PART 2 ECOLOGY AND VECTOR BORNE DISEASE

1. GENERAL

1.1 Objectives

The purpose of this study is to make an assessment concerning whether the project may cause any adverse affect in the environmental and ecological aspects, and to provide available information to the decision makers. To attain the purpose, the following tasks are carried out.

- To study existing natural and social environmental conditions of the area to be affected by the project.
- To implement Environment Impact Assessment (EIA) for evaluating magnitude of impacts from the project.
- To propose countermeasures for mitigating the magnitude of the impacts.
- To evaluate the acceptability of the project through the view point of the environment, and to recommend further study if any.

1.2 Study Area

In general, a range of influence area relating to a irrigation project is rather extensive, especially as this project is closely related to other projects, such as Mgagwagwa Hydroelectric Power Development Project, Sondu/Miriu Hydropower Project. But in this case those connected projects will be excluded from this study, because each of these projects must have been covered by Environmental Study. Also, excluded is the item of water quality and eutrophication which will be covered in another chapter.

1.3 Approach to the Study

Screening and scoping approaches were taken for study to ensure time and cost saving for implementation of Environmental Impact Assessment (EIA) of the project. The screening was conducted based on the existing guidelines related to EIA in Kenya, and the scoping was carried out by considering Initial Environmental Examination (IEE) for the project.

IEE is essentially an initial examination of the environmental effect potentials for the proposed project based mostly on the preliminary information which can readily be obtained in the first stage of study period. Thus, IEE is the first approach of EIA by scoping, which determines whether a detailed EIA will be required or not.

As for the screening, the environment management guideline in the Environmental Management Report prepared by National Environment Secretariat (NES) Ministry of Environment and Natural Resources in 1982, was used as the criteria for screening of types of the Project which EIA is needed to be conducted and for the selection of environmental aspects to be assessed.

2. STUDY OF EXISTING ENVIRONMENTAL CONDITIONS

2.1 Physiography

The study area is physiographically divided into three areas, the Kendu bay strip, the Nyakach plain and the Kano plain. The Kendu bay strip extends between the Awach Kibuon and the Sondu river, and lies in a slender shape at the foot of the Nyabond Escarpment. The Nyakach plain extends between the Sondu river and the Awach river. The plain is a rather elevated hilly area, and extends from the foot of the Nyabond Escarpment to northward. The Kano plain widely extends from the Awach river to northward, and it lies on the vast flat alveolus with the elevation between 1,235m and 1,300m above MSL.

2.2 Climate

The climate in the study area is characterized by two distinct seasons, a rainy season and a dry season. The rainy and dry seasons are further sub-divided into the long and short seasons respectively. The following is the seasonal distribution in the area.

1) Short dry season January - February
2) Long rainy season March - May
3) Long dry season June - October
4) Short rainy season November - December

The seasonal trend of temperature in the area is characterized by its wide variation. The annual mean maximum ranges from about 27°C to 32°C and annual mean minimum ranges from 14°C to 18°C. The relative humidity in the area narrowly varies between 55% and 75%. The annual mean A-pan evaporation in the area ranges from about 1,900mm at Chemelil to 2,200mm at Ahero. The monthly mean evaporation ranges from about 130mm to 220mm. The annual mean rainfall in the area ranges from about 1,200mm at Ahero to 1,600mm at Kibos. The monthly mean rainfall ranges about 77mm to 243mm. The monthly A-pan evaporation far exceeds the monthly mean rainfall throughout the year.

2.3 Vegetation

The study area has high potential for woodland probably because of fairly high rainfall and Combretaceus woodland is existing in some slope of the Nyabond Escarpment. However, it has been modified in most parts of the study area by grazing, burning and cultivating, so that the trees are usually found in relatively small patches with large stretches of wooded grassland in between. Acacia-Themeda and Combretum-Hyparrhenia scattered tree grassland are mainly covered in this area. And planted Eucalyptus trees are also commonly seen on borders of farms and homesteads. The vegetation of the study area is rather poor from a natural point of view.

Nevertheless, within those areas there are swampy areas which are not affected by human activities. There are two main swamps in the study area, the Kano swamp and the Nyando swamp. There are also some other swamps at the mouth of the Sondu river and lakeshore. Kano swamp is a very extensive low-lying flat area in the middle of Kano plain. Nyando swamp is spread widely at the mouth of Nyando river and covers an area of about 7,000ha and extends as far as Nyakach Bay. Papyrus (Cyprus papyrus) is the most common constituent of the lake-side swamp but many other plants are associated with it. Among those, tall grass reeds (Phrgmite austaris) and bulrushes (TyPha domingensis) occur commonly. And also many floating and submerged plants are present, Pista stratiotes, CeratoPhyllum demersum, Nymphaea caerulea, Salvinia molesta, Trapa natans etc.

2.4 Wildlife

2.4.1 Avifauna (bird fauna)

There are over one thousand species (1,065 in 1985) recorded from all over Kenya and it is one of the richest avifauna countries within the African continent. The study area is also quite rich in avifauna especially for waterbirds because the huge lake Victoria. 410 species were recorded in this area.

A total of 79 birds species were collected in the study area, mainly from a few days field survey in July (Table XI-2.1). This included 35(44%) waterbird species which were mainly recorded at paddy fields, lake and lakeshore. It was only a short period of field survey but the data recorded was already enough to conclude that the study area would be a good habitat condition for avifauna and that there is a possibility that more species would be recorded in a further detailed seasonal survey.

2.4.2 Other wildlife

Inquiry and questionnaire surveys were given to farmers, fishermen and specialists of wildlife in the study area. And some of Mammals and Reptiles data were collected (Table XI-2.2). The study area is widely cultivated and farmed, thus is not good habitat for wildlife. So it could commonly get information about mainly small animals like squirrel, mongoose, hare, vervet monkey etc. But it is remarkable that there are few species of water related animals despite the lake and swamps, i.e. Water buck, Otter, Hippopotamus, Crocodile and Terrapin.

2.5 Aquatic Biology

2.5.1 Ichthyofauna (fish fauna)

There were many endemic species, especially cichlid endemism was 99% which had over 300 species in Victoria lake. since the introduction in the late 50s and early 60s of Lates niloticus (Nile perch) and Oreochromis nilotica (Nile tilapia), respectively a voracious predator and a herbivore, there have been large changes in fish species composition. Nile tilapia had competed with endemic tilapias and taken over their habitat, so that some of the endemic tilapia specious, like O.esculentus, Tilapia zilli have been much reduced or may have disappeared. Nile perch have increased dramatically to prey principally on Haplochromis. Because Haplochromis population have much reduced, they switched to pelagic cyprinid Rastrineobola argentea (dagaa), small benthonic shrimp (Caridina nilitica) and even to juveniles including Nile perch itself.

Fishes in Winam Gulf and some rivers, have been collected from inquiry and questionnaire survey (Table XI-2.3). And it was mentioned also increasing of Nile perch and Nile tilapia even in the Gulf and also mentioned reduced species which were endemic tilapias, Labeo victoriae, Barbus altianalis. The observed decline may be due to the migration of Nile perch and Nile tilapia and also a tendency by fishermen to reduce mesh-sizes to catch indiscriminately even Juveniles. The ecosystem of the fish in the study area is still undergoing change and composition of ichthyofauna is also changing.

2.5.2 Water weeds and plankton

Nile cabbage (Pistia stratiothes) were commonly seen floating on the lake and widely along the lakeshore blown by the wind. CeratoPhyllum richardii, Salvinia moresta were also common water weeds of the lake. These weeds are a nuisance sometimes for fisheries, obstructing seining on the beach.

Phytoplankton data were collected from field survey and analyzed by JICA Study Team, shown in Table XI-2.4 and Figure XI-2.1. A study of the species composition and variation in the study area water showed that bluegreen algae (Canopyta) was predominant more than 90% of all plankton cells at all stations. The dominant species were Aphanocapsa sp., Anabena circinalis, Lyngbia linetica, Morismopedium glaucum. AphaenocaPsa sp. and Anabena circinalis are the most dominant species by cell number but Anabe- na circinalis is the main dominant species from biomass view point, because of individual size of the cell which Anabena has much bigger than Aphanocapsa. Those blue-green algae are generally found dominantly under nutrient enriched water and tendency of eutrophicated condition. The species composition and variation between stations has not much differences but cells number is increasing according as away from mouth of the Nyando river and it would be because of the sediment amount in the waterbody. In general, Pytoplankton biomass would be controlled by transparency.

2.6 Fisheries

Annual catches for Kenya Waters of Lake Victoria from the Fisheries Department in Kisumu, are shown in Table XI-2.5, and also shown some typical changed species in Figure XI-2.2. Total catch is increasing most of the year and it was 185,101 tones in 1990. Two migrated species, the Nile perch and the Nile tilapia were increased tremendously, about 1,400 times for Nile perch, 190 times for Nile tilapia within these 15 years. And also the catch of Rastrineobola argenta is increasing. Those three main species occupied about 83% of total catches of Kenya waters of Victoria Lake. It is also remarkable that small mixed catches are increasing probably because of using small mesh-sizes fishnet so called mosquito seining. Predominant fishing gear are gillnets, mosquito seines, beach seines, and long lines. Using of mosquito seines is increasing these few years, especially catching of small mixed species which is dominated by Nile perch juveniles.

Meanwhile, Haplochromis was reduced because of predation by Nile perch, and some other species, Bagrus, Protopterus, Clarias, endemic tilapias etc.; were also tendency of reduction.

Over half of total catches of landings come from open waters and about one third are landed from Winam Gulf beaches, less than 5% are from Nyakach Bay beaches. The newest data from three landing beaches (Kusa, Sango Rota, Nduru) along the Nyakach Bay, is shown in Table XI-2.6, though it is not complete because this year's data goes only to June. It shows that the fishermen along the Nyakach Bay are targeting not only Nile perch but also other small fishes like Clarias, HaPlochromis, Rastrineobola. It may be because of main fishing methods of mosquito seining and beach seining.

There are fishing activities going on some rivers in the study area, like Nyando river and Sondu river. The data of Sondu river has collected and shown in Table XI-2.7. The catches in the river were dominated by the butter fish Schilbe mystus. There has been a tendency to decline in the population of riverine fishes over the last 30 years and declined species include for Labeo victorianus, Alestes spp., Bagrus domac, Oreochromis leucostictus and Barbus neglectus.

2.7 Public Health

2.7.1 Health facilities

Table XI-2.8 shows a number of health institutions at the end of 1988 in Kisumu and South Nyanza District. The institution/population ratio in Kisumu District is 1/11,509, one in South Nyanza District is 1/16,109. Non-government institutions play an important part for public health in both districts.

2.7.2 Common disease

Morbidity of common disease in the study area is shown in Table XI-2.9. Infectious diseases are the leading cause of Morbidity. Malaria may be a main contributory factor to infant mortality.

2.7.3 Vector borne disease

(1) Malaria

Kano plain is classified by WHO as a holoendemic malarial zone with a high prevalence of malaria cases. And most of the study area is in the zone where malaria infection is possible throughout the year (Figure XI-2.3). Malaria is the single leading cause of outpatient morbidity in Kisumu and South Nyanza District in 1988. Because of the high prevalence of malaria in those area, it is thought that malaria may be a main contributory factor to infant mortality.

According to the inquiry survey form KEMRI, "Slide Positive Rate (SPR)," which is obtained by dividing positive blood slides by total slides examined, was recorded at about 70-90% in Kano plain. And according to the Division of Vector Borne Disease in Ministry of Health, rates of 42% and 55% were recorded at two schools' children in Lower Nyakach.

There are three species of human malaria parasite in Kano plain, Plasmodium falciphalam, P.malariae, P.ovale and P.vivax. P.falciphalam is the most common species in this area at about 8085%, P.malariae follows with a rate of about 10-15%, and the other species are found only infrequently. There is also Chloroquine resistant malaria parasite in this area and its rate was estimated at about less than 25% of P.falciphalam by KEMRI.

Anopheles gambiae is the main vector of malaria around the study area and it breeds mainly in paddy field, and open sunshine pools like foot and wheel print's pools. The fluctuation is affected by rain and rice growing cycle at the paddy field and population tends to increase in rain season and submerged period of paddy field. An.funestus is also a critical vector, particularly during dry period, when breeding is restricted to permanent water-bodies such as swamps, marsh and lake etc., and it also breeds in during mature rice field. There are also some other Anopheles species in the study area, An.pharaoensis, An.coustani, An.zemanni; which might transmit malaria disease.

The main method for malaria control is house spraying by Ministry of Health. And using the chemical of Permethrin (Pyrethroids), DDT, Fenitrotion (organochlorine), and Propoxur (Carbamate), but it has not been done systematically because of financial problem. It is also taking some control trial by National Irrigation Board (NIB) which are using of high spread malarial oil, introducing predator fish (Gambusia affinis), spreading Furdan (Lava control), and distributing mosquito net and anti-malarials.

