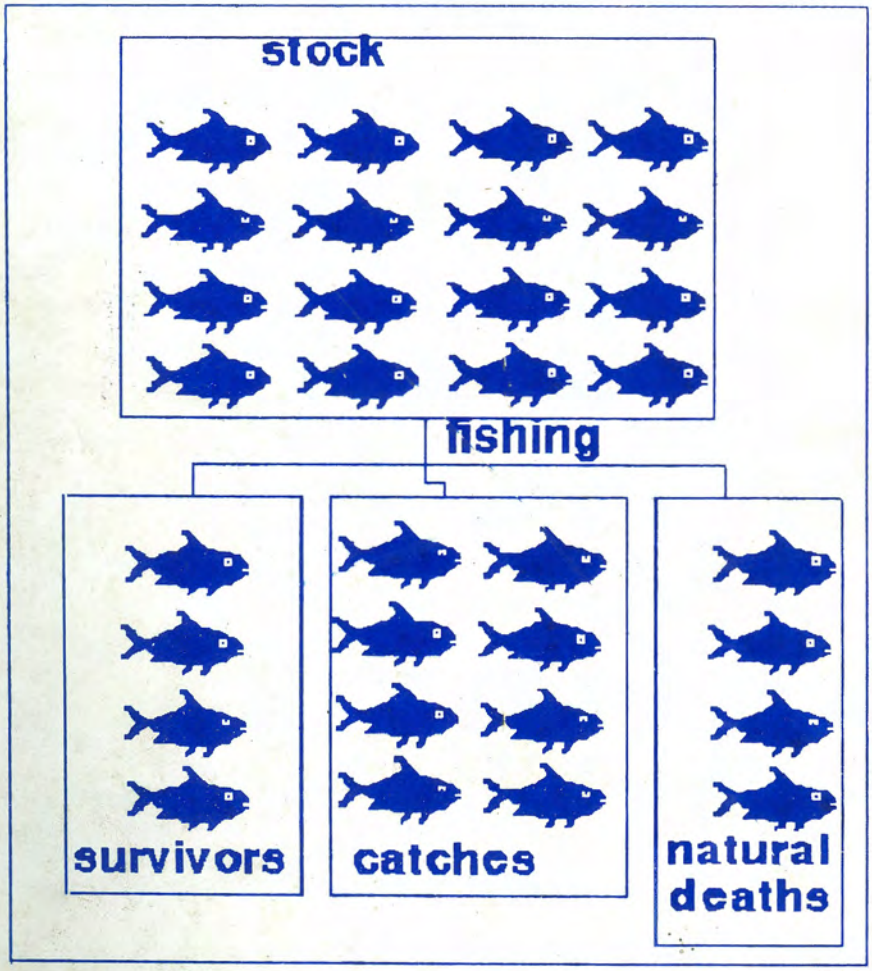
METHODS OF COLLECTION OF INLAND FISHERIES STATISTICS IN INDIA

Part-1: Survey Methodology : Guidelines



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Preparation of this document

The present paper is written with a view to fulfill the needs of supervisory staff responsible for planning and formulation of surveys at state level for collection of Inland Fisheries Statistics. The guidelines contained in this paper are based on the studies conducted under the purview of "Central Sector Scheme for Development of Inland Fisheries Ststistics" in different agro-climatic regions of the country to evolve a suitable methodology for collection of data and estimation of fish production. These guidelines are the outcome of the methodology developed and tested on the basis of sample surveys undertaken in various states and is expected to be of immense help not only for execution of the programme on a uniform basis all over India but also be helpful to those states where trained manpower is in short supply. Some of the difficulties and bottlenecks in the prevailing system have been reviewed and a suitable and operationally convenient procedure of sample surveys in designing the data collection procedures and maintaining proper and up to date data for storage and retrieval on a rational basis have been suggested.

It is hoped that the user agencies would consolidate their efforts in refreshing and strengthning the data collection system by incorporating the suggestions in order to improve the data collection system which will go a long way in building reliable and statistically sound data bases at the micro and macro level.

(R. A. Gupta)
Project Chief

CONTENTS

Guidelines for collection of Inland Fisheries Statistics

Background:

Reliable and firm database is a prerequisite for proper planning and management of Inland fisheries. Various agencies like states' departments of fisheries, ICAR Institutes and Ministry of Agriculture, Govt. of India etc. are engaged in collection and compilation of fisheries statistics in India but the available data display wide variations in terms of coverage, classification and estimation procedure. The deficiencies are so serious that it becomes rather difficult to utilize them for objective planning and development programmes at micro level in order to formulate appropriate policy for their optimum utilization. Hence, the Govt. of India launched a programme of developing Inland Fisheries Statistics under centrally sponsored scheme during 1975 with the involvement of CIFRI, Barrackpore as the nodal agency for evolving a suitable and statistically sound data collection and estimation methodology.

These guidelines are based on system of data collection evolved by CIFRI for estimation of fish production from inland resources during the precess of field surveys conducted in various states. In the following paragraphs an effort has been made to highlight the deficiencies and presented a framework of guidelines based on the evolved methodology which would eliminate the chances of deficiencies in the data collection system.

Deficiencies and bottlenecks in collection of data :

A major bottleneck encountered in data collection refers to ambiguity in the use of concepts and terminologies, nomenclature and classification of the diverse nature of resource in different states and union territories. To overcome this deficiency a complete framework of concepts have been formulated through the experience derived on the basis of pilot studies conducted in various agro-climatic regions of the country in order to bring in uniformity at the national level.

Before presenting the conceptual framework of terminologies and definitions it is worthwhile to spell out the possible types of resource which are the probable source of inland fish production. Although, inland fisheries activity is adopted in almost every water spread area available on land, the water

resources which are found to contribute towards inland fish production basket are enumerated under two broad categories:

A. Fresh water resources such as:

1. Aquaculture ponds and tanks
2. large irrigation tanks
3. Lakes
4. Ox-bow lakes/cut-off meanders
5. Reservoirs
6. Swamps
7. Playas
8. Waterlogged
9. Quarries
10. Ash ponds
11. Excavations
12. Rivers and canals

B. Saline water

1. Lagoons
2. Estuaries
3. Creeks
4. Mangroves
5. Salt pans
6. Marshes
7. Other impoundments (Bherries etc.)

Classification of inland fisheries resources for production assessment

Many of the waterbodies mentioned above contribute very marginally to the total fish production and hence may not be of much importance in formulating strategies for the purpose of production assessment. Hence, all those potential class of waterbodies needed coverage under catch assessment programmes are being classified below for the execution of the methodology in order to provide firm, reliable and statistically sound data base on inland fisheries.

Group I : (Water bodies up to 10 ha. water spread area at full tank level)

1. Aquaculture ponds and tanks
2. Brackish water impoundments
3. Waterlogged areas

Group II :

1. Large Irrigation Tanks
2. Reservoirs and check dams
3. Lakes
4. Ox-bow lakes / Meanders / Channel Scars

Group III

1. Rivers
2. Canals
3. Estuaries
4. Lagoons
5. Back waters

Separate and sound sampling methods devised for estimation of resource area, fish production and other parameters of importance would be discussed in the later part of the estimation procedure.

A great deal of confusion prevails in the minds of field officers in associating a waterbody uniquely with one of the above names. The problem is much serious with regard to large tanks, reservoirs and lakes as a waterbody considered as a tank in one state is known and grouped as reservoir in other state. There is no uniform criteria adopted by different states. This lacunae makes the data incohesive and noncomparable between the states and also difficult to pool at the national level. Hence, to eliminate this possibility, definitions of each resource type have been proposed for adoption in the succeeding sections in order to follow the uniform criteria in all the states and union territories.

Pond: A small body of water usually earthen, though masonry dykes are also included, and shallow made through excavations which represents a restricted environment without a continual interaction with populations of neighbouring biotopes is included in this category.

Tanks: A shallow water unit usually larger than a pond created by constructing earthen or masonary barricades which receives water either from tubewells or rain . Small excavated community ponds and temple tanks and small irrigation impoundments below 10 ha. of water spread at FTL are included in this category.

The above waterbodies namely ponds and tanks up to 10 ha. water spread are considered highly productive due to inherent nutrient status of soil and water, and to a great extent, the nutrient leaching from the surroundings. These water units are found to yield around 500-2000 kg per ha. Scientific farming, however, has resulted in yield exceeding 10 tonnes per ha. per year. This class of water units has vast potential for enhancing fish production per unit area through scientific fish farming. Hence, this class needs elaborate data base for the purpose of micro planning.

Large Irrigation Tank: All those ponds and tanks termed earlier but larger than 10 ha. will fall under this class. Separate data-base is needed for this group as the productivity here is much less than the previous category of

ponds and tanks and therefore seperate sampling may be needed for accurate assessment of fish production.

Lake and floodplain lake: All lentic water bodies of natural origin which are formed due to tectonic movements of earth crust, volcanic or glacial action or wind action in the arid zones, depression from land slides or basin formed due to stream action, silt deposition or erosion or change in stream course (flood plains) are included in this category. These natural lakes constitute an impressive resource for fishery development in the country. Flood plain lakes cover extensive areas in the states of Eastern Uttar Pradesh, North Bihar, West Bengal, Valley districts of Assam, Manipur, Tripura, and foothills of Arunachal Pradesh, and Meghalaya. They are commonly referred to as beels, jheels, mans, chaurs, tals, pats and kols depending on the states in which they are located. The lakes formed due to innundation of low-lying stretches during flood are also categorised under this class.

Reservoir: A large man made impoundment of varying magnitude created by erecting bunds, dams, barrages or other hydraulic structures across streams or rivers serving one or more purposes such as irrigation, power generation, flood control or other water resource development projects. Each reservoir is a separate ecological entity and varies from another in its morphometry, area, geographical location and productivity status.

For the purpose of execution of this methodology , the large irrigation tanks, lakes and flood plain lakes, and reservoirs are further sub-classified on the basis of area under the following :

1. Small : (a) Group I - 10 to 50 ha. of water area at FTL
   (b) Group II - 50 to 500 ha.of water area at FTL

2. Medium reservoir : 500 to 1000 ha. of warer area at FTL)

3. Large reservoir : above 1000 ha. of water area at FTL

Categorisation into above three sub groups is essential for estimating the yield with permissible degree of accuracy as the yield rates show high degree of variation between these sub-groups due to different approaches adopted for fishery management. Small reservoirs are highly productive and usually permit a near total exploitation of the stock due to depletion of water level during summer. An annual stocking and cropping policy is adopted in these waterbodies with other management measures. In medium reservoirs too, stocking forms the mainstay in management but yields are substantially lower than the smaller ones. Large reservoirs on the other hand are managed to get maximum sustainable yield on a long term basis. Endemic fish fauna is generally the chief contributor in such waterbodies and stocking is aimed at

rectifying population imbalances based on natural food spectrum available in the water body. The average productivity from large group is the least.

Rivers and Canals: A river by definition, is a large body of flowing water constrained in a channel. All the small and large rivers along with the major irrigation channels arising out of them are considered under riverine resources for the sake of this survey. The resources under this category are grouped under five major river systems namely the Ganga, the Brahamputra, the Indus, the East coast and the west coast river system.

Estuary and Lagoons: An estuary is a semienclosed coastal body of water which has free connection with the sea and within which the sea water is measurably diluted by freshwater derived from land drainage. This ecotone is a buffer zone between fresh water and saline water of the sea. The river discharge interacts with the seawater and the river water and the sea water are mixed by the action of the tidal motion, wind stress on the surface and the river discharge facing its way in to the sea. Salinity pattern is a good indicator of the estuarine mixing and a pattern of water circulation in an estuary. This resource mainly comprises the Hooghly-Matlah, the Mahanadi, the Godavary and the Narmada system.

Estuary associated coastal water bodies are essential components of this system, often taking the shape of lagoons, creeks, backwaters and so on. The lagoons are usually shallow and the secondary production is often concentrated in the sediments rather than in the water column along with coastal lagoons like Chilka, Pulicate and the chain of backwaters of Kerala.

Brackishwater impoundments: They are estuarine man made impoundments where fresh water is mixed with sea water. Due to tidal action, the beds of many rivers and creeks in the estuarine areas get silted up and in due course of time they are reclaimed for agricultural purposes by constructing bunds to safeguard against floods and tidal water. Some portion of these reclaimed areas are too low for agriculture and are utilized for fish culture. The brackish water tidal wetlands namely mud flats, swamps, marshes, paddy fields etc which are known as bheries in West Bengal are included in this class.

Second type of bottleneck in the system pertains to deficiencies in the analysis of catch and resource data. A critical review of the methods followed in some states points towards number of anomalies which lead to mostly over estimation of fish production. An inkling on these procedures is necessary to bring home the point that how erroneous they are and leading us to nowhere near the reality. For example, a method based on total fish seed distribution is followed in some areas with the following assumptions.

(1) that 50% of the fish seed survives at the end of culture period which contribute to fish production.

(2) that each fish yields about one kilogram of fish weight at the time of harvesting.

(3) that there is no fish seed obtained from private agencies or imported from out of the state clandestinely.

Such methods have severe limitations as they assume that :

(1) The margin given to mortality is sustained uniformally by all the stocking ponds/tanks irrespective of stocking density which varies from tank to tank, (2) Seed suplied by the department is only the source of seed to fish farmers, (3) Each fish surviving becomes of one kg. weight irrespective of productivity status of water body, the period of culture and/or the period of retention of water in the waterbody. (4) The stock is completely harvested during the year. Over and above this there is hardly any objective method of assessment of fish catch from rivers and mostly some figure is added by guess work.

In other states the fish productivty derived on the basis of FFDA ponds is multiplied by the total area to calculate fish production. Under such circumstances the production is likely to be towards higher side as the productivity of FFDA ponds is bound to be higher which will make the estimated production higher by many fold than the actual production. The story of riverine fish production assessment is almost the same as in earlier cases.

It is quite obvious from the above discussions that these methods lead to erroneous results putting a question mark to the reliability of the data.

The way out from this impasse is to follow the methods based on sound statistical procedures based on complete framework of data collection methodology. Since total enumeration of fish catch from each waterbody is not possible for evident reasons, it is only the sample survey which may give the best alternative with minimum input and can help to build reasonably good estimates of production. Efficient sampling design and estimation procedure is the heart of sample survey on which the reliability of estimates depends. Studies under the Scheme in the past have suggested that the system presented in the following paragraphs provides an efficient, statistically sound and operationally convenient method of estimation of fish production from different classes of inland fisheries resource in the country.

