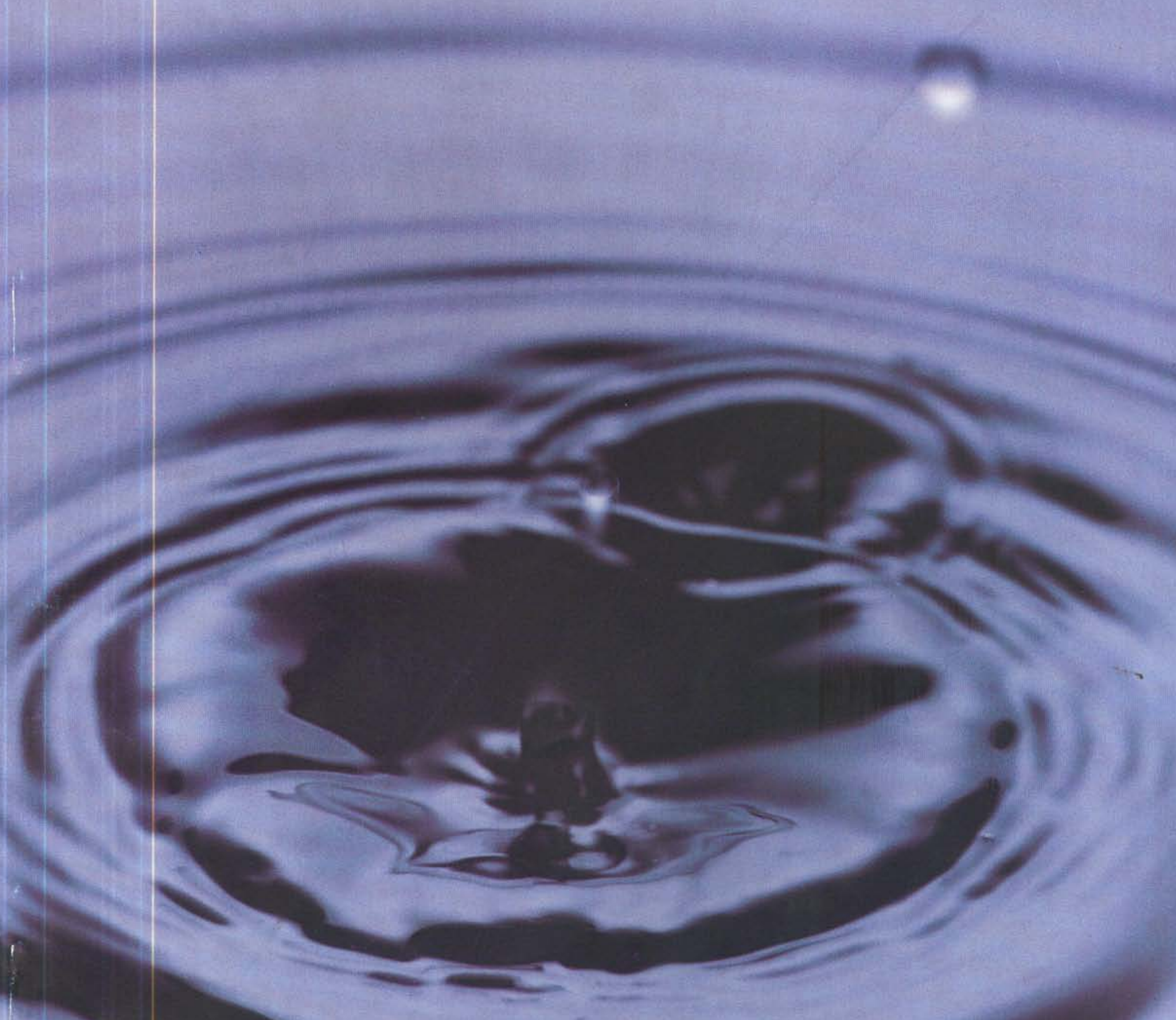
Strategies For development of fisheries In sardar sarovar during Pre- and post-Impoundment stage



