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Reform Design and Implementation

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Report No. 150

Enhancement of Sustainable Fish Production and Fisheries of Wadi El Rayan Lakes

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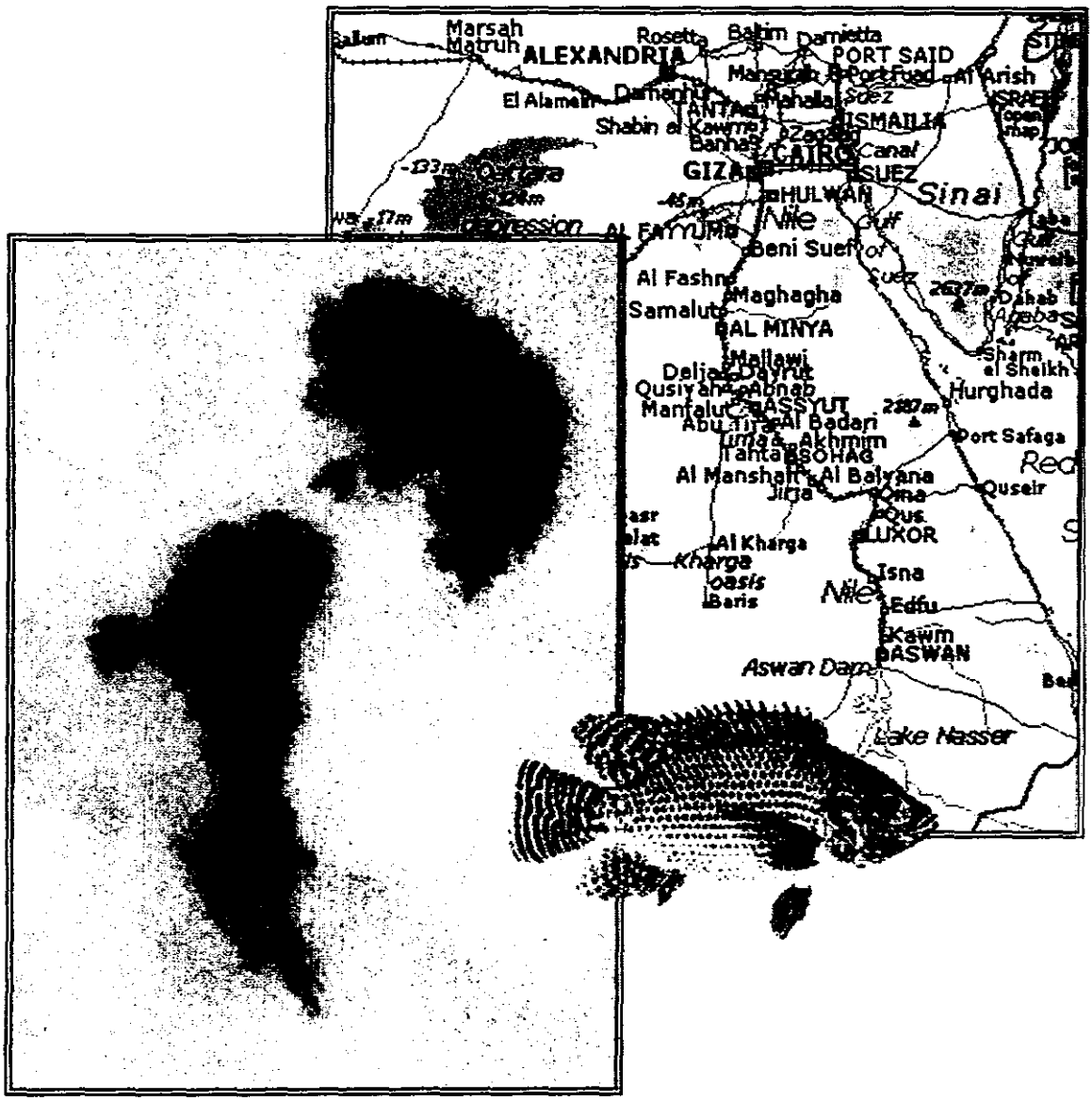

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تطوير الموارد السمكية والإنتاج السمكى المستدام لبحيرات الريان

موجز:

تم القيام بهذه الدراسة لبحث إمكانية وضع برنامج للتطوير المستدام للإنتاج السمكى والمصايد فى بحيرتى الريان. وقد شملت الدراسة مسح حقلى موسع وقراءة شاملة للنشر العلمى حول تلك البحيرات. وتم التعرف على ودراسة المشاكل المختلفة التى تمنع أو تعيق التنمية المستدامة للموارد السمكية لتلك البحيرات سواء على المدى القصير أو الممتد. وقد خرجت الدراسة بخطة لمشروع للتنمية يأخذ فى اعتباره بدرجة كبيرة البعد الإجتماعى والإقتصادى للأنشطة السمكية فى منطق البحيرات أو إقليم الفيوم بوجه عام. وقد تم فى هذه الدراسة أيضا، بحث إمكانات التطوير من خلال تناول واقعى للأمور.

وقد خلصت الدراسة إلى الآتى:

- إن برامج التنمية المطبقة حاليا تحتاج إلى قدر كبير من المراجعة والتطوير.
- هناك معدل فقد كبير للغاية متوقعا فى الزريعة المنقولة نظرا لعدم وجود أى عمليات أقلمة أو حضانة لتلك الزريعة.
- هناك كميات كبيرة للغاية من زريعة اسماك المياه العذبة يتم نقلها إلى البحيرات من مناطق بعيدة للغاية مما يؤدى إلى تحمل تكلفة كبيرة لعمليات النقل بالإضافة إلى كميات الفقد الكبيرة الناتجة عن النقل لمسافات طويلة.
- الإدارة الحالية لمصايد البحيرات لا تعتمد على قواعد علمية وهناك العديد من الحرف المستخدمة حاليا ذات أثر مدمر وتشكل تهديدا بتدمير القطعان السمكية للبحيرة.
- هناك كميات كبيرة من المصيد يتم فقدها نتيجة لغياب أساليب التداول المناسبة.
- أن أى تطوير للبحيرات يجب أن يتم طبقا لتناول يعتمد على التنمية المستدامة لتحاشى المشاكل والخسائر الحالية.
- تطبيق برنامج لأقلمة وحضانة الزريعة من الممكن أن يخفض بدرجة كبيرة الخسائر الكبيرة الموجودة حاليا.
- إقامة مفرخ لأسماك المياه العذبة فى المنطقة يوفر المبالغ السنوية الكبيرة التى تسدد حاليا كثمن لهذه الزريعة ونقلها إلى البحيرات ويشجع تنمية نشاط تربية الأسماك فى الإقليم.
- إقامة مقر للإشراف الفنى والإدارى فى منطقة البحيرات يضمن المتابعة الفعلية لتنفيذ برامج التطوير والتنمية.

- تطوير معدات الصيد وعمليات تداول الأسماك من الممكن أن ينتج عنها زيادة كبيرة للغاية فى الإنتاج السمكى من البحيرات.
- التكلفة الإجمالية للمشروع المقترح تبلغ ٨,٤ مليون جنيه خلال فترة قدرها خمس سنوات.
- العائد المالى المتوقع لتنفيذ مراحل الشروع يصل إلى حوالى ١١ مليون جنيه سنويا.
- يوفر المشروع اكثر من ١٢٠٠ فرصة عمل ثابت وحوالى ٧٥٠٠ فرصة فى الأعمال المؤقتة.

