

# LOW COST IRRIGATION, FARM-LEVEL WATER MANAGEMENT IN WATERLOGGED LOWLAND.

## NYAMTHOI, KISUMU, NYANZA, KENYA.

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### ABSTRACT

*A special programme for food security (SPFS) was launched in Kenya in 1995. For the past decade, Kenya's agricultural production has no longer been able to keep pace with its population growth. The country is now faced with chronic deficits in maize, wheat, rice, oilseeds and sugar. In the past, the Government has given priority to the development of large scale, these top down systems, which have proven too excessively costly to construct and beyond the Government's financial capacity to maintain.*

*The current 7<sup>th</sup> national development plan gives high priority to commercially oriented smallholder schemes based on farmers' own investment and operation, to generate employment, enhance food security and increase rural incomes. FAO assistance is requested to implement the SPFS, especially through pilot small-scale water control activities.*

*A waterlogged lowland in the coast of Victoria lake, in Kisumu, was selected as demonstration area of innovative low-cost irrigation and drainage development and water management in waterlogged lowland. Simple water management in flood protection, water control, agricultural practices, reclamation, furrow and ridge land preparation were successfully introduced to the farmers. The project could convince the farmers that the flood could be managed without jeopardizing the environment and using low cost technology.*

### INTRODUCTION

The Special Programme on Food Production in Support of Food Security (currently, The Special Programme for Food Security-SPFS) was launched in Kenya in 1995 under the name of Kenyan Accelerated Food Production Programme. Subsequently the Programme has been expanded to include a water management component. In view of the importance of improved water management and the considerable opportunities for demonstrating new low-cost approaches to water control improvement, one of the option is farm-level water management in waterlogged lowlands.

The main expected project output will be water management and irrigation demonstration of low-cost water management and irrigation technology and sound operational practices, that are financially accessible, familiar to and accepted by the farming communities to trigger self-sustainable development in and around selected demonstration. A waterlogged lowland in the coast of Victoria lake, in Kisumu, was selected as demonstration area or project area. The project area is located approximately 3 kilometres off the Kisumu - Ahero highway. Figure 1 shows the location of the project area.

District Irrigation Unit of Kisumu District under

FAO-Special Program for Food Security made a Participatory Rural Appraisal (PRA) Report in January 1999. The District Agricultural Office (DAO) of Kisumu District has identified 700 ha of agricultural land in this site. The PRA report that was concluded by public *baraza* (meeting) attended by the District Agricultural Officer, farmers, administration and the PRA Team gives general description of the project area as follow.

The main river that serves the area is Nyamasaria River that is an artificial channel made in 1944 by the contractor who constructed the Kisumu - Ahero road as a way of controlling the flooding situation within the area. Further desilting of the channel was done in 1985 by the Anglican church to control flooding in the area. The Nyamasaria River is a perennial river with a very high variation of discharge and is the main suspected causes of flooding in the area. The catchment area of this river is Nandi hills, Kapsabet and Kaimosi area. This river eventually enters into a swampy area before finally entering Lake Victoria.

The project area lies between 1140 m to 1450 m above sea level experiencing rainfall between 1000 mm to 1400 mm per year. The type of rainfall is bimodal, having long rain between March and May and short rains between September and December.

