PROSPECTS OF AQUACULTURE IN NEPAL

BY

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MUCIA/IAAS

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PROSPECTS
OF AQUACULTURE
IN NEPAL

by

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at the Institute of Agriculture
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Tribhuvan University of Nepal on

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Foreword

This is the first of what we shall term occasional papers. The subjects to be covered are as wide as the interests of our faculty. They will include seminars given by our own or by visiting colleagues. This publication outlet is not intended as a research diffusion channel although the seminars or discussion pieces might well be based on research findings. It is hoped that this series of publications will encourage the careful recording of thoughtful discussions at IAAS. Through this series of papers we may give longer viability to our shared deliberations.

Dr. Garland Wood
MUCIA Chief of Party

* PROSPECTS OF AQUACULTURE IN NEPAL

Introduction

"Aquaculture" means the organized culture or cultivation of useful aquatic animals and plants in enclosed water bodies. In Nepal, at present aquaculture is limited only to the cultivation of fish.

The first part of this paper deals with what has been done in Nepal for fish culture and fisheries development, and the second part deals with what can be done in Nepal for further research and development of fisheries. However, some useful hints about the cultivation of some aquatic cash crops have also been given in this paper. Some of the important aquatic and semiaquatic animals of Nepal also are mentioned.

PART - I: WHAT HAS BEEN DONE IN NEPAL ?

1. History of Fish Farming in Nepal

Fish catching is an ancient occupation in Nepal. Pode, Majhi, Danuwar, Derai and Damar are some important traditional fishermen of Nepal. In 1947, the Agriculture Council of Nepal created a small unit to investigate the possibilities of fish culture in Nepal. It was traditional that Indian major carp fingerlings were brought from India to be cultivated in Nepal, but their cultivation was successful only in the Terai. These fish could not survive in the hills. Kathmandu proved to be too cold for them.

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* Seminar given at IAAS Rampur, Chitwan, Nepal on February 19, 1982. The Seminar paper has been slightly modified.

So, exotic fish such as the Chinese carps and common carp were tried. In 1956, the fisheries section was created to administer the fisheries development program. During 1956-66, six government fish farms were constructed in the country.

2. Justification for producing more fish in Nepal

There is a high consumer demand for fish in Nepal. The average annual consumption of animal protein was only 4.5 kg. per person in 1974-75 and only 0.2 kg. of that came from fish (Silpachai [18], 1980). Other sources of animal protein such as goat meat fetch high prices. The price of goat meat has doubled in the past five years. So, fish will have an increasing demand in Nepal. The price of fish also has risen from Rs. 10 to Rs. 24 in Chitwan and from Rs. 10 to 30 in other parts of Nepal including Kathmandu. Nepal has sufficient agricultural products to feed fish. Also, different farming systems can be linked to fish production.

3. Water bodies of Nepal

The total area of Nepal is 141,06000 ha. The total water surface area of Nepal is 400,000 ha. (Majupuria[12], 1981-82). The irrigated paddy fields have an area of 117,490 ha. In the Terai, the village ponds have a total area of 5000 ha. (Silpachai[18], 1980). The main rivers of Nepal are the Koshi river in the east, the Gandaki river in inner Nepal and the Karnali river in the west.

The most famous lakes of Nepal are: Fewa Lake, Rupa Lake and Begnas Lake (Pokhara), Gaduva Lake, Tamorghila Lake and Kasara Lake

(Chitwan), Styavati Lake (Palpa), Khatpad Lake (Doti), Nandan Lake (Palpa), Stharpu Lake (Jajarkot), Sumra Sarovar (Bajang), Taudaha Lake (South Chobar) and Mahendra Lake (Jumla) (K.T. Augusthy[2], 1979). The UNDP's Integrated Fishery and Fish Culture Development Project Pokhara was started in 1975 in Fewa Lake. Common carp fingerlings were released into the lake and grass carp and silver carp were used in cage culture in the lake (Silpachai[18], 1980). The ecology and fish fauna of Taudaha lake has been studied in detail (Rajkarnikar, Tulsi Man[15], 1981).

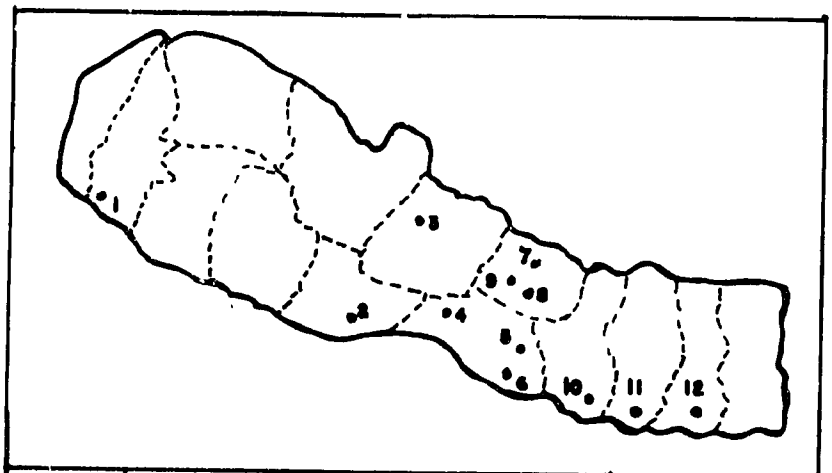
4. Fish Farms of Nepal

The important government fish farms of Nepal, their location and altitude are as shown in figure 1. As evident from the chart given under fig. 1, the altitude of fish farms varies from 76 meters to 1700 meteres from the Mean Seal Level.

