Studies on Morphometry and Hydrology of Gandhisagar Reservoir with Special Reference to its Fisheries

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Gandhisagar, the second largest reservoir of India is located in Mandsaur district of Madhya Pradesh at latitude 24° 44'N and longitude 75° 33'E at an altitude of 403.56m MSL in an orientation from NE to SE. It has an extensive water spread area of 66000 ha at full reservoir level with a maximum and mean depth of 49.52 and 11.73 m respectively. The maximum length and width of the reservoir are 112 and 16 km having a total shore line of 442 km. Details of catchment area, bathymetry, standard hydrological data giving water level relation of the basin to water spread area, volume and fish production and the bottom topographical details of 11 experimental fishing stations and 6 fish landing centres are discussed.

The importance of morphometric and hydrological details of reservoirs to assess the nutrient, physico-chemical, biological and fisheries management is being realised in the work of Rawson (1939, 1952 & 1953), Parsons (1956), Symon *et al.*, (1965), Neel (1966), Sly (1974, 1976) and Fee (1979). Their importance in Indian reservoirs has been pointed out by Sreenivasan (1966, 1969 & 1974), David *et al.* (1969), Ghosh and Rao (1969), Durve (1976) and Jhingran (1982).

Gandhisagar the second largest man made reservoir next to Hirakud in India and the biggest contributor of inland fish to the state of Madhya Pradesh was neglected in this regard even though gross reference to these aspects were made by Dubey & Mehra (1959), Dubey & Chatterjee (1977), Choudhary (1977) and Gupta & Rao (1978). It is the aim of this paper to report the morphometric and hydrological aspects along with the study of the bottom topographical details of the fishing and fish landing areas of Gandhisagar reservoir.

Materials and Methods

Gandhisagar dam is the first of the four hydraulic structures, the others are Ranapratapsagar, Jawahar Sagar and Kota barrage constructed on the river Chambal, the biggest tributary of Yamuna of the Gangetic System for the integrated development of Chambal valley regions. The reservoir bundh is located in north eastern part of the Mandsaur district of Madhya Pradesh at latitude 24°44'N and longitude 75°33'E at an altitude of 403.56 m MSL (top of the dam) in an orientation from NE to SE (Fig. 1).

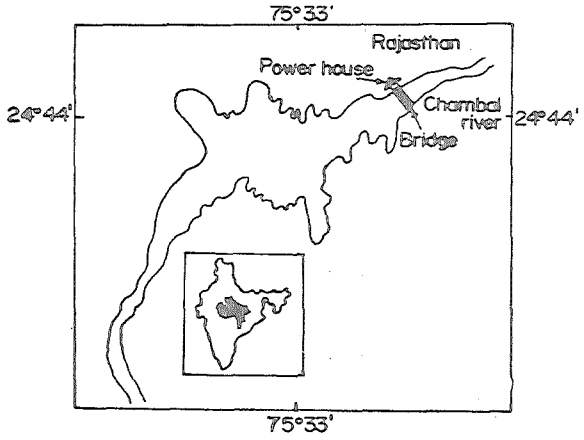

Fig. 1. Location map of Gandhisagar reservoir.

The river Chambal orginates near the Janapao temple at about 24 km south west of Mhow of Indore district at an elevation of 854.35 m above the MSL. At the origin there are three 'nallas' which are 1.6 to 2.4 km in length around the temple and these 'nallas' meet and form the river Chambal. It can be seen that the dam site and tail end of the

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reservoir are narrow (Fig. 2). At the dam site the reservoir emerges into narrow gorge taking north easterly course at a distance of 8 km upto Chourasigarh fort. The tail end of the reservoir commencing from Tatka on the river Chambal and Kalakhedi on the river Shipra is very narrow and runs in the form of a gorge at a distance of 12 km extending upto village Garara. The area from the end of the Basai gorge upto Chourasigarh fort is fairly extensive and constitute the main fishing ground. The central basin is rocky having shallower shore terrace slope and region of deep water along the old Chambal river course.