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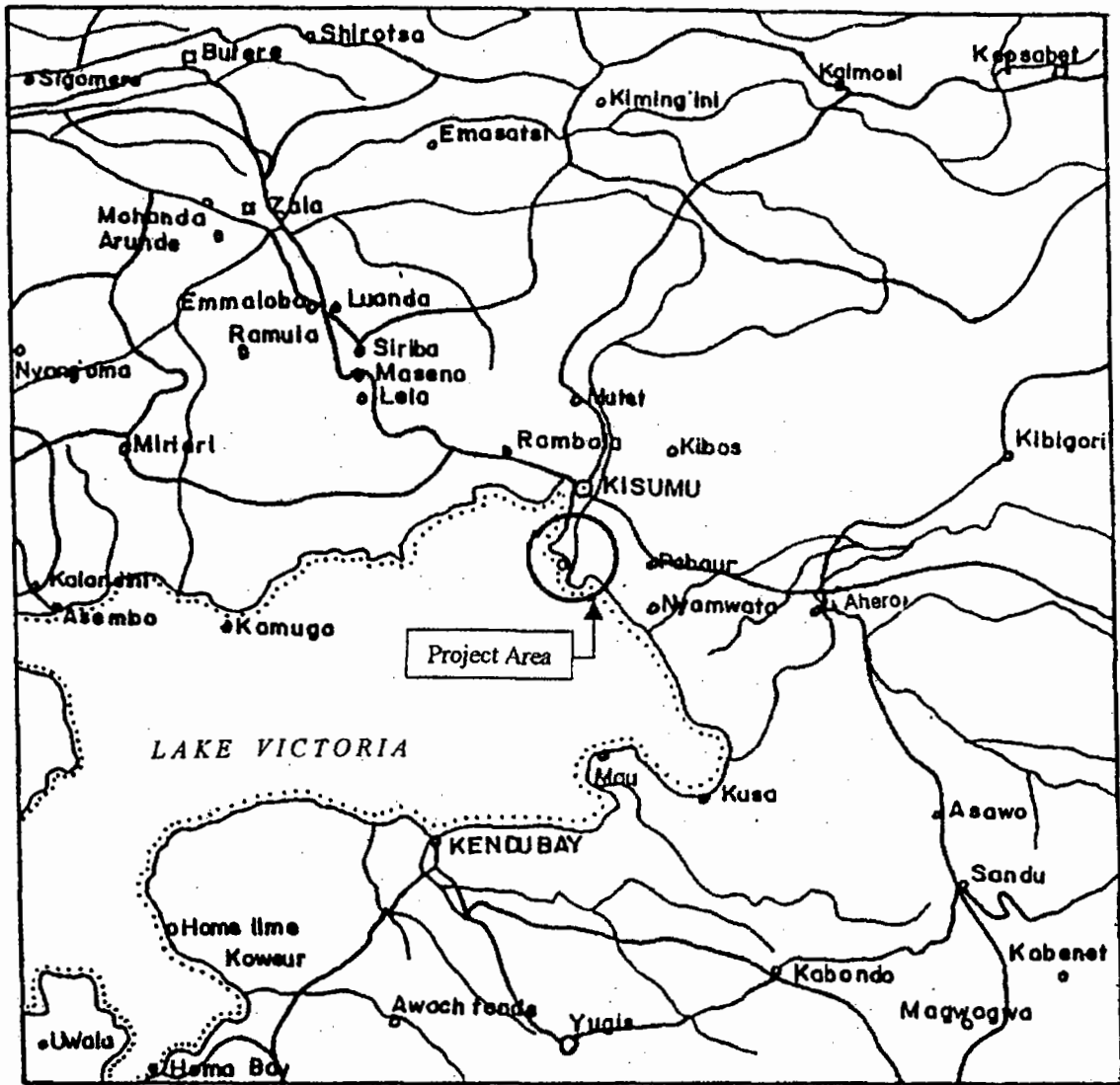


Figure 1. Location of the project area.

The slopes of the project area are low i.e. less than 1%. During the wet season waterlogging is a major problem and the area can be flooded from several weeks up to over a month. For this reason, farmers are currently using the land for farming during the dry season only. There are no settlements in the project area due to the persistent flooding problem. The main crop grown in the area are (main crops) sorghum, maize, sweet potatoes, cassava, beans, bananas, arrow roots and (horticulture) kales, tomatoes, cow peas, local vegetables. The livestock undertaken by the farmers in this area are rearing of cattle, goats and local poultry. The wild animals reported in the area are the waterbuck and hippopotamus that occasionally destroy the growing plants.

The constraints identified during the PRA and the subsequent Baraza, as being faced by Nyamthoe farmers are flooding during rainy season (especially in May) in the lower part of the area, low ground water table and drought during dry season in upper area, theft of crops, input financing, pests, wildlife (hippopotamus and waterbuck), lack of control of grazing animals, land apportionment and registration, access road.

