**Course code: SFM 603** **Research note prepared byYPT**
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## UNIT 1: Meaning and Philosophy of research

**Research**: Research means to search or investigation the problem again and again to find out something more about the phenomena. The first glance may not always be adequate. It may be prone to the error. Therefore, we look into the phenomena again and again and study the problem differently and thoroughly each time. Research therefore is an on-going and ever going activity.

In other word, Research is a human activity based on intellectual investigation and aimed at discovering, interpreting, and revising human knowledge on different aspects of the world.

Some views research in terms of theoretical knowledge, others view it as application of knowledge.

**Definitions**:

- It is a formal, systematic and intensive process of scientific method. __ John W.Best
- It is systematic, controlled, empirical & critical investigation. ___Kerlinger
- It is a structured problem solving, disciplined inquiry and discovery, reinforcement or refinement of knowledge.

In general, Research is a systematic careful inquiry or examination done to discover new information or relationship and to expand, verify existing knowledge for some specific purpose. The specific purpose may be academic (i.e. a problem of theory) or applied (i.e. problem of practice) or both.

### Research methods and Research methodology

**Research methods** are those methods or techniques which are used by the researcher to perform research operations. Generally, the methods of data collection (questionnaire, interviews etc.) and data analysis (qualitative and quantitative analysis) are used by the researcher during the course of studying his/her research problems.

A **Research methodology** is a system of explicit rules and procedures upon which research is based. Research methodology is a systematic and an organized way to solve the research problems. It may be understood as a science of studying how research is conducted scientifically. It studies the steps adopted by a researcher in studying his/her research problem along with the logic behind them. Research methodology explains why particular methods are used & why the others are not used & the logic behind the selection of those particular methods.

On the whole, research methodology outlines the systematic path towards solving the research problems by the way answering the following questions:

- Why a research study has been undertaken?
- How the research problem has been defined?
- In what way & why the hypothesis has been formulated?
- What data have been collected?
- Which particular method of data collection has been adopted& why?
- Why a particular technique of data analysis has been used?

A large numbers of similar other questions are usually answered in research methodology concerning a research problem.

Thus, from the above definitions of research methods & research methodology, we can say that research methodology has many dimensions & research methods do constitute a part of the research methodology or research method is the subset of research methodology. The scope of research methodology is wider than that of research methods.

**End sought or aim of research**

In general, aims of research are:

- Discover new information or relationships, to expand & to verify knowledge.
- Gathers new knowledge; discovers new principle.
- Increases our power to understand, predict and control/manage outcome.
- Ultimate purpose of research is the formulation of theories. As kerlinger puts: "End sought by science is theory".

**Characteristics of research**

Research involves gathering new data or using existing data for a new purpose.
Research is directed toward the solution of a problem.
It is systematic, carefully designed & replicable.
Research places emphasis upon the development of sound theories or upon the discovery of general principles.
Research requires expertise. The researcher knows what is already known about the problem under investigation.
Research involves accurate observation & description.
Research is logical, objective and attempts to minimize bias.
It is carefully recorded and reported.

**Methods of knowing**

To know about the research as a scientific method, first of all, we have to understand four methods of knowing.

1. **The method of tenacity**

In this method, people know some thing to be true simply because a lot of people fervently say or believe it to be true. The more it is so the more valid the truth becomes. This means that frequent repetition of such``truths'' seems to enhance their validity.

2. **The method of Authority**

If well respected or authoritative sources say that something is so, then it must be so. The Bible & Geeta are some of such sources. This is the method of established belief. We must take a large body of facts and information on the basis of authority.

3. **The method of Intuition**

This is based on the notion that people will reach to the truth because their natural inclination will be to do so. It is based on the notion that intuition proposition should agree with reasons & not necessarily with experiences.

4. **The method of science**

In this method, the ultimate conclusion of every man will be same. This method deals with real things whose characteristics are entirely independent of our opinions about them. Personal beliefs, perceptions, biases, values, attitudes and emotions have no place in this method.

**Characteristics of scientific method**

- **Verifiability**: This means that the conclusion drawn through a scientific method is subjected (focused) to verification at any time.
- **Generality**: The law derived through scientific methods is not limited to individuals & useful for universe as a generalization form.

- **Predictability**: The results obtained from scientific methods can be further predicted with sufficient accuracy.
- **Objectivity**: The results obtained from a scientific method must be subjected to objective observation. The main criterion of objectivity is that all persons come to the same conclusion about phenomenon.
- **System**: In every scientific study, there is an accepted mode of investigation. The result arrived by means of a haphazard method, even true, cannot be called scientific because its accuracy is purely accidental.

