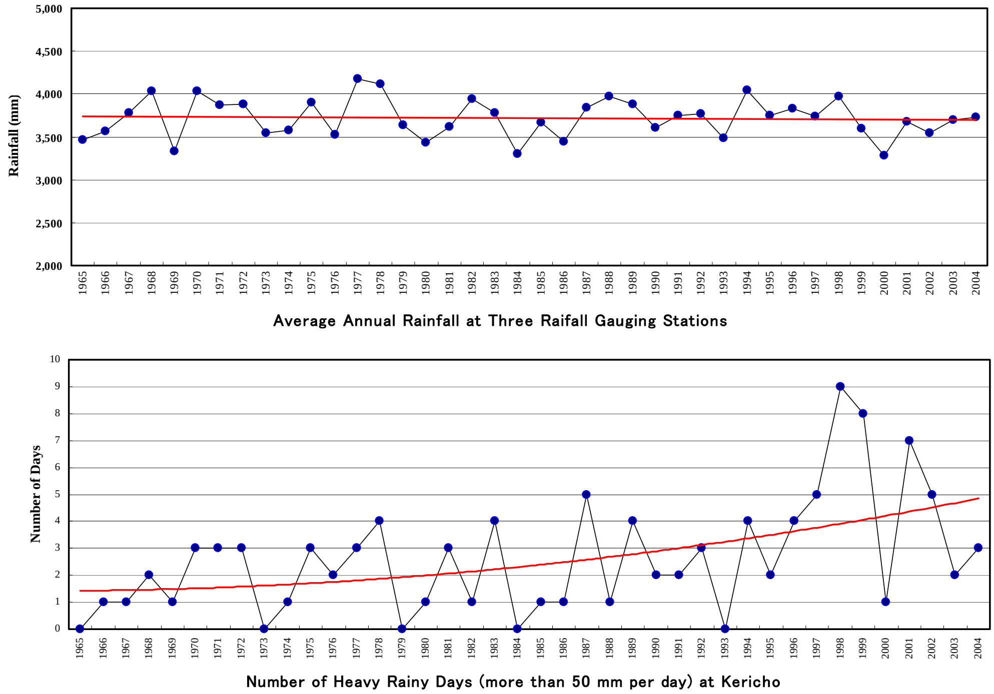
8 "Hydrological Database", Lake Victoria South Water Services Board (LVSWSB)

9 "Project Report for The Western Kenya Integrated Ecosystem Management Project (WKIEMP)", Kenya Agricultural Research Institute (KARI), February 2004

10 "Changes in extreme weather in Africa under global warming", Dutch national centre for information on weather, climate and seismology, 2007

11 "Climate Change Impacts on East Africa A Review of the Scientific Literature", World Wide Fund For Nature (WWF), November 2006

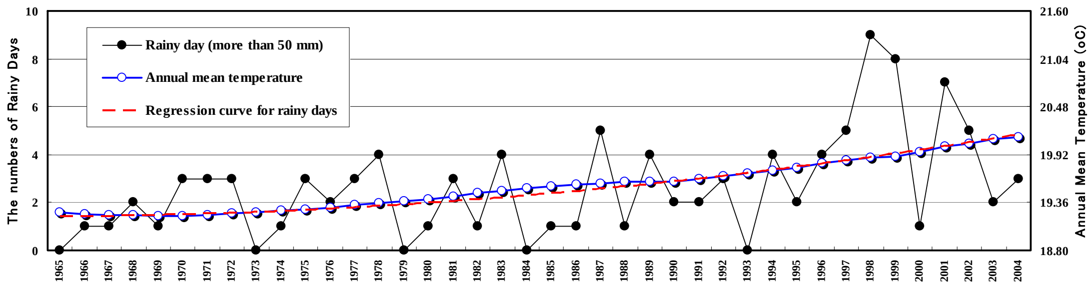
Tinderet at upstream. The data shows that annual rainfall on an average is almost stable for last 40 years, while the numbers of heavy rainy days of more than 50 mm shows the increasing trend at Kericho as shown in Figure 5.9.4. Heavy rainy days of more than 50 mm were also recorded once or twice a year on an average for the other two stations too.



Source: LVSWSB Hydrological database

Figure 5.9.4 Long-term Trend of Annual Rainfall and Heavy Rainy Days

Figure 5.9.5 shows the long-term trends of the number of heavy rainy days with the variation of annual mean temperature. The regression curve for the numbers of heavy rainy days is well fitted with the long-term trend of temperature increase. The global warming is likely to increase the frequency and intensity of heavy rainfall in the highland.



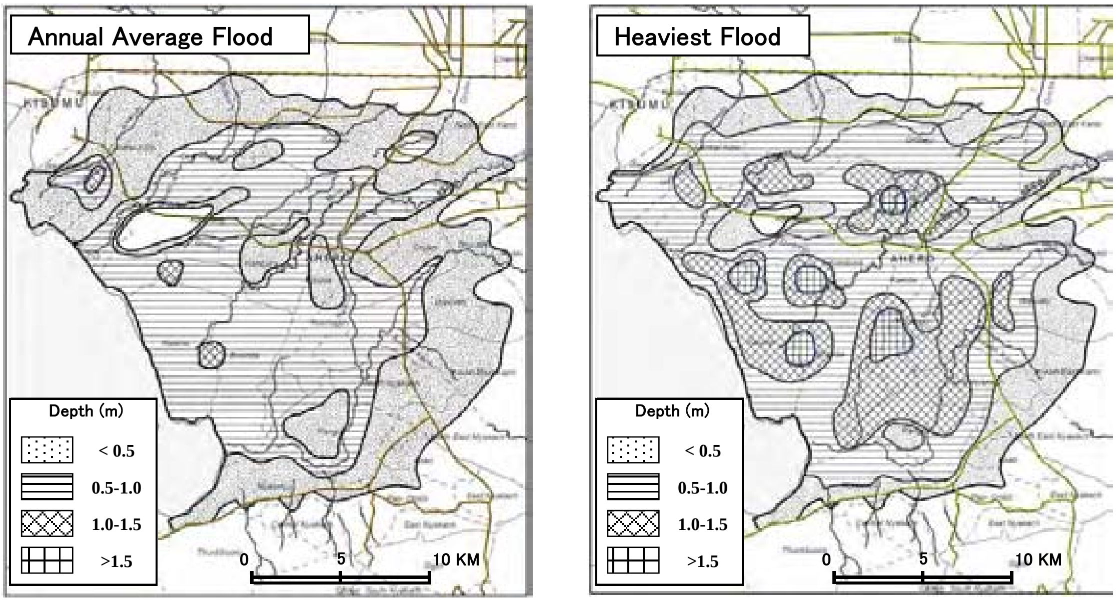
Source: Hydrological databases of LVSWSB and KMD

Figure 5.9.5 Long-term Trends of the Number of Rainy Days and Annual Mean Temperature

Expanding fluctuation of heavy rainy days under constant annual rainfall causes higher risk of flood and drought. The optimum development scale of structural measures was evaluated with the economic index of EIRR and the development scale of a 10-yr flood event was adopted as short-term target. However, the design scale would decrease from 10-yr to less than 10-yr flood event as the heavy rainfall frequently occurs in the future.

(4) Flood Inundation

Various characteristics of the heaviest flood water level and average annual flood level which occurs almost every year were obtained from the interview survey results. Flood disaster map showing the heaviest and annual average inundation areas has been produced as shown in Figure 5.9.6. The volume of flood inundation was estimated at 441.0 million cubic metres (MCM) for heaviest flood and 286.9 MCM for annual average inundation. The series of annual maximum discharges shows that heaviest flood at the interview survey, i.e. people's memory, would be 2002 flood event which is equivalent to the flood magnitude of once in 20 years.



Source: JICA Study Team

Figure 5.9.6 Flood Disaster Map of Annual Average Flood and Heaviest Flood

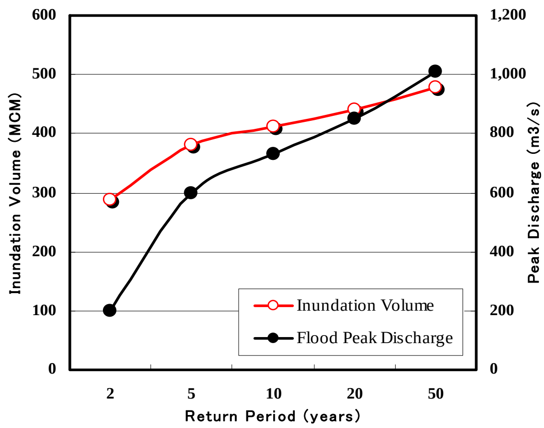
The flood inundation volume was estimated by return period in proportion to the magnitude of probable flood peak discharges as given in Table 5.9.1 and Figure 5.9.7.

Table 5.9.1 Flood Inundation Volume

Return Period (years)	Probable Peak Discharge (m3/s)	Flood Inundation Volume (MCM)
2	200	286.9*
5	600	381.7
10	730	412.6
20	850	441.0*
50	1,010	478.9

Note : "*" shows the survey result

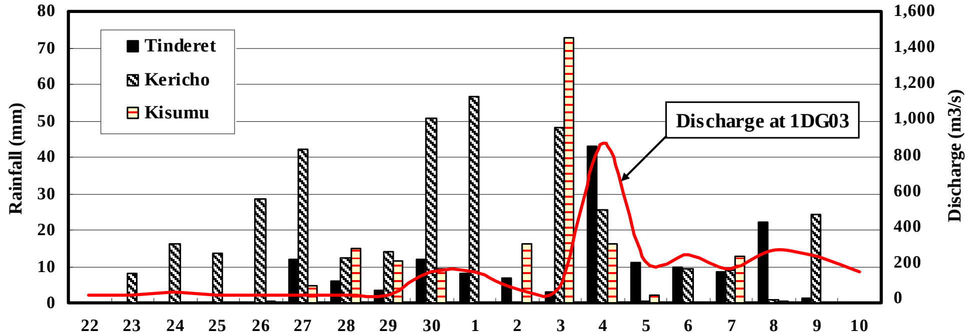
Source: Flood Survey, JICA Study Team (2006)



Source: JICA Study Team

Figure 5.9.7 Inundation Volume and Peak Discharge Flood

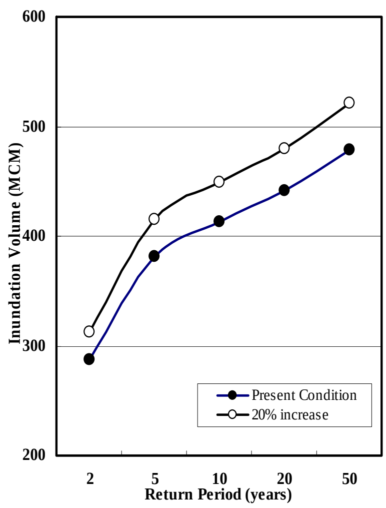
The flood inundation in the Nyando river basin is characterised by the wide-spread inundation for the entire low-lying area. The difference in magnitude of flood inundation at different return period is not the area of inundation but the volume of inundation. The preparedness for flood inundation due to an increase of very extreme high rainfall events is required for the entire low-lying areas. Furthermore, the ratio of the volume of flood inundation and the volume of rainfall during the 2002 flood events was evaluated roughly based on the three rainfall stations, Kisumu, Kericho and Tinderet as shown in Figure 5.9.8.

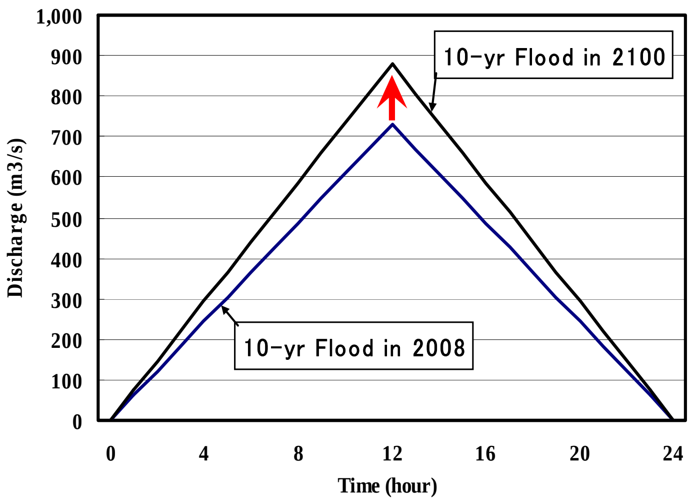


Source: Hydrological Database, LVSWSB

Figure 5.9.8 Daily Rainfall at Tinderet, Kericho and Kisumu during Flood (April 22 to May 10, 2002)

The volume of flood inundation of 441 MCM was estimated at 44% of the volume of basin rainfall of 997 MCM. The magnitude of flood inundation volume was evaluated assuming that heavy rainfall events would increase by 20% in the future and 44% of the basin rainfall retards in the low-lying area. The magnitude of 10-yr flood at present condition would be equivalent to about 5-yr flood event in the future as shown in Figure 5.9.9. The increase of heavy rainfall events by 20% also causes the variation of volume of 10-yr flood event. The flood peak discharge would increase from 730m^3/s in 2008 to 880m^3/s in 2100, which is almost equivalent to 20-yr probable peak discharge in 2008 (Figure 5.9.10).





Source: JICA Study Team

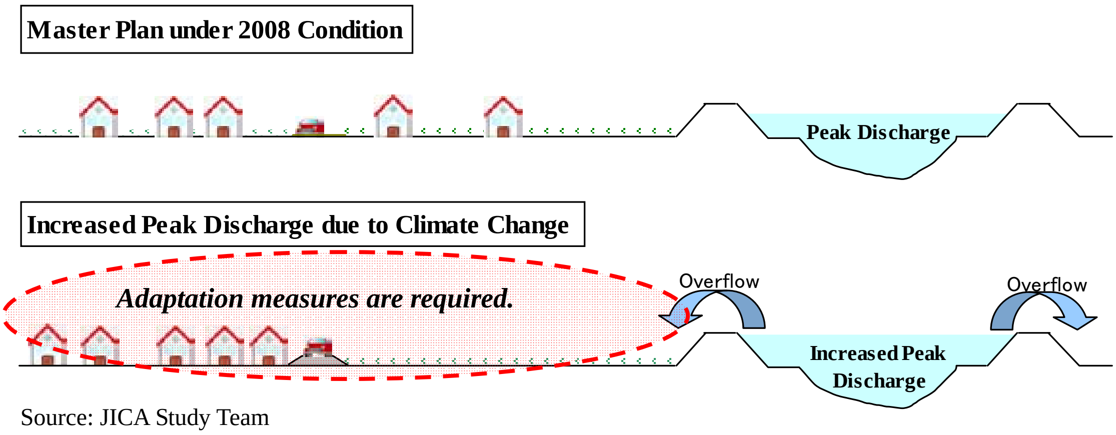
Figure 5.9.9 Flood Inundation Volume

Figure 5.9.10 10-yr Probable Flood Hydrograph

5.9.3 Adaptation Strategy against Climate Change

Around the world, flood damage is steadily increasing due to complex factors such as land degradation, poor land planning and the construction of dams and embankments for flood control. Also, increasingly intense rainfall due to global warming is one of the major causes.

To cope with the extent of flood damage, mitigation measure has been discussed frequently rather than adaptation measures. Mitigation to climate change is any action taken to permanently eliminate or reduce the long-term risk and hazards of climate change to human life, property, such as flood-proofing or retrofitting a flood prone building. While, adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic change, which moderates harm or exploits beneficial opportunities (Figure 5.9.11). Climate mitigation and adaptation should not be seen as alternatives to each other, as they are not discrete activities but rather a combined set of actions in an overall strategy.



Source: JICA Study Team

Figure 5.9.11 Concept on Adaptation Measure against Climate Change

The protection level of flood protection structures would be lower year by year as global warming progresses. However, it is not practical at present to set larger design scales for structures against intensified flood, when considering it requires quite a long time to complete the implementation of structures by the protection levels for confining fully flood discharge in the river channel with dike system. Although structural measure should be implemented continuously to achieve the current design levels, some additional necessary measures also need to be carefully reviewed from the viewpoint of social conditions.

In addition to structural measures, comprehensive flood control measures such as land-use regulation/guidance and prioritization/designation of flood prone areas and establishment of flood forecasting/ dissemination system should also be applied. Community-driven projects should also be promoted for creating a community of water-disaster adaptation with primary focus on urban environment and the reduction of flood disaster risk in addition to economic efficiency and convenience.

The implementation of adaptation strategies will not stop flooding. Flooding will continue to occur unless the area is protected against maximum probable flood. As it is neither feasible nor economically justifiable to adopt the maximum probable flood as the basis for flood control planning, a lesser flood level is selected to set planning controls and protection levels. Floods above that level constitute a residual flood risk, which extends year by year due to frequent heavy intense rainfall.

It is therefore necessary to ensure that the community in the flood prone area understands the consequences of flooding above the design flood level and takes effective action to minimize damage and loss of production and prevent loss of life when a flood of greater magnitude occurs as climate changes.

In general, adaptation strategies for frequent flood due to climate change are formulated by upper, middle and lower catchments, taking into account topography, river morphology, and social and living conditions. Major issues for each catchment are summarised in Table 5.9.2.

Table 5.9.2 Major Issues by Catchment

Catchment	Major Issues
Upper	• Deforestation due to the lack of proper forest management. • Sediment-related disasters are likely to increase due to increased rainfall with higher short-time rainfall intensity. • Increase in sediment run-off is projected to cause sediment deposition in flood control reservoirs as it reaches to lower level.
Middle	• Flooding and inundation are projected to be more frequent due to dike breaches caused by heavier precipitation, higher short-time rainfall intensity, flooding from the upper reaches, and greater sediment runoff. • Land use in the flood plains, originally designed to serve as retarding basins and also to help floodwaters flow back into the main streams, has been changed from agricultural to residential use. This all resulted in change in land use. • Frequent, large-scale floods and increased sediment runoff may destabilize riverbed, causing the destruction of structures, such as bridges, and dike breaches, which may lead to more flooding.
Lower	• Flood water from the middle reaches is likely to cause more frequent inundation and flooding events due to the overflow/breaching of dike. • Lower catchment is over populated with accumulation of property. • Drought due to climate change poses a serious danger for domestic, industrial and agricultural water use.

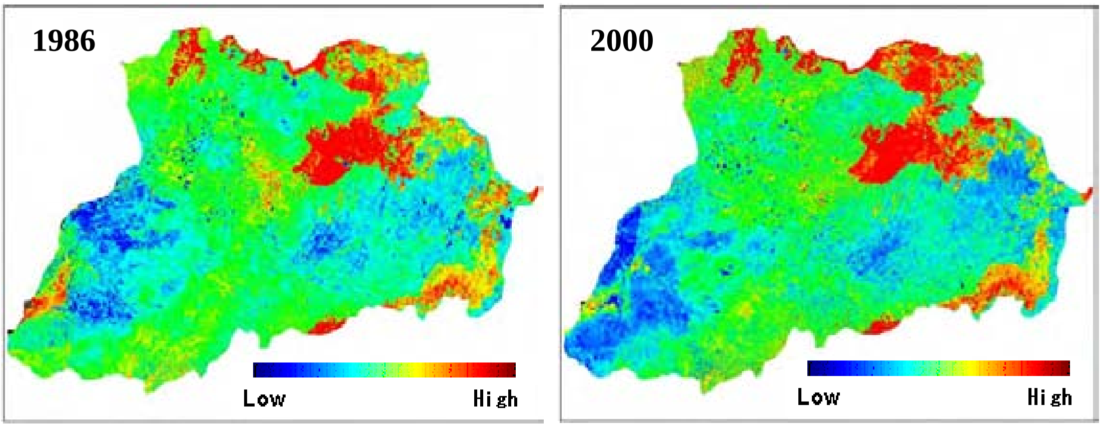
Source: Climate change adaptation strategies to cope with water-related disasters due to global warming (Policy Report), June 2008, MILT(Japan)

5.9.4 Adaptation Measure in Upper and Middle Catchments

Deforestation in this area appears in three distinct forms; (i) expansion of agricultural areas into the forests, (ii) reduction in tree density within the forests, and (iii) reduction in the density of trees in forest remnants outside of the gazetted forests.