S.No.	Name of Fish Farm	Altitude above M.S.L. in m.
1.	DHANGADHI	
2.	BHAIRAHAWA	140
3.	POKHARA	854
4.	BHANDARA	198
5.	HETAUDA	303
6.	PARWANIPUR	100
7.	TRISULI	530
8.	BALAJU	1288
9.	GODAWARI	1700
10.	JANAKPUR	90
11.	FATHEPUR	90
12.	BIRATNAGAR	76

Fig: 1.

MAP SHOWING THE GOVERNMENT FISH FARMS OF NEPAL



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of the hilly rivers of Nepal, such as the mysterious Seti River of Pokhara valley, are only partially known. The fish fauna of hilly rivers above 16,60 meters are not yet studied due to the rugged geography that prevents access to these torrential streams which often meander in hidden paths,

The Cultivated Fish

a) Indigenous fish

The Indian Major Carps

The Indian major carps are the indigenous fish cultivated in the Nepalese Terai. Ther are:

Catla - Catla catla - surface feeder (feeds mainly on plankton and decayed plants on the surface).

Rohu - Labeo rohita - column feeder, feeds on algal forms and decayed vegetation.

Mrigal - Cirrhina mrigala - bottom feeder, feeds on semirooted vegetable matter and detritus.

The Indian major carps do not breed in confined waters. They can be propagated only by induced breeding. These fish do not grow well in the hilly regions of Nepal due to the low temperatures.

Alsa

Fish generally known as Asla are indigenous fish of Nepal. There are two types of Asla, via; 'cuchee' and 'buchee' ('cuchee' = pointed mouth, 'buchee' = flat mouth) 'cuchee' are found in Trisuli. Its scientific name

is Orienus richardsoni. 'Buchee' are seen in Kaligandaki at Jomsom situated at 2800m. above sea level. Its scientific name is Schizothorax plagistomus (K. Masuda[13], 1979).

b) Exotic Fish

The exotic fish generally cultivated in Nepal are the Chinese carps. They are:

Grass carp (Ctenopharyngodon idella)

Silver carp (Hypophthalmichthys molitrix)

Bighead carp (Aristichthys nobilis)

Common carp (Cyprinus carpio)

These fish are having non-competitive feeding habits and so can be cultured together (polyculture) to get more yield from the same pond than that of a single species of fish (monoculture).

c) Feeding habits

Gras carp - eats macrovegetation.

Silver carp - microscopic algae

Bighead carp - zooplankton

Common carp - bottom feeder, but is omnivorous.

d) Breeding habits

Among the above mentioned fish, only common carp breeds in confined water. In other varieties, fingerlings - production is by induced breeding.

Best breeding results can be expected from fish having a body weight 4-5 kg. in females 2-3 kg in males. A good female carp may produce 150,000 eggs per kg. The survival rate of the eggs is not more than 20% (Woynarovich[21], 1975).

The spawning of the common carp under natural conditions occurs usually in spring season when the water warms to around 18 - 20°C. The spawning time of all other Chinese carps is related to water temperature. They spawn in summer in flooded rivers of China. Experience of induced breeding of these fish in Nepal shows that the ripening time of the females depends on water temperature as shown below:

Water temperature °C	Ripening time of females hours
20 - 22	12 - 10
23 - 25	11 - 9
26 - 28	10 - 7

Source: Fish Farming in Nepal by K.T. Augusthy, 1979.

6. Weight of Fish at the time of marketing

The growing period of fish in Nepal is 8 - 9 months. The reported average weight of fish is only 0.8 to 1 kg. in the government farms. In ponds owned by some farmers, fish grew to even 3.5 kg. in one year due to better management (Kalidas Shrestha[17], 1982).

7. Feed Industry

There is no organised fish food industry in Nepal. Certain Suggestions regarding the development of commercial fish foods in Nepal are given under item 13, Part II of this paper.

8. Fish Feed

The main agricultural and animal products used for feeding fish in Nepal and their food values and food quotients are as given in the following two charts.

Plant Products:

Food items	Dry matter %	Digestible protein %	Starch %	Crude Fat %	Fibre %	Ash %	Food quotient
Maize	87	7.0	60.0	4.5	2.1	1.3	4 - 4.5
Wheat	87	9.0	65.0	1.0	1.9	-	4 - 4.5
Wheat bran	87	10.0	20.0	4.6	10.1	-	4.5 - 7
Rice bran	90.5	6.0	37.8	2.7	33.1	10.7	-
Mustard oil cake	89.8	24.6	41.7	1.1	7.1	15.3	-
Guinea grass	-	-	-	-	-	-	48

Animal Products:

Food items	Dry matter	Crude protein	Carbohydrate	Crude fat %	Ash	Food quotient
Fish meal	87	61	1.5	3.5	21	
Blood meal	86	81	1.5	0.8	2.7	
Silk worm pupae (fresh)	35.4	19.1	2.3	12.8	1.2	1.8
Silk worm pupae (dried)	90	55.9	6.6	24.5	1.9	
River snail (fresh)	21.6	12.2	4.3	1.4	3.7	
Fresh water mussels	20.4	18.4	-	0.8	1.2	
Aquatic worms (fresh)	18.9	8.6	-	4.4	1.4	
Chironomids (fresh)	16.1	9.1	-	13.6	7.1	
Locusts (fresh)	34.1	25.5	1.4	2.0	2.2	

Source: Woynarovich, Elek. 1975. Elementary guide to fish culture in Nepal, pp. 59-60.