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STRATEGIES FOR DEVELOPMENT OF FISHERIES IN SARDAR SAROVAR DURING PRE - AND POST - IMPOUNDMENT STAGE

A Work Plan

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STRATEGIES FOR DEVELOPMENT OF FISHERIES IN SARDAR SAROVAR DURING PRE - AND POST - IMPOUNDMENT STAGE

1. PREAMBLE

The whole of the Narmada river basin has been proposed to undergo a series of dams on the mainstream and a lateral chain on the tributaries etc. As such, this sort of ***'Compound Impounding'*** will transform the entire basin into small, medium and large water spreads. Sardar Sarovar dam, the ultimate project on the mainstream is being commissioned 5.6 Km, upstream of village Navagam under Taluka Nandod, District Bharuch, Gujarat State as multipurpose resource which will cater to the needs of the three riparian States; viz, Madhya Pradesh, Maharashtra and Gujarat while Rajasthan will be the fourth beneficiary.

Impounding of any river results into transformation of hitherto fluviatile ecosystem to more or less lentic system and in the process of such modification, comprehensive morpho-ecological changes take place and the adaptability of a host of biotic constituents of the ecosystem succumb to the pressure exerted by the emerged scenario; while a number of these may find congenial environment too. As such , efficient tackling by undertaking the Environmental Impact Assessment (EIA) and framing the judicious management practices becomes the key word towards holistic approach for sustained development and possible conservation of the system under developmental constraints.

2. IMPOUNDMENT CONSEQUENCES

Damming of any river manifests in following ways :

(a) The dam acts as physical barrier which is detrimental to the migration of fishes restricting their accessibility to breeding, nursery and feeding grounds.

(b) Profound morpho-ecological changes both above, and below the dam site take place which include :

i) Hydrodynamic and hydrographic variations associated with water level fluctuations.

ii) Creation of a large mass of water undergoing three defined trophic phase viz, trophic burst, trophic depression and trophic stablization, which offers avenues for fisheries development.

iii) Changes in physico-chemical regime.

iv) Flooding of spawning and feeding grounds . At downstream, reduction in flood plains, even the spawning grounds dry up owing to confined freshwater availability or shallow zones are created which are unaccessable.

(c) Dams commissioned over estuaries or at proximity exert negative impact at downstream due to limited freshwater discharge leading to hypersaline conditions. The anadromous fishery gets a jolt due to changed salt-water balance. Owing to decline in diluting capacity, flushing and transporting of wastes during practically low or no discharge period, the downstream environment will experience severe stress.

2.1 IMPOUNDMENT CONSEQUENCES RELEVANT TO SARDAR SAROVAR PROJECT FROM FISHERIES PERSPECTIVE

The commissioning of dam will deliver its impact in following ways

(a) A new environ i.e .a large mass of deep water (34867 ha at FRL) shall come into existence and Narmada river will undergo comprehensive morpho-ecological changes. The morphometric and hydrodynamic details of the man-made lake i.e ,Sardar Sarovar are offered in Table 1.

(b) The downstream is expected to experience serious repurcussion due to containment in freshwater discharge, the schedule of the same has well been documented in the Narmada Water Dispute Tribunal (NWDT) award. Morpho-edaphic and hydrographic regime will be affected which will impact the downstream productivity.

(c) Due to change in fluviatile pattern and restricted water drainage, severeoceanic intrusion towards river is expected to take place in absence ofcompromising factor. This will lead to increase in salinity regime and other conditions deleterious to the system. The biotic communities will beaffected and there will be profound shift in the biotic communities towardsmarine origin. Adadromous fishery represented by ***Tenualosa ilisha*** which forms the prime fishery will be drastically impacted. ***Macrobrachium rosenbergii,*** the freshwater giant prawn in will also be affected.

(d) Anthropogenic pressure in the form of industrial, agricultural and domestic dicharge will inflicnt its own toll and adversely affect the biological cycle. This is more relevant for the situation when lower estuary is surrounded by large number of industries poursing their effluents and the diluting, flusing and the diluting, flushing and transporting of waste are impacted by curtailment in freshwater discharge.