(2) Schistosomiasis

Two species of Schistosoma occur in Kano plain, S.haematobium and S.mansoni; and most of the study area belongs to Schistosomiasis infected area (Figure XI-2.3). S.mansoni is the most common in the Kano plain and small portion of S.haematobium is occurring. In the case of South Nyanza district, S.mansoni is prevalent among the fishermen along the lakeshore, while S.haematobium predominant among the farmers in the immediate behind the lakeshore belt.

Out-patient morbidity in Kisumu District and South Nyanza District is not so high, a rate of less than 1%. But according to urine survey by KEMRI, 40% of people in Kano plain are infected by S.haematobium. And active case detection by Ministry of Health, Division of Vector Borne Disease, has recorded 37.7% at Ndori school children in Lower Nyakach in 1986. These differences between the rates may be explained by the fact that only serious symptom patients received treatment at hospital. It is estimated that one million people in Kenya are infected with Schistosomiasis.

The intermediate snails hosts for S.mansoni belong to the genus Biomphalaria group and those for S.haematobium is Bulinus africanus group. Biomphlaria group, all the species in the genus have a wide distribution over most Kenya, however specimens have never been along the coast area. Bi.pfeifferi is commonly found in the Kano plain, breed in a variety of permanent habitats ranging from small pools to dam; they breed in canals, furrows, ditches, drains and concrete reservoirs, but they are rarely found in swamps. Bi.sudanica is also found in study area. Bulinus africanus groups host snails have an extensive distribution below 1,800m above sea-level. They have wide range of habitats which may be permanent or temporary, including dams, canals, furrows and drainage systems, reservoirs and night storage dams to irrigation schemes, pools along wet weather water courses, pools caused by river flooding during heavy rains, and depressions. And some of the species, like Bu.nasutus and Bu.globosus can survive five to eight months of drought condition.

The main method for Schistosomiasis control carried out at present is moulluscociding using copper sulphate, niclosomide. And also Health Education to people is carried out by Health Education Unit.

(3) Trypanosomiasis (Sleeping sickness)

According to LBDA research and Health and Disease in Kenya, there is no distribution of trypanosomiasis vector (tsetse fly) in the study area (Figure XI-2.3). According to information from Kenyan Trypanosoma Research Institute (KETRI) at Alupe hospital in Busia, there have been only one patient from the study area in Nyakach, about five years ago. But there have been some patients from west part of South Nyanza district out of the study area. Alupe hospital is the only hospital of trypanosomiasis in Kenya and all the patients are coming to be treated not only from all over the Kenya but other surrounding countries.

There are two types of sleeping sickness would be seen to occur in the Nyanza Province:

1) the Gambian trypanosoma caused by Trypanosoma gambiense,

2) the Rhodesian trypanosoma caused by Trypanosoma rhodesiense.

It is transmitted by Glossina species (tsetse flies). Human and animal disease carrying Glossina pallidipes and G.palparius fucipes. Animal disease propagating G.brevipalpis. The study area is not in good habitat for those tsetse flies which are needed to have a fairly thick bushland.

Gambian Trypanosoma had been completely eradicated from the Nyando river basin by 1958 and Rhodesian trypanosoma has been low and gradually decreasing to a level at which it will be no major public health problem in Kenya.

(4) Result of questionnaire survey

1) For residents

A total of 208 questionnaires were completed. The study population consist of primarily subsistence farmers(92%), 62% of whom have their own paddy field. Most are between 30 to 50 years in age.

(A) Malaria

The proportion of people bitten by mosquitoes was larger in the morning and evening in houses. The frequency of bites increased during the long rainy season. People got bitten many times due to many pools near houses which could be the breeding sites of mosquitoes. People used insecticide but a low percentage of use of mosquito nets(37%) indicates consciousness of mosquito control is not so high. Throughout the year malaria occurred. When asked about malaria 67% of those questioned thought they had it, and 85% of whom thought they had it before. Experience of malaria at 96% finally, this shows the area is endemic area of malaria. Most patients took chloroquine for treatment but it is doubtful that they took a complete treatment, and incomplete treatment can promote drag resistance.

(B) Schistosomiasis

95% of people live near water such as a river or pond, and use water for domestic affairs and for body hygiene. A lot of people worked in paddy field with no protector. They knew that snails are intermediate host of schistosomiasis but no control were progressing. The patient who were clearly able to recognize the disease with blood in the urine(29%), and half of them were not under treatment. The treatment of schistosomiasis was less clearly understood than malaria. Patients were from 5 years old and up, high morbidity was observed for adults more than 20 years old.

(C) Trypanosomiasis

Most of people understood that the tsetse fly is intermediate host of trypanosomiasis. 59% of people raised livestock. They had contact with tsetse flies at outside in the daytime. When we asked about the presence of trypanosoma 6% of those questioned had it and only 33% of these were being treated. The number of patient was not so many but risky contact with tsetse was high.

2) For doctors and medical staff

A total of 16 doctors and medical staff were inquired but no doctors and medical staff were answered about trypanosomiasis. Two veterinaries had answered about animal trypanosomiasis.

(A) Malaria

Almost all doctors had treated more than 100 patients a year. Predominant parasite species was Plasmodium falci- parum. The other parasite species found were P.vivx and P.malariae. Principal medicines for treatment were chloroquine, fancidar and quinine. 66% of doctor answered that they had patients who did not respond to medicine, which means drug resistant malaria was distributed there. During the long rainy season and after the patients number was high. Few organized malaria control measures such as chemoprophylaxis and mosquito control were undertaken by the government.

(B) Schistosomiasis

Almost all doctors had treated patients for schistosomiasis. Number of patients were less than malaria, but throughout the year patients were observed. The parasite species of study area were both Schistosoma mansoni and S.haematobium in the same rate. Praziquantel was used for treatment. Control program was inactive which carried out from government and private.

(C) Trypanosomiasis

Human trypanosomiasis was not prevalent, but animal trypanosomiasis was common. The parasite species of animal trypanosomiasis were Trypanosoma vivax and T.congolense. For treatment, novidium and ethidium were used. The main prevalence season was between March and May.

3. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

3.1 Method of IEE

IEE is the first approach of environmental impact assessment (EIA) by scoping, and result of IEE should lead to the detailed EIA in the following next study stage.

A checklist method was applied as a basic tool for IEE in this study because it is one of the useful initial methods for identification of impact and evaluation of magnitude. The checklist was prepared by using items of environmental effects as stages and area. The expected effect were evaluated from A to C for each item.

<Effect>

+ : positive (better) effect expected
- : negative (adverse) effect expected
= : no relation with the project considered
x : neutral effect expected (not positive and not negative), there may be a change but such change will be neither beneficial nor harmful;

<Magnitude>

A : effect which has relatively high level of magnitude
B : effect which has relatively medium level of magnitude
C : effect which has relatively low level of magnitude

3.2 Ecological Region

In order to specify locations of expected impacts by the project, the study area was divided into the following three ecological regions as follows and shown in Fig. XI-2.4.

- Region 1 : Irrigation area This region will be the irrigated area under the project and it includes from the beginning of main canal to the end of drainage.

- Region 2 : Nyando river and swamp area This region is the area to be influenced directly from the project which includes downstream of Nyando river and Nyando swamp at the mouth of the river.

- Region 3 : Lake area (Winam Gulf and Nyakach Bay) This region is the open lake area including Winam Gulf and Nyakach Bay to be influenced indirectly from the project.

3.3 Result of IEE

Eight environmental items are selected as follows, on basis of studies and information:

- Agricultural chemicals use
- Soil erosion
- Sedimentation
- Resettlement
- Fisheries
- Ecosystem of swamp
- Vector borne disease (Malaria, Schistosomiasis and Trypanosomiasis)

Result of IEE are shown in Table XI-2.10, with preliminary evaluation of the expected effects, by stages and regions.

3.3.1 Problems in construction stage

Effects during the construction stage are examined based on the existing data and the planning of the scheme. Generally, impacts during the construction stage are temporary, and is possible to take countermeasures to reduce those effects. Thus, the magnitude of the expected effects is considered relatively low.

The items of Soil erosion, Sedimentation, Resettlement, Fishery, Ecosystem of swamp and Vector borne disease are considered to have potential negative effects from the project. The result is to be summarized hereafter;

(1) Soil erosion and Sedimentation

Soil erosion could be occur at the ecological region-1 due to construction of facilities such as regulation ponds and canals. The construction would be carried out gradually with the proper method and also the main construction would be carried out during dry season to avoid an increase erosion. So, the soil erosion caused by the project will not be rise much as existing condition, and the effect would not be so serious.

Sedimentation is also not so harmful because of this item is caused by soil erosion from the project area.

(2) Resettlement

Some of the people who live in the proposed regulation pond and canal area, may be resettled. However, the canal routes are planned to avoid resettlement, and present condition of the area of regulation pond will be changed during construction stage of Sondu-Miriu Hydropower project. Therefore, resettlement will not cause severe problem.

(3) Fisheries and Ecosystem of swamp

Effects on fisheries and ecosystem of swamp during construction would be caused by sediment of water-body from the project area. So, it would be almost no problem because of a small amount of sediment and limited period of construction.

(4) Vector borne disease

Workers and laborers will possibly migrate from other regions not infected by vector borne disease, and the potential of vector borne disease, especially for malaria and schistosomiasis may rise. It was basically planned that labor would be supplied from a same area. Thus the effect of the magnitude would not be so high, but it was concluded to make further assessment because of serious existing condition.

Although, cases of trypanosomiasis were revealed in the questionnaire survey, according to the inquiry survey and existing data, it appears that trypanosomiasis does not exist around study area. So, trypanosomiasis would be excluded from the item, but care should be taken not to bring the disease into the project area by construction labors.

3.3.2 Problems in operation stage

Effects during operation stage are also examined based on the existing data and the proposed scheme. Proposed agricultural chemicals' use, Soil erosion, Sedimentation, Fishery, Ecosystem of swamp and Vector borne disease are considered to be potentially affected negatively by the project, and only fisheries will gain some positive effect. The result is to be summarized hereafter;

(1) Agricultural chemicals use

Although use of agricultural chemicals would possibly affect deterioration of downstream water quality, fisheries and ecosystem of the swamp and lake, the dosage and application of chemicals would be limited to high value added crops as vegetables and cotton, and also used when the plants are in poor condition, probably be in dry season. In addition to this, pest-resistant varieties, with low toxicity, which decompose quickly will be selected. Therefore, the effect of this item would not make serious troubles and magnitude is very little.

(2) Soil erosion and Sedimentation

Soil erosion in the irrigation area could possibly rise, due to cultivating the land, especially maize and beans. But it should not be so serious by under the proper management, with gradual irrigation and a cultivation period.

Sedimentation of the canal and mouth of the river could be raised, because of soil erosion. However, velocity of running water in canal is planned to be 30-70cm/sec., and even with a sediment will not clog the bottom of the canal. Paddy field will be located at the end of irrigation area so that it would stop element of sedimentation to the mouth of the river. Therefore, the effect of those items are negligible on this stage.

(3) Fisheries

Water quality deterioration and eutrophication are expected to be raised due to use of fertilizer and agricultural chemicals at project area. Such a change could affect to the behavior of fish and their ecology, and fishing activities. Existing fish ecosystem is undergoing change due to introduced species. The main targeting species, the Nile perch, Nile tilapia and Rastrineobola, seem to be tolerant of deterioration and eutrophication of water body. So, the magnitude of this item would not be so high, but should be evaluated further assessment because of importance of the area.

Fishing would be possible in the canal. But it would not make so much benefit, because the canal would be constructed to avoid the habitat of vectors (mosquitoes, snails) of disease. It is not good habitat for the fishes also. So, this positive effect would not be so important and magnitude would be as a neutral.

(4) Ecosystem of swamp

All of the above changes in the natural environment could affect to the ecosystem of swamp directly and indirectly. Though, it is very difficult to evaluate the magnitude of effect, this item is also very important for the ecosystem of the lake and its fishes, also for the fisheries. Therefore, it would be chosen as a item to be assessed.

(5) Vector borne disease

Kisumu District is classified by WHO as a holoendemic malarial zone with high prevalence of malaria cases and infection is possible throughout the year. Also schistosomiasis is widely spread throughout the study area. Vectors of Malaria and Schistosomiasis which breed in stagnant water and irrigation water could possibly increase the density of those populations, especially where it is planned to cultivate paddy field. Diseases related to those vectors could also rise. And this item is considered to be major, because of a serious existing condition.

Trypanosomiasis seem to be very rare in this area, so it would be negligible from items to be assessed.

Taking the result of IEE into account, the following three environmental impacts are considered to require more detailed assessment in order to evaluate the magnitude of effect and to propose necessary countermeasures.