Afforestation, on the other hand, occurred within certain parts of the forests and within the agricultural landscapes outside of the forests. The vegetation cover of the upper catchment mainly consists of forest, Tinderet Forest, while the middle part of the catchment may be classified as vegetative i.e. scattered trees and grass, which has greatly been modified by clearing, cultivation and burning due to human settlement. There are two major irrigation schemes in lower catchment: Ahero and West Kano schemes.

Overall, it appears that total tree cover is remaining more stable as shown in Figure 5.9.12, which indicates the variation of vegetation cover index between 1986 and 2000. The effort on afforestation should be continued by the institutions, the NGOs and the community people with the assistance of government agencies.

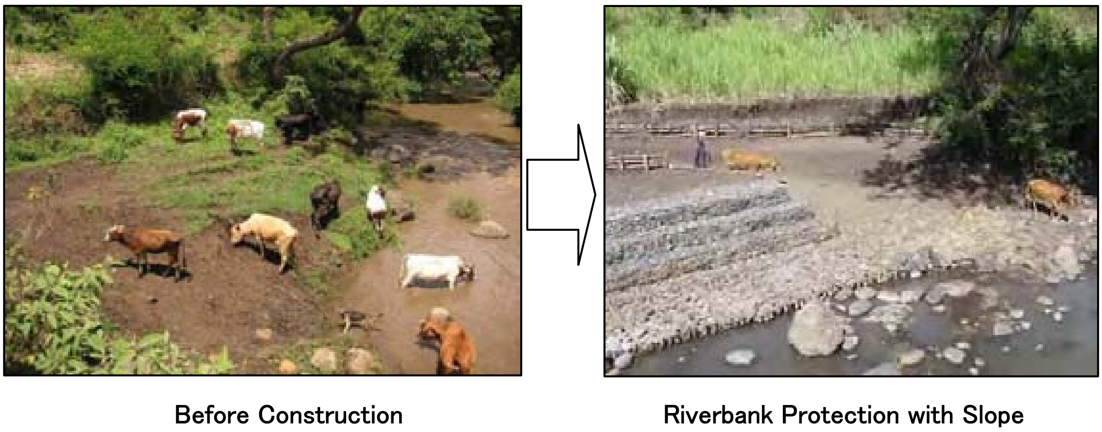


Source: JICA Study Team

Figure 5.9.12 Changes in Vegetation Cover Index in Nyando River Basin

The above fact induces the rate of surface soil erosion is rather smaller than the riverbank erosion in the upper and middle catchments. The risk of sediment due to bank erosion, which causes riverbed aggravation and clogging of drainage channel in the lower catchment, is cited as one of the major factors hampering economic development in flood prone area, as the risk of investment losses is considered very high in most flood prone areas. The unpredictable nature of the annual floods has also made farmers risk averse, planting only one rainfed paddy crop annually.

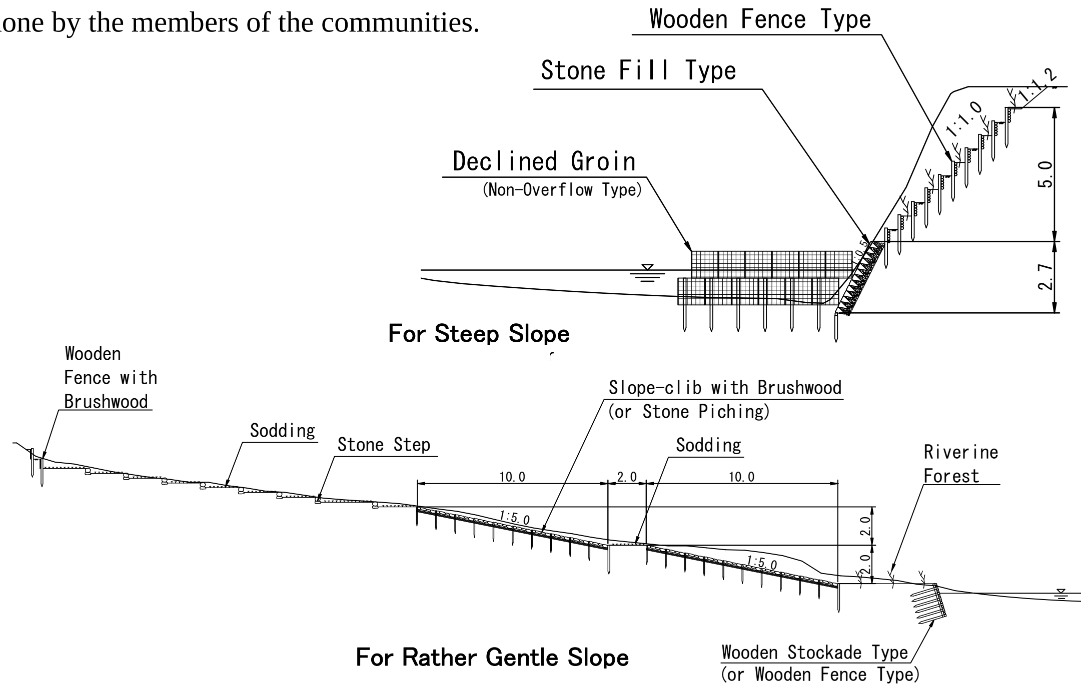
As part of adaptation measures, community participation in riverbank protection works is an approach in coping with riverbank erosion better and in a timely manner. This concept was introduced as pilot projects in this master plan study when community-based organizations elected by the people became functional at village levels. The establishment of a community-oriented institutional framework for implementing flood management (both structural and nonstructural) was examined during the implementation of pilot projects and an effective and practical participation strategy developed.



Source: JICA Study Team

Figure 5.9.13 Community-driven Riverbank Protection Work at Middle Catchment

In the case that the community encounters the financial constraints, the utilisation of wooden structures could be applied to riverbank protection as community initiative works. These are the structures that have traditionally been adopted for many years in Japan (Figure 5.9.14). Moreover, since special techniques are not required, the construction and maintenance can be done by the members of the communities.



Source: JICA Study Team

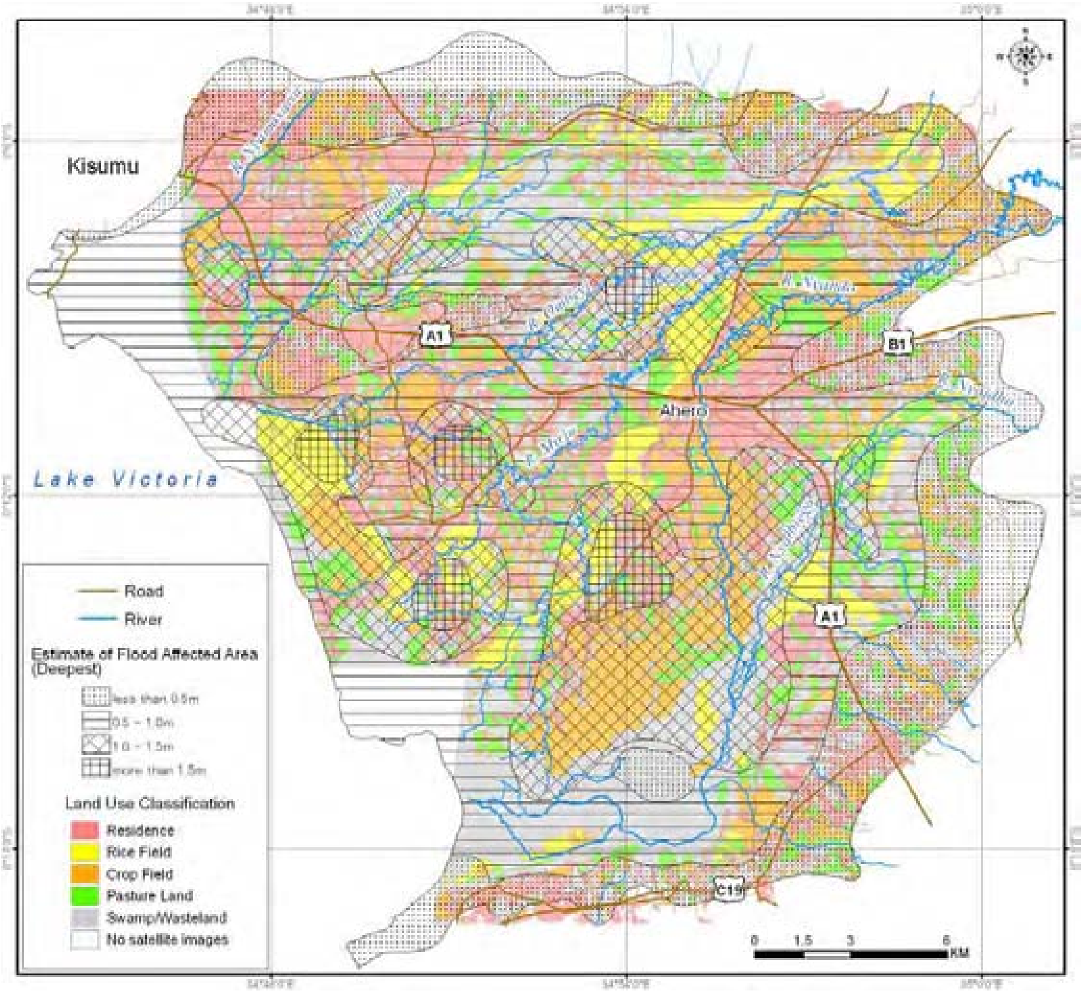
Figure 5.9.14 Example of Wooden Slope Protection Works

5.9.5 Adaptation Measure in Lower Catchment

(1) General

In the flood prone area, both structural and non-structural measures should be provided taking into account the priority for protection area based on present land use as shown in Figure 5.9.15. It is increasingly apparent that non-structural solutions are essential for effective flood management. These include implementing flood warning systems, preparing evacuation plans, discouraging random floodplain development, improving drainage and giving rivers room to flood by restoring retarding basin.

Moreover, communities in the flood prone area know better than any one else, the environments in which they live and this reservoir of indigenous knowledge could successfully be tapped in support of development efforts. Table 5.9.3 shows the possible adaptation measures applicable to the Nyando river basin against intense flooding due to global warming.



Source: JICA Study Team (2008)

Figure 5.9.15 Present Land Use in Flood Prone Area

Table 5.9.3 Possible Adaptation Measure against Climate Change in the Lower Catchment

Structural Measure

1.	Retarding Basin	The magnitude of 10-yr flood event under present condition would be equivalent to about 5-yr flood event as heavy rainfall increases in the future. Possible adaptation measures are to allow flood inundation for short period in the river terrace as a buffer for retarding the incremental discharge.
2.	Road Raising	The flood inundation area does not change but the depth and frequency would be increased. The community road utilised as evacuation activities should be raised with freeboard. The priority for implementation should be given to the road raising which is situated in parallel to the dike alignment along Nyando River. These road raisings will function as secondary and tertiary dikes when the extraordinary flood occurs and overflows into inland areas.
3.	Sediment Retention	Increased frequency of heavy rainfall would trigger the surface erosion and lateral erosion of river banks. Sediment transported to downstream will cause riverbed aggradations and sediment plumes into Lake Victoria. Thus, catchments conservation to reduce surface erosion would be more important.

Non-structural Measure

1	Strengthening of coordination activities among communities.	There are 550 communities in the flood prone area of the Nyando river basin. More frequent flooding forces community people to stay longer at the evacuation centre which are located by community. Repeated relief activities during frequent flood managed by the Disaster Management Committee (DMC) and/or NGOs may encounter financial and capacity constraint. Strengthening of community-based evacuation activities in close liaison with communities, such as the provision of relatively large-scale evacuation centre for several communities will lead to the effective relief activities.
2	Publicising by media	Publicising of the climate change to community people through media, i.e., TV and radio is one of effective methods to educate community people about the danger of frequent flooding.
3	Land use regulation	Buffer zones mainly comprise natural vegetation in riparian areas such as river banks and wetlands. Such lands have currently been allocated to individuals or converted to other public uses by the community. Loss or degradation of buffer zones is undesirable, since buffer strips are effective in retarding flood discharge and in trapping sediment under Kenyan environmental conditions. This is a trend that needs to be checked, more in the Nyando basin where the flood prone area is proportionately smaller and is surrounded by escarpments.
4	Diversification of Income generation	Most of the community people in the flood prone area are farmers. They are cultivating the limited crop, such as rice, sugarcane, maize, by communities. Frequent flooding might cause the devastating damage in case if the community people depend only on the income from their limited crops. The diversification of income generation from the limited crops to livestock harvesting, fishery and handcrafting in addition might secure their incomes.

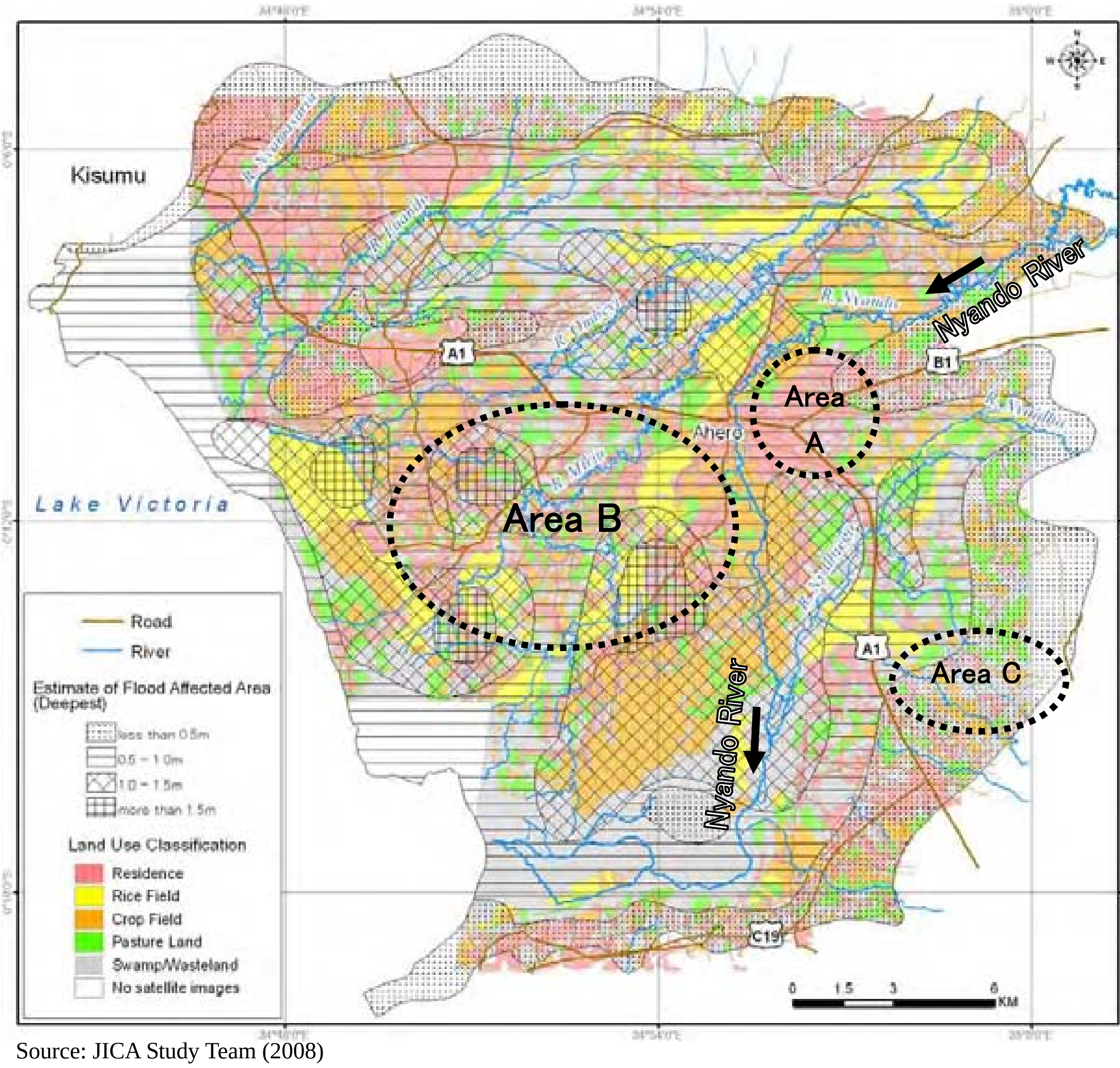
Source: JICA Study Team (2008)

(2) Priority Areas for Structural Measure

Flood risk cannot be banned totally although the effort has been done to confine flood water into the river channel with high embankment at both river banks. In recent years, a tolerable flood inundation has been discussed when the protection measures are subject to extreme flood events due to climatic change.

In the Nyando river basin, the priority for providing possible measure were given to the following three areas as shown in Figure 5.9.16:

(1) Area A : Residential area around a junction of A1 and B1 National Roads,
(2) Area B : Residential area at western side of Nyando River, and
(3) Area C : Sediment source area.



Source: JICA Study Team (2008)

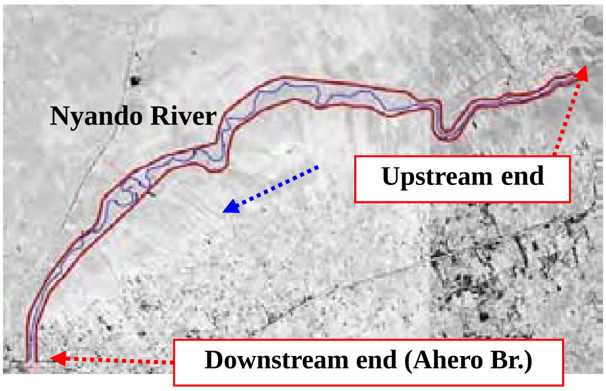
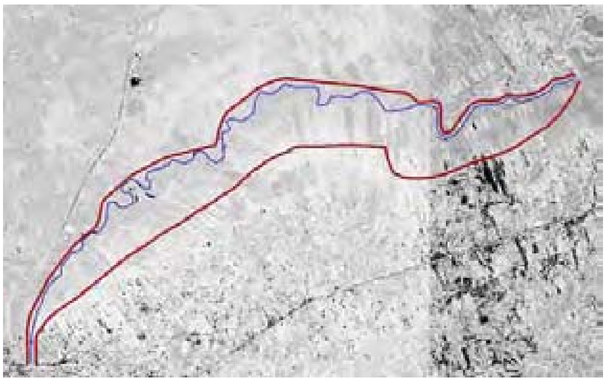
Figure 5.9.16 Priority Areas in the Nyando River Basin

(3) Structural Measure against Global Warming

Area A : Retarding Basin as Buffer Zone for Flood Peak Discharge

Possible measures are to allow flood inundation for short period in the river terrace as a buffer for retarding the incremental discharge. In Nyando river basin, three alternatives were examined for the stretch of 8 km long as shown in Table 5.9.4.

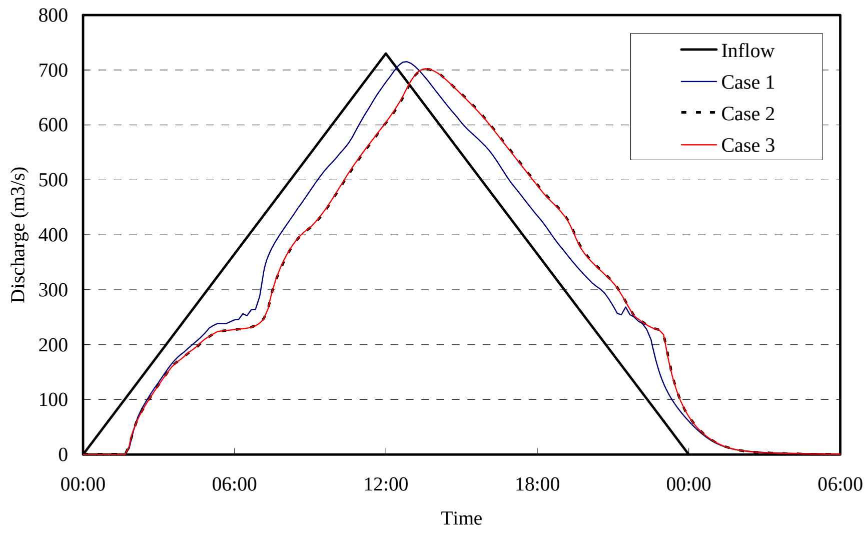
Table 5.9.4 Structural Arrangement

Case	Structure	Arrangement
1	Straight dike Straight dike of 8 km long is constructed along the main channel of Nyando River.	
2	Road raising at south bank The existing road for agricultural uses is raised in parallel with the main channel. The raised road functions as dike during flood. The widening of north bank is not practical since the paddy field extends at north bank as part of Kano Irrigation System.	
3	Road raising with ramp In addition to the Case 2, several ramps are provided at a right angle to the river channel. The ramp would accelerate the retardation of flood water.	