## Types of research:

On the categorization of science, Bio-physical and social sciences research differs from each other in the following respects:

| | **Bio-physical research** | | **Social science research** |
|---|---|---|---|
| 1. | Bio physical searches for biophysical laws in natural phenomena. | 1. | Social sciences investigate laws related to human or it's social behaviors. |
| 2 | The basic elements of it can be separated by analysis. | 2 | The basic elements of it cannot be separated analytically. |
| 3 | It possesses greater exactness. | 3 | Being related to the study of society, it can make less exactness. |
| 4 | It can make more prediction due to a higher degree of exactness | 4 | Because of it lesser exactness, it can make comparately fewer predictions. |
| 5 | Objectivity is achieved with easily in it. | 5 | For this reason, Objectivity is achieved with difficulty in social sciences. |
| 6 | It is not so difficult to construct laboratories for bio-physical sciences. | 6 | It is difficult to construct laboratories for social sciences. |
| 7 | The fundamental elements of it are physically related. | 7 | The fundamental elements of it are psychologically/socially related. |

## Qualitative and quantitative research

*Qualitative research* differs from *quantitative research* in the following ways:

- The data is usually gathered using less structured research instruments.
- The findings are more in-depth since they make greater use of open-ended questions.
- The results provide much more detail on behaviour, attitudes and motivation.
- The research is more intensive/rigorous and more flexible, allowing the researcher to probe or investigate since she/he has greater latitude (autonomy) to do so.
- The results are based on smaller sample sizes and are often not representative of the population.
- The research can usually not be replicated or repeated, giving it low reliability; and
- The analysis of the results is much more subjective.
- Because of the nature of the interaction with respondents, the training and level of expertise required by the person engaging in the direct communication with the respondents must be quite high.

By nature of the problem, there are two types of research:

**Exploratory research and Conclusive research**

The level of uncertainty or difficulty in clearly identifying the problem will determine whether the research is exploratory or conclusive in nature.

**Exploratory research** is conducted as the first step in determining appropriate action. It helps delimit the problem and clearly outline the information needed as part of future research. Exploratory research tends to rely on secondary research or data, and qualitative research techniques such as pilot study, case study and focus groups.

In exploratory research, the researcher is involved in investigating the subject in which he/she has not sufficient knowledge to formulate the hypothesis about the problem. Exploratory research is conducted without a formal research design and is flexible and open to all possible ideas to solve the problem. It investigates all alternatives until a better idea is formed.

Methods of exploratory research

-Study of secondary sources of information

-Pilots survey/experience (review) survey)/survey of individuals with ideas

- Analysis of selected cases

**Conclusive research** provides a reliable or representative picture of the population. Conclusive research tends to be quantitative research in nature, whether the source is secondary or primary research.

It can further be sub-divided into two major categories:

1. Descriptive Research
2. Causal Research

**Descriptive Research**: Descriptive research or statistical research provides data about the population or universe being studied. But it can only describe the "who, what, when, where and how" of a situation, not what caused it. Observation technique and survey techniques are most commonly employed to obtain the descriptive data.

**Causal Research**: To determine whether there is a cause and effect relationship between variables, causal research must be undertaken. In this type of research, the objective is to determine which variable might be causing certain behaviour, e.g. is the increase in sales due to price, packaging, advertising, etc? One variable would be changed with the others being kept constant to allow for the determination in changes in behaviour.

## UNIT 2: Language of Social research

### Concept and construct

Before any theory to be tested, first of all the terms in that theory must be defined clearly. In addition, they must be linked in some meaningful way with the empirical world. This means that the terms used must be amenable to some kind of measurement or quantification.

One way of looking at the terminology of social science is to make a distinction between concepts and constructs.

**Concept**: Definitions:-

- A concept expresses an abstraction formed by generalization from particulars. Concepts are abstractions and represent only certain aspects of reality. --F.N. Kerlinger
- Concepts are logical constructs created from sense, impressions, percepts or even fairly complex experiences of individual or society. --Goode and Hatt

From the above definitions, it is clear that concepts have direct empirical reality and we can point out and make some figure in our mind.Foreg, when we say ‘’book”, we can point to numerous properties of books such as length, weight, thickness, colour, subject matter and the like. Similarly, red color, fruits, vegetable, height, weight, length, mass, energy etc. are concepts. Such terms are most amenable for measurement of some kind. Other conceptual variables might be race, nationality, political party, achievement, religion affiliations etc.Although these terms are less a part of our empirical reality than a book or chair however they can be taken into account readily into our theories.

**Categories of Concept:** The concept can broadly be divided into two categories, namely:

1. **Postulated Concept**: It does not possess rigid meaning. It may be changeable and gives different meaning according to time and context. This means when these concepts are used in two different theories, these communicate two different meanings, sometimes even dramatically different and opposite from each other. Such as "Elasticity" has one meaning in Economics and another meaning in Physics.Similarrly``Mass" has one meaning in social sciences and different in physical or natural sciences.
2. **Intuitive Concept**: It has particular (rigid) meaning which never change in different context. The meanings of these concepts are constant whoever one uses it. The meaning is abstracted from wider empirical context i.e. red color.

The important features of concepts are:

- Each field of science develops its own concepts. Concepts are the basic elements of scientific research.
- Each concept communicates an enormous amount of experience and information to the specialists.
- A scientific concept avoids multiple meanings in the same field.
- With the development of knowledge and passage of time, a concept may change its meaning which may be narrowed or broadened.
- Concept is symbolic and short.

A good concept possesses the following features:-

- The concept should be clear and definite i.e. good concept must be precise.
- It should be comprehensive clear in formulation and understanding.
- It should avoid multiple meanings in the same field.
- It should be based on logic and law.
- If the concept does not possess above features, they create problems and do harm than good to the researcher.