Item	Stage	Magnitude
Fisheries	Operation stage	Low
Ecosystem of swamp	Operation stage	Low
Vector borne disease		
-Malaria	Construction stage	Low
	Operation stage	High
-Schistosomiasis	Construction stage	Low
	Operation stage	High

4. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

4.1 Fisheries

The Winam gulf including the Nyakach bay is under moderately eutrophicated condition at present, and it could raise more to be added nutrients due to the project. The bloom, causing by Blue-green algae, Anabena circinalis, Aphanocaspa sp., Lyngbya limnetica is appearing in the Winam gulf during the investigation in July. And it was more in the Winam gulf area than the Nyakach bay area, maybe because of transparency of water-body. According to inquiry survey at LBDA, some fish death seemed to be caused by the bloom about five years ago.

Fisheries may suffer from the result increasing nutrients of water-body due to implementation of the project. If blooms caused by blue-green algae biomass increased and appeared frequently and heavily, it would be worrying because this could lead to oxygen lack in the lake's deep waters and might cause of fish dying. Also, increasing of quantity of floating water weeds such as Nile cabbage due to the eutrophication of lake water cause problem for laying and pulling fishnet. There might be changed composition of fish fauna caused by changing of water quality.

But the ecosystem of the lake fish is still undergoing change due to the Nile perch and the Nile tilapia introduction and also the use of small mesh-sized fishnet, and eutrophicated condition due to several agro-processing factories and urban drainage water etc. So it would be very difficult to evaluate magnitude of impact only from the project.

The main targeting species for fisheries are the introduced Nile perch and Nile tilapia. When Nile perch was first introduced, people around the study area did not prefer this fish because of its oily meat. Since then, the fish have been exported to foreign countries, the price has gone up, and many fishermen started targeting the Nile perch. Now the Nile perch is the main fishing species not only around the Winam gulf area but also all over Victoria lake. The people around the study area prefer tilapia, though the species has replaced to the Nile tilapia from the endemic tilapias. So far, the project itself could not do much harm to those main fisheries species of the Nile perch and the Nile tilapia, because those fishes are normally quite tolerant to eutrophicated situation.

4.2 Ecosystem of the Swamp

Effect on this item is the most complicated and it is difficult to evaluate the impact from only a certain project. But almost all the natural environmental items are related to ecosystem. So any thing may influence the system. Ecosystem of the swamp plays the most important role for the lake, including purification of nutrients, reducing sediment materials, breeding, hiding and feeding habitat of the fishes and other animals etc.

Generally, ecosystem is both tolerant and sensitive to environmental changes. But the swamp laid at the mouth of a river normally has strong tolerance to the nutrients and sedimentation etc. because of its character of location. The Nyando swamp is extending widely at the mouth of Nyando river, and papyrus, bulrush, and reeds are growing fairly densely. Plant growth would become more dense and thick to absorb the nutrients from the project area and also the floating and submerged water plant quantities would be increased. But it would not destroy much of their ecosystem chain caused by the project because of its tolerance.

4.3 Vector Borne Disease

Malaria and schistosomiasis are considered to be a major impact of this project. To attain assessment of those items, examples of effect on water resources development were collected from existing data, shown in Table XI-2.11. It shows that it is to increase vector borne disease both malaria and schistosomiasis, unless countermeasures are taken. But there are many effective countermeasures and Table XI-2.12, shows some examples of successful controls.

Effects during construction stage of both malaria and schistosomiasis would not be serious since the workers and laborers will stay within the same area. Even if it would require labor from other place, there would be fairly easy ways of the control, like taking chemoprophylaxis.

4.3.1 Malaria

According to habitat of An.gambiae which is main vector of malaria in Kano plain, this species would be increased around paddy fields. The case of Ahero pilot scheme is shown in Figure XI-2.5, and Figure XI-2.6. It shows that the irrigation scheme had raised population of An.gambiae. The slurry of mud and water produced by the movement of the workers in the rice field create highly suitable condition for the breeding of An.gambiae. Prevalence of this species is highly linked with cultivating pattern and become the most abundant just after transplantation of rice. The other critical species An.funestus seems to prefer breeding more in the less exposed field and could be increased during taller mature rice fields. It not likely to increase An.gambiae and An.funestus in main or secondary canals because velocity will be about 30-70cm/sec. always which would be too fast for breeding. But if small stagnant pools appear in canals they may clogged by trashes or grown plants, become breeding sites for vectors. And in the tip canal and drainage canal where velocity would not be so fast, also the vector mosquitoes could breed. The sporozoite rate of An.gambiae were estimated high about 1-10% by KEMRI's research.

The project area has a very high prevalence of malaria. The SPR was examined 70-90% by KEMRI and the most of people (96%) in the study area were answered to have been infected by malaria from questionnaire survey. Those rates might be too high to increase any more, but it does not mean there are no effect by the project. Rate of infection of children especially under age 9 is still relatively low (less than 50%). The effect to the infant is more serious than adult group because their required immunity is weak.

Therefore, it would become more serious situation, if countermeasures are not taken.

4.3.2 Schistosomiasis

According to example (Table XI-2.11), large scale water utilization projects including irrigation projects, are likely to result in increase prevalence and massive occurring of schistosomiasis. An example at Mwea/Tabere Irrigation Scheme, the prevalence of S.mansoni has increased rapidly. And S.mansoni prevalence has gone up as high as 60% for school children, although not a single case of S.mansoni or S.haematobium of examination of 1,000 people was detected in the same area before the project. Also, it has found widespread Bi.pfeifferi breeding along the lower reaches of main and secondary canals, drains and ditches in older establish sections of the irrigation scheme.

Therefore, it is likely to that vector snails will invade and increase, especially Biomphalaria pfeifferi which is a main intermediate host of S.mansoni in this area. Also, the Bulnis africanus group will increase, which is vector of S.haematobium, and which has wide ranges of habitat, from permanent to temporary water.

Paddy fields, tip and drainage canals have possibility to become a breeding site for host snails. And even a main and secondary canal has possibility of breeding vector snails especially if water plants would be grown at the edge of canal.

Although, there are some snails which can survive several month under drought conditions, the single rice cropping pattern which planned by the project, would be helpful to reduce host snails like Bi.pfeifferi.

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Several impacts are expected to cause negative effects on the environmental aspect through the IEE, and following EIA. It was concluded that only the effects on vector borne disease, malaria and schistosomiasis, would reach critical conditions. So, it is necessary to take appropriate countermeasures. Effect on fisheries, ecosystem of swamp also could have some problems, but the magnitude of impact would be relatively low and would not be unavoidable effects of implementation of the project. These also need appropriate countermeasures and careful attention.

Though, it would be need further proper detailed and careful planning, the proposed project is considered to be acceptable from an environmental point of view.

5.2 Recommendation

5.2.1 Fisheries

Introduction of the Nile perch and the Nile tilapia into the lake, has led to changes in fish communities in the Winam gulf. There is also a tendency by fishermen to reduce mesh-size to catch other species as they reappeared. If the Winam gulf or the Nyakach bay become more eutrophied due to not only this project but any other human activity in the catchment area, it was concluded that it might become serious. The effect on fish and fisheries activities seems to be caused more by existing factors than by the project, but we can not exclude the project factors. The farmers should be advised to use the absolute minimum amount of fertilizer and agricultural chemicals. Also, it should need to keep attention on ecology of the Winam gulf, especially to the item of water quality and eutrophication. It is also recommended that monitoring of the phytoplankton survey is necessary so much as water quality, and it could be done at the same time and stations as water quality monitoring. Swamp area, which will be mentioned after, is also a very important factor to the fish habitat and their ecology, so that it should strongly be protected in this area from any kind of development scheme.

5.2.2 Ecosystem of the swamp

This item is also affected mainly indirectly from many factors of environmental items, so, it is difficult to evaluate the magnitude due to the project. But it was concluded that the effect seems to be not so serious by the project, because of the huge size and the tolerance of the swamp.

Ecosystem of the swamp have the most important role of the lake and lakeshore area, and may of functions, purification of nutrients and sediment. If the swamp would be destroyed, effects of other items would become more serious. It is recommended that human activities should be prevented in the swamp, like land reclamation by drainage. The most important thing is not to touch any of the swamp. Disappearance of the swamp will definitely destroy the ecosystem of the Winam gulf and impact seriously on fisheries and many other items of environment.

5.2.3 Vector borne disease

The study area is a high prevalence zone of both malaria and schistosomiasis and the risk of increasing incidence would be the main problem caused by the project. It could cause increased malaria and schistosomiasis without taking appropriate countermeasures.

Following are recommended countermeasures against these diseases;

<For both malaria and schistosomiasis>

- Lining canal by concrete to prevent canal erosion and growth of water weeds in which vectors will breed.

- Cleaning canals by removing water weed and trash to reduce habitat of the vectors.
- Chemoprophylaxis and chemotherapy for migrant workers and children of residents.
- Dispatch of professional staff such as parasitologist, microbiologist and doctor to investigate the situation of out-break of disease before construction stage.
- Physical control of breeding site such as elimination of water pools near the local residences.
- Snailciding and insecticiding or oiling of the breeding site.
- Health education of the local people.

<For malaria>

- Residual insecticide house spraying, immediately after mosquitoes are detected. It would be more effective if it would be done systematically within a whole area and regularly.
- Biological control of introducing predator fish, such as Gambusia affinis, Tilapia zilli.
- Distribution of mosquito nets preferably insecticide-treated net.

<For schistosomiasis>

- Building bridges to avoid crossing the canal.
- Putting on protectors when going into the water.

Several control methods are shown and there is a need for an integrated control strategy. But in this stage the most recommendable countermeasure is a concrete canal lining. It would be the most effective measure to avoid the habitat of vectors and to control malaria. However, lining, significantly raise project cost. Other countermeasures should be applied in the early stage of the development. If other measures would not be effective in spite of those efforts, the lining will be made. Lining may also be strengthened to improve water management system when its cost can be beared by the society. House spraying may be the most effective for malaria control when measure is taken properly and there are many successful cases, although care should be taken in choosing the chemicals because there are resistant species to certain chemicals. Health education is also important factor for vector borne disease. Lack of awareness of the problem by farmers, is one of the high prevalence factors in this area. Using snailcide and insecticide in the breeding sites of the vectors is also one of the control methods, but it is toxic to fish, humans, domestic stock, and destroys ecosystem. So, it is recommended to use in only certain periods when breeding site are few or only under critical situation. It is clearly understood that such measures described should be carried out not only in the limited area but in the region as a whole. These measures require many numbers of medical staffs, parasitologists, microbiologists and many others. It is recommended to carry-out such measures systematically and therefore to promote programmes, for instance, Rural Public Health Improvement Programme, such program should be undertaken by other agencies aside from Irrigation Operation Maintenance Office.

Tables

Table XI-1.1 Result of Water Quality Analysis

Item	Station unit	St.1 Nyando river Nyando bridge	St.2 Nyando river Ahero	St.3 Nyando river Apondo	St.4 Nyando river River mouth	St.5 Sondu river Nyakuwere	St.6 Nyakach bay Centre of bay	St.7 Nyakach bay Border of bay	St.8 Winam gulf East of gulf
a) Sampling date	-	July 2, '91	July 2, '91	July 2, '91	July 3, '91	July 2, '91	July 3, '91	July 3, '91	July 3, '91
b) Sampling time	-	9:05 a.m	9:45 a.m	10:20 a.m	10:00 a.m	11:40 a.m	10:25 a.m	10:45 a.m	11:30 a.m
c) Climate	-	fair	fair	fair	fair	fair	fair	fair	fair
d) Air temp.	C	23.8	24.2	27.0	23.9	25.7	25.0	25.4	24.5
e) River flow	m3/s	9	13	15	-	27	-	-	-
f) Colour	-	Red brown	Red brown	Red brown	Light brown	Light brown	Light olive	Light olive	Light olive
g) Water temp.	C	21.1	21.7	22.2	26.5	20.4	26.6	27.1	26
h) Transparence	cm	5	5	5	25	30	40	40	85
i) DO	mg/l	6.5	5.6	6.0	5.0	6.6	5.5	6.6	6.9
j) SS	mg/l	407	776	589	28	66	112	19	40
k) EC	uS/cm	130	150	150	130	41	120	120	110
l) COD	mg/l	16.9	20.4	14.3	4.2	2.2	2.6	2.0	1.8
m) Coliform no.	MPN	1900	250	6	450	130	10	Nil.	Nil.

note: All samples were analyzes by the Kenyan Bureau of Standard (KBS).
Location of the sampling stations are shown on Figure 1.