It is clear from these two charts that the food quotient (the quantity in kg. of food required to produce 1 kg. of fish) of the different items of food varies highly. For example, 1 kg. fish can be produced by feeding 1.8 kg. Silk worm pupae whereas 48 kg. Guinea grass has to be fed to produce one kg. of fish. The food quotients of two common agricultural products, viz; mustard oil cake and rice bran have yet to be determined through research studies.

9. Amphibian Fauna

Many biogeographic races of amphibians are found in Nepal (Shrestha Tej Kumar[16], 1982). The most important of these from a commercial point of view are:

Bull Frog - Rana tigrina

Green Frog - Rana hexadactyla and

Hyla or Rhacophorus.

The possibilities of setting up an industry to process and export the legs of Rana tigrina and Rana hexadactyla have been spotlighted by K.T. Augusthy in 1979 in his book Fish Farming in Nepal. These two species are found in the lowland and midland zones of Nepal respectively. Hyla is distributed in the Mahabharat Lekh. A single species of Hyla fetches Rs. 22/- in Bhimphedi and Hetauda Bazar (Shrestha, Tej Kumar[16], 1982).

The toads of Nepal may be used to make fancy articles after tanning their skin. The amphidian fauna of Nepal range from 80m. to 5000m. They include coecilians, salamanders and common frogs offering excellent opportunities for researchers in biological and medical sciences (Majupuria[12], 1981-82).

10. Aquatic Reptiles (Crocodiles and Tortoises)

Two species of crocodiles are found in Nepal. They are (1) The marsh muggar (Crocodylus palustris) and the Gharial (Gavialis gangeticus). Both of these are fully protected in Nepal by the Wildlife Conservation Act. (T.M. Maskey and H.R. Mishra[14], 1980).

Gharial is a fish eating crocodile. Their estimated population in Nepal is 159 (Behura and Singh[7], 1978). Maskey and Yadav in 1980 reported that therewere 53 Gharials in Narayani out of which 7 are males. There is a rearing site for Gharial at Kasara lake in Chitwan.

Land tortoises (Kachuga) distributed in central Nepal can be considered to be at least partially aquatic.

11. Aquatic mamals

The Gangetic dolphin, Platanista gangetica is one of the rare species of fresh water dolphins found in the Narayani river that flows through the Chitwan valley of Nepal. Dolphins are also believed to be present in Karnali and Koshi rivers of Nepal (D.R. Uprety and T.C. Majupuria[19], 1981-82).

PART - II

FUTURE PROSPECTS OF RESEARCH AND DEVELOPMENT

The following are some of the important fields for future research and development of aquaculture in Nepal.

1. The need for establishing a fish pituitary bank

The pituitary gland located in the ventral side of the brain is taken and administered to the dorsal muscles of brood fish by injection for the induced breeding of fish. The pituitary gland contains reproductive hormones. The pituitary glands collected from carps with 1-2 kg. body weight has a dry weight of 2 mg. per kg. of body weight.

Even though well maintained, and sexually mature brood fish are present on farms, the production of fingerlings on fish farms of Nepal sometimes becomes inconvenient due to the lack of well preserved pituitary glands. This will affect all the fish culture operations of the government farms and that of the private farms that depend on the government farms for the supply of fingerlings. The more the delay in producing fingerlings, the more is the delay in stocking fingerlings in production ponds and hence the number of days available for fish to grow in a year is cut down.

This problem can be solved by establishing a pituitary bank at the Central Office of the Fisheries Section, Kathmandu. Arrangements can be made to preserve and supply pituitary glands from all the government and private farms to Kathmandu. This does not involve a high cost because the pituitary gland can be taken by dissecting the skull of the fish just before marketing the table fish harvested from production ponds.

This does not affect consumer demand in any way if the public are told why the skulls of the fish they purchase are opened a little bit.

The pituitary glands can be dried and defattened in acetone and kept in sterile phials stored at 50°F. So, the most important arrangement needed for a pituitary bank is mechanisms for maintaining a temperature of 50°F.

2. Depth Vs Area

The depth of fish ponds in government farms is only 2 - 3½ feet. Actually, light can panetrate up to 7 feet deep in water and hence fish food (microscopic algae and fish food organisms) can be produced all through the 7 foot water column. So, by increasing the depth of ponds, more fish can be produced in the same area of land. Some research in this line will prove valuable to support future development of fisheries in Nepal.

3. Impact of altitude and temperature on fish production and fish breeding

a) Fish production:

Nepal's climate, altitude and geography are extremely diverse. The altitude ranges from 100 feet in the Terai (South) to 29,028 in the North at Sagarmatha, (Mount Everest). The average temperature falls one degree every 3000 feet in altitude. This great diversity of climate can be attributed to the unusual difference in altitudes within a relatively short physical span. The number of cold days in a year

is more in places of high altitude than at lower altitude. Fish eat less at low temperatures and more at high temperatures. As fish growth depends on the quantity of food consumed, the imapct of temperature variations on fish growth is significant. This can be studied at different geographic locations of Nepal. The growth of fish is much less during winter months and hence keeping fish in ponds in winter results in loss in many ways. So, a growth study based on altitude (and hence temperature variations) can be helpful in determining the harvesting date of fish in each locality. Based on this information, the management of fish culture activities can be modified.

b) Fish breeding:

The ripening time of females, spawning of fish and incubation of eggs are related to water temperature and hence to altitude. There is much scope of research in these areas on fingerling production.