**Construct:** A construct is a concept that is deliberately invented for a special scientific purpose. It is a term invented to account for internal and indirectly observable psychological processes that in turn account for behavior. It cannot be seen, heard or felt. It is inferred from behavior. Constructs are not directly part of our empirical world. Scientists consciously and systematically use it in two ways:-
First, it enters into theoretical schemes and is related into various ways to other constructs.
Second, it is so defined and specified that it can be observed and measured.
To clear above ways, consider the construct "Intelligence". It can be used as:
1st, School achievement is in part a function of intelligence.
2nd, we make observations of the intelligent of children by administering X intelligent test to them.
Other examples of construct are:-
Anxiety, faith, social class, prestige etc.

There are two definitions about construct.
1. A **constitutive or nominal or conceptual** definition explains the same meaning which is frequently found in the usual dictionary. It defines a construct with other constructs. For instance, we can define "Anxiety" by saying that it is the "subjectified fear''.
2. An **operational** definition is the quantification of nominal definition and assigns meaning to a construct by specifying the necessary activities/operations to measure it.

Most of the terms used by social scientists are in constructual form. When one use these terms, he must supply set of attributes to constructs to bring them closer in the empirical world. He must bring them more into measurable form similar to concepts that already have relatively convenient and direct empirical referents.

## SCALE OF MEASUREMENT

Definitions

Measurement is the assignment of numerals to objects or events or persons according to some prescribed rules. - F.N. Kerlinger

Measurement consists of rules for assigning numbers to objects such a way as to represent quantities of attributes. - J.C. Nunnally

A scale of measurement is the type of variable being measured and the way it is measured. It is imperative that the type of scale is known since different statistics are appropriate for different scales of measurement.

There are 4 types of scale of measurement:

1. Nominal (classification) scale:-

It is that lowest level of scale in which numbers (or symbols) are given to various objects just to distinguish one object from other. The numbers or symbols used have no numerical meanings and they cannot be added or ordered. Generally, observations are assigned to categories based on equivalence.

For e.g., Assignment of numerical symbols to the football players.

Personal attributes: - Sex, eye color, race

Demographic attributes: - State of residence, institution.

"Contrived" group: - Attendance at this class (Yes/No categories)

Other examples are: Religious affiliation, Political affiliation, school affiliation, ethnic background etc.

2. Ordinal Scale (Ranking Scale)

In this scale, observations are ranked in order of some measure of magnitude. Then, numbers assigned to groups to show that, one is more (higher) than other but how much greater is not implied. Numerical values are used to indicate simply rank order.

For e.g. Grading of service personals as: Professor, reader, lecturer, teaching assistant,

1 2 3 4

Here, $1>2>3>4$ but, $2-1 \neq 3-2$ etc.

Letter grades (in exam): A, B, C or D

Achievement such as: low, medium, high

Age category such as: infant, child, adult, senior

Other examples are: Social class, social distance, prestige rankings, rating of universities, organization and many attitudinal phenomena etc.

(3)Interval Scale

Intervals on the scale represent equal distances on the properly being measured; there is no absolute zero (It is with relative zero point). Zero does not represent the absence of the characteristics being measured.

Foe eg. Temperature=$0^0$C, it is meaningful & not true or absolute zero point]

(4) Ratio-Scale. (Most important and widely used scale in Research)

Same characteristics as interval scales, but the zero represents the absence of the characteristics being measured. Or an interval scale with an absolute zero point is called Ratio-scale. Ratio between measures becomes meaningful.

For e.g. Years of experience, monthly income, time, height, weight, length etc.

If a stick has 3 cm length of another B stick has 6 cm length. It means both are measured from 0. B has double length than A.

Ratio of two weights in Gms of anything is identical to the ratio of two weights in pounds of the same thing.

A sentence to help remember all 4 types of scale of measurement:

A horse no.7 finished in $3^{rd}$ place in $30^0$C heats, with a time of 4 minutes.

Nominal: Race horse NO.7 (identifies)

Ordinal: - finished in $3^{rd}$ place (orders)

Interval: - in 30 degree heat [temp, (no true zero point)]
Ratio: - with a time of 4 min. (clocked time; true zero point from start)
A dichotomous variable measured as 0 & 1 can be considered to be any of these scales

Likert Scale: It is summated rating Scale. When an individual responds to the statements, he expresses his attitude on a scale of 1 to 5 (or some times 1to 3 or 1to 7) with 1 represents strongly disagree and 5 represents strongly agree of the statements (can consider opposite of this). These scales can be arranged with many other similar items. When the items all are summated the total number is an indication of some general attitude.
The feature looks like this:
Strongly agree (5) __Agree (4)___Undecided(3)___Disagree(2) ___Strongly disagree(1)

This scale produces an ordinal scale which generally requires non -parametric statistics. Use of likert scale:
For model for 3x3 table,

| | | Independent (Wealth) (Frequencies) | | |
|---|---|---|---|---|
| Dependent (Perception) | | High (Rich)3 | Middle 2 | Low (poor) 1 |
| High (Agree) | 3 | 12 | 11 | 11 |
| Middle (Neutral) | 2 | 23 | 14 | 21 |
| Low (Disagree) | 1 | 20 | 21 | 22 |

To measure the degree of association between perceptions levels of members of FUG towards CF (for the statement grazing must be stopped to protect the forest) with respect to wealth, Kruskal's Gamma coefficient ($\gamma$) as well as coefficient of contingency will be used and its significance can be tested by chi-square.

Thurstone Scale. It is equal appearing interval scale. It is associated with differential scales which have been developed using consensus scale approach. Under such an approach the selection of items is made by panel of judges who evaluate the items in terms of whether they are relevant to the topic area and unambiguous in implication.