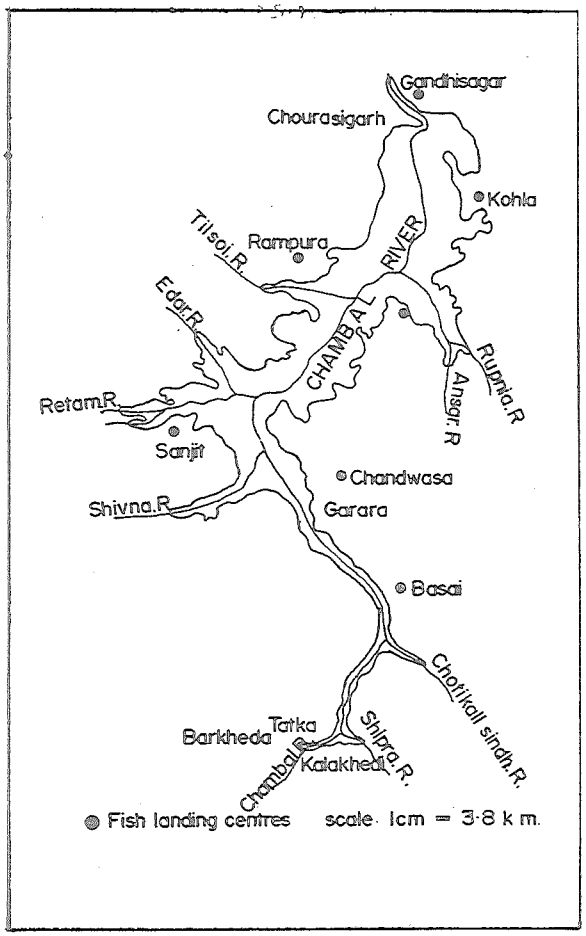

Fig. 2. Physical features of Gandhisagar reservoir.

The catchment area of Gandhisagar reservoir (GSR) is bounded by Vindhyan range in the South and Aravalli range in the north east forming a rectangular fan shaped area (Fig. 3). GSR enjoys a vast catchment area of 23025 km². The important tributaries of Chambal discharging their water in the reservoir are Shipra, Chhoti Kalisindh, Ansar, Rupniya on the eastern side and Tilsoi, Edar, Retum and Shivna on the western side of the reservoir.

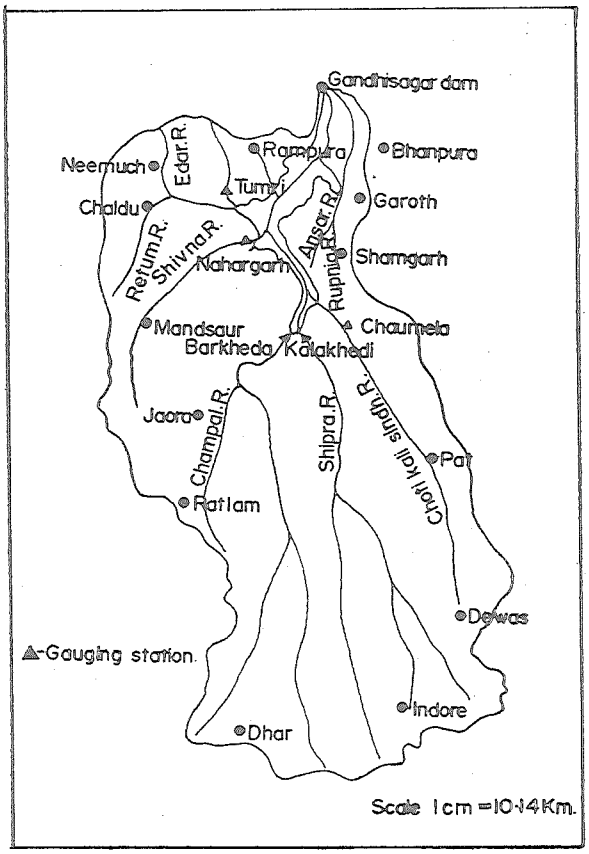

Fig. 3. Catchment features of Gandhisagar reservoir.

The morphometric and hydrological characteristics of GSR were recorded as per the methodologies suggested by Hutchinson (1937, 1957), Welch (1952) and Wetzel (1982). By following the method suggested by Welch (1948) the mean values on GSR morphometry were derived. Planimeter and sounding equipments were used from 9.20 m OAL wooden motorised fishing boat for making depth measurements and area computations. The topographical studies of eleven fishing and six fish landing areas were carried out by making transect sketches of the individual areas from the bathymetric map of GSR (Fig. 6).