Sampling Design :

The whole state is divided into three nearly homogeneous groups called strata (each stratum comprising a number of districts) on the basis of

certain characteristics such as climate, rainfall, soil quality etc. Strata should be formed in such a way that geographical contiguity of districts within the stratum is maintained. From each stratum a sample of 30% districts may be selected at random for the sample survey. Further sampling within each selected district is discussed for each group separately in the succeeding paragraphs.

Sampling procedure for Group I water bodies:

Sampling frame should be prepared for each selected district by making a list of villages. This can be achieved by using the census records. Villages having waterbodies of this group may be highlighted and clusters of five nearby villages may be formed from among the pond bearing villages. From these clusters a sample of nine clusters be selected by random sampling for assessment of water spread area. A further sampling of five ponds in each cluster is recommended for estimation of fish production.

The whole selection procedure may be encompassed under stratified three stage sampling where districts, clusters and ponds are first, second and third stage units of selection respectively.

Sampling procedure for Group II water bodies:

As far as area statistics is concerned, a total inventory of resource under each stratum for group-II should be prepared and a sub group of small, medium and large units as defined elsewhere in the text be made. 25 to 30% sample water bodies at random from each subgroup of each stratum should be selected for collection of data on fish catch. Catch data from selected waterbodies is recorded in the following manner.

Investigations have shown that two types of exploitation pattern is adopted in these waterbodies. They are:

(1) Waterbodies which are harvested for a short interval extending from a fortnight to about a month during the year. These waterbodies are mostly small reserviors and lakes which fall under the perview of state departments and exploitation is affected either by auctioning them to private contractors under certain terms and conditions or exploited departmentally by engaging contract labour. Hence, the bulk of harvest is a one time operation which continues for a fortnight to about a month. Data for such waterbodies may be collected on total enumeration basis.

(2) Water bodies which are exploited round the year by fishermen cooperatives or individual fisherman on the basis of licenses, free fishing, royalty or any other such mode. In such situations 4 to 6 days may be selected

for on the spot observation of catch and production may be assessed as per the formula given under estimation procedure.

In brief this procedure can be described as stratified two stage sampling where selection of waterbody is the first stage and sample days is second stage of selection.

Sampling Procedure for Group III water bodies:

Sampling frame for this group is prepared by enlisting district-wise all the fishing villages/landing centres in each of the strata. 25 to 30% of these units are selected by random sampling from amongst the selected districts of each stratum at the second stage. For each selected unit 4 to 6 sampling days within a month are further selected at the third stage for collection of catch data.

Hence, the above procedure may be termed as stratified three stage sampling where districts, villages and days of sampling form the first, second and the third stage of sampling respectively. The observation of catch is made by the following procedure.

Each selected centre/fishing village is physically observed on two consecutive days in each of the first and second fortnight during the month. On a selected day of sampling at a centre, data is collected during 1200 to 1800 hrs. and on second day from 0600 to 1200 hrs. Data on night landings, if any, in between the consecutive days are collected by inquiry on the second day. On the selected day of observation the investigator should collect information on the total number of fishing units operated on that day, and the total catch landed from the observed units and species composition. He should also ascertain the number of fishing holidays observed during the last month. However, the sampling days in a month may be increased depending on the available resources and the units potential in fish landings.

(The diagrammatic representation of each stage of sampling for the above three groups is given in figure 1.)

Third type of deficiency in data collection can be attributed to lack of uniformity in categorisation of various qualitative and quantitative information recorded on characteristics of waterbodies and other aspects of culture and capture operations. Hence, in order to avoid discrepencies at the later stage of analysis, each parameter on which information is to be collected is discussed below.

Water spread area:- Water spread area of a water body changes due to derivation of water from it for other purposes and due to evaporation. Secondly, the water area recorded in the land utilization records also is unsatisfactory as it

is outdated and at variance with the actual situation in the field. Due to various reasons such as silt load and other human intervention, it has undergone shrinkage and therefore this statistics need to be collected with caution. Keeping in view the above factors in mind the following uniform recording procedures may be maintained.

Three types of water spread area of a water body should be recorded namely :

i) Water spread area from the land utilization records along with its identification number.

ii) Water spread area by actual physical observation on the date of sampling. Minimum and maximum water area which normally reached during pre and post monsoon period should be recorded by inquiry.

iii) Area should be recorded in units in hectares only. In case it is available in local units, it may be converted into hectares by using local conversion factor and recorded in the proformae.

Depth : Recording of depth may pose some problems as it may be difficult to gauge the depth by the enumerator on the day of sampling. Hence, it may be recorded by inquiry from either the owner of the water body or through authoritative sources. Maximum and minimum depth refers to the depth during post monsoon and pre-monsoon period respectively. The depth should always be converted into meters and recorded in the schedule.

Ownership : Categorisation of water bodies in terms of their ownerhip will help to assess the contribution of private and public ponds to fish production. For simplicity we classify this parameter into three different categories namely; (i) Private, which means that the water body belongs legally to an indidividual or group who has title in his name individually or jointly. (ii) Public, which includes all those water bodies which are owned by Central or State Governments, corporation, cooperatives , gram panchayats or municipalities etc. (iii) Disputed, which includes all those water bodies for which the ownership is in dispute or subjudice may be between individuals or between an individual and public.

Seasonality : The fish productivity depends on the period of culture which ultimately relates to period of retention of water by the water unit. Hence, all the water bodies should be uniformly classified into few sub-classes on seasonality scale for proper estimation of production.

The proposed classification listed below may be followed uniformly.

i) Short seasonal - (water retention up to 3 months)

ii) Seasonal - (water retention upto six months)

iii) Long seasonal - (water retention upto nine months)

iv) Perennial - water retention throughout the year.

Source of water : Information on source of water is needed to have an understanding of the dependance of the unit on the source of water. These sources may be classified as follows.

1. Rain water
2. Ground water + Rain water
3. Surface water + Rain water (such as river, reservoir , lakes & canals etc.)

Soil type : Quality of soil is helpful in culture management and hence each waterbody should be categorised as per the following soil types. Since type of soil may not be possible to assess by the field enumerator, it may be recorded by enquiry.

Sandy
Clayey
Loamy
Rockey

Weed infestation and silting : Infestation of weeds in large number of waterbodies has become hazard and inhibit the growth of fish whereas silt reduces the available water area. These parameters need to be investigated for the point of view of developing them into potential fishery resource. Hence, information about them will be quite useful. Since, these are qualitative in nature these may be measured in terms of percentages.

Marginally	0-25%	Not silted	0-25%
Moderate	25-50	Partially silted	25 to 50
Full	75-100%	Heavily	50 onwards

Reasons of non-utilization : Many water units although suitable for fishery may not be under this activity due to various reasons. These reasons should be recorded to understand the extent of area under fish culture. To maintain uniformity they may be grouped as;

Disputed
Multiple ownership

Weed problem
Poaching
Not-interested

Culture type : Production of fish from the body of water depends on the type of culture adopted by the farmer. Hence, to measure this aspect more precisely, we can classify this into these type of operations :

i) Intensive fish culture
ii) Semi-intensive
iii) Extensive

Here it is essential to follow uniform criteria for categorisation of culture ponds into one of the above three.

Source of seed : Information on source of seed may be grouped into the following classes.

From State Govt.
From private parties within the state
From outside the state

Duration of crop : Production from pond to pond varies also on account of the period of culture operations. So, it seems necessary to collect the data on this aspect to study the variability of production and its reasons.

Name of water body : In case of large water bodies such as beels, lakes and reservoirs which extend their water spread from one district to other or from one state to another are known locally by different names. This poses real problem in enlistment of a water body in the state or at the national level. It may be ensured that the name is recorded as per the definition given with local name in the bracket.

Controlled by and Fishery managed by : In case of large water bodies, the information seems to be necessary on the above two aspects. One relate to the controlling authority of the water body which means that the authority who takes all the decisions about the waterbody such as maintaining the water level, repairing, release of water for irrigation etc. The other aspect namely "fishery managed by" pertains to the agency who is looking for the management of fish biomass in the waterbody including decisions pertaining to stocking, harvesting, and auctioning etc. There may be situations where both these operation may lie with a single agency or it may be divided into two different agencies.

Mode of exploitation (Fishing rights) : Recording of data on modes of exploitation of water body poses problems as their are diverse ways in which a water body is put to fish harvesting. These may be free fishing, licensing, royality or departemental fishing or lease etc. Hence, waterbodies may be uniformally categorised into the following.

Free fishing
Outright auctioning
Licensing (Fishermen, boats or nets)
Royality system
Departmental fishing

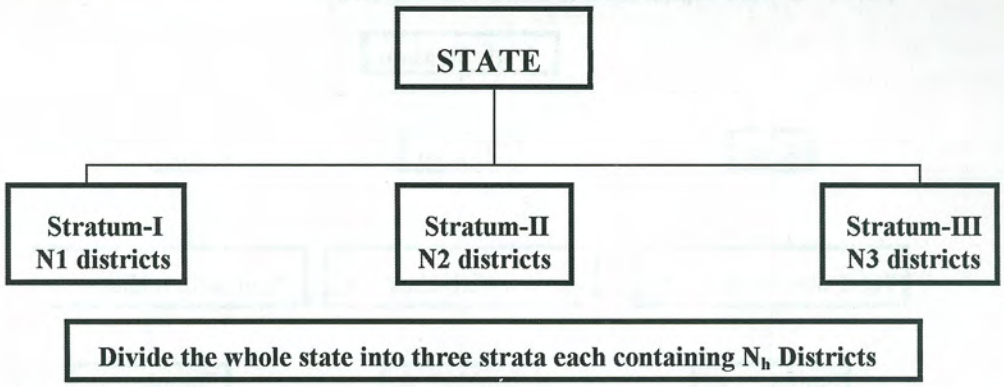
Fishing village : The concept of fishing village varies from state to state and it is therefore, essential to define the criteria of fishing village to maintain uniformity over the entire coverage. Hence the following definition of a fishing village may be adopted for making the frame of the coverage for selection. A fishing village is one which is located on the periphery of the water system and possesses professional fishing parties/fishermen who are engaged in fishing operations either on full time or part time basis.

Fishing crafts and gears : Inland fishery is basically a multi-species fishery exploited by artisanal fishermen with the help of various types, length and mesh size of nets. Collection of data by the above categories may pose real problem due to such variations and a uniform criterian need to be adopted for recording statistics in the field. Hence, to maintain uniformity and at the same time simplicity, the data may be recorded in terms of the following broad types with number of units operated irrespective of their length and mesh size in order to avoid complication in analysis.

Gill net
Drag net
Cast net
Hook
Others

(Format of the proforma shedules used for collection of data on the various characteristics is presented under appendix-1. There are three proformae namely 1.1, 1.2 and 1.3 for collection of basic information for each of the three groups respectively. The remaining three proformas namely 2.1, 2.2 and 2.3 pertain to catch assessment for each of the three groups respectively)

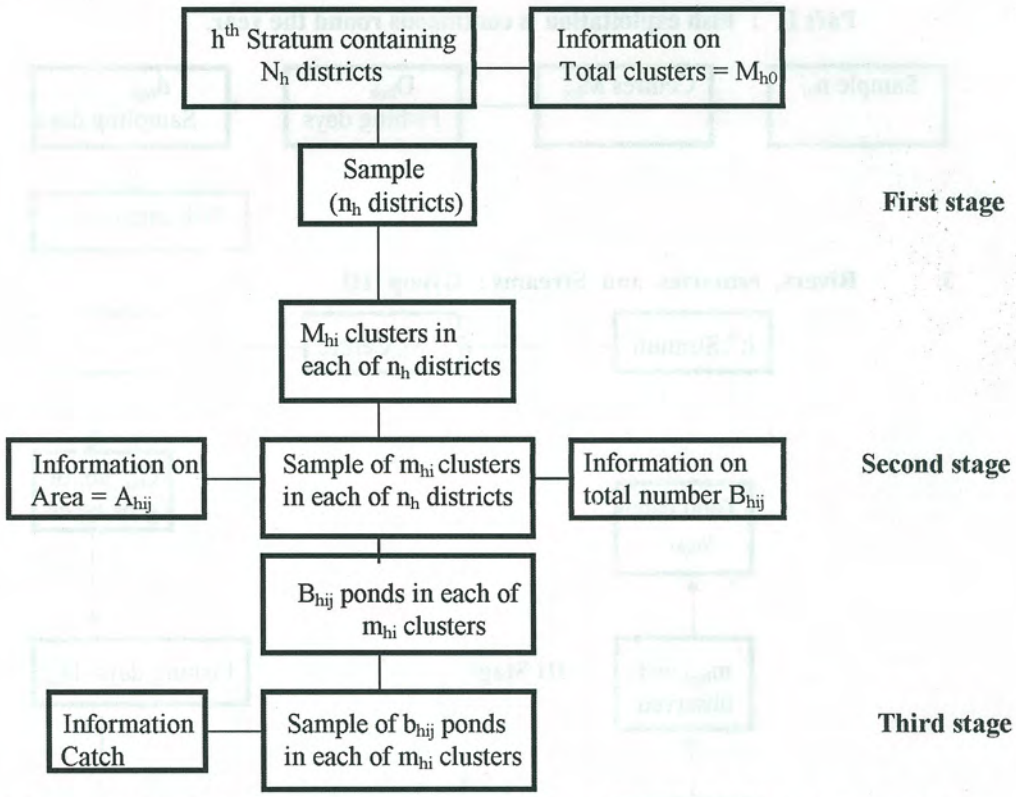
Fig. 1 DIAGRAMMATIC REPRESENTATION OF SAMPLING STAGES



Further sampling in each stratum is to be resource adopted seperately for each group in the following manner.

