CHAPTER 5 FORMULATION OF THE MASTER PLAN

5.1 REVIEW OF PAST STUDIES

5.1.1 Kenya Nile Water Resource Study (Alexander Gibbs & Partners, 1954 & 1962)

This Study led to the establishment of two river irrigation schemes, namely, Ahero Pilot Scheme (840 ha) and West Kano Pilot Scheme (870 ha). The Ahero draws its irrigation water from the Nyando River while the West Kano is fed from Lake Victoria.

5.1.2 Pre-investment Study for Water Management and Development of the Nyando and Nzoia River Basins (ItalConsult, 1983)

The Ministry of Water Development (MWD) formulated the Pre-investment Study for Water Management and Development (1983) in the lower reaches of the Nyando River. The major purposes of this study are to decrease harvest losses, increase yields, and shift the farming patterns toward a more profitable combination of crop and livestock activities. Flood control and drainage systems are necessary for accomplishing those purposes. The measures envisaged to form part of the Master Plan in Kano Plain are given in Table 5.1.1.

Table 5.1.1 Main Features of Master Plan (1983)

Project Component	Descriptions
1. Irrigation System	Development of an irrigation scheme of 57,000 ha. Irrigation water is ensured by the inter-basin water transfer from Sondu-Miriu and Yala rivers.
2. Irrigation System	Expansion of Ahero irrigation scheme from 840 ha to 3,000 ha drawing water from the Nyando River.
3. Embankment	Construction of embankment dike system parallel to the river channels of Kibos, Nyando and Awach-Kano rivers and low-lying areas.
4. Main drainage canal	Drainage system to collect discharges from tributaries.
5. Other infrastructure	Dams, roads, power transmission lines, domestic water supplies, agriculture and livestock facilities.

Source: Pre-investment Study for Water Management and Development of the Nyando and Nzoia River Basins (1983)

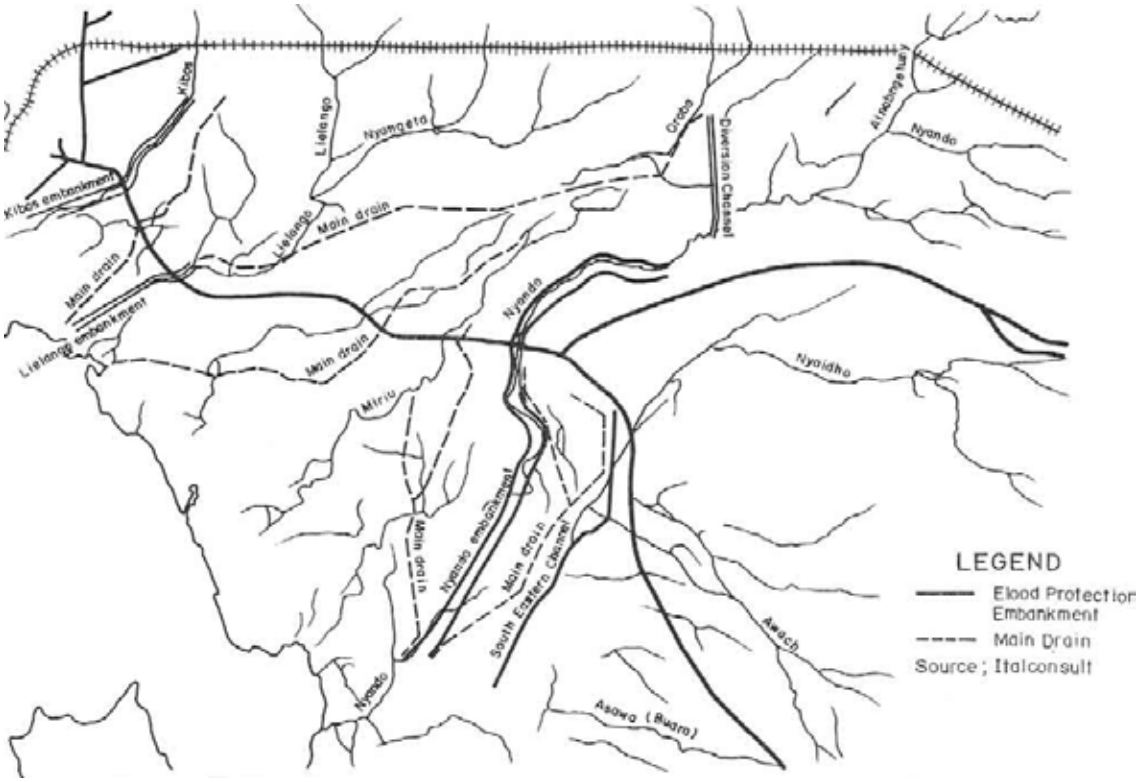
Also, various options for flood control and drainage systems were studied to address issues concerning floods, drainage and irrigation in the Kano Plain and a phased development plan was formulated. The proposed plan for a design flood scale with a probability of once in 50 years is organised into short and long term intervention measures including the development of 20 potential dam sites. The flood control components proposed in the short term plan are given in Table 5.1.2 and Figure 5.1.1.

Aside from the above short term plan, the long term plan includes 1) construction of additional dikes concerning irrigation in the lower Nyando, Lielango and Kibos rivers and along the lakeshore, and construction of dams for multipurpose use.

Table 5.1.2 Proposed Plans in the Pre-Investment Study (1983)

Item	River		
	Nyando	Kibos (Nyamasaria)	Lielango (Luando)
Length of improvement (km)	21	7.5	5.7
Design flood scale (return period-years)	50	50	50
Design discharge (cu.m/s)	750	300	230
Construction of dikes (km)	21	7.5	5.7
Construction of diversion channels (km)	4.7	-	-
Construction of canals (site)	6		
Reconstruction of bridges (nos)	9		
Construction of farm roads (LS)	1		
Construction cost (Ksh. in 1983 price level)	1,114,000,000		

Source: Pre-investment Study for Water Management and Development of the Nyando and Nzoia River Basins (1983)



Source: 1987 Study of Integrated Regional Development Master Plan for Lake Victoria Development Area (JICA),
Note: not in scale

Figure 5.1.1 Dike Alignment in the Pre-Investment Study (1983)

5.1.3 Nyando Flood Protection Project (MoWD and LBDA, 1988)

The Ministry of Water Development (MoWD) and the Lake Basin Development Authority (LBDA) reviewed the Pre-investment Study (1983) and prepared a project proposal for future flood control schemes. The proposal analysed the nature of the flooding problems in the Nyando river basin, and apportioned administrative and financial responsibilities to the various government agencies. A phased development plan was proposed in the proposal:

Phase I : Nyando Flood Protection Project (Short-Term)

Measures in the proposal are organised into soil conservation for the upper catchment, flood protection dykes with drainage facilities and an early warning system. The phased development of the flood protection dykes was proposed with a protection level of once in 25 years probability in the short-term plan since the land use of the protected area is mainly for agricultural lands with settlements.

Phase II : River training and Drainage (Medium and Long-Term)

Phase II is to accelerate the outflow of flood water to Lake Victoria. This includes the opening of the mouth of the Nyando River and the construction of a number of drainage channels.

Phase III : Dams and Associated Development

Among 24 potential dam sites identified in the studies in the past, the following 3 dams in Table 5.1.3 were selected for further study.

Table 5.1.3 Prospective Dam Sites and Dimensions by Project Proposal (1988)

Dam Site No.	River	Sub-Basin Code	Catch-ment Area (sq. km)	Purpose	Live Storage (MCM)	Dam Crest Length (m)	Dam Height (m)	Construction Cost (Ksh in 1983 price level)
05	Ainapngetuny	1GB5	404	Flood control/ Irrigation	120	1,450	90	1,845,000,000
11	Nyando	1GC6	867	Flood control/ Irrigation	81.5	620	70	645,000,000
51	Kibos	1HA	119	Irrigation	82	540	100	721,000,000

Source: Pre-Investment Study for Water Management and Development of The Nyando and Nzoia River Basins, Italconsult, 1983.

5.1.4 National Water Master Plan (1992)

In 1992, the Ministry of Water Development (MoWD) formulated a comprehensive water resources development plan for the Kano Plains under technical cooperation with JICA. The lower reaches of Nyando, Kibos, Luando, Nyaidho and Awach Kano rivers were part of the target river basin for flood control. A development plan with three phases was proposed. For the first phase, urgent works were proposed with a design flood scale of once in 25-yr flood. Table 5.1.4 shows the project features of the first phase:

Table 5.1.4 Proposed Plans by National Water Master Plan (1992)

Item	River				
	Nyando	Kibos	Luando	Nyaidho	Awach
Length of improvement (km)	20	10	24	12	5
Design flood scale (return period-years)	25	25	25	25	25
Design discharge (cu.m/s)	590	55	65	55	60
River Improvement Works					
Construction of dikes (km)	18	10	24	12	5
Rehabilitation of existing dikes (km)	2				
Reconstruction of bridges (nos.)	1 (Ahero br.)	2	4	1	1
Construction cost (million Ksh. in 1992 price level)	297	42.,2	112.1	46.5	21.1

Source: National Water Master Plan (JICA, 1992)

For the second and third phases, the dikes constructed in the first phase are to be raised to protect against a 50-yr design flood in the above five rivers. Besides the above plans, the development of two multipurpose dams was proposed in the Nyando and Kibos river basin for the purpose of domestic water supply.

5.1.5 Study on Flood Control in the Lower Reaches of the Nyando River (2004)

MWRMD again carried out a review of the Nyando Pre-investment Study (1983) in 2004 for the purpose of further implementation of flood mitigation works for Nyando river basin. In 2004, about 8 km of dykes were constructed along Nyando River. Considering the above current accomplishments, a further phased development programme is recommended.

In addition to the dyke system, the inventory of proposed dam sites were reviewed and four dams, No. 03 in Ainamutua river, and 08, 11 and 13 in the Nyando River were proposed for flood control and irrigation purposes.

5.1.6 Strategy for Flood Management for Lake Victoria Basin, Kenya (WMO, 2004)

This document outlines a proposed flood management strategy recommended for the Lake Victoria Basin in Kenya. It is expected to serve as a base document for developing the National Strategy and Policy for Flood Management in Kenya.

It is emphasised that a strategy for flood management not only directly deals with the flood hazard but also has strong links with national social, economic and other development policies. Furthermore, disaster prevention and mitigation due to floods is therefore a multidisciplinary endeavour taking into account the vulnerability of society to floods and removal of socio-economic and environmental factors to increase flood damage. As well as policies of flood management, an action plan with phased implementation is proposed.

5.2 KEY ISSUES TO BE ADDRESSED IN FLOOD MANAGEMENT

5.2.1 Frequent Flooding

Almost every year, serious flooding occurs and a number of casualties are reported in this area. In 2003, 119 casualties were reported in the Nzoia River basin near the Nyando River and 5 casualties in the Nyando basin in addition to the 2,400 people working and living in the 2,000 ha of irrigated land that were heavily affected. The flood of 2004 caused almost the same human and physical damage. The recent flood damages are enumerated in Table 5.2.1

Table 5.2.1 Recent Flood Damage in Nyando District

Year	Number of people			Camps	Persons per camp	Infrastructures affected		Educational institutions affected		Agricultural land submerged (ha)
	Casual-ty	Dis-placed	Affected			Washed away	Roads (km)	Prim-ary	Second-ary	
2002	-	10,000	28,650	-	-	-	Several	27	3	3,090
2003	6	5,000	15,000	8	1,200	5	Several	40	5	3,000
2004	6	400	10,000	19	101	1	Several			4,000

Source: MWRMD, 2004a and Ocharo et al. (cited to JICA "Baseline Survey", 2005)

Though MWI implements projects in line with the concept of "the Pre-investment Study (1983)", it has achieved only slight progress. In the most recent 20 years, development of small irrigation schemes (10 schemes in the Kano Plain of 3,000 ha in total) and 4 km of dyke construction in the lower catchment of the Nyando river have been completed. It is planned to extend the dykes from Ahero Bridge for 20 km downstream and 5 km upstream.

However, the existing dykes do not function properly. Submergence of settlements and roads, and isolation by the blockage of the National Route because of submergence, are problems almost every year in this area. Submergence of cultivated land causes a decrease in agricultural productivity too. The effects of floods are summarised in Table 5.2.2.

5.2.2 Soil Erosion

Measures to reduce environmental deterioration and improve agricultural productivity are carried out continuously in the upper catchment, while in the middle reaches the volume of sediment has increased with the development of large-scale sugarcane plantations and lateral erosion of river banks since the 1980s.

On the other hand, another problem of this area is that the water drained from the food processing factories using sugarcane worsens the water quality of the Nyando River. This may spread disease during flood in the lower reaches. Also, sediments accumulated in the river channel reduce flow capacity and cause inundation in the lower reaches.

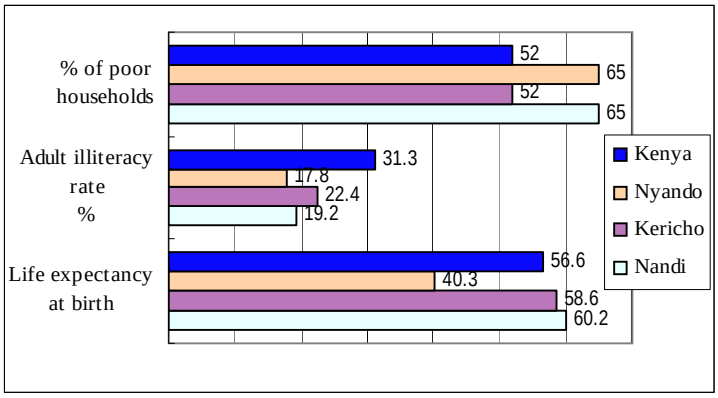
Table 5.2.2 Effects of Floods in Nyando River Basin

	Damaged Item	Effects of Floods
1.	Property	During the floods, many houses suffer damage as the mud walls are washed away. Repair of the houses then becomes an annual procedure after the flood. The 1999 population census indicates that 75% of the households in Nyando District have houses whose floors are earth and 72% have mud walls. Only 12.2% of households have permanent houses with stone, brick or block walls.
2.	Temporary out-migration	Due to the disruption caused by flooding, and the resulting unsanitary environment, some families find it necessary to migrate out of the flood prone areas. They are forced to move out in search of pasture for their livestock and a safe place for their families. The out-migration adds to the disruption of life.
3.	Health and sanitation	Health and sanitary conditions are notoriously bad during floods. The incidents of water related disease increase during floods. There is water everywhere but no clean water to use. Water contamination occurs in several ways. Rivers and wells are not even options for domestic water sources because they are submerged. The 1999 Population census shows only 36% of the population has access to the viable sources, which are roof catchments, boreholes and piped water.
4.	Social functions	When floods occur, household routines and social functions are interrupted. During the floods there may be food but most of the community will not be able to cook their food because their fireplace is on the floor and is submerged during the floods.
5.	Schools	Many children cannot attend school because their family life is disrupted and some have to migrate out of the area. It is a common practice in the area that when there are floods, schools close until the floods subside. These students must make up for lost time.
6.	Agriculture	Apart from rice, all other crops in the basin rely on rainfall for their cultivation. The rainfall is in seasons and therefore the cultivation of crops follows the same pattern. The occurrence of floods interferes with this pattern. Fields under water cannot be ploughed. The farmer must wait until the water subsides. Since the rains do not wait for the farmers' activities, the farmer often finds that rains are over before their crops are mature. This does not improve the food supply or the food security situation in the region, bearing in mind that the region is a net importer of foods. Furthermore, different crops have different tolerance levels to flood conditions. The main crops grown in the Kano Plain are sugarcane, cotton, rice, maize and sorghum. Rice and sugarcane tolerate flood conditions well but they are not staple foods but cash crops while crops like beans have no tolerance for flood conditions and therefore they are not grown.
7.	Livestock	When the pastures are under floods the livestock do not have an alternative source of food. Animals also do not favour standing in water for long periods of time. It is noted that people in this area do not have large herds of livestock and this can be partially attributed to the difficulties they encounter in handling the animals during the floods. Poultry also suffer displacement during the floods.

Source : Proceedings of a Workshop on Reversing Environmental and Agricultural Decline in the Nyando River Basin (WAC, NEMA,LVEMP, MARD, 2002)

5.2.3 Poverty as potential risk

In the Nyando River Basin, the percentage of households in absolute poverty in the Nandi South and Nyando Districts is higher than the Kenyan average by 13%. This fact indicates that the northern part of the basin is the poorest in Kenya. By comparison, in Kericho District in the southern part of the basin, the rate of poor households is the same as the Kenyan national average of 52%. Also, the adult illiteracy rate in all these districts is around 20%, which is lower than the Kenyan average. Further, the life expectancy at birth in Nyando District is 40.3 years being much lower than the Kenyan average (56.6 years) due to the high HIV/Aids infection rate. Poverty in the area mentioned above is regarded as a serious constraint to sustainable community disaster management.



Source: JICA "Baseline survey" 2005, and UNDP Kenya "HDR Kenya" 2004

Figure 5.2.1 Socio-Economic Condition of Study Area

5.3 NECESSITY OF INTEGRATED FLOOD MANAGEMENT (IFM)

5.3.1 Socio-economic Impacts of Flood

Management of the Nyando river basin involves trade offs between flood risk and water resource development. Beneficial aspects of floods are: (i) recharging water sources in the form of river flow, freshwater supply and recharge of groundwater, (ii) enriching the soil with nutrients and sediment transported by flood water, (iii) providing an abundant supply of fish and alternative income source for fishermen, and (iv) Maintaining biodiversity in river and flood plains with seasonal variability and variable sediment and flow regimes. Conversely, flood risk takes the form of loss of lives and property including livelihoods, the danger to health and safety, financial costs associated with property damage, mass migration or population displacement to safer places against flooding, and degradation of water resources and the environment.

Most of the people in the flood plain of the Nyando River basin are farmers that cultivate their own land for cash crops and have no alternative than to move from their homeland because there are no measures for income generation in other industries. They endure the widening gap between rich and poor, rural and urban incomes and hence the disparity in living standards.