(e) The fishing gears and crafts being presently used may become obsolete and thus invite modifications situated for the new environ.

3. SCIENTIFIC MANAGEMENT STRATEGIES FOR SARDAR SAROVAR

The scientific management of Sardar Sarovar for development of sustained fisheries entails accentuating the beneficial and mitigating the detri-mental aspects. More precisely, for complishing the abovetwo vital requisites, certain management measures are required at pre-project (pre-impoundment) as well as at post-impoundment stage.

3.1. PRE-IMPOUNDMENT STRATEGIES

Pre-impoundment strategies which fröm a prelude to the development of fisheries in any multipurpose resource, entails acquiring of comprehensive information on certain aspects followed by steps required to address any adverse condition. The important aspects are as follows :

3.1.1. INVENTORY OF THE EXISTING FISH POPULATION OF THE RIVER, BOTH ABOVE AND BELOW THE PROPOSED DAM SITE.

This information will enable to have the prevailing status of the different components of the fishery of the river which will help in deciding the need of rehabilitation of already threatened fishes at this stage. Moreover, this will be basic yard-stock for delineating the shift in fisheries spectrum at post-project stage.

There are a number of fish faunal studies on record from river Narmada but owing to different approach, these are not sufficient to suffice the need. Fishery survey of the entire Narmada river basin, based on a statistically viable programme is essentially required. In this context, faunistic survey of the deep pools is quite important because of their possible role in conserving a number of indigenous fauna.

3.1.2. LIKELY RESPONSE OF THE ENDEMIC FISH POPULATION TO THE VARIOUS MORPHO-ECOLOGICAL CHANGE ANTICIPATED AT THE COMPLETION OF THE PROJECT.

Fish fauna inhabiting rivers are by and large tuned to the riverine conditions particularly currents and their horzontal spatial distribution is quite pronounced, unlike in lakes where vertical spatial distribution is well defined. The former are termed as rheop hilic and the latter, the limnophilicfishes. The commissing of a dam brings in certain morpho-ecological changes in the hitherto fluviatile condition and as such under the emerged scenario, a few fishes may not be comfortable and succumb to the pressure while other may migrate to congenial environment. Anticipation of response of indigenous fish fauna particularly the rheophilic species based on secondary information will enable to have an insight about the possible vacant niches which can be duly colonized by supplementary stocking by noncompetitive and eco-friently fish species and this is key to the successful venture.

3.1.3. LOCATION OF BREEDING AND NURSERY GROUNDS WITH THE SUBMERGENCE AND UPSTREAM WITH THE VIEW TO ASCERTAIN THE NATURAL RECRUITMENT.

Information regarding the extent of disruption of breeding and nursery grounds and possible emergence of fresh grounds at new sites like rivulets, nallahs etc. is very vital tool for forecasting the future fishery of any aquatic resource. From migration points of view, the fishes are categorised as:

(a) Resident

(b) Local migrant and

(c) Long distance migrant

The Narmada river has quite good population of resident fish comprised of minor carps, feather back, murrels etc. Since these fishes have confined migratory extent, as such this group by and large is not much impacted.

With regrads to local migrants, major carps and Mahseers need to be mentioned. Information regarding the breeding and nursery grounds at pre-project level will enable to assess the extent of loss at post-project stage by mapping these areas under submergence limits. This information eill provide valuable guidelines for the need of remedial measures which include supplementary stocking and habitat modification suited for such venture. Based on the supplementary stocking needs, infra-structure development requirement may be reached right now which is very crucial to realize the advantage of "trophic burst" phase.

For the long distance migrant, ***Tenualosa ilisha,*** the dam is not to act as physical barrier since its spawning run is confined to below the dam site.