Enhancement of Sustainable Fish Production and Fisheries of Wadi El Rayan Lakes

EXECUTIVE SUMMARY

This study was carried out to find out the possibility of starting a sustainable fisheries development program for the two lakes of Wadi El Rayan. The study included extensive field surveys and review of available literature. The different problems affecting or preventing suitable levels of development of fisheries in the lakes either on the short or long term were studied. The study came out with a project plan that considered very much the socioeconomic side of development for the lake area or the whole region of El Faiyum. The development possibilities were reviewed and a realistic approach was adopted.

The study conclude the following:

- The present management program requires a great deal of revising and improving.
- Great losses of transported fry are expected as a result of the absence of acclimatization or nursing facilities.
- A large number of fresh water fish fry is transported from areas far away from the lakes, an operation which includes large losses and transport cost.
- Fisheries management of the lake is not based on scientific knowledge and many destructive gears are in use threatening with destructive exploitation of the lakes.
- Large losses in the catch were reported as a result of the absence of suitable handling facilities.
- The development of the lakes should depend on a sustainable approach to avoid the present problems and losses.
- Inducing an acclimatization and fry-nursing program can to a great extent reduce the losses in transported fry.
- Building a fresh water fish hatchery in the area can reduce dramatically the cost of fry and its transport and can also support aquaculture activities in the region.
- Having a management center in the area can assure follow up of development program.
- Improving fishing gears and fish handling can increase dramatically the catch from the lakes.

- The total cost of proposed project is 8.4 million pounds over a period of five years.
- The expected annual return of applying the project reaches about 11 million pounds.
- The project creates more than 1200 permanent jobs and about 7500 associated jobs.

Introduction:

This study was conducted to review the possibility of enhancing fisheries activities of Wadi El Rayan Lakes through a sustainable approach. The aim of the study was mainly to propose a long-term development plan for fisheries and fish production from those lakes. The work was also planned to evaluate the history and present status of the activity in the lakes and its surroundings. The study was conducted during September 2001 by a team of experts and included a series of field visits and extensive review of published and unpublished literature, reports and data. The field studies included a general limnological survey to update the available information on the lakes aquatic environment.

Fisheries of the lakes were also reviewed and the catch was inspected. The study team also interviewed the local GAFRD staff, members of fisheries cooperatives, fishermen and fish farmers. Meetings were also held with the Governor and the local government staff, aquatic and environment protection police and some members of the lake development committee. A list of persons met is attached in annex1.

The study was planned to achieve the following tasks:

- Evaluate the present condition of fish production and fisheries of the lake.
- Reviewing and evaluating the history of fisheries management of the lakes.
- Evaluating the applied policy of restocking the lakes with fish fry.
- Proposing fisheries and restocking plan to ensure sustainable production from the lakes.
- Determining the required cost and/or investment for the project.
- Propose an action plan for implementation and time schedule for each step pf this plan.

1-General Background:

1-1- Wadi El Rayan Area – general characters.

A- Geology:

The Governorate of Faiyum occupies an area of the Western Dessert of Egypt characterized with its relatively simple topography. The most outstanding geomorphologic features of the Governorate are the two depressions of Faiyum and Wadi El Rayan. The two depressions are

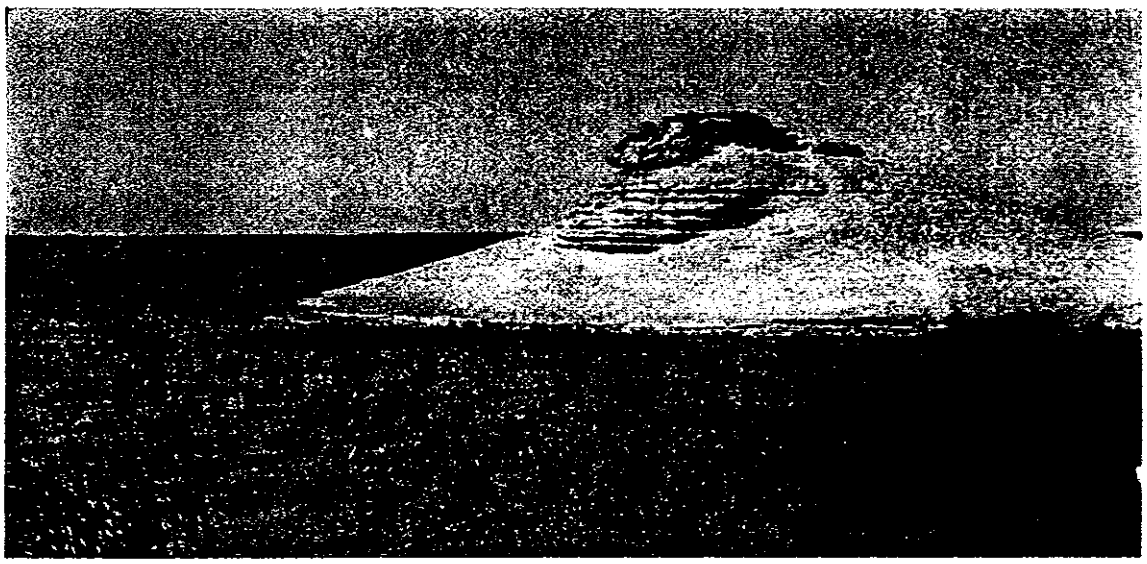

Plate 1: Wadi El Masakheet, the upper Wadi El Rayan Lake

separated from each other by the 24 meters high, 15 km wide, northwest to southeast running topographic saddle of Gabal El Hadid.

To the southwest of the Faiyum Depression the compound depression of Wadi El Rayan is located. It consists of two depressions of Wadi El Rayan (-64 m) and the smaller, shallower depression to the northeast of it; Wadi El Masakheet (-29 m). Similar to the Faiyum Depression, these depressions appear to have been excavated by wind action. The compound depression of Wadi El Rayan is bounded on its southern and southeastern sides by the vertical scarp of Minqar El Rayan which rises up to 184 m above sea level. The scarp is made of the highly fossiliferous, hard limestone of middle Eocene, with shale and marl intercalations. On the northern side of the depression a series of small limestone hills are found, most prominent of which are El Midawarra and El Mashquiqa. The depression floor rises gradually forming undulating, dissected pediplains that are mostly covered by deflated sand.

B- Surface Hydrology:

The Faiyum Depression is a typical example of internal drainage basins, several of which are found in the depressions of the Western Desert of Egypt. Nile water comes to Faiyum Depression through the Bahr Yusuf Canal, which is a natural branch of the Nile. Since 1869, Bahr Yusuf is

Plate 2: The outlet of the connecting canal, the lower Wadi El Rayan lake

taking its water from El Ibrahimya canal near the city of Dayrut. Water entering the Faiyum Depression through this canal flows naturally through an extensive system of irrigation canals to be used for irrigating farmlands, eventually draining through drainage networks into either Lake Qaroun or Upper Rayan Lake. A rather primitive and inefficient irrigation system is in use in the governorate. Water balance calculations show that the present irrigation system efficiency in Faiyum is no more than 60%. Excess water then flows passively into the still lower drainage canals. Four drainage networks cover agricultural areas in the Faiyum Depression. Three of these network drainage canals discharges its water into Lake Qaroun. The fourth network covers areas south and west of the Faiyum Depression and drain into the Wadi El Rayan Drain which, in turn discharge into the Upper Rayan Lake. All surface water entering the Faiyum and El Rayan Depressions thus drains into the lower part of these depressions, and can only leave by evaporation.