1. Ponds and Tanks : Group - I

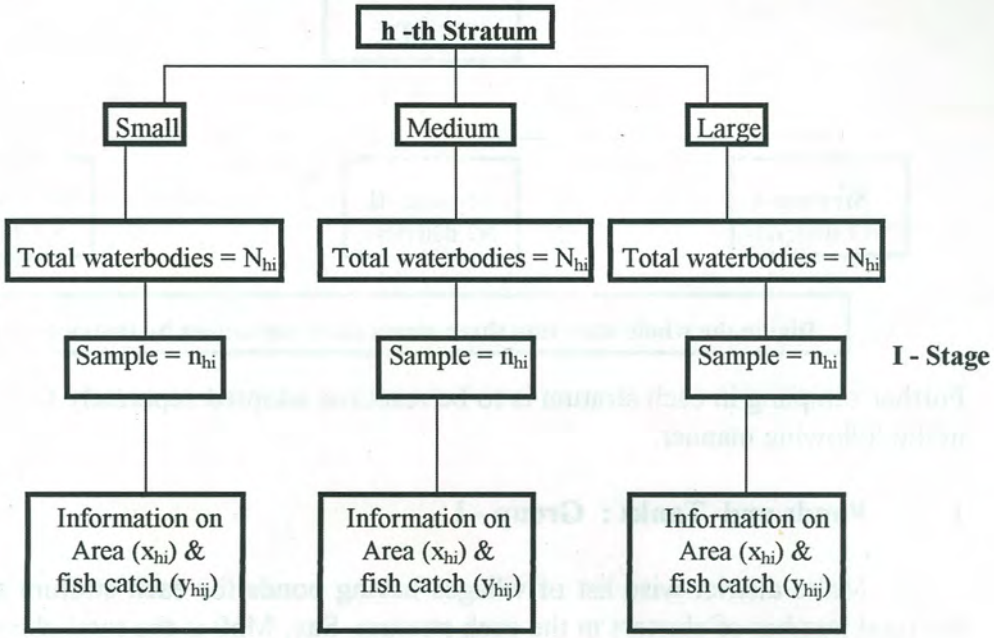
Make district-wise list of villages having ponds for each stratum and record the total number of clusters in the each stratum. Say, Mh0 is the total clusters in h-th stratum.



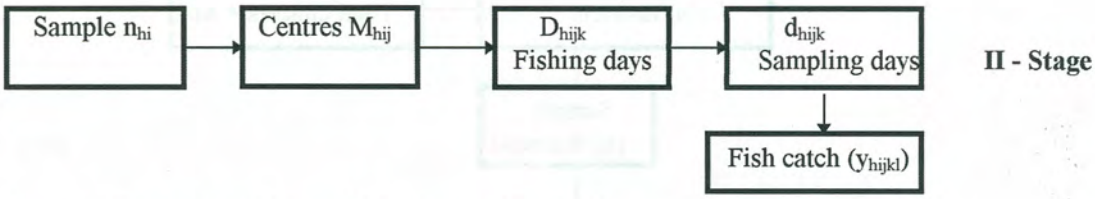
Note : From each district having M_{hi} clusters, select m_{hi} clusters by SRS. And from each m_{hi} clusters having B_{hij} ponds select b_{hij} ponds.

2. Reservoirs, lakes and large irrigation tanks : Group II

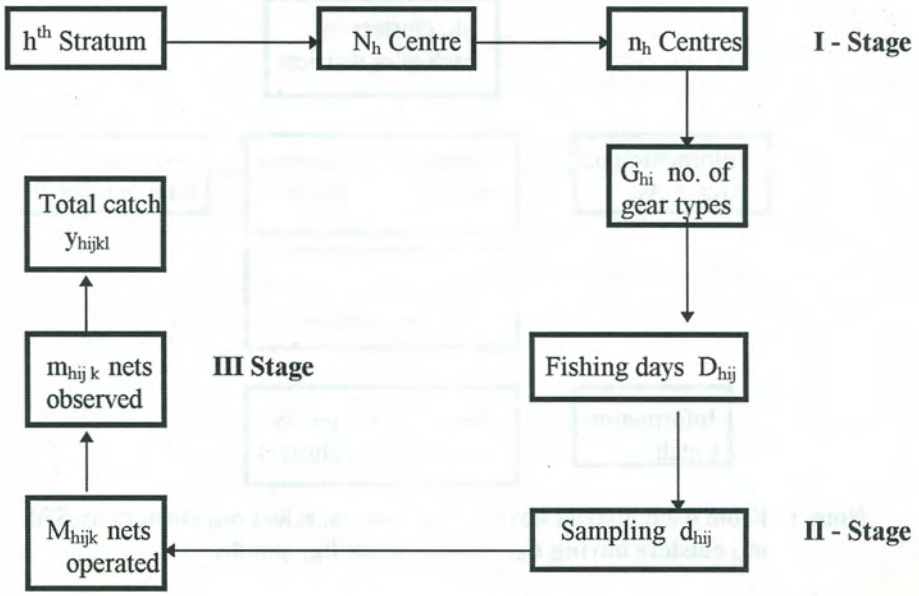
Part I : Fish exploitation is a short time activity.



Part II : Fish exploitation is continuous round the year.



3. Rivers, estuaries and Streams : Group III



Statistical Estimation and formulae:

Ponds and tanks: Group-1

Notations:
Let
N_h = Number of districts in h-th stratum
n_h = Number of districts selected in h-th stratum
M_{hi} = Number of clusters in i-th district
m_{hi} = Number of clusters selected in i-th district

$$M_{h0}=\sum_{i=1}^{N_h} M_{hi} \qquad \text{=Total clusters in h-th stratum}$$

B_{hij} = Total number of ponds in j-th cluster of i-th district
B'_{hij} = Number of ponds harvested in j-th cluster of i-th district
b_{hij} = Number of ponds selected in j-th cluster of i-th district
a_{hijk}= Area of k-th pond in j-th cluster of i-th district
A_{hij} = Area of all waterbodies in j-th cluster of i-th district

$$A_{hij}=\sum_{k=1}^{B_{hij}} a_{hijk}$$

A'_{hij} = Area of all waterbodies harvested in j-th cluster of i-th district

$$A'_{hij}=\sum_{k=1}^{B'_{hij}} a_{hijk}$$

(a) Estimation of total area (Two stage sampling)

POPULATION

Average area per cluster in h-th stratum

$$\bar{A}_h=\frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}} A_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h}\sum_{i=1}^{N_h} w_{hi}\bar{A}_{hi} \qquad \text{----------(I)}$$

$$where\ \bar{A}_{hi}=\frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}}A_{hij}\ ;\ \bar{M}_h=\frac{1}{N_h}\sum_{i=1}^{N_h}M_{hi}\ ;\ w_{hi}=\frac{M_{hi}}{\bar{M}_h}$$

Average area harvested per cluster in h-th stratum

$$\bar{A}_h^{/}=\frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}}A_{hij}^{/}}{\sum_{i=1}^{N_h}M_{hi}}=\frac{1}{N_h}\sum_{i=1}^{N_h}w_{hi}\,\bar{A}_{hi}^{/}\qquad\text{----------(2)}$$

Where

$$\bar{A}_{hi}^{/}=\frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}}A_{hij}^{/}\ ;\ \bar{M}_h=\frac{1}{N_h}\sum_{i=1}^{N_h}M_{hi}$$

Total water area and total area harvested in h-th stratum are

$$A_h = \bar{A}_h * M_{h0}\qquad\text{----------(3)}$$

$$A_h^{/} = \bar{A}_h^{/} * M_{h0}\qquad\text{----------(4)}$$

SAMPLE

Estimate of average area per cluster

$$\hat{\bar{A}}_h=\frac{1}{n_h}\sum_{i=1}^{n_h}w_{hi}\,\bar{a}_{hi}\ ;\ where\ \bar{a}_{hi}=\frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}}A_{hij}\qquad\text{-------(5)}$$

Estimate of average area harvested per cluster

$$\hat{\bar{A}}_h^{/}=\frac{1}{n_h}\sum_{i=1}^{n_h}w_{hi}\,\bar{a}_{hi}^{/}\ ;\ where\ \bar{a}_{hi}^{/}=\frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}}A_{hij}^{/}\qquad\text{-----(6)}$$

Estimate of total area in h-th stratum

$$\hat{A}_h = \hat{\bar{A}}_h * M_{h0} \; ; \; where \; M_{h0} = \sum_{i=1}^{N_h} M_{hi} \qquad \text{----------(7)}$$

Estimate of total harvested area in h-th stratum

$$\hat{A}_h^{/} = \hat{\bar{A}}_h^{/} * M_{h0} \qquad \text{----------(8)}$$

Estimate of variance is given by

$$v(\hat{\bar{A}}_h) = (\frac{1}{n_h} - \frac{1}{N_h}) s_{hb}^2 + \frac{1}{N_h n_h} \sum_{i=1}^{m_{hi}} w_{hi}^2 (\frac{1}{m_{hi}} - \frac{1}{M_{hi}}) s_{hwi}^2 \qquad \text{------(9)}$$

where

$$s_{hb}^{\ 2} = \frac{1}{n_h - 1} [\sum_{i=1}^{n_h} (w_{hi} \bar{a}_{hi})^2 - n_h \hat{\bar{A}}_h^2]$$

$$s_{hwi}^{\ 2} = \frac{1}{m_{hi} - 1} [\sum_{j=1}^{m_{hi}} (A_{hij} - \bar{a}_{hi})^2$$

Estimate of variance of total harvested water area is given by,

$$v(\hat{\bar{A}}_h^{/}) = (\frac{1}{n_h} - \frac{1}{N_h}) s_{hb}^{/\,2} + \frac{1}{N_h n_h} \sum_{i=1}^{m_{hi}} w_{hi}^2 (\frac{1}{m_{hi}} - \frac{1}{M_{hi}}) s_{hwi}^{/\,2} \qquad \text{---------(10)}$$

where

$$s_{hb}^{/\,2} = \frac{1}{n_h - 1} [\sum_{i=1}^{n_h} (w_{hi} \bar{a}_{hi}^{/})^2 - n_h \hat{\bar{A}}_h^{2/}] \; and \; s_{hwi}^{/\,2} = \frac{1}{m_{hi} - 1} [\sum_{j=1}^{m_{hi}} (A_{hij}^{/} - \bar{a}_{hi}^{/})^2]$$

Estimate of variance of total is $[v(\hat{A}_h^{/})] = M_{h0}^2 \; v(\hat{\bar{A}}_h^{/})$ .....(11)

Estimation of total number of ponds:

POPULATION

Average ponds per cluster in h-th stratum

$$\bar{B}_h = \frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}} B_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h}\sum_{i=1}^{N_h} w_{hi}\bar{B}_{hi} \qquad \text{.....(12)}$$

$$where\ \bar{B}_{hi} = \frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}} B_{hij}\ ;\ \bar{M}_h = \frac{1}{N_h}\sum_{i=1}^{N_h} M_{hi}\ ;\ w_{hi} = \frac{M_{hi}}{\bar{M}_h}$$

Average ponds harvested per cluster in h-th stratum

$$\bar{B}'_h = \frac{\sum_{i=1}^{N_h}\sum_{j=1}^{M_{hi}} B'_{hij}}{\sum_{i=1}^{N_h} M_{hi}} = \frac{1}{N_h}\sum_{i=1}^{N_h} w_{hi}\bar{B}'_{hi} \qquad \text{.....(13)}$$

where

$$\bar{B}'_{hi} = \frac{1}{M_{hi}}\sum_{j=1}^{M_{hi}} B'_{hij}\ ;\ \bar{M}_h = \frac{1}{N_h}\sum_{i=1}^{N_h} M_{hi}\ ;\ w_{hi} = \frac{M_{hi}}{\bar{M}_h}$$

Total ponds and total harvested ones in h-th stratum

$$B_h = \bar{B}_h\, M_{h0} \qquad \text{.....(14)}$$

$$B'_h = \bar{B}'_h\, M_{h0} \qquad \text{.....(15)}$$

SAMPLE

Estimate of average number of ponds per cluster

$$\hat{\bar{B}}_h = \frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\ \bar{b}_{hi}\ ;\ where\ \bar{b}_{hi} = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B_{hij} \qquad .....(16)$$

Estimate of average ponds harvested per cluster

$$\hat{\bar{B}}_h' = \frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\ \bar{b}_{hi}'\ ;\ where\ \bar{b}_{hi}' = \frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B_{hij}' \qquad .....(17)$$

Estimate of total ponds in h-th stratum

$$\hat{B}_h = \hat{\bar{B}}_h * M_{h0}\ ;\ where\ M_{h0} = \sum_{i=1}^{N_h} M_{hi} \qquad .....(18)$$

Estimate of total ponds harvested in h-th stratum

$$\hat{B}_h' = \hat{\bar{B}}_h' * M_{h0} \qquad .....(19)$$

Estimate of variance may be given as

$$v(\hat{\bar{B}}_h) = \left(\frac{1}{n_h} - \frac{1}{N_h}\right)s_{hb}^2 + \frac{1}{N_h n_h}\sum_{i=1}^{m_{hi}} w_{hi}^2\left(\frac{1}{m_{hi}} - \frac{1}{M_{hi}}\right)s_{hwi}^2 \qquad ...(20)$$

$$where\ s_{hb}^2 = \frac{1}{n_h - 1}\left[\sum_{i=1}^{n_h}(w_{hi}\bar{b}_{hi})^2 - n_h\hat{\bar{B}}_h^2\right]\ and\ s_{hwi}^2 = \frac{1}{m_{hi}-1}\left[\sum_{j=1}^{m_{hi}}(B_{hij} - \bar{b}_{hi})^2\right.$$

Estimate of average area per pond is

$$\hat{\bar{A}}_h\ /\ \hat{\bar{B}}_h \qquad .....(21)$$

Estimation of fish yield (Three stage sampling) :

Let

y_{hijk} = Yield of k-th ponds in j-th cluster of i-th district in h th straum

x_{hijk} = Area of k-th pond in j-th cluster of i-th district in h-th stratum

POPULATION

Average yield per pond of j-th cluster is

$$\bar{Y}_{hij} = \frac{1}{B'_{hij}} \sum_{k=1}^{B'_{hij}} y_{hijk} \qquad \text{.....(22)}$$

Average yield per cluster of i-th district is

$$\bar{Y}_{hi} = \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} \sum_{k=1}^{B'_{hij}} y_{hijk}$$

$$= \frac{1}{M_{hi}} \sum_{j=1}^{M_{hi}} B'_{hij} \bar{Y}_{hij} \qquad \text{.....(23)}$$