Statement A

| Category (x) | No. of judges placing item in the category (f) | fx |
|---|---|---|
| 1(most favorable) | 5 | 5 |
| 2 | 2 | 4 |
| 3 | 6 | 18 |
| 4(Middle) | 8 | 32 |
| 5 | 3 | 15 |
| 6 | 0 | 0 |
| 7 (least favorable) | 1 | 7 |
| | N=25 | $\sum$fx=81 |

Average value of the statement A or weight of statement A=$\sum$fx/N=81/25=3.2
Similarly, other weights for different statements can be found out in this manner.

**VARIABLE:**
Characteristics by which persons or objects can be described.
Characteristics that do vary & can be put on a continuum or spectrum.
(Statistical definition)

Characteristics that can change from time to time for given persons or objects, or change (vary) from person to person, or from object to object.
Must have more than one level (It takes various values).

CONSTANT: A number that does not change

Statistical Adjectives for a variable
DISCRETE VARIABLE - Can only take on specific values (whole number values) [also called categorical and discontinuous variable) eg:- Marital status, hair colour, sex, family size, no. of goals etc.
CONTINUOUS VARIABLE: Variable that can take any values (whole no. as well as fractional) within a certain range. E.g. IQ score, age, height, weight

Both of the above can be of dependent or independent.

INTERVENING, EXTRANEOUS, CONFOUDING OR CONTAMINATING VARIABLE
Things affect dependent variable other than the independent variable i.e. uncontrolled variables that may affect the dependent variable.

CLASSFICIATION OF VARIABLE

INDEPENDENT VARIABLE
* Presumed cause
* Antecedent
* Variable predicted from
* Generally denoted by X
* The thing you think will produce a difference and the thing the experimenter changes somehow
* Treatments
* Factors

DEPENDENT VARIABLE
* Presumed effect
* Consequence
* Variable predicted to
* Generally denoted by Y
* The thing that is supposed to change thing that should be affected
* Criterion
* Observation

TYPES OF INDEPENDENT VARIABLES
ATTRIBUTE VARIABLE - Variable that cannot be manipulate. For eg Sex, Socio-economic status, Score on I.Q. tests etc.
- Also referred to as assigned, measured, organismic, personlogical, sociological, psycho-sociological and demographic variables.
Some variables can be manipulated but are not manipulated in a particular investigation.
Examples: - type of curriculum completed in high school, section of a course enrolled in etc.
Usually subjects self-select the level of the independent variable or naturally occurring.
Common in ex-post facts research (Ex-post facto means from after the fact)
ACTIVE: - Variables that can be manipulated & are maniputed in a particular investigation. (It is manipulated variable)
Example: Method of teaching - Experimental Vs control

Similarly, variable may be of quantitative (height, weight, length, income etc) and qualitative (sex, intelligence, etc)

## Hypothesis: Definition:

Hypothesis is usually considered as the principal instrument in research.

In social research, hypothesis starts with what we are looking for.

- It is a proposition which can be put to a test to determine its validity. ----Gode & Hatt
- The hypothesis is a tentative justification, the validity of which remains to be tested. - G.A. Lundberg
- A hypothesis is a conjectural statement of the relation between two or more variable. Hypotheses are always in declarative sentence form & they relate, either generally or specifically, variables to variables.-------Fred N. Kerlinger

Ordinarily, when one talks about hypothesis, one simply means a mere assumption or some supposition to be proved only or disproved. But for a researcher, hypothesis is a formal question that he intends to resolve.
A research hypothesis is a predictive statement, capable of being tested by scientific methods, that relates an independent variable to some dependent variable.
Thus a hypothesis is a kind of suggested answer to the problem. Hypothesis is stated in declarative form and they always relate either generally or especially variable to variable.
For e.g., Persons coming from the upper & middle socio-economic status have stronger academic ability than persons coming from a lower-socio-economic status.

There are two criteria for good hypothesis statement.

- Statements about the relations between the variables.
- Statements carrying clear implication for testing of stated relations.

**Utility of Hypothesis**

- It is with the help of hypothesis, that it becomes easy to decide as to what type of data to be collected and what type of data is simply to be ignored.
- Hypothesis makes it clear as to what is to be accepted, proved or disproved & that what is the main focus of study.
- It helps the investigator in knowing the direction in which he is to move. Without hypothesis it will be just duping in the dark & not moving in the right direction.
- A clear idea about hypothesis means saving of time, money & energy which otherwise will be wasted, thereby botheration (trouble) of trial & error will be saved.
- It helps in concentrating only on relevant factors and dropping irrelevant ones. Many irrelevant factors which otherwise get into the study can easily be ignored.
- A properly formulated hypothesis is always essential for drawing proper & reasonable conclusions.

Thus, hypothesis is the pivot of the whole study. Without well formulated hypothesis, the whole study will be out of focus & it will be difficult to draw right & proper conclusions. In fact, hypothesis is a necessary link between theory & investigation which will result in the addition to the existing knowledge.

**Sources of Hypothesis**

There are different sources which help in building a hypothesis.