Source : Prepared by JICA Study Team

Table XI-1.2 Water Flow Regime of the Winam Gulf and Nyakach Bay

Existing	unit	Winam Gulf			Nyakach Bay		
a) Surface area	km2	1,400			36		
b) Average depth	m	6			3		
c) Storage volume(a*b)	10^6 m3	8,400			108		
d) Annual inflow	10^6 m3/y	2,731.0			510.9		
e) Retention time(d/c)	times/y	0.33			4.73		
Alternatives		Case-1	Case-2	Case-3	Case-1	Case-2	Case-3
f) Irrigable area	ha	24,220	20,240	14,930	24,220	20,240	14,930
g) Diverted water volume	10^6 m3/y	520	467	372	520	467	372
h) Evapotranspiration and permeabi'ty	mm/day	4	4	4	4	4	4
i) Irrigable days	day	365	365	365	365	365	365
j) Loss of irrigation water (f x h x i)	10^6 m3/y	354	296	218	354	296	218
k) Return flow(g-j)	10^6 m3/y	167	171	154	167	171	154
l) Return flow rate (k/g)	%	32.0	36.7	41.4	32.0	36.7	41.4
m) Annual inflow to Gulf (d-j)	10^6 m3/y	2,377	2,435	2,513	-	-	-
n) Annual inflow to Bay (note 1)	10^6 m3/y	-	-	-	636	661	665
o) Change of inflow rate (m/d)	%	87.1	89.2	92.0	124.6	129.3	130.2
p) Retention time(m/c)	times/y	0.28	0.29	0.30	5.89	6.12	6.16

note 1 : The water from 18,240 ha of the total irrigation area will inflow to the Bay in Case-1, the water from 17,700 ha in Case-2, and the water from all irrigation area in Case-3.

Source : Prepared by JICA Study Team

Table XI-1.3 Existing Conditions of Water Quality and Pollution Load

	unit	COD	T-N	T-P
Water quality				
a) Diverted irrigation water	mg/l	2.2	4.94	0.02
b) Nyando river	mg/l	4.2	1.19	0.10
c) Center of Nyakach Bay	mg/l	2.6	0.62	0.04
d) Inflow water to Gulf (assumption)	mg/l	5.0	1.00	0.06
e) Center of Winam Gulf	mg/l	1.8	0.47	0.02
Pollution load				
f) Load from Bay to Gulf	t/y	1,328	317	20
g) Inflow load to Bay	t/y	2,146	608	51
h) Purificated load in Bay (h-g)	t/y	817	291	31
i) Load from Gulf to main Lake	t/y	4,916	1,284	55
j) Load from inflow water to Gulf	t/y	13,655	2,731	164
k) Purificated load in Gulf (m-j)	t/y	8,739	1,447	109

Note : Concentration of COD is quoted from the sampling results, and T-N and T-P are estimated based on the existing data and the sampling results.

Source : Prepared by JICA Study Team

Table XI-1.4 Pollution Load (COD) by Land Use Change

Item	Load unit (kg/km2/day)	Existing Area (ha)	Existing COD load (t/y)	With Project Area (ha)	With Project COD load (t/y)	Increment (t/y)
Case-1						
Irrigated area	28.0	3,590	367	24,220	2,475	2,108
Other cultivated land	7.0	20,630	527	0	0	-527
Others	4.0	0	0	0	0	0
Total	-	24,220	894	24,220	2,475	1,581
Case-2						
Irrigated area	28.0	2,790	285	20,240	2,069	1,783
Other cultivated land	7.0	17,450	446	0	0	-446
Others	4.0	0	0	0	0	0
Total	-	20,240	731	20,240	2,069	1,338
Case-3						
Irrigated area	28.0	780	80	14,930	1,526	1,446
Other cultivated land	7.0	14,150	362	0	0	-362
Others	4.0	0	0	0	0	0
Total	-	14,930	441	14,930	1,526	1,085

Source : Prepared by JICA Study Team

Table XI-1.5 Pollution Load (T-N) by Land Use Change

Item	Load unit (kg/km2/day)	Existing Area (ha)	Existing T-N load (t/y)	With Project Area (ha)	With Project T-N load (t/y)	Increment (t/y)
Case-1						
Irrigated area	8.8	3,590	115.31	24,220	777.95	662.64
Other cultivated land	7.6	20,630	572.28	0	0.00	-572.28
Others	0.5	0	0.00	0	0.00	0.00
Total	-	24,220	687.59	24,220	777.95	90.36
Case-2						
Irrigated area	8.8	2,790	89.61	20,240	650.11	560.49
Other cultivated land	7.6	17,450	484.06	0	0.00	-484.06
Others	0.5	0	0.00	0	0.00	0.00
Total	-	20,240	573.68	20,240	650.11	76.43
Case-3						
Irrigated area	8.8	780	25.05	14,930	479.55	454.50
Other cultivated land	7.6	14,150	392.52	0	0.00	-392.52
Others	0.5	0	0.00	0	0.00	0.00
Total	-	14,930	417.57	14,930	479.55	61.98

Source : Prepared by JICA Study Team

Table XI-1.6 Pollution Load (T-P) by Land Use Change

Item	Load unit (kg/km2/day)	Existing Area (ha)	Existing T-P load (t/y)	With Project Area (ha)	With Project T-P load (t/y)	Increment (t/y)
Case-1						
Irrigated area	0.88	3,590	11.53	24,220	77.79	66.26
Other cultivated land	0.26	20,630	19.58	0	0.00	-19.58
Others	0.01	0	0.00	0	0.00	0.00
Total	-	24,220	31.11	24,220	77.79	46.69
Case-2						
Irrigated area	0.88	2,790	8.96	20,240	65.01	56.05
Other cultivated land	0.26	17,450	16.56	0	0.00	-16.56
Others	0.01	0	0.00	0	0.00	0.00
Total	-	20,240	25.52	20,240	65.01	39.49
Case-3						
Irrigated area	0.88	780	2.51	14,930	47.96	45.45
Other cultivated land	0.26	14,150	13.43	0	0.00	-13.43
Others	0.01	0	0.00	0	0.00	0.00
Total	-	14,930	15.93	14,930	47.96	32.02

Source : Prepared by JICA Study Team

Table XI-1.7 Fertilizer Consumption in the Proposed Irrigation Area

	Consumption unit		Csae-1			Case-2			Case-3		
	A-sul(Kg/ha.y)	TSP(t/ha.y)	Area(ha)	A-sul(t/y)	TSP(t/y)	Area(ha)	A-sul(t/y)	TSP(t/y)	Area(ha)	A-sul(t/y)	TSP(t/v)
Cropping Pattern											
a)Paddy-Beans	465	200	1,710	795	342	4,400	2,046	880	2,690	1,251	538
b)Maize-Paddy	700	200	950	665	190	1,560	1,092	312	1,740	1,218	348
c)Maize-Groundnuts	350	100	1,910	669	191	1,910	669	191	0	0	0
d)Maize-Beans	465	200	7,680	3,571	1,536	5,520	2,567	1,104	765	356	153
e)Vegetable-Vegetable	1,160	200	960	1,114	192	880	1,021	176	1,570	1,821	314
f)Maize-Cotton/Beans	603	200	5,530	3,335	1,106	1,240	748	248	765	461	153
g)Sugarcane	263	50	3,870	1,018	194	3,660	963	183	5,130	1,349	257
h)Napier Grass	700	50	470	329	24	350	245	18	1,270	889	64
i)Pasture	0	0	1,140	0	0	720	0	0	0	0	0
j)Fruit Tree	293	63	0	0	0	0	0	0	1,000	293	63
Total	-	-	24,220	11,495	3,774	20,240	9,349	3,112	14,930	7,638	1,889
Net amount of N and P											
Net Nit'n Amount (t/y)	-	-	-	2,414	-	-	1,963	-	-	1,604	-
Net Pho'te Amount (t/y)	-	-	-	-	1,736	-	-	1,431	-	-	869

note : A-sul means ammonium sulphate, and TSP means tri-super phosphate.

Source : Prepared by JICA Study Team

Table XI-1.8 Change of Pollution Load and Water Quality by each Alternative

Item	unit	Nyakach Bay COD	Nyakach Bay T-N	Nyakach Bay T-P	Winam Gulf COD	Winam Gulf T-N	Winam Gulf T-P
a) Existing annual inflow	10^6 m3/y	511	511	511	2,731	2,731	2,731
b) Existing inflow load	t/y	2,146	608	51	13,655	2,731	164
Case-1							
c) Volume of diverted water	10^6 m3/y	520	520	520	-	-	-
d) Load by diverted water	t/y	1,145	2,570	10	-	-	-
e) Increased load by irrig'n	t/y	1,191	68.05	35.16	1,581	90.36	46.69
f) Total inflow load(b+d+e)	t/y	4,481	3,247	97	15,236	2,821	211
g) Self purification load	t/y	817	291	31	8,739	1,447	109
h) Expected actual load(f-g)	t/y	3,664	2,955.31	66.00	6,497	1,374	101
i) Loss of irrigation water	10^6 m3/y	354	354	354	354	354	354
j) Expected annual inflow	10^6 m3/y	636	636	636	2,377	2,377	2,377
k) Expected water quality(h/j)	mg/l	5.76	4.64	0.10	2.73	0.58	0.04
l) Increased concentration	mg/l	3.16	4.02	0.06	0.93	0.11	0.02
Case-2							
c) Volume of diverted water	10^6 m3/y	467	467	467	-	-	-
d) Load by diverted water	t/y	1,027	2,306	9	-	-	-
e) Increased load by irrig'n	t/y	1,170	66.84	34.53	1,338	76.43	39.49
f) Total inflow load(b+d+e)	t/y	4,342	2,980	95	14,993	2,807	203
g) Self purification load	t/y	817	291	31	8,739	1,447	109
h) Expected actual load(f-g)	t/y	3,525	2,689.26	64.30	6,253	1,360	94
i) Loss of irrigation water	10^6 m3/y	296	296	296	296	296	296
j) Expected annual inflow	10^6 m3/y	661	661	661	2,435	2,435	2,435
k) Expected water quality(h/j)	mg/l	5.34	4.07	0.10	2.57	0.56	0.04
l) Increased concentration	mg/l	2.74	3.45	0.06	0.77	0.09	0.02
Case-3							
c) Volume of diverted water	10^6 m3/y	372	372	372	-	-	-
d) Load by diverted water	t/y	819	1,838	7	-	-	-
e) Increased load by irrig'n	t/y	1,085	61.98	32.02	1,085	61.98	32.02
f) Total inflow load(b+d+e)	t/y	4,049	2,508	91	14,740	2,793	196
g) Self purification load	t/y	817	291	31	8,739	1,447	109
h) Expected actual load(f-g)	t/y	3,232	2,217.03	59.90	6,000	1,346	87
i) Loss of irrigation water	10^6 m3/y	218	218	218	218	218	218
j) Expected annual inflow	10^6 m3/y	665	665	665	2,513	2,513	2,513
k) Expected water quality(h/j)	mg/l	4.86	3.33	0.09	2.39	0.54	0.03
l) Increased concentration	mg/l	2.26	2.71	0.05	0.59	0.07	0.01

Source : Prepared by JICA Study Team

Table XI-1.9 Possibility of Eutrophication of Nyakach Bay and Winam Gulf

		Existing	Case-1	Case-2	Case-3
Nyakach Bay					
a)Surface area	km2	36	36	36	36
b)Average depth	m	3	3	3	3
c)Storage volume(a x b)	10^6 m3	108	108	108	108
d)Annual inflow	10^6 m3	511	636	661	665
e)Retention time(d/c)	times/y	4.73	5.89	6.12	6.16
f)Concentration of T-P	mg/l	0.04	0.10	0.10	0.09
g)T-P surface area load(d x f/a)	t/km2.y	0.57	1.83	1.79	1.66
h)Re'tion time x Ave. depth(e x b)	times.m/y	14.19	17.68	18.35	18.47
Winam Gulf					
a)Surface area	km2	1,400	1,400	1,400	1,400
b)Average depth	m	6	6	6	6
c)Storage volume(a x b)	10^6 m3	8,400	8,400	8,400	8,400
d)Annual inflow	10^6 m3	2,731	2,377	2,435	2,513
e)Retention time(d/c)	times/y	0.33	0.28	0.29	0.30
f)Concentration of T-P	mg/l	0.02	0.04	0.04	0.03
g)T-P surface area load(d x f/a)	t/km2.y	0.04	0.07	0.07	0.06
h)Re'tion time x Ave. depth(e x b)	times.m/y	1.95	1.70	1.74	1.80

Source : Prepared by JICA Study Team

Table XI-2.1 Avifauna in Study Area by Field Survey

ENGLISH NAME	ENGLISH NAME
Little Grebe	Fischer's Lovebird
Great White Pelican	Emerald Cuckoo
Greater Cormorant	Slender-tailed Nightjar
Darter	White-rumped Swift
Night Heron	Horus Swift
Cattle Egret	Giant Kingfisher
Yellow-billed Egret	Pied Kingfisher
Great White Egret	Pygmy Kingfisher
Grey Heron	Striped Kingfisher
Purple Heron	Woodland Kingfisher
Black-Headed Heron	White-throated Bee-eater
Hamerkop	Lilac-breasted Roller
Abdim's Stork	Grey Hornbill*
Marabou*	Lesser Honeyguide*
Open-billed Stork	Mosque Swallow
Yellow-billed Stork	White-headed Roughwing Swallow
Sacred Ibis	Pied Crow
Hadada	Grey Tit
African Spoonbill	Black-lored Babbler
Greater Flamingo*	Arrow-marked Babbler
White-faced Whistling Duck	Yellow-throated Longclaw
Secretary Bird*	African Pied Wagtail
Bateleur	Long-tailed Fiscal
Fish Eagle	Fiscal
Black Kite	Taita Fiscal
Helmeted Guineafowl*	Great Grey Shrike
Crowned Crane	Hidelbrandt's Starling
Black Crake*	Superb Starling
Jacana	Fischer's Starling
Long-toed Plover	Ashy Starling
Wattled Plover	Red-billed Oxpecker
Common Sandpiper	Golden-backed Weaver
Common Pratincole	Cardinal Quelea
Grey-headed Gull	Grey-headed Sparrow
Whiskered Tern	Rufous Sparrow
Speckled Pigeon	White-browed Sparrow Weaver
Mourning Dove	Green-backed Twinspot
Red-eyed Dove	Red-billed Firefinch Indigo Bird
Laughing Dove	Black and White Mannikin
Namagua Dove	

*: Recorded from questionnaire survey

Total : 39 Families
63 Genera
79 Species.