Results and Discussion

The morphometric and hydrological particulars recorded are given in Table 1 & 2 respectively.

Table 1. *Morphometric characteristics of GSR*

a) *Particulars of the dam*

Type	:	Straight gravity
Length at top	:	513.60 m
Maximum height	:	63.70 m
Deepest foundation level	:	339.85 m
Length of spill way	:	182.80 m; 10 gates (10.2 x 8.5 m)
Sluices	:	9 (3 x 7.6 m)
Penstock	:	5 Nos. (5 m)

b) *Particulars of the reservoir*

i) *General*

Length	:	112 km
Width	:	16 km
Shore line	:	442 km

ii) *Water elevation*

Road at top level	:	403.60 m
Maximum water level	:	401.00 m
Full reservoir level	:	399.90 m
Crest of over flow	:	391.30 m
Dead storage level	:	381.00 m
Average bed level	:	341.40 m
Mean fluctuation of water level	:	11.00 m

iii) *Area*

Gross storage level	:	74,000 ha
Full storage level	:	66,000 ha
Average level	:	40,200 ha
Dead storage level	:	14,400 ha

iv) *Capacity*

Gross storage	:	774.40 THMT
Live storage	:	691.10 THMT
Dead storage	:	83.30 THMT

v) *Depth*

Maximum at FSL	:	49.52 m
Maximum at DSL	:	39.62 m
Fluctuations	:	18.89 m

vi) *Derived measures on morphometry*

Mean width	:	6.048 km
Mean depth at FRL		11.73 m
Mean depth at DSL	:	5.69 m
Mean fluctuations in water level	:	10.82 m
Mean depth and maximum depth relation		0.20
Maximum depth and surface water relation		0.00227
Shore development	:	4.783
Volume development	:	0.601

Table 2 denotes the standard hydrological data giving the water level relation of the basin to the water spread area and water volume. The information furnished by the hypsographic (Fig. 4) and volume curves (Fig. 5) are of great value in the reservoir fisheries. By knowing the area, volume and other parameters, it is possible to decide the type of fisheries to be harvested by using suitable gear and methods to increase the fishing efforts in large water bodies like GSR.

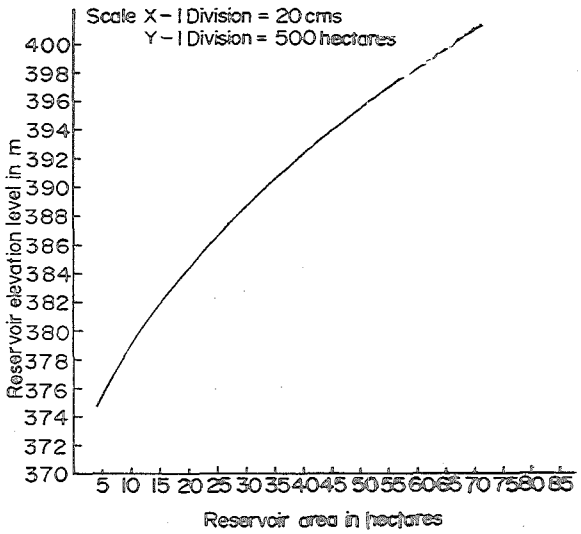

Fig. 4. Hypsographic curve.

Mathematical model connecting the reduced water level in metres and area in hectares is worked out by using exponential curves of the form.

$Y = A.B^x$ where 'Y' is the area in hectares and 'x' is reduced level in metres. The fitted equation for Fig. 4 is

$$Y = (4.7296 \times 10^{-13})\ (1.10433)^x$$

Likewise mathematical model connecting reduced water level in metres and capacity in THMT is worked out by using exponential curves of the form.