- General culture: In social studies, a hypothesis may be formulated with the help of general pattern of culture. The culture has a great influence upon the thinking process of people and hypothesis may be formed to test one or more of these ideas.
- Scientific theory: A theory gives us the basic idea of what has been found to be correct. The knowledge of theory leads us to form further generalization or corollaries from it. These generalizations & corollaries form parts of a hypothesis.
- Analogies: Sometimes a hypothesis is formed from the analogy. A similarity between two phenomena is observed at a circumstance. A hypothesis is then formed to test whether two phenomenon are similar in other circumstances too.
- Personal Experiences: Sometimes facts are there but only a right individual set it in right perspective & formulate a hypothesis. Thus, for example, everybody has seen the falling an apple, but Isaac Newton was only the person who could strike the idea of force of gravity.

**Characteristics of usable hypothesis**

The entire hypotheses which are developed cannot be used. There are some usable hypotheses, while the others are not. The characteristics of usable hypothesis are as under:

- Conceptual clearness

The hypothesis should be clearly expressed. At times we have certain in mind but it is reducing in writing, it may not carry exactly the sense that we have in mind. To avoid such situations, following two considerations are to be taken.

Firstly, the definitions & terms used in hypothesis are those which are commonly accepted terms and not our own creations.

Secondly, if new terms have to be used, their definition & meaning in terms of already existing concepts should make clear.

- Specific

All the operations & predictions indicated in the hypothesis must be clearly spelled out.

- Related to available technique

As a hypothesis has to be tested and verified, it should be, in most cases, so formed that it is easily tested or verified by an available technique. A hypothesis that cannot be tested by available technique is a useless hypothesis.

- Related to the body of theory

No subject can develop without building on an existing body of facts & theory. It can never develop, if each study is an isolated survey. In the words of Goode & Hatt, "What is important is that, whatever the source of your hypothesis it must be logically derivable from & based on a set of sociological propositions.

- Capable of empirical test

The hypotheses should be such that it can be put in empirical test. It should not be a moral judgment. Empirical test is necessary to achieve the objective.

- Simple

The hypothesis should be simple & to be point. Simpler the hypothesis better it will be both for the researcher as well as research. It should be brief so that it is possible to observe that. A hypothesis can become brief if it is stated in scientific terms. Brevity will also help in better understanding of underlying concepts & meanings.

**Relationship between theory & facts**

Theory & facts are in constant interaction.

While facts are empirically verifiable observations, theory refers to the relationship between facts or the ordering of facts in some meaningful way. **Theory** is considered as a tool of science in the following way,

- It defines the measure orientation of a science by defining the kind of data to be abstracted.
- It offers a conceptual frame work by which the relevant phenomena are systematized, classified &interrelated.
- It summarizes facts into empirical generalizations and systems of generalizations (i.e. it helps to theoretical model)
- It predicts facts.
- It points to the gap in knowledge.

Facts are considered as tools of science in the following way:-

- Facts help in initiating theory.
- They lead to reformulation of existing theories.
- They cause the rejection of theories which do not fit the facts.
- They change the orientation and focus of theories.
- They clarify and reduced theory.

From above we conclude that:

- Indeed, theories cannot be constructed without facts and facts cannot be understood without theories. Facts without theories are meaningless and theories without facts are unfounded (such theories are imaginary and false).
- While facts are concrete, theories are abstraction.
- While facts are wide and scattered, theory is brief and limited.
- In the scientific process of research, facts are gathered first and then ordered through theories.
- Facts cannot themselves establish some principle. They are the raw materials which provide knowledge only after being subsumed (included) under the structure of theories

## RELIABILITY OF A MEASURE:

Reliability is an accuracy or a precision of a measuring instrument.

- F.N. Kerlinger

The reliability of a measuring instrument is defined as the ability of the instrument to measure consistently the phenomena as it is designed to measure.

A scale should be reliable ie should give the same measurement under similar conditions. For eg. an economic status scale is reliable only if two persons with apparently same economic status show the same score. Reliability means dependability, stability, predictability, consistency and accuracy of the scale.

**There are 3 different definitions of Reliability**:

(1) If we measure the same set of objects again & again with the same or comparable measuring instruments & we get the same or similar result, then the measurement is called reliable.
This gives the definition of reliability in terms of stability, dependability & predictability.

(2) Reliability means the measures obtained from the measuring instrument are the true measures of the property measured. This definition implies the accuracy of the scale.
Compared to the 1st definition, it is further removed from common sense & intuition but it is also more fundamental. These (1) & (2), definitions can be summarized in the words Stability & accuracy.

(3) Reliability means absence of error in the measuring instrument.
This definition helps to solve both theoretical & practical problems associated in the definition of reliability. This definition inquires how much error is there in measuring instrument. Does our measuring instrument consistently measure our observation accurately? This is the case of defining reliability in terms of absence of errors in a measurement in measuring instrument.

**Two aspects of reliability with improvements**

**(1) Stability aspect**

It is concerned with securing consistent results with repeated measurements of the same person & with the same instrument. By comparing the results of repeated instruments, we usually determine the degree of stability.

Improvement: - By standardizing the conditions under which measurement takes place ie minimizing the external sources of variation ie boredom, fatigue etc.

**(2) The Equivalence aspect**

It considers how much error may get introduced by different investigators (Non-sampling error) or different samples of the items being studied (Sampling error). A good way to test for the equivalence of measurements by two investigators is to compare their observations of the same events.

Improvement:-

By carefully designed directions for measurement with no variation from group to group, by using trained, qualified & motivated persons to conduct the research and by increasing the size of the samples used.

**Tests of Reliability**

Following are the methods used to test the reliability of a scale.