Average yield per cluster in h-th stratum

$$\bar{Y}_h = \frac{1}{\sum M_{hi}} \sum_{i=1}^{N_h} \sum_{j=1}^{M_{hi}} \sum_{k=1}^{B'_{hij}} y_{hijk}$$

$$= \frac{1}{N_h} \sum_{i=1}^{N_h} \frac{M_{hi}}{\bar{M}_h} \bar{Y}_{hi} \qquad \text{.....(24)}$$

$$= \frac{1}{N_h} \sum_{i=1}^{N_h} w_{hi} \bar{Y}_{hi}; \text{ where } w_{hi} = \frac{M_{hi}}{\bar{M}_h}$$

Similarly, average area per cluster in the h-th stratum is

$$\bar{X}_h = \frac{1}{N_h} \sum_{i=1}^{N_h} w_{hi} \bar{X}_{hi} \qquad \text{.....(25)}$$

SAMPLE : Based on first stage unit totals

Estimate of yield per pond in j-th cluster is

$$\bar{y}_{hij}=\frac{1}{b_{hij}}\sum_{k=1}^{b_{hij}} y_{hijk} \qquad \text{.....(26)}$$

Estimate of yield per cluster in i-th district is

$$\hat{\bar{Y}}_{hi}=\frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B'_{hij}\bar{y}_{hij} \qquad \text{.....(27)}$$

Estimate of yield per cluster in h-th strarum is

$$\hat{\bar{Y}}_{h}=\frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\hat{\bar{Y}}_{hi}= =\frac{1}{n_h}\sum_{i=1}^{n_h}\frac{w_{hi}}{m_{hi}}\sum_{j=1}^{m_{hi}} B'_{hij}\,\bar{y}_{hij} \qquad \text{.....(28)}$$

Estimate of variance of the above estimate is given by

$$v(\hat{\bar{Y}}_{h})=(\frac{1}{n_h}-\frac{1}{N_h})s_{by}^{\,2}+\frac{1}{n_h}\frac{1}{N_h}\sum_{i=1}^{n_h} w_{hi}^{\,2}(\frac{1}{m_{hi}}-\frac{1}{M_{hi}})s_{iy}^{\,2}+$$

$$\frac{1}{N_h}\frac{1}{n_h}\sum_{i=1}^{n_h}\frac{w_{hi}^{\,2}}{M_{hi}m_{hi}}\sum_{j=1}^{m_{hi}} B_{hij}^{\prime\,2}(\frac{1}{b_{hij}}-\frac{1}{B'_{hij}})s_{ijy}^{\,2} \qquad \text{.....(29)}$$

where; $s_{by}^{\,2}=\frac{1}{n_h-1}\sum(w_{hi}\hat{\bar{Y}}_{hi}-\hat{\bar{Y}}_{h})^2$; $s_{iy}^{\,2}=\frac{1}{m_{hi}-1}\sum(B'_{hij}\bar{y}_{hij}-\hat{\bar{Y}}_{hi})^2$

$$s_{ijy}^{\,2}=\frac{1}{b_{hij}-1}\sum(y_{hijk}-\bar{y}_{hij})^2$$

Estimate of total yield in h-th stratum

$$\hat{Y}_{h}=(\hat{\bar{Y}}_{h})*M_{h0}$$

Similarly estimate for area based on selected ponds is,

Estimate of area per cluster is

$$(\hat{\bar{X}}_{h})=\frac{1}{n_h}\sum_{i=1}^{n_h} w_{hi}\hat{\bar{X}}_{hi}\ ;\ where\ \hat{\bar{X}}_{hi}=\frac{1}{m_{hi}}\sum_{j=1}^{m_{hi}} B'_{hij}\bar{x}_{hij} \qquad \text{.....(30)}$$

$$and\ \bar{x}_{hij}=\frac{1}{b_{hij}}\sum_{k=1}^{b_{hij}} x_{hijk}$$

Yield per hectare (Ratio Estimate)

$$\hat{R}=\frac{(\hat{\bar{Y}}_h)}{(\hat{\bar{X}}_h)} \qquad \text{.....(31)}$$

Estimate of total yield from h-th stratum based on the ratio estimate is

$$(\hat{Y}_{hR})=\hat{R}.\ A_h' \text{ or } (\hat{\bar{Y}}_{hR})=\hat{R}.\ \bar{A}_h' \qquad \text{.....(32)}$$

where A_h'=*total area harvested under ponds and tanks in the stratum This may be replaced by* $\hat{A}_h'$

The above estimate is biased but consistant. The bias will be negligible.

Estimate of variance of the estimate is

$$v(\hat{\bar{Y}}_{hR})=(\frac{1}{n_h}-\frac{1}{N_h})(s_{by}^2-2\hat{R}_h s_{bxy}+\hat{R}_h^2 s_{bx}^2)+$$

$$\frac{1}{n_h}\frac{1}{N_h}\sum_{i=1}^{n_h} w_{hi}^2(\frac{1}{m_{hi}}-\frac{1}{M_{hi}})(s_{iy}^2-2\hat{R}_h s_{ixy}+\hat{R}_h^2 s_{ix}^2)+$$

$$\frac{1}{n_h}\frac{1}{N_h}\sum_{i=1}^{n_h}\frac{w_{hi}^2}{m_{hi}M_{hi}}\sum_{J=1}^{m_{hi}} B_{hij}^2(\frac{1}{b_{hij}}-\frac{1}{B_{hij}'})(s_{ijy}^2-2\hat{R}_h s_{ijxy}+\hat{R}_h^2 s_{ijx}^2) \qquad \text{.....(33)}$$

where; $s_{bxy}^2=\frac{1}{n_h-1}\sum(w_{hi}\hat{\bar{Y}}_{hi}-\hat{\bar{Y}}_h)(w_{hi}\hat{\bar{X}}_{hi}-\hat{\bar{X}}_h)$;

$$s_{ixy}^2=\frac{1}{m_{hi}-1}\sum(B_{hij}'\bar{y}_{hij}-\hat{\bar{Y}}_{hi})(B_{hij}'\bar{x}_{hij}-\hat{\bar{X}}_{hi})\ ;$$

$$s_{ijxy}^2=\frac{1}{b_{hij}-1}\sum(y_{hijk}-\bar{y}_{hij})(x_{hijk}-\bar{x}_{hij})$$

s_{by}^2, s_{iy}^2, s_{ijy}^2 *can be obtained from* (29) *and*

s_{bx}^2, s_{ix}^2, s_{ijx}^2 *can be got by replacing y by x in* (29)

Reservoirs, lakes and large irrigation tanks : Group-II

Notations

Let

N_{hi} = Total number of water bodies of the i-th sub-group in h-th stratum

N_{hi}` = Number of water bodies harvested in i-th sub-group of h-th stratum

n_{hi} = Number of water bodies selected from N_{hi}

n_{hi}` = Number of selected water bodies which have been harvested among n_{hi}

x_{hij} = Area of j-th water body of i-th sub-group in h-th stratum

y_{hij} = yield of j-th water body of the i-th sub- group in h-th stratum

(Value of y_{hij} is obtained by recording total fish catch in cases where water body is harvested during the short interval of the year. However, water bodies which are harvested during the entire year as discussed in the sampling procedure, y_{hij} is estimated by further sampling as under)

(1) If total fish catch is recorded at a centre on each sampling day:

Average catch at k-th centre per day

$$\bar{y}_{hijk}=\frac{1}{d_{hijk}}\sum y_{hijkl} \qquad \text{.....(34)}$$

Estimate of average catch at k-th centre during the month/year

$$D_{hijk}\,\bar{y}_{hijk} \qquad \text{.....(35)}$$

Estimate of total catch from j-th water body

$$(\hat{Y}_{hij})=\sum D_{hijk}\,\bar{y}_{hijk} \qquad \text{.....(36)}$$

where

y_{hijkl} = yield of l-th day of k-th centre at j-th waterbody of i-th sub-group

D_{hijk} = Total fishing days in the k-th centre of j-th waterbody in i-th sub-group during the month/year

d_{hijk} = sample days selected out of D_{hijk} during the month/year

(Month/year will depend on whether estimates are prepared monthly or yearly)

(2) If fish catch is recorded by observing further sampling of few gears out of the total gears used on the sampling day:

(Under this situation y_{hijkl} may be replaced by $M_{hijkl} * \bar{y}_{hijkl}$ where M_{hijkl} is the total number of nets operated on l-th day and $\bar{y}_{hijkl}$ is the average fish catch per net of sampled nets on l-th day)

POPULATION:

Average yield per water body

$$\bar{Y}_{hi} = \frac{1}{N_{hi}} \sum_{j=1}^{N_{hi}} y_{hij} \qquad \text{.....(37)}$$

Similarly, average area per water body is

$$\bar{X}_{hi} = \frac{1}{N_{hi}} \sum_{j=1}^{N_{hi}} X_{hij} \qquad \text{.....(38)}$$

Yield per hectare (Ratio estimate)

$$R_{hi} = \frac{\bar{Y}_{hi}}{\bar{X}_{hi}} \qquad \text{.....(39)}$$

Total yield of waterbodies of i-th sub-group of h-th stratum

$$Y_{Rhi} = R_{hi} * X_{hi} \qquad \text{.....(40)}$$

Total fish production for the state under Group-II water bodies

$$(Y_{g2}) = \sum_{h=1} \sum_{i=1} R_{hi} * X_{hi} \qquad \text{.....(41)}$$

SAMPLE

Average yield per selected water body is

$$\bar{y}_{hi}=\frac{1}{n_{hi}}\sum_{j=1}^{n_h} y_{hij} \qquad \text{.....(42)}$$

$$\bar{x}_{hi}=\frac{1}{n_{hi}}\sum_{j=1}^{n_h} x_{hij} \qquad \text{.....(43)}$$

Estimate of yield per hactare (Ratio estimate)

$$(\hat{R}_{hi})=\frac{\bar{y}_{hi}}{\bar{x}_{hi}} \qquad \text{.....(44)}$$

Estimate of total yield is (on the basis of total harvested area)

$$\hat{Y}_{Rhi}=(\hat{R}_{hi})*X'_{hi} \qquad \text{.....(45)}$$

where X_{hi}' is the total harvested area. Since the total harvesed area is not known for the population , we may replace it by (P_{hi} * X_{hi}) assuming that the ratio of total harvested area to total area is same for population as well as sample. i.e.,

$$\frac{X'_{hi}}{X_{hi}}=\frac{x'_{hi}}{x_{hi}}=P_{hi}$$

The estimate of variance is given by

$$Est.V(\hat{Y}_{Rhi})=\frac{N_{hi}(N_{hi}-n_{hi})}{n_{hi}(n_{hi}-1)}\sum_{j=1}[\ y_{hij}-(\hat{R}_{hi})x_{hij}\ ]^2 \qquad \text{.....(46)}$$

Here the variance at second stage of sampling adopted in case of water bodies exploited throughout the year is considered to be negligible. However, in certain cases it may not be negligible but to avoid further complications in analysis, it may be assumed negligible.

Estimate of total fish production for the state under Group-II is given by;

$$\hat{Y}_{g2}=\sum_{h=1}\sum_{i=1}(\hat{R}_{hi})\ X'_{hi} \qquad \text{.....(47)}$$

Estimate of variance of the estimate is

$$\sum_{h=1}\sum_{i=1}\frac{N_{hi}(N_{hi}-n_{hi})}{n_{hi}(n_{hi}-1)}\sum_{j=1}[\ y_{hij}-(\hat{R}_{hi})x_{hij}\ ]^2 \qquad \text{.....(48)}$$

Rivers, streams, estuaries and lagoons: Group - III

Fishing village/landing centre approach: The sampling procedure for this class of resource has been given in the preceeding section. As per the formulated programme the state is divided into three approximately equal strata each comprising a number of geographically contiguous districts. The procedure has been designed separately for (i) water bodies where it is easier to identify fishing villages / landing centres and (ii) where it is difficult to identify landing centres/fishing villages. Analysis of fish production from each stratum for these two methods is explained below which will enable to provide estimates of total monthly catches as well as gear-wise catches. The catch from each stratum is added to calculate the total production of the state.