Source: JICA Study Team (2008)

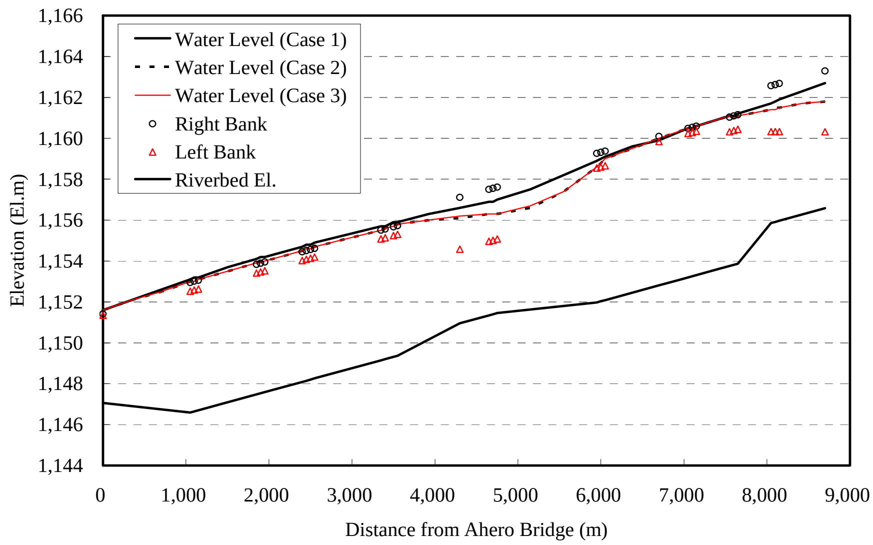
Figure 5.9.17 shows the 10 yr peak discharge at downstream end (Ahero Bridge). The peak discharge of 730 m^3/s at upstream end is reduced for each case. However, the difference of peak discharge is not identified for Cases 2 and 3.

Figure 5.9.18 shows flood water level at both banks. The overflow would occur for the stretch from 3.5 km to 6.0 km without dike system. Flood water level at 5.0 km would reach 150 cm to 200 cm in maximum for Case 1, while water level would be less than 150 cm for whole stretch for Cases 2 and 3. Especially, the several ramps would accelerate retardation of flood water as shown in Figure 5.9.19.



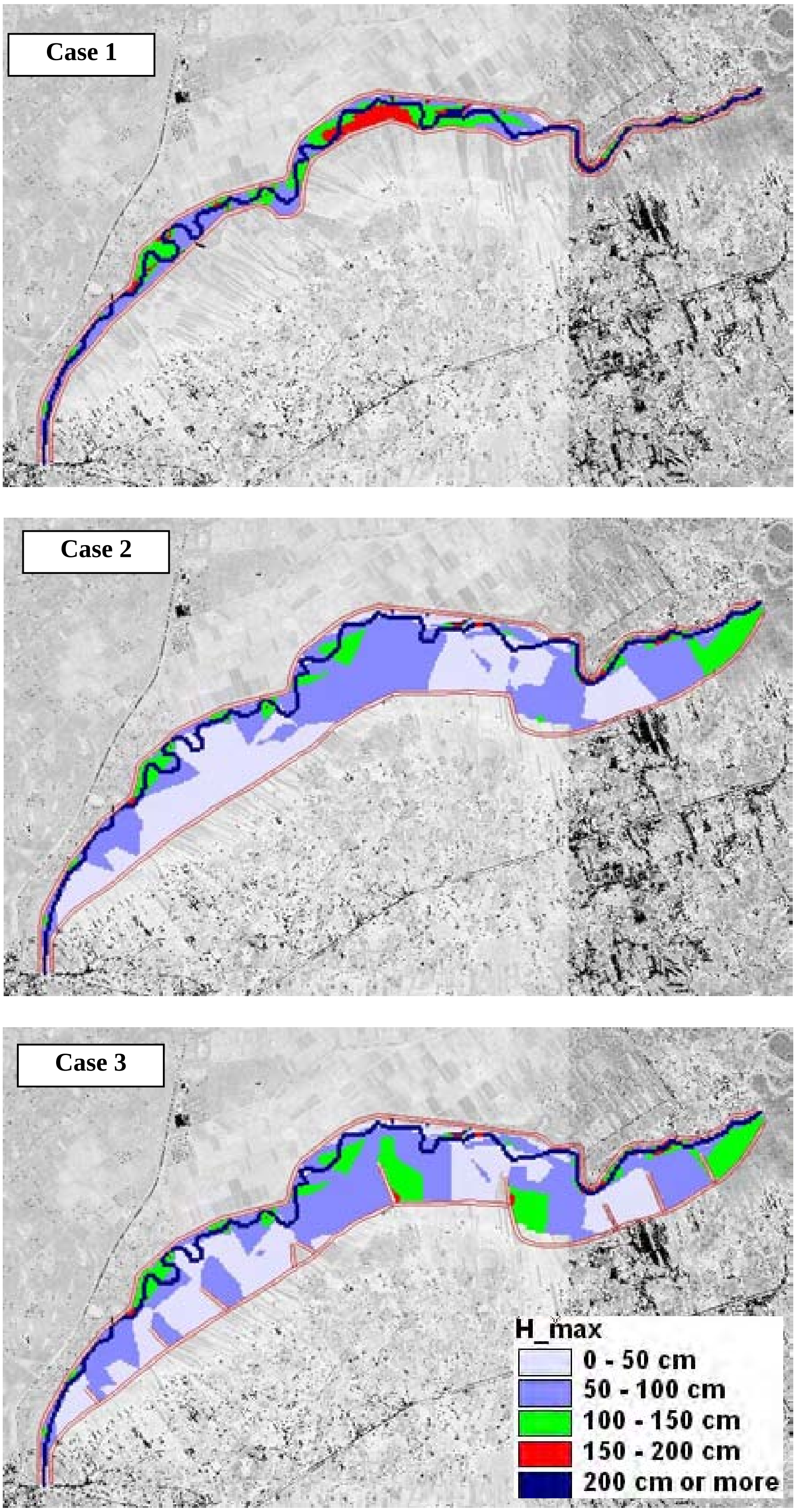
Source: JICA Study Team

Figure 5.9.17 Peak Discharge at Downstream End (Ahero Bridge)



Source: JICA Study Team

Figure 5.9.18 Flood Water Level and River Bank Elevation

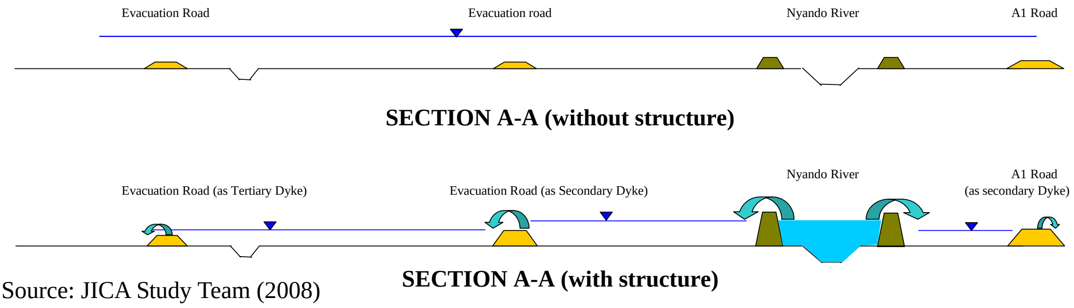


Source: JICA Study Team

Figure 5.9.19 Maximum Flood Water Depth during 10-yr Flood

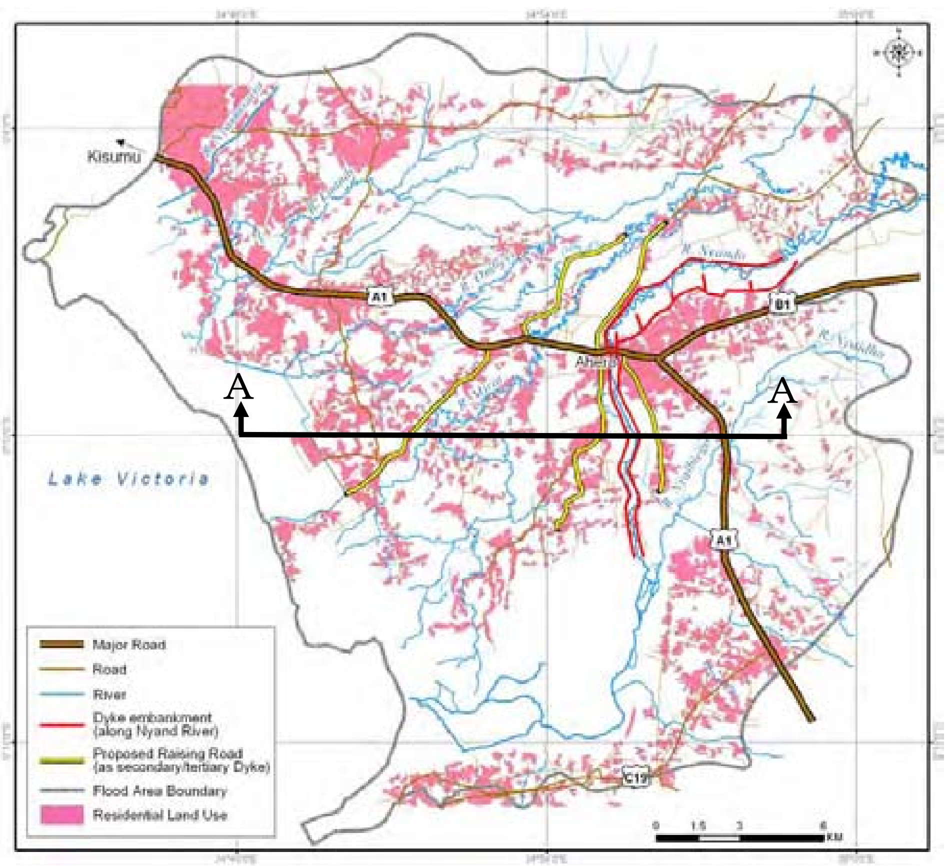
Area B : Community Road Raising as Secondary/Tertiary Dike

As well as the raising of frequently submerged section of A1 national road for ensuring its role as the main passable road for relief and evacuation activities in case of emergency, the network of community roads connecting with A1 national road is also to be raised for evacuation activities as part of community-driven disaster management. The raising of these community roads would function as secondary/tertiary dike against the intense flooding as shown in Figure 5.9.20. The schematic arrangement of the raising of community roads are shown in Figure 5.9.21.



Source: JICA Study Team (2008)

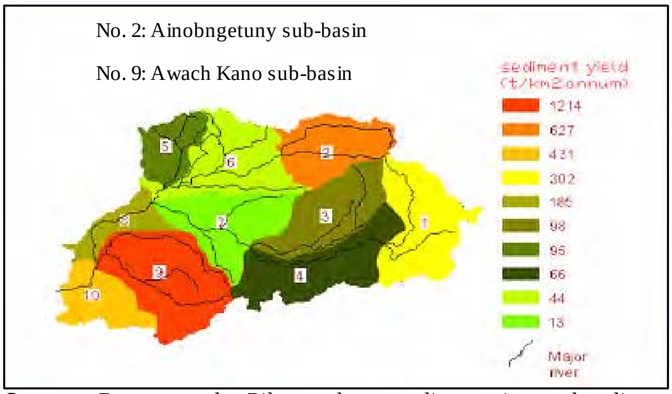
Figure 5.9.20 Schematic Arrangement for Secondary and Tertiary Dikes



Source: JICA Study Team (2008)

Figure 5 9.21 Schematic Arrangement of Road Raising as Secondary/Tertiary Dikes

Area C : Sediment Retention Structure with Income generation

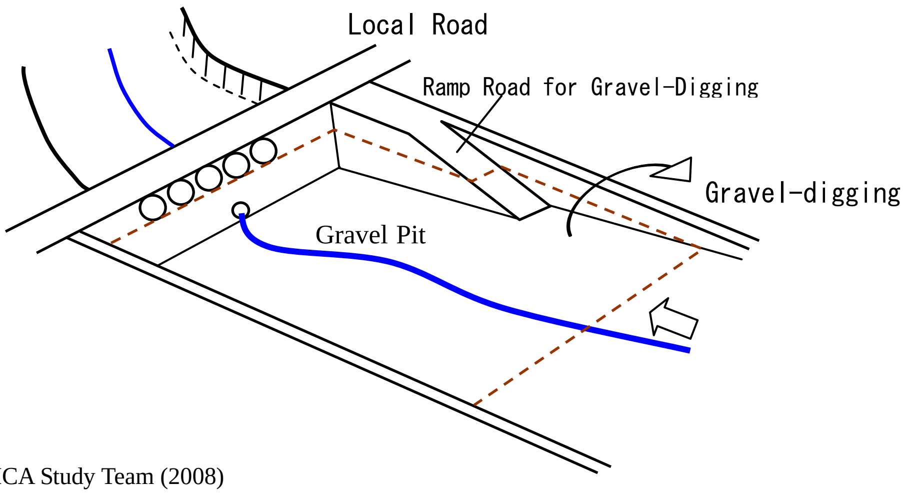


Source: Report on the Pilot study on sedimentation and sediment characteristics on Nyando and Nzoia River mouths and Winam Gulf of Lake Victoria, LVEMP. 2005

Figure 5.9.22 Annual Mean Sedimentation Yield

At the main stream of Awach Kano River (Figure 5.9.22), the volume of sediment due to the gully erosion is estimated at 2,600m^3 per flooding, and that due to lateral erosion of the riverbank is estimated at 3,960m^3 per flooding. At the left tributary, the volume of sediment due to the gully erosion is more serious, and it is estimated at 5,000m^3, and the sediment discharge due to the collapse of the riverbank is estimated at 612m^3 per flooding. In future, these erosion rates would likely to increase with the increase in frequent heavy rainfall due to global warming.

The sediment retention structures are required to prevent development of the gully erosion as source of sediment. The community roads, which are being deeply cut by gully erosion and will likely to become impassable, will be restored by the structure for storing sediment. An example of sediment retention structures is shown in Figure 5.9.23. The community road, with a series of culverts for ensuring safe transportation, functions as sand pocket for storing sediment and boulders. The stored sediment and boulders will be collected by community organisation and can be sold as construction material. This activity will provide an additional source of extra income generation for the community people.



Source: JICA Study Team (2008)

Figure 5.9.23 Imaginary View of Sand Pocket Structures

(4) Necessity of Community-based Flood Management with Government Help

The followings are the activities for strengthening the community-based flood management which were adopted through the implementation of pilot projects in the Nyando river basin.

STEP 1 : Establishment of Community Flood Management Organisation (CFMO)

Community institutions are important to plan, implement and monitor different activities related to flood disaster and minimisng the impacts of flood on the community. Community development will start with the component of mobilization of communities, to strengthen the organisational bases for local flood mitigation initiatives. Unlike the past practices in which people are hastily organised primarily for the construction of physical facilities, more focus should be placed on awareness-raising and capacity building of the communities themselves.

Prior to the formation of the Community Flood Management Organisation (CFMO), required information such as importance of community institutions, role and responsibilities of CFMO, formation process and involvement of the community, women, affected groups etc. should be disseminated to the concerned officials of sub-location and representatives from government agencies, local leaders, teachers and the community.

STEP 2 : Preparation of Community Flood Hazard Mapping

In a community the vulnerability to flood may be different at different locations. The type of damage for those living along the river bank is different from those away from it. Similarly different types of houses in the same area may have different degrees of vulnerability according to the mode of construction. CFMO should first prepare a map identifying the area in accordance with the type of flood prone area. On the map, features like public land, public utilities, high land, roads etc. should be delineated. The map should also delineate areas having different depths of water or duration of standing water.

STEP 3 : Establishment of Communication Network

One of the serious concerns for communities located at flood prone area of Nyando river basin is to secure the communication network among the communities, government agencies and NGOs, since no electricity is available at almost all of the communities. Hence, CFMO should interact with the people and also seek help of organizations working in disaster management. The sub-location office of Disaster Management Committee (DMC), assistant chief of sub-location, several NGOs and social organizations can also provide technical support during flood.

STEP 4 : Fund Raising for Community-based Flood Management

Fund raising can be defined as a process of soliciting finances for an activity or a process of mobilizing resources for implementing an activity. NGOs and CFMOs in developing nations often neglect local sources of funds. Local fund raising is, however, very important for two reasons: the CFMO gains its own income, which it can control directly, and it is much easier to convince donors to give their support when the NGO/CFMO can show that it has already has a significant proportion of its funds.

STEP 5 : Community Involvement as Self-help Activities

The most common elements of community involvement are partnership, participation, empowerment and ownership by the local people. There needs to be an opportunity where people can be involved from the initial programming stage of disaster management activities. Through these community-based activities, people should be able to participate along side government officials and experts group as the direct stakeholders of these activities. This process induces sense of ownership to the people which results in their continuous engagement and long term commitment to these activities. Involvement of communities is important in both pre-disaster mitigation and post disaster response and recovery process.

STEP 6 : Evacuation Drill

Evacuation is an important aspect in saving lives and minimising property damage and more. Thus need is to establish a system in place that enable early warnings for communities to evacuate, how to evacuate, what is to be done while at the evacuation centre, how to deal with the injured and the sick during evacuation, dissemination of information to government and humanitarian organization and the management of evacuation centre.

CHAPTER 6 PRELIMINARY DESIGN OF PRIORITY SCHEMES

6.1 PRIORITY SCHEMES

Among the proposed short-term measures, the highest priority schemes were scrutinised during discussions at Technical Workshops, the Nyando River Basin Water Management Forum, and Technical Sub-committee Meetings. Finally, four priority schemes were approved by the Steering Committee Meeting, namely: (i) the strengthening of existing dikes downstream from Ahero Bridge along the Nyando River; (ii) the establishment of a network of evacuation roads connecting the affected communities; (iii) capacity development for community-driven flood management; and (iv) establishment of a hydrological monitoring network.

(1) Strengthening of existing dikes:

Several stretches of the existing dikes along the Nyando River downstream from the Ahero Bridge have seriously deteriorated due to insufficient compaction during construction and lack of maintenance. The dikes should be strengthened using proper construction methods. Ramps with gentle slopes should be provided for crossing the dikes.

(2) Network of evacuation roads connecting the affected communities:

Frequently submerged sections of National Road A1 trunk road should be raised to ensure its role as the main trafficable road for relief and evacuation activities during an emergency. The level of the network of community roads connecting to A1 trunk road should also to be raised for implementing community-driven disaster management.

(3) Capacity development of community-driven flood management:

Capacity development for flood management in prioritised communities should be implemented as packaged programmes through: preparation of community flood hazard maps; establishment of community-driven flood management organisations; training in flood management, including evacuation drills; and construction of community-driven structural measures.

(4) Establishment of a hydrological monitoring network:

Water level gauging stations are located at various sites on the main stream and several major tributaries. However, water level measurement at more than half of the stations has been terminated or abandoned due to financial constraints. The hydrological monitoring network should urgently be refurbished and automatic recorders should be provided for the prioritised water level gauging stations. These efforts will increase the accuracy of flood forecasting and warning systems.