(1) **Test-retest Method** :

This method is used whether 1st definition is true or false. In this method, the same scale is applied twice to the same population & the results obtained are compared by computing correlation between 1st (test) and 2nd set (re test) of scores.

The technique of control group is also used whenever application at different time is not possible. Also to avoid the effects of causative factors in prolonged period of two tests, two similar groups are used to test a scale.

The reliability coefficient in this method is called "Stability coefficient".

Advantages:

(1) Can permit the instrument to be compared directly to it.
(2) Directly reveals the continuity of the measure from one time period to the other.
(3) It is quick to apply & easy to evaluate.
(4) Offers the greater degree of control over the extraneous factors.

Disadvantages

(i) Expanded time intervals are necessary.
(ii) No prescribed time period of two tests administrations.
(iii) Extremely difficult for the researcher to recognize the impact of extraneous variables on any sample of individuals.
(iv) The method of determining test reliability is not full proof.

2**. Alternative or parallel form methods (Multiple methods)**

According to this method, two forms of scales (Alternative eg. parallel) are constructed & they are administrated at the same population. If the results obtained by two methods show the high degree of similarly (measured by correlation coefficient). Then the scale is considered reliable. The correlation coefficient in this case is called the self correlation coefficient & indicates the degree of equivalence in two forms of a test. The reliability coefficient in this case is called stability coefficient.

**Advantages**

(1) Respondents are unable to affect the test results through recall in a test retest situation.
(2) A conventional waiting period between the two tests administration is not necessary.

**Disadvantages**

(1) Two tests must be constructed instead of one.
(2) Equivalence of tests is difficult to establish.

**VALIDITY:**

Definition:

Validity of a test is the accuracy with which it measures that which is intended or supposed to measure. ---- Lindquist

Validity is a property of a measuring instrument that you want to test for. --- T.L. Baker

Are you measuring what we think we are measuring? - F.N. Kerlinger

The emphasis in this question is on what is being measured. For eg. a teacher has constructed to test to measure understanding of scientific procedures & has included in the test only factual items about scientific procedures. The test is not valid because while it may reliably measure the pupils' factual knowledge of scientific procedures, it does not measure their understanding of such procedures. In other words, it may measure what it measures quite well, but it does not measure what the teacher intended it to measure.

## TYPES OF VALIDITY

1. **Content or Face validity**
   It is the extent to which a measuring instrument provides adequate coverage of the topic under study. If the instrument contains a representative sample of the universe, the content validity is good. Its determination is primarily judgmental & intuitive. It can also be determined by using a panel of persons who shall judge how well the measuring instrument meets the standards, but there is no numerical way to express it.
2. **Criterion related validity (Pragmatic validity)**

**A criterion related validity is a broad term that actually refers to**

(i) Predictive validity (ii)Concurrent validity

(i) The predictive validity refers to the usefulness of a test in predicting some future performance where as
(ii) Concurrent refers to the usefulness of a test in closely relating to other measures of known validity.

Thus, Criterion related validity is expressed as the coefficient of correlation between test scores & some measure of future performance or between test scores & scores on another measure of known validity.

3. **Construct validity**

When validity of a measuring instrument cannot be evaluated so directly & certain other evidences are necessary to find out whether measuring instruments are valid or not, that approach is construct - validation.

For determining construct validity, we associate a set of other propositions with the results received from using our measurement instrument. If measurements on our devised scale correlate in a predicted way with these other propositions, we can conclude that there is some construct validity.

**The following procedure is recommended to establish the validity of an instrument**.

1. Clearly define what it is that you want to measure (eg. reactions, knowledge level, people involvement, behavior change) etc.
2. Prepare a draft of your instruments in consultation with other colleagues. Search for existing instruments related to your topic of interest to use as a guide in developing your own instrument. You may use the similar question formats & response categories.
3. Identify 5-7 persons to serve as a panel of experts for reviewing your instruments in terms of content, format & audience appropriateness. Remember that the members of the panel should be familiar about the purpose of the study. Ask the panel of experts to review the instrument & give feedback.
4. Revise the instrument by incorporating the suggestions offered by the panel of experts.
5. Field test the instrument to find out its suitability & clarity. Select about 10 persons who are similar to the target audience to participate in the field test. Watch people complete the questionnaire. Watch for hesitation, erasures or skipped; questions. Seek verbal feed back after you have watched them complete the instrument. If some respondents appear confused or hesitant to answer, find out why? Review the instrument for clarity content, wording & length. Based on the feedback, revise your instrument.

**Methods of test of Validity**

1. Logical validation
2. Jury opinion
3. Known groups

4. Predictive measure

**Potential sources of error in a research study:**

Whether you are designing research or reading and evaluating it, it is useful to approach the task as one of controlling for or looking for errors. The following is a list of the types of errors to watch for when designing research or reading research reports. The principles and methods we are discussing are largely designed to control for error.