Notations:

N_h = Number of landing centres/fishing villages in h-th stratum
(h=1,2,3.)
n_h = Number of landing centres/ fishing villages selected in h-th stratum
G_{hi} = Types of nets/gears used in i-th village

D_{hij} = Number of fishing days during the month of j-th type net in i-th village of h-th stratum

(j=1,2.....Ghi; i=1,2.....Nh)

d_{hij} = Number of sample days during the month of j-th type net in i-th village of h-th stratum

(j=1,2.....Ghi; i=1,2.....nh)

M_{hijk} = Number of j-th type net operated on k-th day in i-th village

m_{hijk} = Number of j-th type net observed on k-th day in i-th village

y_{hijkl} = Fish yield of each unit of j-th type net on k-th day i-th village of h-th stratum

Population : (Monthly fish production)

Average catch per unit gear (net/net-tide)

$$\bar{Y}_{hijk} = \frac{1}{M_{hijk}} \sum_{l=1} y_{hijkl} \qquad \ldots(49)$$

Average catch per day of j-th type net in i-th centre

$$\bar{Y}_{hij} = \frac{1}{D_{hij}} \sum_{k=1} M_{hijk} \bar{Y}_{hijk} \qquad \ldots.(50)$$

Average catch per centre

$$\bar{Y}_h = \frac{1}{N_h} \sum_{i=1} \sum_{j=1} \sum_{k=1} M_{hijk} \bar{Y}_{hijk}$$

$$\text{or} \quad \bar{Y}_h = \frac{1}{N_h} \sum_{i=1} \sum_{j=1} D_{hij} \bar{Y}_{hij} \qquad \ldots.(51)$$

Total monthly catch in h-th stratum is

$$Y_h = \bar{Y}_h * N_h \qquad \ldots(52)$$

Sample (Monthly estimates of fish catch)

Average catch per unit (net/net-tide)

$$\bar{y}_{hijk}=\frac{1}{m_{hijk}}\sum y_{hijkl}$$

Estimate of average catch of j-th type net per day .....(53)

$$\bar{y}_{hij}=\frac{1}{d_{hij}}\sum M_{hijk}\,\bar{y}_{hijk}$$

Estimate of average catch per month of j-th type net .....(54)

$$\frac{D_{hij}}{d_{hij}}\sum M_{hijk}\bar{y}_{hijk}$$

Estimate of average catch per centre .....(55)

$$(\hat{\bar{Y}}_h)=\frac{1}{n_h}\sum\sum\frac{D_{hij}}{d_{hij}}\sum M_{hijk}\bar{y}_{hijk}$$

$$or\quad (\hat{\bar{Y}}_h)=\frac{1}{n}\sum\sum D_{hij}\bar{y}_{hij} \qquad .....(56)$$

Total monthly catch in h-th stratum is

$$(\hat{Y}_h)=\frac{N_h}{n_h}\sum\sum\frac{D_{hij}}{d_{hij}}\sum M_{hijk}\bar{y}_{hijk} \qquad .....(57)$$

$$or\quad (\hat{Y}) = (\hat{\bar{Y}})*N \qquad .....(58)$$

Variance of the estimate is given by,

$$V(\hat{\bar{Y}}_h)=(\frac{1}{n_h}-\frac{1}{N_h})S_{by}^2+\frac{1}{n_hN_h}\sum_{i=1}\sum_{j=1}D_{hij}^2(\frac{1}{d_{hij}}-\frac{1}{D_{hij}})S_{ijy}^2+$$

$$\frac{1}{n_hN_h}\sum_{J=1}\frac{D_{hij}}{d_{hij}}\sum_{k=1}M_{hijk}^2(\frac{1}{m_{hijk}}-\frac{1}{M_{hijk}})S_{ijky}^2 \qquad .....(59)$$

where

$$^2_y=\frac{1}{N_h-1}\sum_{i=1}(\sum D_{hij}\bar{Y}_{hij}-\bar{Y}_h)^2;\quad S_{ijy}^2=\frac{1}{D_{hij}-1}\sum(M_{hijk}\bar{Y}_{hijk}-\bar{Y}_{hi}$$

$$S_{ijky}^2=\frac{1}{M_{hijkl}-1}\sum_{k=1}(Y_{hijkl}-\bar{Y}_{hijk})^2$$

Estimated variance of the estimate is,

$$Est\ V(\hat{\bar{Y}}_h)=(\frac{1}{n_h}-\frac{1}{N_h})s^2_{by}+\frac{1}{n_hN_h}\sum_{i=1}\sum_{j=1}D^2_{hij}(\frac{1}{d_{hij}}-\frac{1}{D_{hij}})s^2_{ijy}+$$
$$\frac{1}{n_hN_h}\sum_{j=1}\frac{D_{hij}}{d_{hij}}\sum_{k=1}M^2_{hijk}(\frac{1}{m_{hijk}}-\frac{1}{M_{hijk}})s^2_{ijky} \qquad .....(60)$$

where

$$s^2_{by}=\frac{1}{n_h-1}\sum_{i=1}(\sum D_{hij}\bar{y}_{hij}-(\hat{\bar{Y}}_h))^2;\ s^2_{ijy}=\frac{1}{d_{hij}-1}\sum(M_{hijk}\bar{y}_{hijk}-\bar{y}_{hij})^2$$
$$s^2_{ijky}=\frac{1}{m_{hijk}-1}\sum_{k=1}(y_{hijkl}-\bar{y}_{hijk})^2$$

Note: It has been reported that the geography of some waterbodies was such that every point on the bank tends to be a landing location for the fisherman. Under such situations it is advised to select a location near a fishing village or a cluster of such small units and collect the fishing data as suggested. In such situations the M_{hijk} may be found out from the nearest village by inquiry in order to provide the weights. Rest of the procedure is same.

Attention: The application of these methods have been shown in appendix-2 by analysing the actual data collected in the field under three different groups.

APPENDIX-1

Schedule 1.1 : Resource estimation under ponds and tanks (Units of area upto 10 ha at full tank level) (Group-I)

1. Sample Code : (Leave blank) | 2. State | 3. Stratum No.

4. District : | 5. Tehsil/Taluka :

7. Police Station : | 6. Village :

8. Total No. of water bodies in the village :

9. Total Area (ha) in the village : | 10. Date :

11. Details of water units :

No./ Pond Code	Revenue Record		Physical Observation					Name of Farmer
	Plot No.	Pond area (ha.)	Pond area (ha)	Max. area (ha)	Min. area (ha)	Depth (m)		
						Max.	Min.	
1	2	3	4	5	6	7	8	9

If leased give details		Type Fresh/ Brackish (F/B)	Water Retention (months)	Source of water	Soil type	Extent of Silting	Aquatic (%) weeds
Duration (years)	Rent/ year in Rs.						
10		11	12	13	14	16	17

No./ Pond No.	Ownership Private/ Public	Utilization of water bodies		Culture type Intensive/ Semi Int.	Whether under FFDA (Yes/No)
		Fishery (state type)	If no, give reasons		
	18	19	20	21	22

Inputs used (say Yes/No)			Duration of crops (in months)	Months of fishing	Av. Production (in Kgs.) (By inquiry)	Remarks (if any)
Manure/ Fertilizer	Supplementry Feed	Stocking				
23	24	25	26	27	28	29

Schedule 1.2. Resource inventory of large irrigation tanks, reservoirs, beels and lakes : (Area above 10 ha at full level) (Group II)

1. Sample Code : (Leave blank) | 2. State : | 3. Stratum No.

4. District : | 5. Reference Year :

6. Details of water bodies :

i) Name of water body :

ii) Type : IT | R | B | L

iii) Main purpose : | iv) Source of water :

v) Controlled by : | vi) Seasonality : P | LS | S | SS

vii) Type and Shape (For beels only) : Type | Shape

viii) Area at FRL | Area at MRL

ix) Utilised for fishery : Yes | No

If not used for fishery, give reasons :

x) Fishery exploited by : Individual / Society / Corporation / State

xi) Mode of exploitation : Free/Licencing/Lease/Royalty/Others

xii) If given on lease : Duration (yrs) | Lease amount : (Rs./Yr)

Lease Individual/Society

xiii) Water Retention : From | To

xiv) Choice of sampling units : Landing centre/Fishingvillage/Others

xv) Annual fish production : (in Kgs) (By inquiry)

xvi) Average fishing days per year

7. Inventory details :

S. No.	Fishing village/ Centre	Head of the Household	Family size		Fishing as occupation Full time/Part time/None
			A	C	
1	2	3	4		5

Boats		Gears (No's)					Mode of disposal
No's	Type	Gill	Drag	Cast	Others	Total	
6		7					8

Schedule 1.3 . Resource inventory of rivers and canals, estuaries and lagoons. Group III

1. Sample Code : (Leave blank) 2. Stratum No. 3. Date of sampling: 4. Reference Year:

5. State : 6. District :

7. Name of the Stream : 8. Main/Tributary :

9. Seasonality : P LS S SS 10. Water retention : To

11. Length (Km) : 12. Breadth (m) : Min. Max.

13. Area (ha) : Max. Min. 14. Fishery exploitation : Yes No

15. Exploitation by : Individual/Society/State 16. Mode of exploitation : Free fishing/Licensing/Lease/Auction/Other

17. Choice of sampling units : Landing centre Fishing village Both Others 18. Fishing Period : From To

19. Inventory details :

S. No.	Name of the village	Head of the Household	Family size		Fishing as occupation	Boats		Gears (No's)					Mode disp-osal
			A	C	Full time/Part time/None	No's	Type	Gill	Drag	Cast	Others	Total	
1	2	3	4		5	6		7					8

19. Inventory details : (Contd...)

S. No.	Name of the village	Head of the Household	Family size		Fishing as occupation	Boats		Gears (No's)					Mode disp-osal
			A	C	Full time/Part time/None	No's	Type	Gill	Drag	Cast	Others	Total	
1	2	3	4		5	6		7					8

Schedule 2.1 : Fish Catch Statistics of ponds & tanks (Group I)
(Units upto 10 ha water area at FTL)

1. Sample Code : (Leave blank) 2. Stratum No. 3. State :

4. District : 5. Panchayat/Anchal :

6. Police station : 7. Village : 8. Total Ponds :

9. Total Area : 10. No. harvested during the year :

11. Area harvested : 12. Date :

13. Details of area and production :

(i) Water unit (Fresh/ Brackish)	1 (F / B)	2 (F / B)
(ii) Name of Fish Farmer Whether FFDA pond (Yes/No)		
(iii) Water Area at stocking : (ha)		
(iv) Culture Type : (Intensive/Semi Inten./Non Inten.)		
(v) Water retention (months) :		
(vi) Crop Number : (1/ 2/ 3)		
(vii) Date of Stocking :		
(viii) Species stocked :		
(ix) Number stocked :		
(x) Size stocked (cm) :		
(xi) Source of seed :		
(xii) Date of harvesting :		
(xiii) Culture duration : (months)		

(xv) Production (Kg) :	1 Sporadic	1 Bulk (Inq/obs) **	2 Sporadic	2 Bulk (Inq/obs)
Fish				
Prawn				

(i) Water unit (Fresh/ Brackish)	3 (F / B)	4 (F / B)
(ii) Name of Fish Farmer		
Whether FFDA pond (Yes/No)		
(iii) Water Area at stocking : (ha)		
(iv) Culture Type : (Intensive/Semi Inten./Non Inten.)		
(v) Water retention (months) :		
(vi) Crop Number : (1/ 2/ 3)		
(vii) Date of Stocking :		
(viii) Species stocked :		
(ix) Number stocked :		
(x) Size stocked (cm) :		
(xi) Source of seed :		
(xii) Date of harvesting :		
(xiii) Culture duration : (months)		

(xv) Production (Kg) :	3 (F / B)		4 (F / B)	
	Sporadic	Bulk (Inq/obs)**	Sporadic	Bulk (Inq/obs)
Fish				
Prawn				

Note: Sporadic catches refers to small catches taken out in between stocking and bulk harvesting.
** Inq=Inquiry, obs=Observed.

Schedule 2.2 : Catch assessment survey for reservoirs, lakes, and large irrigation tanks (Area above 10 ha. at full level) (Group II).

1. Sample code : [ ] 2. State: [ ] 3. Reference Year: [ ]

(Leave Blank)

4. District : [ ]

5. Stocking details during the reference year :

6. Name of water body : [ ]

7. Type : [LIT/R/L/B]

8. Name of Landing centre/ Fishing village : [ ]

9. Block/Tehsil/Panchayat : [ ]

	I	II	III
Date :			
Species			
No. stocked			
Size (cm)			
Source			

10. Date of Sampling : [ ]

11. Nets operated :

Type				
No.				

12. Fish catch details from sampled fishing units :

S. No	Nets Observed	Operation time		Total Catch	Species-wise catch (Kgs)				Non - fishing days	
	Type	From	To	In Kgs.	Major Carps	Minor Carps	Cat-fishes	Other	Last month	Current month
1	2	3		4	5				6	7

A(II) - 9

12. Fish catch details from sampled fishing units : (Contd...)

S. No	Nets Observed	Operation time		Total Catch	Species-wise catch (Kgs)				Non - fishing days	
	Type	From	To	In Kgs.	Major Carps	Minor Carps	Cat-fishes	Other	Last month	Current month
1	2	3		4	5				6	7

Note : In case the exploitation in a short time activity during the year.

A(I) - 10

Schedule 2.3 : **Catch assessment survey for rivers, canals, estuaries and lagoons . (Group III).**

1. Sample code : (Leave Blank) 2. State: 3. Stratum No: 4. Year

5. District : 6. Stocking details during the year of sampling (March-Feb) :

7. Date of sampling :

8. Time : From To

9. Name of water body :

10. Type :

11. Name of Landing centre/ Fishing village :

12. Block/Tehsil/Panchayat :

	I	II
Month		
Species		
No. stocked : Size (cm)		
Source		

Nets operated : No.

Type				

13. Fish catch details from sampled fishing units :

S. No	Net Observed Type	Operation time From	To	Tide 1/2/3/4	Total Catch In Kgs.	Species-wise catch (Kgs) Major carps	Minor carps	Cat-fishes	O	Non - fishing days Last month	Current month
1	2	3		4	5	6				7	8

A(I) - 11

13. Fish catch details from sampled fishing units : (Contd...)

S. No	Net Observed Type	Operation time From To	Tide 1/2/3/4	Total Catch In Kgs.	Species-wise catch (Kgs) Major carps	Minor carps	Cat-fishes	O	Non - fishing days Last month	Current month
1	2	3	4	5	6				7	8

APPENDIX-2

Ponds and Tanks - Group I

Exercise 1 :- In a survey programme conducted in a state for estimation of parameters, the following sampling scheme was adopted. A state was divided into three strata each containing a group of contigenous districts. From each stratum, two sample districts were selected at random at the first stage. Five and six clusters of five villages each were selected from the respective sampled districts at the second stage. From each cluster a sample of five ponds was taken for the survey at the third stage. The data are reproduced in the table given below for stratum - I of the state. Estimate the total area, total ponds and total fish production along with their standard errors.