The problem of scarcity of water especially during period of August – January is identified. This condition is also expressed by simple water balance that is calculated by Rachilo et al (1984). The calculation of data of Kisumu Station show the probability obtained for long rainy season (March - May) indicate that on average in one out of ten

seasons crop water requirement will not to be met by rainfall. And the period of August - January shows a high probability (0.94) that the crop water requirement will not be satisfied.

The farmers and residents that have organised themselves into an organisation known as the Kolwa Nyamthoe Farming Development Project (formed in 1997) proposed a canalisation (deepening and widening the Nyamasaria River) to cope with the prevailing flood. This proposal seems expensive to be implemented and has environmental risk of drying up the swampy area that is a sanctuary of many species of migrating birds and fish, and a source of drinking water for wild animals in the dry season, in particular when draught prevails.

A new concept of development deals with the water management is introduced. This concept should prevent the agricultural area of being flooded during rainy season.

### PROBLEM APPROACH

The development of waterlogged lowland, which is part of the water resources development, has a broad meaning and includes all human activities that make water available for a desired purpose. That is, all activities constructed for impoundment, drainage, or recapture of any portion of water resources for irrigation, flood control, livestock watering, fisheries and wildlife preservation. Where water resources are abundant, both quantitative and qualitative senses, relative to the demand, water resources seem to be free goods. However, when competition between its function increases, it becomes clear that water resources are indeed scarce. Therefore, it is the task of the people to sustain the available water resources to future generation.

The World Commission on Environment and Development (WCED 1987) defined the objective of sustainable development as : "*to meet the needs of the present generation without jeopardising the possibilities of future generation to meet their own needs*".

The Dublin Statement gave guiding principles on water and sustainable development and asked concerted action which is needed to reverse the present trends of over consumption, pollution and rising treats from drought and floods. The four guiding principles are:

1. Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Effective management of water resources demand, a holistic approach, linking

social and development with protection of natural ecosystem.

2. Water resources development and management should be based on a participatory approach, involving users, planner and policy makers at all levels. A participatory approach should be taken to raise the awareness of the importance of water among policy makers and the general public.
3. Women play a central part in the provision, management and safeguarding of water. Empower women to participate at all levels in water resources programs, including decision making and implementation in way defined by them.
4. Water has an economic value in all its competing uses and should be recognised as an economic good. Managing water as an economic good is an important way of achieving efficient and equitable use and of encouraging conservation and protection of water resources.

In the project area, the deficit of water for agriculture that happens during month of August up to January (PRA Report, 1999), brings about the difficulty to the farmers to grow their second crop. The excessive water that normally come and flooding the project area in May, although the duration of flooding is only about one or two weeks could destroy the crop. Management of water resources that could satisfy these two extreme conditions needs a holistic approach with protection of natural resources and awareness of the importance of water among the policy makers and the farmers. It should be understand that controlling floods by means of deepening the river as a floodway, may result in reduction of groundwater recharge via flood plains and a loss of seasonal or permanent wetland.

Water management could not be simple if there is a water shortage. There are three approaches proposed to ease with water scarcity :

1. To strict but rationally manage the demand for precious water resource
2. To seek ways and means to preserve and augment the supply,
3. More preferably to combine the previous two options in an integrated management plan aiming ultimately to sustainable development.

The existence of the farmers and residents organisation of East, Central and West Kolwa Locations is an important asset for the participatory-based development of the project area.

The participation of the farmers in the water resources management program will enhance the stability of the development. The stability of

development can be achieved by managing the stability of water availability as well as planning the cropping pattern and the size of beneficiary area based on water availability.

The farmer participation in irrigation management could improve irrigation performance, water distribution and system maintenance.

A number of key lessons can be extracted from the experience of participatory programs (Bryan Bruns and Helmi, 1996):

1. Participation improves planning, helping to provide valuable local information, prevent problems and optimise use of local resources.
2. Local cost sharing increases benefits, both by mobilising additional resources and by increasing accountability to farmers, which then helps improve the quality and appropriateness of construction.
3. Institutional reforms promoted by participatory programs have often helped highlight problems and support changes, such as more equitable water distribution.
4. Training programs have helped improve capacity to carry out participatory programs. Training should continue to help orient staff taking up new responsibilities.
5. There has been a tendency to make participatory approaches excessively complicated. Simpler, more focused approaches to Participatory Irrigation Management are likely to be more effective.