6.2 STRENGTHENING OF THE EXISTING DIKES

6.2.1 Particular Site Conditions and Principles for Design

(1) River Condition: The length of the affected stretch is about 9.0 km from the confluence of the Nyaidho River to Ahero Bridge. The existing river course seems to be stable as it is enclosed by natural levees on both banks. The riverbed slope downstream of the Ahero Bridge is 1/1,400. A swamp exists at the downstream junction with the Nyaidho River, which is located 8.2 km downstream of the Ahero Bridge.

(2) Existing Facilities: An intake weir is located 350 m downstream from the Ahero Bridge. Bank protection works are provided upstream/downstream of the weir on both banks. Continuous earth dikes are installed along some stretches. However, the dimensions of all these dikes are not sufficient for flood protection.

(3) Dikes: In this stretch, dike system is the only measure for preventing river water from flooding. Dikes should be provided on both banks.

(4) Channel Excavation: No excavation/dredging is proposed, since the riverbed comprises thick sediment deposits and it is likely that an artificially excavated channel would soon silt up.

(5) Bank Protection: No major bank protection works are planned. Bank protection works will only be installed upstream/downstream of structures and at levees damaged by flooding on December 2006.

The proposed site for dike strengthening is part of the low-lying area surrounding Lake Victoria. The ground surface elevation in this area is between 1,141 and 1,151 m ASL. The area is presently suffering from long lasting inundation due to floodwater from the Nyando River and local torrential rainfall.

The Nyando River Improvement Project includes (1) dike and (2) bank protection as the major project components. The main function of the Nyando River Improvement Project is to lead floodwater from the upper basin to Lake Victoria as early as possible in order to mitigate downstream flooding. The dike will protect the surrounding villages and farmland from flooding.

6.2.2 Design of the River Channel

Table 6.2.1 shows the design discharge and design scale of rivers in the Study Area. The design discharge of 730 m^3/s is much greater than the existing bank-full channel capacity of the lower stretch of the Nyando River. A freeboard of 1.0 m is required because the effective channel capacities are being reduced by sedimentation.

Table 6.2.1 Design Discharge

River	Stretch	Design Flood Scale (year)	Design Discharge (m^3/s)
Nyando	River mouth to 30 km upstream	1/10	730

Source: JICA Study Team

In order to convey the design discharge volume smoothly and safely below the Design High Water Level (DHWL), channel works which include level raising and widening of existing dikes, and construction of new dikes are required, as shown in Figure 6.2.1. The alignment of the new dike was decided by considering the existing low water channel route, existing dike alignments, and flood flow so that floodwater could flow smoothly. While the width of the existing dikes is narrow, new dikes have been planned with sufficient width to secure the flood area against the design flood discharge. Figure 6.2.1 illustrates the design alignment of the existing and proposed new dikes.

The total length of the improved stretch is about 8,200 m. The slope of the DHWL for the Nyando River has been set to 1/1400 for the lower reaches, extending downstream from the intake weir located downstream of the Ahero Bridge, and 1/700 for the upper reaches that extend upstream from the weir. These DHWL grades were determined by considering the elevation of the existing riverbanks, riverbed and dikes constructed by the National Water Conservation and Pipeline Corporation (NWCPC). The design dike elevation was decided by taking a 1-m freeboard as corresponding to the design discharge of 730m^3/s. The design longitudinal profile for the Lower Nyando River is shown in Figure 6.2.2. This figure shows the water level calculated by the Non-uniform Flow Formula. Manning's roughness coefficients for the flow calculations were assumed as follows:

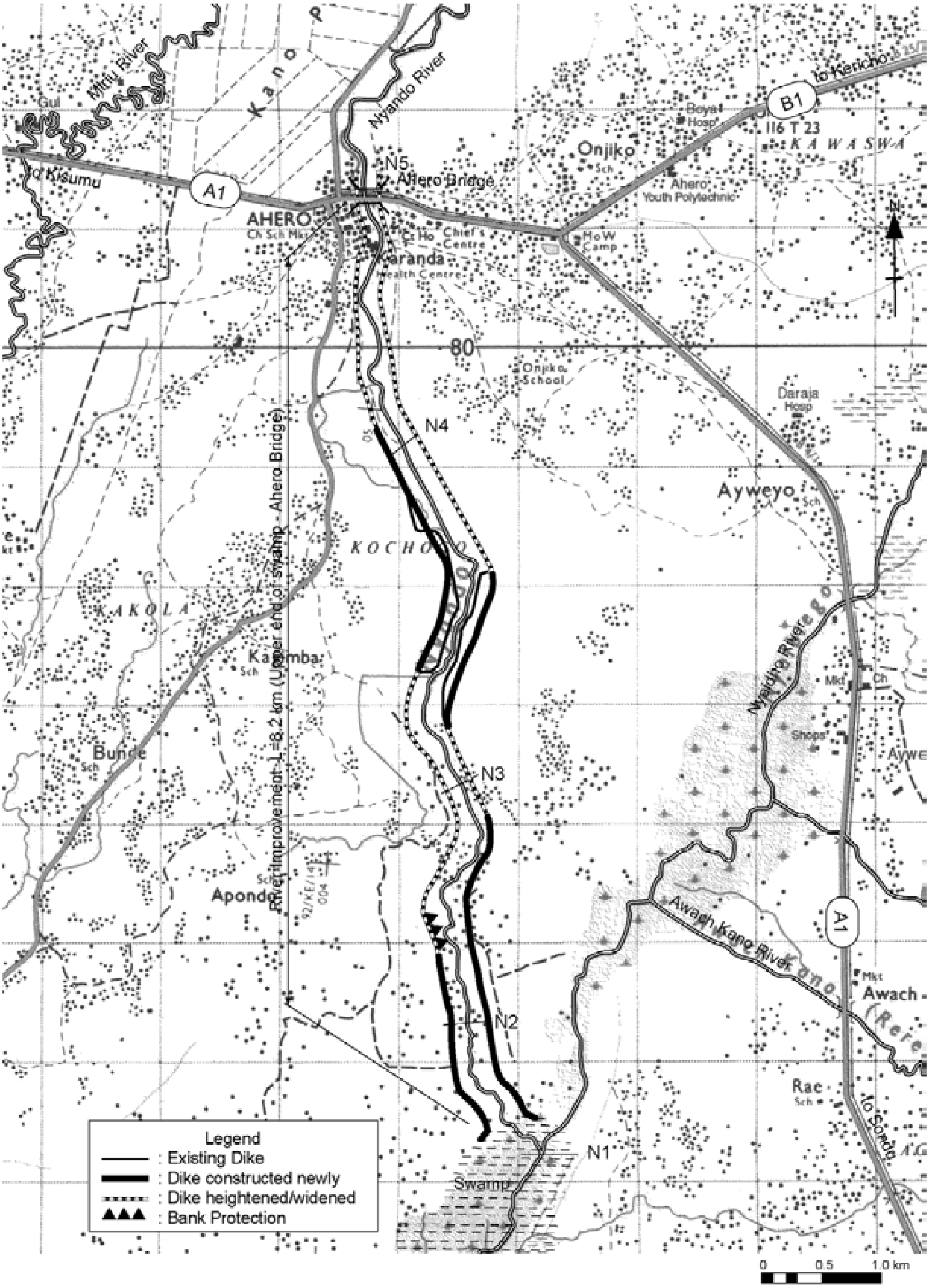
- n = 0.030 for low-water channel
- n = 0.050 for high-water channel

The design elevation at each section is summarised in Table 6.2.2.

Table 6.2.2 Design Elevation

Section	Dike Crest (m ASL)	DHWL (m ASL)	Riverbed (m ASL)
N-00 (Upper end of swamp)	1144.90	1143.90	1137.70
N-02	1145.47	1144.47	1138.27
N-03	1147.15	1146.15	1139.95
N-04	1149.13	1148.13	1141.93
Weir (downstream)	1150.49	1149.49	1144.00
Weir (upstream)	1151.50	1150.50	1145.50
N-05 (Ahero Bridge)	1152.00	1151.00	1146.00

Source: JICA Study Team



Source: JICA Study Team

Figure 6.2.1 Proposed Layout of the Lower Nyando River Improvement Works

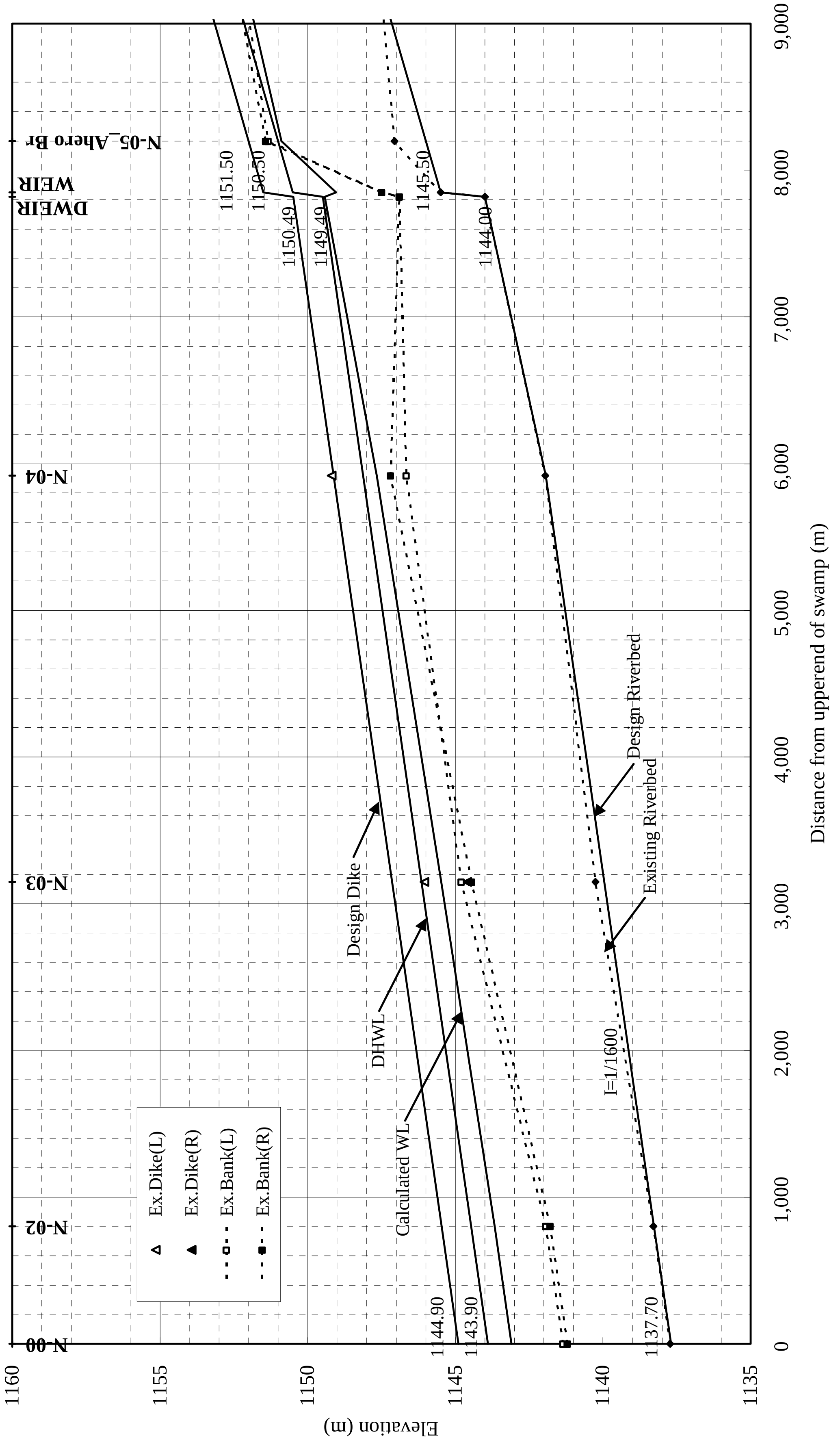
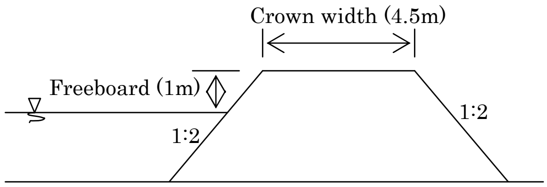


Figure 6.2.2 Design Longitudinal Profile of the Lower Nyando River

Source: JICA Study Team

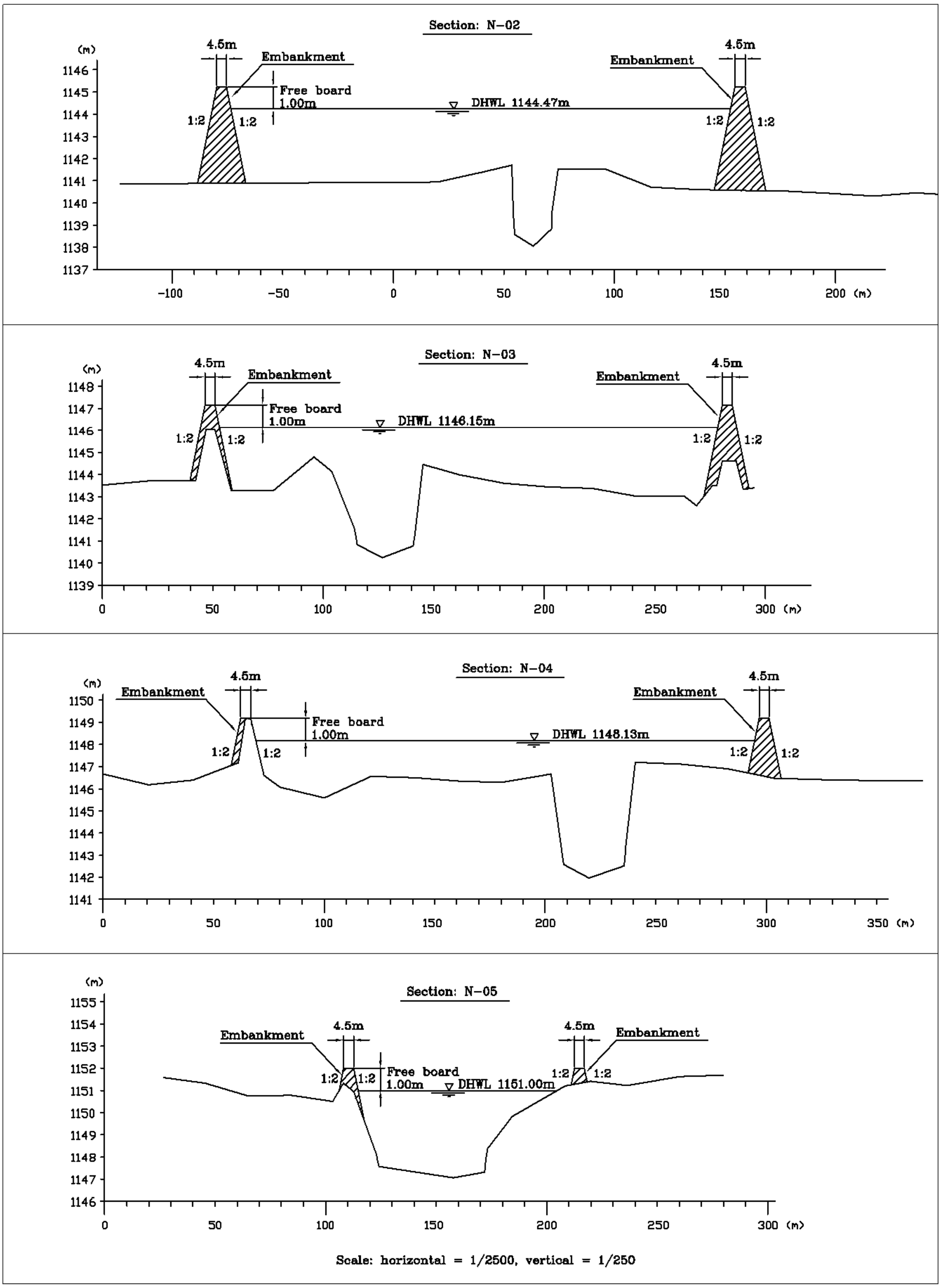
Dikes will be provided to prevent floodwater from spilling over the land surface. Earth dikes will be adopted because of their durability and ease of repair and strengthening, even during flooding. Standard dikes will have a 4.5m-width at the crown, 1.0m of freeboard, and a slope of 1:2 (1 unit vertically and 2 units horizontally), as shown in Figure 6.2.3.



Source: JICA Study Team

Figure 6.2.3 Standard Dike Cross Section

In order to increase the channel capacity in the target stretch of the Nyando River, dikes have been proposed in the reaches extending from the upper end of the swamp (section N-00) to the Ahero Bridge (section N-05). The required area of dike cross section to control the design discharge flow was determined using a non-uniform flow calculation. The calculated water level is shown in Figure 6.2.2. The design crest elevation of the dike provides a 1 m freeboard above the height corresponding to a design discharge of 730 m^3/s. Various design sections are shown in Figure 6.2.4.

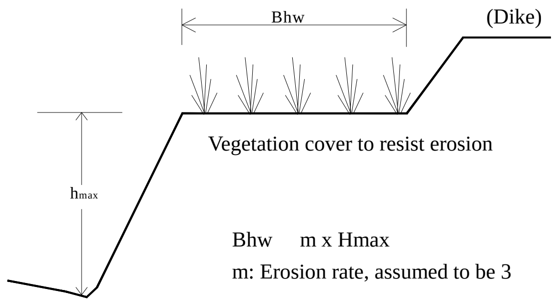


Source: JICA Study Team

Figure 6.2.4 Proposed Standard Design Sections

A high-water channel is to be provided primarily for floodwater conveyance, but also to ensure the safety of the dike by protecting it from bank erosion and slope failure. If bank protection is not provided, the high-water channel will need to be wide enough to resist bank erosion and slope failure at least during the flood season. By considering the data for bank erosion rates in Japan, the required minimum width of high-water channel was calculated as 16 m. The design criteria and method for calculating this width are shown below. Figure 6.2.5 illustrates a typical unprotected dike cross section, showing the important dimensions.

(Dike Cross Section without Protection Works)



Source: JICA Study Team

Figure 6.2.5 Minimum Width of Unprotected High-Water Channels

$$Bhw = m \times Hmax$$

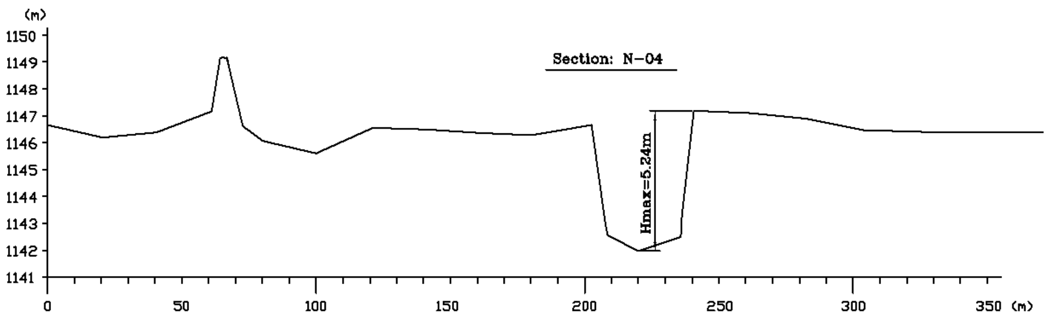
where, *Bhw* : Required minimum width of the unprotected high-water channel

Hmax : Bank height at the foot of the slope (= 5.24 m, as shown in Figure 6.2.6)

m : Erosion rate, assumed to be 3

The required width of high water channel for the target stretches was calculated as follows:

$$Bhw = 3 \times 5.24 = 15.72 \Rightarrow 16 \text{ (m)}$$



Source: JICA Study Team

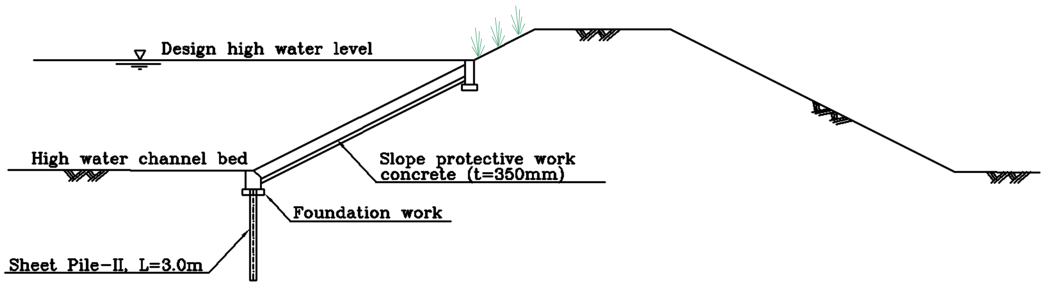
Figure 6.2.6 Hmax in Section N-04

The width of high water channel for the target stretches is more than 16 m. Therefore, bank protection work against erosion and land failure is not required. However, in the following stretches, bank protection works should be installed:

1) Upstream and downstream of Ahero Bridge; and
2) In the stretch where the dike was broken during flooding in December 2006. This stretch is located on the right bank, 100 m upstream of the N-02 section.