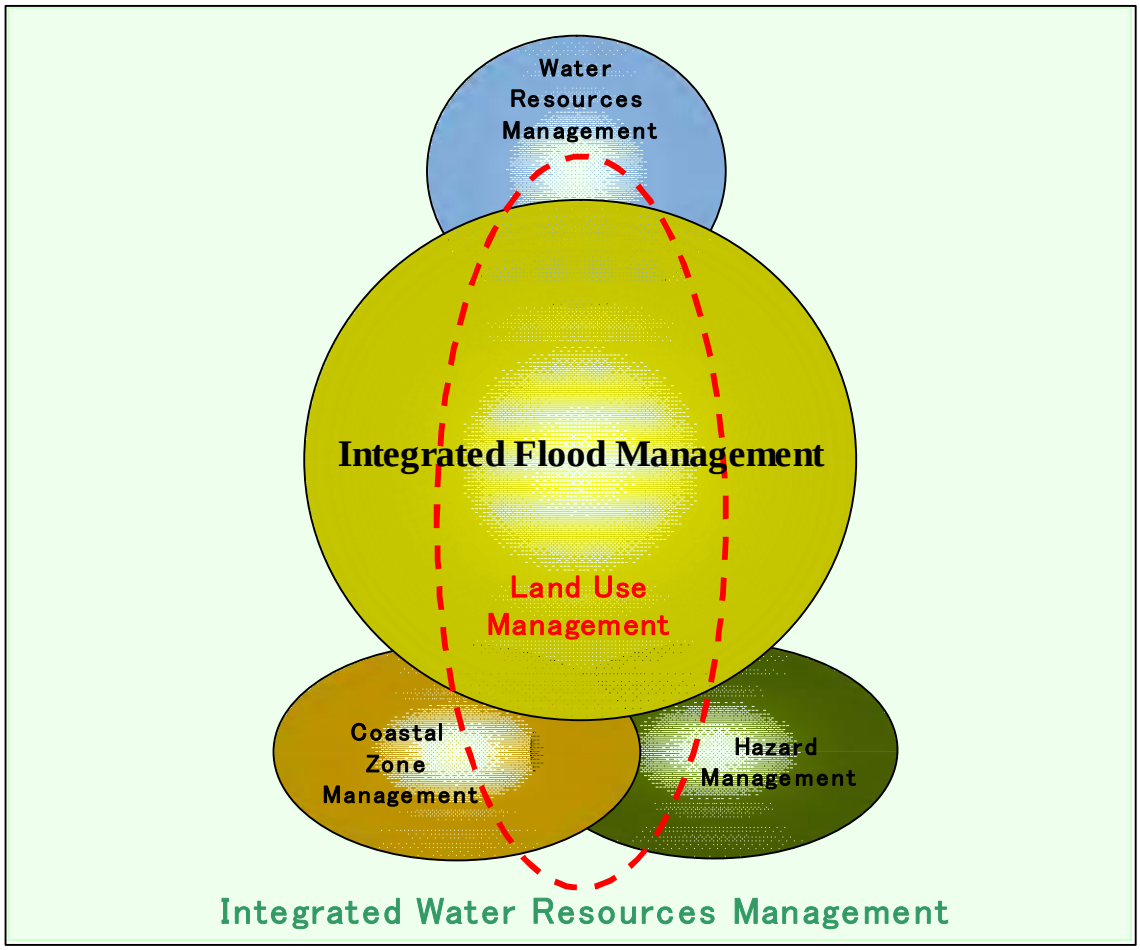
Traditional flood management options have largely focused on reducing flooding and reducing the susceptibility to flood damage through the implementation of engineering interventions, such as large-scale dikes, river improvements and reservoirs. However, these interventions frequently interrupted the socio-economic activities among the communities in the flood plain and hence aggravated the vulnerability of communities.

5.3.2 Objectives and Principles of Integrated Flood Management (IFM)

The objectives of the flood management policy are defined recognising the relative emphasis on the various objectives such as:

- Minimising loss of life
- Maximising benefits to the flood plains: ensuring livelihood security and thereby reducing vulnerability
- Sustainable development: balancing development needs and flood risks
- Environmental preservation

Flood management has focused on defensive practices but it is widely recognised that a paradigm shift is required from defensive action to the proactive management of risks due to flooding. The paradigm shift seeks to integrate land and water resources development in a river basin within the context of Integrated Water Resources Management (IWRM) as shown in Figure 5.3.1, and manage floods based on risk management principles in order to optimise the net benefits to the flood plains while minimising the loss of life from flooding.



Source : Concept Paper, Integrated Flood Management (WMO, 2006)

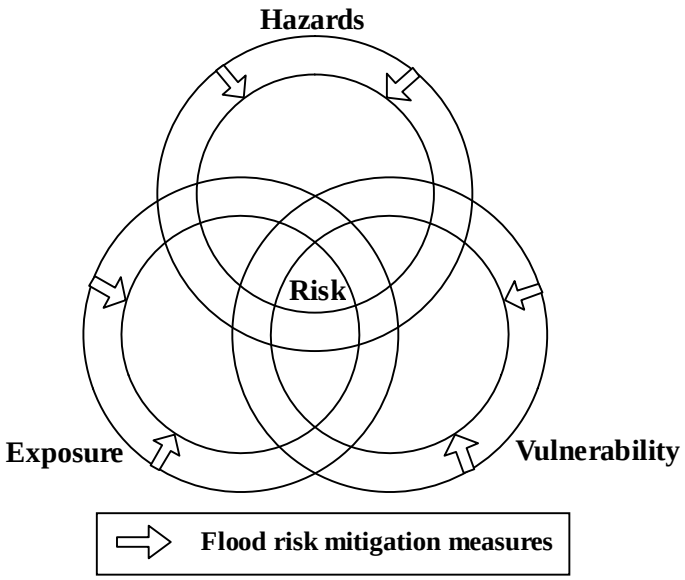
Figure 5.3.1 IFM Model within the Context of IWRM

The defining characteristic of IFM is integration, expressed simultaneously in different forms: an appropriate mix of strategies, points of interventions, types of interventions, either structural or non-structural measures, short or long-term, and a participatory and transparent approach to decision making.

The following are the five essential elements to IFM:

- To manage the water cycle as a whole (effective use of flood water and maximise benefit)
- To integrate land and water management (consistency in planning)
- To adopt a best mix of strategies (combination of structural and non-structural measures)
- To ensure a participatory approach (combination of bottom-up and top-down approaches)
- To adopt integrated hazard management approaches (wider risk management system)

IFM aims at reducing the flood risks through a judicious combination of measures that address the magnitudes of the **hazards**, **exposures** and **vulnerabilities,** defined as follows (Figure 5.3.2):



Source : Social Aspects and Stakeholder Involvement in Integrated Flood Management(WMO, 2006)

Figure 5.3.2 Construct of Flood Risk and its Reduction

Hazard : A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. For example, dams and reservoirs can reduce the severity of flood hazard in their downstream by detaining floodwater during flood peaks.

Exposure : Quantification of the receptors that may be influenced by a flood, for example, number of people and their demographics, number and type of properties. Improvement of dikes and proper evacuation activities would reduce the severity of flood exposure of life and property in a flood plain.

Vulnerability: The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Vulnerability to floods is a combination of complex, dynamic and inter-related mutually reinforcing conditions that can be divided into three major groups; namely, (i) physical or material; (ii) constitutional or organisational; and (iii) motivational or attitudinal. Social factors contribute to or influence these conditions to determine community vulnerability. Some of these are relevant to flood management such as poverty, livelihood opportunities, cultural beliefs, human rights, gender inequalities, and special needs of weaker social groups.

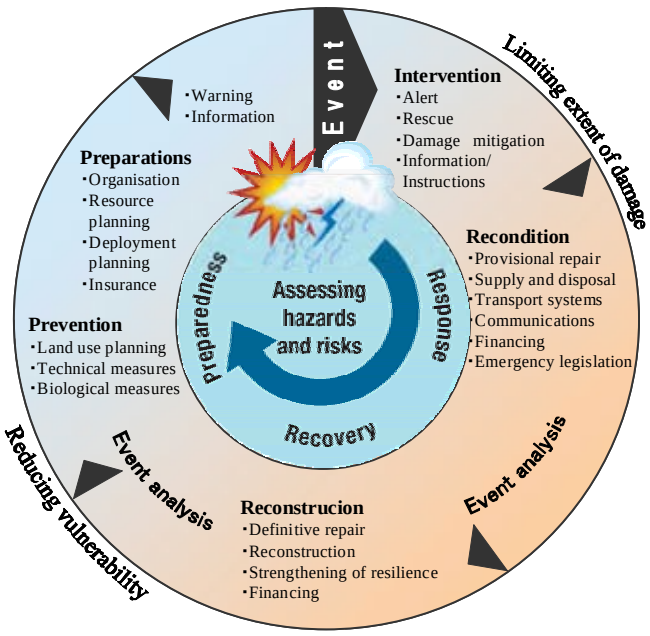
Flood risk reduction measures must be undertaken in conjunction with water resources management and development activities in the basin and regional and national spatial planning. Hence, the entire river basin should be taken as a single entity taking into account the hydrological condition which causes minimum impacts on the environment.

Furthermore, the unwise development of land in flood plains has historically taken place in many areas, probably due to a natural tendency for settlers to utilise land that is near bodies of water. Unfortunately, the potential for flooding is often recognised only after it is too late. These problems will not materialise if development takes place in a manner that does not place it at any risk of flooding. Conversely, failure to comply with the policy may in effect make new developments in flood plains publicly subsidised. Where land is already alienated, it is necessary to determine the risk of flooding and to discourage potential development by planning and zoning regulations and by removing any economic advantages or subsidies that would otherwise encourage such development.

Finally, where development has already taken place or cannot be avoided, policies should be implemented that are intended to minimise potential flood damage by ensuring that flood proofing measures are implemented and that the development does not further exacerbate the flooding problem by impeding flows or by unduly constricting the flow channel.

5.3.3 Risk Management

An integrated risk management approach provides measures for preventing a hazard from turning into a disaster. It consists of systematic actions in a cycle of preparedness, response and recovery as shown in Figure 5.3.3 and should form part of IWRM. These actions are taken, depending on the conditions of risk and social, economic and physical settings, with major focus on reducing vulnerability and improving resilience. These have to be addressed through local actions to overcome the global challenges.



Source : Swiss Civil Protection

Figure 5.3.3 Risk Management Cycle

Preparedness : This consists of preventive and precautionary measures to prepare for an event before it occurs. It aims at minimising the effect of development activities on accentuating the magnitude of hazards, reducing the exposure to natural hazards and minimising the socio-economic vulnerability of people and material assets exposed to these hazards. Prevention deals with long-term planning and is incorporated into the development process. Preparation deals with reducing the vulnerability at the local level and limiting the extent of adverse impacts of the inevitable event in the short-term.

Response : This consists of measures that limit the effects of exposure to a hazard, and its duration. It mainly focuses on alerting people, rescuing victims and providing assistance in cases of need. It also includes immediate measures to prevent further adverse impacts, provisional reconditioning of important infrastructure and documenting events.

Recovery : This aims at enabling the economic and social activities to return to normal with a minimum delay. It also involves the analysis of the disaster in order to learn lessons and integrate corrective measures into prevention and preparedness plans.

The effectiveness of the risk management cycle in reducing risks and damages depends on the political will to apply the risk management principles in development planning, the existence of well-defined institutional responsibilities and a democratic process of consultation and social control with effective governance.

5.3.4 Stakeholder Involvement

In recent years, the need for increased cooperation and collaboration across sectors and public participation has become more widely accepted. The effectiveness of an IFM approach depends largely on mobilising and rallying for greater stakeholder participation from the start.

Greater participation of all stakeholders in flood policy development is considered vital since it enables communities of flood-prone areas to choose the level of risks they are ready to take. The combined participation of government agencies, technical specialists and local residents in carrying out risk assessment is identified as a critical function that promotes public participation at local and national levels. A shared consensus has emerged in the past decade on the importance of participatory planning in disaster management. Individual and community ownership, commitment and concerted actions in disaster mitigation produce a wide range of appropriate, innovative and feasible mitigation solutions, which are cost-effective and

sustainable.

Hence, it is necessary to identify the players who should be involved in the participatory process. However, too many stakeholders can render the process unwieldy and unproductive. For effective integrated flood management and river basin development, it is important to carefully identify all relevant stakeholders.

5.3.5 Community Involvement

Communities in flood prone areas as major stakeholders are at the core of all flood management activities. Communities affected occasionally by controlled flooding aimed at preventing flooding of strategic areas should also form part of flood-prone groups. NGOs can influence the behaviour of stakeholders, particularly basin communities, by building awareness and disseminating information and can help flood-prone communities organise themselves.

Technical NGOs can provide information about the complex and uncertain state of knowledge and processes to the man on the street in readily understandable language and help them voice their concerns. They can also provide important input by presenting unbiased scientific studies. In flood emergency situations a number of voluntary organisations come forward and play a crucial role during emergency response. Similarly, the private sector, which is directly or indirectly affected by flooding, is an important stakeholder.

5.3.6 Strategies for Integrated Flood Management in Nyando River Basin

In line with the objectives and concept on Integrated Flood Management, the following strategies are established in the Nyando river basin.

(1) Moving from the concept of flood protection to flood management

Floods remain the most frequent risk associated with water. Many people currently live in the flood plains of the lower catchment of the Nyando river basin and a number of casualties due to flooding have been reported.

A general tendency in developed countries is to look at floods in an integrated manner acknowledging the fact that complete protection against flood is impossible, but the concept of flood mitigation should be adopted within the framework of integrated flood management. Furthermore, imbalanced reliance on structural measures would have detrimental effects on the river and riverbed ecosystems.

Allowing certain floods in areas that are less vulnerable is an approach that is applicable to Nyando river basin. This approach intensifies the need and added-value for people to negotiate land use measures, and in general to be involved with all other stakeholders in designing and financing flood management strategies based on their knowledge and experience.

network's function as evacuation and relief roads. The rapid deterioration of infrastructure has mainly been due to poor quality workmanship and lack of regular maintenance.

In the absence of a clear and comprehensive disaster management policy and a coherent institutional framework to implement it, the GOK's response to flood disasters has tended to be ad-hoc and uncoordinated. The responses were unsustainable because little attention was paid to the underlying causes of the problems including the provision of temporary shelter to displaced families and the procurement and distribution of relief supplies to the affected people. People are also unaware of the applicability of structural and non-structural measures adopted elsewhere that can help in living with floods.

(2) Factors Increasing Flood Disaster

Increasing flood disasters in Nyando river basin are a complex construct of the increasing vulnerability of the population occupying the flood prone areas, and the increasing number of flooding instances. WMO (2004) depicts three major anthropogenic factors which contribute to increased flood disaster in the Nyando river basin.

1) Population pressure : Intensive economic use of the flood plains for agriculture and livestock farming.

2) Deteriorating infrastructure : Lack of systematic and routine maintenance of dykes causes deterioration of embankments, resulting in breaches of dykes.

3) Environmental degradation : Uncontrolled and unregulated human activity, especially large-scale deforestation and cultivation causes environmental degradation, such as increased flood peak discharge, reduction of flood carrying capacity of the rivers due to siltation, and shifting of river courses.

There is also a growing concern about the impact of climate variability and change on the frequency and intensity of floods although the long-term trend of annual rainfall has not changed much and no increase in flood peak discharge has been identified as of this writing.

(3) Establishment of Nyando River Basin Forum

The Nyando River Basin Forum (the Forum) is composed of stakeholders drawn from various fields that are concerned with water resources management in the Nyando river basin. The membership includes Government institutions, Parastatals, NGOs, Private Organisations, and Community Based Organisations (CBOs), which are locally based in the Nyando river basin or are involved in the water management in the Nyando river basin.

The Forum develops its capacity and function with the new vision for water management in the basin. The scope of the Forum activities will expand to encompass the overall water management in the Nyando River Basin in the future. The objectives of the forum are to i) monitor and deliberate the progress and out-puts of the Study, ii) prepare recommendations for WRMA on issues concerning flood management, iii) establish linkage between communities and WRMA, and iv) propose post-study activities for the Forum including soliciting for funds from potential donors.

(4) Vulnerability of Communities to Floods

Vulnerability of farming communities to floods reflects lack of real improvements in their living conditions and the poor state of infrastructure which hampers the delivery of supplies and essential services. Serious flooding destroys the fundamental infrastructure, particularly the road

5.4 FLOOD MANAGEMENT IN FLOOD PRONE AREAS

5.4.1 Structural Measures

(1) Possible Structural Measures and Functions

Possible structural measures are examined with due consideration of various characteristics of existing river channels, meteo-hydrology, and flood mechanisms in the Nyando and Nyamasaria river basins. The Nyando and Nyamasaria river basins are characterised by steep topography surrounded by mountainous areas, a large amount of intense rainfall, and densely populated areas in the lower basin. The possible structural measures are nominated taking into account the current river conditions and traditional methods developed in Japan.

Menu of Possible Measures

The following enumerates possible structural measures applicable to the lower catchment of Nyando and Nyamasaria river basins, namely, 1) dikes/embankments/levees, 2) de-siltation of river channels, 3) drainage channels, 4) cut-off channels, 5) diversion channels, 6) bank protection work, 7) retarding ponds/regulating ponds, 8) ring dykes, 9) culvert improvement, 10) raising of community roads, 11) flood mitigation dams, 12) slit type weirs to protect against flash floods, 13) raising of evacuation roads, 14) riverine forest zone, and 15)flood proofing,

Impacts Resulting From Implementation of Possible Structural Measures

In implementation of the above possible measures, various social and environmental impacts might arise. To foresee and understand the impacts that could be caused by project implementation is important for environmental preservation and future sustainable development. Such impacts will be more precisely investigated throughout the feasibility study for the project implementation and the detailed design for the construction works in the future stages. Throughout such studies/investigations including the Environmental Impact Assessment (EIA), positive impacts shall be maximised and negative impacts shall be minimised as much as possible by various mitigation measures.

The major positive and negative impacts foreseen and those mitigation measures are described with regard to environmental preservation and future sustainable development as given in Table 5.4.1.