1. Problem definition error: Conceptualization of research problem may not adequately or accurately reflect the real situation.
    - Use of a theory or assumptions that are faulty or do not apply
    - Research problem does not address the management questions
    - Reductionism-Omission of key variables
2. Surrogative information error: Variation between the information required to solve the problem and the information wanted by the researcher.
3. Measurement error: Variation between the information required and the information produced by the measurement process (reliability and Validity).
4. Population specification error: Variation between the population required to provide needed information and the population required by the researcher (rule for clearly defining the study population).
5. Frame error: Variation between the population as defined by the research and list of population elements used by the researcher.
6. Sampling error: Variation between a representative sample and the sample generated by a probability sampling method(Sampling error estimates, checking for representativeness)
7. Selection error: Variation between a representative sample and the sample obtained by a non-probability sampling method (check for representativeness).
8. Non-response error: Variation between the sample that was selected and the one that actually participated in the study.(evaluating non-response)
9. Experimental error: Variation between the actual impact of treatment and the impact attributed to it based on an experimental design.(pre-measurement,interaction,selection,history,maturation,instrumentation,mortality,treactive error,timing,surrogate situation-will define later when we cover experimental design)
10. Data processing error: Errors in coding and handling of data.(cleaning)
11. Analysis errors: Covers a variety of errors including violation of assumptions of statistical procedures, use of inappropriate or incorrect procedures, mis-handling of missing values, calculation errors and faulty interpretation of results.
12. Reporting and communication errors: Errors made in preparing oral or written reports including both typographic and logical errors. Faulty interpretation of results made by users (editing).
13. Application errors: Inappropriate or faulty application of the research results to a management problem.Over-generalising the results to situations where they may not apply is a common error in applying research results.

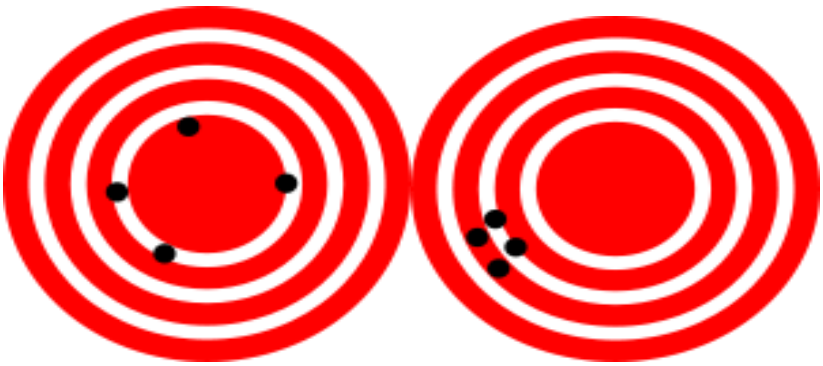
**Bias**

In statistics, the difference between an estimator's expected value and the true value of the parameter being estimated is called the bias.

**Accuracy and precision**

- The closeness of an estimate value to the true value is called accuracy.Unbiasness represents the ideal or perfect accuracy.
- Whether the distribution of estimated value

- is narrowly concentrated around the target value, precision is high or instead is widely spread out around it, precision is low.
- Actually precision is related with standard error of mean.



**High accuracy, but low precision** **High precision, but low accuracy**

- **Accuracy describes the closeness of arrows to the bullseye at the target center. Arrows that strike closer to the bullseye are considered more accurate. The closer a system's measurements to the accepted value, the more accurate the system is considered to be.**

The results of calculations or a measurement can be accurate but not precise; precise but not accurate; neither; or both. A result is called *valid* if it is both *accurate* and *precise*

## UNIT 3: Basic steps of a research

**Why Conduct Research?**

Any research, if correctly designed and undertaken, will build knowledge because it represents an objective investigation of facts about a certain subject. Whereas basic or *pure research* attempts to expand the limits of knowledge, *applied research* attempts to find the solution to a specific problem.

With the growth of the hospitality and tourism industries and the increasing global competition, managers are looking to research in an effort to improve an organization's chances of success. Take a look at the attached summary of the major types of research conducted in businesses. But not all decisions are based on research; managers will also resort to 'rules of thumb' or commonly accepted truths, rely on authoritative sources of information such as governmental agencies, or on intuition. However, unless tested through objective research, none of these approaches will necessarily lead to correct conclusions.

In the hospitality and tourism industries, the orderly investigation of a defined problem or opportunity – or *scientific method*– is very often multidisciplinary in nature: relying on insights gained by such diverse disciplines as behavioral sciences, business, history, geography, anthropology, political science, planning and design – to name but a few! Hence it is critical to think in broad terms when determining the sources of information that might inform the research problem or the appropriate *research design*.

**The Research Process**

In order to make a decision on a given course of action and choose between several alternatives, the decision-maker must clearly recognize the problem to be solved or opportunity to be seized. S/he will then have to determine the information that is already available and what further information is required as well as the best approach for obtaining it. Finally, the information obtained must be assessed objectively to help inform the decision. This systematic approach to decision-making is referred to as the research process.

The research process involves six distinct phases, although they are not always completely linear, since research is iterative (earlier phases influence later ones, while later ones can influence the early phases). Perhaps one of the most important characteristics of a good researcher is the unwillingness to take shortcuts, to rush through the research. It is important to keep an open mind to recognize changes that must be accommodated to ensure the *reliability* and *validity* of the research.

The six phases are:

1. Problem definition

2. Literature review
3. Selection of research design, subjects and data collection technique(s)
4. Data gathering
5. Data processing and analysis
6. Implications**,** conclusions and recommendations

## Problem Definition

Although research reports state the objectives or purpose of the research early on, this is not always the starting point. Often, considerable analysis of historical data or secondary information has been undertaken to help define in very clear and precise terms what is the problem or opportunity. Apparently, Albert Einstein went so far as to say that "the formulation of a problem is often more essential than its solution"! Sometimes, *exploratory research* is required to help in the formulation of the research problem.