## FIELD SURVEY

### Topography Survey

In order to know the potential of the project area to be irrigated and to be drainage, a survey of topography and hydrology should be achieved. The hydro-topographical condition of the land could define the way to irrigate and to drain the excess water.

Two transects profiles were made across the project area from Nyamasaria River to Odeso River. The result of these transects show the origin of the formation of the flood plain. The deposition of river sediment during flood created a wide levee along the Nyamasaria River. In this wide levee which is a fertile soil, the farmers grow their horticulture and food crops. This levee is about one meter above the mean water level of Nyamasaria River (in January 1999), it become lower and even lower than mean water level of Nyamasaria River, in the Odeso River flood plain.

The relation of land level and mean water level of the source of water (Nyamasaria River) could define the type of zone as follow :

- Zone I : Land elevation above the mean river water level, shallow ground water table,
- Zone II : Land elevation below the mean river water level, deep ground water table,
- Zone III : Land elevation close to mean river water level (swampy area)
- Zone IV : Land elevation below the mean water level, always submerged by water (swampy area).

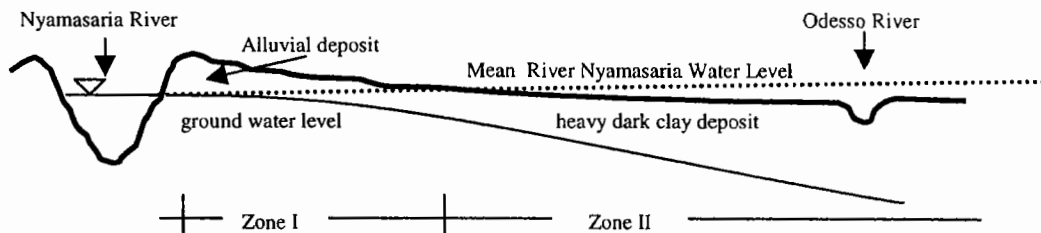


Figure 2a. Sketch of ground level in the upstream area.

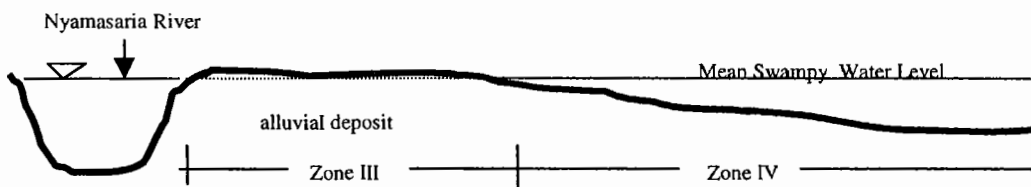


Figure 2b. Sketch of ground level in the downstream area.

## Soil Survey

A soil survey was conducted in the project area. The field observation involved mainly a grid system of auger-hole observations. Augerings were made to a depth of 200 cm. There were 6 points of observation, 3 of them were in the demonstration area. Soil profiles were observed from the auger-holes, their description was determined by using Munsell Soil Colour Charts. Two samples were taken from each auger-hole in depth of 0 - 50 cm and 50 - 100 cm.

The results show an alluvial deposit near the river. Close to the river, the alluvial deposit is generally silty clay to sandy clay until the depth of 1.50 m, and heavy dark clay is found below this layer. In the distance of 100 m from the Nyamasaria River, the alluvial deposit become tinny, which is found up to 0.50 m depth and the heavy dark clay is found below this layer.