Table 2. *Area and water volume at different water elevations at GSR*

Reduced level	Area ha	Water volume THMT
374.90	4180.40	31.20
381.00	14568.70	83.30
384.00	19910.50	136.30
387.10	26102.20	206.60
388.60	29542.00	248.50
390.10	33305.60	296.00
391.70	37433.40	349.70
393.20	42006.30	412.00
393.80	43948.80	438.50
394.40	45972.20	456.40
395.00	47955.20	494.00
395.60	50019.10	524.80
396.60	52123.40	555.70
396.80	54268.30	589.60
397.50	56575.00	622.30
398.10	58841.20	659.30
398.70	60188.40	676.90

$Y = A. B^x$ where 'Y' is the capacity and 'x' is reduced level in metres. The fitted equation for Fig. 5 is

$Y = (1.3201 \times 10^{-19}) (1.13397)^x$

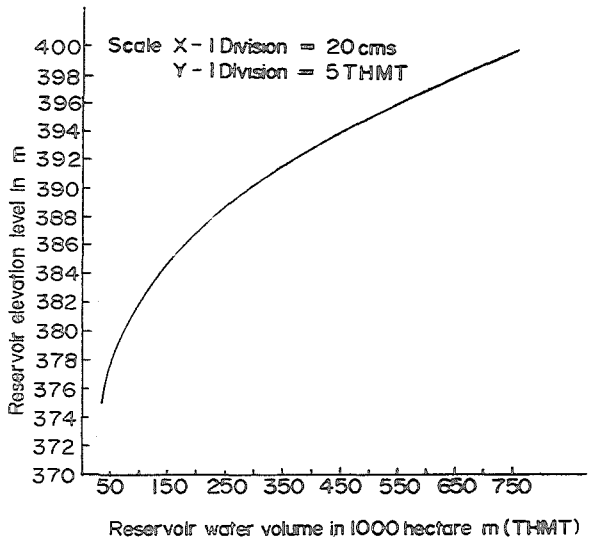

Fig. 5. Volume curve

The morphometric and hydrological factors are of utmost importance to reservoir fisheries as it influences the entire reservoir metabolism. Much attention has been focussed on the importance of lake morphometry especially mean depth and lake productivity to climatic and edaphic factors (Hutchinson, 1937; Rawson, 1952 & 1953). Mean depth is regarded as the best single index which determines the eutrophic or oligotrophic nature of the reservoir. The mean depth of GSR is 11.73 m. The plankton production is less and primary productivity values are not high in spite of having large shallow area in Gandhisagar reservoir (Rao *et al.*, 1986). Much information is needed to assess the biological status of GSR and the available reports are of preliminary nature.

The volume development of GSR is 0.601 and this value is comparatively less than other Indian reservoirs. The walls of the reservoir are convex towards water and the basin is saucer shaped in nature. The characteristics features of GSR in general conform with a biologically more productive basin having shallow water with a gradually sloping basin than a deep one with steep sides.

The shore development of GSR is 4.783. The shore line is of irregular nature making provision for greater contact of water with land. This has enhanced the total area of production of rooted vegetation and provide greater opportunity for the photosynthetic zone. The extent of shallow water

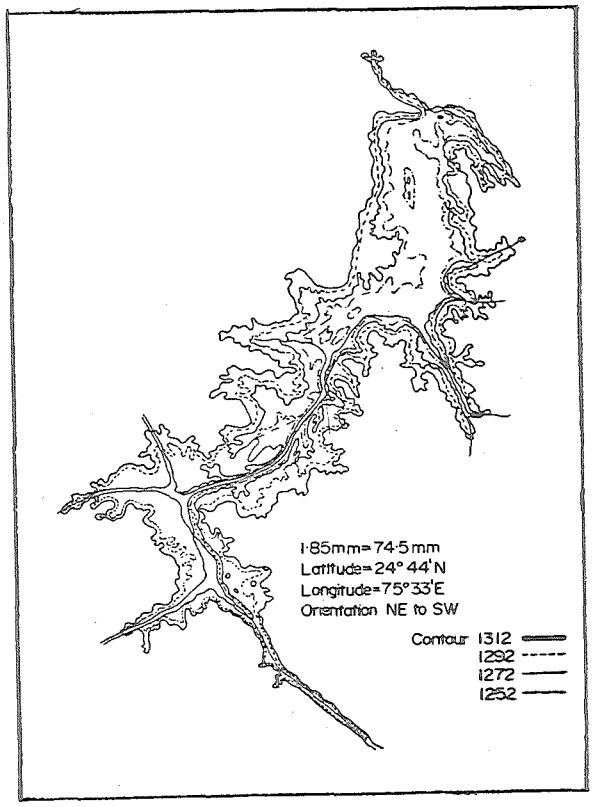

Fig. 6. Bathemetric map of Gandhisagar reservoir

is an important aspect to increase the total biological activity and the development of bottom organisms. GSR is located at a comparatively lower elevation and the maximum reservoir elevation is 401.00 m.