Table 5.4.1 Impacts by Implementation of Possible Measures

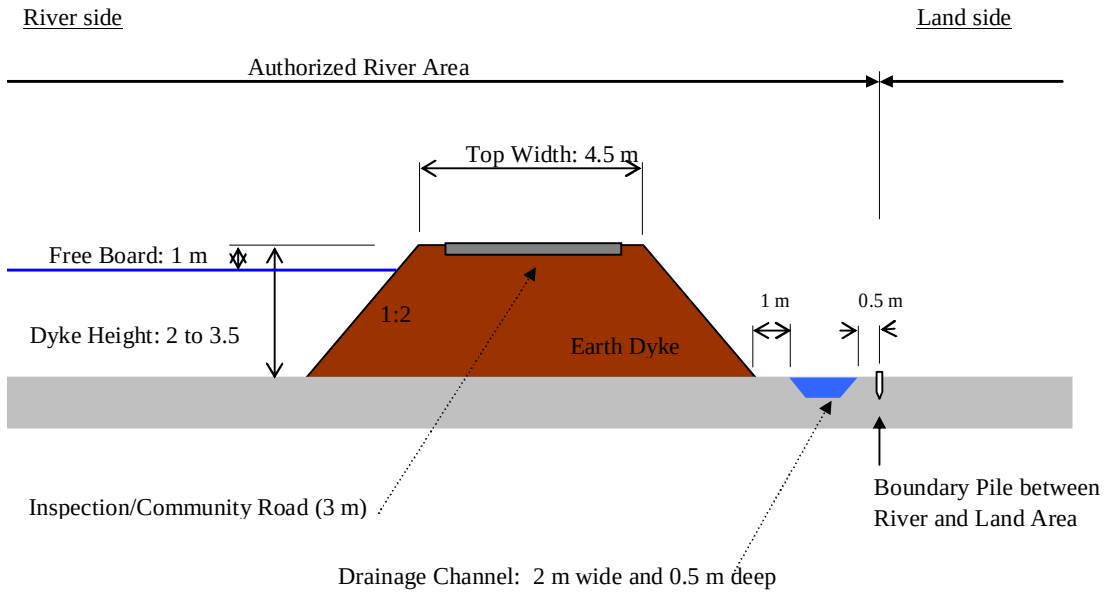
Measure	Positive Impact	Negative Impact	
		Negative Impact	Countermeasure
Construction of river dykes/levees	- Mitigation of inundation (livelihood condition is improved) - Effective land use - Dyke is used as community road and evacuation place in emergency	- Deposition of fertile soil onto farm land is decreased - Drainage of land areas is worsened - Decreased accessibility to river channel - Land acquisition and compensation, if needed	- EIA is needed - Drain along dyke - Ramp is provided - Dyke crest is utilised as community road - Resettlement is needed
Widening and de-siltation of low water channel with dyke	- Mitigation of inundation - Effective land use - Dyke is used as community road and evacuation place in emergency	- Land acquisition, if needed - Disposal of excavated materials	- EIA is needed - Proper disposal of excess materials
Reconstruction of bridge	- Clogged channel is opened - Securing transport system - Social and economic activity is accelerated	- During reconstruction, transport system in the region is disturbed	- EIA is needed - Provision of temporary bridge
Construction of retarding pond/basin	- Storing excess water - Mitigation of inundation - Create new eco-system, if management is appropriate - In dry season, stored water is utilised for irrigation	- Land acquisition is needed - Outbreak of mosquitoes in pond - In dry season, pond dries up	- EIA is needed - Providing substitute land - Exterminate harmful insects - Maintenance flow for maintain eco-system
Construction of drainage channel	- Drainage condition is improved - Mitigation of inundation	- Land acquisition and compensation is needed - Disposal of excavated sand	- EIA is needed - Provide substitute land - Proper disposal of excavated sand
Construction of slit type weir	- Reduction of sediment due to trapping - Flow velocity is reduced - River channel in the lower reach will be stabilised	- Break of continuous eco-system including aquatic animals	- EIA is needed (impact is minimised) - Installation of fish passage
Planting of riverine forest zone (This is not creation of forest zone but planting of trees in a strip of 30 m wide along river channel)	- Riverbank is strengthened against scouring. - Reduction of sediment flow onto land area during flood - Farm land and houses are protected against sediment and high flow velocity. - Environment in riverine area is improved	- Land acquisition for planting zone is needed - Access to channel is not more difficult	- EIA is needed - Construction of ramp
Raising of existing road	- In floods, raised road is utilised as evacuation road or evacuation place - In flooding, acts as secondary dyke and flood water is confined	- During raising works, transportation is disturbed	- Bypass is provided - Construction is executed one side at a time
Construction of dam	- Peak flow is decreased - Mitigation of inundation in the lower reaches - Stored water is effectively utilised for various purposes in dry season	- Environmental and social (resettlement) issues arise - Ordinary flow volume in channel is decreased	- EIA is needed - Resettlement is needed - Maintenance flow to maintain river eco-system is discharged

Source: JICA Study Team / Environmental Aspects of Integrated Flood Management, APFM, (Jan. 2006)

Functions of Possible Measures

1) Dykes/Embankments/Levees

A dyke is generally an artificial trapezoidal earthwork structure built along a river channel for the purpose of protecting adjacent land or human settlement from inundation by flood waters, therefore, the earthwork is required to have enough width and height, and sufficient density consolidated well enough to prevent penetration of flood water. The dyke crest can be used for not only maintenance works but also flood fighting and community roads under normal conditions. Figure 5.4.1 illustrates a typical cross section and dimensions to be considered.



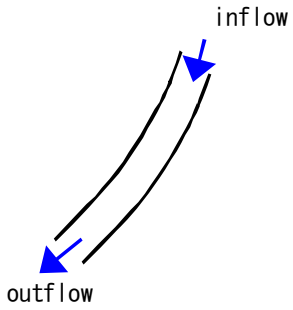
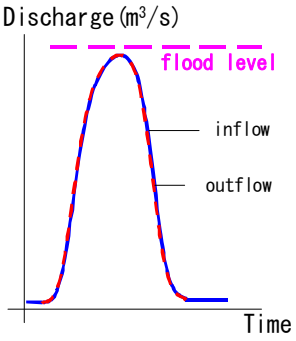
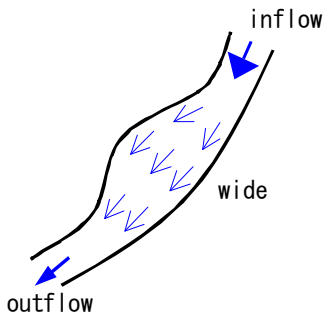
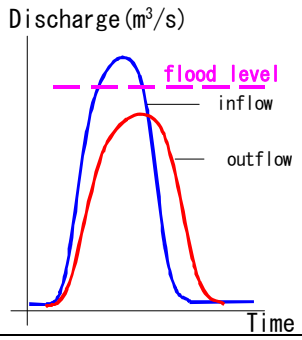
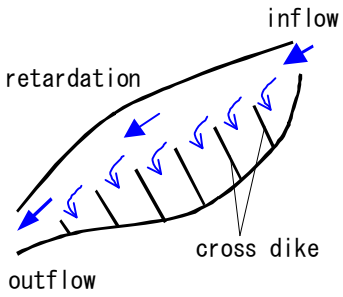
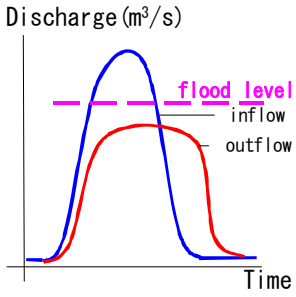
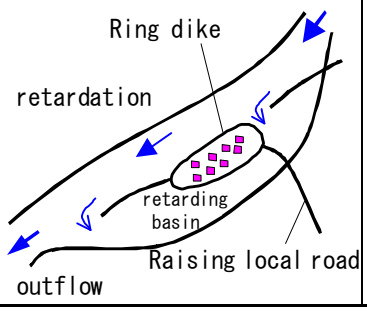
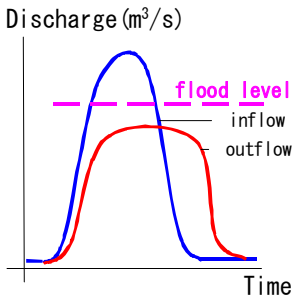
Source: JICA Study Team

Figure 5.4.1 Dyke Section and Dimensions

Figure 5.4.2 shows possible alternatives of dike system in the Nyando river basin. Among the possible measures, three alternatives were examined for the stretch of 8 km long in order to evaluate the reduction of peak discharge and retarding effect against flood. The alternatives are;

① Case 1: Straight dike at both banks
② Case 2: Straight dike at north bank and road raising at south bank
③ Case 3: Structure at Case 2 and several ramps

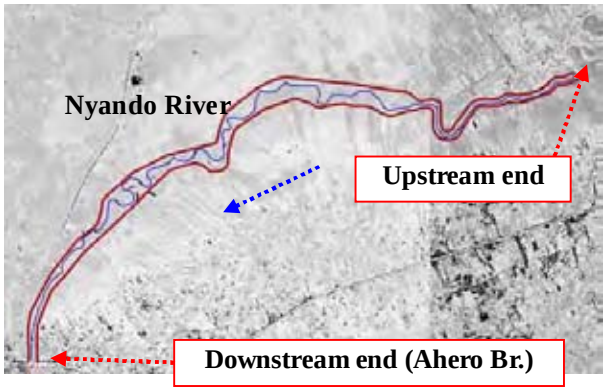
The structural arrangement for each case is summarised in Table 5.4.2.

Dike System	Hydrograph	Merit/Demerit
Straight Dike 	**Inflow=Outflow** 	Merit * small land acquisition area * no stagnant water Demerit * no retarding effect of peak discharge * higher height of dike * higher water level * poor drainage of inland water
Retarding basin with wide river 	**Inflow>Outflow** 	Merit * reduction of peak discharge * reduction of flow velocity * lower height of dike * lesser sediment to downstream Demerit * wider land acquisition area * limited land use * sediment deposition and desiltation
Retarding basin with cross dike 	**Inflow>>Outflow** 	Merit * reduction of peak discharge * reduction of flow velocity * lower height of dike * lesser sediment to downstream Demerit * wider land acquisition area * limited land use * sediment deposition and desiltation
Retarding basin with ring dike 	**Inflow>>Outflow** 	Merit * reduction of peak discharge * reduction of flow velocity * lower height of dike * lesser sediment to downstream * land use within ring dike Demerit * wider land acquisition area * sediment deposition and desiltation

Source : JICA Study Team (2006)

Figure 5.4.2 Alternatives of Dike System

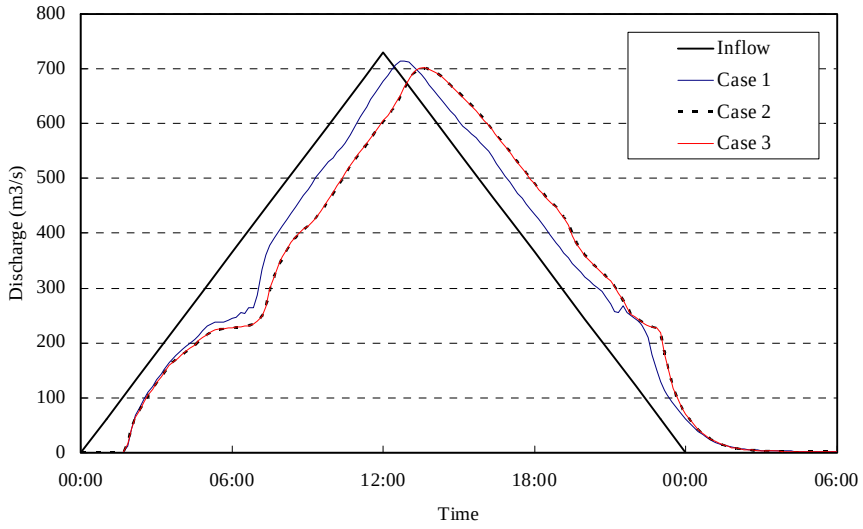
Table 5.4.2 Structural Arrangement

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)

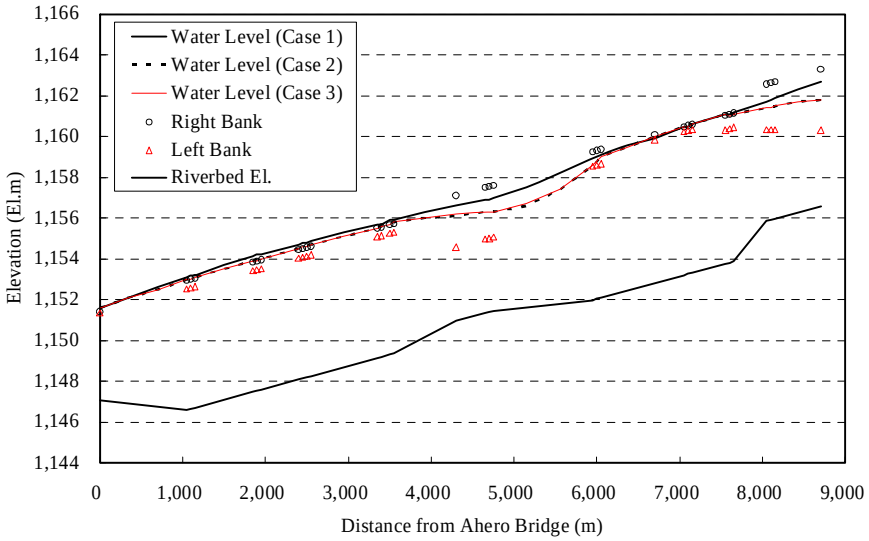
(1) Reduction of Peak Discharge

Figure 5.4.3 shows the 10 yr peak discharge at downstream end (Ahero Bridge). The peak discharge of 730 m3/s at upstream end is reduced for each case. However, the difference of peak discharge is not identified for Cases 2 and 3. Figure 5.4.4 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 5.4.5.



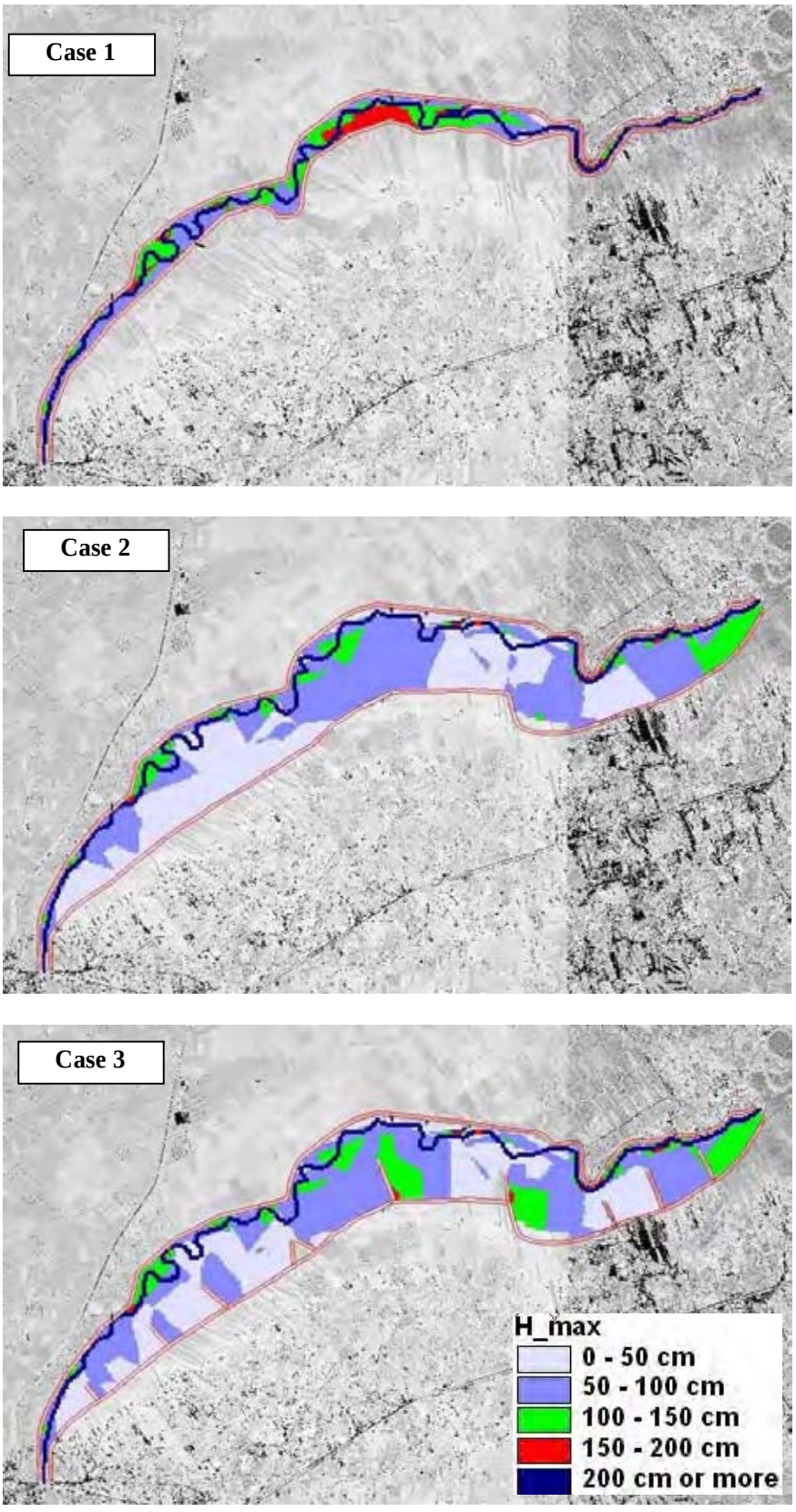
Source: JICA Study Team

Figure 5.4.3 Peak Discharge at Downstream End (Ahero Bridge)



Source: JICA Study Team

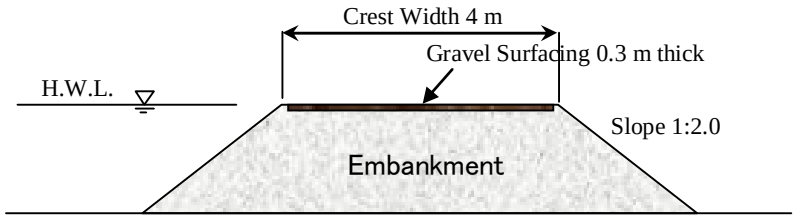
Figure 5.4.4 Flood Water Level and River Bank Elevation



Source: JICA Study Team

Figure 5.4.5 Maximum Flood Water Depth during 10 yr Flood

Assuming the typical cross section of road raising as shown in Figure 5.4.6, the embankment volume for dike was calculated based on the maximum flood water level as height of road. Freeboard was not considered for the purpose of comparison.

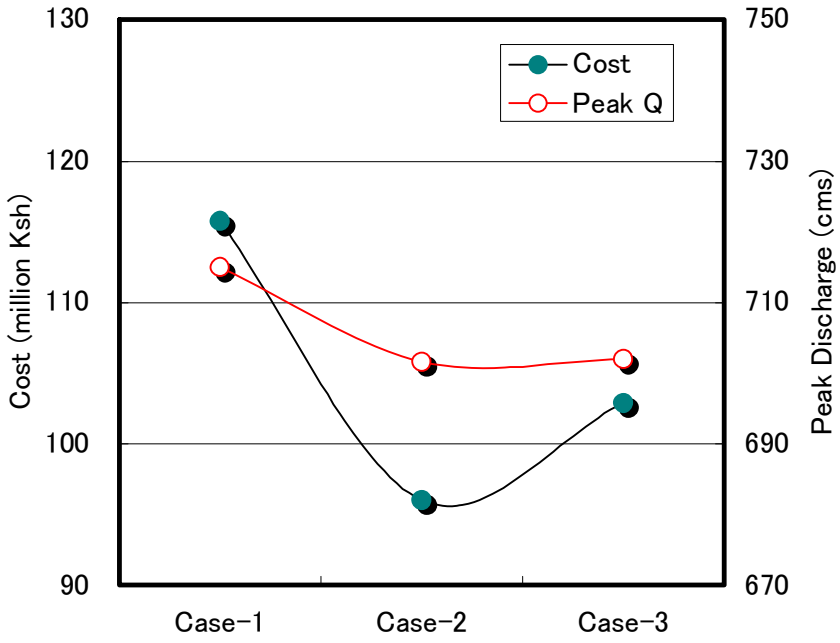


Source: JICA Study Team

Figure 5.4.6 Typical Cross Section of Road Raising

Applying the unit prices of Ksh 670/m^3 for embankment and Ksh 5,580/m^3 for gravel surfacing, the construction cost and reduction of peak discharge were given in Figure 5.4.7. The road raising at south bank is effective for the purpose of flood control with cheaper construction cost.