4. Establishment of meterological stations in fish farms

The establishment of meterological stations (to collect data on temperature, humidity, rain fall and atmospheric pressure) in every fish farm will be of much help for conducting research in fish production and fish breeding.

5. Protection of fingerlings from predators

Fingerlings stocked in production ponds are often eaten by predators of many kinds like frogs, snakes, predatory fish and birds. Some farmers lose 100% of their stocked fingerlings by these predators.

At present, an extra large number of fingerlings to allow for predators are stocked in the farm ponds - both government and private. Research can be conducted on the protection of fingerlings from predators. Fingerlings can be grown in nursery ponds well protected with nylon net to prevent the entry of predators. After growing for a month or so, the fingerlings can escape the attack of predators and can be released into the production ponds. Preliminary experiments in these lines were conducted at the Institute of Agriculture and Animal Science of the Tribhuvan University of Nepal (Augusthy, K.T.[3], 1981).

6. Investigation of the aquatic fauna of Nepal

a) Fish fauna:

The fish fauna of Nepal between an altitude of 1650 to 3323 meters above mean seal level are practically untouched and so there remains much scope for exploration of these fauna. After the investigation of this fauna, the biology of some important species can be studied, and based on these results, some of these fish can be considered for culture in the cold water streams of the hills.

b) Other aquatic organisms:

Crabs, clams and snails of various kinds are present in Nepal. These fauna can be investigated. Crabs are important ecological aerators of soil and are not harmful for paddy seedlings (Yadav, U.K.[22], 1980). Mollucs fix calcium in fish ponds and rice fields. Their body calcium is available when their shells break down by sun heat after death (Augusthy, K.T.[4], 1980/82).

7. Makhna - cum - Fish (Air-breathing fish) Culture

As the perennial and stagnant water bodies of N. Bihar, India and that of the Terai regions of Nepal such as Janakpur are likely to be similar in many respects, Makhna-cum-Fish Culture can be tried in Nepal too along the same lines as in N. Bihar. Air-breathing fish naturally occur in the Terai of Nepal. It is learned from reliable sources that Makhana grows wild in the village ponds of Janakpur. Makhana-cum-Fish Culture can be organized on scientific lines in Nepal too (Augusthy K.T.[2], 1979).

In N. Bihar, air-breathing fish culture is done in ponds in which Makhana, Euryale ferox Salisb (family Nymphaceae), an aquatic cash crop is grown. Makhana are cultivated in Assam amd Madhya Pradesh. Dhrubanga district of North Bihar grows 'Makhana' on a commercial scale. Makhana grows well in old perennial water bodies having a depth of 1 - 1.5m. with muddy bottoms. Newly constructed ponds are not favourable for its growth. Only air-breathing fish can be cultured in these water bodies. Heteropneustes fossilis and Clarias batrachus are the preferred species of air-breathing fish recommended for this purpose. A gross production of Makhana worth Rs. 3000 Indian currency per acre per year can be obtained. An additional crop of 1200 kg./ha./year of fish also can be obtained from mixed cultivation in such ponds (P.V. Dehadrai[9], 1976).

Makhana remains deeply rooted in the pond bottom by firbrous roots. It has orbicircular leaves floating on the water surface (Cook, C.D.[8], 1974) as shown in Fig. 2.