3.1.4. SITE SELECTION FOR INFRA-STRUCTURE DEVELOPMENT.

The man-made lakes having feeble or no natural recruitment require supplementary stocking for due tapping of all the niches. As such, siting of infra-structure for locating hatchery complex will have to be taken up at pre-project stage becauseofenormous effort and time needed for development of such vital need. The essenceof infra-structure development has already been emphasized under 3.2.3. The site selection for fish hatchery complex is based on certain criteria, the important being topography, soil type, supply of water and electricpower, access to motorable roads and near to the stocking points, so that transportation risk is minimised and the overall package proveseconomical.

3.1.5. TIMBER AND OTHER PHYSICAL OBSERVATION CLEARANCE.

Removal of timbur is an important aspect in the scientific management ofreservoir and this should be achieved well before submergence since the cost of post-impoundment clearance is several times higher than that at pre-impoundment. Opinious are divided on this important issue since this is involved with certain beneficial as well as detrimental aspects.

(a) **BEBEFICIAL ASPECTS**

- ★ It serves as substrate for periphyton which is important food items of several commercial fish species
- ★ It is helpful in checking over-fishing
- ★ It serves as refugia for fish; makes the predators less efficient in cropping the prey,
- ★ With decomposition, lake productivity is increased since this adds to the organic content,
- ★ Carbon dixoderelease is associated with the decomposition of the timber which may help in flocculation of colloidal clay turbidity and
- ★ Substantial saving in the cost.

(b) **DETRIMENTAL ASPECTS**

- ★ During first submergence, decomposition of huge vegetation causesdeoxygenation or even leads to hydrogen sulphide gas formation as soon as thermal stratification is established. This involves extensive "Fish kills".
- ★ Impediment for fishing gear operations
- ★ Serves as anchorage for nuisance macrophytes at littoral zone; results in lower biological productivity by inhibiting photosynthesis due to shading effect.
- ★ Obstruction to fishing and transportation crafts.
- ★ Reduces wind-induced oxygenation of the system.
- ★ Provides substrate for snails, vector for Schistosomiasis.

Opinions regarding extent of timber clearance varies. Some advocate selective clearance of timber upto drawdown level to facilitate shoreseine fishing. The others have suggested that the areas having highest fish concentration should be subjected to timber clearance since these are the target areas for gears and craft operations. The areas having gentle sloping shore should be considered for clearance upto 5 m depth from economic and utiliterian points of view.

A critical evaluation of the prospects and consequences of timber clearance issue in context of Sardar Sarovar Reservoir, revealed that the entire forest clearance should be taken up well before the first submergence owing to the following reasons :

(a) The reservoir is quite deep having maximum depth of 120.68 m at FRL and sheltered between Vindhyas and Satpura hill ranges. Deep reservoirs are prone to thermocline development particularly during summer, leading to creation of anoxic hypolimnion.

(b) 13385 ha of forest is getting submerged which on decomposition may compound the problem with the setting of thermocline, leading to development of anoxic condition and H2S formation, detrimental not only to fishes but also to the metallic portion of the turbine.

3.1.6. IDENTIFICATION OF 'HOT SPOTS'

Anthropogenic pressure in terms of industrial, domestic and agricultural dischargees are liable to degrade the aquatic environment. It is imperative to identify such confluence points and their proximity to the reservoir proper. Second step in this regard will be to quantify and assess the nature of the discharge and their impact on the aquatic life including fishes. This is essential so that the corrective measures may be initiated right now.

3.2. POST-IMPOUNDMENT STRAGIES

Post-impoundment strategies areaimed at development of a sustained fisheries and their rational exploitation copuled with possible habitat conservation. A reservoir is a man-made lake which is unique by possessing both lotic as well as the lentic characters and its biological productivity is regulated by climatic, edaphic morphometric features and as such, these are considered for developing productivity indices for the reservoir.

The scientific management of impoundments involves basically 'Eco-oriented' approach which is also relevant to Sardar Sarovar. More precisely, the philosophy of management at post-impoundment stage involve following essential exercises :

3.2.1. STUDY OF INTERACTION ABIOTIC AND BIOTIC COMPONENTS OF THE ECOSYSTEM.

This study is basic for development of certain indicase of reservoir productivity which in torn will decide the scientific management norms for realizing optimum fish yield from the impoundment. This study may be divided as follows :

3.2.1.1. ABIOTIC COMPONENTS.

(a) Climatological Morphometric, and meteorological features which encompass :

(i) Morphometric features like index of shire development (DL), Volume development (DV), mean depth (Z), mean depth maximum depth ratio (Z/Zm) and development of littoral area.