	Case-1	Case-2	Case-3
Cost (million Kshs)	115.76	96.02	102.91
Peak Dischage (cms)	715.00	701.60	702.00



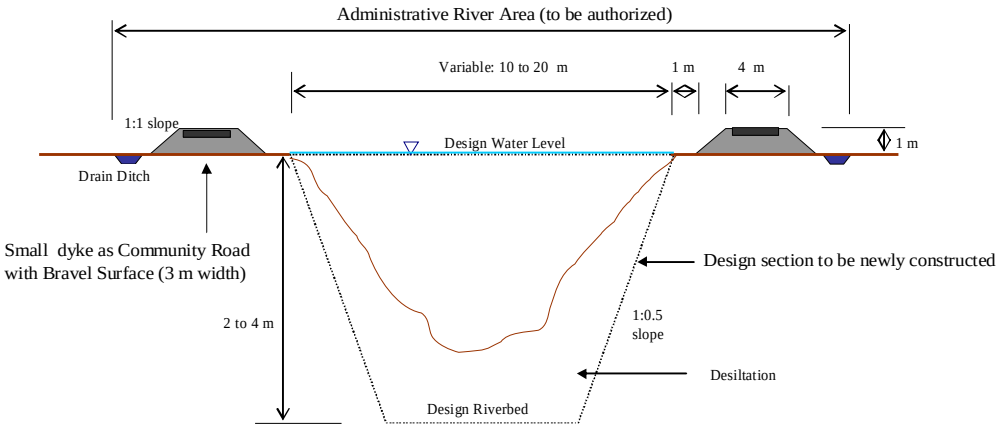
Source: JICA Study Team

Figure 5.4.7 Construction Cost of Road Raising and Reduction of Peak Discharge

2) De-siltation of River Channels

The Nyando and Nyamasaria river basins suffer from clogging of the river channels due to siltation transported from the upstream catchments. De-siltation is to increase channel flow carrying capacity by removing silt materials from the channel. Figure 5.4.8 shows an illustration of de-siltation work for a river channel.

The silt material that is removed is sometime utilised as embankment material for dykes. However, spoil banks for the silt materials are required in the case of excessive volume of de-siltation.



Source: JICA Study Team

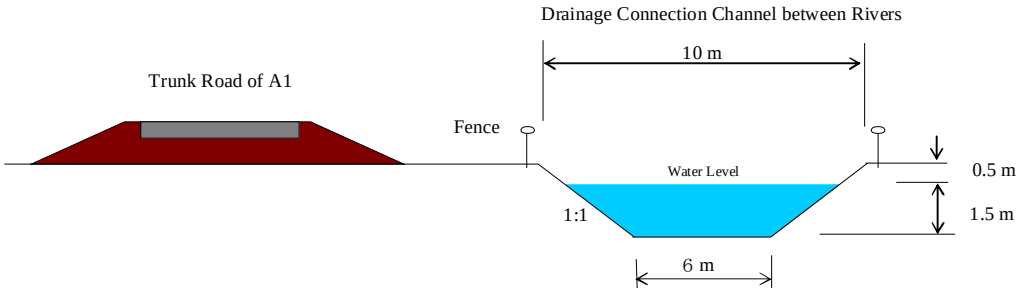
Figure 5.4.8 Image of De-siltation of River Channel

3) Drainage Channels

A network of drainage channels connecting tributaries in Nyamasaria and Awach Kano river basins would be effective in subsiding inundation much earlier and shortening the duration of flood inundation in the lower catchment of Nyando river basin; however, detailed design of the alignment of drainage channels and hydraulic considerations are required prior to the construction works.

If water pans are attached to the network of drainage channels, the water pans fill with excess water during flooding and this impounded water could be utilised in the dry season.

Figure 5.4.9 shows a typical cross section of a drainage channel along the upstream side of a road.

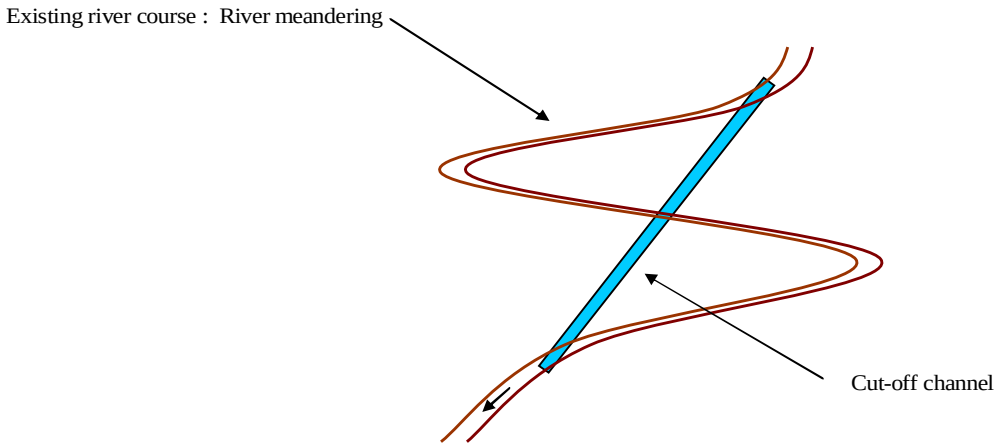


Source: JICA Study Team

Figure 5.4.9 Drainage Channel to be newly constructed

4) Cut-off Channel

A Cut-off Channel is an artificial channel designed to carry flood flow and to increase channel flow carrying capacity by shortening of channel length and changing riverbed gradient to be slightly steeper. Figure 5.4.10 shows an illustration of a cut-off channel.

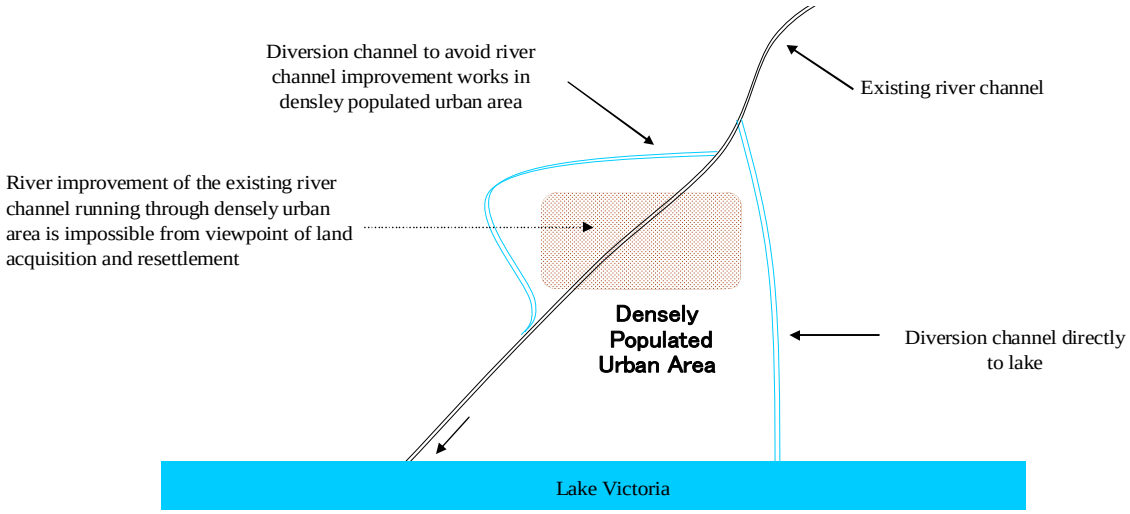


Source: JICA Study Team

Figure 5.4.10Image of Cut-Off Channel

5) Diversion Channel

When the re-alignment of the river course or the widening and deepening of the current river channel can not be realised because of the land use pattern and settlement along the river channel, a diversion channel diverting part of flood flow can be constructed. Figure 5.4.11 shows an illustration of a diversion channel.

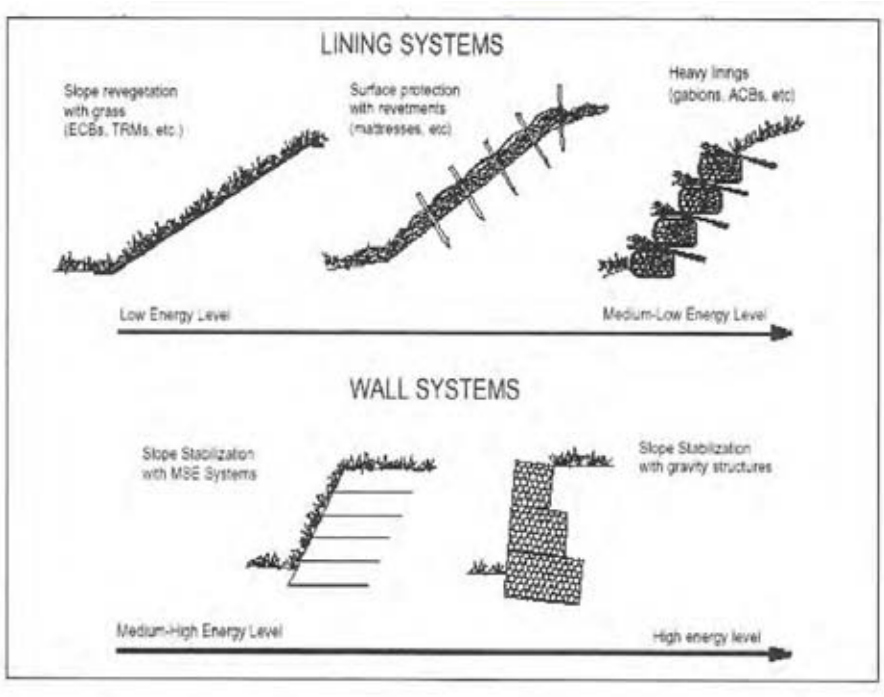


Source: JICA Study Team

Figure 5.4.11 Image of Diversion Channel

6) Bank Protection Works

Many kinds of bank protection works have been introduced in the world. Among the protection works, bank protection with gabion mattresses would be effective and applicable to the Study Area. There are many advantages of the Gabion type system over conventional protections that make it an appealing solution for the rehabilitation of riverine environments. Figure 5.4.12 shows various types of bank protection works by means of gabion mattresses.

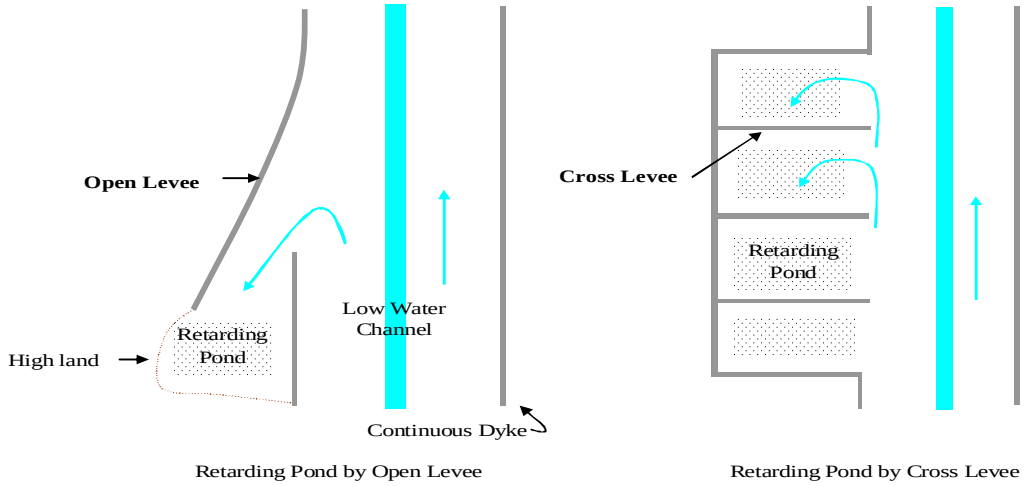


Source: Dale Chaychuk, The use of Gabions and Reno Mattresses in River and Stream Rehabilitation, April 2005

Figure 5.4.12 Bank Protection Works with Gabions

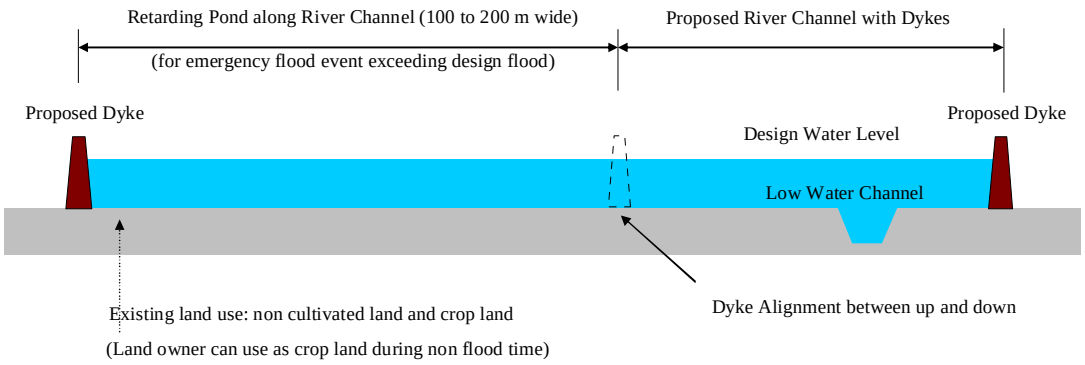
7) Retarding Ponds/Regulating Ponds

Figures 5.4.13, 5.4.14 and 5.4.15 show illustrations of retarding ponds/basins constructed (Type 1) by means of open levees or cross levees as developed in Japan and (Type 2) by excavating ponds, respectively.



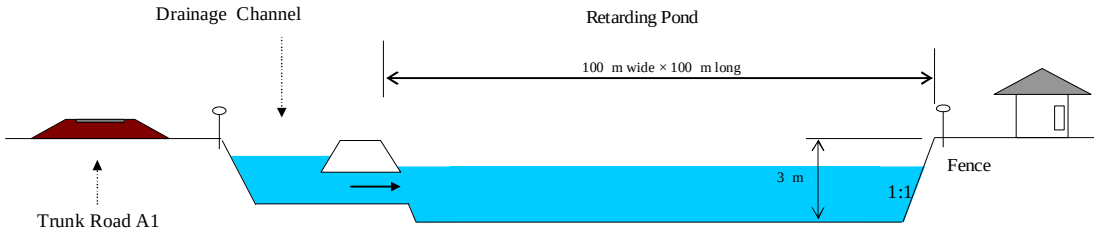
Source: JICA Study Team

Figure 5.4.13 Layout Image of Retarding Pond (Type 1)



Source: JICA Study Team

Figure 5.4.14 Retarding Pond along River Channel (Type 1)



Source : JICA Study Team

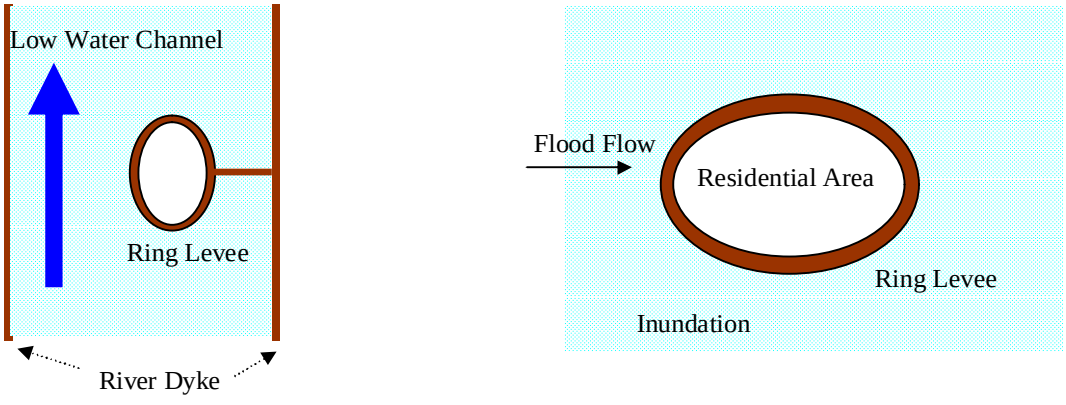
Figure 5.4.15 Excavated Pond for Retarding Purposes (Type 2)

Retarding ponds temporarily store flood runoff to decrease flood peak discharges, and function as buffer zones against extraordinary floods. In the Nyando and Nyamasaria river basins, the aforementioned two types are possibly applicable as retarding ponds/basins. Type (1) is provided by constructing open or cross levees, while Type (2) is constructed by excavating the ponds. The open levee or cross levee is a traditional measure developed in Japan.

8) Ring Dykes

A ring dyke protects a settlement area by completely surrounding it to prevent the entry of flood flow. This measure is also one of the traditional methods in Japan. Figure 5.4.16 shows an illustration of a ring Dyke.

Overview



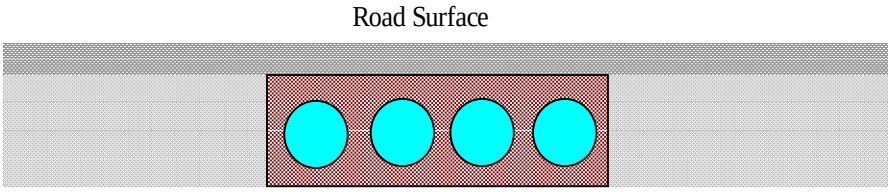
Source: JICA Study Team

Figure 5.4.16 Image of Ring Levee

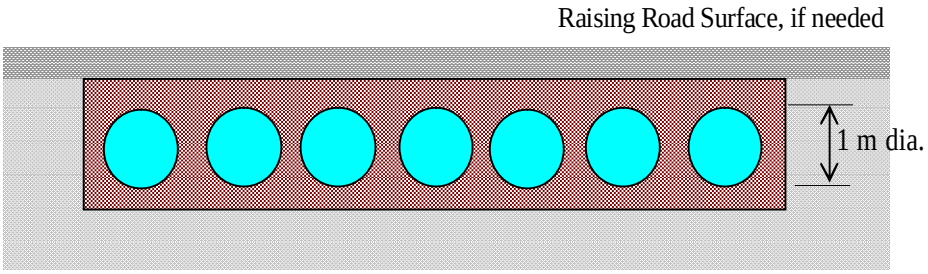
9) Culvert Improvement

The improvement of culverts underneath road embankments is to increase channel flow carrying capacity and to avoid clogging by floating timber or other obstacles through widening the cross sectional area or increasing the number of holes. The improvement of culverts largely depends on the characteristics of the river and road. The raising of the road surface elevation is often required as shown in Figure 5.4.17.