Source : Prepared by JICA Study Team

Table XI-2.2 Result of Inquiry, Questionnaire and Field Survey of Animals

Name	A	B	C	D	Notes
Vervet Monkey	Δ	Δ	Δ	Δ	Common
Aardvark	Δ	Δ	Δ		
Hare	Δ	Δ	Δ	Δ	Common
Squirrel	Δ	Δ	Δ	Δ	Common
Porcupine	Δ	Δ			Rare
Bat-eared Fox	Δ	Δ	Δ		Rare
Striped Polecat	Δ		Δ		
Otter	Δ	Δ		Δ	Rare
Civet	Δ		Δ		
Mongoose	Δ	Δ	Δ		
Hyaena	Δ	Δ	Δ		
Leopard	Δ	Δ	Δ		
Hylax	Δ	Δ			Rare
Hippopotamus	Δ	Δ	Δ	Δ	Common
Sitatunga			Δ		
Water buck	Δ		Δ		
Reed buck			Δ		
Oribi	Δ	Δ			Rare
Impala	Δ	Δ	Δ		
Tortoise	Δ	Δ	Δ	Δ	
Terrapine		Δ			Common
Lizard	Δ	Δ	Δ	Δ	Common
Python		Δ			
Hissing sand snake		Δ			
Forest cobra		Δ			
Black spitting cobra		Δ			
Puff adder		Δ			
Crocodile	Δ	Δ	Δ		

A: Questionnaire survey to farmers and fishermen
B: Inquiry survey to National Museum in Kisum
C: Inquiry survey to Wildlife Office in Kisum
D: Field survey

Source : Prepared by JICA Study Team

Table XI-2.3 Ichthyofauna in Victoria Lake and Sondu Miriu

Families	Species
Protopteridae	Protopterus aethiopicus
Mormyridae	Pterocephalus castostoma
	Mormyrus kannume
	Marcusenius grahami
	Gnathonemus longibarbis
	Gnathonemus victoriae
Cyprinidae	Barbus alrianalis
	Barbus jacksoni
	Barbus kerstenii
	Barbus neglectors
	Labeo victoriae
	Rastrineobola argenta
Characidae	Alestes jacksoni
	Alestes sadleri
	Alestes spp.
Bagridae	Bagrus dormac
Schilbeidae	Schilbe mystus
Clariidae	Clarias Allvadi
	Clarias gariepinnis
	Clarias mossambicus
	Xenoclarias sp.
Mochokidae	Synodontis afrofischeri
	Synodontis victoriae
	Synodontis victorianus
Aplocheilidae	Aplocheil eduardis
Centropomidae	Lates niloticus
Centrarchidae	Micropterus salmoides
Cichlidae	Haplochromines spp.
	Oreochromis esculentus
	Oreochromis leucostictus
	Oreochromis niloticus
	Oreochromis variabilis
	Tilapia rendalli
	Tilapia zilli
Anabantidae	Ctenopoma muriei
Mastacembelidae	Afromastacembelus frenatus

Total : 14 Families
22 Genera
36 Species.

Source : Prepared by JICA Study Team

Table XI-2.4 Distribution of Phytoplankton Species in the Winam Gulf.

CLASS	SPECIES	STATIONS					
		St.1	St.2	St.3	St.4	St.5	St.6
CYANOPHYCEA	Dactylococcopsis sp.	4	8	10	15	3	5
	Microcystis aeruginosa						53
	Aphanocapsa sp	1467	933	14683	37751	19515	10237
	Chroococcus sp.	37	11			80	
	Merismopedium elegans					341	64
	Merismopedium glaucum	139	644	102	810	981	27
	Merismopedium tenuissimum			205	64		64
	Anabaena circinalis	160	4640	4080	2953	28473	22034
	Lyngbya limnetica	1067	1117	1200	3919	2280	720
BACILLARIOPHYEAE	Melosira distans					5	
	Melosire granulata	42	21	32	4	137	469
	Cyclotella spp.	24	137	5	12	8	7
	Rhizosolenia longiseta						5
	Synedra ulna	1					
	Nitzschia acicularis	15	27			3	5
	Nitzschia spp.	28	27	10	12	20	51
DINOPHYCEAE	Peridinium sp.		1		5	1	
	Glenodinium sp.	3	1				4
	Ceratium hirundinella			3	5		1
CRYPTOPHYCEAE	Cryptomonas sp.		1		7		4
EVGLENOPHYCEAE	Euglena spp.	4	3				
	Phacus sp.	1	1				
	Trachelomonas spp.	29	7				
CHLOROPHYCEAE	Chlamydomonas sp.			2	26		4
	Gloeocystis gigas			6			
	Dictyosphaerium ehrenbergianum	43					
	Dictyosphaerium pulchellum		37	26		21	
	Oocystis sp.	5	5	2	16	5	1
	Schroederia setigera	1			1	1	1
	Pediastrum tetras v. tetraodon	5					
	Coelastrum sphaericum	11	53				
	Crucigenia crucifera	11	43				
	Crucigenia tetrapedia	4	21				
	Tetrastrum heterocanthum		5				
	Scenedesmus spp.	27	69	35	61	3	5
	Straurastrum sp.						1
6 CLASSES	36 SPECIES Number of sp	23	22	15	16	17	21
	Cel/ml	3128	7812	20401	45661	26251	33762

All sampling was conducted on 27th July, 1991.

Source : Prepared by JICA Study Team

Table XI-2.5 Annual Catches for Kenya Waters of Lake Victoria (1975-1990)

Name	1975		1976		1977		1978		1979		1980		1981		1982	
	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%
O. esculentus	28	0.2	49	0.3	42	0.2	180	0.8	94	0.3	90	0.3	139	0.4	399	1.3
O. niloticus	202	1.2	421	2.3	465	2.4	972	4.1	962	3.1	1,184	4.4	1,858	4.9	2,581	8.3
Other tilapia	412	2.5	537	2.9	928	4.8	1,454	6.1	1,683	5.5	3,739	13.9	1,900	5.0	1,495	4.8
Alestes	14	0.1	2	-			35	0.1	23	0.1			4	-	2	-
Bagrus	1,389	8.4	1,025	5.5	1,141	5.9	1,396	5.9	1,769	5.8	642	2.4	430	1.1	2,532	8.1
Lates	51	0.3	97	0.5	203	1.1	1,066	4.5	4,286	14.0	4,310	16.0	22,834	59.8	3,334	10.7
Protopterus	1,469	8.9	935	5.0	773	4.0	612	2.6	472	1.5	370	1.4	187	0.5	239	0.8
Haplochromines	4,620	27.9	6,368	34.1	5,378	27.0	6,621	27.8	6,599	21.6	3,636	13.5	916	2.4	2,546	8.2
Clarias	2,584	15.6	2,507	13.4	1,755	9.1	1,729	7.3	3,029	9.9	1,223	4.5	1,003	2.6	2,062	6.6
Barbus	283	1.7	182	1.0	183	0.9	199	0.8	417	1.4	421	1.6	292	0.8	692	2.2
Synodontis	126	0.8	191	1.0	310	1.6	155	0.7	482	1.6	388	1.4	127	0.3	232	0.7
Mormyrus	58	0.3	89	0.5	102	0.5	102	0.4	359	1.2	333	1.2	208	0.5	2,678	8.6
Labeo	108	0.7	123	0.7	936	4.8	148	0.6	443	1.4	482	1.8	112	0.3	918	2.9
Schilbe	54	0.3	57	0.3	129	0.7	120	0.5	320	1.0	117	0.4	49	0.1	78	0.3
Rastrineobola	4,548	27.4	5,652	30.3	6,704	34.7	8,710	36.6	9,321	30.5	9,443	35.1	7,635	20.0	10,419	33.4
Small mixed	635	3.8	445	2.4	280	1.4	327	1.4	333	1.1	536	2.0	483	1.3	961	3.1
Total	16,581		18,680		19,329		23,826		30,592		26,914		38,177		31,168	

Name	1983		1984		1985		1986		1987		1988		1990	
	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%	tons	%
O. esculentus	108	0.1	99	0.1	42	-			3	-	105	0.1		
O. niloticus	2,516	3.3	6,136	8.5	7,573	8.5	7,853	7.6	9,020	8.0	25,450	12.6	38,305	20.7
Other tilapia	1,658	2.1	1,243	1.7	1,827	2.1	1,311	1.3	1,326	1.2	870	0.4	565	0.3
Alestes	4	-	1	-									1	-
Bagrus	1,243	1.6	88	0.1	61	0.1	62	0.1	40	-	116	0.1	134	0.1
Lates	52,337	67.7	41,319	57.5	50,029	56.5	56,975	55.2	68,540	60.7	95,765	47.6	71,514	38.6
Propopterus	108	0.1	81	0.1	150	0.2	150	0.1	50	-	31	-	84	-
Haplochromines	612	0.8	41	0.1	6	-	3	-	183	0.2	2,100	1.0	1	-
Clarias	895	1.2	780	1.1	547	0.6	762	0.7	340	0.3	469	0.2	507	0.3
Barbus	100	0.1	53	0.1	113	0.1	248	0.2	120	0.1	3,719	1.8	5,320	2.9
Synodontis	47	0.1	75	0.1			1	-			2	-	38	-
Mormyrus	218	0.3	89	0.1	49	0.1	59	0.1	12	-			578	0.3
Labeo	81	0.1	58	0.1			161	0.2	47	-	8	-		
Schilde	22	-	3	-	5	-	25	-	1	-			95	0.1
Rastrineobola	16,444	21.3	19,437	27.1	25,866	29.2	34,518	33.5	33,140	29.3	68,918	34.2	46,738	25.2
Small mixed	894	1.2	2,351	3.3	2,321	2.6	1,013	1.0	165	0.1	3,719	1.8	21,221	11.5
Total	77,287		71,854		88,589		103,141		112,987		201,272		185,101	

- : less than 0.1%
Source : Fisheries Department in KISUMU

Table XI-2.6 Catches of Nyakach Bay Area Landing Beaches (Kusa, Sango Rota, Nduru) during the Period from January to June in 1991

Unit : (%)

Name	Jan.	Feb.	Mar.	Apr.	May	Jun.	Total (%)
Lates	10,871	1,355	1,336	1,716	1,191	252	16,721 (22)
Clarias	61	76	13,331	106	295	295	14,164 (18.6)
Haplochromis	5,895	0	56	0	4,051	6,844	16,846 (22.1)
Tilapia	1,745	326	524	487	1,744	1,161	5,987 (7.9)
Synodontis	53	44	2,575	448	149	486	3,755 (4.9)
Schlibe	63	0	475	473	527	623	2,161 (2.8)
Rastrineobola	8,140	3,729	0	1,100	2,210	1,308	16,487 (21.7)
Total	26,828	5,530	18,297	4,330	10,167	10,969	76,121

Source : District Fisheries Office in KISUMU

Table XI-2.7 Mean Monthly Catch by Numbers of Fish Sampled in the Sondu Miriu River from May 1986- May 1988