As a result of the very low efficiency of the present irrigation system, at least 40% of the irrigation water supplies must be disposed of. The present disposal capacity of the Faiyum Basin is estimated as follows:

Wadi El Rayan Drain	150,000,000	m^3/year
Open water evaporation	160,000,000	m^3/year
Lake Qaroun evaporation	600,000,000	m^3/year
Total	910,000,000	m^3/year

1. Climate:

The climate of Faiyum is typical of that of the hyper-arid Sahara; hot and dry with scanty winter rain and bright sunshine throughout the year. Temperature ranges from as high as 48.8° C to as low as -1.2° C and annual precipitation averages 10.1 mm almost totally in the form of rain which is rather irregular in time and place. Potential evapo-transpiration rate is extremely high throughout the year, and coupled with the scanty precipitation, makes the area one of the most arid localities in the world. Wind blows mostly from the north, northeast or northwest. Violent sand and dust storms locally known as *Khamasin* occur regularly during the spring months.

Plate 3: Lower Wadi El Rayan Lake, a lake in the middle of the desert

1-2-Wadi El Rayan Lakes, history, characters and future prospective:

Rayan lakes were created as a part of a pioneering agriculture development project in El Faiyum region. The construction of the Aswan

High Dam have allowed surplus irrigation water allocation to the region that facilitated adding new irrigated agriculture areas. This has resulted in increasing the volume of agriculture drainage water far beyond the capacity of lake Qaroun which use to receive all the drainage water of the region. The agriculture land to the south of the lake was always threatened by flooding as a result of the increase in lake water level associated with the increase of drainage water. To avoid this problem, Wadi El Rayan Drainage project was designed and executed to receive the drainage water of Southern and Western areas of the region.

Plate 4: The waterfall at the outlet of the canal to the Lower Lake

The project was basically consisting of a network of drainage canals that flow into the main drain of Wadi El Rayan that discharge into El Masakheet depression. As a result of the large difference in level (about 17 meters), a tunnel was dug between the end of the drain and the depression. Based on the calculation of drainage water flow and the storage capacity of El Masakheet depression, a connecting canal to the larger and deeper El Rayan depression was dug through the hilly ridge that separate the two depressions. The filling of the upper depression of Wadi El Masakheet commenced in 1974 forming the Upper El Rayan Lake. The depression was filled to its capacity (-10 m contour) in 1980, spilling over, via the canal, into the lower depression of Wadi El Rayan and forming the Lower El Rayan Lake.

The Upper Rayan Lake is a more or less freshwater lake with an average salt content of about 1.5 g/l. The average depth of the lake is

10.7 m and its surface area has stabilized at 12750 feddans and a volume of 5,450,000 m^3. Water reaching the Upper Lake from the delivery tunnel ranges in salinity from 0.55 to 0.69 g/l and in pH from 7.2 to 7.5. Salinity and pH generally increase as water moves through the lake and then to the Lower Lake. In the Upper El Rayan Lake, dissolved oxygen level is nearly always around full saturation at all depths. For a brief period during summer an oxycline develops, below which anaerobic conditions prevails. Table 2 shows main limnological features of the Upper Rayan Lake.

Table 2: Main limnological features of Upper Lake El Rayan at surface and 1m depth () in different seasons.

Parameter	Summer	Autumn	Winter	Spring
Dissolved Oxygen (% Sat.)	110 (103)	104 (102)	96 (97)	99 (99)
Temperature (° C)	27.9 (27.8)	20.9 (20.7)	15.2 (15.2)	20.0 (19.7)
Electric Conductivity (mS/cm)	1.867	1.97	1.99	1.94
Transparency (cm)	380	245	280	210
Air Temperature (° C)	30.5	23.9	15.0	19.9

The Lower Rayan Lake is the unstable of the three Faiyum lakes. Water started to flow into the Wadi El Rayan depression forming this lake

Plate 5: The lower Wadi El Rayan Lake, an unstable developing lake.

in 1980. The water level in the Lower Lake is maintained close to the -13 m contour where the rate of water inflow into the lake equals the rate of water loss by evaporation. The average depth of the lake is 11.0 m, its total volume is 8,500,000 m^3 and its total surface area is 19250 feddans. The water of this lake is brackish with an average salinity ranging from 3.86 to 5.22 g/l and pH of 8.1 to 8.6. Salinity and pH generally increase in shallower areas and as distance from water inlet increases. Salinity of

the lake is generally rising at a rate of about 0.25 g/l/year because of the yearly influx of salts carried by the drainage water feeding the lake. The Lower El Rayan Lake is relatively poor in organic material and an oxycline is not observed, although during summer there is a gradual decline in oxygen content with increasing depth. Table 3 shows main limnological features of the Lower Rayan Lake.

Table 3: Main limnological features Lower Lake El Rayan at surface and 1m depth () in different seasons.

Parameter	Summer	Autumn	Winter	Spring
Dissolved Oxygen (% Sat.)	110 (108)	108 (106)	104 (104)	110 (112)
Temperature (° C)	29.6 (29.1)	19.8 (19.6)	15.2 (15.2)	21.1 (20.2)
Electric Conductivity (mS/cm)	4.95 (5.01)	5.05 (5.10)	5.10 (5.21)	4.76 (4.96)
Transparency (cm)	290	245	203	167
Air Temperature (° C)	34.1	23.1	16.6	23.5

Accordingly, the upper lake will always be a slightly brackish water lake while the lower lake is expected to be saline after two or three decades. The large volume to surface ration of the lake is also expected to result in the formation of vertical salt gradient with more saline water near the bottom. With the time, a unique system is expected to develop in the area where two lakes one fresh and the other is saline are connected to each other. This will create a new environmental structure allowing a large diversity of aquatic fauna and flora.

2. *Fisheries Development and Fish production:*

For a long time, fisheries was the only activity practiced in the lakes. The period of the late seventies and early eighties witnessed the starting of the commercial fisheries activity. In 1980, the local governmental authorities of El Faiyum Governorate have given a fisheries franchise to a private company formed by local investors. The company hired a number of fishermen to work in the first lake on 28 fishing boats. During that time, fisheries of the lake was depending on the exploitation of the limited fish stocks reached the lakes with the drainage water. In the autumn of 1980, the company has introduced gray mullet to the upper lake.

After the establishment of the General Authority for Fish Resources Development (GAFRD) in 1983, a different exploitation approach was executed. This approach was depending on developing the fish stocks of the lakes in terms of quality and quantity. A program of stocking the lakes with more valuable and diverse fish species was applied. The program at its very beginning was an extension of that applied in lake Qaroun depending on transplanting with mullet fry (mainly *Mugil cephalus* and

Liza ramada). Few years later, the common carp *Cyprinus carpio* was introduced and followed by grass carp *Ctenopharingdon idella* and lately by silver carp *Hypophthalmichthys molitrix* and the Nile tilapia *Oreochromis niloticus*. Fish fry transplantation was not based on any previous studies on lake environmental characters or fish population dynamics. All fish transplantation was based on rough estimates and evaluation of results was not scientifically guided.