A cross section illustrating the required bank protection works is shown in Figure 6.2.7. It is recommended that the high-water channel be covered with vegetation, such as reeds, to resist erosion.

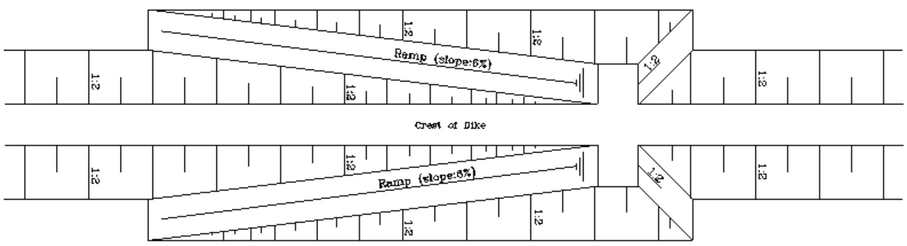
(Dike Cross Section *with* Protection Works)



Source: JICA Study Team

Figure 6.2.7 Typical Dike Cross Section where Bank Protection Work is Required

Ramps should be installed every 1 km on the right and left side of the dikes to allow easy and safe access to the river. A plan view of a typical ramp is shown in Figure 6.2.8.



Source: JICA Study Team

Figure 6.2.8 Plan View of a Typical Ramp to the Dike

6.3 NETWORK OF EVACUATION ROADS CONNECTING THE AFFECTED COMMUNITIES

6.3.1 Target Works of Road Improvement

In the Study Area, the roads and railway are the principal modes for inland transportation. However, the road is the dominant mode, both for passenger and freight transportation.

The road surface type in the Study Area can be categorised into two categories: (i) bitumen; and (ii) compacted earth (i.e. non-surfaced). The surface of many earth roads becomes rutted during and after the rainy season. The surface conditions of many bitumen roads have deteriorated due to lack of maintenance, and many potholes can be observed. During the rainy season, some roads become non-trafficable due to flooding at river crossing points.

The level of frequently submerged sections of National Road A1, which is an international trunk road, should be raised to ensure its role as the main trafficable road for relief and evacuation activities in case of inundation. The level of local roads, which play a role in networking community roads connecting to National Road A1, should also be raised for community-driven disaster management.

Component Works: In order to secure traffic ability of evacuation road and ensure efficient rescue operations, raising road levels and improving bridges have been selected as priority schemes. Table 6.3.1 shows the identified road improvement components. The selected roads and bridges are shown in Figure 6.3.1.

Table 6.3.1 Road Improvement Components

Road	Class	Raising Road Levels	Bridge Improvement (River Crossings)
National Road A1	A	Ayweyo-Awach, L=3km	Nyamasaria Luando Ombeyi Miriu Nyando Nyaidho Tributary of Awach Kano Awach Kano
Local Roads	D	Ahero-Ombeyi (D293), L=5km Ahero-Apondo (D293), L=5km Kobura-Bwanda (D290), L=5km	

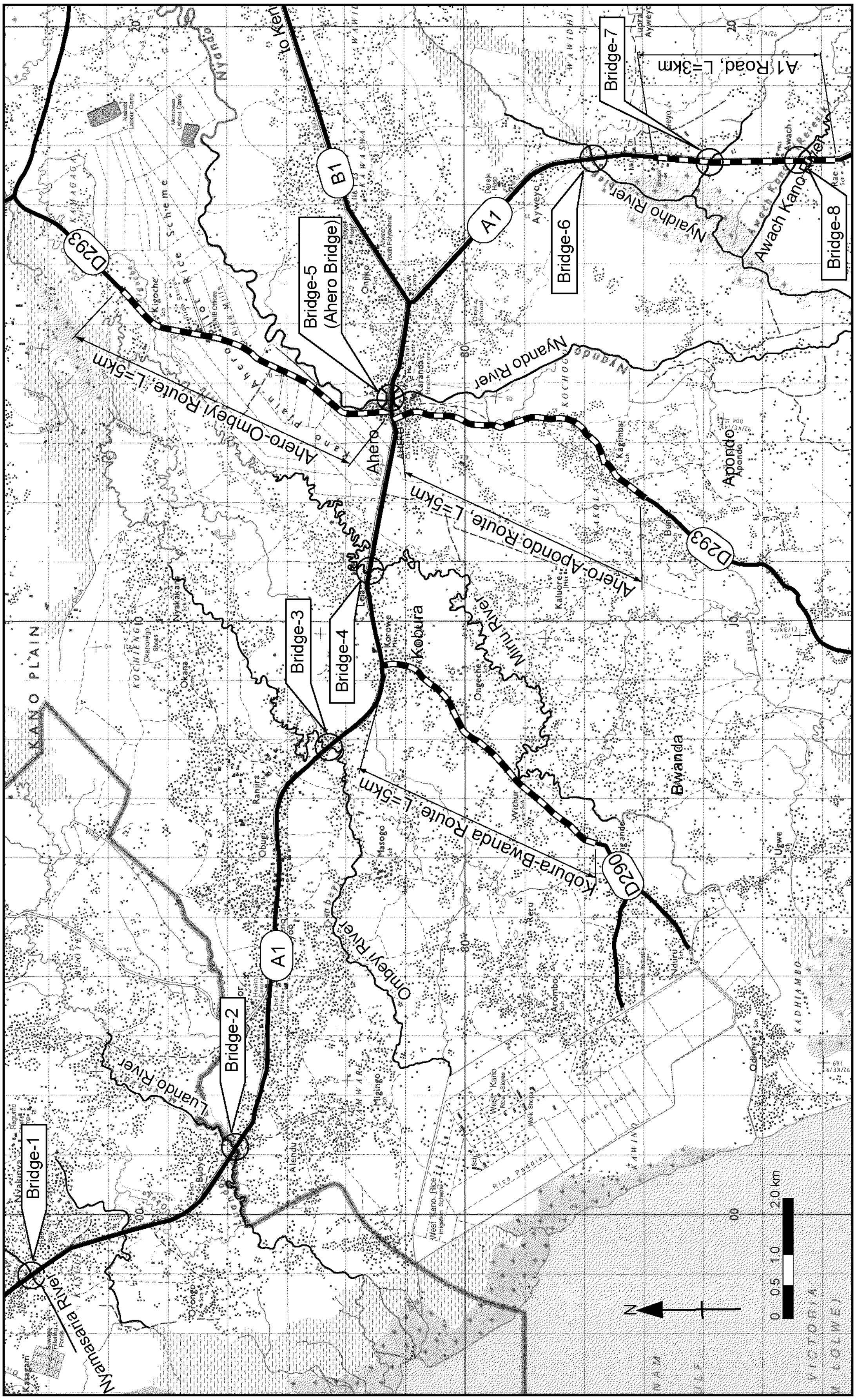


Figure 6.3.1 Layout of Proposed Road Improvement

Source: JICA Study Team

The level of the above four routes is to be raised as these roads have being suffering from chronic inundation. The level that these roads will be raised was determined by considering annual inundation depths. At the eight bridge sites listed in Table 6.3.1, flood flows stagnate due to insufficient flow area of the bridge sections and the bridges are frequently submerged. Roads in Kenya are classified into Class A, B, C, D and E according to Kenya's Road Design Manual. Table 6.3.2 shows the road classifications. The target routes of the priority road project are either Class A (National Road A1) or Class D (secondary roads).

Table 6.3.2 Kenya's Road Classification System

Road Class	Definitions
A	International Trunk Roads: Roads linking centers of international importance and crossing international boundaries or terminating at international ports.
B	National Trunk Roads: Roads linking nationally important centers. (Principal Towns/Urban centers).
C	Primary Roads: Roads linking provincially important centers to each other or to higher class roads. (Urban/Rural centers)
D	Secondary Roads: Roads linking locally important centers to each other or to a more important center, or to higher class roads. (Rural/Market centers)
E	Minor Roads: Any road link to a minor center (Market/Local centers)

Source: Road Design Manual, Road Department, Part 1 Geometric Design of Rural Roads

6.3.2 Design of National Road A1

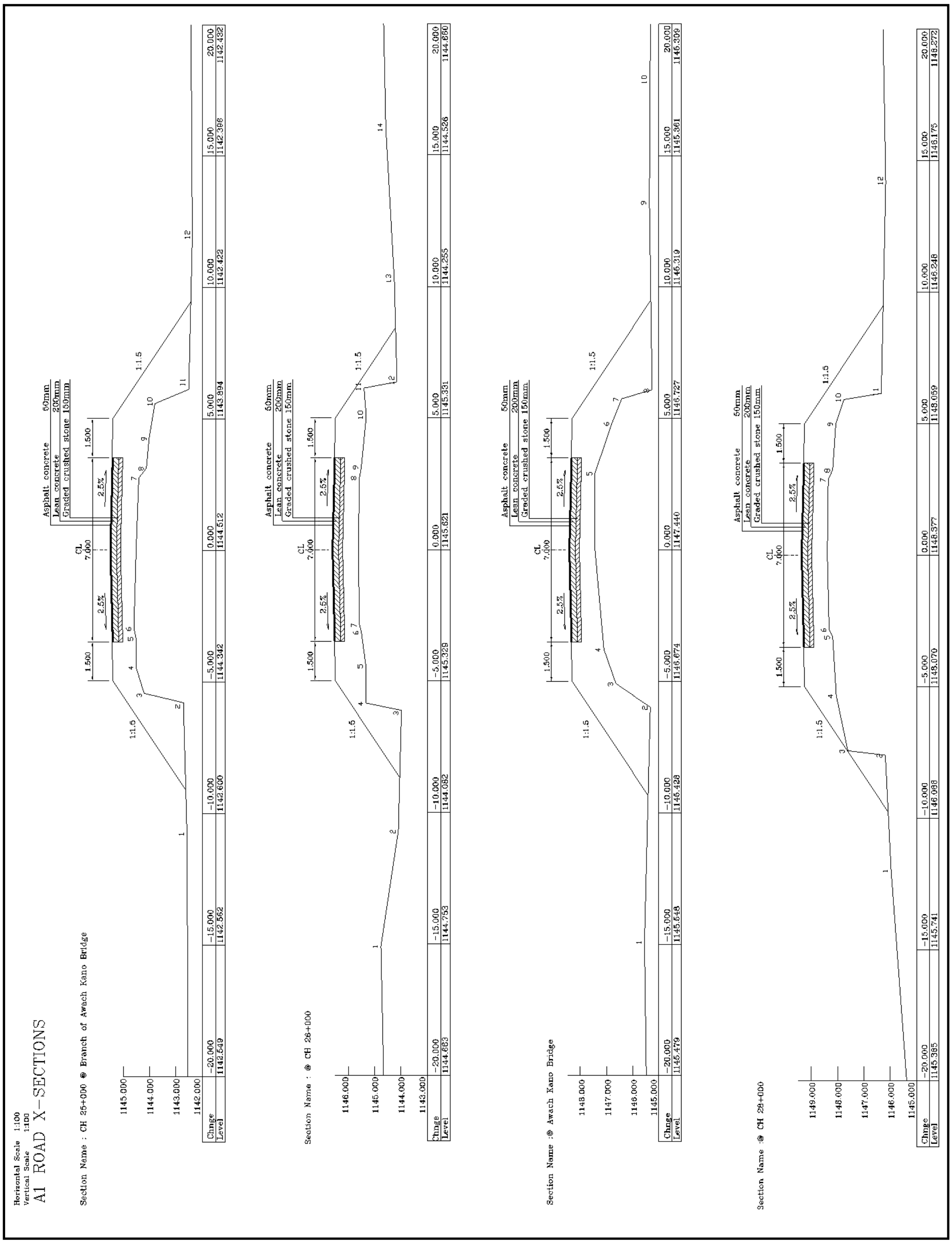
(1) Raising Road Levels

The target for raising the level of National Road A1 is three kilometres between Ayweyo to Awach. The top elevation of this stretch is low compared with the flooding level or inundation depth.

Road alignments that are to be raised have basically been designed to follow the existing road alignments. The average annual inundation depth of target routes can be estimated at 0.5 m according to Figure 4.4.11 (Longitudinal Profile of A1 Trunk Road) and 4.6.5 (Flood Disaster Maps). Therefore, the target route will be raised by 0.5 m above the existing road elevation to provide a safe and trafficable road that will not be subject to annual inundation.

Pavement: The pavement shown below was designed for A1 Trunk Road based on Kenya's Road Design Manual and design work undertaken for other projects:

- Surfacing : Asphalt concrete, t=50 mm
- Base course : Lean concrete, t=200 mm
- Sub-base : Graded crushed stone, t=150mm
- Cross Section : The standard design cross section is shown in Figure 6.3.2.



Source: JICA Study Team

Figure 6.3.2 Design Cross Section of National Road A1

(2) Bridge Improvement

Some river cross sections located at some bridges along National Road A1 are stream flow bottlenecks. Flood water flow becomes stagnant at these bridges due to a lack of flow area during flood, and severe inundation frequently occurs in the rainy season. The flooding obstructs quick and safe evacuation, makes it difficult to transport relief supplies, and delays the treatment of injured people. To provide countermeasures against these problems, it is planned to reconstruct existing bridges and culverts crossing major rivers along the National Road A1 route in order to provide increased flow areas. As a result, floodwaters will flow smoothly, alleviating the problem of stagnation and frequent inundation.

Eight bridges have been selected as priority projects. These bridges, which are along National Road A1 and cross the main rivers in the Study Area, are easily inundated during the rainy season. Figure 6.3.3 shows the present situation at each of the selected priority project bridges.

Bridge-1:Nymasaria River

Bridge-2: Luando River

Bridge-3: Ombeyi River

Bridge-4: Miriu River

Bridge-5 (Ahero Bridge): Nyando River

Bridge-6: Nyaidho River

Bridge-7: Awach Kano Tributary

Bridge-8: Awach Kano River

Source: JICA Study Team

Figure 6.3.3 Existing Situation at Priority Project Bridges

Hydraulic Condition: According to Kenya's Road Design Manual (Part IV: Bridge Design) a bridge has to secure 1 m clearance against a 25-year probable flood water level. Existing flow capacities and 25-year probable flood discharges at the bridges to be reconstructed on seven rivers and one tributary are shown in Table 6.3.3.

Table 6.3.3 Existing Carrying Capacity and 25-year Probable Discharge

River	Existing carrying capacity (m^3/s)	25-year probable discharge (m^3/s)
Nyamasaria River	55	84
Luando River.	35	83
Ombeyi River	20	37(*1)
Miriu River	20	37(*1)
Nyando River	660	890
Nyaidho River	40	90
Awach Kano Tributary	30	48(*2)
Awach Kano River	40	48(*2)

(*1) The 25-year probable discharge of Ombeyi River and Miriu River is calculated as 72.8 m^3/s in total. The value has been divided in half (37 m^3/s) as this will probably be the 25-year discharge for each river because the catchment areas of the both rivers are considered nearly equal.

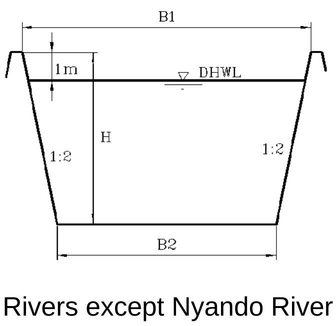
(*2) The 25-year probable discharge of the Awach Kano Tributary and Awach Kano River is calculated as 95 m^3/s in total. The value has been divided in half (48 m^3/s) as this will probably be the 25-year discharge for each river, for same reason as (*1).

Source: JICA Study Team (Interim Report, Tables 4.2.5, 4.2.6, 4.4.2, and Figure 4.4.7)

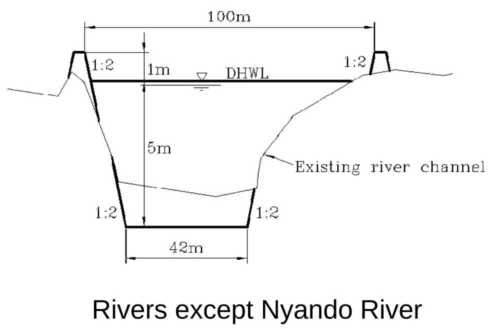
The design river cross sections for the 25-year probable discharges were determined using the Uniform Formula. For in this calculation, a value of 0.03 and 0.05 was used for Manning's roughness coefficient in the low water channel and high water channel, respectively. The adopted riverbed slope was taken to be the same value as the existing one. Design river cross sections for 25-year probable flood levels are shown in Table 6.3.4

Table 6.3.4 Design Cross Section for 25-year Probable Discharge

River	Q_{25} (m^3/s)	Riverbed Slope	B1 (m)	B2 (m)	H (m)
Nyamasaria River	84	1/1200	25	5	5.0
Luando River	83	1/1600	34	20	3.5
Ombeyi River	37	1/1600	25	13	3.0
Miriu River	37	1/1600	25	13	3.0
Nyando River	890	1/700	100	42	6.0
Nyaidho River	90	1/1600	36	22	3.5
Awach Kano Tributary	48	1/1600	25	17	2
Awach Kano River	48	1/1600	25	17	2



Rivers except Nyando River



Rivers except Nyando River

Source: JICA Study Team

Three types of bridge (Type-A, Type-B, and Type-C) were designed to match the dimensions of the river sections required to accommodate the 25-year probable discharge that was mentioned earlier. The span length of each type of bridge are: (i) Type-A: 25 m span for bridges crossing the Nyamasaria, Ombeyi, Miriu, and Awach Kano Rivers and the Awach Kano Tributary; (ii) Type-B: 40 m span for bridges crossing the Luando and Nyaidho Rivers; and (iii) Type-C: 100 m span for the bridge crossing the Nyando River, i.e. the Ahero Bridge. The location of each bridge type is shown in Table 6.3.5 and the proposed design criteria for each bridge is summarised in Table 6.3.6.