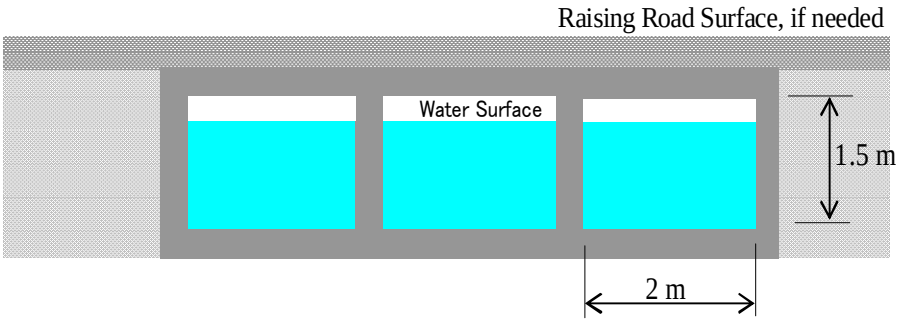
Existing Condition (concrete or corrugated pipe)



Improvement 1
(increasing of number of concrete pile by widening of channel width at bridge section)



Improvement 2
(reconstruction into box culvert, widening of channel width at bridge section)

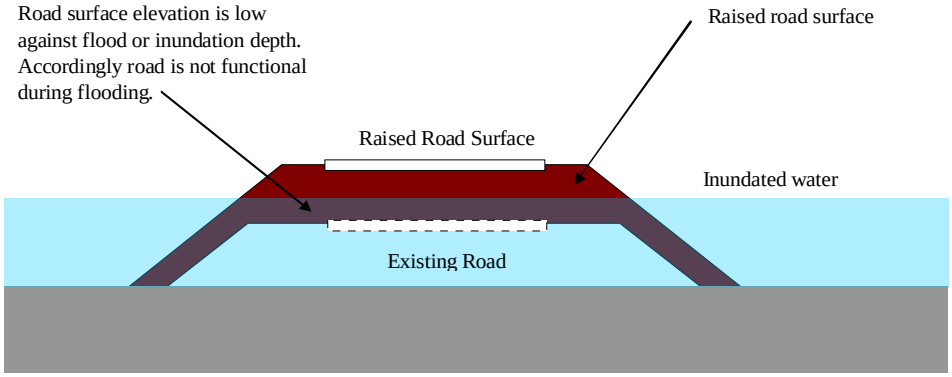


Source: JICA Study Team

Figure 5.4.17 Image of Culvert Improvement

10) Raising of Community Roads

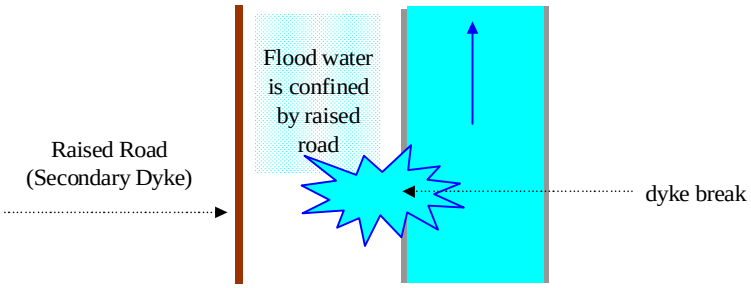
Raising the elevation of community roads is one of the solutions to keep the transportation system operating without interruption during flooding. In addition, the road itself is also utilised as an evacuation route in case of emergency. Figure 5.4.18 shows an illustration of raising the road surface.



Source: JICA Study Team

Figure 5.4.18 Raising a Road Surface

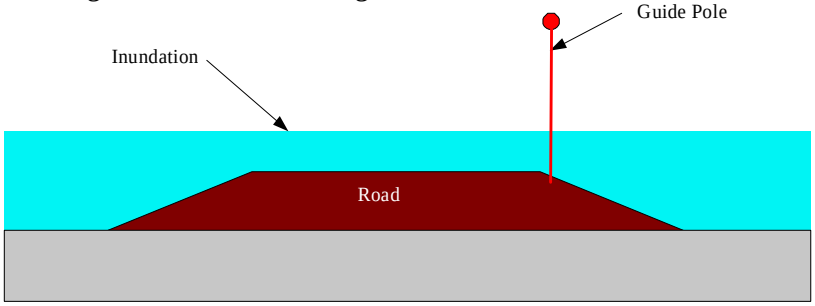
A raised road is sometimes called a secondary dyke, which enhances the degree of safety in the event of failure of the main dyke as shown in Figure 5.4.19. The secondary dyke is fairly effective as an absorber or buffer against a break of the main duke during extraordinary floods.



Source: JICA Study Team

Figure 5.4.19 Image of Secondary Dyke

In addition to road raising, the guide poles along the road are effective for evacuation and transportation during flood, as shown in Figure 5.4.20.

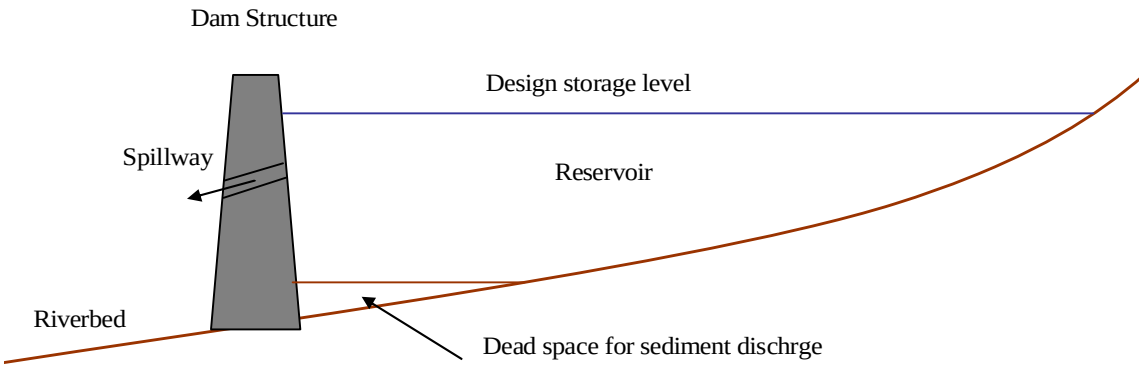


Source: JICA Study Team

Figure 5.4.20 Guide Poles along Road

11) Flood Mitigation Dam

Figure 5.4.21 illustrates the longitudinal section of a flood mitigation dam.



Source: JICA Study Team

Figure 5.4.21 Longitudinal Section of Dam

A flood mitigation dam reduces peak flood discharge towards downstream reaches by taking a part or all of flood runoff into a reservoir impounded by a dam structure.

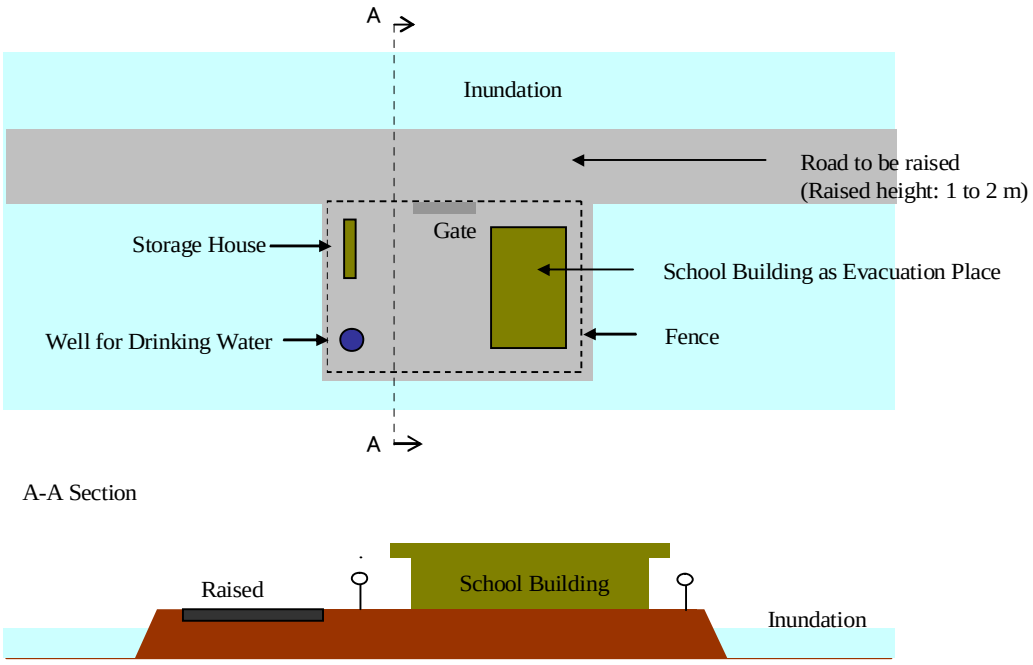
12) Slit Type Weir (Energy Dissipater) to protect against Flash Floods

Figure 5.4.22 illustrates a slit type weir that protects against flash floods. Slit-type weirs generally reduce flood peak discharge temporarily by retarding flood water in the immediate upstream in-channel storage area. The weir also traps sediment flow coming from the upper basin. The slit-type weir would be an applicable structural measure in Nyamasaria and Awach Kano river basins because of the occurrence of flash floods with rather short travel times and high sediment concentrations. This option has been adopted in Japan as one of the sediment retention structures.

Figure 5.4.22 Example of Slit-type Weir

13) Raising the elevation of Community Roads

Raising the elevation of community roads is to secure a safety network of evacuation routes during floods and at the same time prevent the inundation from overflowing. Figure 5.4.23 shows an illustration of raising a community road.

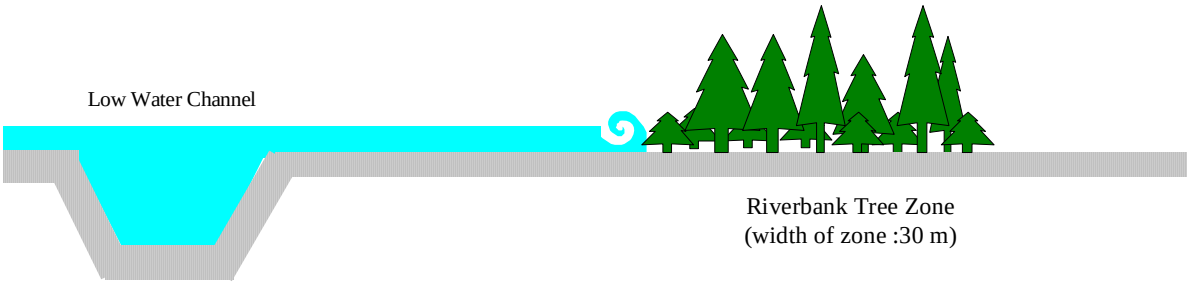


Source: JICA Study Team

Figure 5.4.23 Image of Raising a Local Road

14) Riverine Forest Zone

Riverine forest zones function as energy dissipaters to protect against flash floods. The forest zones reduce flow velocity and protect settlement areas from destruction or farmlands from erosion and siltation by reducing sediment. The riverine forest also strengthens riverbank resistance to scour (slope stability) and influences channel morphology of narrowing and deepening. However, those degrees of impacts depend on the size of the zone and site conditions. Figure 5.4.24 illustrates an image of a riverine forest zone.



Source: JICA Study Team

Figure 5.4.24 Image of Riverine Forest Zone

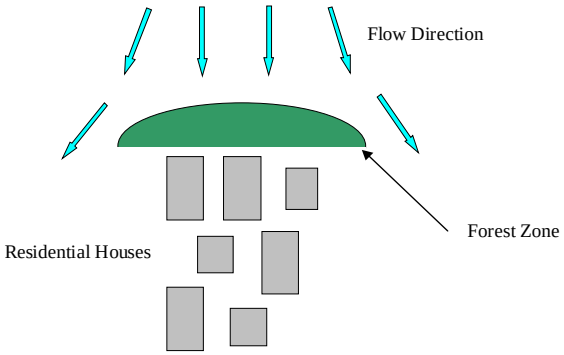
Furthermore, riverine forests serve as interfaces between terrestrial and aquatic ecosystems and provide varied and essential habitats for the local riparian species. Also a continuous forest zone offers transport routes for arboreal animals (living in trees). Likewise, forest zones including riverine forests have close relationships with ecosystems and flood processes (positive and negative impacts). Such relationships with ecosystems and flood processes will be summarised in below Table 5.4.3.

Table 5.4.3 Relationship between Ecosystem and Flood Process

Relationship	Upper Reaches	Middle Reaches	Lower Reaches
- Positive impact	- Regulate hydrological process through increased infiltration and transpiration - Increased infiltration reduces runoff of short duration and low intensity storms - Soil stabilisation helps reduce landslides depending on geographical, topographical and climate factors - Provide thermal regulation to the waters	- Forests alongside the river channel can increase bank resistance to scour because of their binding effect - Narrow and deepen river channel to maintain water levels for a given flow - Help reduce shallow landslides and consequent high sediment concentration in streams	- Retard flood waves due to roughness of the flood plain vegetation
- Negative impacts/ - limitation	- Flood regulating effect depends on size, soil structure and antecedent conditions - Flood regulating effect may not be appreciable in extreme events	- Vegetation in the river channel can increase flow resistance and raise water levels - Log jams in narrow waterways can further decrease their carrying capacity, thereby raising water levels upstream - Flood regulating effect may not be efficient in extreme events	- Log jams, in narrow waterways can further decrease their carrying capacity, thereby raising water levels upstream

Source: Environmental Aspects of Integrated Flood Management, Associated Programme on Flood Management (APFM) under WMO and Global Water Partnership, Aug.2006

This measure is also one of the traditional methods in Japan. In order to protect private houses suffering from overland flow from river or mountain areas, the forest zone is made effective by planting trees against the flow direction as seen in Figure 5.4.25.

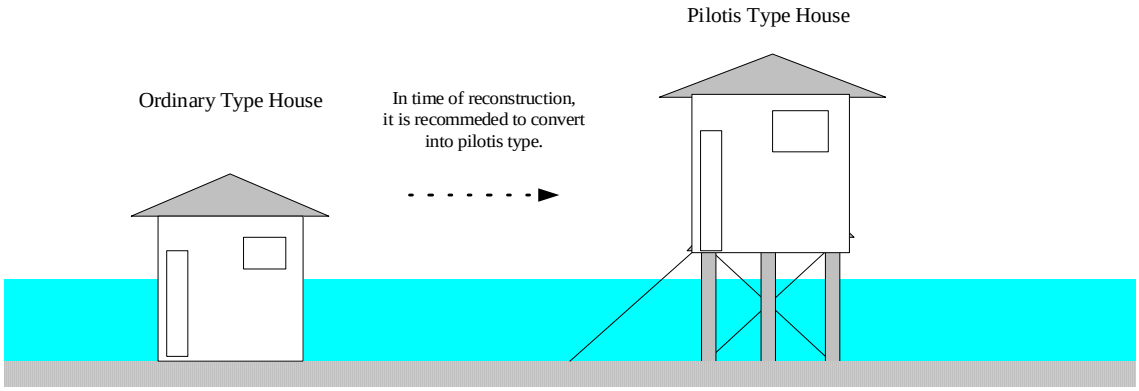


Source: JICA Study Team

Figure 5.4.25 Image of Tree (Forest) Zone to protect Housing Area

15) Flood Proofing

Flood proofing is defined as the modification of buildings, structures and/or their immediate surroundings to reduce damage in flooding. Figure 5.4.26 shows one of the options of flood proofing, a pilotis-type house with the floor elevation raised above the inundation depth.
The raising of the land surface elevation within an entire development complex or village as described in Item 13) is another option. Such options largely depend on the initiatives of the residents.



Source: JICA Study Team

Figure 5.4.26 Pilotis-Type House

(2) Community Driven Structural Measures

In order to increase the sustainability of the structural measures built to protect against flooding, it is recommended that small scale structural measures should be built using community initiative and involvement. Because of their involvement in the construction and the knowledge they gain that the structure is highly useful for the community, the community will manage and maintain those structures as their own property.

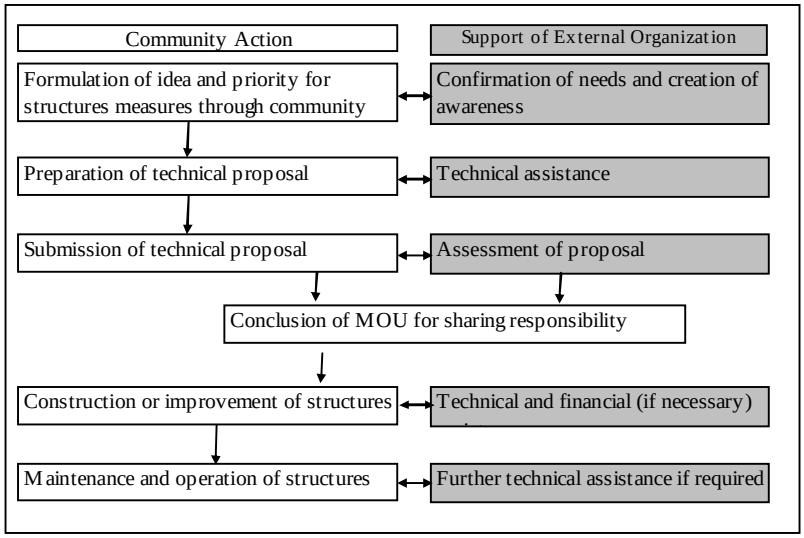
Care Kenya and VIRED International implemented community-driven structural measures such as excavation of existing local ditches and rivers, construction of ditches, and road improvement under the Flood Mitigation Food for Work Project. However, they noted that there are design and quality control constraints for construction and improvement of structures due to limited engineering knowledge. It is therefore important to involve qualified engineers or technical experts in community driven structural measures.

For flood management in the lower Nyando river basin, various measures are available as community driven structural measures as shown in Table 5.4.4. The procedure for sharing responsibility between the community and external organisations is illustrated in Figure 5.4.27.

Table 5.4.4 Possibility of Community Driven Structural Measures

Structural Measures	Possibility of Community Driven Measures	Remarks
1. Dike Construction	This construction is basically not possible. But installation of ramps for easy and safe access to the river would be possible.	Locations for the ramps of dike will be selected by the community. Proper coordination between government and the community should be made.
2. De-siltation of river channels and drainage channels	Most cases are possible. However, impact to communities located in the downstream area should be carefully checked.	Priority will be considered by both the community and government.
3. Construction of drainage channels	Drainage works within the community is possible, while inter-community drainage should be constructed by the government.	
4. Cut-off Channels	Most cases are very difficult.	Engineering knowledge and experience are required.
5. Diversion channels	Most cases are very difficult.	Engineering knowledge and experience are required.
6. Bank protection work	Small scale protection is possible.	Material supply will be required for the community.
7. Retarding ponds/regulating ponds	Small scale ponds such as water pans are possible.	
8. Ring levees	Small scale ring levees are possible.	Arrangement of material supply may be required for the community.
9. Culvert improvement	Small scale improvement is possible.	Material supply will be required for the community.
10. Flood control dams	Not possible.	
11. Raising local roads	Community roads are possible, while inter-community roads should be improved by the government.	
12. Riverbank forest zones	Most cases are possible.	Arrangement of material supply may be required for the community.
13. Flood proofing	Small scale improvements such as for individual houses are possible.	