(ii) Climatological and meteorological variables like rainfal, max-min air temperature, win. velocity, solar radiation, inflow, outflow, flushing rate and reservoir level.

(b) **Physico-chemical regime of water and soil includes:**

Physical factors

Water

i) Transparency

ii) Colour of the water

iii) Water temperature, column-wise fordelineating thermal stratification

Soil

i) Texture

Chemical factors

Water

i) Dissolved oxygen (DO)

ii) Carbon dixide (CO2)

iii) Total alkalinity

iv) pH

v) Calcium and Magnesium

vi) Total dissolved solids (TDS)

vii) Specific conductivity

viii) Dissolved Organic matter

ix) Chloride and Fluoride

x) Edaphic fators- the natrient status in terms of phosphats, silicate, nitrate and sulphate and

xi) Radox potential

SOIL

i) Organic carbon

ii) C/N ratio

iii) Available phosphate

iv) pH

v) Free Calcium Carbonate

vi) Available and total nitrogen

3.2.1.2. BIOTIC COMPONENTS.

(a) Qualitative and quantitative assessment of plankton in time and space, its successional patterns and diversity.

(b) Qualitative and quantitative evaluation of benthic population, its spatio-temporal variations and diversity index.

(c) Periphytic communities in time and space, its fluctuations and diversity.

(d) Microbial density.

(e) Biology of the important fishes from commercial as well as conservational point of view.

(f) Spawn prospecting studies for assessing the level of natural recruitment.

3.2.1.3. PRIMARY PRODUCTIVITY.

(a) Gross production

(b) Net production

(c) Community Respiration.

3.2.2. POTENTIAL YIELD APPROXIMATION.

Potential yield approximation is an essential pre-requisite for scientific management since this indicates to the expected harvest and the comprehensive management measures are targetted towards achieving the same. A number of methods for calculating potential yield are available, the most acclaimed methods are placed as follows :

3.2.2.1. MORPHO-EDAPHIC INDEX (MEI) :- RYDER MODEL.

Ryder (1965) proposed this index which comprised an edaphic factor *viz,* total dissolved solids (TDS) and other morphometric factor being mean depth (Z). The relationship between these two limonological variables is as shown below :

$$MEI = TDS / Z$$

and the calculation of the potential yield Y is based on the regression equation **Y = K. xa**

Where **X** = **MEI,**

K = coefficient for climatic effect and

a = an exponent approximating 0.5

3.2.2.2. JENKINS MODEL

Jenkins (1967) while working on U.S. reservoirs found following regression between the standing crop of fish and MEI :

$$Y = 2.07 + 0.164 \; X$$

where Y = Standing crop of fish and

X = log MEI

Jenkins and Morais (1971) have modified the above model by incorporating environmental variable and offered following regression.

$$Y = 0.2775 - 0.2401 \; X1 + 1.0201 \; X2 - 0.2756 \; X3$$

Where

Y = Total harvest in kg/ha.

X1 = log area

X2 = log growing season and

X3 = log age of the reservoir.

3.2.2.3. GULLAND MODEL

Gulland (1971) devised a simple equation relating potential yield to virgin ichthyomass, the equation is

$$Y = K.M.B.$$

Where Y = Total fish yield

K = a constant whose value lies between 0.3 and 0.5

M = Natural mortality cofeficient and

B = Biomass prior to fishing

3.2.2.4. TROPHODYNAMIC MODELS.

The trophodynamic models are based on the primary production status of the impoundment.

Mellack (1976) has described a regression equation between the fish yield and gross photosynthesis after considering 15 Indian lakes, the equation is

$$\log FY = 0.122 \; PG + 0.95$$

Where FY = Fish yield and

PG = Gross photosynthesis.