Table 6.3.5 Bridges Type

Type	Span Length (m)	River	Width of river (m^3)
Type-A	25	Nyamasaria River Ombeyi River Miriu River Awach Kano Tributary Awach Kano River	25 25 25 25 25
Type-B	40	Luando River Nyaidho River	34 36
Type-C	100	Nyando River	100

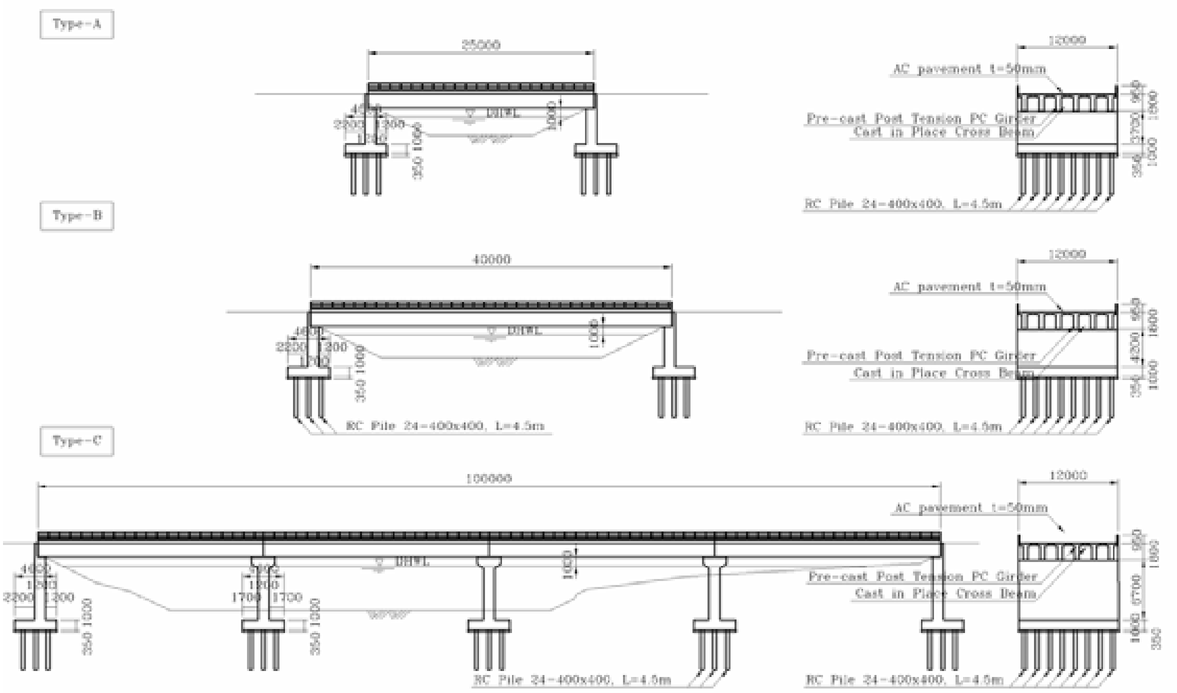
Source: JICA Study Team

Table 6.3.6 Proposed Bridge Design Criteria

Criteria	Type-A	Type-B	Type-C
Bridge Length	25 m	40 m	100 m
Bridge Width	12 m		
Superstructure	Pre-cast post tensioned PC girder with cast-in-place cross beams		
Foundation Type	Piled spread foundation (4.6m x 12.75m x 1.0m) 24 x RC piles (400mm x 400mm), Pile length L=4.5m		
Pavement	Asphalt Concrete, t=50mm		

Source: JICA Study Team

The foundation design for the above bridges is based on the visual observation of the riverbed without detailed geological survey. Therefore, a detailed geological foundation survey, including boring is required at the detailed design stage. The proposed three bridge designs are shown in Figure 6.3.4.



Source: JICA Study Team

Figure 6.3.4 Typical Design Layout of Proposed Bridges

6.3.3 Design of Local Road

The level of local roads will be raised along three target routes: (i) D293 route (Ahero-Ombeyi, L=5km); (ii) D293 route (Ahero-Apondo, L=5km); and (iii) D290 route (Kobura-Bwanda, L=5km).

Alignment: The roads to be raised are generally designed to follow the existing road alignments.

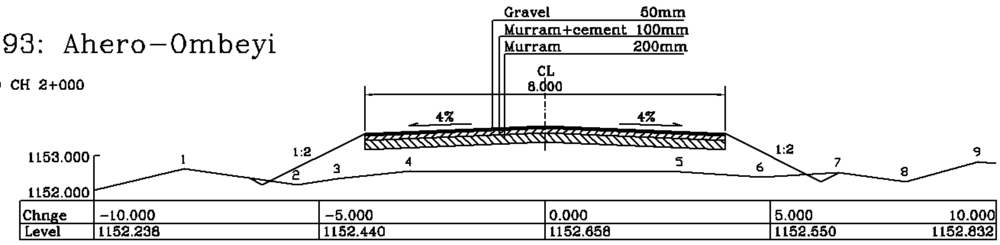
Height to be raised: The average annual inundation depth of the target routes was estimated at 0.5 m, based on Figure 4.6.5 (Flood Disaster Map) that was shown previously in Chapter 4. Therefore, the target routes will be raised 1.0 m above the existing road elevation to ensure the construction of safe and trafficable roads that are protected from annual inundation.

Pavement: Gravel pavement should be adopted for the local roads. This is suggested because existing local roads are paved with grave. The purpose of raising the road level is to ensure that safe and trafficable roads are available during periods of inundation, not to upgrade the road class.

Design Cross Section: A standard design cross section for three local roads is shown in Figure 6.3.5.

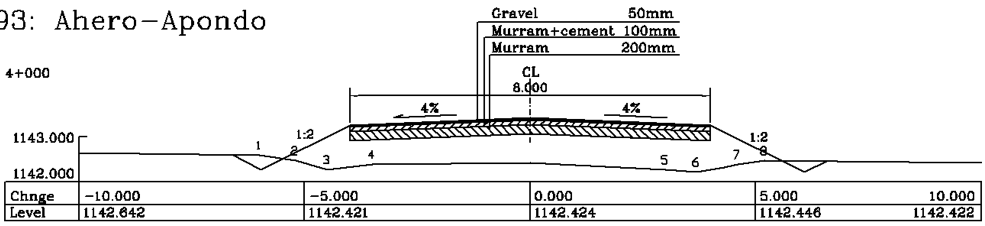
Route D293: Ahero–Ombeyi

Section Name :⊗ CH 2+000



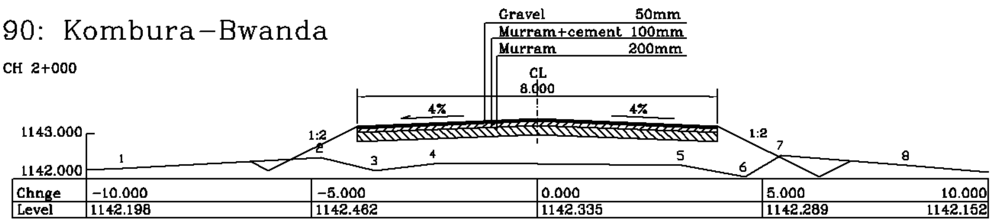
Route D293: Ahero–Apondo

Section Name : ⊗ 4+000



Route D290: Kombura–Bwanda

Section Name :⊗ CH 2+000



Source: JICA Study Team

Figure 6.3.5 Design Cross Section of Local Roads

6.4 CAPACITY DEVELOPMENT OF COMMUNITY-DRIVEN FLOOD MANAGEMENT

6.4.1 Basic Concept of Institutional Framework Design for Implementing the Scheme

As mentioned in detail in the following Chapter 7, during the Study, four pilot projects were implemented within flood prone areas in order to learn key lessons for future community-driven flood management projects. Based on the pilot project experience, the following points should be considered as basic concepts when implementing the scheme:

(1) Prioritisation of communities based on present and past flood damage

In the pilot projects, communities that have experienced serious flood damage were selected. Accordingly, their community action plans indicated a very large need for flood protection and management. Therefore, the selection of communities should be done by using flood disaster maps and the knowledge of local people about present and past flood damage.

(2) Participatory approach to ensure community-driven flood management

The pilot projects used various participatory approaches, including Participatory Rural Appraisal (PRA), participatory community flood hazard mapping, Community Action Plan (CAP) formulation, development of Community Flood Management Organisations (CFMOs), involvement in structural measure construction, organising evacuation drills, and monitoring of the pilot projects. As a result, it was found that the CFMOs generally desired to manage flooding by themselves by using locally available resources. Therefore, the same approach will be applied when implementing the scheme.

(3) Capacity development based on "learning by doing"

In the pilot projects, the CFMOs learned institutional development through actual activities of the CFMO, financial management through fund operation raised by labour fees, flood management concepts through evacuation drill excises, and maintenance of structural measures through involvement in labour work. The teachers for these activities also learned how to teach flood management more effectively through development of teaching materials. The aspect of "learning by doing" will be emphasised in the scheme.

6.4.2 Priority Communities for the Scheme

The target communities will be located in flood prone areas within the Study Area and they will have had past experience with floods. The number of communities requiring flood management schemes is estimated to be around 550, covering 55 sub-locations. The experience gained from the pilot projects indicates that 20-50 communities could be trained annually, considering the capacity of WRMA and available human resources of local NGOs. Therefore, the flood affected communities within the Study Area need to be prioritised, based on the flood damage level.

By overlaying the flood disaster map on the boundary of sub-locations, priority sub-locations could be selected. The criteria for first priority selection were that more than 20% of the sub-location area has experienced floods of more than 1 m depth. The criteria for second priority selection were that more than 50% of the sub-location area has experienced floods of more than 0.5 m depth. The third priority communities were the remaining communities that were not identified as first or second priority. The results of the priority selection process are summarised in Table 6.4.1 and illustrated in Figure 6.4.1 below.

Table 6.4.1 Number of Target Sub-Locations by Priority

District	Division	First Priority Sub-location (No.)	Second Priority Sub-location (No.)	Third Priority Sub-location (No.)	Target Sub-locations (No.)
Kisumu	Winam	2	2	4	8
	Kadibo	5	8	0	13
Nyando	Lower Nyakach	1	2	7	10
	Miwani	2	2	6	10
	Nyando	5	5	3	13
	Upper Nyakach	0	0	1	1
	Total	15	19	21	55

Source: JICA Study Team (2007)

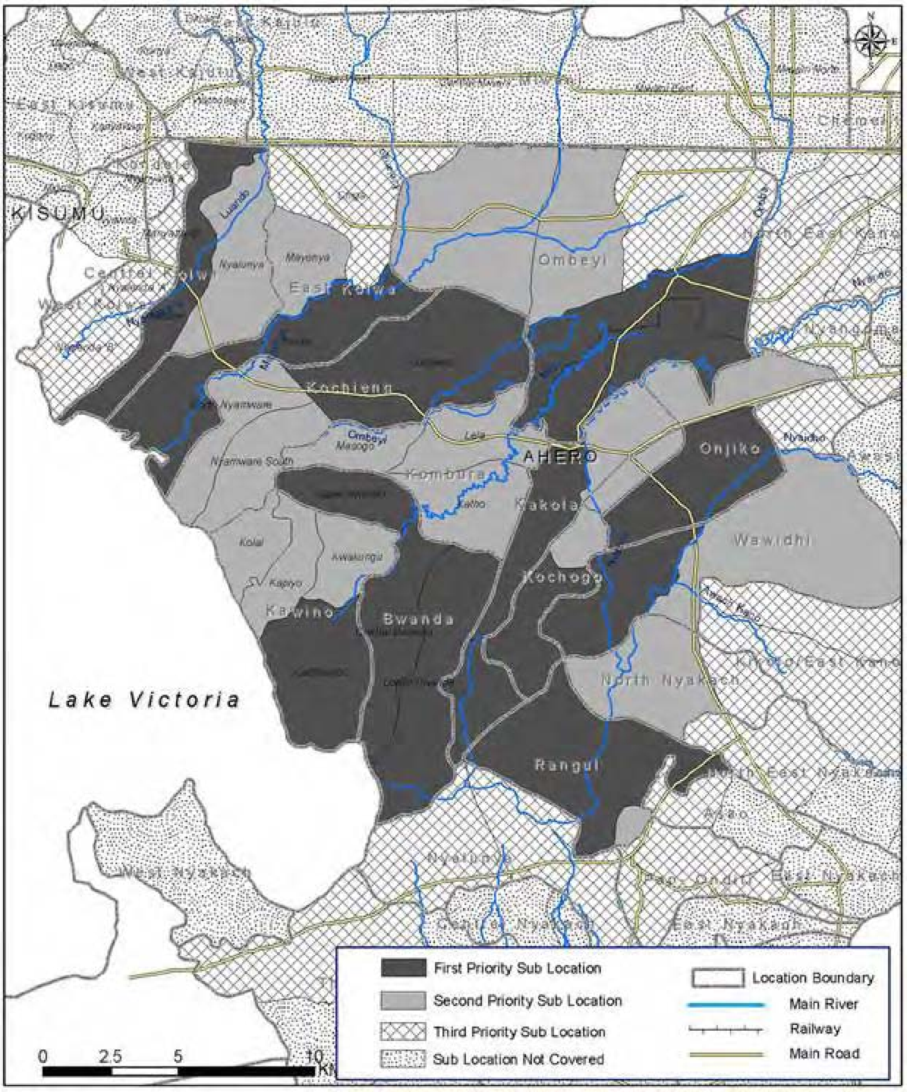


Figure 6.4.1 Location of Target Sub-Locations by Priority

6.4.3 Procedure for Formulation and Implementation

Based on the pilot project experience, the following procedure should be applied for formulation and implementation of capacity development for community-driven flood management:

(1) Kick Off Meeting for Target Sub-Locations:

The number of target sub-locations should be finalised based on the availability of funds in the relevant fiscal year. Meetings to explain the community surveys should be held with the Chief and Assistant Chief of the target sub-locations. The WRMA should organise the kick off meeting with the cooperation of local governments.

(2) Meetings at Target Sub-Location Level:

In order to understand the flood condition, meetings at target sub-locations should be held. The participants should discuss the selection of priority communities for flood management at the sub-location level by considering past flood damage and present economic and social condition. Based on the experience gained in the pilot projects that were executed under the Study, 1-3 villages should be selected as priority communities. For smooth implementation of meetings, a qualified facilitator is required.

(3) Community Surveys:

A survey team consisting of a facilitator, mapping specialist and technical staff for flood management should be organised. The survey team should hold kick-off meetings to explain the survey, CAP workshop, PRA workshop including key-informant interviews, history of the community, problem ranking, Venn diagram map preparation, production of community flood hazard maps, etc. Based on the experience gained in the pilot project, 5-7 days in total will be required for implementation of the community survey in each community. The number of staff in WRMA is limited, although WRMA does have enough capacity to implement the community surveys. It is therefore recommended that local NGOs be engaged to assist with the process, since they have sufficient capacity to implement community surveys.

(4) Formulation of Community Driven Flood Management Projects:

Based on the CAP, the expert team should assist the communities to formulate proposals for Community Driven Flood Management Projects. The key points for formulation of the projects are: i) the priority of the CAP should be carefully considered; ii) the balance between structural and non-structural measures should be considered; iii) negative impacts on other communities should be avoided; iv) land re-arrangements, necessary approvals and appropriate fees should be examined; and v) if there is any limitation on funds or other components in the project, the reason for non-selection should be explained to the communities.

(5) EIA Clearance:

If structural measures are included in the project, EIA clearance will be required according to applicable law in Kenya. An expert team engaged by WRMA should assist the communities to prepare applications and provide necessary information for obtaining an EIA Clearance from NEMA. It is noted that the social impact on land, benefit sharing, and equal involvement of the whole community should be carefully assessed. Because the proposed structural measures will only be developed at the community level, negative impacts on the natural environment are expected to be minimum.

(6) Approval of Proposals and Explanation Meetings with Target Communities:

The project management authority should review and check the proposals submitted by the communities for approval. If any additional information is required, feedback should be provided as quickly as possible. After the approval of a proposal, an explanatory meeting should be arranged with the target community. The meeting topics should include: i) approved components of the project; ii) additional components if any; iii) responsibilities of concerned stakeholders; iv) the content of a draft memorandum of understanding (MOU) for implementation of the project; and v) an implementation schedule.

(7) Training for Development of CFMO:

A new CFMO will be established for implementation of the project. Training programmes for development of the CFMO should be presented at the beginning. The training items should include: i) holding public meetings to build awareness of the need for the CFMO; ii) establishment and development of the CFMO; iii) grouping the villages as appropriated for building the CFMO; iv) registration of the CFMO as a Self-Help Group with the corresponding District Office; v) preparation and finalisation of the bylaws of the CFMO; vi) organisational training to achieve smooth, self-dependent and sustainable operation of the organisation; vii) financial arrangements and management; and viii) proposal preparation to access external funding sources for realisation of action plans.

(8) Implementation of the Projects:

Funds for project work will be allocated to the bank account of the CFMO. Necessary structural measures, non-structural measures, and other community development approaches should be implemented as community initiatives with the technical support provided by WRMA and the expert team. Figure 6.4.2 shows some images of facilities (structural measures) and training (non-structure measures).

			
Well Installation	Dike Improvement	Community Flood Management Organisation	Community Flood Hazard Mapping
			
Raised Road	Riverbank Protection	Disaster Education Programme	Evacuation Drill

Source: JICA Study Team

Figure 6.4.2 Images of Structure and Non-Structure Measures

The followings are recommended for implementation of the projects:

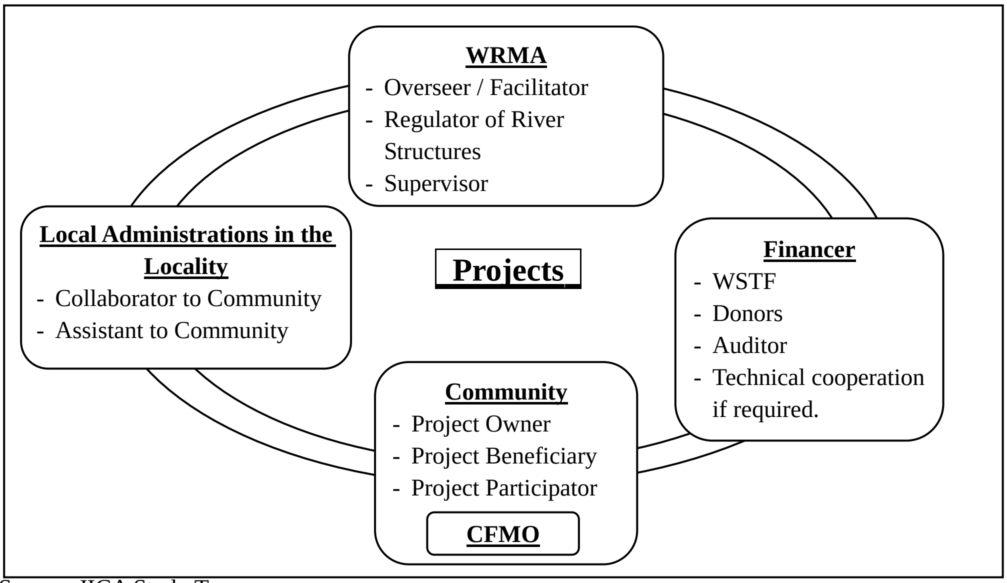
- ✓ The capacity of the construction contractor should be carefully checked in the pre-qualification and tender process. In the tender process, the construction plan and supporting documents for the Bill of Quantity (BOQ) should be submitted and reviewed. In the review of tender documents and subsequent negotiation, contractors with little understanding of construction practices and standards must be disqualified.
- ✓ In general, local NGOs have little technical knowledge about construction work, although they do have good skills and knowledge about institutional development at the community level. It is recommended that the structural measures be undertaken by the construction contractor or local foreman engaged by the CBO. It is also noted that local NGOs have little capacity for O&M training relating to structural measures due to their limited knowledge of engineering work. Accordingly, WRMA or concerned ministries should directly carry out the O&M training programme. On the other hand, local NGOs do have a good capacity for providing organisational and financial training for CBOs.
- ✓ Kenya Red Cross has good knowledge and experience in implementing training programmes for flood management. Kenya Red Cross also has experience in holding evacuation drills through participation in the pilot projects. Accordingly, this allowed the quality of the work for evacuation drill to be improved. It is therefore strongly recommended that the project be undertaken in cooperation with the Kenya Red Cross for implementation of training programmes for flood management and for evacuation drills.

(9) O&M of the Projects:

O&M should be carried out by the community, either by themselves or with support from government agencies. In addition, expansion of the project to more community members or other communities should be considered.

6.4.4 Structure of Implementation

For implementation of the project for capacity development of community-driven flood management, various organisations will be involved. The key organisations and institutional framework for project management are illustrated in Figure 6.4.3, namely WRMA-LVSC; the Financer including, Water Services Trust Fund (WSTF), Donors, etc.; Local Administrations in the locality, and the Community.



Source: JICA Study Team

Figure 6.4.3 Institutional Framework for Project Management

Before commencement of the project works and activities, a memorandum of understanding (MOU) for organising the project management should be signed by each party.

6.5 ESTABLISHMENT OF A HYDROLOGICAL MONITORING NETWORK

6.5.1 WRMA's Activities in 2006

Daily water levels on the rivers are recorded twice a day by gauge readers who receive an honorarium. The levels are read from staff gauges in the morning and evening and data are entered in the Hydrological Log Books. Returns are made to the Regional Office via the Sub-regional and District Offices on a monthly basis and these records are computerised by the Database Section. Data from automated data-loggers (most of which are non-operational) are usually downloaded on a monthly basis. Discharge measurements are made during low flows, medium flows and high flows.