Source : JICA Study Team (2006)



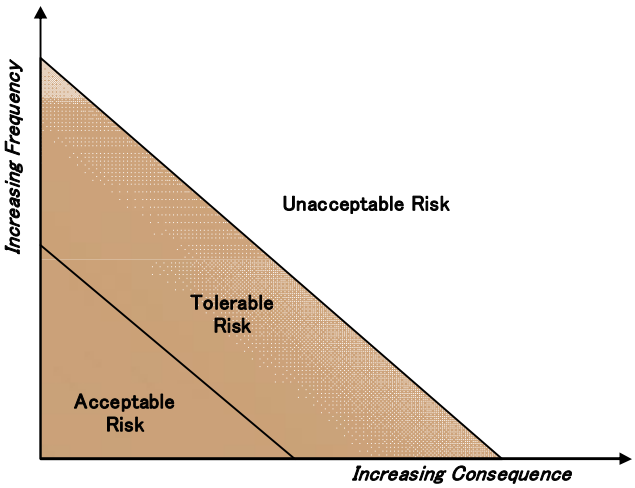
Source : JICA Study Team (2006)

Figure 5.4.27 Flowchart of Community Driven Structural Measures

5.4.2 Non-Structural Measures

(1) Residual Risk

Flood risk cannot be totally eliminated in spite of protection measures on the planning and operational level as shown in Figure 5.4.28. This remaining risk is called residual risk and describes the amount of risk after structural or non-structural flood mitigation measures have been applied. The residual risk cannot be allocated or exactly quantified but it has to be borne by the potentially affected parts of a community. Hence, acceptable and unacceptable levels of risk have been discussed. The aim of each mitigation measure is to reduce risk to an acceptable level. People should be aware that structural mitigation measures do not exclude all kinds of risk. Reasons for this may have technical or financial aspects.



Source : Flows-project (Technical Univ. of Hamburg)

Figure 5.4.28 Type of Risk with Different Consequence

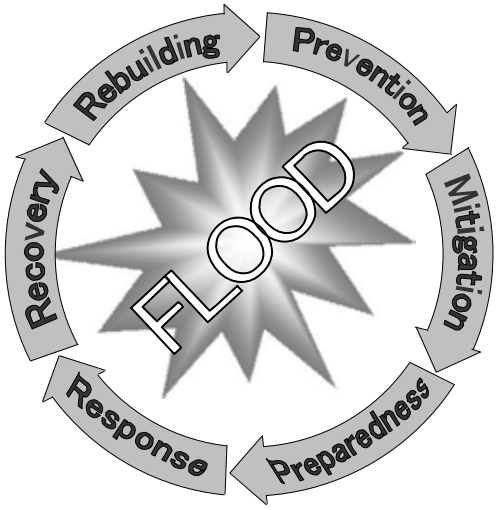
Residual risks of flooding are those which arise after the construction of flood control structures or control systems, when the structures or systems are subjected to unquantifiable or extreme events. The events may exceed the design parameters and cause overtopping of the structures or they may subject the structures to large forces which cause structural failure and subsequent collapse of sections of the structures. Other types of residual risk events which can lead to flooding include breakdown or failure of pumps/freshwater supply and serious siltation within drainage systems. In Nyando river basin, residual risks have a high probability of occurrence because of insufficient scale and strength of flood control structures.

(2) Flood Management Cycle

1) Continuous Process of Flood Management

Non-structural measures aim to reduce or avoid the potential losses from hazards, assure prompt and appropriate assistance to victims of disasters, and achieve rapid and effective recovery. The continuous process of the cycle as shown in Figure 5.4.29 illustrates the ongoing process by which governments, businesses, and civil society plan for and reduce the impact of disasters, react during and immediately following a disaster, and take steps to recover after a disaster has occurred. Appropriate actions at all points in the cycle lead to greater preparedness, better

warnings, reduced vulnerability or the prevention of disasters during the next iteration of the cycle. Furthermore, the complete integrated flood management cycle includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.



Source : Speightstown Community Disaster Management Plan, (JICA, 2006)

Figure 5.4.29 Flood Management Cycle

The mitigation and preparedness phases occur as improvement of integrated flood management in anticipation of a flood. Developmental considerations play a key role in contributing to the mitigation and preparation of a community to effectively confront a disaster. As a disaster occurs, disaster management organisations become involved in the immediate response and long-term recovery phases. The four disaster management phases, mitigation, preparedness, response and recovery, do not always, or even generally, occur in isolation or in this precise order for the sustainable development of non-structural measures. Phases of the cycle often overlap and the duration of each phase greatly depends on the severity of flooding.

- ***Prevention/Mitigation*** : Minimising the effects of disaster. (building codes and zoning, vulnerability analyses, public education)
- ***Preparedness*** : Planning how to respond. (preparedness plans; emergency exercises/training; warning systems)
- ***Response*** : Efforts to minimise the hazards created by a disaster. (search and rescue; emergency relief)
- ***Recovery*** : Returning the community to normal in the short-term. (temporary shelter, evacuation centre, grants; medical care)
- ***Rebuilding*** : Returning the community to normal in the long-term. (community infrastructure and houses)

2) Prevention /Mitigation

Prevention and mitigation activities actually eliminate or reduce the probability of disaster occurrence, or reduce the effects of unavoidable disasters. Prevention and mitigation measures include building codes; vulnerability analyses updates; zoning and land use management; building use regulations and safety codes; preventive health care; and public education. Mitigation will depend on the incorporation of appropriate measures in national and regional

development planning. Its effectiveness will also depend on the availability of information on hazards, emergency risks, and the countermeasures to be taken. The mitigation phase, and indeed the whole disaster management cycle, includes the shaping of public policies and plans that either modify the causes of disasters or mitigate their effects on people, property, and infrastructure.

3) Preparedness

The goal of emergency preparedness programmes is to achieve a satisfactory level of readiness to respond to any emergency situation through programmes that strengthen the technical and managerial capacity of governments, organisations, and communities. These measures can be described as logistical readiness to deal with disasters and can be enhanced by having response mechanisms and procedures, rehearsals, developing long-term and short-term strategies, public education and building early warning systems. Preparedness can also take the form of ensuring that strategic reserves of food, equipment, water, medicines and other essentials are maintained in case of national or local catastrophes.

During the preparedness phase, governments, organisations, and individuals develop plans to save lives, minimise disaster damage, and enhance disaster response operations. Preparedness measures include preparedness plans; emergency exercises/training; warning systems; emergency communications systems; evacuations plans and training; resource inventories; emergency personnel/contact lists; mutual aid agreements; and public information/education. As with mitigations efforts, preparedness actions depend on the incorporation of appropriate measures in national and regional development plans. In addition, their effectiveness depends on the availability of information on hazards, emergency risks and the countermeasures to be taken, and on the degree to which government agencies, non-governmental organisations and the general public are able to make use of this information.

4) Response

The aim of emergency response is to provide immediate assistance to maintain life, improve health and support the morale of the affected population. Such assistance may range from providing specific but limited aid, such as assisting refugees with transport, temporary shelter, and food, to establishing semi-permanent settlement in camps and other locations. It also may involve initial repairs to damaged infrastructure. The focus in the response phase is on meeting the basic needs of the people until more permanent and sustainable solutions can be found. Humanitarian organisations are often strongly involved in this phase of the disaster management cycle.

5) Recovery

As the emergency is brought under control, the affected population is capable of undertaking a growing number of activities aimed at restoring their lives and the infrastructure that supports them. There is no distinct point at which immediate relief changes into recovery. There will be many opportunities during the recovery period to enhance prevention and increase preparedness, thus reducing vulnerability.

Recovery activities continue until all systems return to normal or better in the short-term. Recovery measures include returning vital life-support systems to minimum operating standards; temporary housing; public information; health and safety education, counselling programmes; and economic impact studies.

6) Rebuilding

The aim of rebuilding is to maintain economic and social activities at the levels that existed before the disaster. Ideally, there should be a smooth transition from recovery to on-going development. Rebuilding activities continue until all systems return to normal or better in the long-term. Rebuilding measures are reconstruction of houses and public infrastructure. Information resources and services include data collection related to rebuilding, and documentation of lessons learned.

(3) Possible Non-Structural Measures

The following enumerates possible non-structural measures applicable to the lower catchment of Nyando and Nyamasaria river basins: 1) flood forecasting system, 2) early warning system, 3) dissemination, 4) education for disaster prevention, 5) flood hazard mapping, 6) evacuation system, and 7) community driven flood management organisation.

1) Flood Forecasting System

As the protection level against flooding inevitably has to be limited, and as flood return periods of only 25 years were selected in Nyando river basin, flood forecasting and warning may, in some instances, provide a realistic means to authorities and individuals to reduce the damage inflicted on persons and properties in lower catchments exposed to flood risks.

With longer or shorter lead times, depending on the drainage basins and hydro-meteorological parameters, flood forecasting can permit the prediction of the progress of floods, enabling the responsible authorities and involved populations to make personal, material and organisational decisions to reduce the detrimental consequences of the imminent flood. The basis of flood forecasting is the analysis and interpretation of all available data from preceding or initiating events which create or contribute to the development of flooding at some other, downstream

point of the drainage basin in a future time whatever the future uncertain events.

The data most frequently used in flood forecasting are (i) antecedent rainfall in the catchment, (ii) soil saturation level at various points in the drainage basin, and (iii) stream flow at points in the drainage basin upstream from the point of concern.

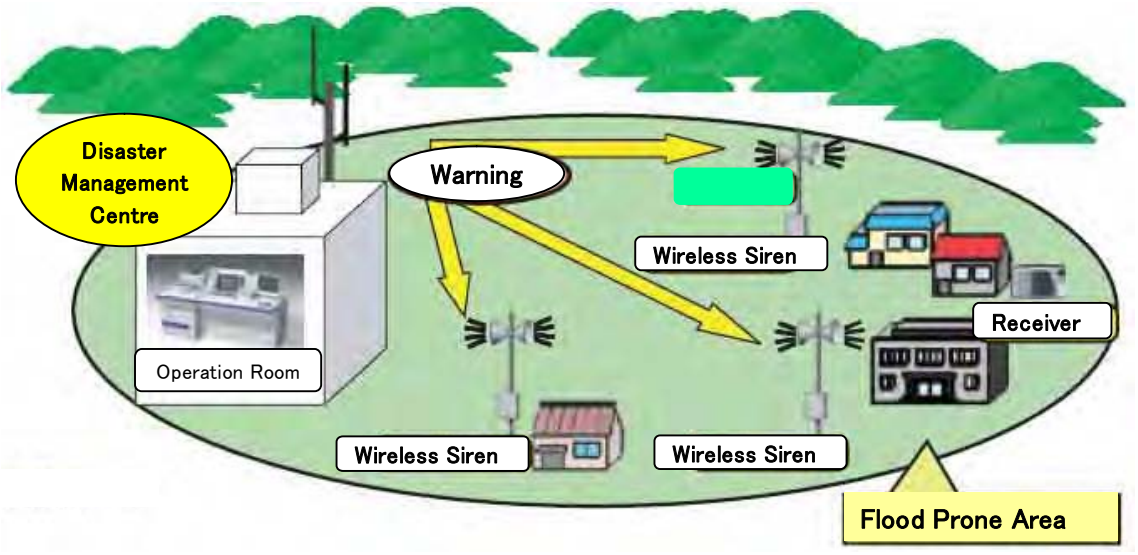
Normally, flood forecasting is expressed with a prediction of the river "stage" or water level, or of the discharge at some future time at the downstream point of concern. Additionally, it can also provide, if feasible, an indication of the maximum expected level and its timing. It is evident that the further ahead the forecast event is, the less precise will be its accuracy. Therefore, the period must inevitably be limited in order to avoid issuance of alarmist information which in the end would tend to undermine the credibility of the forecasting amongst the population at risk.

Flood forecasting systems must be thought through fully beforehand and the flood warning and measures to be taken based on very precise quantitative data. Several elements must be assembled and combined to form the data base, including:

- ✓ The flood forecasting system, which needs an efficient means of data acquisition, a reliable system of data transmission, an experienced forecaster, and a flood forecasting communication centre with competent and responsible persons who can be put on alert at any time;
- ✓ An inventory of the area's existing logistics and their applicable strengths and weaknesses must be developed, covering: the traffic and transportation network, energy supplies (particularly electric power); and water supplies for domestic use;
- ✓ An inventory of flood management structures and their attributes must be developed; this inventory must include the operating procedures for these structures, and the organisations and staff responsible for their operation and maintenance;
- ✓ A list of the authorities in charge of the flood or emergency warnings, and of those in charge of rescue operations;
- ✓ An inventory of the safety and protection measures for the infrastructures vital to the continuation of major economic activities.

2) Early Warning System

Warned of the threat of floods, even if there might be no evidence of rain in the populated areas, people can take a number of temporary precautions to protect their property and possessions, and, ultimately, to protect their lives by moving safely out of the identified danger zone (Figure 5.4.30).



Source : JICA Study Team (2006)

Figure 5.4.30 Typical Warning System in a Flood Prone Area

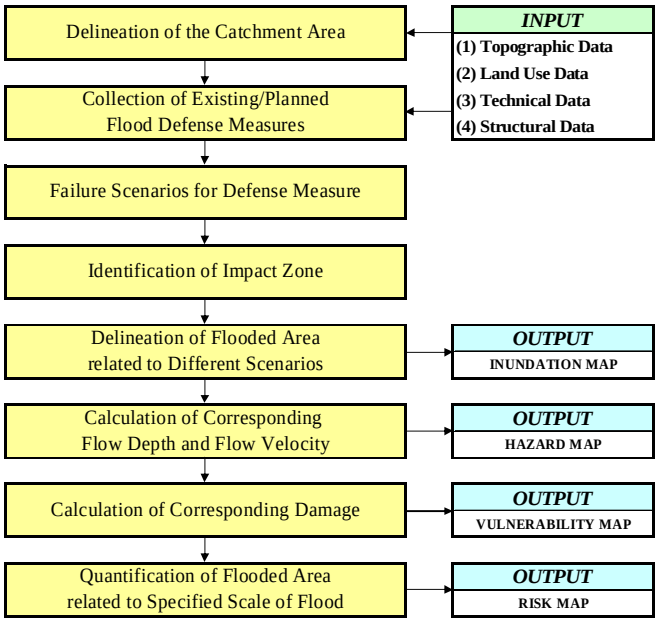
Warning of an on-coming flood is usually the responsibility of authorities who also can implement associated collective measures, analysed and planned in advance, to reduce potential flood damage. The key input to flood warnings lies in the timeliness and accuracy of the forecasts of impending flooding provided by the flood forecasting process. Flood warning systems are based on detailed analyses of at least:

- ✓ Flooded areas with a rating of the risk involved in each of them (list of people and goods and their different levels of exposure – a means of communication for different flood magnitudes), the varying degrees of risk according to their location, and a means of communicating this risk;
- ✓ Structures for flood protection (dams, dikes, flood ways, etc.);
- ✓ Hydrology of the catchment area.

The term "risk" is a function of the probability of an adverse effect and the severity of the resulting effects. In a larger sense, risk describes the possibility that human, material, economic or environmental losses can be caused by a potentially damaging event or phenomenon.

The scientific approach defines the risk as the probability and extent of damage due to a particular flood. Conventionally the risk is expressed by the notation ***Risk = Flooding x Vulnerability***. Flood related risk refers to the probability of harmful consequences, or expected losses resulting from interactions between natural hazards and vulnerable conditions.

The assessment is a step in the risk management process and describes the process of evaluating adverse effects caused by a natural phenomenon as shown in Figure 5.4.31. The assessment refers to two aspects of risk, the magnitude of the potential loss, and the probability that the loss would occur. The process of evaluating likelihood, threats, vulnerabilities and the theoretical effectiveness of structural and non-structural protection measures is not only designed for determining expected loss but also to establish the degree of acceptability related to residual risk.



Source : Flows-project (Technical Univ. of Hamburg)

Figure 5.4.31 Flowchart of Risk Assessment

3) Dissemination System

All parties involved in the process of flood mitigation must understand the necessity of communication and learn how to express themselves in such a way that their input can be inter-linked with the input of others.

It is clear that the sender and not the receiver of a message should determine its format. In mobilisation more then in any other aspect of flood management, it is essential to check that the message is received, understood and accepted. Seven principles apply when communicating public information on flooding:

- Confidence in the source must be built
- Message must be confirming, not contradicting
- Simplicity is required in phrasing the message
- Repetition and consistency of warnings builds trust
- Content of message must be relevant to the receiver's value system
- Media that are respected by the audience should be used
- Audience's habits, degree of literacy and knowledge should be taken into account

Wireless communication systems are preferable because telephone systems may fail during floods. Sophisticated and high-technology means of communication may not always be effective to reach the targeted people. Also, warnings can be disseminated in many traditional ways such as loudspeakers, flags, drums, fireworks, church bells, slogans, messengers, etc.

4) Education for Disaster Prevention

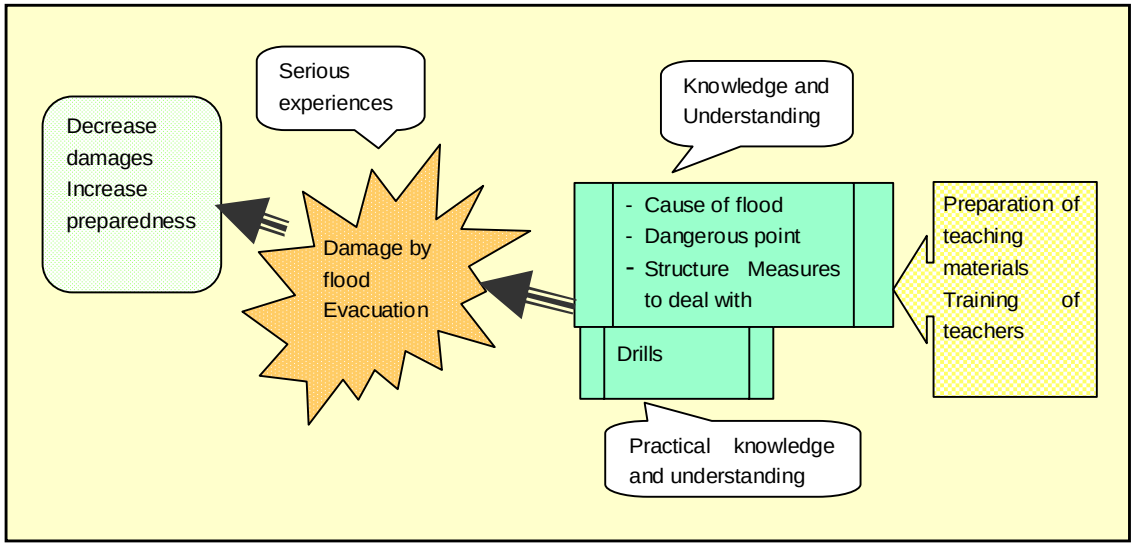
Overview

Education for disaster prevention in elementary and secondary schools is necessary. The overall purpose of that education is to enhance the knowledge and understanding of pupils and for them to share that knowledge and understanding with their family members.