	J	F	M	A	M	J	J	A	S	O	N	D
Lates niloticus	65	49	85	52	686	4	114	12	66	184	172	136
Clarias gariepinnis	24	28	-	6	32	20	424	120	12	52	136	22
Schilbe mystus	275	1345	1780	515	85	15	16	32	40	130	354	240
Bagrus docmac	5	3	4	1	1	-	2	5	13	14	7	4
Oreochromis niloticus	64	120	12	104	154	176	734	302	76	32	84	104
Oreochromis variabilis	76	30	20	104	20	136	800	748	70	68	562	160
Oreochromis leucostict	4	2	6	32	20	11	53	131	14	72	6	16
Tilapia zilli	4	-	-	26	11	9	40	184	5	4	5	6
Barbus neglectus	10	10	4	18	12	-	436	64	30	32	62	48
Barbus altianalis	8	4	43	53	12	5	9	72	16	4	11	48
Barbus jacksoni	-	-	2	5	32	-	11	-	-	-	-	-
Barbus kerstenii	-	-	-	-	1	2	-	4	-	-	-	-
Labeo victorianus	20	6	57	46	37	4	20	5	-	71	13	101
Synodontis victoriae	22	15	181	137	116	6	29	8	38	118	164	265
S. afro fischeri	10	-	-	38	15	5	18	101	10	14	6	12
Alestes sadleri	8	-	-	5	12	14	34	8	-	-	-	-
A. Jachsonii	2	24	22	22	12	77	31	10	-	4	-	1
Xenoclarias	-	-	-	1	44	-	-	-	-	-	-	-
Mastucembelus frenatu	-	-	-	-	-	4	-	-	-	-	-	1
Ctenopoma muriei	3	-	-	-	-	1	5	9	-	-	-	-
Haplochromis spp	10	10	12	24	154	5	628	208	6	-	42	32
Aplocheil eduardis	-	-	-	-	2	3	1	-	-	-	-	-
Micropterus salmoides	-	-	-	-	-	1	-	4	-	-	-	-
Protopterus aethiopicus	-	-	-	7	23	10	-	1	-	-	-	-
Mormyrus kannume	-	1	6	-	2	-	-	2	-	-	-	-
Petreophalus cutostom	-	-	-	-	2	4	-	3	-	-	-	-
Gnathonemus longiberl	-	-	13	3	1	-	-	-	-	-	-	-
Marcusenius grahami	-	-	37	-	-	-	-	-	-	-	-	-

Source : UNDP, FAO, 1990

Table XI-2.8 Number of Health Institutions in Kisumu District and South Nyanza District

Institution	Kisumu District			South Nyanza District		
	GOK	NGO	Total	GOK	NGO	Total
Hospital	2	9	11	2	3	5
Health Center	13	1	14	38	5	43
Dispensary	28	12	40	20	9	29
Total	43	22	65	60	17	77

Source : SOCIO-ECONOMIC PROFILES

Table XI-2.9 Out-patient Morbidity in Kisumu District and South Nyanza District. (1986)

Disease	Kisumu District		South Nyanza District	
	N. of patients*	N./1000 popu.**	N. of patients*	N./1000 popu.**
Malaria	342,633	506	312,859	270
Respiratory Disease	150,074	221	106,285	92
Skin Disease	65,819	97	-	-
Intestinal Worms	43,834	65	56,296	49
Diarrheal Disease	63,748	94	59,559	51
Bilharzia	2,869	4	7,669	7
Anaemia	12,420	18	21,633	19
Urinary Tract Infections	10,835	16	23,532	20
Eye Infections	26,204	39	24,305	21
Gonarrhea	27,542	41	22,854	20
Accidents	14,489	21	10,255	9

Source : SOCIO-ECONOMIC PROFILES

* number of out-patients

** out-patient morbidity rate per 1,000 population

Table XI-3.1 Checklist of Initial Environmental Examination

Stage	Construction stage			Operation stage		
Item/ Ecological region	1	2	3	1	2	3
Agricultural chemicals region	=	=	=	=	x	x
Soil erosion	x	=	=	x	=	=
Sediment	=	x	x	=	x	x
Fisheries	=	x	x	x	-/C	-/C
Ecosystem of the swamp	=	x	x	=	-/C	-/C
Resettlement	x	=	=	=	=	=
Vector borne disease						
- Malaria	-/C	=	=	-/A	=	=
- Schistosomiasis	-/C	=	=	-/A	x	x
- Trypanosomiasis	x	=	=	x	=	=

<Effect>

+ : Positive (better) effect expected

- : Negative (adverse) effect expected

= : No relation with the project considered

x : Neutral effect expected (not positive and not negative), there may be a change but such change will be neither beneficial nor harmful

<Magnitude>

A : Effect which has relatively high level of magnitude

B : Effect which has relatively medium level of magnitude

C : Effect which has relatively low level of magnitude

<Ecological region>

1 : Irrigation area

2 : Nyando river and swamp area

3 : Lake area (Winam Gulf and Nyakach Bay)

Source : Prepared by JICA Study Team

Table XI-4.1 Examples of Effects of Water- Resources Development

COUNTRY	DEVELOPMENT	DISEASE	PREVALENCE CHANGE
Kenya	Irrigation, Small pond for fish production (Kano Plain)	Malaria	Increased
Egypt	Aswan High Dam, Irrigation	Malaria	Caused 130,000 deaths (1942/1943)
China	Irrigation (Between Hwang Ho And Hwai Ho)	Malaria	Density of vector mosquito has increased by five times.
Kenya	Irrigation (Mwea/Tebere)	Schistosomiasis	1961 : Not detected a single case After : 60%
Ghana	Akosombo Dam	Schistosomiasis	Before : 5-10%(Children) 1968 : Over 90%(Children)
Egypt	Aswan Low Dam, Irrigation	Schistosomiasis	1934 : 2-11% 1937 : 44-75%
	Aswan High Dam, Irrigation	Schistosomiasis	Increased
Ivory Coast	Dam (Bandama)	Schistosomiasis	Increased
Mali	50 Small Dams(Bandiagara)	Schistosomiasis	1976 :79.4% 1977 : 93.4%
Sudan	Sennar Dam, Irrigation	Schistosomiasis	S. haematobium 1924-1944 : Less than 1% 1952 : 21% (Adults) 45% (Children) S. mansoni 1947 : 5% 1973 : 77-86% (Children)
Nigeria	Kainji Dam	Schistosomiasis	Before : No data 1970-1972 : 44-60%

Source : Prepared by JICA Study Team

Table XI-4.2 Examples of Successful Control

COUNTRY	DISEASE	PREVALENCE CHANGE	METHOD OF CONTROL
Sudan (Gezira-Managil	Malaria	1975 : 20% 1983 : 0.1%	House spraying, Larviciding, Aerial spraying, Chemoprophylaxis
Kenya (Nandi District)	Malaria	Parasite rate Before 1953 :23% 1956 : Less than 3%	Chemoprophylaxis, Chemotheraphy, House spraying
Kenya (Kericho District)	Malaria	Parasite rate Before : 37% After : 10%	House spraying
Kenya (Malindi District)	Malaria	Before : Hyperdemic area After : Below 2.5% (Parasite rate)	House spraying, Chemoprophylaxis, Chemotheraphy
Sudan (Gezira-Managil, Rajad)	Schistosomiasis	Before 1979 : Over 50% 1983 :10%	Chemotheraphy, Water supply systems, Public latrines, Health education, Canal weeding, Molluscicide
Philippines (Leyte : Tanauan, Tolosa, Sta. Fe San Miguel)	Schistosomiasis	1978-1979 : 17.1% 1982-1983 : 8.4%	Molluscicide, Water sealed toilet, Water supply systems, Health education, Drainage, Construction of hospital
Philippines (Mac Arthur)	Schistosomiasis	Before 1956 : About 100% 1970 : 18.6%	River conservation work
Japan (Hiroshima)	Schistosomiasis	The decline of schistosomiasis	Linings of canal by concrete
Japan (Saga)	Schistosomiasis	1948 : 15.3% 1984 : 0%	Linings of canal by concrete, Molluscicide

Source : Prepared by JICA Study Team

Figures

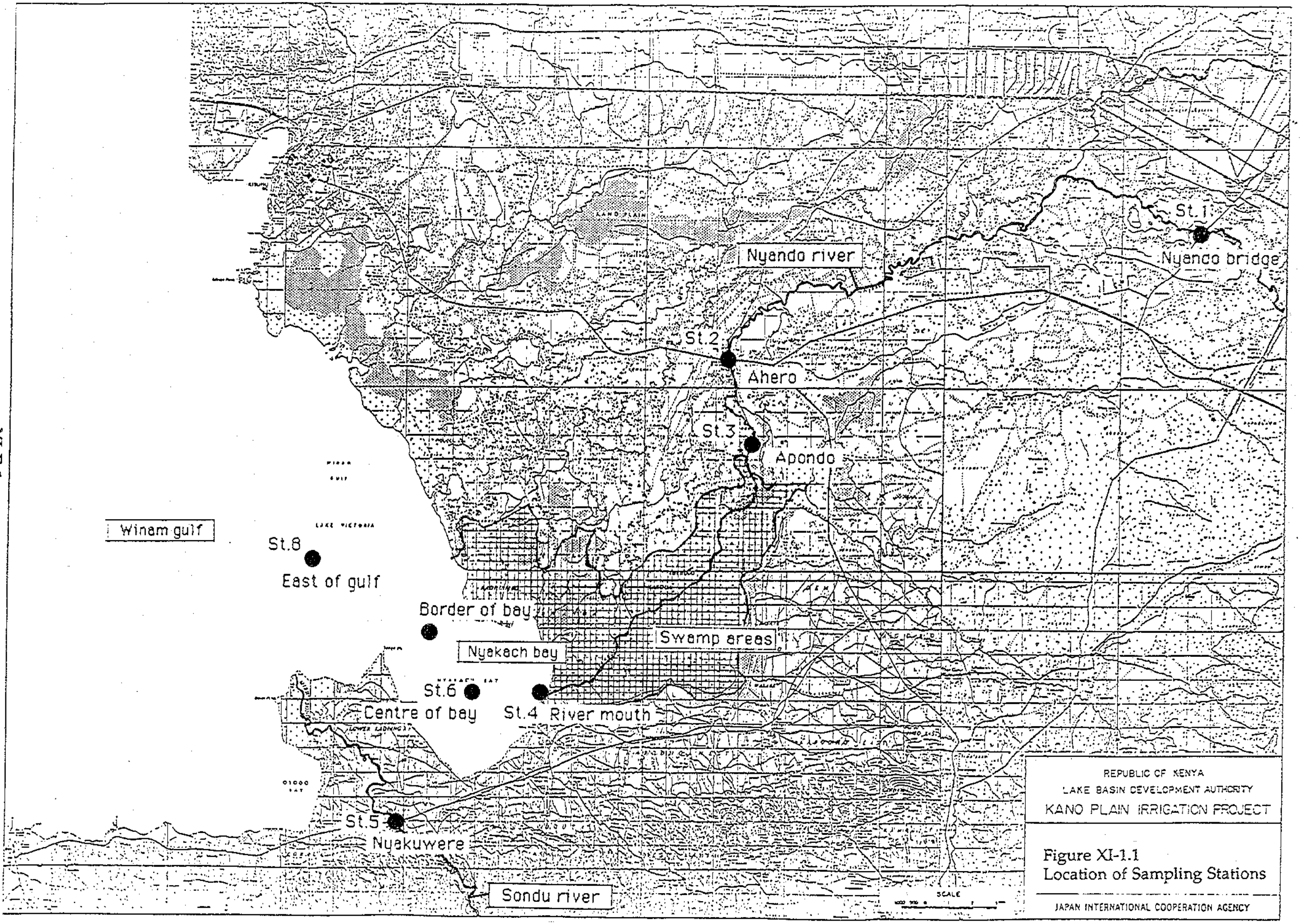
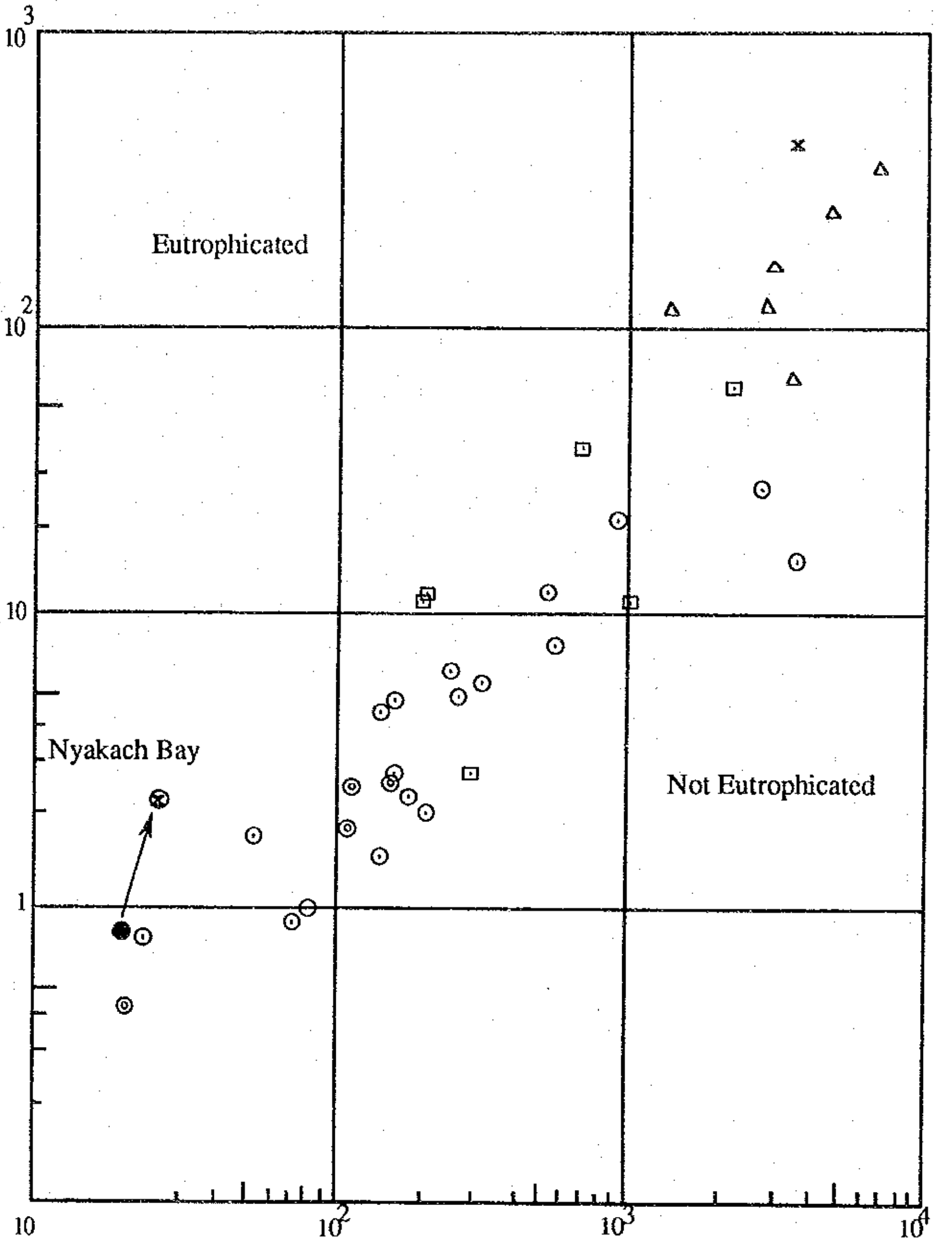