The number of transported fry to the lakes varied greatly over the time. In 1983, a total of 1.6 million mullet fry and 2 million common carp fry were stocked in the two lakes. A sharp increase in the stocked number of fry was reported in 1985. A total number of more than 50 million mullet fry was reported for this year. The transported number was then reduced to a more moderate figure of 20-25 million during the following years. Studying the catch statistics for the same period, no relation was found between the change in the number of the stocked fry and the catch. This can indicate that such an operation was not based on suitable knowledge. Since that time, until now, stocking of the lakes with fish fry was random and numbers are decided without any scientific guidance. In recent years, the statistics shows a steady and continuous, followed by sharp increase in both the total catch and the catch of transplanted species from the lakes (table 3 and figure 1).

Table 3: Variation in the total catch, mullet and carp catch from Wadi El Rayan lakes.

	1984	**1988**	**1992**	**1996**	**2000**
Mullets	49.9	206.2	231.0	187.0	562.0
Carps	-	0.14	3.0	35.0	94
Total	464.6	544.7	546.0	702.0	1876.0

The reported catch of 2000 is assumed to be mainly from the mullet fry stocked in 1986 (based on data from previous studies). The available GAFRD report by El Faiyum department shows that only 5.55 million mullet fry were stocked in the two lakes in 1998-1999. Compared with mullet production level, the figure is very surprising as only a total mortality level of 55% was calculated from stocking of fry till the catch of market size fish with an average weight of 200 grams per fish. This can be due to the fact that in 1988, the reported mullet catch of 206 tons was resulting from stocking the lakes with more than 46 million fry.

The lake-restocking program was always a major activity and involves a great deal of transportation of fry from the delta to the lakes. Fry transport was not only dedicated to mullets, carps and Nile tilapia are

also recently considered to have an increasing importance in the restocking program.
Mullet fry stocked in the lakes are transported from Port Said, Damyetta and Suez. This means that mullet fry have to be transported for a distance of 300-380 kilometers. A trip that takes 6-8 hours by fry transport trucks. According to the present stocking density applied in the

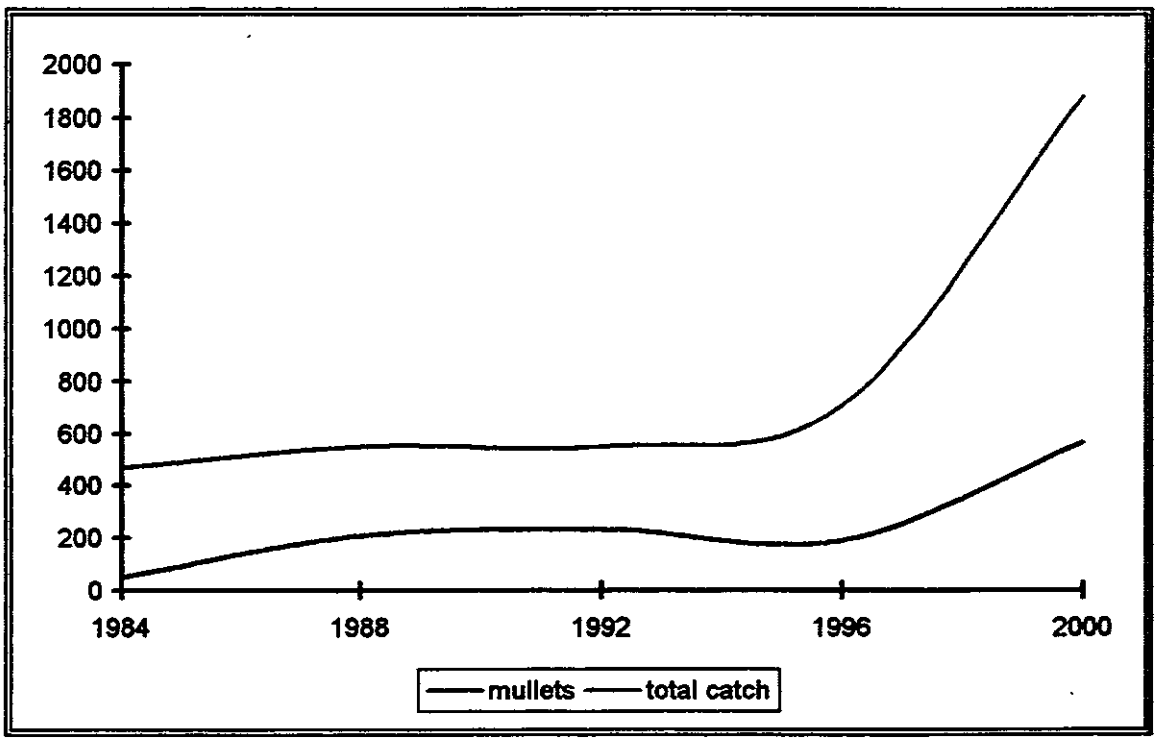

Figure 1: Variation in mullet and the total fish catch from the lakes.

tanks of fry transport trucks, 10 –16 truckloads are required for each one million fry. Mullet fry is presently released directly from the tanks of the trucks into the lakes. Very limited or probably no acclimatization to the new environment is applied.

Mullet fry transported to the lakes are collected from the coastal water of the Mediterranean Sea. Fry are then collected in enclosures or small ponds before stocking into the transport trucks. The tanks of transport trucks are usually filled with salt water from the fry collection site. Such fry if directly released into the low salinity water of the lakes are expected to suffer of lethal shock. Losses resulting from such condition may reach very high figure.

Losses of Mullet fry directly released to the lakes are not only that resulting from salt shock, large number of released fry is expected to be devoured by predators. The exhausted fry after a long trip, shocked by salt change is also a good meal for non-predator omnivorous fish like

tilapia. Accordingly, very high level of losses in the transported fry at arrival to the lake is expected. Other fish fry are also suffering losses resulting from handling, transport and predation. The problem is a result of the absence of any acclimatization or nursing facilities at the lake site. The kind of available transport truck is far from being suitable or enough to facilitate the transport of the planned number of fry.