## Hydrology Data

Climatic data are collected from Kibos Cotton Experimentation Station (9034081) and Kibos Sugar Research Station (9034105) that could represent the catchment area of Nyamasaria River. The table 1 shows the rainfall data in January 1999 from Kibos Sugar Research Station. A temporary observation of Nyamasaria River water level is also conducted during the topography survey. The river water level in the project area is really influenced by the rainfall in upstream area. During field visit on the 23<sup>rd</sup> January 1999, after several days' consecutive rainfall, the river water level raised about 20 cm above the river water level observed on the 21<sup>st</sup> January 1999. And the river water level decreased about 50 cm after 2 weeks of absence of rainfall as observed on the 9<sup>th</sup> February 1999. Considering this hydrological condition, aiming the possibility to irrigate the project area, the management of water source in the lower part of the project area is indispensable. An installation of staff-gauge in the project area for a routine observation of river water level is needed.

Simple water balance is calculated by Rachilo et al (1984) in the Report of Semi Detailed Soil Survey of a Part Nyanza Sugar Belt Rehabilitation Area, Kisumu /Nandi District. The calculation of data of Kisumu Station show the probability obtained for long rainy season (March - May) indicate that on average in one out of ten seasons crop water requirement will not to be met by rainfall. And the period of August - January shows a high probability (0.94) that the crop water requirement will not be satisfied.

Table 1. Daily Rainfall (mm) in January 1999  
[Kibos Cotton Experimentation Station (R<sub>1</sub>) & Sugar Research Station (R<sub>2</sub>)]

Date	R <sub>1</sub> (mm)	R <sub>2</sub> (mm)	Date	R <sub>1</sub> (mm)	R <sub>2</sub> (mm)	Date	R <sub>1</sub> (mm)	R <sub>2</sub> (mm)
1.	Nil	Nil	11.	18.7	2.4	21.	30.4	Trace
2.	Nil	Nil	12.	Trace	2.1	22.	12.4	2.0
3.	Nil	Nil	13.	Nil	17.3	23.	Nil	7.4
4.	Nil	Nil	14.	Nil	Trace	24.	Nil	Nil
5.	Nil	Nil	15.	10.9	Trace	25.	Nil	Nil
6.	Nil	Nil	16.	15.8	1.8	26.	Nil	Nil
7.	Nil	Nil	17.	Nil	50.8	27.	Nil	Nil
8.	22.7	Nil	18.	8.4	14.7	28.	Nil	Nil
9.	11.4	16.8	19.	10.7	1.0	29.	Nil	Nil
10.	2.7	1.5	20.	Nil	1.2	30.	Nil	Nil
						31.	Nil	Nil

Note: R1 is automatic rainfall gage, R2 is manual rainfall gage (data is recorded the day after)

The figure 3 shows the rainfall deficit during period of July - February.

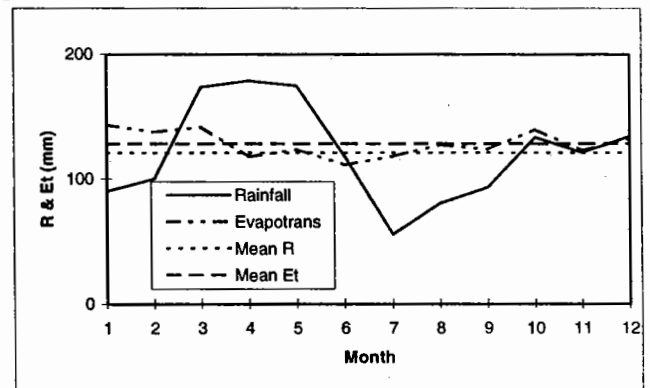


Figure 3. Simple water balance of mean monthly rainfall and mean monthly evapotranspiration (Kibos Station)

Another comparison of rainfall and evapotranspiration has been made base on 10 years rainfall data (1989-1998) and 10 years evaporation (1973-1982) prepared by Meteorological Observer NFRC - Kibos. The evapo-transpiration supposes to be 2/3 of the evaporation rate.

## PROPOSED CONCEPT OF DEVELOPMENT

Waterlogged lowland could be defined as an area that in its original state subject to be flooded permanently or seasonally due to bad natural drainage system. The transformation of the water logged land into an agriculture land could be done by intervention in the natural hydrological system i.e. land reclamation, impoldering or improvement of drainage system. The appropriate intervention should consider the land elevation relative to the mean water level of the adjacent natural drainage system.

The hydro-topography analysis divide the project area into 4 zones as stated above.