Figure XI-1.1
Location of Sampling Stations

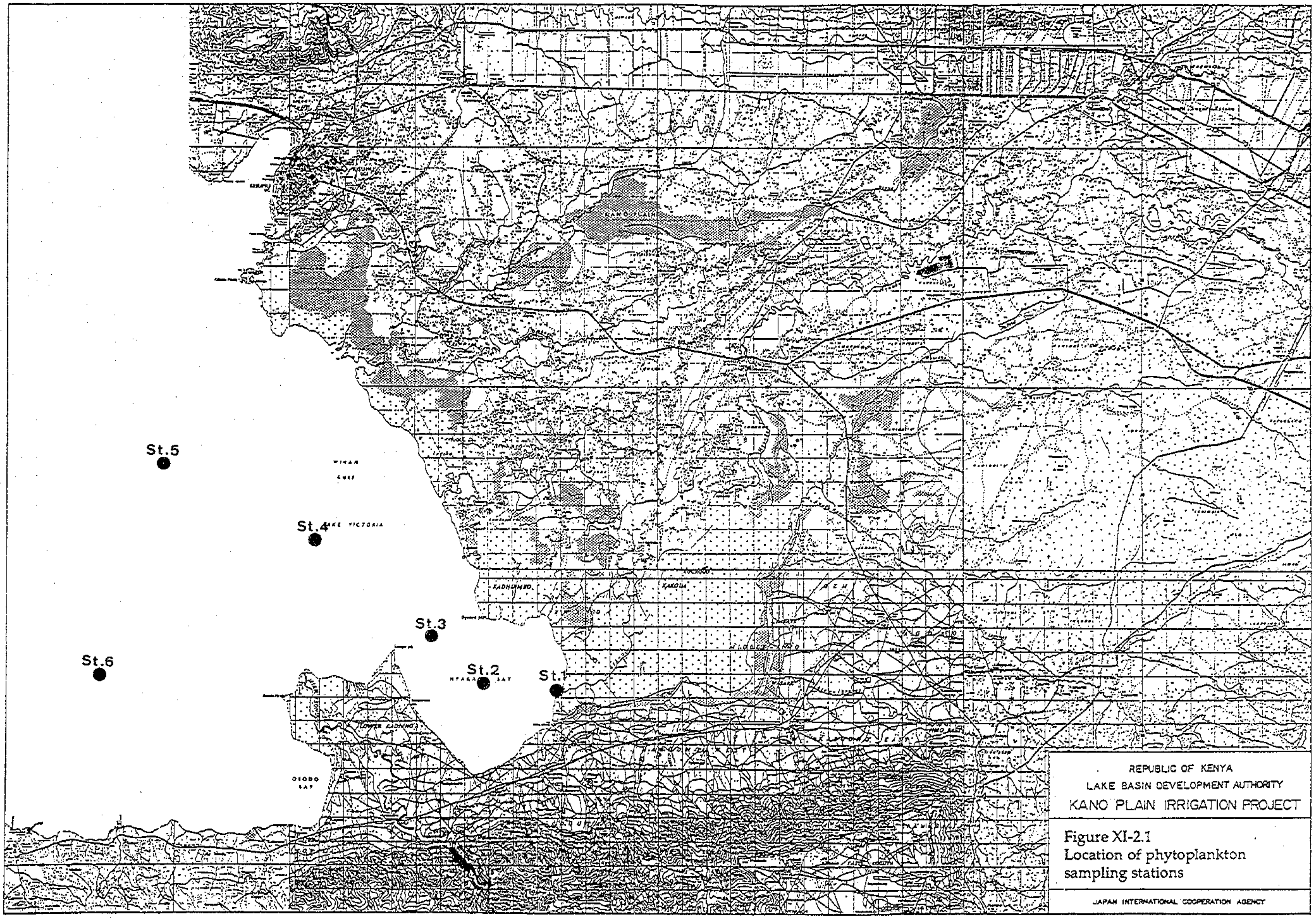


LEGEND

● Existing condition
⊗ With project condition
◎ Not eutrophicated water body
⊙ Slightly eutrophicated
⊡ Moderately eutrophicated
△ Eutrophicated
x Heavily eutrophicated

Note: The background data in this figure are the cases in Japan quoted from the report prepared by the Japan Electric Power Research Institute.

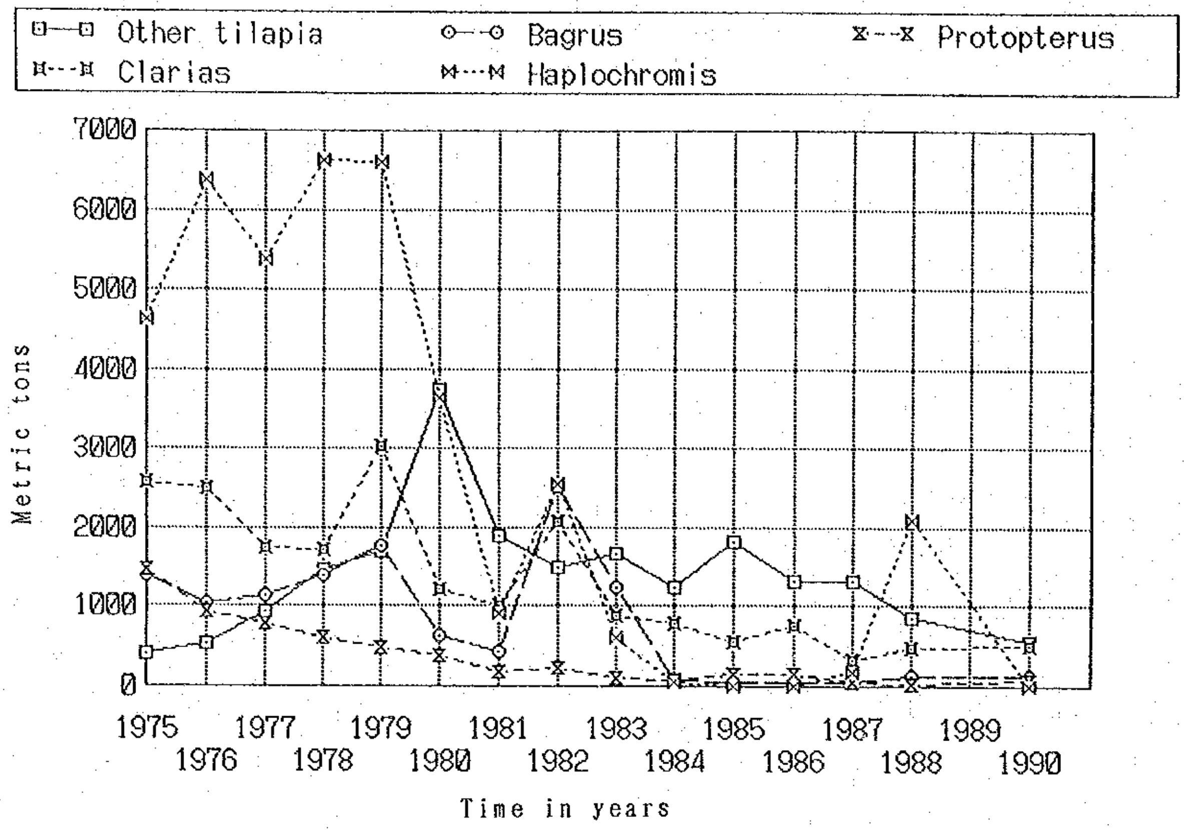
Fig. XI-1.2 Possibility Of Eutrophication of the Nyakach Bay