Oglesby (1977) has proposed an equation relating standing crop of summer phytoplankton and fish yield and the equation is

$$\log Y = 1.98 + 1.7 \log Chls$$

Where Y = Annual yield of fish as dry weight per square meter of lake surface and

Chls = Summer phytoplankton standing crop.

3.2.2.5. DRAINAGE INDEX

Ramakrishniah (1986) after considering 21 Indian reservoir representing different drainage systems reached to a regression equation as below :

$$Y = 0.8613 + 0.577 X$$

where Y = log fish yield/ha and

X = log drainage idex (DI)

The drainage index (DI) as defined by him can be calculated as follow

$$DI = \frac{\text{Catchment are}}{\text{Reseervior area} \times \text{mean depth}}$$

3.2.3 HABITAT MANAGEMENT FOR OPTIMISING YIELD ON A SUSTAINED BASIS.

Habitat management for optimising fish yield from the impoundments is an intricate issue since it involves stocking of the reservoirs with compatible, fast growing and eco-friendly fish fingerlings to colonize all the vacant niches came into existence as a result of damming on one hand and on the other, device prescription of exploitation based on the maximum sustainable yield (MSY) by asdjusting fishing effort, observance of closed season and gear selectivity towards conservational measures. As a matter of fact, the management of large reservoir like Sardar Sarovar is based on the principle of stock manipulation and other measures as ascribed above. The important components of habitat management are as follows :

3.2.3.1. STOCKING

Stocking of the reservoir is a very vital aspect and in present context it needs to play the dual role of optimising fish yield and conserve the endemic fish fauna. Further, the subjective purpose of stocking gets more pronounced in case of reservoirs with feeble or no natural recruitment of fishes due to a spectrum of factors includinhg disruption of pristine floodplains.

With regard to stocking in the Sardar Sarovar, multi-species stocking based on the eco-oriented approach and considering the prevailing status of edemic fauna, will have to be resorted to. The essence of stocking with the view to plant the vacant, shared and unshared ecological since lost of food is available during this period and if these niches are not filled up with compatible and eco-friendly fish species, these will get occupied by the trash fishes having higher proliferation rate due to being prolific breeder and the ultimate result will be the dominance of trash fishes associated with low fish yield from the reservoir.

For taking the decision for the species combination to be stocked in the reservoir, the main pathway for conservation of primary energy into harvestable material will have to be established. There are two main pathways *viz.* Grazing and detritus chain for conversion of primary energy into fish flesh. The extent of contribution of these pathways in the total energy package willreflect the spectrum of species to be stocked in the reservoir. In Sardar Sarovar, similar exercise will have to be taken up for reaching the species combination for optimising the fish yield.

In Sardar Sarovar, Indian major carps, which are fast growing and quite compatible to the endemic fauna of the Narmada River System will be the indispensable major stocking component under multispecies stocking programme. However, these craps are not able to consume phytoplankton in fair quantity which is by and large the mainstay of the planktonic abundance in Indian reservoirs. For utilising this dominant fraction and other unutilised food items, ***Pangasius pangasius, Puntius pulchellus, Labeo bata, L fimbriatus, L calbasu, Tor tor, T. khudree*** will be stocked in suitable numbers depending upon the quantum of food available in Sardar Sarovar reservoir. This coupled with maintenance of viable prey-preadator ratio will also take care of conservational needs of Sardar Sarovar reservoir.

3.2.3.2. STOCKING COMPUTATION

Decision regarding number of fingerlings to be stocked in any impoundment is very vital and depends upon the potential of the biotope which can be calculated by trophodynamic models as suggested earlier. There are a number of formulae suggested for computation of stocking rate. The formula provided by Hust (1900) can be conveniently used and is presented below :

$$\text{Stocking rate (Nos.of late fingerlings per hectare)} = \frac{\text{Total production in Kg}}{\text{Average individual growth in Kg}} + \text{Loss}$$

3.2.3.2.1. STOCKING REQUIREMENT FOR SARDAR SAROVAR

There is no conformity in the stocking rate being followed by different Status. Rate of stocking adopted in the States of Uttar Pradesh and Madhya Pradesh is 372 - 495 fingerlings/ha. As per the recommendations of Fish Seed Committee, the stocking rate of 500 fingerlings/ha of the size range of 45-150 mm should be followed. The National Workshop on Reservoir Fisheries Organised at Central Inland Fisheries Research Institute, Barrackpore from 3-4 January,1990, have recommended stocking rate of 300 Nos. of advanced fingerlings of 100 mm size.