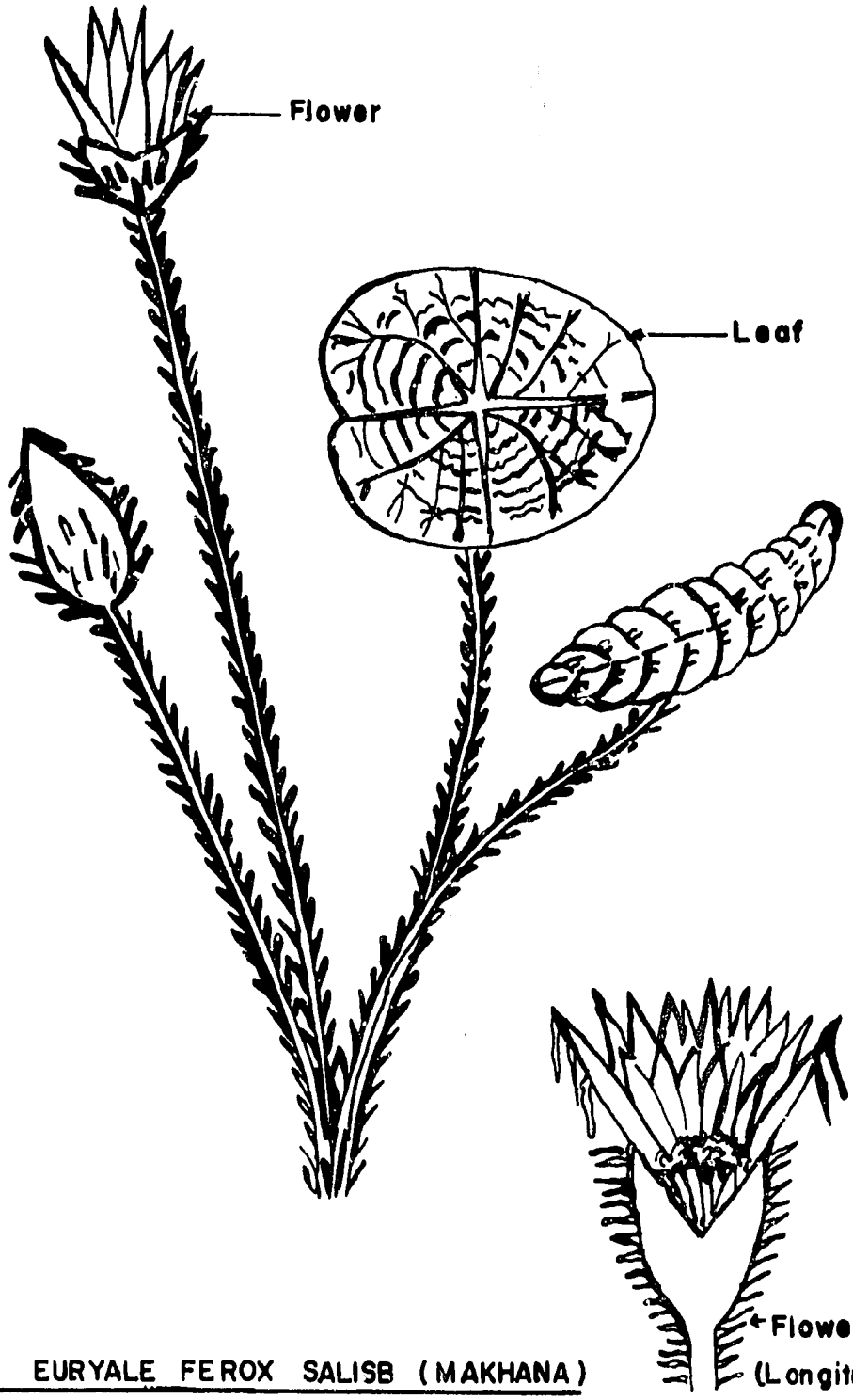

FIG. 2 EURYALE FEROX SALISB (MAKHANA)

Source: Cook C. D. 1974, Water Plants of the World P. 336

In Durhanga District, Bihar, the Makhana seed is sown in October-November. Fourty to fifty kg. of seeds are sown in one acre pond. The seeds sink to be bottom and germinate. Sprouting occurs during February-March. Thinning is carried out during this period and transplanting is done by keeping a distance of one meter between two plants. Flowering occurs at the end of May. Fruits are formed in June. Mature fruits burst in September. The fruits are spongy. Each fruit contains 20-25 seeds. The seeds sink to the pond bottom. These seeds are collected by trained persons and processed before marketing. Roasted seeds of Makhana are used in various kinds of delicious milk preparations and also for making curry. It is also used for medicinal purposes.

The food value of Makhana is as given below. Moisture - 12.8%, protein - 9.7%, fat - 0.1%, mineral matter - 0.5%, carbohydrates 76.9%, calcium - 0.02%, phosphorus 0.09%, iron - 1.4 mg/100 gm, carotene, trace. (The wealth of India Raw Materials Vol. III D-E^{20}, 1952). During the second year of cultivation, the remaining seeds will germinate and the only care to be taken is transplanting the germinated seedlings to maintain a proper distance. The fry of air-breathing fish can be introduced before the sprouting of these seeds occurs. The fish can be harvested after harvesting the Makhana.

The culture of air-breathing fish is appropriate in the undrainable village ponds of Nepal where the lack of dissolved oxygen sets a limit for culturing other fish. The air-breathing fish are commonly found in ponds in rural areas and rural people are familiar with these. Therefore, perhaps it may be easier to help them improve the culture of these varieties in

selected localities. Once their culture is organized, it is easier to make it an internal part of rural aquaculture. Besides yielding fish meat, these fish act as sanitary agents by controlling mosquitos and hence malaria.

8. Other aquatic cash crops (plants)

Other aquatic cash crops like water chestnut can be tested for cultivation in suitable water bodies.

9. Azolla and its utilization in fish culture

Azolla can be tried in rice fields as a nitrozen fixing and weed controlling agent. Grass carp can be incorporated with Azolla in rice fields after determining whether grass carp will eat a sufficient quantity of Azolla.

If grass carp are proved to be eating Azolla, then Azolla can be incorporated in fish ponds but it should be kept under proper control (by Grass carp and ducks) so that sunlight won't be blocked from penetrating into the pond water.

10. Fish Culture in Rice Fields

Fish culture in rice fields even though popular, is not well organized in Nepal due to many reasons. Fish culture in rice fields can be popularized in the near future. Increasing irrigation facilities will give more opportunity for this.

11. Possibility of Duck-cum-Fish culture in Bhairahawa and Janakpur

As there are natural sources of water and clayey soil to make ponds in Janakpur and Bhairahawa, there is much chance for research and development of duck-cum-fish culture in these areas on a commercial scale. Local and exotic ducks (e.g. Pekin ducks) can be grown on fish farms and their ecological adaptation and capacity of egg and meat production can be studied.

12. Recycling system in an integrated plant - animal farm

There has been a growing interest among technologists in the farming systems that will provide better understanding of the new appraoch in maximizing production of an integrated plant - animal farm as well as optimizing ways of utilizing its waste products. Thus some of the basic information on recycling system of an integrated plant and animal farm is presented in Fig. 3.

Six components involved in the recycling system are:

1) Algae production
2) Livestock production
3) Biogas production
4) Crop production
5) Duck production
6) Fish production

These components complement each other reducing the operational cost of food production under an integrated farming scheme (Jose A. Eusebio, B.I. Rabino and E.C. Euseibo[10], 1976) as shown in Fig. 3.