Children in the flood prone areas suffer from flood damage and experience evacuations. Education for disaster prevention will give them rational knowledge of floods and means of preparedness, and practice will strengthen their preparedness.

Education for pupils in disaster prevention is not greatly different from the public awareness and hazard mapping for adult people, though the measures need to be simplified. Also, they are expected to transfer the contents of this programme to their family members; education to children is expected to have an impact on their families; it is reported in Japan that more than 60% of families of school pupils heard the contents of education for disaster prevention from the pupils.

The education consists of three units: enhancement of pupils' understanding of floods, increase of the preparedness for evacuation, and on-site practice. Figure 5.4.32 shows the framework of the education for disaster prevention.



Source: JICA Study Team

Figure 5.4.32 Education for Disaster Prevention

To enhance pupils' understanding of floods

In this education unit, a basic understanding of natural conditions and floods are taught; including the river system of the basin, causes of floods and flood damage nearby. For children living in the flood prone areas of Nyando river basin, flooding is not remote knowledge but

experience that occurs almost every year and injures them. In these circumstances, this programme will enhance their understanding by linking with their experience. For enhancement of their understanding of floods, it is effective to teach them some science and geography. It is also effective to visit the places along the river where water floods and river structures such as dykes have been constructed to mitigate floods.

To increase the preparedness for evacuation

It is important for pupils to learn comprehensive means of flood preparedness. In this unit pupils learn of existing flood forecasting and warning systems, location and contents of notice boards, locations of and routes to evacuation centres and preparation for floods before the rainy season.

Many children living in this area have repeatedly evacuated with their family members; and without this knowledge, they grow up continuously suffering flood damage. Knowledge will remain in their minds even when they become adults if it is given repeatedly when they are young. The following learning practices are proposed to be applied in the classes:

- Pupils make a community hazard map and apply it to further learning.
- Pupils interview village elders to hear the traditional ways of flood management.
- Pupils visit the facilities of flood mitigation and flood preparedness.

Practice

Practice of evacuation drills is expected to give pupils the same direct effects as for adult people. The practice gives pupils the knowledge of evacuation procedures and flood preparedness and pupils are expected to be ready to prepare for the occurrence of real floods after the drills are repeated often. It is proposed to include in the practice not only the evacuation drills but also learning of village traditions from village elders and of participatory self-help activities for upper class students.

Remarks

a) Education programmes need to be coordinated with the Ministry of Education.

b) The following matters need to be covered prior to the commencement of the education of the pupils:

   - Manuals/textbooks for pupils: Similar to regular education programmes, the programme of disaster prevention needs to be taught at a level of complexity appropriate to the form/grade.
   - Teaching materials: considering Kenyan circumstances, educational materials are to be as simple as possible and made of local materials as used in the PRA workshop.
   - Training of teachers

c) It is proposed that the education programme should be implemented before the flood period; the period between January and February would therefore be appropriate.

5) Flood Hazard Mapping

Hazard Mapping

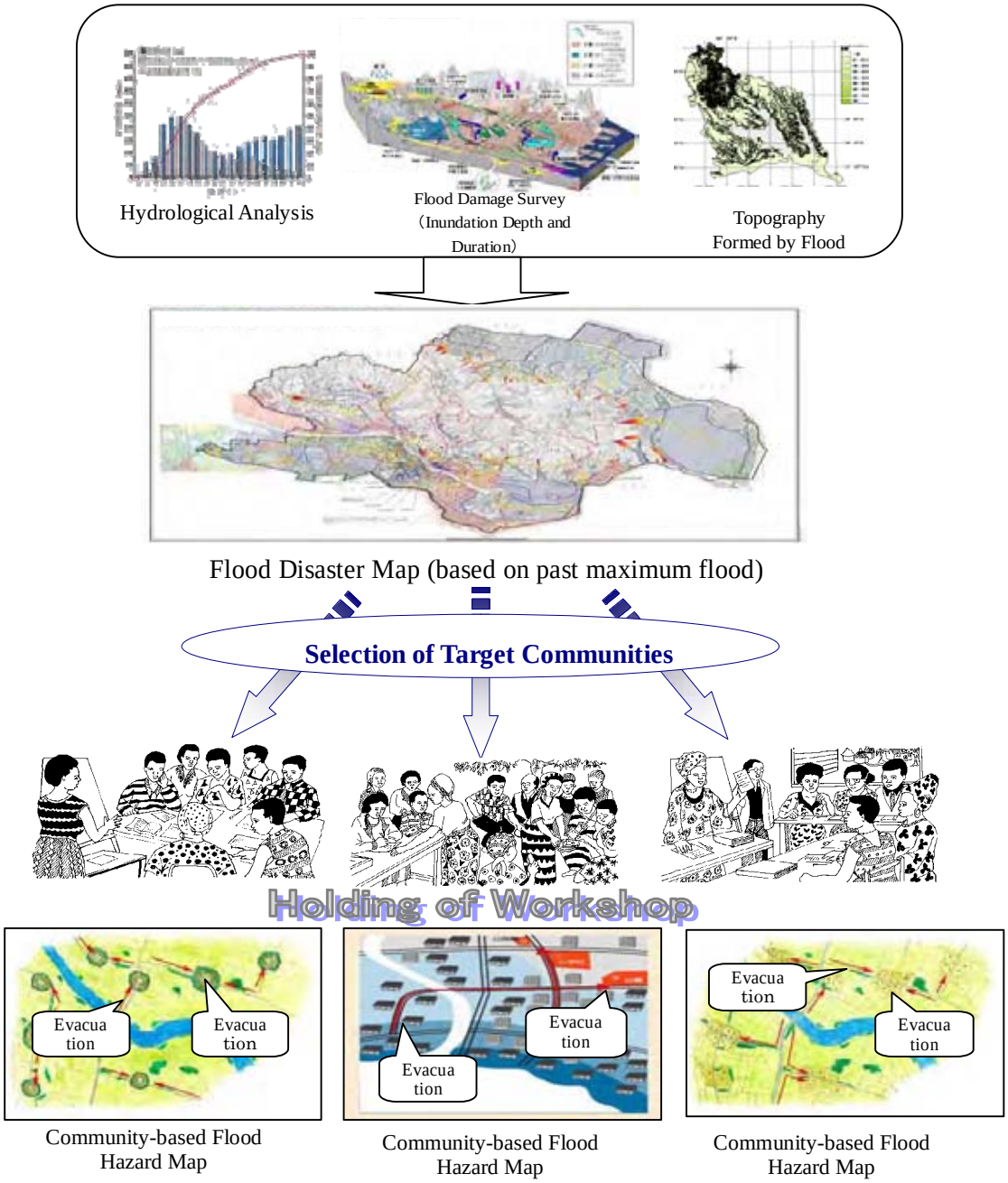
A seminar entitled "Disaster and the Community (what are useful hazard maps and flood warning systems for the communities?)" was held by JICA on February 9, 2006. The lessons learnt addressed in the seminar are given in Table 5.4.5.

Table 5.4.5 Lessons learnt from Hazard Mapping in the Past JICA Projects

1)	Flood hazard maps prepared by the government without involving the people in the communities do not produce successful results.
2)	A community participatory approach should be adopted to empower communities to cope with the flood disasters and also to share their information with the government and other key players.
3)	Preparation of the maps does not function well without involving a leader who has community-based understanding.
4)	Vague information does not make people move. Detailed information from the District should be provided. Warning messages should be confirmed with community-based information.
5)	The scale of mapping is set to be detailed enough for the residents to identify their own houses. Otherwise, residents do not feel the reality of the extent of damage.

Source: JICA (2006)

A flood disaster area of about 240 km^2 lies in the lower catchment of Nyando river basin. A flood hazard map which covers the whole flood disaster area would be too broad to provide community-based flood preparedness. In the Study, disaster and hazard maps are being prepared. The former covers the whole disaster area based on the results of flood damage surveys, and the latter cover the flood prone areas in the prioritised communities as shown in Figure 5.4.33.



Source: JICA Study Team 2006

Figure 5.4.33 Procedures of Community-based Flood Hazard Mapping

Flood Disaster Map

A flood disaster map covering the whole flood disaster area will be utilised as the base of flood hazard maps for each community. The map delineates topographic condition and information on the most serious flooding in the past as well as the fundamental water-related infrastructures.

A flood disaster map and a flow direction and velocity map for the flood inundation areas on a

scale of 1:50,000 were prepared based on the results of the flood damage surveys, satellite images, and GIS data. In addition, public hearings were held three times with 340 participants in total to verify their accuracy with community-based experience from residents, and to feedback for future modifications. Detailed information on the preparation is mentioned in sub-chapter 4.6. Those maps can be utilised for formulation of regional planning including, road improvement plans for evacuation, drainage improvement, appointment of new evacuation facilities, and prioritisation of communities for training on flood management as shown in Figure 5.4.34.

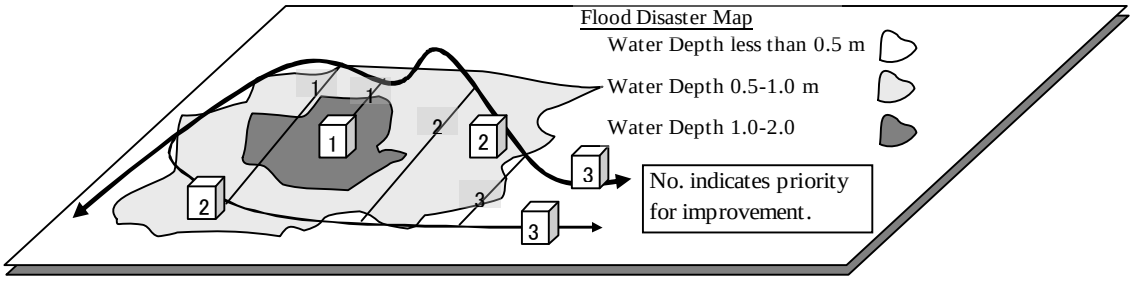
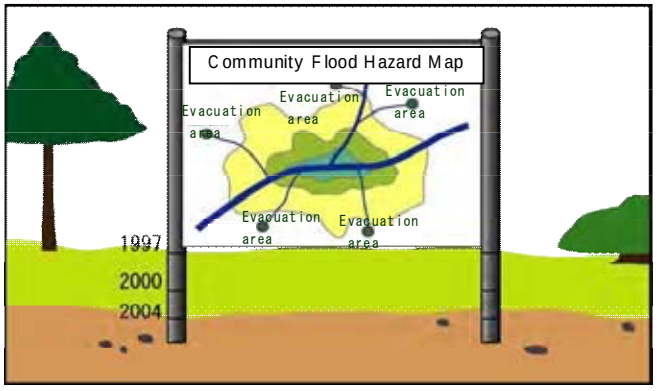


Figure 5.4.34 Image of Utilisation of Flood Disaster Map for Regional Planning

The existing flood disaster map will be updated from time to time by WRMA regional office. The update works include: i) collection of new information on extent of flooding when it occurs, ii) collection of information on establishment of new evacuation facilities, iii) updating of the information in the GIS database, and iv) provision of updated flood disaster maps to local administrations concerned.

Participatory Community-based Flood Hazard Maps

Enhancing and empowering community-based disaster preparedness is necessary as a part of the non-structural measures. A "participatory community-based flood hazard map" will be produced through workshops or PRA under the community survey programme. In the mapping process, the people, along with the executing agencies and the concerned governmental officials, demarcate flood hazardous areas, evacuation centres and evacuation routes.



Source: JICA Study Team

Figure 5.4.35 Image of Community Flood Hazard Map

The objectives of production of community flood hazard maps are to: i) understand the characteristics of flood in the community, ii) understand the weaknesses to floods in the

community, iii) increase awareness of personal flood mitigation measures, and iv) assist the establishment and strengthening of community organisations for flood disaster mitigation. It is desirable that community flood hazard maps should be shown on the community board for dissemination of proper evacuation routes and places dangerous to the community as illustrated in Figure 5.4.35. The community flood hazard maps will be prepared according to the procedures as shown in Figure 5.4.36.

Preparatory Work

1. Arrangement of Place
2. Arrangement of Map and Stationary
3. Formulation of Program

Implementation

1. Introduction
2. Group formulation and Preparation
3. Map Arrangement

4. Analysis of present condition
   - Drawing of natural condition in the communities (residential area, agricultural land, grass land, forest, river, hilly area etc.)
   - Drawing of community infrastructure (road, footpath, drainage, open space etc,)
   - Drawing of community resources (office, school, hospital, church, evacuation facility, kiosk, storage dike etc.)

5. Analysis of community vulnerability
   - Drawing past flooded area and duration
   - Indicating past accident and damages during flood period
   - Indication evacuation route, evacuation place, resource activity, communication etc

6. Formulation of countermeasures
   - Discussion on community based necessary actions such as resource, evacuation route, evacuation center management, communication etc.
   - Discussion on necessary support from external resources.

7. Presentation of each group
8. Conclusion

Figure 5.4.36 Procedure for Production of Community Flood Hazard Maps

6) Evacuation System

Improvement of evacuation centres

The survey of existing evacuation centres indicates that the key issues are shortage of toilets, and poor water supply facilities. Those have caused increasing water related diseases such as diarrhoea, dysentery, cholera etc. It is noted that poor sanitation conditions in the evacuation centres or temporary shelters increase possible loss of life in a huge disaster. Therefore, improvement of sanitary conditions for existing evacuation centres should be made the highest priority as shown in Table 5.4.6.

Table 5.4.6 Poor and Improved Condition on Toilet and Water Supply Facility

Item	Poor Condition	Improved Condition
Toilet Poor construction quality and maintenance		
Water Supply Poor construction quality and maintenance	 (No water is provided)	

It is reported that there is a shortage of space in evacuation centres. In case of long term evacuations (more than one week), the operation of schools is also seriously affected due to occupation of school rooms by refugees. No tents, mosquito nets or first aide kits are stocked, since no storage facilities are provided in any of the evacuation centres. People have to wait for a long time for emergency goods to be transferred from Kisumu. It is therefore recommended that storage with necessary goods should be installed in each evacuation centre. If tents are available in the stock, the space of the centres can be utilised efficiently. For protection from malaria caused by floods, mosquito nets will be very useful.

In is also reported that some evacuation centres are sometimes submerged by flood. This

means that people have to relocate to other centres during the flood period and accordingly their movement will be very dangerous. It is therefore recommended that ring dikes or land raising of evacuation centres should be promoted to avoid submerged condition as illustrated in Figure 5.4.37.

Image of Ring Dyke

Image of Land Raising

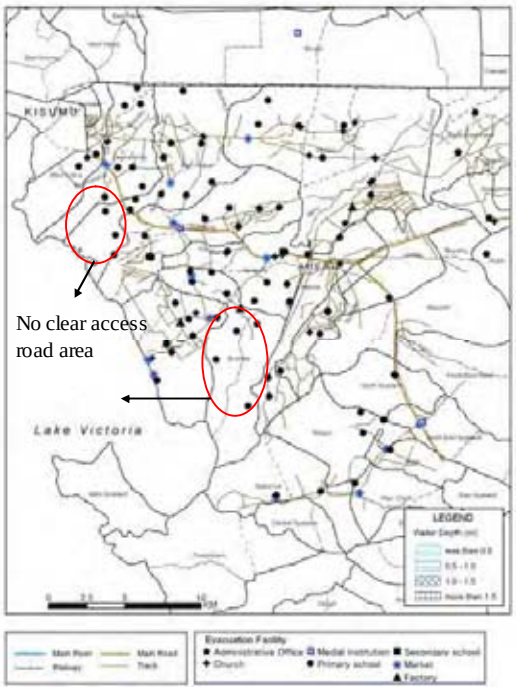
Source: JICA Study Team, 2006

Figure 5.4.37 Images of Ring Dyke and Land Raising for Evacuation Centre

Access to evacuation centres

According to the analysis of satellite images, most evacuation centres have access roads as shown in Figure 5.4.38. However, there are no clearly identifiable access roads to some evacuation centres located in the downstream area in East Kolwa and Bwanda locations. Therefore, it may be difficult for local people to get to these evacuation centres and accordingly, some improvements will be required. According to the flood damage survey, respondents noted dangerous rocks and snakes near the submerged roads during evacuation. In addition, it is quite dangerous to cross small tributaries or canals during flood.

The following countermeasures are proposed.

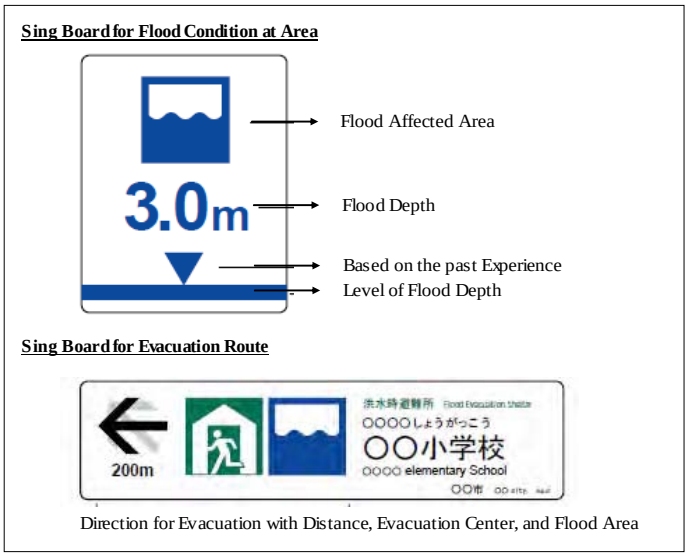


Source: Analysis result of JICA Study Team Based on Aster Image

Figure 5.4.38 Access Road to Evacuation Centre

- ✓ As explained in the community flood hazard map, communities should discuss which evacuation routes are dangerous and which are safe through preparation of community flood hazard maps. And those results should be disseminated to the public through information boards.

- ✓ In Japan, sign boards are widely utilised to disseminate information regarding flood conditions in an area and indicate safe evacuation routes as illustrated in Figure 5.4.39. Those sign boards could be useful in the Study Area, since the installation cost is cheap. In addition, guide poles indicating evocation routes are also useful, since it is difficult to identify the evacuation route under submerged conditions. Based on the result of the community flood hazard map, the necessary sign boards and guide poles should be installed under the community initiative with financial support of the government.



Source: HP of Ministry of Construction and Transportation, Japan

Figure 5.4.39 Signboard for Flood Damage Mitigation in Japan

- ✓ As structural measures, road raising should be promoted to maintain safe evacuation routes to evacuation centres. The above mentioned sign boards with road raising are more effective.