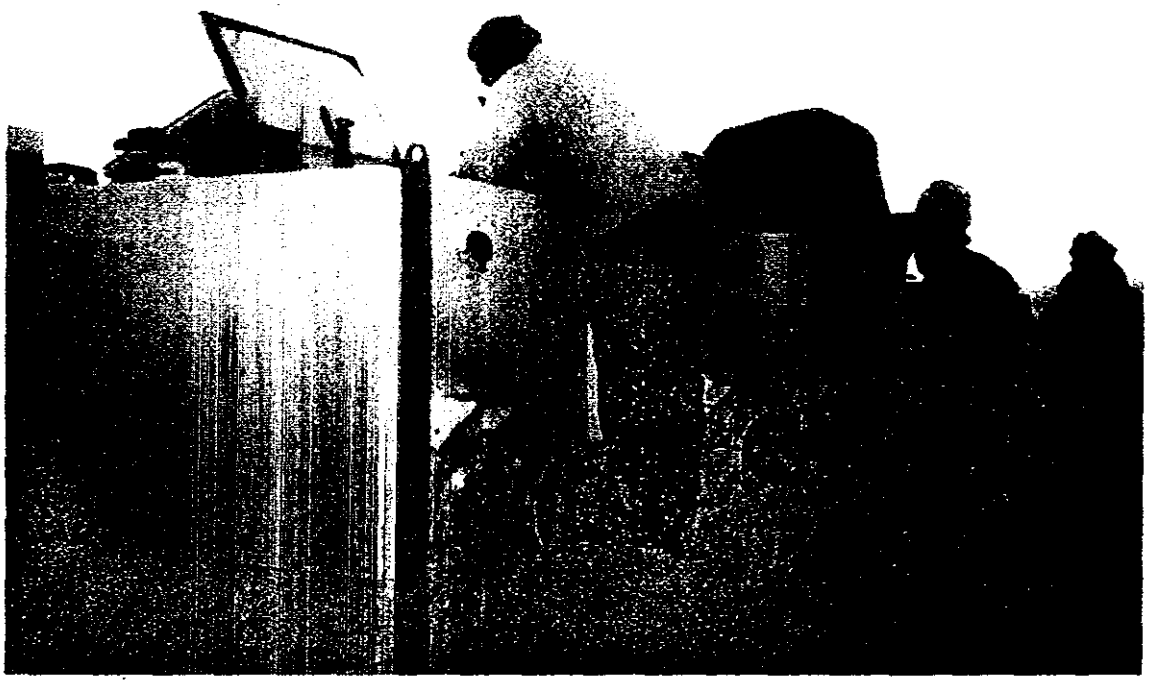

Plate 6: Fry transport by GAFRD equipped trucks to Wadi El Rayan

The fishery in Wadi El Rayan lakes is a labor-intensive activity. The fishing operation is carried out by 600 licensed oaring boats with more than 1800 registered fishermen working in both lakes. More than 27 species of fish are coat commercially in the lakes (Table 4). Gill nets and trammel nets are the two registered fishing gears allowed in the lakes. Hook and line and harpooning are also used for catching large predators (Nile perch).

The catch is landed in five landing sites in both lakes, three in the upper and two in the lower lake. The landing sites are basically places selected for the suitability of position for anchoring and being near to roads. The sites are not more than very primitive buildings where fish are sorted, weighed and collected by whole sellers. The landing sites are built and operated by the fishermen cooperative. The place is far from being hygienically satisfactory and the basic requirements such as clean running water or electricity are not available. This can be expected to result in lower quality of fish, shortening of the keeping quality and losses.

Fisheries management strategies in the two lakes is supervised by a development committee. The committee is formed of members representing the fishermen, GAFRD, Academy of Science, Ministry of Environment and Aquatic and Environment Police. Among the main tasks of the committee is the restocking programs and deciding the no fishing season for each lake. In the upper lake, fishing is not allowed twice each year. The first is during the month of February while the second starts at the second week of June till the second week of September. In the second (lower lake), fishing is stopped only once each year starting at the last week of July till the first week of November.

Plate 7: Discarded fish as a result of insufficient handling facilities.

The no-fishing periods in both lake do not seem to be related to the breeding of the important fish species in the lakes as it seems to be more directed towards avoiding fishing during the hot summer months. This can also point out at the fact of the deteriorated conditions of the landing facility and absence of ice and onboard icing facilities. The control of the no-fishing period on the other hand, is not effective. The local police forces suffer of sharp shortage in patrolling equipment, accommodation facilities and logistic support.

Fish farming activities started in Wadi El Rayan area since about ten years. An investment aquaculture project was established and an area of 1000 feddans on the sides of the connecting canal was leased to the

project. The project is designed to be an intensive land-based tank system for growing tilapia. The farm is presently constituted of 90 (20 × 20 meters) ongrowing tanks. Production target of the farm is 8 tons of fish per tank; still the reported average is not more than 4 tons from some tanks that produced market size fish. The farm was assumed to cover 200 tanks; still only 90 tanks were built.

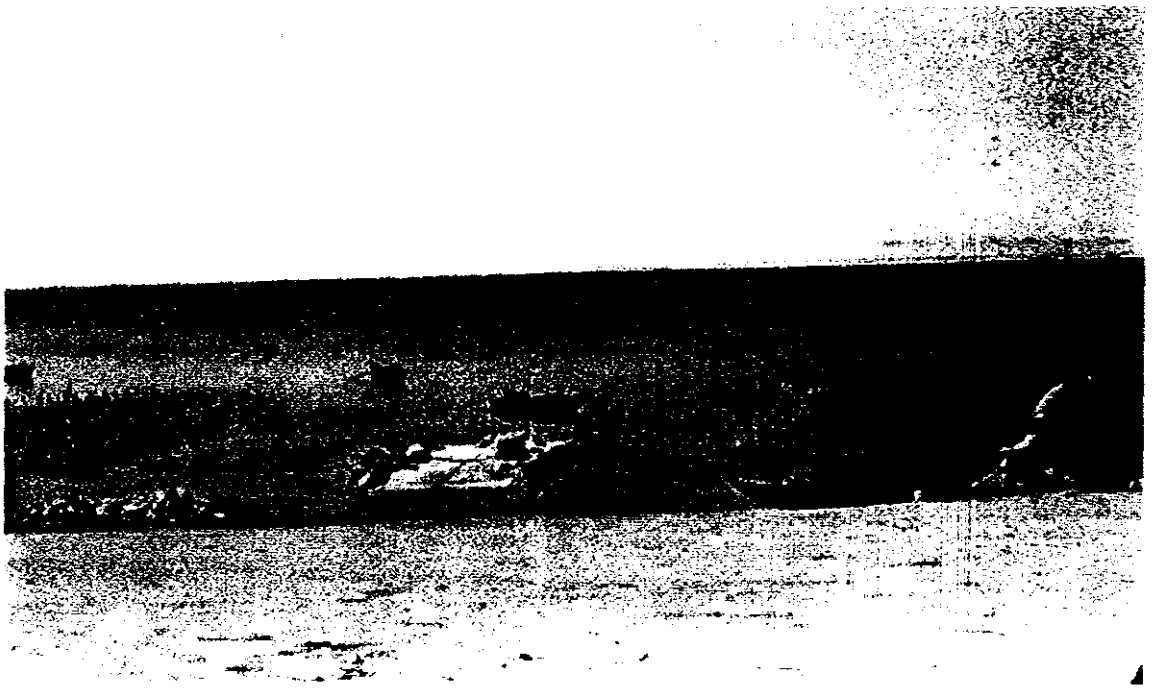

Plate 8: Fishing boats at a landing site in the lower Wadi El Rayan Lake.

Another fish farming project is in its preparatory stage. The project is owned by El Faiyum Fish Farming Cooperative and 1300 feddans were dedicated to its members. The fish-farming complex will adopt the semi-extensive system depending on the water flow in the connecting canal. The project area will be divided to 102 ponds with a production target of one ton per feddan.