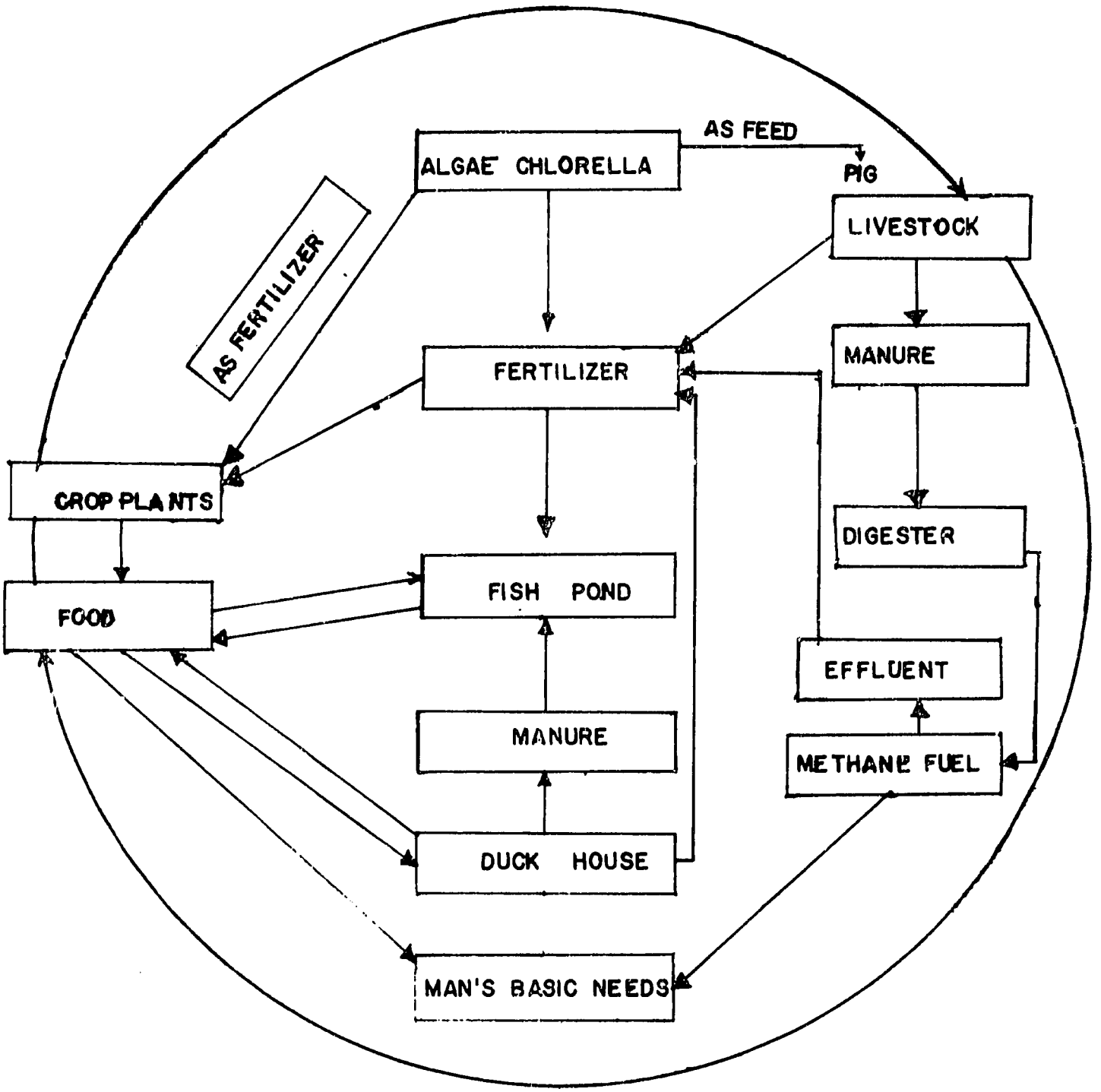

FIG. 3. RECYCLING SYSTEM IN INTEGRATED PLANT ANIMAL FARMING

13. Development of Commercial Fish food:

a) Frog wastes and their utilization as fish feed:

Nepal has good prospects for establishing a frog-leg industry. Edible frogs are available in Nepal. The hind legs of frogs which are the only portion exported come only to 35% of the body weight. Until recently the remaining 65% of the body weight was rejected. Experiments have been conducted and a formula was developed for the preparation of frog meal by the Central Institute of Fisheries Technology Cochin, India. Frog meal is comparable to fish meal. It can be used as a fish feed and poultry feed. Frog meal contains 60.6% protein where as fish meal (taken as the average values of three fish via; Caranx, Jeus Fish and Oil Sardine) contains 58.53% protein.

b) Survey and identification of the aquatic plants of Nepal:

The indigenous aquatic plants of Nepal can be surveyed and experimented with as food for grass carp. The desirable plants can be introduced into fish ponds or can be cultivated in the vicinity of fish farms.

c) Silk-worm cultivation can be organized in Nepal. After removing the silk , the silk-worm pupae can be fed to fish. The pupae are the best food for fish and have a conversion ratio of 1.8 (Hickling[10]).

14. Possibility of a Fish-cum-Frog Industry

It seems that a multipurpose fish-cum-frog industry is possible in Janakpur. This industry can be mainly concerned with the frog-leg export to international markets (K.T. Augusthy[2], 1979).

With some modification, this frog-cum-fish industry may also be utilized for preserving various kinds of meat products.