Considering that hydro-topography condition, the project area could be distinguished into two ways of development:

1. The upper part of the project area (zone I & II), actually needs a supply of water during "dry season" (June – February), due to the water deficit (see figure 2). The deficit of water, (irrigation) could be supplied from the daily rainfall, surface irrigation (pumping) and sub-surface irrigation (high ground water table). Therefore the existence of water in the Nyamasaria River is very important for maintaining the ground water level and as the source for pumping irrigation. In the wet season, although in short period, the project area is reported being flooded that could destroy the cultivated crop. A flood protection consequently is needed it can be solved by building dike or improving the capacity of the river and drainage system. The improvement of discharge capacity of the Nyamasaria River and the inner drainage system is unfavourable because it will create a deep water table that is unexpected solution. The intention of building dike in this area is making the water flow less violent, so that there is a gentler flooding of the area in order not to destroy the soil and cause soil erosion. Flooding can supply rich alluvial sediment to the project area.
2. Development of the lower part (zone III & IV) involves land reclamation of the waterlogged lowland. Generally, reclamation of the waterlogged lowland associates with improvement of the

drainage system and deepening of the riverbed in the effort of evacuation of excess water. The disadvantage of this effort are a loss of seasonal or permanent wetland and lowering of mean water level of Nyamasaria River that will influence to the lowering the ground water table in the upper part.

The conservation of the seasonal swampy area in the lower part of the project area is important to support the availability of water source in the whole area. The backwater effect of the swampy water to the river water level could maintain the ground water level in the upper part of the project area. Figure 4 is a sketch to explain the influence of the improvement of river capacity by deepening the riverbed or widening the cross section to the lowering of the mean river water level and loss of source of water for irrigating the upper part of the project area.

Since the development of the lower part (zone III & IV) should not evacuate the excess water, the system developed should make use the abundant water by maintaining the water level in the area in the certain level. A furrow and ridge system that is widely used in Indonesia can be adopted for this purposes.

The construction of furrow in ridge involves lowering part of soil surface to improve the possibilities for growing crop during dry season and creating raised bed with the excavated soil where crop can grow during rainy season. The determination of the depth of the furrow and height of the ridge depend on the fluctuation of water level in the field and the depth of root zone of the cultivated crop. The sketch of furrow and ridge is shown in figure 5.

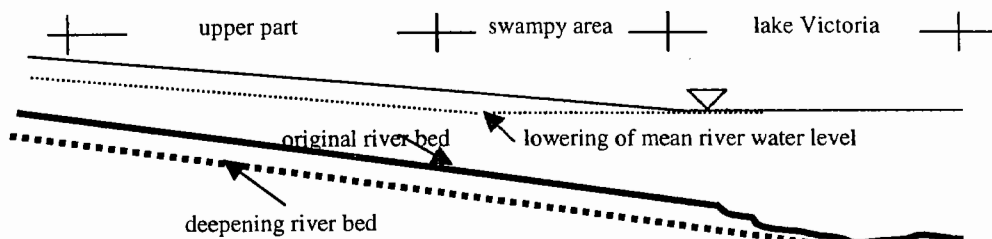


Figure 4. The effect of river deepening to the river water level.

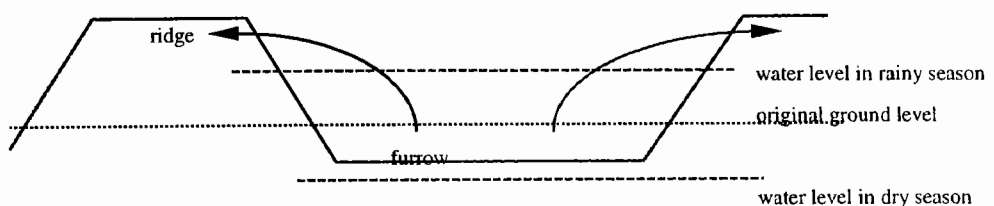


Figure 5. Sketch of furrow and ridge.

The other advantage of keeping the abundant water in the lower part is collecting the sediment that will be deposited and raise the ground level.