3-Project Target and Objectives:

3-1- Development Concepts:

The project targets a broad-spectrum development approach that can benefit a large sector of the local community of El Faiyum Region. The project considers the development of the local fisheries and fish production sector as a major effective development sector in the region. Fisheries is a labor-intensive activity and a fisheries development program can accordingly result in creating a large number of jobs in a wide range of directly or indirectly related activities. The development of

fisheries activity in Wadi El Rayan Lakes is becoming more urgently needed. This is to absorb part of the large number of fishermen presently overexploiting Lake Qaroun. This environmentally deteriorating lake, as a result of increasing pollution and sulfate levels, will suffer after few years of sharp decline in fish production. This will result in an intolerable unemployment problem that can be avoided by developing the activity in Wadi El Rayan.

The targeted development through the project is not only by increasing fish production of the lakes. The creation of new activities in the area that can support this development is also considered. Among these activities is the production of fresh water fish fingerlings for restocking. Development of fish handling and preservation and transport can improve very much the quality of the product and reduces the large level of losses. This activity can create another potential job opportunity.

3-2- The Need for Sustainable Development:

Although many years have passed since the GAFRD started the restocking program of the lakes, the activity is still controlled by the same concepts of the early eighties. The restocking program is not based on scientific knowledge of the lake habitats. Fish species used for restocking are selected on the bases of availability not suitability. Very large numbers of fish fry are transported for very long distances from the northern delta to the lakes. These fry are released randomly into the lakes to suffer very high mortalities. The required acclimatization and nursing of transported fry is totally neglected. This is simply due to the fact that such facilities are not available. The present restocking program and the system of application results in uncontrolled numbers of different species of fish fry reaching the lakes. This system, although involve great effort and expenses but still can not support any short or long term fisheries management program.

These facts indicate the great need for adopting a new approach for fish stock management in the lakes. Many of the presently stocked fish species are hatchery produced and transported to the lakes from different locations. To cover the requirements, carp and tilapia fry are sometimes transported from hatcheries in Nagaa Hammadi or Souhag over a distance of more than 600 kilometers. In addition to the high transport cost, large losses are resulting from handling and transport. A sustainable development program can never depend on such conditions. The project is considering assuring the supply of suitable number of the required fish species at the right time for a minimal cost.

4-*Project structure:*

4-1-Improvement of restocking program:

The application of this item will result in two goals. The first is improving the production from the lake to reach its maximum capacity, and the second is to reduce to a minimum the current losses of transplanted fry.

4-1-1-*Finding the right species structure and numbers of fry for restocking the lakes.*

The proper understanding of ecological niches and fish population structure in the lakes can be a good guidance for any scientifically based restocking program.

4-1-1-A-Evaluation of the carrying capacity of the lakes:

Any restocking program should depend on proper knowledge of the primary productivity of the water body. Primary productivity is a very good measure to estimate quantitatively the daily natural food production in the water body. This means that a good estimate of the biomass of foraging plankton feeder fish (Secondary productivity) the water body can sustain can be calculated. Reaching this information, the amount of fish that can be produced in tones each year can be forecasted. This information is not yet available for use in the present management program.

The project, as a first step, should apply a suitable study on the productivity and carrying capacity of the lakes. This will be done in a number of selected stations representing the different sectors of the two lakes. To reach an acceptable level of accurate information, the study will cover at least six successive seasons.

4-1-1-B-Estimating the best species structure of transplanted fish stock:

Fish are having different feeding habits. In an environmentally balanced water body, the diversity of fish living in that water body is usually associated with the diversity of the food items. Getting a proper knowledge on the feeding habits of local fish and the food components in the water body can assist in evaluating the best fish stock structure that can make the full use of available food. This can accordingly result in maximizing the total fish production from the lakes.

The different plankton, benthos, nekton and epiphyton populations in the lakes must be studied. The study can facilitate getting the required knowledge on the qualitative characters of the natural food in the lakes. The relative abundance of food items can indicate the best proportional relation of fish species in the lakes. This can also show the gabs in the feeding chain that can be filled either with introducing new fish species or by increasing the numbers of an already present fish species.

Qualitative studies of the natural food of the lakes will be carried out in selected stations representing the different areas of the lakes. Plankton and other food items will be sampled, identified and classified in collected samples from those stations in six successive seasons. The relative abundance of different planktonic group will be recorded and evaluated.

Using the resulting knowledge of the two items (4-1-A&4-1-B) and the present structure of fish stocks in the lake, the species composition and stocked numbers of fry from each species can be calculated.

4-1-2-*Improving the efficiency of restocking program*:

This can be carried out through building acclimatization and nursery facilities at both lakes.

4-1-2-A-Reducing fry acclimatization losses:

Great losses in transplanted fry can result from insufficient acclimatization to the new environment. Mullet fry are sensitive to sudden change in water salinity. Tilapia, on the other hand, is more sensitive to temperature change. Mullets are in general very sensitive species of fish. Very high losses as a result of rough handling and unsuitable transport operation usually occur. The acclimatization to new environmental conditions, especially variable levels of salinities, requires several hours that may exceed a full day. Losses of up to 93% of mullet fry are reported after the direct transport from salt to fresh water. Such levels of losses can be expected in the present fry transport operation to Wadi El Rayan Lakes as no fry acclimatization is carried out. This is a result of the absence of suitable acclimatization facilities in the area.

At least two acclimatization stations (one for each lake) should be built through the project. The acclimatization station is consisted of a group of small land based tanks each of four cubic meters. Tanks should be constructed of water inert matter with suitable bottom slope and surface finishing to allow self-cleaning. The tanks are supplied with lake

water through a small pumping station. The acclimatization unit should have an on site stationed staff with suitable knowledge on handling and acclimatizing fry. The station should also be equipped with fry handling gears conductivity meters and thermometers and fry counting devices. The acclimatization unit should be designed in a way that facilitates moving acclimatized fry to nursery tanks through a built in piping system.

4-1-2-B-Reducing predation losses:

The current restocking program depends on transplanting young fry (less than one gram) to the lakes. Such small fry are not capable of defending itself or escaping predation. On arrival, fry are directly released to the open water of the lakes. The exhausted un-acclimatized very small fry are easy prey for many of the local fish. The majority of stocked fry is usually lost in the very first few hours after arriving to the lakes. This simply means that those valuable creatures after being transported for hundreds of kilometers are lost for feeding the predators in the lakes. Fingerlings of 3-5 grams body weight can actively escape predation and in this size some species can even defend itself. Restocking the lakes with nursed fingerlings can reduce greatly the losses resulting from predation.

The main reason for transporting fry instead of the larger size fingerlings is reducing transport cost. Transport of live fish is usually calculated by biomass of live fish per cubic meter of truck tanks. Transporting one million fry each of 0.3-0.5 grams means moving not more than 500 kilograms of biomass. If the same number of fingerlings transported, more than 5 tones of fish biomass should be handled. This means that moving a certain number of fingerlings will require ten times the transport units used for the same number of fry.

Nursing fry to fingerlings in the lake area can very much reduce transport cost and predation losses. A number of nursing ponds can be constructed near the lakeshore. Suitable sites should be selected where soil can hold water and the direct release of fingerlings into the lakes can easily be done. The nursing ponds should be connected to the acclimatization units and managed by the same staff. Nursing ponds can be used as fish farm after the end of nursing season.