REPUBLIC OF KENYA
LAKE BASIN DEVELOPMENT AUTHORITY
KANO PLAIN IRRIGATION PROJECT

Figure XI-2.1
Location of phytoplankton sampling stations

JAPAN INTERNATIONAL COOPERATION AGENCY



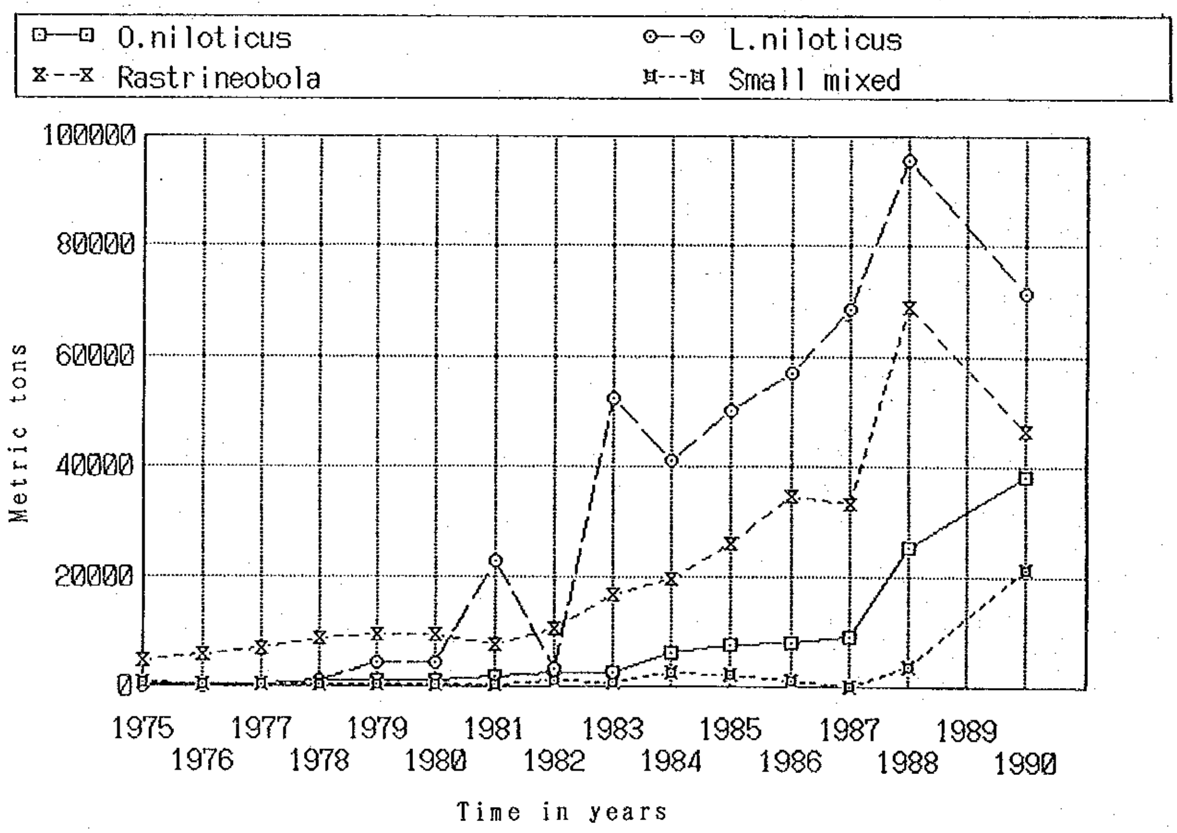


Figure XI-2.2 Annual catches of main species of Lake Victoria

Source : Fisheries department in Kisumu

REPUYBLIC OF KENYA KANO PLAIN IRRIGATION PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

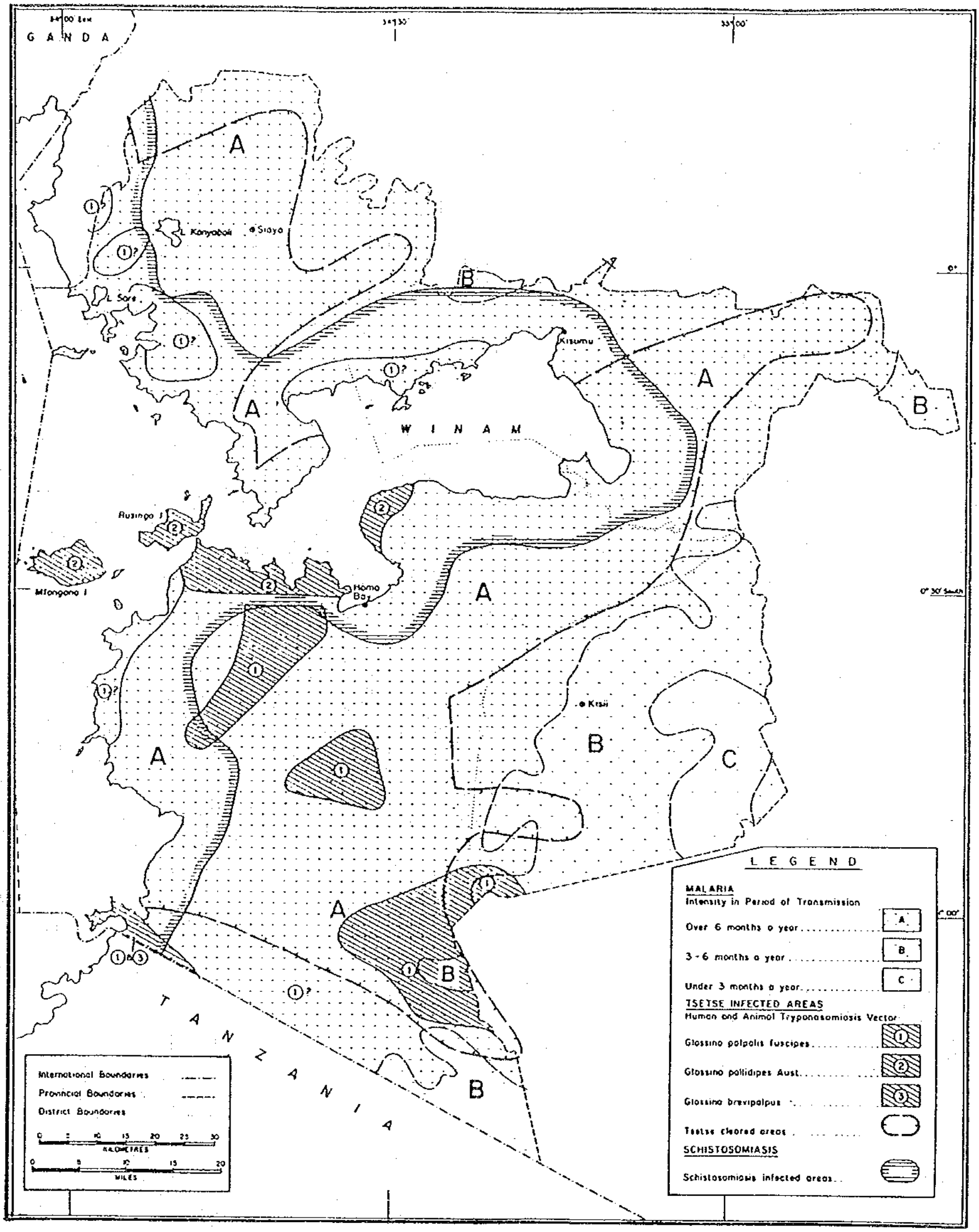


Figure XI-2.3 Malaria, schistosomiasis, and tsetsefly patterns

Source : LBDA, 1986

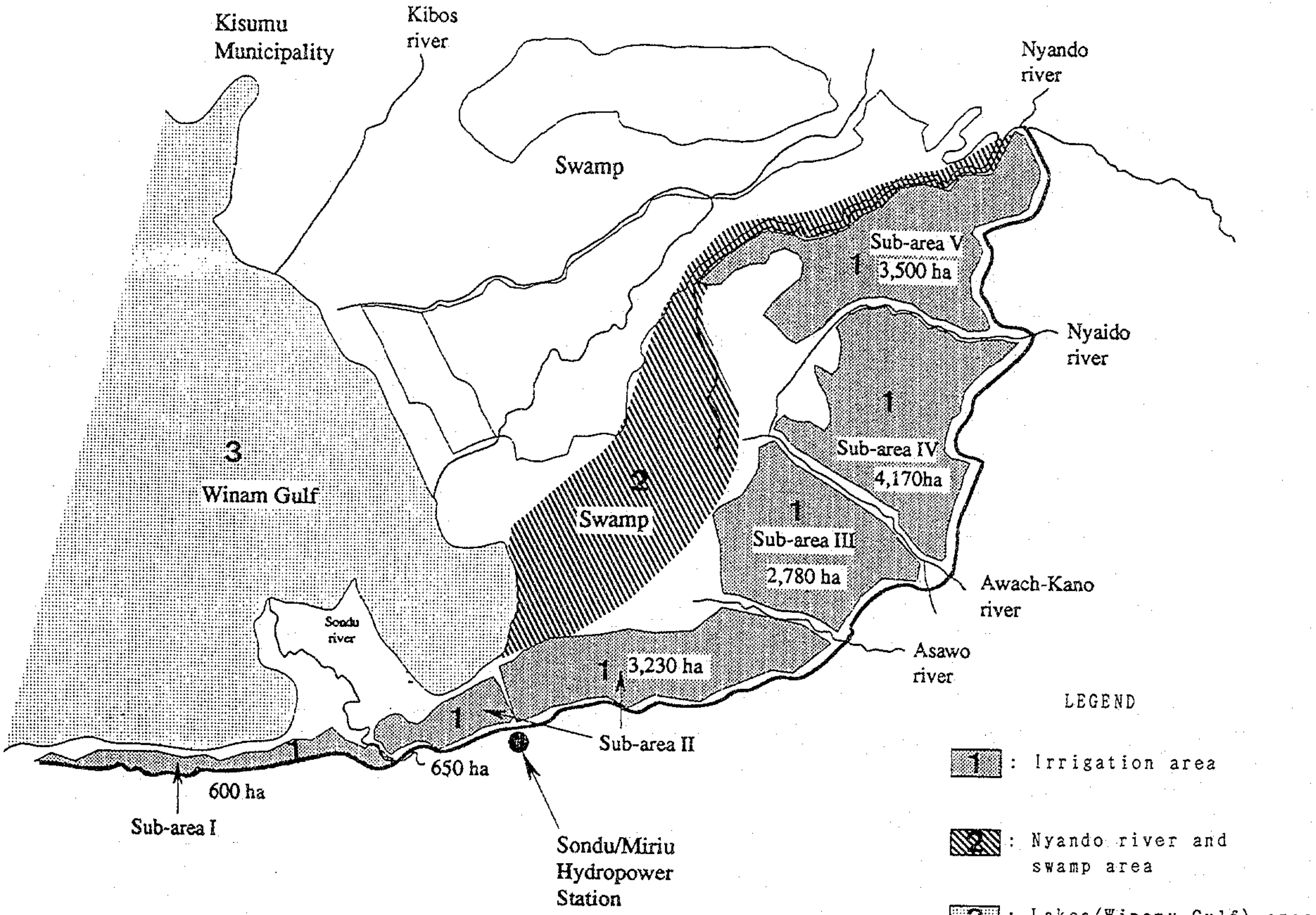


Figure XI-3.1 Schematic distribution of ecological regions

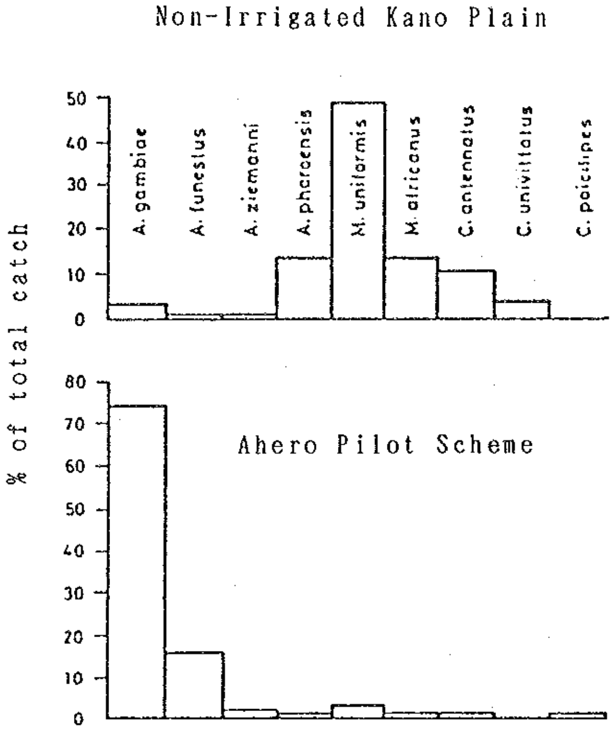


Figure XI-4.1 Species composition of mosquito catches in light traps indoors on the Kano plain and the Ahero rice fields

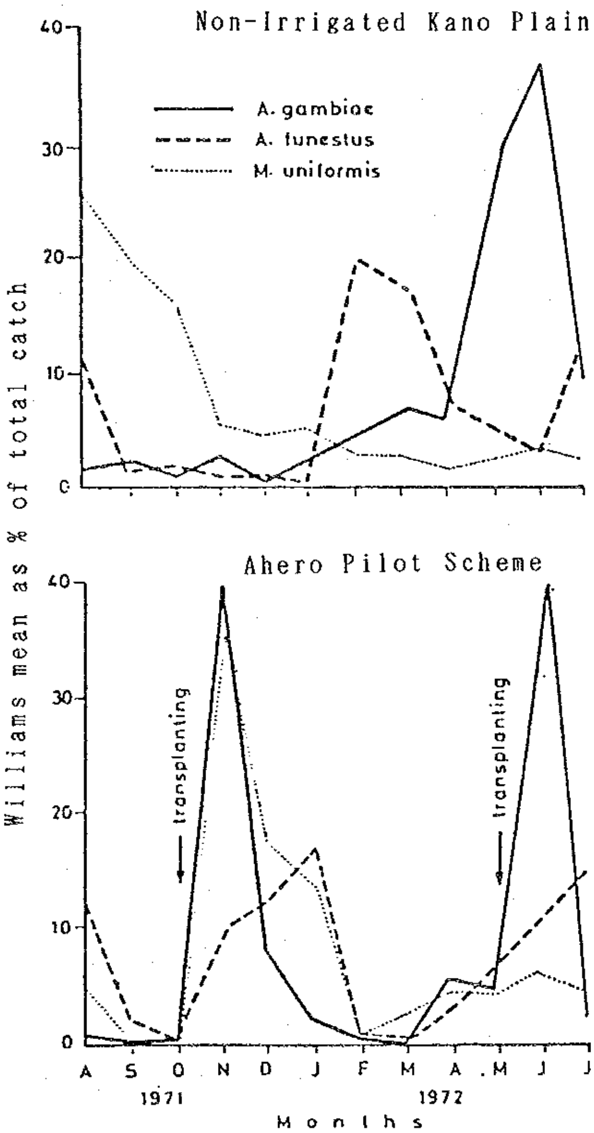


Figure XI-4.2 Seasonal prevalence of the principal endephilic species taken in light trap indoor on the Kano plain and the Ahero rice fields

Source : J.Med.Ent. 1975