During the workshop, different categories of Regular Gauging Stations (RGS) were identified. Some of, these stations were given priority status, based on assessment guidelines and field inspection, as described below. Both National Stations (NS) and Management Stations (MS) were categorised as Priority 1 stations, which will require upgrading with automated data loggers in addition to maintaining the existing manual staff gauges.

The processes of assessing prioritised stations earmarked for rehabilitation was carried out by first developing RGS Assessment Guidelines in the office and through field visits, with the assistance of the Technical Advisor (TA). Secondly, a 4-day training programme on RGS assessment (office and field) was organised, as shown in Figure 6.5.1. Some important lessons were learnt during the training. For example, it emerged that some of the stations might require relocation and adjustments were needed to make up for some of the replaced gauges. It is commendable that most of the stations were perfectly located, considering the hydraulic controls (natural and artificial) and hence require no relocation.

Source: Annual Report (WRMA, 2006)

Figure 6.5.1 Training on RGS Assessment at 1GD03

The rehabilitation exercise was carried out just before the onset of the long rains. The RGS assessment guidelines were used to assess stations that required immediate attention. Within the Nyando River Basin, only one automated gauging station (Station 1GD03) had a functional data-logger. The prioritised RGS Stations that needed urgent rehabilitation are summarised in Table 6.5.1. However, not all the management stations are functioning. It was planned to rehabilitate the RGS Stations during the dry season. The task of rehabilitating the gauging stations was has now become the responsibility of the sub regional offices of WRMA. Since 2006, gauges at three RGS stations have been rehabilitated. In addition, one Inter-management Station (1HD06) was also rehabilitated.

Table 6.5.1 Prioritised RGS (National Stations) Rehabilitated by WRMA

RGS No.	River Name	Date of Work	Description
National and Management Station			
1GD03	Nyando	12 –Mar-06 to 17-Mar-06	• Construction of stairs from 1st to 6th gauge plate • Re-enforcement of logger house fence with cedar posts • Re-alignment of 3-4th and 7 -8th gauge plate • De-silting of 3-4th and 5-6th gauge plates • Replacement of the 7 to 10m gauge plates • Painting of struts and posts • Clearing of bush surrounding logger house • Maintenance of old AWL recorder and station
1GB03	Ainapmutua	17-Mar-06	• De-silting and bush clearing of station vicinity • Replacement of 0-1.5 and 1.5-3m gauge plates • Painting of struts and posts
1GD07	Nyando	17-Mar-06	• Bush clearing and de-silting • Re-installation of 1-1.5m and 1.5-3m struts and gauge plates • Painting of struts
Inter-management Station			
1HD06	Eaka Kioge	Feb-06	• Replacement of gauge plates and painting

Source: Annual Report (WRMA, 2006)

6.5.2 Installation of Regular Gauging Station (RGS)

At present, the field units of MWI have jurisdiction over the hydrological observatory network on a district basis. Therefore, different MWI District Water Officers are in charge of various river gauging stations in a particular river basin. There is a need to reorganise the existing monitoring structure for flood emergency management. This will be feasible under the ongoing institutional reform process.

It is essential that all hydrological observation stations in the Nyando river basin be placed under the charge of the Disaster Management Centre (DMC) for the whole basin. Doing this will ensure better coordination and supervisory control.

For flood forecasting purposes, the Study Team chose the locations where new Regular Gauging Stations should be installed. The location of river base stations was selected as close as possible to the foothills. The location of flood forecasting stations were chosen just upstream of the flood prone areas. River cross-sections will also be required at regular intervals and the new gauges will need to be connected to a reference datum. Based on the rainfall patterns, the consequent flood areas were identified and selected.

For the priority schemes, eight rainfall stations with automatic recorders and six water level gauging stations from the Inter-Management Unit were nominated as the first priority. These stations are managed by WRMA in cooperation with the Kenya Meteorological Department (KMD), as shown in Table 6.5.2 and Figure 6.5.2.

Rainfall gauging stations are located throughout the whole basin under the management of sub-regional offices of WRMA. Water level gauging stations are installed for the main and smaller rivers located upstream of the flood prone areas.

Table 6.5.2 List of RGS for Priority Schemes

Rainfall observatory station

Management Unit (WRMA)	Station Name	KMD No.
Upper Nyando	Anaimoi Chief Camp Rainfall station	
	Kipkelion W/S Rainfall station	90035028
	Kabujoi Meteorological Station	89034089
	MbogoVale	
Lower Nyando	Ahero Irrigation Rainfall station	90034086
Northern Shoreline Streams	Kibos Water Supply Kajulu	90034069
	Kibos Natural Fiber Research Centre	90034081
	Kenya Sugar Research Foundation	90034105

Source: WRMA

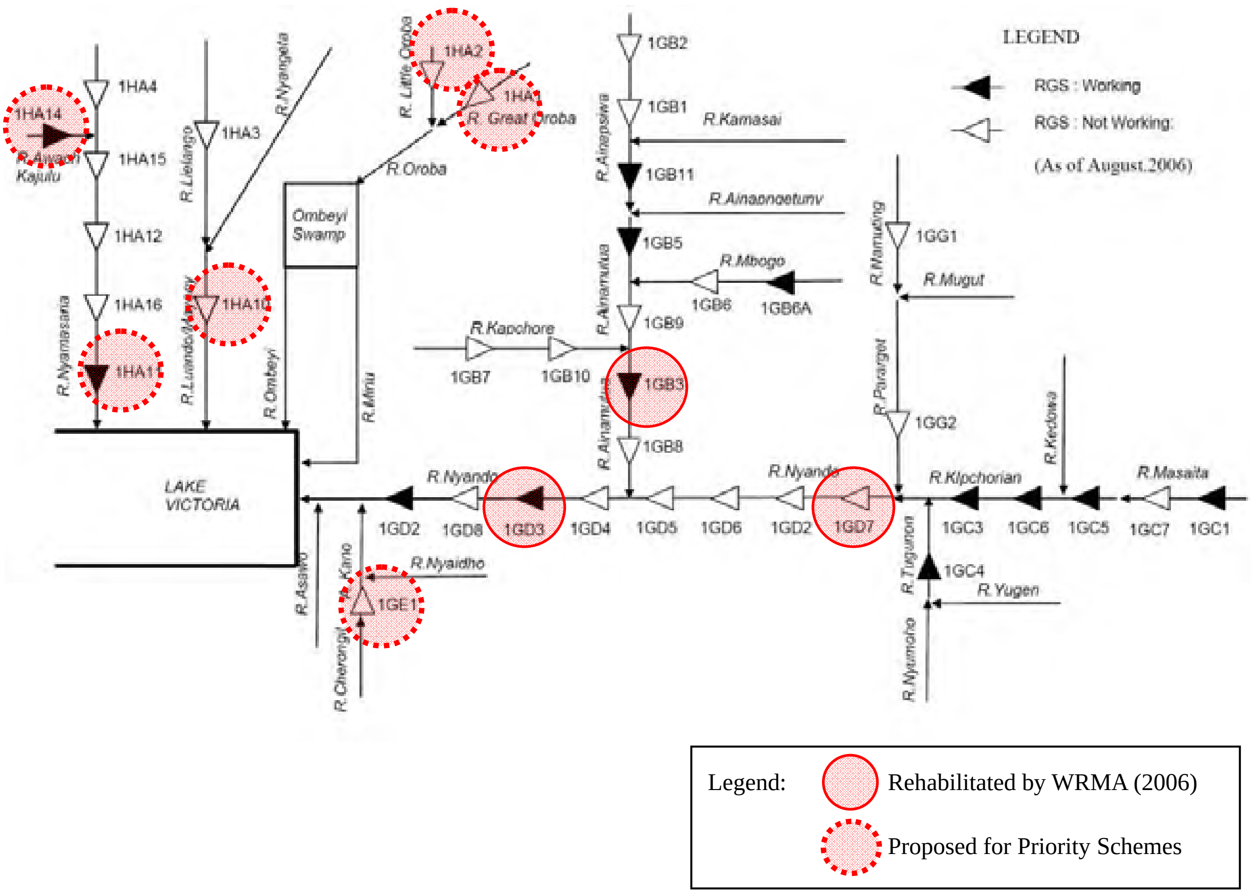
Note; KMD: Kenya Meteorological Department

Water level observatory station

Station type	RGS St. Code	River Name	Gauge Type
Inter Management Unit	1GE01	Awach Kano	S,A
	IHA11	Nyamasaria	S,A
	IHA1	Greater Oroba	S,A
	IHA2	Little Oroba	S,A
	1HA14	Awach Kajulu	S,A
	1HA10	Luando	S

Source: WRMA

Note: Special Gauge type: S=staff, A=automatic recorder



Source: LVSWSB and WRMA

Figure 6.5.2 Schematic Diagram of Hydrological Monitoring Network

6.6 PRELIMINARY COST ESTIMATE

6.6.1 Basic Assumptions of the Cost Estimate

(1) Sub-Projects and Works for Cost Estimation

The priority project consists of the following sub-projects:

1) Strengthening of existing dikes
   - 1-1) Raising and strengthening of deteriorated dikes
   - 1-2) Riverbank protection works on several stretches
   - 1-3) Ramps
2) Network of evacuation roads connecting the affected communities
   - 2-1) National Road A1
   - 2-2) Local Road
     - Ahero-Ombei Route
     - Ahero-Apondo Route

- Kombura-Bwanda Route

3) Capacity development for community-driven flood management
   3-1) Community Survey
   3-2) Community Driven Flood Management
   - Flood Management Training
   - Construction of Community Structure
   3-3) Monitoring and Evaluation
4) Establishment of a hydrological monitoring network
   4-1) Rehabilitation and reconstruction of water level gauging stations

(2) Basis of the Cost Estimate

The project cost and other related unit costs are expressed in terms of the conditions prevailing in June 2007. The project cost comprises direct cost, land acquisition and compensation cost, administration cost, engineering service cost, and physical contingency. The project cost was estimated based on the following procedures and assumptions:

(1) Civil works 1) Preparatory works: 10% of direct cost
2) Direct cost: unit cost basis
3) Miscellaneous: 20% of direct cost

(2) Land acquisition cost 1) Land purchase cost
2) Miscellaneous: 10% of land cost

(3) Administration by government: 5% of Item (1)

(4) Engineering services: 15% of Item (1)

(5) Sub-total = (1) + (2) + (3) + (4)

(6) Physical contingency: 15% of Items (5)

(7) Total

(3) Unit Work Costs

The work cost is estimated based on the quantity of work multiplied by a standard unit work cost. The unit work costs were assumed based on cost data for similar work executed in Kenya. The standard work costs that were applied are listed in Table 6.6.1. As for the land acquisition and compensation cost, the unit price of Ksh. 89,000/ha (Ksh. 8.9/m^2) was assumed, based on information obtained for on-going projects in Nyanza Province.

Table 6.6.1 Standard Work Costs

Work	Specifications	Unit	Cost (Ksh)
1) Clearing and Stripping		m^2	30
2) Excavation		m^3	320
3) Embankment		m^3	670
4) Sodding		m^2	110
5) Gabion mattress		m^3	5,580
6) Gravel		m^3	3,820
7) Crusher run		m^3	3,300
8) Concrete		m^3	14,000
9) Reinforcement bar		ton	54,300
10) Asphalt Concrete		m^3	4,300
11) Graded Crushed Stone		m^3	3,670
12) Marrum	t=200mm	m^2	180
13) Marrum plus Cement		m^3	400
14) Culvert	D=600mm	m	3,050
15) Pile	Steel sheet pile	tonne	177,000
16) Bridge	Type-A (L=25m)	m	3,220,000
(T-Post Tension Beam)	Type-B (L=40m)	m	3,040,000
	Type-C (L=100m)	m	2,860,000

Source: JICA Study Team

6.6.2 Land Acquisition Cost

The area of land that needs to be acquired for the priority projects was estimated by using satellite images. The area of the required land is summarised by sub-project in Table 6.6.2.

Table 6.6.2 Land Acquisition Cost

Sub-project	Land Area (m^2)
1) Strengthening of existing dikes	263,000
2) Network of evacuation roads connecting the affected communities	69,000
① National Road A1	18,000
② Local Road	51,000
Total	332,000

Source: JICA Study Team

Land acquisition often causes social problems and delays or suspension of the project implementation. Careful consideration should be given on these mattes and proper procedures should be followed, allowing enough time to communicate with relevant organisations and individuals.

6.6.3 Project Cost

(1) Strengthening of Existing Dikes

The project cost for strengthening existing dikes is summarised in Table 6.3.3.

Table 6.6.3 Summary of the Project Cost for Strengthening Existing Dikes

(Unit : Ksh)

No.	Work Item	Unit	Unit Cost	Q'ty	Amount
1	**CIVIL WORKS**				478,526,000
1.1	PREPARATORY WORKS				36,810,000
1.2	CHANNEL WORKS				368,097,000
1.2.1	Earth Works				356,520,000
	Clearing	m^2	30	252,000	7,560,000
	Embankment	m^3	670	488,000	326,960,000
	Sodding	m^2	110	200,000	22,000,000
1.2.2	Stone Works				218,000
	Gabion Mattress	m^3	5,580	39	218,000
1.2.3	Concrete Works				11,359,000
	Concrete	m^3	12,010	329	3,951,000
	Crusher run	m^3	3,300	100	330,000
	Sheet Pile (Type-II)	ton	177,000	36	6,372,000
	Reinforcement Bar	ton	54,300	13	706,000
1.3	MISCELLANEOUS				73,619,000
2	**LAND ACQUISITION COST**				2,575,000
2.1	Land	m^2	8.9	263,000	2,341,000
2.2	Miscellaneous				234,000
3	**ADMINISTRATION**				23,926,000
4	**ENGINEERING SERVICE**				71,779,000
5	**SUB TOTAL (1+2+3+4)**				576,806,000
6	**PHYSICAL CONTINGENCY**				86,521,000
	GRAND TOTAL				663,327,000

Source: JICA Study Team

(2) Network of Evacuation Roads Connecting Affected Communities

The project cost for the network of evacuation roads connecting the affected communities is summarised in Table 6.6.4.

Table 6.6.4 Summary of the Project Cost for Network of Evacuation Roads

(Unit: Ksh.)

No.	WORK ITEM	UNIT	UNIT COST	Road Improvement Total Cost	
				Q'ty	Cost
1	CIVIL WORKS				675,512,000
1.1	PREPARATORY WORKS				51,962,000
1.2	CHANNEL WORKS				5,426,000
1.2.1	Earth Works				5,426,000
	Excavation	m^3	320	16,959	5,426,000
1.3	ROAD WORKS				264,032,000
1.3.1	Earth Works				139,014,000
	Clearing	m^2	30	17,100	513,000
	Excavation	m^3	320	3,629	1,161,000
	Embankment	m^3	670	193,000	129,310,000
	Sodding	m^2	110	73,000	8,030,000
1.3.2	Pavement Works				124,195,000
	Asphalt Concrete	m^3	4,300	1,050	4,515,000
	Lean Concrete	m^3	14,000	4,200	58,800,000
	Graded Crushed Stone	m^3	3,670	3,150	11,560,000
	Gravel	m^3	3,820	6,000	22,920,000
	Marrum + Cement	m^3	400	12,000	4,800,000
	Marrum(t=200mm)	m^2	180	120,000	21,600,000
1.3.3	Concrete Works				823,000
	Culvert (D=600mm)	m	3,050	270	823,000
1.4	BRIDGE WORKS				250,167,000
1.4.1	Bridge				209,375,000
	Type-A (L=25m)	m	625,000	75	46,875,000
	Type-A (L=40m)	m	625,000	160	100,000,000
	Type-A (L=100m)	m	625,000	100	62,500,000
1.4.2	Stone Works				6,774,000
	Gabion Mattress	m^3	5,580	1,214	6,774,000
1.4.3	Concrete Works				34,018,000
	Concrete	m^3	14,000	1,989	27,846,000
	Crusher run	m^3	3,300	620	2,046,000
	Reinforcement Bar	ton	54,300	76	4,126,000
1.5	MISCELLANEOUS				103,925,000
2	LAND COST				674,000
2.1	Land	m^2	8.9	69,000	613,000
2.2	Miscellaneous				61,000
3	ADMINISTRATION				33,776,000
4	ENGINEERING SERVICE				101,327,000
5	SUB TOTAL (1+2+3+4)				811,289,000
6	PHYSICAL CONTINGENCY				121,693,000
	GRAND TOTAL (Ksh)				932,982,000

Source: JICA Study Team

(3) Capacity Development of Community-Driven Flood Management

The project cost for capacity development of community-driven flood management is summarised in Table 6.6.5.

Table 6.6.5 Summary of the Project Cost for Capacity Development of Community-Driven Flood Management

(Unit : Ksh)

Item	Unit	Unit Price	Quantity	Amount
1. COMMUNITY SURVEY	**Community**	**400,000**	**100**	**40,000,000**
2. COMMUNITY-DRIVEN FLOOD MANAGEMENT				
2.1 Training for Flood Management	Community	1,000,000	100	100,000,000
2.2 Construction of Community Structure	Community	3,000,000	100	300,000,000
2.3 Others	Community	100,000	100	10,000,000
Sub-total				**410,000,000**
3. MONITORING & EVALUATION	**Community**	**300,000**	**100**	**30,000,000**
4. TOTAL OF ITEM 1. 2. AND 3.				**480,000,000**
5. ADMINISTRATION COST				**24,000,000**
6. CONSULTANCY SERVICE				**48,000,000**
6. PHYSICAL CONTINGENCY				**82,800,000**
GRAND TOTAL				**634,800,000**

Source: JICA Study Team

(4) Establishment of Hydrological Monitoring Network

The project cost for establishment of the hydrological monitoring network is summarised in Table 6.6.6.

Table 6.6.6 Summary of the Project Cost for Establishment of the Hydrological Monitoring Network

(Unit : Ksh)

Item	Unit	Unit Price	Quantity	Amount
1. AUTOMATIC RAINFALL GAUGING STATION				
1.1 Automatic rainfall gauge	set	88,000	1	88,000
1.2 Leveling concrete	cub.m	7,000	2	14,000
1.3 Solar cell (12V/87W)	pcs.	250,000	1	250,000
1.4 Storage battery (150AH)	pcs.	123,000	1	123,000
1.5 Installation fee (10% for Items a.1 to a.4)				47,500
1.6 Consumables (recording paper)	L.S.	33,000	1	33,000
Sub-total (Items a.1 to a.6)				555,500
Total for 8 stations			8 stations	**4,444,000**
2. AUTOMATIC WATER LEVEL GAUGING STATION				
2.1 Automatic water level gauge	set	405,000	1	405,000
2.2 Solar cell (12V/87W)	pcs.	25,000	1	25,000
2.3 Storage battery (150AH)	pcs.	123,000	1	123,000
2.4 Installation fee (10% for Items b.1 to b.3)				55,300
2.5 Consumable (recording paper)	L.S.	33,000	1	33,000
Sub-total (Items a.1 to a.6)				641,300
Total for 5 stations			6 stations	**3,848,000**
3. MANUAL WATER LEVEL GAUGING STATION				
3.1 Staff gauge	m	2,000	8	16,000
3.2 H-type steel beam (8" x 5.25 x 6 m)	pcs.	21,000	6	126,000
3.3 Concrete blocks	cub.m	7,000	3	21,000
3.4 Installation fee (20% for Items c.1 to c.3)				32,600
Total for 6 stations				**196,000**
4. MEASUREMENT EQUIPMENT				
4.1 A digital current metre	pcs.	251,000	2	502,000
4.2 An echo sounder	pcs.	856,000	1	856,000
Total				**1,358,000**
5. TOTAL OF ITEM 1. 2. 3. and 4.				**9,846,000**
5. ADMINISTRATION COST				**492,000**
6. PHYSICAL CONTINGENCY				**1,551,000**
GRAND TOTAL				**11,889,000**

Source: JICA Study Team

(5) Total Project Cost

The total project costs, including the four (4) priority schemes are summarised in Table 6.6.7.