4-1-2-C-Reducing handling and transport losses of fry:

Large losses are reported among the transported fry as a result of bad handling and unsuitable environment condition in the fry transport tanks.

The presently applied system of handling and counting fry involve a high level of stress and injuries. The impact of this can some time escape observation, but its results appears few hours and some times days after the arrival of fry to the site.

The stress of handling can be greatly reduced by introducing new counting system. The currently used counting system depends on hand counting. This operation involve allot of exposure of fry to non aquatic environment and rough stocking in hand nets made of rough material. Laser guided counting machines where fry in sufficient amount of water passes through the counting units can substitute this system.

Transport losses is in a large part a result of overstocking fry, insufficient oxygen supply and deterioration of water quality in tanks. Increasing the number of good designed fry transport truck can solve the problem. The trucks should be equipped with insulated glassfiber tanks supplied with compressed air through standard air diffusers. The trucks should be equipped with petrol or diesel operated air blower and a portable water pump.

4-1-3-*Assuring a sustainable supply of fry for restocking*:

All the major restocked species of fish except mullets are hatchery produced. The supply of the lakes with such fry is usually faced by problems of availability of suitable number at the proper time. This fry are also produced in hatcheries hundreds of kilometers away from the lakes. The transport of such fry involves large handling and transport losses. The cost of transporting the required number of fry also adds extra cost to the restocking program. The introduction of fry from other geographical areas can involve the hazards of transporting disease causative organisms. To avoid these problems, a fresh water fish hatchery can be constructed at an area near the planned nursing facilities at Wadi El Rayan area. The upper lake can be preferred for having better water quality for fresh water species. The locally applied hatchery systems in Egypt can produce different species of carp and tilapia under the same roof. The hatchery can also supply the developing aquaculture projects in the area with part of its requirements of fish fry.

4-2- Improving fisheries management system:

4-2-A- Fishing gears and catches control:

Fisheries in Wadi El Rayan lakes are to a large extent a culture-based activity. Most of the catch in terms of value is originated from

artificially stocked species. Such fishery is very sensitive to management operations. The calculation of fishing effort that can assure the maximum sustainable yield of fish from the lake is a basic fisheries management tool. This tool is presently not known and most of management operations are based on data of landed catch. This data even if it is correct or accurately collected cannot be used as guidance for managing such a sensitive fishery like the one in Qaroun or Wadi El Rayan.

The fishing gears used in Wadi El Rayan lakes has not been studied for suitability to get a sustainable harvest from the lakes. Trammel nets which is extensively used with variable mesh size are will known to be non selective. The nets and the system of its use in the lake allow catching variable size of fish starting from less than 50-gram tilapia or 100 gram mullet to large size fish in the same net. The use of trammel nets involves a great loss of potential production.

The detailed study of the fisheries and fishing gears in Wadi El Rayan lakes is an important step on the road to reach a sustainable development program. A lake management unit must be organized and supplied by suitable number of will-trained staff stationed in the area. The members of this unit should be responsible for collecting and analyzing fisheries data. The unit can be equipped with suitable scientific tools and equipment and work in close cooperation with the restocking group and the fisheries cooperatives.

4-2-B-Improving quality of the catch:

Losses resulting from improper handling and preservation of the fish catch can reach a large figure (plate 7). A large part of the fishes caught during summer is landed in a condition which is unsuitable for handling and it is some times tainted. To avoid these losses, the present system avoids fishing during summer. This results in losing a large production opportunity. The main reason behind that level of losses is the long distance that fish have to be transported for in the unequipped oaring fishing boats.

A system of fish collection from the fishing boats on different areas of the lakes can be implemented. Motorized boats equipped with balances, insulated chilling rooms and ice blocks can be used for collecting fish from the fishing boats and supply them by ice, food and clean fish boxes. The boats can be owned and run by the cooperatives and its running cost can be covered by collected a nominal fee from the fishermen. This can also solve the present problem of landing the catch at unofficial sites, which is also considered as smuggling.

4-3-Enhancement of lake based aquaculture:

Aquaculture is a labor-intensive activity. Wadi El Rayan lakes are among the very few places in Egypt ideal for aquaculture in floating cages. The depth of the lake which in many areas exceeds 35 meters and the availability of sheltered area facilitate an extensive cage culture activity. The physical characters of the lake water, especially the lower lake, where light transparency exceeds 3.5 meters support good observation of cage from the surface. The high level of light transparency indicates a low suspended solids (mainly plankton) level. This can confirm the findings of the observed very low nutrient content of the lake water. With the depth of the lake and its huge volume, the cage culture activity cannot result in any negative effect on the lake environment.

Suitable anchorage site and cage farm design can be carried out through the project. The activity will also create new job opportunities in the industry of manufacturing cages and its requirements.

4-4- initial Stock support program:

The fish stock of the lakes requires an initial restocking program as a first treatment of the present overexploitation problem. Fingerlings of selected carp and tilapia species are to be transported in suitable numbers into the lakes. Grass carp, a fish that have not being stocked since many years in the lake is among the most required species. The abundance of filamentous algae and other submerged macrophyta, which is not presently consumed by any fish, can support millions of grass carp of different age groups. This can in return add a large amount of catch to the lake harvest. Common carp is another species that has not contributed enough to the resources of the lakes. Such fish which reported to be caught in very large individual sizes from the lakes (15-28 kg) can be introduced in suitable numbers. Nile tilapia stock of the lake can be supported with fingerlings to increase the proportion of good class fish in the lake.

On this bases, at the very early stage of the project, fingerlings of the different species of fish should be stocked in the lake through a long season stocking program. This can assure the succession of age group and sizes of fish and accordingly, those fish can be harvested over a long harvesting season. Tilapia and carp can be brought from the nearest Upper Egypt hatcheries in Benisweif or El Minya.

5-Results of application of the project:

The implementation of the project will result in **an annual direct income of about eleven million pounds.** A number of goals of socioeconomic importance are also expected, among which:

- Creating more than 1200 new permanent jobs.
- At least 7200 person will benefit indirectly from the activities of the project.
- Reducing the current pressure on the fisheries of lake Qaroun by moving fishermen to the more productive Wadi El Rayan lakes.
- An increase in catch value of 2.8 million pounds in its first year reaching more than 6.3 million pounds each year after completing the two phases of the project.
- A surplus fish production of more than three million pound from cage culture.
- An annual increase of 10-15 % of the catch of the lakes.
- Reducing the fry losses by more than 75%.
- An annual production of 25 million tilapia fry and 20 million carp fry with a total value of 1.2 million pounds.
- Reducing dramatically fish losses resulting from bad handling.
- Extending the fishing season to reduce part time unemployment.
- Improving the species structure of the catch towards higher value fish.

6-Proposed Action plan and time schedule:

The implementation of the project is planed to be in two phases. The first phase is planned to be a preparatory phase and extends for two years.