15. Fish Farming in the Hills

The people of the hilly area of Nepal get only a scanty supply of fish due to the following reasons:

1) lack of transportation
2) lack of fish preservation and marketing facilities
3) lack of fish farming facilities (ponds)
4) lack of water lifting mechanisms
5) retardation of growth of certain fish species in the hills. (e.g. Indian Major Carps).

Although the prospects of fish farming in the hills is limited, more encouragement can be given by cultivating fast growing indigenous fish of the hill streams. This needs thorough scientific investigation of the ecology and biology of selected species of hill stream fish. Now in Nepal Asla fish are being studied along these lines.

16. Application of Water Lifting Machines

A simple and locally made water lifting machine that can lift up water to a height of 13 feet (without using other power) from a flowing stream is shown in Fig. 4.

A water fall can rotate the turbine. The axil fixed to the turbine rotates the drive wheel to which is attached a belt connected to the pully of a centrifugal pump. The centrifugal pump pumps up water into the fish pond located at a higher level than the water fall.

Water lifting Machine (Without using power)

(NOT TO SCALE)

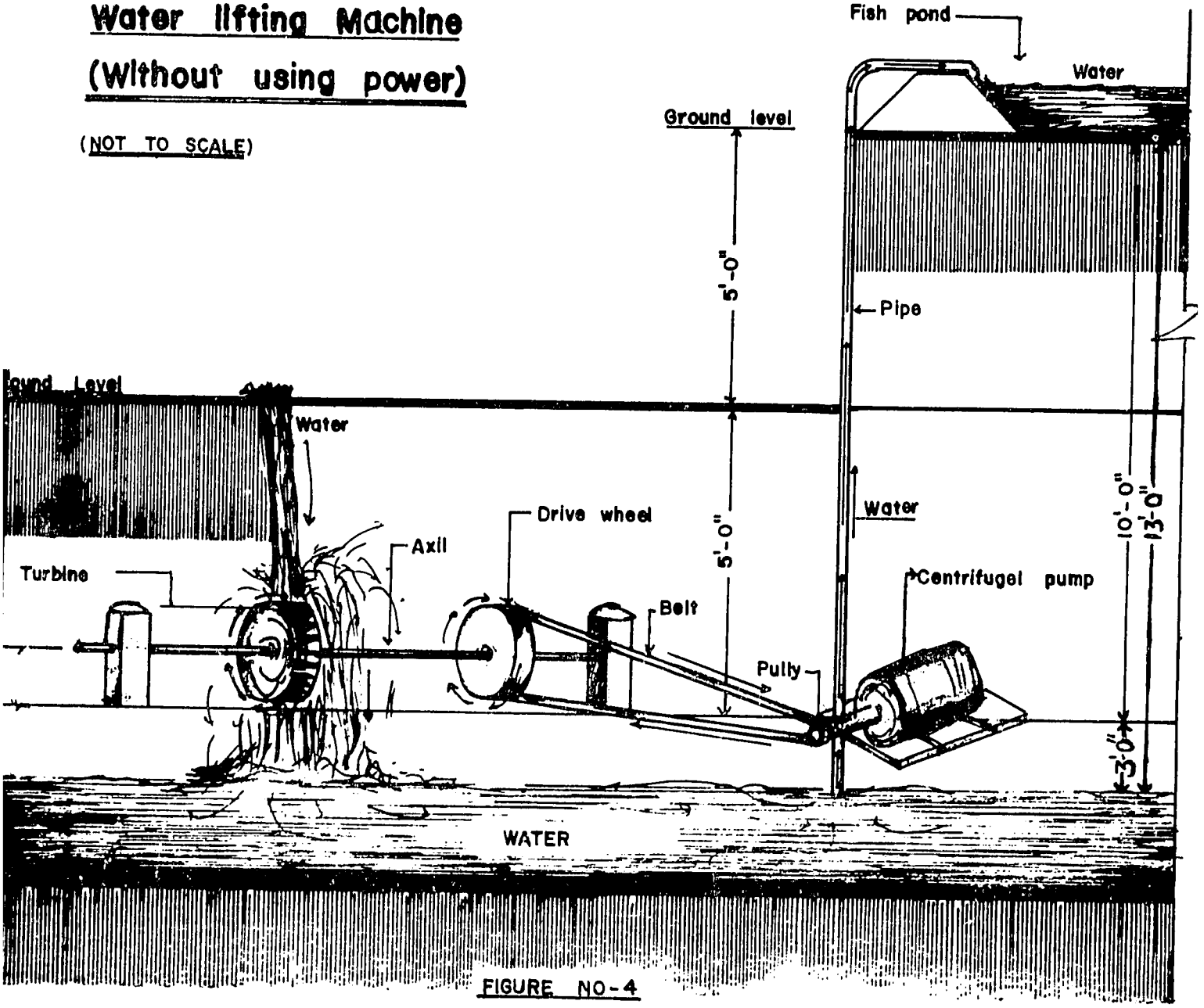

FIGURE NO-4

This machine is being used by Narendra Patak, a progressive fish farmer in Thadi (Ratnagar), Chitwan, Nepal (Augusthy K.T.[5], 1982). Various modified forms of such machines are used in Nepal for lifting up water for irrigation. Booklets on hydraulic rams are available at Balaju Yantra Sala (Balaju Machinery House), Kathmandu, Nepal. Such machines may be used in selected localities on the hills for lifting up water for fish pond or rice field.