The proposed interventions in the project area that based on sustainable flood management and water management can be pointed out as follow.

1. Build a dike and fence locally (block of farm) to prevent flood destroys the cultivated crop and protect from wild animal.
2. Allow the project area to be flooded for several days that could give alluvial sediment to enrich the fertility of the land.
3. Prevent excessive drainage cause by deep drainage channel or deep river bed,
4. Allow 5 m - 10 m free space from the river edge as shallow flood-way,
5. Matching the cropping pattern to the climatic condition,
6. Applying furrow and ridge land formation in the low-lying area for giving possibility-growing crop in the wet season and in the dry season.
7. Introducing a kind of uplift device to elevate the river water to the upper part of the project area.
8. Encouraging the farmer organisation to participate in the design, construction and maintenance of the project as well as planning the cropping pattern that will enhance the stability of the development.

## PROJECT IMPLEMENTATION

A new concept of development deals with the water management is introduced. This concept should prevent the agricultural area of being flooded during rainy season. It is development of mini polder in the area with small variation of field level, surrounded by dike and collector canal. The collector drain supposes to be a diversion canal that could let the flood flows to other lower area that act as silting area and act as irrigation canal when needed. The tertiary canal maintains the water table inside the polder. A furrow and ridge is also introduced. The construction of furrow in ridge involves lowering part of soil surface to improve the possibilities for growing crop during dry season and creating raised bed with the excavated soil where crop can grow during rainy season. The demonstration area was selected in the area of about 10 ha consist of two demonstration sites of 5 ha each that represent the waterlogged lowland in the lower part and the temporary flooding area in the upper part. The proposed interventions for developing the water logged lowland in The Kolwa Nyamthoe Farming Development Project are as follows:

### 1. Flood Protection

- Build a dike along the boundary of the demonstration area, this dike could be use as the path road for the inspection of the whole scheme,
- Grow fence behind the dike (Napier Grass),
- Allow the area being flooded as long as not destroy the land formation and the crop,
- Allow 5 m - 10 m free space from the river edge to the dike as flood way,
- Prevent the excessive drainage by having shallow drainage system.

### 2. Water Control

- Dig shallow channel in the outer-ring of the demonstration area that could be used for irrigation and drainage purposes,
- Build tertiary channel that could supply or drain the water to or from the farmer field, tertiary channel could be in the boundary of the farmer field or inside the farmer field,
- Install orifice (PVC pipe with diameter of 4") across the main dike connecting the outer-ring channel with tertiary channel, the farmer should close or open this orifice as needed.
- Build temporary check dam in the tertiary or inner channel (if needed) to prevent excessive drainage and allow deposition of sediment for reclamation purposes.

### 3. Agricultural Practices

- Matching the cropping pattern to the climatic condition, avoid growing crop in the flood time,
- Applying the furrow and ridge system,
- Grow crop that match to the land suitability regarding the soil fertility and ground water elevation of the season.
- Ground water level fluctuation should be observed weekly during one year and plotted in to the graph. The farmer can use this graph for determining the height of ridge and the depth of furrow and also the type of crop grown.

### 4. Reclamation

- Flooding the lower area with river water, keep the water in the field, as the river sediment will be settled down.

### 5. On Farm Training.

- Introduction of flood management which means flood protection and land reclamation
- Introduction of furrow and ridge land preparation
- Training on the construction method of dike

- Training on water management, the operation and maintenance of the system, the task of farmer organisation on the O&M.
- Suggestion on cropping pattern considering the land suitability

The detail design and the computation of the channel capacity, dike height and required structures were simplified. As first approximation of the calculation, since soil mechanic and hydrological data (monthly river water level fluctuation) were not available, it is use the available data in the surrounding area to design the height of the dike. The aim of building dike is not to avoid flooding completely but aim at making the water flow less violent. The approximate design velocity for channel capacity calculation is about 0.4 m/s. The volume of water evacuated from the farm polder is calculated base on the volume of rain water during 2-3 consecutive days with 2 – 3 days drainage time. It is also advised to use an orifice (PVC) as a structure to control the incoming water and drainage water. This structure is cheap and easy to be managed.