During the first phase the following actions are planned:

1. Restocking support program:

Enhancement of the present fish stocks of the lake by transporting fingerlings. During the first year of this phase, 5 million Nile tilapia fingerlings, two million common carp and one million grass and silver carp fingerlings are to be stocked in the upper lake. This will result in a surplus catch of 125 tons of tilapia in the first year with a market value of 750 thousand pounds. The stocked carps are expected to produce 225 tons

of fish with a market value of 675 thousand pounds. This production is added to the present production of other stocked fish like mullet. In the second year of this phase the surplus catch of tilapia will reach 218.75 tons with a market value of 1.53 million pounds, the total catch of stocked carp will reach 260 tons with a value of 1.04 million pounds.

During the same period, six million tilapia, two million common carp and one million grass and silver carp fingerlings are to be stocked in the lower lake each year. This will result in adding 150 tons of tilapia and 180 tons of carp with a total value of 1.38 million pounds. In the second year the surplus catch of these fish as a result of the new restocking program will be 195 tons of tilapia and 260 tons of carp with a total value of 2.21million pounds.

2. Field studies:

A. Studying the primary productivity of the lakes at different selected stations to calculate the overall carrying capacity of the lakes.

B. Studying the food web in the lakes to find out the best fish species structure for restocking in the lakes.

C. Studying fishing gears and creating a data collecting system for fisheries studies.

3. Site selection, planning and construction:

In this stage, the site selection and planning for acclimatization, nursing units and other supportive buildings in both lakes should take place.

A- Acclimatization units: Considering the number of transported fry to each lake, 12 self cleaning tanks each of 4 cubic meters capacity should be constructed for each lake according to specifications as in item 4-1-2-A.

B- Nursing units: An area of 50 feddans should be selected at each lake to construct 30 nursing ponds each of one feddan. Nursery units are connected systematically to the acclimatization units.

C- Management center: including office-laboratory room, accommodation for one senior staff member and three staff members. The building includes a store, power station and power distribution panel.

The center should be equipped with a computer, water sampling facilities, salinity, oxygen and temperature measuring equipment. A rubber boat with an outboard engine and carrying trailer and a four-wheel drive double cabin pickup truck should be dedicated for the center.

4. Reducing catch handling losses:

To reduce the present problem of on board spoilage of caught fish four fish transport motorized boats, two for each lake, is planned to be available shortly after the start of the project. The boats are equipped with a balance for weighing fish, an icebox of suitable size for keeping collected fish, and crushed ice or ice flakes store.

An on land facility including a suitable size icemaker and a fish washing, sorting and handling room can be built as one central for each lake.

The second phase:

The second phase of the project will extend for three years. During this phase a sustainable development system for the lakes will be established. The following actions are planned:

1. Constructing a fresh water fish hatchery for the production of tilapia and carp fry. The hatchery will be integrated with the acclimatization and nursing facilities of the upper lake (4-1-3).

2. Six equipped fry transport trucks, each with six 1.25 cubic meters insulated tanks (4-1-2-C).

3. Continuation of the fisheries studies for measuring stocks and maximum sustainable yield (4-2-A).

4. Starting an extension project for cage culture to recruit, train and support fish farmers (4-4).

7-Investments, cost and return:

The cost and returns shown in this report are the additional costs required to apply the project without including the present expenses and revenues of the current GAFRD program. The cost of the project will be distributed over the period of five years. The value of expenses can differ from one year to the other depending on the development of the project. A large part of the expenses will be dedicated to serving infrastructure for

the fisheries sector. The rest will be invested on covering the cost of fish fry, transport of fry, studies and extension. The estimated total cost of the project will sum up to **a total of 8.343 million pounds** distributed over the two phases of the project on the different items according to the following scheme.

Phase one:

The total cost of this phase sums up to **4.715 million pounds** distributed as follows:

First year: with a total cost of **2.087 million pounds**.

1. Tilapia fingerlings (11 millions).	605 thousand pounds.
2. Mixed carp fingerlings (6 millions).	198 thousand pounds.
3. Fingerlings transport.	55 thousand pounds.
4. Field studies, incentives and extension.	360 thousand pounds.
5. Acclimatization units (two lakes).	180 thousand pounds.
6. Management center (two lakes).	420 thousand pounds.
7. Fish handling facilities (two lakes).	260 thousand pounds.

Second year: with a total cost of **2.628 million pounds**.

1. Tilapia fingerlings (11 millions).	605 thousand pounds.
2. Mixed carp fingerlings (6 millions).	198 thousand pounds.
3. Fingerlings transport.	55 thousand pounds.
4. Field studies, incentives and extension.	190 thousand pounds.
5. Nursing facilities.	1500 thousand pounds.
6. Maintenance, fuel and running cost.	80 thousand pounds.

Phase two:

The total cost of this phase is **3.628 million pounds** distributed over the three years period of this phase as follows.

First year: with a total cost of **2.168 million pounds**.

1. Tilapia fingerlings (11 millions).	605 thousand pounds.
2. Mixed carp fingerlings (6 millions).	198 thousand pounds.
3. Fingerlings transport.	55 thousand pounds.
4. Field studies, incentives and extension.	190 thousand pounds.
5. Hatchery facilities.	1000 thousand pounds.
6. Maintenance and running cost.	120 thousand pounds.

Second year: with a total cost of **0.730 million pounds**.

1. Fry transport trucks (three). 360 thousand pounds.
2. Field studies, incentives and extension. 190 thousand pounds.
3. Maintenance and running cost. 180 thousand pounds.

Third year: with a total cost of **0.730 million pounds**.

1. Fry transport trucks (three). 360 thousand pounds.
2. Field studies, incentives and extension. 190 thousand pounds.
3. Maintenance and running cost. 180 thousand pounds.

Annex 1

Table 4: Fish species recorded from Rayan Lakes

	English name	Local name	Scientific name
1	Nile carp	Libies	*Labeo niloticus*
2	Barbel	Binni	*Barbus bynni*
3	Sardinella	Raya	*Sardinella ssp.*
4	Flathead gray mullet	Bouri	*Mugil cephalus*
5	Thinlip gray mullet	Tobar	*Liza ramada*
6	Golden gray mullet	Dahaban	*Liza aurata*
7	Silverside	Bisarya	*Atherina boyeri*
8	Silverside	Bisarya	*Atherina ssp.*
9	Tooth carp	Botriekh	*Aphanius dispar*
10	Tooth carp	Botriekh	*A. fasciatus*
11	Catfish	Bayad	*Bagrus bayad*
12	Catfish	Dokmak	*B. docmak*
13	Sharptoothed catfish	Qarmout	*Clarias gariepinus*
14		Shall	*Synodontis schall*
15	European seabass	Qarous	*Dicentrarchus labrax*
16	Spotted seabass	Noqt	*D. punctatus*
17	Gilthead seabream	Denies	*Sparus auratus*
18	Halfbeak	Abomongar	*Hemiramphus far*
19	Blue cichlid		*Haplochromis ssp.*
20	Nile perch	Samous	*Lates (Lates) niloticus*
21	Tilapia	Bulti Akhdar	*Tilapia zillii*
22	Tilapia	Bulti Abyad	*Oreochromis niloticus*
23	Tilapia	Bulti hassany	*O. aureus*
24	Tilapia	Bulti Malawi	*Sarotherodon galilaeus*
25	Common carp	Mabrouk	*Cyprinus carpio*
26	Grass carp	Hashaesh	*Ctenopharyngodon idella*
27	Silver carp	Sinfer	*Hypophthalmichthys malitrix*