Evacuation Drills

After production of a community flood hazard map, practical evacuation drills are necessary to identify and mitigate flood hazards in the real world situations. The objectives of the evacuation drills are to:

- ✓ Afford an opportunity to community leaders, CBOs, and local people at community level to prepare in a practical manner for the real event;
- ✓ Analyse the availability and functionality of the equipment and resources deployed to run the warning and evacuation systems; and
- ✓ Ensure greater role clarity of the key players, i.e., community leaders, CBOs, and local people.

A sample evacuation drill programme is shown in Table 5.4.7.

Table 5.4.7 Evacuation Drill Programme (Sample)

Activity	TIME
1. Registration	0.00 – 0.15
2. Recitation	0.15 – 0.20
3. Explanation of Objectives of the Drill	0.20 – 0.25
4. Introduction to the Drill Process	0.25 – 0.35
5. Evacuation Process and Routes & Evacuation Centre	0.35 – 1.00
6. Announcement of Warning Directive by Administrator	1.00 – 1.05
7. Execution of Drill	1.05 – 2.00
8. Discussion and Feedback	2.00 – 2.45
9. Assessment of observer	2.45 – 2.55
10. Final Remarks and Close	2.55 – 3.00

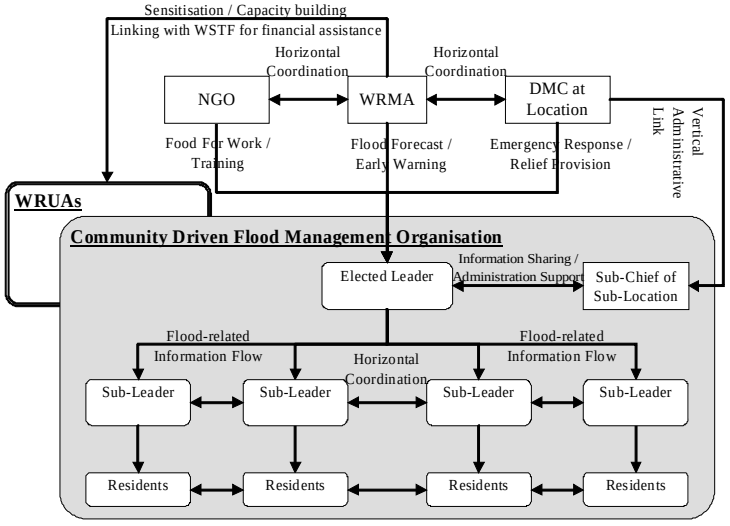
In the evacuation drill, the following points should be discussed amongst participants in order to increase awareness of disaster management.

- ✓ Recommendations for evacuation of potentially vulnerable areas as illustrated in the community flood hazard map should be explained.
- ✓ Proper evacuation with community participation should be undertaken with assistance from community leaders and CBOs.
- ✓ Roles of community leaders and CBOs should be clarified in order to compel evacuation within their jurisdictions to provide prompt and necessary actions to save the lives of the members of their community.
- ✓ The condition of established evacuation routes should be confirmed.
- ✓ It is desirable that the assembly point should be within no more than a 30 minute walk.
- ✓ It is preferable to encourage the entire family to evacuate together as a unit.
- ✓ It is preferable to secure their homes. Close and lock doors and windows.
- ✓ Adequate communication, toilets, and water supply are essential. This will minimise confusion and congestion.
- ✓ All organisations involved in the evacuation must have a common understanding of their roles and responsibilities in order to avoid confusion and panic.
- ✓ Elderly and disabled persons should be transferred to the nearest evacuation centre with the help of the local people assigned.

(7) Community-Driven Flood Management Organisations

Currently, there are several types of flood control or disaster management bodies at grass-root level. These are typically implementing small-scale structural measures such as de-silting of drainages / canals, developing water pans, raising rural roads and so on, while some are being trained in flood management by NGOs. However, these measures have limitations to prevent flood damage and protect human life and properties and there is no well-organised flood management organisation at community level. In addition, most of these measures have been driven by external organisations, and accordingly it seems that the self-will of communities is still not strong enough to continue the activities or maintain the structures after the completion of external assistance.

With the above background, it is of necessity that community driven flood management organisations be established to mainly deal with both small-scale structural measures and non-structural measures. The institutional framework at community level is conceptualised in Figure 5.4.40.



Source: JICA Study Team (2006)

Figure 5.4.40 Concept of Community Driven Flood Management Organisation

It is emphasised that the activities should be community-driven. Therefore, the activities related to mutual help with external organisations for flood management should be done through community initiative, and external organisations should focus on creation of awareness of flood disaster mitigation measures. On the other hand, the external organisations can assist activities related to self help for flood management through capacity development of community driven flood management organisations. Fortunately, WRUAs, with which WRMA can directly liaise, could be one of the strong external organisations to support in provision of capacity building and financial assistance, when the community organisation becomes a member of WRUAs.

The proposed activities of community driven flood management organisations and necessary assistance of external organisations are listed in Table 5.4.8.

Table 5.4.8 Role of Community Driven Flood Management Organisation and External Organisation

Item	Community driven flood management organisation	External Organisation
1. Establishment of organisation	✓ Understanding of necessity of organisation ✓ Formulation of organisation and appointment of key members ✓ Preparation of by-laws	✓ Awareness creation through workshop on community flood hazard map ✓ Training in disaster management to members
2. Education for disaster management	✓ Posting and maintenance of sign boards showing community hazard maps ✓ Coordination with schools and external organisations	✓ Technical assistance including provision of materials
3. Evacuation drill	✓ Preparation of drill ✓ Sharing roles amongst community members ✓ Improvement of evacuation drill	✓ Technical assistance including provision of materials
4. Maintenance of existing structural measures	✓ De-silting culverts, streams and channels ✓ Developing water pans ✓ Rehabilitation of rural access roads ✓ Request for external assistance, if necessary	✓ Technical assistance ✓ Financial assistance including provision of machinery, if necessary
5. Monitoring of river flow level	✓ Request for external assistance from WRMA ✓ Monitoring and reporting to WRMA	✓ Technical assistance ✓ Financial assistance including provision of equipment, if necessary
6. Dissemination of information	✓ Coordination with WRMA and DMC ✓ Disseminating early warning information within the community ✓ Collection of information on victims ✓ Reporting to DMC	✓ Technical assistance ✓ Installation of sirens ✓ Coordination with community ✓ Analysing and Providing information
7. Relief and evacuation	✓ Assisting socially vulnerable people for evacuation ✓ Management of evacuation centres ✓ Coordination with DMC ✓ Temporary construction of flood barriers	✓ Coordination with community ✓ Analysing and Providing information ✓ Supply of emergency food, medicine and goods etc.
8. Restoration of community	✓ De-silting culverts, streams and channels ✓ Rehabilitation of rural access roads ✓ Request for external assistance	✓ Technical and financial support
9. Improvement of flood preparedness	✓ Community meeting for improvement of disaster management ✓ Revision of community flood hazard map ✓ Request for external assistance, if needed	✓ Inspection of affected area ✓ Public hearing ✓ Revision of flood disaster map

Source : JICA Study Team

In reality, disaster prevention activities are wasted efforts if no disasters occur. Based on this reality, the communities where flood damage is serious and the need for flood prevention measures are high, are designated as prioritised communities. For establishment of community driven flood management organisations, it is proposed to prioritise communities in terms of the level of flood damage risk as shown in the flood disaster maps (Figure 4.6.5).

In general, the communities affected by floods are economically and socially stunted compared to other communities due to such flood phenomenon. For example, those communities have common problems with poor access roads to town due to muddy conditions, limited economic activities during the rainy season, spread of malaria and contamination of domestic water due to poor drainage, etc. If those situations are improved, people will be motivated to conduct flood prevention activities. This means that flood prevention activities need some economic and social development in flood affected communities. In addition to preparation of flood prevention activities, other measures to be developed by utilising flood prevention measures or by-products of the prevention measures have to be considered for further development of the communities. That approach will provide good incentives to the affected communities to maintain and improve flood prevention activities. The following best mixes are assumed.

- ✓ Combination of road improvement and income generation skills training

  Road improvement resulting from disaster prevention measures improves access to markets. To maximise the effect of new markets, road improvement can be combined with income generation skills training. Diversification of income sources including apiculture, fish farming and obtaining basic business knowledge including bookkeeping and formulation of implementation plans are considered for the training menu.

- ✓ Combined use of evacuation facilities

  Construction of evacuation centers is assumed to be a component of the flood prevention measures. Where the existing facilities, including existing schools, are utilised as evacuation centers, the facilities are to be improved and repaired. Plus, disaster prevention education is to be provided for the students. On the other hand, where evacuation centers are newly constructed the centers are to be utilised as community halls for meetings of community organisations and events.

- ✓ Improvement of drainage channels in cultivated land

  Overall function of irrigation facilities is reduced due to sedimentation in the irrigation channels, so removal of accumulated soil in irrigation channels is to be implemented. Enhancement of crop productivity and strengthening drainage capacity in the communities are expected through the removal of accumulated soil. Removal of accumulated soil in the irrigation or drainage channels should be done by the communities.

In the concept, WRMA will be expected to play a key role in provision of flood forecast service and early warning information to the communities through an established disseminating system. Then, the flood information will be disseminated from the leader through a sub-leader to the

community residents for prompt response to any emergency. It is proposed that the organisation should be headed by an elected leader from the community employing the existing structure applied by CARE, while the Sub-Chief of his sub-location should connect with and provide administrative support to the organisations.

5.5 UPPER WATERSHED MANAGEMENT

5.5.1 Existing Activities in Upper Nyando Catchment

The following activities related to catchment conservation are identified in the upper Nyando catchment.

Table 5.5.1 Existing Activities related to Catchment Conservation in Upper Nyando Catchment

Activity	Site	Responsible institution	Source of funding
Eucalyptus plantations for wood fuel supply	Western and S/western Mau Forests-Kericho	Multinational tea estates	Own development budget
Eucalyptus plantations for wood fuel supply	Tinderet Highlands	Tinderet Tea Company	Own development budget
Community based conservation of natural forest in Tinderet Hills	Tinderet Forest	Kenya Forest Service and WWF	WWF
Reforestation of pulpwood logging sites	Timboroa Forest / Northern Tinderet Forest	Kenya Forest Service in association with Panpaper Mills	Panpaper and GOK
Forest boundary management and protection through use of tea buffer belts.	South Nandi Forest	Nyayo Tea Zones Development Corporation	NTZDC and the African Development Bank
Research in catchment cover rehabilitation	Londiani/ Western Mau Forests	Kenya Forestry Research Institute	GOK and other KEFRI partners
Soil and Water Conservation programme under the National Agriculture and Livestock Extension Programme (NALEP)	Agricultural highlands in Kericho, Uasin Gishu and Nandi South districts	Ministry of agriculture and SIDA	SIDA and GOK
Land rehabilitation and forestation for carbon sequestration	Agricultural highlands in western Kenya including Nyando	KARI under the Western Kenya Integrated Ecosystems management project (WKIEMP)	GoK and the World Bank

Source: JICA Study Team

5.5.2 Restoring Hydrological Balance in the Nyando River Basin

The bulk of stream flow is produced in the upper and middle catchments of the Nyando river basin. However, the land's capacity to hold rainwater decreases due to encroachments on forest catchments, cultivation on steep slopes and prevalence of shallow soil areas. Therefore, the land's capacity to hold rainwater should be restored so as to maximise infiltration in line with the principle of holding rainwater where it falls. Particularly targeted areas are the Lower highland and Upper Midland belts in Nandi Hills, Tinderet, Timboroa and Londian and the middle catchments of the Ainobngetuny, Mbogo/Kipsiwa, Malaget and Masaita. The following interventions will be applied to restore hydrological balance in the basin: i) intervention in land use in slope areas, and ii) intervention to recreate hydrological buffer zones.

(1) Intervention in land use in slope areas

According to the Agriculture Act, all land with slopes in excess of 30% should be reserved for conservation as either forests or bush lands. Failure to apply this requirement in the Nyando basin causes the high erosion rates observed for the Ainobngetuny and Malaget sub-basins and also accounts for the frequent occurrence of landslides in Tinderet division. The situation is likely to be aggravated by the ongoing trend of opening up more bush lands for settlement and cultivation which will ultimately alter the ability of the land to hold and transmit rainwater thus leading to more runoff and erosion, ultimately converting the land into one giant rock catchment. The following countermeasures will be applied.

- Alternative land-use options: Land owners should be discouraged from opening up and settling on land in excess of 30% slope. Instead, such land could be developed as forest plantations or woodlots as currently being promoted by Thuiya Enterprises. Indeed, the Government of Kenya should look for means of promoting the concept of contractual wood farming.
- Increase of woody vegetation on already settled areas: Where the land is already settled, and tilled, agro-forestry should be intensified with a view to increasing the carbon stocks on the farms, firstly to shield the land from direct rain action while anchoring the land against shearing and incidence of mass slides. The trees are also proving to be a viable cash crop which is another option for confronting poverty.
- Use of soil conservation measures: Measures such as terracing should only be adopted where the soil is determined to be deep enough to facilitate seepage without risking mass slides. In such cases, the professional consultants that are working in soil conservation under the National Soil and Water Conservation Project (NSWCP) should be tapped to sustain on-farm conservation under the Local Area Development Committees.
- Adoption of runoff detention measures: Shallow soil areas have a limited natural capacity to hold rainwater. The key characteristic of such watersheds is the tendency to suffer peak floods which are lagged after the rains followed by low dry season flows due to absence of base flow recharge. In this case, installation of small reservoirs across the rivers will be crucial in stabilising stream flow for purposes of reducing flood severity downstream while storing runoff for dry season water supply.

(2) Interventions to recreate lost hydrological buffer zones

Buffer zones mainly comprise natural vegetation in riparian areas such as river banks and wetlands[1]. Though most land classified as wetlands was reserved under the Trustlands Act, many such lands have currently been allocated to individuals or converted to other public uses by the community. Continued loss or degradation of riparian buffer zones are undesirable, since degradation of buffer strips deny the land vital anchorage against erosive action and could accentuate river meandering thus exposing flood plains to untold damage from migrating river channels. This is a trend that needs to be checked, more so in the Nyando basin where the flood plain is proportionately smaller and is surrounded by escarpments from which water ensues with great force. The following countermeasures will be applied.

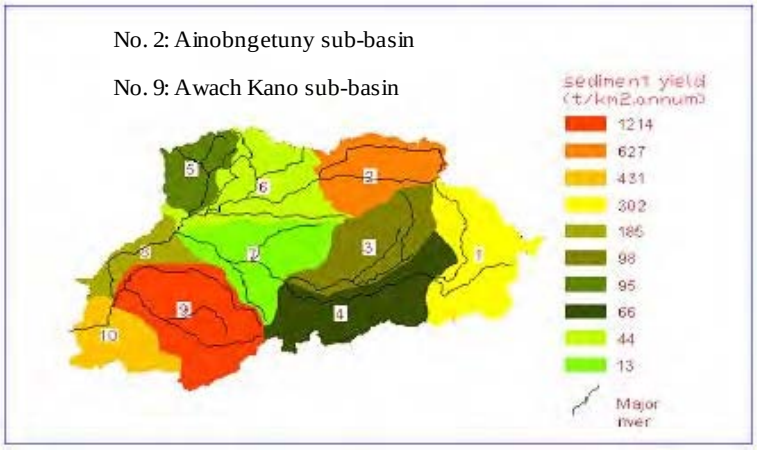
- Policy review: Reclamation of wetlands for agriculture is officially supported by the government as a means of combating food insecurity and rural poverty. It is not clear that national economic goals should always override other strategic interests, and though this aspiration is captured in diverse policy documents, its does little to influence critical decisions. It is a requirement that could benefit from further elaboration under the ongoing review of the national irrigation policy. Indeed, the irrigation policy should come out quite forcibly on when a wetland should not qualify for conversion into an irrigation scheme.
- Implementation of requirements of the Water Act 2002: In the past, lack of a designated agency responsible for wetlands left them orphaned and thus exposed to indiscriminate abuse. However, the Water Act and its associated Draft Water Rules now clearly afford protection for wetlands alongside other riparian areas. Alongside resolving other institutional issues (see section on policy below), WRMA should move to spearhead measures towards protection of wetlands and river bank areas as stipulated in both the agriculture land Use rules and the Draft Water Rules.

5.5.3 Mitigation of Soil Erosion and Sedimentation

In spite of cultivation and settlement on very steep land, the problem of sediment load within the main Nyando River is moderately severe. As shown in sub-chapter 4.2, the sediment load is estimated to be in the order of 200 to 300 t/ km^2/year which is low compared to the 300 to 500 t/ km^2/year in other basins nearby. This possibly indicates the prevalence of a low

[1] In the highland areas, wetlands such as Simboyon, Bartion, and Kibrong (all in Londiani Location of Kericho district), the Kamngorion in Aldai location of Nandi district, the Chagaiya swamp in Timboroa location of Uasin Gishu etc, are former dams and ponds that silted up and became colonised by papyrus vegetation. The Central Kano Wetland (covering about 20 km^2) is located at the confluence of several small streams including the Ombeyi, Oroba and little Miriu all draining the sugar belt at Miwani.

sediment delivery ratio on account of eroded soil being trapped and detained by bush lands and sugarcane farms towards the lowlands. However, in the rest of Nyando basin, localised belts suffering correlated soil erosion and attendant sediment yield will be encountered such as the Katuk Odeyo gully site in Awach Kano sub-basin. In this regard, both the Awach Kano sub-basin and the Miteitei Valley in Ainobngetuny sub-basin are leading in sediment delivery into Lake Victoria as shown in Figure 5.5.1.



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 5.5.1 Annual Mean Sedimentation Yield in Nyando River Basin

- Rehabilitation and construction of water pans: Urgent attention should be focused on the Awach Kano sub-basin at the Kericho-Nyando District boundary where existing water pans require de-silting, expansion and fitting with draw off systems to supply cattle troughs downstream to eliminate the need to walk long distances to access water. Additional water pans are also required to augment the current water supply.

- Management of the woody vegetation: A combination of measures aimed at reversing the ongoing decline of standing woody biomasses needs to be put in place. These should include demand driven tree nursery development and tree planting as currently being promoted and technical support in promoting natural regeneration under controlled grazing. A whole range of techniques such as fencing of saplings, selective retention of non-palatable woody species etc. can be applied to effect re-establishment of desired stocks of standing woody biomasses in pasture lands.

- Evacuation options: The Katuk Odeyo Gully site has been the subject of many rehabilitation efforts including tree planting. The key issue here is subsurface drainage of water through sodic layers which are selectively eroded leaving a hanging over-burden which later on collapses to create a badland. Once the

badland has set in, it is quite difficult to rehabilitate as there are no readily available means for control. Even terracing and cutoff drains are likely to initiate gully development through concentrating and infiltrating runoff water, while any measure that concentrates trampling pressure in one place is likely to also trigger new gully heads. Therefore, the entire area in the vicinity of the gully site becomes unsuitable for human settlement and should be evacuated in favor of conservation.