Fig. 6 denotes the bathymetric details of GSR. The deepest portion (49.52 m) of the reservoir is at the gorge in the lower reaches where the dam is constructed. The shallower area identified in the present study are located at 2–10 m depth in the lower and middle reaches and 2–5 m in the upper reaches of the reservoir.

The experimental trawling and gill netting area identified for the study are given in Fig. 7. The transect of the experimental trawling station Nanor (Fig. 8. a) had trenches towards the western bank and trawling was conducted towards the gradual slope of the eastern bank. The river mouth areas of Ansar and Rupniya (Fig. 8. b & f) are comparatively shallower (5–6 m) and the transect showed a gradual slope on the eastern and western banks. Good trawl catches were obtained from these areas in spite of the presence of spiny twigs of decaying plants. Both eastern and western slope of Karanpura and Chourasigarh (Fig. 8.c. & d) are very

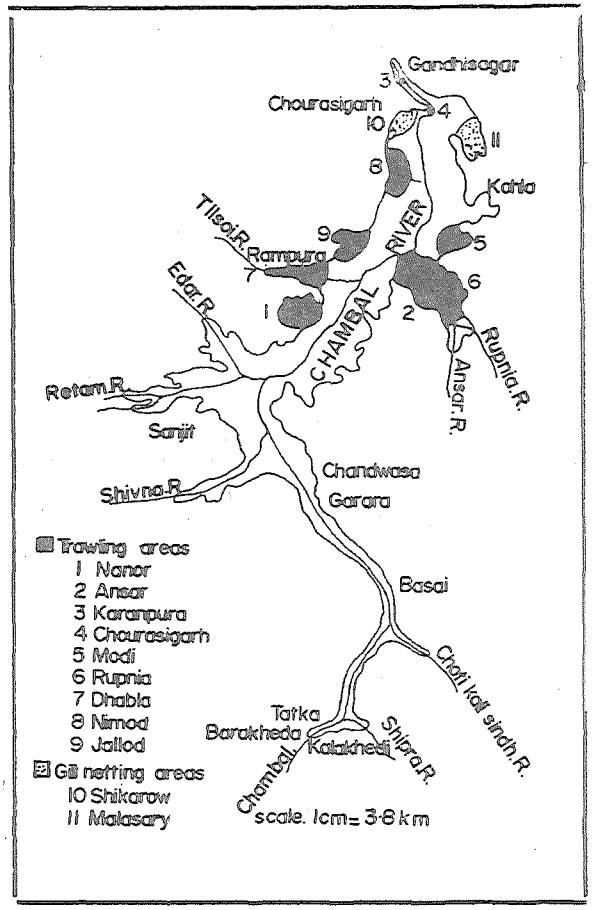

Fig. 7. Experimental fishing areas

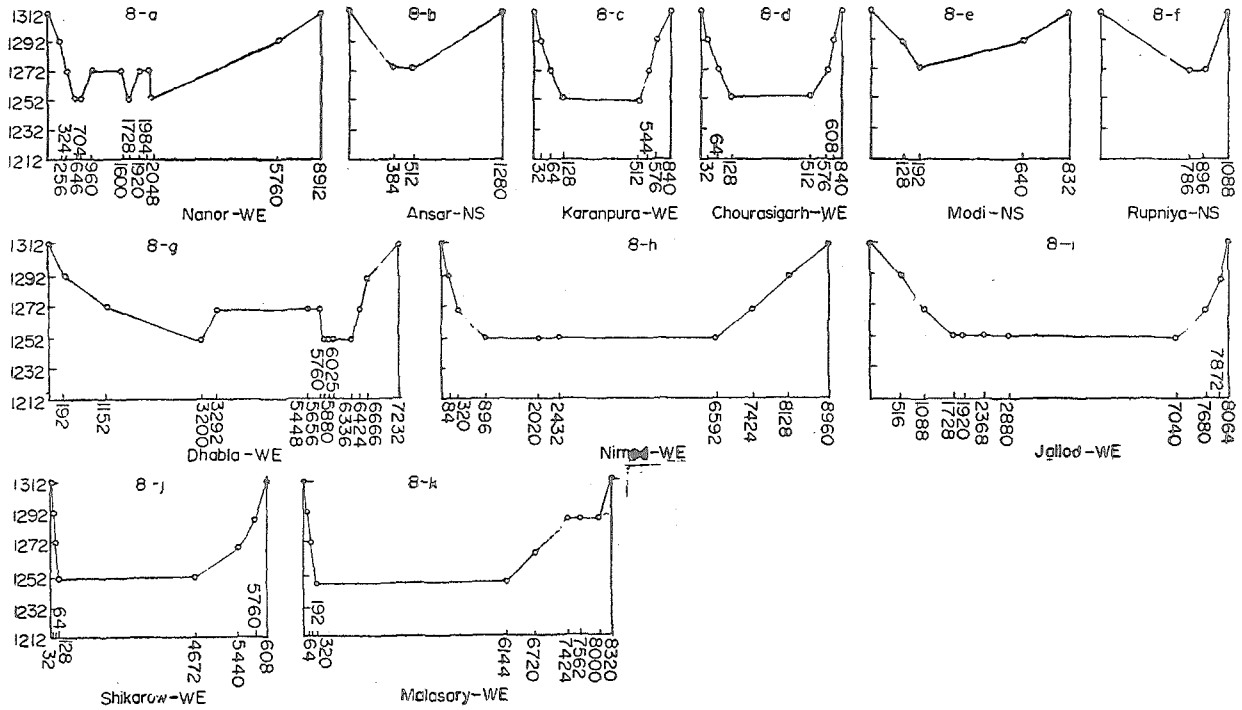

Fig. 8. Transect of experimental fishing areas

steep and the trawl catches obtained had to be abandoned because of large number of stones. Two boat midwater trawl operations were conducted from Modi and Nimod (Fig. 8 e & h) at depth ranging from 20–30 m. Station no. e showed a gradual smooth gradient towards the eastern bank and comparatively sharper gradient towards the western bank. Station no. h is comparatively steeper with a wide rocky basin in the centre. Two boat bottom trawling was conducted in Dhaba and Jallod (Fig. 8 g & i) situated on either side of the Tilsoi river. Their transect showed that the Dhalbla had gradual slope towards the western bank and steeper slope towards the eastern bank. The transect of Jallod is comparatively wider having steeper slope on the eastern and western banks. Experimental gill netting areas selected were Shikaro and Malassary (Fig. 8 j & k). The transect of Shikarow showed comparatively graded slope towards the eastern bank while the western bank is comparatively steep. The basin is comparatively wider with a phased gradient towards the eastern bank.