District - I :- Total no. of clusters -349 **District - II** :- Total no. of clusters -751

Cluster	No. of ponds	Total Area (ha)	No. of ponds harvested	Harvested Area (ha)	Cluster	No. of ponds	Total Area (ha)	No. of ponds harvested	Harvested Area (ha)
1	28	11.37	10	4.67	1	25	9.02	9	4.37
2	31	6.52	9	2.39	2	22	10.31	10	6.33
3	23	5.04	7	1.72	3	32	12.36	14	6.79
4	35	15.49	12	6.32	4	37	15.75	15	8.77
5	30	7.36	14	4.72	5	42	20.87	19	8.86
					6	24	9.59	10	4.22

District - I **District - II**

Cluster	Pond no.	Area (ha)	Catch	Cluster	Pond no.	Area (ha)	Catch
1	1	1.00	375	1	1	0.52	300
	2	0.13	135		2	0.17	200
	3	0.01	14		3	0.12	100
	4	0.05	20		4	1.60	343
	5	0.17	40		5	0.15	40
2	1	0.13	20	2	1	0.06	72
	2	0.17	114		2	0.15	115
	3	0.01	7		3	0.27	200
	4	0.03	56		4	0.19	100
	5	0.18	111		5	0.75	600
3	1	0.15	88	3	1	0.42	180
	2	0.08	43		2	0.57	300
	3	0.17	50		3	0.33	200
	4	0.21	105		4	0.06	40
	5	0.37	200		5	0.11	70
4	1	2.00	600	4	1	0.19	130
	2	0.04	60		2	0.21	142
	3	0.04	33		3	0.14	100
	4	0.16	170		4	0.07	60
	5	0.23	160		5	0.05	30
5	1	0.14	30	5	1	0.11	50
	2	0.32	190		2	0.46	250
	3	0.04	70		3	0.36	170
	4	0.12	100		4	0.24	120
	5	0.24	170		5	1.01	900
				6	1	0.02	40
					2	0.09	64
					3	0.17	80
					4	0.21	100
					5	0.36	300

Solution to Exercise -I (a) Estimation of water spread area :-											
Total no. of clusters in the stratum = M_{h0} = 5626 , Total no. of districts in the stratum N_h = 10, Districts selected n_h = 2, $\bar{M}_h$ = 562.6											
District I		M_{hi}=349	m_{hi}=5								
1	2	3	4	5	6	7	8	9	10	11	12
Cluster	No.of Ponds (B_{hij})	Total Area in ha (A_{hij})	$\bar{A}_{hi}$	$w_{hi} = M_{hi}/\bar{M}_h$	$w_{hi}*\bar{A}_{hi}$	$(w_{hi}*\bar{A}_{hi})^2$	$n_h A_h^2$	$(A_{hij}-\bar{A}_{hi})^2$	s_{hwi}^2	w_{hi}^2 * $(1/m_{hi}-1/M_{hi})$	(10) x (11)
1	28	11.37	9.16	0.62	5.68	32.26	264.75	4.88	18.03	0.08	1.37
2	31	6.52						6.97			
3	23	5.04						16.97			
4	35	15.49						40.07			
5	30	7.36						3.24			
Total	147	45.78						72.14			
District II		M_{hi}=751	m_{hi}=6								
1	25	9.02	12.98	1.33	17.33	300.37	264.75	15.68	20.92	0.29	6.12
2	22	10.31						7.13			
3	32	12.36						0.38			
4	37	15.75						7.67			
5	42	20.87						62.25			
6	24	9.59						11.49			
	182	77.9						104.61			
				Sum =	23.01	332.63					7.49
				n_h =	2						
				Mean =	11.51						
				Total =	64755.3						
				s_{hb}^2 =	67.88						
			$(1/n_h-1/N_h)*s_{hb}^2$ =		27.15						
		$1/n_hN_h \Sigma w_{hi}^2(1/m_{hi}-1/M_{hi})s_{hwi}^2$ =			0.37						
				V(A_h) =	27.53						

Solution to Exercise -I (a) Estimation of water spread area harvested :-											
Total no. of clusters in the stratum = M_{h0} = 5626 , Total no. of districts in the stratum N_h = 10 ,Districts selected n_h = 2, M_h = 562.6											
District I		M_{hi}=349	m_{hi}=5								
1	2	3	4	5	6	7	8	9	10	11	12
Cluster	No.of ponds harvested (B'_{hij})	Harvested area (ha) (A'_{hij})	$\overline{A}_{hi}'$	$w_{hi} = M_{hi}/\overline{M}_h$	$w_{hi} * \overline{A}_{hi}'$	$(w_{hi} * \overline{A}_{hi}')^2$	$n_h A_h'^2$	$(A'_{hij} - \overline{A}'_{hi})^2$	s'^2_{hwi}	w_{hi}^2 * $(1/m_{hi} - 1/M_{hi})$	(10) x (11)
1	10	4.67	3.96	0.62	2.46	6.05	62.94	0.50	3.53	0.08	0.27
2	9	2.39						2.46			
3	7	1.72						5.02			
4	12	6.32						5.57			
5	14	4.72						0.58			
Total	52	19.82						14.13			
District II		M_{hi}=751	m_{hi}=6								
	9	4.37	6.56	1.33	8.75	76.60	62.94	4.80	4.11	0.29	1.20
	10	6.33						0.05			
	14	6.79						0.05			
	15	8.77						4.88			
	19	8.86						5.29			
	10	4.22						5.48			
	77	39.34						20.55			
				Sum =	11.21	82.65					1.47
				n_h =	2						
				Mean =	5.61						
				Total =	31561.86						
				s'^2_{hb} =	19.71						
			$(1/n_h - 1/N_h) * s'^2_{hb}$ =		7.88						
		$1/n_h N_h \Sigma w_{hi}^2 (1/m_{hi} - 1/M_{hi}) s^2_{hwi}$ =			0.07						
				$V(A_h)$ =	7.96						

(b) Estimation of number of ponds:-											
Total no. of clusters in the stratum = M_{h0} = 5626 , Total no. of districts in the stratum N_h = 10 .Districts selected $\overline{n_h}$ = 2, M_h = 562.6											
District I		M_{hi}=349	m_{hi}=5								
1	2	3	4	5	6	7	8	9	10	11	12
Cluster	No.of Ponds	Total Area in ha								w_{hi}^2 *	
	(B_{hij})	(A_{hij})	$\overline{B}_{hi}$	$w_{hi} = M_{hi}/\overline{M}_h$	$w_{hi}*\overline{B}_{hi}$	$(w_{hi}*\overline{B}_{hi})^2$	$n_h B_h^2$	$(B_{hij}-\overline{B}_{hi})^2$	s_{hwi}^2	$(1/m_{hi}-1/M_{hi})$	(10) x (11)
1	28	11.37	29.40	0.62	18.24	332.33	1724.02	1.96	19.30	0.08	1.46
2	31	6.52						2.56			
3	23	5.04						40.96			
4	35	15.49						31.36			
5	30	7.36						0.36			
Total	147	45.78						77.20			
District II		M_{hi}=751	m_{hi}=6								
1	25	9.02	30.33	1.33	40.49	1627.32	1724.02	28.41	64.27	0.29	18.93
2	22	10.31						69.39			
3	32	12.36						2.79			
4	37	15.75						44.49			
5	42	20.87						136.19			
6	24	9.59						40.07			
Total	182	77.9						321.33			
				Sum =	**58.73**	**1959.65**					20.40
				n_h =	**2**						
				Mean =	**29.36**						
				Total =	**165179.36**						
				s_{hb}^2 =	**235.63**						
				$(1/n_h-1/N_h)*s_{hb}^2$ =	**94.25**						
				$1/n_hN_h \Sigma w_{hi}^2(1/m_{hi}-1/M_{hi})s_{hwi}^2$ =	**1.02**						
				$V(B_h)$ =	**95.27**						

(b) Estimation of number of ponds harvested :-											
Total no. of clusters in the stratum = M_{h0} = 5626 , Total no. of districts in the stratum N_h = 10 ,Districts selected n_h = 2, M_h = 562.6											
District I		M_{hi}=349	m_{hi}=5								
1	2	3	4	5	6	7	8	9	10	11	12
Cluster	No.of Ponds harvested (B'_{hij})	Harvested area(ha) (A'_{hij})	$\bar{B}_{hi}$	$w_{hi} = M_{hi}/\bar{M}_h$	$w_{hi}*\bar{B}_{hi}$	$(w_{hi}*\bar{B}_{hi})^2$	$n_h B_h^2$	$(B_{hij}-\bar{B}_{hi})^2$	s_{hwi}^2	w_{hi}^2 * $(1/m_{hi}-1/M_{hi})$	(10) x (11)
1	10	4.67	10.40	0.62	6.45	41.60	276.60	0.16	7.3	0.08	0.55
2	9	2.39						1.96			
3	7	1.72						11.56			
4	12	6.32						2.56			
5	14	4.72						12.96			
Total	52	19.82						29.20			
District II		M_{hi}=751	m_{hi}=6								
1	9	4.37	12.83	1.33	17.07	291.38		14.67	14.97	0.29	4.38
2	10	6.33						8.01			
3	14	6.79						1.37			
4	15	8.77						4.71			
5	19	8.86						38.07			
6	10	4.22						8.01			
Total	77	39.34						74.83			
				Sum =	23.52	332.99					4.93
				n_h =	2						
				Mean =	11.76						
				Total =	66161.76						
				s_{hb}^2 =	56.39						
				$(1/n_h-1/N_h)*s_{hb}^2$ =	22.56						
				$1/n_hN_h \Sigma w_{hi}^2(1/m_{hi}-1/M_{hi})s_{hwi}^2$ =	0.25						
				$V(B_h)$ =	22.80						

(c) Estimation of Fish Production :-													
District I		M_{hi} = 349		$\bar{M}_h$ = 562.6	w_{hi} = 0.62								
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cluster	Pond	Area	Catch										
	no.	(ha)	(Kg)					$(x_{hijk} - \bar{x}_{hij})^*$				$(s_{ijy}^2 - 2R_h s_{ijxy} +$	B'^2_{hij} *
		x_{hijk}	y_{hijk}	$(y_{hijk} - \bar{y}_{hij})$	$(y_{hijk} - \bar{y}_{hij})^2$	$(x_{hijk} - \bar{x}_{hij})$	$(x_{hijk} - \bar{x}_{hij})^2$	$(y_{hijk} - \bar{y}_{hij})$	s_{ijxy}	s_{ijy}^2	s_{ijx}^2	$R_h^2 s_{ijx}^2)$	$(1/b'^2_{hij} - 1/B'^2_{hij})$
1	1	1.00	375	258.20	66667.24	0.73	0.53	188.49	60.41	23208.70	0.17	16001.21	10.00
	2	0.13	135	18.20	331.24	-0.14	0.02	-2.55					
	3	0.01	14	-102.80	10567.84	-0.26	0.07	26.73					
	4	0.05	20	-96.80	9370.24	-0.22	0.05	21.30					
	5	0.17	40	-76.80	5898.24	-0.10	0.01	7.68					
Total		1.36	584	0.00	92834.80	0.01	0.68	241.64					
Mean		0.27	116.8										
2	1	0.13	20	-41.60	1730.56	0.03	0.00	-1.25	2.92	2482.30	0.01	1331.73	7.2
	2	0.17	114	52.40	2745.76	0.07	0.00	3.67					
	3	0.01	7	-54.60	2981.16	-0.09	0.01	4.91					
	4	0.03	56	-5.60	31.36	-0.07	0.00	0.39					
	5	0.18	111	49.40	2440.36	0.08	0.01	3.95					
Total		0.52	308	0.00	9929.20	0.02	0.03	11.68					
Mean		0.10	61.60										
3	1	0.15	88	-9.20	84.64	-0.05	0.00	0.46	6.48	3969.70	0.01	473.03	2.8
	2	0.08	43	-54.20	2937.64	-0.12	0.01	6.50					
	3	0.17	50	-47.20	2227.84	-0.03	0.00	1.42					
	4	0.21	105	7.80	60.84	0.01	0.00	0.08					
	5	0.37	200	102.80	10567.84	0.17	0.03	17.48					
Total		0.98	486	0.00	15878.80	-0.02	0.05	25.93					
Mean		0.20	97.20										
4	1	2.00	600	395.40	156341.16	1.43	2.04	565.42	175.15	52470.80	0.66	101721.60	16.8
	2	0.04	60	-144.60	20909.16	-0.53	0.28	76.64					
	3	0.40	33	-171.60	29446.56	-0.17	0.03	29.17					

	4	0.16	170	-34.60	1197.16	-0.41	0.17	14.19					
	5	0.23	160	-44.60	1989.16	-0.34	0.12	15.16					
Total		2.83	1023	0.00	209883.20	-0.02	2.64	700.58					
Mean		0.57	204.6										
5	1	0.14	30	-82.00	6724.00	-0.03	0.00	2.46	6.07	841.00	0.01	-2025.14	25.2
	2	0.32	190	78.00	6084.00	0.15	0.02	11.70					
	3	0.04	70	-42.00	1764.00	-0.13	0.02	5.46					
	4	0.12	100	-12.00	144.00	-0.05	0.00	0.60					
	5	0.24	170	58.00	3364.00	0.07	0.00	4.06					
Total		0.86	560	0.00	18080.00	0.01	0.05	24.28					
Mean		0.17	112										
District II		M_{hi} =751		$\bar{M}_h$ = 562.6	w_{hi} = 1.33								
Cluster	Pond	Area	Catch										
	No	(ha)						$(x_{hijk} - \bar{x}_{hij})^*$					
		x_{hijk}	y_{hijk}	$(y_{hijk} - \bar{y}_{hij})$	$(y_{hijk} - \bar{y}_{hij})^2$	$(x_{hijk} - \bar{x}_{hij})$	$(x_{hijk} - \bar{x}_{hij})^2$	$(y_{hijk} - \bar{y}_{hij})$	s_{ijxy}^2	s_{ijy}^2	s_{ijy}^2		
1	1	0.52	300	103.40	10691.56	0.01	0.00	1.03	63.38	16497.80	0.40	100246.02	7.2
	2	0.17	200	3.40	11.56	-0.34	0.12	-1.16					
	3	0.12	100	-96.60	9331.56	-0.39	0.15	37.67					
	4	1.6	343	146.40	21432.96	1.09	1.19	159.58					
	5	0.15	40	-156.60	24523.56	-0.36	0.13	56.38					
Total		2.56	983	0.00	65991.20	0.01	1.59	253.50					
Mean		0.51	196.6										
2	1	0.06	72	-145.40	21141.16	-0.22	0.05	31.99	58.97	48023.80	0.07	2527.43	10
	2	0.15	115	-102.40	10485.76	-0.13	0.02	13.31					
	3	0.27	200	-17.40	302.76	-0.01	0.00	0.17					
	4	0.19	100	-117.40	13782.76	-0.09	0.01	10.57					
	5	0.75	600	382.60	146382.76	0.47	0.22	179.82					
Total		1.42	1087	0.00	192095.20	0.02	0.29	235.86					
Mean		0.28	217.4										