It is suggested to stock Sardar Sarovar reservoir at the stocking rate of 300 advanced fingerlings / ha (11 mm size) and since the Narmada river has high abundance of predatory fishes, the loss allowance may be considered as 25%. The average available are based on FRL+DST / 2 of the Sardar Sarovar reservoir comes to 23131 ha, so total number of fingerlings required is computed to be 8.674 million during the trophic burst phase. This is just the ad hoc figure since the reservoir is not in existence. As soon as the potential of the reservoir is calculated, the precise figure may be reached.

3.2.3.2.2. INFRA-STRUCTURE REQUIREMENTS FOR RAISING 8.674 MILLION ADVANCED FINGERLINGS

(i) SPAWN REQUIREMENT

(a) Based on 65% survival from fry to advanced fingerlings, 13.344 million fish fry are required,

(b) Based on 50% survival from spawn to fry, 26.688 million spawn are required

(ii) NURSERY POND REQUIREMENT FOR RAISING ADVANCED FINGERLINGS

For raising, 8.674 million advanced fingerlings, 13.344 million fry are required and at stocking rate of 0.5 million / ha, total 66.72 ha of rearing ponds are required.

Regarding the ideal site for releasing the stocking material, coves and bays away from the spill way and main canal which do not experience rapid fluctuations of the water, may be considered as the ideal venues for this purpose. Such congenial require to be identified and hatchery complex should also be sited in proximity so as to avoid mortality during transportation.

3.2.3.2.3. EXPLOITATION NORMS AND OTHER CONSIDERATIONS

The prescription of the exploitable quota will be based on the *Maximum Sustainable Yield (MSY)* criterion since this has great relevance ro realising sustained fish yield and conservation. More precisely, this encompasses maintaining the fishing effort to the optimum level coupled with assessment of stock by catch per unit effort (CPUE) which is very sensitive tool for stock productivity. For Sardar Sarovar reservoir, exploitation quota shall be fixed after MSY consideration which would help in deciding the optimum fishing effort towards developing a well conserved and sustained fishery. Besides above, *mesh regulation of the gear, observation of closed season* for allowing natural recruitment and *maintenance of viable prey - predator ratio* will further add towards judicious management of fishery of Sardar Sarovar for optimum returns. A total ban on commercial fishing for at least three years is recommended so as to assess the stock and success of the planted fish by experimental fishing. This will also lead to the development of a good population of prospective breeders. Moreover, the conservation of the catchment area, rational use of agricultural inputs like fertilizers, presticides etc. and ban on release of untreated pollutants directly into the reservoir should be considered under an integrated approach towards fisheries development in Sardar Sarovar.

Table 1 IMPORTANT MORPHOMETRIC AND HYDRO-DYNAMIC FEATURES OF SARDAR SAROVAR RESERVOIR.

River bed level at dam site (RL)	:	18.00 m
Full reservoir level (FRL)	:	138.68 m
Maximum Water level (MWL)	:	140.21 m
Maximum draw down level	:	110.64 m
Area (submergence) at FRL	:	34867.00 ha
Gross storage capacity	:	0.95 M ha m
Live storage capacity	:	0.57 M ha m
Dead storage capacity	:	0.37 M ha m
Length of the reservoir	:	214.00 Km
Maximum width of the reservoir	:	16.10 Km
Average width of the reservoir	:	1.77 Km
Maximum depth (Zm)	:	120.68 m
Mean depth (Z)	:	27.24
Mean depth / maximum depth	:	0.2257
Index of volume development (DV)	:	0.6771
Index of shore development	:	1.3761