The construction of the dike that were done by the farmers, were supervised intensively by the District Irrigation Engineer. This dike are built in a layer of 25 cm, let the soil settle down by rainwater and continued with the next layer. The soil for the construction of the dike are the soil yielding from digging the outer channel which is generally light clay soil, instead of using the dark heavy soil that is found in lower layer (below 75 cm of the ground level). It was reported that the farmers have finished, enthusiastically, the construction of 860 m dike and collector canal that is not only surrounding the demonstration area but up to the boundary of their land. In certain part, especially in the part that close to the river, the dike and the canal show its effectiveness of preventing flood inundation. The farmers are convinced that the dike can help them in developing the waterlogged lowland. The introduced furrow and ridge land formation were done by group of farmers. The first experience working with the group of farmers to build 5 rows of ridge with 5 m length and 1.5 m width just took 2 hours working hours. The farmers appreciated this land formation after they experienced their crops were survived when the water table rises due to high water level outside of the polder. In the other day they copied this method to the other land in the demonstration area.

The figure 6 shows a general layout of demonstration project.

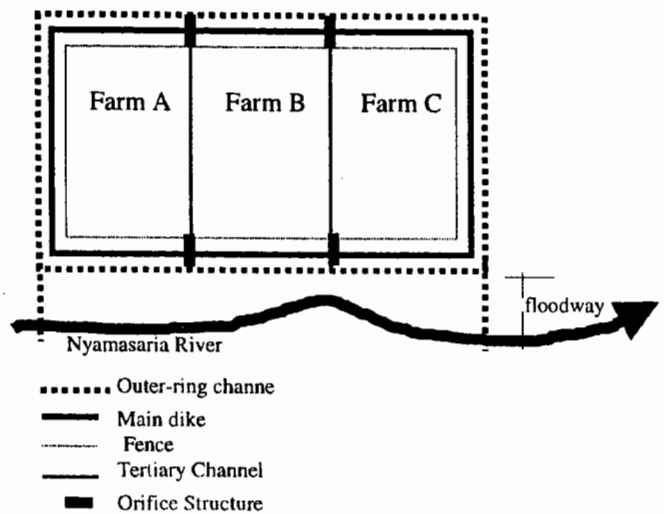


Figure 6. Sketch of the Design of the Demonstration Area

## CONCLUSIONS AND RECOMMENDATIONS

The potential of waterlogged lowland for agricultural areas is due to the fertility of the soil and its simple requirement in water management facilities. If properly planned and executed accompanied with well-executed conservation of important vulnerable ecosystem, the development of waterlogged lowland has important short and long-term advantages. The conservation of the swampy area in the lower part, will conserve the function of water retention as the source of water in the project area and surrounding, conserve the wild life and other biological life (flora & fauna) that support the ecosystem of the whole area.

Water management in the waterlogged lowland means either evacuating excess water or maintaining a stable ground water level for agricultural purposes. Water management options in waterlogged lowland are to a large extent determined by the prevailing soil and hydro-topographical conditions. This makes it in principal possible to subdivide an area into different zones on the basis of identical water management potentials and constraints. These water management zones could be a useful tool both at the planning stage to delineate areas where a specific hydraulic system design will be adopted, as well as during operations of the system to serve as guidelines on water management for both field staff and farmers.

Land preparation practices through furrow and ridge system could give possibility of having crop diversification. The construction of furrow in ridge involves lowering part of soil surface to improve the possibilities for growing crop during dry season and



creating raised bed with the excavated soil where crop can grow during rainy season.

The drain depth and drainage spacing that could control the ground water level was determined considering the depth of root zone of the crop. The drain depth is 60 cm from its original ground level, with 60 cm width, and drainage spacing is about 7 – 10 m.

For the stability of the system (stability of water supply, stability of water availability, stability of production, stability of water management) the farmer organisation should be encourage to participate in the design, construction and maintenance of the project as well as planning the cropping pattern. There must be a training for the farmer and for the trainer that consist of the basic criteria of the development of waterlogged lowland, the advantage and disadvantage of development, problem identification, the solution, the design technique and the method of operation and maintenance.

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