3	1	0.42	180	22.00	484.00	0.12	0.01	2.64	21.82	11020.00	0.05	1812.70	25.2
	2	0.57	300	142.00	20164.00	0.27	0.07	38.34					
	3	0.33	200	42.00	1764.00	0.03	0.00	1.26					
	4	0.06	40	-118.00	13924.00	-0.24	0.06	28.32					
	5	0.11	70	-88.00	7744.00	-0.19	0.04	16.72					
Total		1.49	790	0.00	44080.00	-0.01	0.18	87.28					
Mean		0.30	158										
4	1	0.19	130	37.60	1413.76	0.06	0.00	2.26	3.31	2218.80	0.01	37.13	30
	2	0.21	142	49.60	2460.16	0.08	0.01	3.97					
	3	0.14	100	7.60	57.76	0.01	0.00	0.08					
	4	0.07	60	-32.40	1049.76	-0.06	0.00	1.94					
	5	0.05	30	-62.40	3893.76	-0.08	0.01	4.99					
Total		0.66	462	0.00	8875.20	0.01	0.02	13.24					
Mean		0.13	92.4										
5	1	0.11	50	-248.00	61504.00	-0.13	0.02	32.24	-33.04	229575.00	0.03	286151.52	53.2
	2	0.46	250	-48.00	2304.00	0.22	0.05	-10.56					
	3	0.36	170	-128.00	16384.00	0.12	0.01	-15.36					
	4	0.24	120	-178.00	31684.00	0	0.00	0.00					
	5	0.01	900	602.00	362404.00	-0.23	0.05	-138.46					
Total		1.18	1490	0.00	474280.00	-0.02	0.13	-132.14					
Mean		0.24	298										
6	1	0.02	40	-76.80	5898.24	-0.15	0.02	11.52	12.47	28024.00	0.02	18859.09	10
	2	0.09	64	-52.80	2787.84	-0.08	0.01	4.22					
	3	0.17	80	-36.80	1354.24	0.00	0.00	0.00					
	4	0.21	100	-16.80	282.24	0.04	0.00	-0.67					
	5	0.36	300	183.20	33562.24	0.19	0.04	34.81					
Total		0.85	584	0.00	43884.80	0.00	0.07	49.88					
Mean		0.17	116.8										

(c) Estimation of Fish Production :-									
District I		M_{hi} = 349	w_{hi} = 0.62	$\bar{M}_h$ = 562.6					
1	2	3	4	5	6	7	8	9	10
Cluster	No.of ponds harvested								$(w_{hi}Y_{hi} - Y_h)$*
	B'_{hij}	$\bar{x}_{hij}$	$B'_{hij} * \bar{x}_{hij}$	$(B'_{hij} * \bar{x}_{hij} - X_{hi})$	$(B'_{hij} * \bar{x}_{hij} - X_{hi})^2$	$w_{hi} X_{hi}$	$(w_{hi} X_{hi} - X_h)$	$(w_{hi} X_{hi} - X_h$	$(w_{hi}X_{hi} - X_h)$
1	10	0.27	2.72	-0.13	0.02	1.77	-1.31	1.73	-1576.34
2	9	0.10	0.94	-1.91	3.66				
3	7	0.20	1.37	-1.48	2.18				
4	12	0.57	6.79	3.94	15.54				
5	14	0.17	2.41	-0.44	0.20				
Total	**52**		**14.23**		**21.60**				
Mean			**2.85**						
District II		M_{hi} = 751	w_{hi} =1.33	$\bar{M}_h$ = 562.6					
1	9	0.51	4.61	1.31	1.71	4.40	1.32	1.75	1576.34
2	10	0.28	2.84	-0.46	0.21				
3	14	0.30	4.17	0.87	0.76				
4	15	0.13	1.98	-1.32	1.74				
5	19	0.24	4.48	1.18	1.40				
6	10	0.17	1.70	-1.60	2.56				
Total	77		**19.78**	**0.57**	**8.39**				
Mean			**3.30**						
Overall Total						**6.17**		**3.48**	
Overall Mean						**3.08**			

11	12	13	14
$(B'_{hij} * \bar{y}_{hij} - Y_{hi})*$			
$(B'_{hij} * \bar{x}_{hij} - X_{hi})$	s_{ix}^2	s_{ixy}	$(s_{iy}^2 - 2*R_h*s_{ixy}+R_h^2 s_{ix}^2)$
15.24	5.40	1698.76	651402.12
1398.75			
893.89			
4612.14			
-125.00			
6795.02			
-818.59	1.68	1257.40	1810451.80
101.77			
-159.78			
1332.18			
3867.86			
1963.57			
6287.01			
	7.08	**2956.16**	

					s_{bx}^2 =		3.48		
					R =		646.58		
					s_{bxy}^2 =		3152.69		
				$(1/n_h-1/N_h)(s_{by}^2 - 2R_h s_{bxy}^2+R_h^2 s_{bx}^2)$ =			92075.19		
		$1/(n_h*N_h)\ \Sigma\ w_{hi}^2(1/m_{hi}-1/M_{hi})(s_{iy}^2 -2R_h s_{ixy}^2+R_h^2 s_{ix}^2)$ =					28857.16		
$1/(n_h*N_h)\ \Sigma\ (w_{hi}^2/m_{hi}*M_{hi})\ \Sigma\ B'^2_{hij}(1/b_{hij}-1/B'_{hij})(s_{ijy}^2 -2R_h s_{ijxy}^2+R_h^2 s_{ijx}^2)$ =								342.40		
				$v(Y_{hR})$ =			121274.75		

(c) Estimation of Fish Production :-									
District I		M_{hi} = 349	w_{hi} = 0.62	$\bar{M}_h$ = 562.6					
1	2	3	4	5	6	7	8	9	10
Cluster	No.of ponds harvested	Catch/pond							
	B'_{hij}	$\bar{y}_{hij}$	$B'_{hij} * \bar{y}_{hij}$	$(B'_{hij} * \bar{y}_{hij} - y_{hi})$	$(B'_{hij} * \bar{y}_{hij} - y_{hi})^2$	$w_{hi} Y_{hi}$	$(w_{hi} Y_{hi} - Y_h)$	$(w_{hi} Y_{hi} - Y_h)^2$	s_{iy}^2
1	10	116.80	1168.00	-117.20	13735.84	797.25	-1194.21	1426137.52	590615.84
2	9	61.60	554.40	-730.80	534068.64				
3	7	97.20	680.40	-604.80	365783.04				
4	12	204.60	2455.20	1170.00	1368900.00				
5	14	112.00	1568.00	282.80	79975.84				
Total	**52**		**6426.00**		**2362463.36**				
Mean			**1285.20**						
District II		M_{hi} = 751	w_{hi} =1.33	$\bar{M}_h$ = 562.6					
1	9	196.60	1769.40	-625.83	391663.19	3185.66	1194.20	1426114.44	2734120.81
2	10	217.40	2174.00	-221.23	48942.71				
3	14	158.00	2212.00	-183.23	33573.23				
4	15	92.40	1386.00	-1009.23	1018545.19				
5	19	298.00	5662.00	3266.77	10671786.23				
6	10	116.80	1168.00	-1227.23	1506093.47				
Total	**77.00**		**14371.40**		**13670604.03**				
Mean			**2395.23**						
Overall Total						**3982.91**		**2852251.96**	
Overall Mean						**1991.46**			
	District	$w_{hi}^2(1/m_{hi}-1/M_{hi})$		$w_{hi}^2/m_{hi}M_{hi}$	$\Sigma B'^2_{hij}(1/b_{hij} -1/B'_{hij})$		$(s_{iy}^2-2R_h s_{ixy}+R_h^2 s_{ix}^2)$		
					$(s_{ijy}^2-2R_h s_{ijxy}+R_h^2 s_{ijx}^2)$				
	1	0.08		0.0002	1828814.35		651402.12		
	2	0.29		0.0004	16205691.38		1810451.80		

				s_{by}^2 =	2852251.96				
				$(1/n_h - 1/N_h)*s_{by}^2$ =	1140900.78				
			$1/(n_h*N_h)\ \Sigma\ w_{hi}^2\ (1/m_{hi}-1/M_{hi})\ s_{iy}^2$ =		42007.22				
		$1/(N_h*n_h)\ \Sigma\ w_{hi}^2/M_{hi}\ m_{hi}\ \Sigma\ B'^2_{hij}\ (1/b_{hij} - 1/B'_{hij})\ s_{ijy}^2$ =				280.38			
				$v(Y_h)$ =	1183188.38				
		Estimate of the total yield = Y_h =			11203936.52				
		in the h-th stratum							
			R (Ratio Estimate) =		646.58				
	Estimate of total yield in stratum is = (Y_{hR}) = $R*A'_h$ =				20407201.86				
Similarly, the estimate of variance can also be calculated for the above estimate by the formula given in equation (28)									

Reservoirs and Large Irrigation Tanks - Group - II

Exercise : 2(a) Fish catch data collected on sampling days at the landing centre located around a medium reservoir is presented below. Estimate the total fish production for the month from this water body assuming that it has only one landing centre and the total fishing days observed in the water body during the month is 24.

	1st gear			2nd gear		
Date	No.of units observed (m_{hijkl})	Catch from the units (Σy_{hijklm})	No.of units operated on the days (M_{hijkl})	No.of units observed (m_{hijkl})	Catch from the units (Σy_{hijklm})	No.of units operated on the days (M_{hijkl})
5.10.96	5	56	16	4	39	12
12.10.96	6	42	21	7	51	15
19.10.96	4	50	12	5	34	14
26.10.96	5	45	18	6	41	16

Exercise : 2(b) Given below are the fish catch details of selected reservoirs/lakes in Rajasthan under Group II category. While selection of these water bodies, the state has been divided into three strata each having 4443 ha, 51047 ha and 19731 ha of water area under the category of 10-500 ha class. A sample of 8,10 and 8 waterbodies of this category have been taken from three strata respectively. Estimate the total fish production for the state by applying the suggested methodology under group - II.

Stratum I Total area (10 to 500 ha) = 4443 ha

Name of the waterbody	Area(ha)	Catch (kg)
1. Onda (Sirohi)	80	16450
2. Tokra (Sirohi)	90	7810
3. Hemawas (Pali)	105	53255
4. Muthana (Pali)	42	16551
5. Sindhara (Pali)	51	4036
6.GhagarDepression No.8 (Hanumangarh)	200	32778
7.GhagarDepression No.4 (Hanumangarh)	100	62688
8.Bandh Pichak (Jodhpur)	50	3885

Stratum II Total area (10 to 500 ha) = 51047 ha

Name of the waterbody	Area(ha)	Catch (kg)
1. Fatch Sagar (Udaipur)	179	17515
2. Udai Sagar (Udaipur)	345	97295
3. Harchand (Udaipur)	55	41410
4. Ayani (Kota)	65	0
5. Kothari Dam (Bhilwara)	75	53054
6. Khari Dam (Bhilwara)	200	0
7. Govata Dam (Bhilwara)	500	0
8. Borda (Chittorgarh)	350	8246
9.Ramakheda (Chittorgarh)	100	11000
10. Murli (Chittorgarh)	60	658

Stratum III Total area (10 to 500 ha) = 19731 ha

Name of the waterbody	Area(ha)	Catch (kg)
1. Paiwala Pura (Bundi)	410	0
2. Bhimlat (Bundi)	250	1000
3. Pech Ki Bawri (Bundi)	78	18260
4. Urmila Sagar (Dholpur)	310	15987
5. Talab Sahi (Dholpur)	140	8685
6. Bandh Mui (S.M.Pur)	105	0
7.Bandh Pachna (S.M.Pur)	475	0
8.BandhManchari(S.M.Pur)	85	0

Solution to Exercise: 2(a) Estimation of monthly fish production D_{hijk} = 24

Ist Gear

1	2	3	4	5	6	7
Date	No.of units observed	Catch from the units observed (Kg)	Catch per unit effort	No.of units operated on the day	Catch on the day	Total estimated catch
	(m_{hijkl})	(Σy_{hijklm})	y_{hijkl}	M_{hijkl}	(4) x (5)	$D_{hijk}\ \bar{y}_{hijk}$
5.10.96	5	56	11.2	16	179.2	3829.20
12.10.96	6	42	7.0	21	147.0	
19.10.96	4	50	12.5	12	150.0	
26.10.96	5	45	9.0	18	162.0	
Total					638.2	
Average				$\bar{y}_{hijk}$ =	159.55	

2nd Gear

1	2	3	4	5	6	7
Date	No.of units observed	Catch from the units observed (Kg)	Catch per unit effort	No.of units operated on the day	Catch on the day	Total estimated catch
	(m_{hijkl})	(Σy_{hijklm})	y_{hijkl}	M_{hijkl}	4 x 5	$D_{hijk}\ \bar{y}_{hijk}$
5.10.96	4	39	9.75	12	117.0	2584.20
12.10.96	7	51	7.28	15	109.2	
19.10.96	5	34	6.80	14	95.2	
26.10.96	6	41	6.83	16	109.3	
Total					430.7	
Average				$\bar{y}_{hijk}$ =	107.68	
		Total monthly catch of the centre = y_{hij} =				**6413.40**

2(b) : Estimation of fish production at the state level.				
Stratum I Total area (10 to 500 ha) = 4443 ha				
Name of the waterbody	Area(ha)	Catch (kg)	Catch/ha	Total production
	x_{hij}	y_{hij}	R_{hi}	y_{Rhi}
1. Onda (Sirohi)	80	16450	275.004	1221843.56
2. Tokra (Sirohi)	90	7810		
3. Hemawas (Pali)	105	53255		
4. Muthana (Pali)	42	16551		
5. Sindhara (Pali)	51	4036		
6. Ghagar Depression No.8 (Hanumangarh)	200	32778		
7. Ghagar Depression No.4 (Hanumangarh)	100	62688		
8. Bandh Pichak (Jodhpur)	50	3885		
Total	718	197453		
Mean	89.75	24681.63		
Stratum II Total area (10 to 500 ha) = 51047 ha				
Name of the waterbody	Area(ha)	Catch (kg)	Catch/ha	Total production
	x_{hij}	y_{hij}	R_{hi}	y_{Rhi}
1. Fatch Sagar (Udaipur)	179	17515	118.81	6064722.33
2. Udai Sagar (Udaipur)	345	97295		
3. Harchand (Udaipur)	55	41410		
4. Ayani (Kota)	65	0		
5. Kothari Dam (Bhilwara)	75	53054		
6. Khari Dam (Bhilwara)	200	0		
7. Govata Dam (Bhilwara)	500	0		
8. Borda (Chittorgarh)	350	8246		
9. Ramakheda (Chittorgarh)	100	11000		
10. Murli (Chittorgarh)	60	658		
Total	1929	229178		
Mean	192.90	22917.80		
Stratum III Total area (10 to 500 ha) = 19731 ha				
Name of the waterbody	Area(ha)	Catch (kg)	Catch/ha	Total production
	x_{hij}	y_{hij}	R_{hi}	y_{Rhi}
1. Paiwala Pura (Bundi)	410	0	23.71	467794.01
2. Bhimlat (Bundi)	250	1000		
3. Pech Ki Bawri (Bundi)	78	18260		
4. Urmila Sagar (Dholpur)	310	15987		
5. Talab Sahi (Dholpur)	140	8685		
6. Bandh Mui (S.M.Pur)	105	0		
7. Bandh Pachna (S.M.Pur)	475	0		
8. Bandh Manchari (S.M.Pur)	85	0		
Total	1853	43932		
Mean	231.63	5491.50		
Total Production for i-th sub group (10-500 ha) category for the state = Σy_{Rhi} =				**7754359.90**

Exercise 3 : Fish catch data collection at twelve sampling centres located in and around upper hooghly estuary during the month of July 1996 are presented below. (Mitra.P. Personal communication). The total number of centres in this selected stretch is 20. Estimate the fish production in this selected stretch and also calculate the estimated variance of the estimate as per the estimation procedure described.