Table 6.6.7 Summary of the Total Priority Project Cost

Project	Total (Million KShs)
1) Strengthening of existing dikes	663.3
2) Network of evacuation roads connecting affected communities	933.0
2-1) National Road A1	660.0
2-2) Local Roads	273.0
- Ahero-Ombei Route	92.7
- Ahero-Apondo Route	90.9
- Kombura-Bwanda Route	89.4
3) Capacity development for community-driven flood management	634.8
4) Establishment of the hydrological monitoring network	11.9
TOTAL	**2,243.2**

Source: JICA Study Team

6.6.4 Operation and Maintenance Cost

Operation and maintenance activities are assumed at 0.5 % of the construction or instillation cost. The annual cost required for operation and maintenance is summarised in Table 6.6.8.

Table 6.6.8 Operation and Maintenance Cost

Project	O&M (Million KShs/yr)
1) Strengthening of existing Dikes	2.4
2) Network of evacuation roads connecting the affected communities	3.4
2-1) National Road A1	2.4
2-2) Local Road	1.0
- Ahero-Ombei Route	0.4
- Ahero-Apondo Route	0.3
- Kombura-Bwanda Route	0.3
3) Capacity development for community-driven flood management	1.5
4) Establishment of the hydrological monitoring network	0.1
TOTAL	**7.4**

Source: JICA Study Team

6.7 PRELIMINARY PROJECT EVALUATION OF PRIORITY SCHEMES

6.7.1 Basic Assumption

Four priority schemes comprise of both structure and non-structure measures. The project benefits of non-structure measures are not tangible and can not be quantified. In contrast, the project benefits can be quantified for the projects associated with construction works such as strengthening existing dike and network of evacuation roads. Thus, the following methods are applied for the respective priority schemes for the project evaluation.

Table 6.7.1 Methodology of Project Evaluation

Priority Schemes	Methodology
1. Strengthening Existing Dikes	Economic evaluation applying flood damage
2. Network of Evacuation Roads	Economic evaluation applying flood damage
3. Capacity Development of Community-Driven Flood Management	Descriptive and qualitative evaluation
4. Establishment of Hydrological Monitoring Network	Descriptive and qualitative evaluation

Economic evaluation is made based on the following assumptions:

1) Economic useful life of the projects is 50 years from the start of the project,

2) Construction period is limited to maximum five years including detailed design works and pre-construction works and assuming the construction will complete by year 2012,

3) All prices are expressed in October 2006,

4) Exchange rate is set at 1US$= 72.00 Ksh= 118.00 Yen,

5) Standard conversion factor of 0.82 is applied to the price of non-traded goods and services, and,

6) Project benefits are assessed based on the benefits calculated in Chapter 5.

6.7.2 Economic Evaluation for the Strengthening of Existing Dikes

(1) Project Benefits

Benefits under economic evaluation will be accrued from the flood damages during flood. The benefit is estimated as difference of annual flood damage value between “with project” and “without project” conditions. In Chapter 5, sub-section 5.6.4, both direct and indirect damages are taken into consideration as the project benefits for flood prone areas of 567 km^2, while this priority scheme is to strengthen existing dikes along the Nyando river downstream from Ahero bridge. Therefore, the project benefits are limited to the direct damage of agricultural harvesting, repairing costs of houses, and relief operation costs. Thus, the benefits accounted for this priority scheme can be assessed and allocated taking cost ratio at 0.32 (Ksh. 663 million divided by Ksh. 2,074 million) for 10 years return period as presented in Table 6.7.2.

Table 6.7.2 Damages Assessed for Priority Scheme of Strengthening Existing Dikes

(Unit: Million Ksh.)

Items	Damages assessed for Master Plan	Damages assessed for Priority Scheme
(a) Direct Damage		
Agricultural harvesting	674.3	215.8
Repairing cost of houses	737.8	236.1
Repairing cost of roads	72.9	Not Applicable
Relief operation cost	37.0	11.8
(b) Indirect Damage		
Traffic damages	56.8	Not Applicable
Total Damage	1,578.8	463.7

Source: JICA Study Team

(2) Annual Benefit

Based on the above assessed damages (benefits), annual average damages for the priority scheme are estimated at Ksh. 108 million as given in Table 6.7.3.

Table 6.7.3 Annual Benefit for Priority Scheme of Strengthening Existing Dikes

Return Period (year)	Peak Discharge (cm/s)	Damage (Mil. KSh)	Exceedance Probability	Annual Average Damage			
				Average Damage	Exceedance Probability	Average (Mil. KSh)	Accumulated (Mil. KSh)
2	200	0	0.50				
				215.0	0.30	64.5	64
5	600	430	0.20				
				446.8	0.10	44.7	**108**
10	730	464	0.10				

Source: JICA Study Team

(3) Economic Project Costs

Economic project costs for the priority scheme are estimated applying the standard conversion factor at 0.82 for non-traded goods and services as shown in Table 6.7.4.

Table 6.7.4 Economic Cost for Priority Scheme of Strengthening Existing Dikes

(Unit: Ksh.)

	Work Items	Strengthening Existing Dike	
		Financial Cost	Economic Cost
1	Civil works	478,526,000	417,716,000
1.1	Preparatory works	36,810,000	30,184,000
1.2	Channel works	368,097,000	322,943,000
1.3	Miscellaneous	73,619,000	64,589,000
2	Land cost	2,575,000	0
3	Administration	23,926,000	20,886,000
4	Engineering service	71,779,000	62,657,000
5	Sub total	576,806,000	501,259,000
6	Physical contingency	86,521,000	75,189,000
7	Grand Total (Ksh.)	663,327,000	576,448,000

Source: JICA Study Team

(4) Net Present Value (NPV) for the Priority Scheme of Strengthening Existing Dikes

The above estimated cost and benefit are allocated for 50 years time span for calculation of the key indicators under the following conditions.

1) Project cost is evenly allocated for five years construction period,

2) Annual O&M cost is assumed at 0.4% of the civil works or Ksh. 1.7 million,

3) Project benefit starts after the construction, gradually increasing from the first year and achieving full benefit in fifth year after the construction. The full benefit is assumed to continue until 50th year.

Based on the above conditions, the key economic indicators are estimated as shown in Table 6.7.5.

Table 6.7.5 Results of Economic Evaluation for the Priority Scheme of Strengthening Existing Dikes

Items	Values
NPV (Million Ksh.)	152.3
EIRR (%)	12.6
B/C	1.3
Switching condition turning to negative NPV	35% increase of the project cost

The results indicate that the project holds economic viability for implementation. Sensitivity analysis indicates that the NPV will become negative or EIRR will be equal to the discount rate of 10%, when the overall project costs increase by 35%.

6.7.3 Economic Evaluation for the Network of Evacuation Roads Connecting the Affected Communities

(1) Project Benefits

Similarly to the priority scheme of the strengthening existing dikes mentioned above, the benefit is estimated as difference of annual flood damage value between "with project" and "without project" conditions. In Chapter 5, the following direct and indirect damages are considered as the project benefits associated with the damages on road and traffic.

1) Road repair cost: Ksh. 7.8 million per km,

2) Additional detour cost: Additional detour cost between Kisumu and Londiani is considered due to road closure of A1 road at Ahero Bridge is presumed,

3) Economic stagnation: Road closure at A1 road of Ahero-Katitu section is presumed as economic stagnation in the Nyanza Province.

For this priority scheme, the above benefits are fully applicable since the project is designed to reduce the above costs by road raising and bridge improvement at all major rivers in the flood area.

In addition, the project is considered to reduce relief and evacuation costs as well. This is estimated at Ksh. 16.6 million to applying the cost ratio of 0.45 (Ksh.933 million divided by Ksh. 2,074 million) to Ksh. 37 million, which is used in Chapter 5. Thus, the project benefits associated with the damages on road and traffic can be estimated Ksh. 170 million for 25 years return period as presented in Table 6.7.6

Table 6.7.6 Damages Assessed for Priority Scheme of Network of Evacuation Roads

Return period (year)	Peak Discharge (cm/s)	Inundation Volume (MCM)	Road Repair		Detour		Economic Stagnation (Mil. Ksh.)	Relief Operation (Mil. Ksh.)	Total Damage (Mil. Ksh.)
			Length (km)	Cost (Mil. Ksh.)	Road closure (days)	Cost (Mil. Ksh.)			
2	200	287	0	0	0	0	0	0	0.0
5	600	382	8.7	67.5	18	14.3	28.5	16.6	127.0
10	730	413	9.4	73.0	24	19.0	37.8	16.6	146.4
20	850	441	10.0	78.0	30	23.3	46.4	16.6	164.3
25	**890**	**451**	**10.2**	**79.7**	**32**	**24.7**	**49.2**	**16.6**	**170.3**

Source: JICA Study Team

(2) Annual Benefit

Based on the above assessed damages (benefits), annual average damages for the priority scheme are estimated at Ksh. 40 million as given in Table 6.7.7.

Table 6.7.7 Annual Benefit for Priority Scheme of Network of Evacuation Roads

Return Period (year)	Peak Discharge (cm/s)	Damage (Mil. KSh)	Exceedance Probability	Annual Average Damage			
				Average Damage	Exceedance Probability	Average (Mil. KSh)	Accumulated (Mil. KSh)
2	200	0	0.50				
				63.5	0.30	19.1	19
5	600	127	0.20				
				136.7	0.10	13.7	32
10	730	146	0.10				
				155.4	0.05	7.8	39
20	850	164	0.05				
				167.3	0.01	1.7	**40**
25	890	170	0.04				

Source: JICA Study Team

(3) Economic Project Costs

The project benefits are accounted for only A1 road since traffic data has been available for only A1 road, while the project component includes improvement of A1 and D class roads. Therefore, the only costs associated with A1 road are included and estimated as the economic project costs for this analysis. Thus, economic project costs for the priority scheme are estimated at Ksh. 638 million, applying the standard conversion factor at 0.82 for non-traded goods and services as shown in Table 6.7.8.

Table 6.7.8 Economic Cost for Priority Scheme of Network of Evacuation Roads

(Unit: Ksh.)

	Work Items	Network of Evacuation Road (A1 Road only)	
		Financial Cost	Economic Cost
1	Civil works	478,115,000	462,557,000
1.1	Preparatory works	36,778,000	35,581,000
1.2	Channel works	5,426,000	4,742,000
1.3	Road works	112,188,000	106,139,000
1.4	Bridge works	250,167,000	244,932,000
1.5	Miscellaneous	73,556,000	71,163,000
2	Land cost	176,000	0
3	Administration	23,906,000	23,128,000
4	Engineering service	71,717,000	69,384,000
5	Sub total	573,914,000	555,069,000
6	Physical contingency	86,087,000	83,260,000
7	Grand Total (Ksh.)	660,001,000	638,329,000

Source: JICA Study Team

(4) Net Present Value (NPV) for the Priority Scheme of Network of Evacuation Roads

The above estimated cost and benefit are allocated for 50 years time span for calculation of the key indicators under the following conditions.

1) Project cost is evenly allocated for four years construction period,

2) Annual O&M cost is assumed at 0.4% of the civil works or Ksh. 1.85 million,

3) Project benefit starts after the construction, gradually increasing from the first year and achieving full benefit in fifth year after the construction. The full benefit is assumed to continue until 50th year.

Based on the above conditions, the key economic indicators are estimated as shown in Table 6.7.9.

Table 6.7.9 Results of Economic Evaluation for the Priority Scheme of Network of Evacuation Roads

Items	Values
NPV (Million Ksh.)	-276.9
EIRR (%)	4.6
B/C	0.5
Switching condition turning to positive NPV	54% reduction of the project cost or 115% increase in the benefit

The results show the negative NPV and the smaller value of EIRR than the discount rate of 10%. Sensitivity analysis indicates that the NPV will turn to positive, when the overall project costs is reduced by 54% or the project benefits increase by 115%. The evaluation result does not indicate economic viability of the project. The accounted benefits, particularly the cost of economic stagnation does not include the supply stoppage of goods and services that would have been available with project condition, but transportation costs of the traffic volume between Kisumu and Katitu. It is considered that the supply stoppage of goods and services have much more values than the transportation costs, because these goods and services include passengers of matatu or buses, goods or products carried by trucks / lorries, of which values are not quantified. Therefore, the accounted benefits are still underestimated and the project is considered to be worth implementing to secure a smooth transportation function throughout the national roads.

6.7.4 Qualitative Evaluation for the Priority Schemes

(1) Capacity Development of Community-Driven Flood Management

Unlike the above priority schemes, the benefit of capacity development is not tangible. However, this bottom-up approach will be another important aspect as voluntary self-help in the integrated flood management, since the community will be the driving force of flood management at micro level. Community capacity development in flood management will raise awareness of flood disaster and enable to protect human and properties against flood.

Furthermore, the Pilot Projects have proved that the community based structural measures within this scheme will have little negative environmental impacts.

(2) Establishment of Hydrological Monitoring Network

In short and long terms, this priority scheme will provide a fundamental system for catchment management. The established network will have intangible positive impacts in the basin wide to:

a) Strengthen WRMA's capacity of catchment management including data collection, management and analysis.

b) Enhance evacuation drill activities by the communities and enable them to evacuate effectively through dissemination of early warning information.

Thus, the realisation of this priority scheme is a minimum prerequisite to enable to provide information on flood forecast and early warning, while it will strengthen capacity of WRMA.

(3) Integrated Approach for the Priority Schemes

The four proposed priority schemes are in fact mutually related and interacted in achieving the maximum project impacts as illustrated in Figure 6.7.1.

The strengthening of existing dikes will provide physical protection against floods, minimising the flood damages to the settlement areas and farms. Network of evacuation roads will provide a promising road network linking major townships as well as securing evacuation route for the residents in the flood plain. Hydrological monitoring network will enable flood forecasting and early warning so that the communities will be able to evacuate upon the warning. Capacity development of community-driven flood management should not stand alone and would not be fully effective until these series of official helps have been realised.

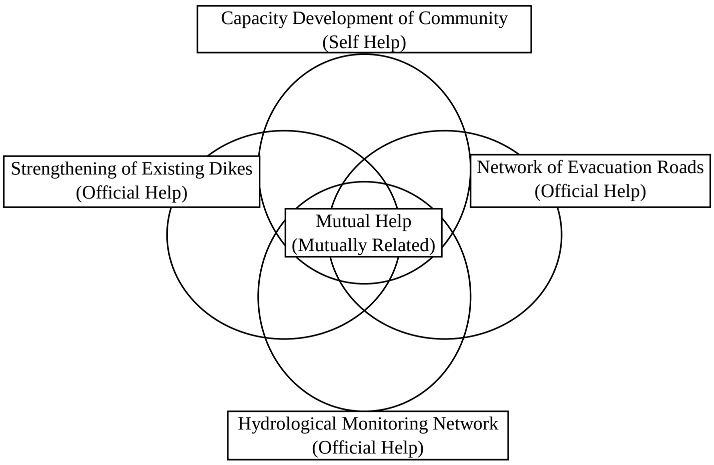


Figure 6.7.1 Schematic Diagramme of Relationship of the Priority Schemes

Therefore, it is recommended that the four priority schemes should jointly be implemented for their synergy effects for flood damage mitigation.

6.8 ENVIRONMENTAL CONSIDERATIONS

6.8.1 General

Using a scoping matrix, ratings of environmental impact expected to result from the priority scheme were examined from both social and natural environment viewpoints. In addition, countermeasures were also examined where any negative impacts were expected. The results of the analysis are shown in Attachment I and are summarised in the following sections.

6.8.2 Strengthening of Existing Dikes

The proposed components for the scheme are summarised in Table 6.8.1

Table 6.8.1 Dike Improvement Components

Dike	Dike Improvement	Others
Right bank	New construction: 4.5 km Improvement: 3.7 km	One (1) for riverbank protection Eight (8) ramps
Left bank	New construction: 4.0 km Improvement: 4.2 km	Eight (8) ramps

Source: JICA Study Team

In the detailed design stage, some involuntary resettlement will be required. According to the results of the survey undertaken by the JICA Study Team, 25 houses will require involuntarily resettlement due to the scheme for strengthening existing dikes. Out of these 25 households, 10 houses are located along the alignment of the bank and 15 houses are located between the river and planned bank. The scale of involuntary resettlement caused by project implementation is limited. A preliminary land acquisition and resettlement plan should be prepared before the implementation of a land acquisition and resettlement plan. The land acquisition and resettlement plan should: (i) describe a land acquisition and resettlement system for the dike strengthening scheme in accordance with applicable law in Kenya; (ii) provide appropriate information to local administrators; and (iii) assist the Government of Kenya and local administrators with timely implementation of land acquisition and resettlement activities. It is noted that restoration of the livelihoods and living standards of the relocated households should be considered and proposed in the plan, based on socioeconomic studies on the resettlement.

In the construction stage, various negative impacts including air pollution, water pollution, noise and vibration, and production offensive substances may be caused by the construction work. Therefore, appropriate construction methods should be selected in order to minimise the potential negative impacts. Access to the river for drawing water and fishing will be blocked in some communities during dike construction. Therefore, temporary access should be provided during this time. The crossing points to the river should also be planed carefully when preparing the construction plan. In addition, information about the construction work, river access limitations, and temporary access points should be provided to the local people before the construction starts.

In the operation stage, negative impacts on cultivated areas along the dikes can be expected because sediment flow, which previously would have recharged the soil with nutrients through flooding, will no longer occur. Floods have damaged crops almost every year, so crop damage will be reduced. However, decreased crop yield due to loss of soil nutrients will need to be improved by use of organic material and chemical fertiliser in the cultivation area. Therefore, agricultural extension services should be utilised in order to plan for and manage the anticipated negative impact on soil fertility.

6.7.3 Network of Evacuation Roads Connecting the Affected Communities

The proposed components for the scheme are summarised in Table 6.8.2.

Table 6.8.2 Road Improvement Components

Road	Class	Raising Road Levels	Bridge Improvement (River Crossings)
National Road A1	A	Ayweyo-Awach, L=3km	Eight (8) Bridges
Local Road	D	Ahero-Ombeyi (D293), L=5km Ahero-Apondo (D293), L=5km Kobura-Bwanda (D290), L=5km	

Source: JICA Study Team

In the detailed design stage, explanations and information about the road improvement project should be given to local people. In the construction stage, various negative impacts, including air pollution, water pollution, noise and vibration, and offensive subsidence may be caused by the construction works. Appropriate construction methods should be selected in order to minimise these potential impacts. National Road A1 and its associated bridges is the main Nakuru-Kericho-Kisumu route. Therefore, the existing traffic flow will be disturbed during the construction stage. A traffic survey undertaken in May 2007 indicated that the traffic volume on National Road A1 for a week-day was about 5,900 vehicles at Nyamasaria. A proper construction plan with traffic controls and temporary routes will be formulated in order to minimise the disturbance of traffic flow. In addition, information about the construction work, traffic controls, and temporary routes should be provided to the local people before the construction starts. In the operation stage, no negative impacts are expected because the scheme focuses on improvement of the existing road and bridges.

6.7.4 Capacity Development for Community-Driven Flood Management

The proposed components consist of structural measures and training programmes for 100 communities. The structural measures will be formulated on a community basis by considering the needs of each community. These needs will be determined by undertaking a community survey. In general, the scheme is not expected to cause serious negative impacts because the scale of the structure will be limited to the specific target communities. Negative impacts might occur, such as involuntary land re-arrangement and conflicts between community members arising from the structural measures. Therefore, land re-arrangement should only be undertaken with the full acceptance of owners. Consensus-building among community members should be carefully looked into before the scheme is implemented.

In the construction stage, some negative impacts may be caused by the construction work. However, any impacts will be limited to within certain areas and specific periods of effect. Information about potential negative impacts should be provided to the community. The community should discuss these issues and decide whether the scheme should be implemented. In the operation stage, some negative impact may also occur. The community organisation should solve any such issues through discussions with community members.

6.7.5 Establishment of the Hydrological Monitoring Network

The proposed components comprise only the installation of automatic rainfall gauges and water level gauges. No negative impacts are expected in the pre-installation, installation, or operation stages.