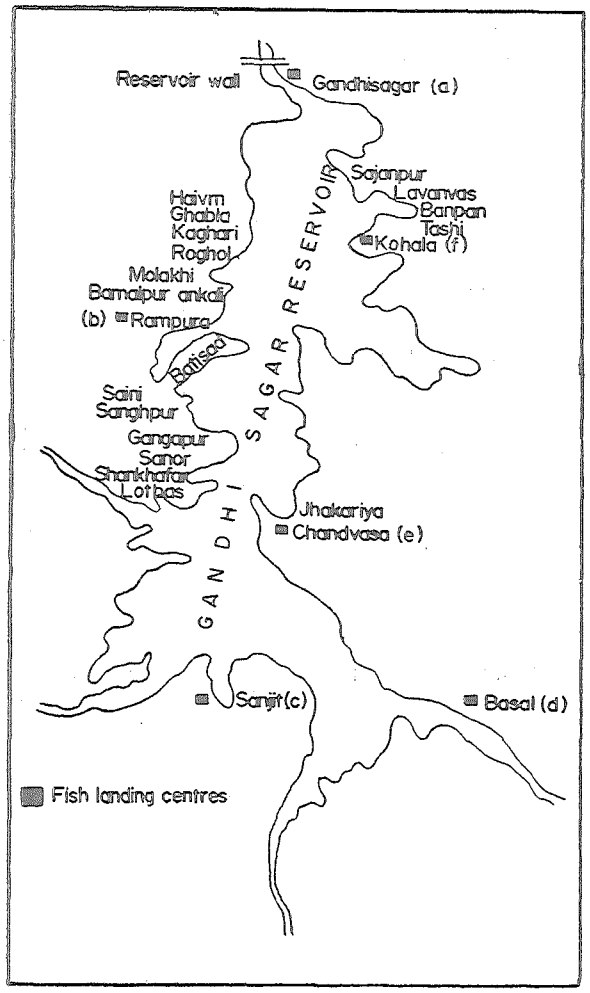

Fig. 9. Fish landing centres of Gandhisagar reservoir

Fig 9 indicates the fish landing centres of GSR. Eventhough the fish landing centres were in operation for the last 25 years, no detailed topographical studies are available. Gandhisagar and Rampura (Fig. 10 a & b) are the two important fish landing centres of GSR. The transect of the former has a steep eastern and western banks with rocky basin in the centre and the latter with uneven triangular elevations at the bottom. Comparatively poor berthing facilities are available in both the major centres The berthing facilities of the other centres like Sanjit (10c), Basai (10 d), Chandwasa (10 e) and Kohala (10 f) are extremely very poor and used as temporary landing centres In Sanjit 2/3rd floor area towards the eastern baruk is shallow and uniform. The remaining area is comparatively deeper with irregular phased eastern bank. The east and west banks of Basai are steep with a depth of 5–10 m. Chandwasa is very shallow (2–5 m) having uniform gradient for the eastern and western bank with increasing depth. Fish landing centre Kohala is comparatively deeper (15–20 m) with irregular phased gradient on the eastern and western bank.

Details of average water level and fish landings from 1968–69 to 1985–86 are shown in comparative histogram (Fig. 11) From the histogram it is found that the fish catches have gradually improved with the decrease in water volume Highest catches were recorded during 1982–83 and 1983–84 may be related not only to gradual decrease in water volume but nlso to increased fishing efforts and there exist an inverse relationship between water level and fish production.

The authors are thankful to Madhya Pradesh Council of Science and Technology, Bhopal for the financial assistance and the authorities of Madhya Pradesh Irrigation and Fisheries Departments for providing facilities.