		$N_h = 20$		$n_h = 12$								
Name of the Centre	Name of the Gear	Date of Observation	No.of nets operated	No. of nets observed	No.of net tide operated	No.of net tide observed	Catch (kg)					
					M_{hijk}	m_{hijk}	Σy_{hijkl}	$\bar{y}_{hijk}$	$M_{hijk} * \bar{y}_{hijk}$	$\bar{y}_{hij}$	$\bar{y}_{hij} * D_{hij}$	s_{ijy}^2
Medgachi	Chandi	3/7/96	4	4	8	4	1.65	0.41	3.30	4.71	146.01	5.27
		11/7/96	4	2	8	2	1.3	0.65	5.20			
		19/7/96	3	3	6	3	1.3	0.43	2.60			
		30/7/96	4	3	8	3	2.9	0.97	7.73			
			15	12	30	12	7.15	2.46	18.83			
	Sanglo	3/7/96	3	3	6	3	0.60	0.20	1.20	3.10	96.10	2.50
		11/7/96	4	4	8	4	1.25	0.31	2.50			
		19/7/96	4	4	8	4	1.95	0.49	3.90			
		30/7/96	4	3	8	3	1.80	0.60	4.80			
			15	14	30	14	5.60	1.60	12.40			
	Scitki	3/7/96	2	2	4	4	0.90	0.23	0.90	1.32	40.92	0.38
		11/7/96	2	2	2	2	0.85	0.43	0.85			
		19/7/96	3	2	6	4	1.45	0.36	2.18			
		30/7/96	3	2	6	4	0.90	0.23	1.35			
			10	8	18	14	4.10	1.24	5.28			
	Bitti	3/7/96	150	10	600	20	1.45	0.07	43.50	29.91	927.21	142.12
		11/7/96	200	12	600	24	1.20	0.05	30.00			
		19/7/96	150	14	300	28	1.35	0.05	14.46			

		30/7/96	200	12	400	24	1.90	0.08	31.67			
			700	48	1900	96	5.90	0.25	119.63			
											1210.24	
Batagarh	Dholi	2/7/96	10	4	20	4	2.2	0.55	11.00	11.86	367.66	23.19
		10/7/96	12	5	24	5	3.9	0.78	18.72			
		18/7/96	10	4	20	4	1.5	0.38	7.50			
		27/7/96	12	4	24	4	1.7	0.43	10.20			
			44	17	88	17	9.30	2.13	47.42			
	Chandi	2/7/96	4	3	8	3	1.80	0.60	4.80	5.50	170.50	5.35
		10/7/96	4	3	8	3	3.30	1.10	8.80			
		18/7/96	4	4	8	4	1.70	0.43	3.40			
		27/7/96	4	4	8	4	2.50	0.63	5.00			
			16	14	32	14	9.30	2.75	22.00			
	Kona	2/7/96	3	2	6	2	2.75	1.38	8.25	10.01	310.31	38.38
		10/7/96	3	2	6	2	6.40	3.20	19.20			
		18/7/96	3	2	6	2	2.05	1.03	6.15			
		27/7/96	3	2	6	2	2.15	1.08	6.45			
			12	8	24	8	13.35	6.68	40.05			
	Sanglo	2/7/96	4	3	8	3	1.15	0.38	3.07	2.51	77.81	0.21
		10/7/96	4	4	8	4	1.15	0.29	2.30			
		18/7/96	5	3	10	3	0.6	0.20	2.00			
		27/7/96	5	3	10	3	0.8	0.27	2.67			
			18	13	36	13	3.70	1.14	10.03			
	Thopa	2/7/96	7	4	14	8	2.35	0.29	4.11	3.00	93.00	2.72
		10/7/96	8	4	16	8	2.35	0.29	4.70			
		18/7/96	3	3	6	6	1.45	0.24	1.45			
		27/7/96	3	2	6	4	1.15	0.29	1.73			

			21	13	42	26	7.30	1.12	11.99			
											1019.28	
Hooghly	Chandi	6/7/96	10	4	20	4	3.10	0.78	15.50	21.84	677.04	23.24
ghat		12/7/96	10	4	20	4	4.15	1.04	20.75			
		19/7/96	10	4	20	4	5.00	1.25	25.00			
		27/7/96	11	4	22	4	4.75	1.19	26.13			
			41	16	82	16	17.00	4.25	87.38			
	Sanglo	6/7/96	18	6	36	6	3.50	0.58	21.00	23.41	725.71	24.38
		12/7/96	21	6	42	6	3.55	0.59	24.85			
		19/7/96	21	6	42	6	2.60	0.43	18.20			
		27/7/96	25	6	50	6	3.55	0.59	29.58			
			85	24	170	24	13.20	2.20	93.63			
	Charpata	6/7/96	4	3	8	6	8.40	1.40	11.20	12.30	381.30	5.43
		12/7/96	3	3	6	6	9.55	1.59	9.55			
		19/7/96	4	3	8	6	10.80	1.80	14.40			
		27/7/96	4	3	8	6	10.55	1.76	14.07			
			15	12	30	24	39.30	6.55	49.22			
	Thopa	6/7/96	8	4	16	8	2.3	0.29	4.60	3.16	97.96	1.05
		12/7/96	7	4	14	8	1.75	0.22	3.06			
		19/7/96	4	4	8	8	2.2	0.28	2.20			
		27/7/96	6	4	12	8	1.85	0.23	2.78			
			25	16	50	32	8.10	1.01	12.64			
											1882.01	
Nawabganj	Sanglo	4/7/96	15	6	30	6	1.40	0.23	7.00	24.22	750.82	414.34
		12/7/96	20	3	40	3	0.50	0.17	6.67			
		20/7/96	35	7	70	7	3.75	0.54	37.50			
		30/7/96	40	7	80	7	4.00	0.57	45.71			
			110	23	220	23	9.65	1.51	96.88			

	Dholi	4/7/96	5	3	10	3	2.10	0.70	7.00	8.88	275.28	23.01
		12/7/96	5	3	10	3	0.95	0.32	3.17			
		20/7/96	5	4	10	4	4.50	1.13	11.25			
		30/7/96	4	4	8	4	7.05	1.76	14.10			
			19	14	38	14	14.60	3.90	35.52			
	Charpata	12/7/96	2	2	4	4	4.125	1.03	4.13	10.51	325.81	130.82
		20/7/96	4	3	8	6	10.4	1.73	13.87			
		30/7/96	4	3	8	6	10.15	1.69	13.53			
			10	8	20	16	24.68	4.46	31.53			
	Nangar	12/7/96	3	2	6	2	2.05	1.03	6.15	6.15	190.65	
											1542.56	
Konnagar	Khuti	4/7/96	2	2	4	2	1.00	0.50	2.00	2.10	65.10	0.03
		12/7/96	2	2	4	2	1.15	0.58	2.30			
		18/7/96	2	2	4	2	1.10	0.55	2.20			
		26/7/96	2	2	4	2	0.95	0.48	1.90			
			8	8	16	8	4.20	2.10	8.40			
	Sanglo	4/7/96	3	3	6	3	1.25	0.42	2.50	2.90	89.90	1.23
		12/7/96	3	3	6	3	0.80	0.27	1.60			
		18/7/96	3	3	6	3	1.65	0.55	3.30			
		26/7/96	3	3	6	3	2.10	0.70	4.20			
			12	12	24	12	5.80	1.93	11.60			
											155.00	
Baranagar	Chandi	3/7/96	14	5	28	5	5.40	1.08	30.24	31.55	978.05	4.94
		11/7/96	15	5	30	5	5.60	1.12	33.60			
		20/7/96	15	5	30	5	4.85	0.97	29.10			
		27/7/96	14	4	28	4	4.75	1.19	33.25			
			58	19	116	19	20.60	4.36	126.19		**978.05**	

Godakhali	Chandi	2/7/96	40	5	80	5	6.25	1.25	100.00	85.50	2650.50	387.67
		10/7/96	50	5	100	5	5.10	1.02	102.00			
		17/7/96	50	5	100	5	3.00	0.60	60.00			
		26/7/96	50	6	100	6	4.80	0.80	80.00			
			190	21	380	21	19.15	3.67	342.00			
	Dholi	2/7/96	6	3	12	3	8.40	2.80	33.60	28.36	879.16	27.33
		10/7/96	5	3	10	3	6.35	2.12	21.17			
		17/7/96	5	3	10	3	8.60	2.87	28.67			
		26/7/96	4	2	8	2	7.50	3.75	30.00			
			20	11	40	11	30.85	11.53	113.43		3529.66	
Nurpur	Chandi	4/7/96	3	3	6	3	0.80	0.27	1.60	9.84	305.04	90.67
		20/7/96	10	3	20	3	1.15	0.38	7.67			
		30/7/96	16	6	32	6	3.80	0.63	20.27			
			29	12	58	12	5.75	1.28	29.53			
	Bhola	4/7/96	3	2	6	2	4.60	2.30	13.80	28.67	888.77	211.74
		20/7/96	5	3	10	3	8.80	2.93	29.33			
		30/7/96	8	5	16	5	13.40	2.68	42.88			
			16	10	32	10	26.8	7.91	86.01			
	Been	4/7/96	6	4	12	4	15.5	3.88	46.50	81.3	2518.75	2415.13
		20/7/96	16	4	32	4	14.5	3.63	116.00			
			22	8	44	8	30.00	7.50	162.50		3712.56	
Uluberia	Been	3/7/96	2	2	4	2	11.00	5.50	22.00	21.10	654.10	1.62
		12/7/96	2	2	4	2	10.10	5.05	20.20			
			4	4	8	4	21.10	10.55	42.20			

	Thor	3/7/96	6	6	12	6	4.90	0.82	9.80	10.80	334.80	1.00
		12/7/96	6	6	12	6	5.40	0.90	10.80			
		20/7/96	6	6	12	6	5.90	0.98	11.80			
			18	18	36	18	16.2	2.70	32.40			
	Pata	3/7/96	1	1	2	2	1.40	0.70	1.40	1.57	48.67	0.14
		12/7/96	1	1	2	2	1.30	0.65	1.30			
		20/7/96	1	1	2	2	2.00	1.00	2.00			
			3	3	6	6	4.70	2.35	4.70			
	Hooks	3/7/96	1	1	2	1	5.10	5.10	10.20	6.53	202.43	10.33
		12/7/96	1	1	2	2	4.20	2.10	4.20			
		20/7/96	1	1	2	2	5.20	2.60	5.20			
			3	3	6	5	14.50	9.80	19.60			
	Chandi	3/7/96	6	6	12	6	2.30	0.38	4.60	7.40	229.40	8.44
		12/7/96	8	8	16	8	5.20	0.65	10.40			
		20/7/96	8	8	16	8	3.60	0.45	7.20			
			22	22	44	22	11.10	1.48	22.20			
	Veshali	12/7/96	1	1	2	2	8.20	4.10	8.20	6.65	206.15	4.81
		20/7/96	1	1	2	2	5.10	2.55	5.10			
			2	2	4	4	13.30	6.65	13.30			
											1675.55	
Gobinda	Been	2/7/96	3	3	6	3	5.50	1.83	11.00	12.70	393.70	5.78
		15/7/96	2	2	4	2	7.20	3.60	14.40			
			5	5	10	5	12.70	5.43	25.40			
	Pata	2/7/96	1	1	2	2	1.1	0.55	1.10	1.10	34.10	

	Chandi	2/7/96	6	6	12	6	1.2	0.20	2.40	3.60	111.60	2.88
		22/7/96	7	7	14	7	2.4	0.34	4.80			
			13	13	26	13	3.60	0.54	7.20			
											539.40	
Kalaghat	Been	6/7/96	10	5	20	5	17.00	3.40	68.00	92.20	2858.20	1171.28
		16/7/96	10	5	20	5	29.10	5.82	116.40			
			20	10	40	10	46.10	9.22	184.40			
											2858.20	
Denan	Been	6/7/96	6	4	12	4	8.60	2.15	25.80	28.23	875.13	11.84
		16/7/96	4	3	8	3	11.50	3.83	30.67			
			10	7	20	7	20.10	5.98	56.47			
	Chandi	6/7/96	20	20	40	20	9.20	0.46	18.40	16.20	502.20	9.68
		16/7/96	20	20	40	20	7.00	0.35	14.00			
			40	40	80	40	16.20	0.81	32.40			
	Pata	6/7/96	1	1	2	2	1.3	0.65	1.30	1.30	40.30	
											1417.63	
											20520.14	
										$\bar{\bar{Y}}_h$ =	1654.85	
										$\bar{Y}_h$ =	33097.00	
								$(1/n_h - 1/N_h) * s_{by}^2$ =			198819.1	
						$1/(n_h * N_h) \Sigma\Sigma D_{hij}^2 (1/d_{hij} - 1/D_{hij}) s_{ijy}^2$ =					7770.429	
			Third stage variance has not been calculated due to want of data									
									Est $V(\bar{Y}_h)$ =		206589.53	
									S.E $(V(\bar{Y}_h))$ =		454.52	