17. Need for co-ordination of HMG and University experts through seminars and workshops

Tribhuvan University has a few eminent ichthyologists and fish biologists like Dr. Jiwan Shrestha, Prof. T.C. Majupuria, and Dr. Tej Kumar Shrestha. Their co-ordination into the fish culture activities of Nepal launched by Fisheries Section, HMG can result in better suggestions for research and development of fisheries. Exchange of ideas and literature between these two factions is important.

18. Survey, Collection and Identification of the Indigenous Wild Poisonous Plants used for killing fish in Nepal

The traditional fishermen of Nepal, like the Derai and the Tharu use a number of wild plants for killing fish in water bodies. The fish so killed are edible. These plants can be utilized to eradicate the predatory fish (wild fish) from production ponds in a fish farm before stocking the fingerlings of commercially grown fish varieties. These

predatory fish have air-breathing organs and are able to survive in mud even when there is less water. They are also known by the name 'mud-fish'. These fish feed on fingerlings of cultivated fish on a large scale.

In Nepal, commercially available fish poisons such as pro-Nox-Fish have been recommended for killing predatory fish in production ponds. These poisons are very costly and have to be imported to Nepal. If the traditionally used plants are identified, these manufactured poisons can be substituted by these indigenous wild plants to kill the wild fish. These plants can be surveyed, identified and tested to kill wild fish and later on, can be extended and recommended to the fish farmers to promote commercial fish production in farm ponds all over Nepal.

19. Importance of the incorporation of the traditional fishermen of Nepal into organized fish culture programs

Mention has been made of the traditional fishermen of Nepal in the first part of this paper. They always live in colonies adjoining the natural water bodies. It seems that these traditional fishermen and fish are made for each other. These fishermen do not hesitate to go into the water or pond mud because it is their way of life. Moreover, their inborn skill in catching and handling fish is commendable. They can be trained to become low level technicians or skilled laborers at fish farms. Then they are likely to offer the appropriate service at fish farms.

Dr. Sha Wen Ling, popularly known by the name "Father of US Fish Farming" says: "Villagers are conservative, but in a positive sense. They cannot take on a new breed of fish, simply because someone tells them that it is better than their past one. The authority of the expert is nothing compared to the authority of ages. They must be shown, then they learn fast, maybe faster than any other group of human being" (FAO Booklet[1], 1971). This must be true with the traditional fishermen of Nepal also. No doubt, they are the authority of ages.

20. A detailed study of the crafts and gears used by the traditional fishermen of Nepal

A detailed study of the crafts and gears used by the traditional fishermen of Nepal can bring into light some important technologies for catching and handling fish. These technologies, being age old, have been tested and evolved through trial and error methods and hence must be considered as the appropriate technologies. Had these not been appropriate, their survival would have been impossible.

It is not unusual that catching fish from farm ponds is delayed due to the lack of suitable crafts and gears. Trapping fish and keeping them under captivity is necessary during breeding operations in farms. Proper handling of brood fish in farms is necessary. Fish also need to be caught, kept under captivity and handled properly during research experiments. No doubt, all these fish culture operations can be done in a better way with appropriate crafts and gears. Use of imported crafts and gears may not be very appropriate technologically and economically

in comparison to those used by the traditional fishermen. Moreover, the traditional fihsermen use local materials for making these crafts and gears. Some of these technologies can be accepted by fish farms to facilitate easier fish culture operations. Trained traditional fishermen will be the best technicians for handling these technologies.

Conclusions and Summary

Aquaculture in Nepal is now limited to fish production. The progess that fisheries development has achieved from 1947 through 1982 has been commendable, especially when considering the extremely rough topography of Nepal that offers a great challenge to the production and distribution of fingerlings and table fish. Despite all these efforts, the annual consumption of fish in Nepal is only 0.2 kg. per person. Much remains to be done to increase the consumption of fish.

The second part of this paper has highlighted many suggestions towards increasing fish production in Nepal by the better management of whatever facilities already exist. These suggestions focus on many new avenues for research and development.

As Nepal is blessed with different biogeographic aquatic natural laboratories in the form of an array of water bodies, there are many opportunities for research in fishery science. Nepal is a land having extreme biogeographic diversities within a relatively short physical span. Altitude based studies on the hiology of fish and other aquatic animals like dolphins and semiaquatic animals like amphibians can be of much interest not only to fishery science

but also to other branches of biological sciences. More or less in the same way as livestock and farming systems are moulded by the climate or "Havapani" so is fishery. Establishment of meterological stations at government fish farms will be of much help to study the impact of climate on the different aspects of fish production.

Fish fauna of the high hill streams has yet to be investigated. The biology of some of these fish can be studied and these can be considered for cultivation especially in some selected cold water bodies of the hills. The establishment of a pituitary bank can boost the production of fingerlings and hence promote fish production. Experiments to protect fingerlings from predators have to be conducted.

Increasing the depth of existing fish ponds with adequate water supply can result in more fish production from the same area of land. Useful aquatic plants like Makhana (Euryale ferox Salisb) and Azolla can be incorporated in fish production in selected localities having suitable fish culture practices. Recycling of wastes to produce fish, meat, egg, milk and crops through integrated plant animal farming can be linked to different farming systems. Frog legs can be processed and exported to earn foreign exchange. Development of commercial fish feeds by using natural products like farm wastes can be considered. The technical know-how and skills of traditional fishermen can be adopted to improve different fish culture practices in Nepal. All these efforts will contribute towards an increased fish production that in turn will improve the nutritional status and economy of the Nepalese people.

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