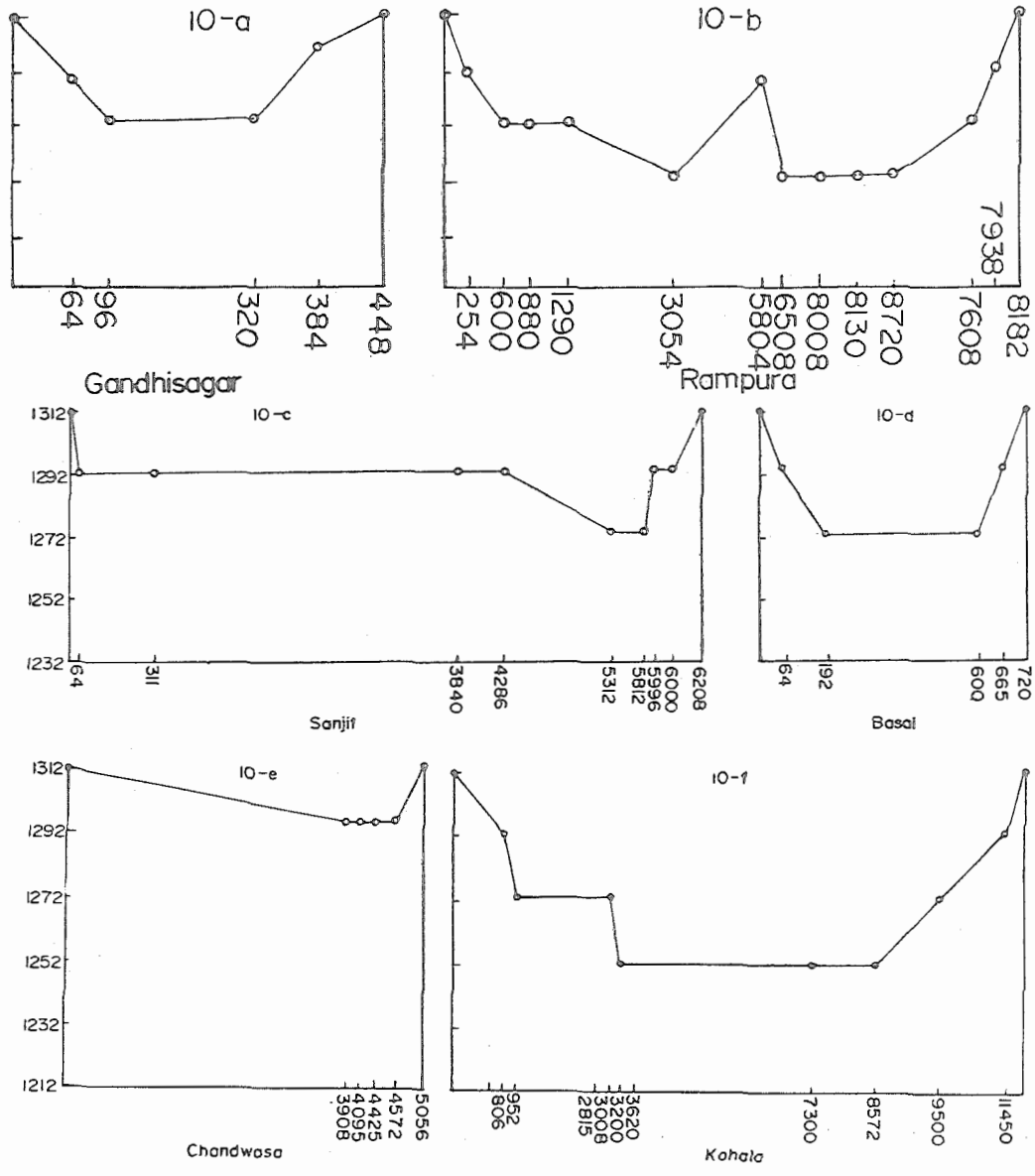

Fig. 10. Transect of fish landing centres.

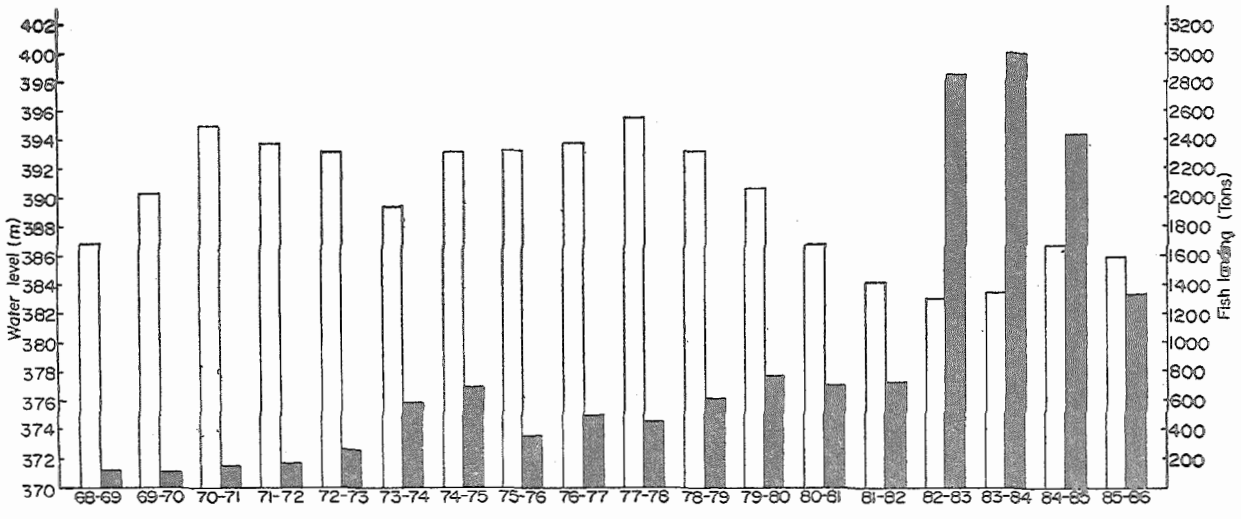

Fig. 11. Average water level and fish landings in Gandhisagar reservoir in different years.

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