After an introduction which describes the broader context within which the research should be situated, it is important to state the objectives or purpose pursued by the research itself. Often, this is a fairly broad or general statement as well.

## Literature Review

Knowledge is cumulative: every piece of research will contribute another piece to it. That is why it is important to commence all research with a review of the related literature or research, and to determine whether any data sources exist already that can be brought to bear on the problem at hand. This is also referred to as secondary research. Just as each study relies on earlier work; it will provide a basis for future work by other researchers.

The literature review should provide the reader with an explanation of the theoretical rationale of the problem being studied as well as what research has already been done and how the findings relate to the problem at hand. The quality of the literature being reviewed must be carefully assessed. Not all published information is the result of good research design**,** or can be substantiated. Indeed, a critical assessment as to the appropriateness of the methodology employed can be part of the literature review.

This type of secondary research is also extremely helpful in exploratory research. It is an economical and often easily accessible source of background information that can shed light on the real scope of the problem or help familiarize the researcher with the situation and the concepts that require further study.

## Research Design, Data Collection Techniques and Selection of Subjects

Once the problem has been carefully defined, the researcher needs to establish the plan that will outline the investigation to be carried out. The *research design* indicates the steps that will be taken and in what sequence they occur.

There are two main types of research design:

1. Exploratory research

2. Conclusive research itself subdivided into

   - *Descriptive research* and
   - *Causal research*

Each of these types of research design can rely on one or more data collection techniques:

1. *Primary research*

   - *Observation technique*
   - Direct communication with subjects, e.g. survey technique, interview or projective methods

1. Secondary research, which essentially means reviewing literature and data sources, collected for some other purpose than the study at hand.

Irrespective of the data collection technique used, it is critical that the researcher analyze it for its *validity* and *reliability.*

Another critical consideration in determining a study's methodology is selection of subjects. If the researcher decides to study all elements within a *population*, s/he is in fact conducting a census. Although this may be ideal, it may not be very practical and can be far too costly. The alternative is to select a *sample* from the population. If chosen correctly, it is considered to be representative of the population. In this case, we are dealing with one of the probability sampling techniques. If the sample is not representative, then one of the non-probability sampling techniques was employed.

## Primary Research

In primary research, data is collected specifically for the study at hand. It can be obtained either by the investigator observing the subject or phenomenon being studied, or communicating directly or indirectly with the subject. Direct communication techniques include such *qualitative research* techniques as in-depth interview, focus group and projective techniques, and *quantitative research* techniques such as telephone**,** self-administered and interview *surveys.*

## Probability Sampling Techniques

In *probability sampling,* the sample is selected in such a way that each unit within the population or universe has a known chance of being selected. It is this concept of "known chance" that allows for the statistical projection of characteristics based on the *sample* to the *population*.

Most estimates tend to cluster around the true population or universe mean. When plotted on a graph, these means form what is called the *normal or bell curve.* This theoretical distribution allows for the calculation of the probability of a certain event occurring (e.g. the likelihood that an activity studied will be undertaken by people over 65 years old, if those are the variables being studied).

There are three main types of probability or random sampling that we will review more closely:

- (Simple) Random
- Stratified
- Cluster

## Non-Probability Sampling Techniques

In *non-probability sampling,* the sample is selected in such a way that the chance of being selected of each unit within the *population or universe* is unknown. Indeed, the selection of the subjects is arbitrary or subjective, since the researcher relies on his/her experience and judgement. As a result, there are no statistical techniques that allow for the measurement of *sampling error*, and therefore it is not appropriate to project the sample characteristics to the population.

In spite of this significant shortcoming, non-probability sampling is very popular in hospitality and tourism research for *quantitative research*. Almost all qualitative research methods rely on non-probability sampling techniques.

There are three main types of non-probability sampling that we will review more closely:

- Judgment Sampling
- Quota Sampling
- Convenience Sampling

## Questionnaire Design and Wording

The questionnaire is a formal approach to measuring characteristics, attitudes, motivations, opinions as well as past, current and possible future behaviors. The information produced from a questionnaire can be used to describe, compare or predict these facts. Depending on the objectives, the survey design must vary. For instance, in order to compare information, you must survey respondents at least twice. If you are comparing travel intentions and travel experience, you would survey respondents before they leave on vacation and after they return to see in which ways their perceptions, opinions and behaviors might have differed from what they thought prior to experiencing the destination.

Everything about a questionnaire – its appearance, the order the questions are in, the kind of information requested and the actual words used – influences the accuracy of survey results. Common sense and good grammar are not enough to design a good questionnaire! Indeed, even the most experienced researchers must

pre-test their surveys in order to eliminate irrelevant or poorly worded questions. But before dealing with the question wording and design and layout of a questionnaire, we must understand the process of measurement.

## Measurements and Scaling

The first determination in any survey design is "What is to be measured?" Although our problem statement or research question will inform us as to the concept that is to be investigated, it often does not say anything about the measurement of that concept. Let us assume we are evaluating the sales performance of group sales representatives. We could define their success in numerical terms such as dollar value of sales or unit sales volume or total passengers. We could even express it in share of sales or share of accounts lost. But we could also measure more subjective factors such as satisfaction or performance influencers.

In conclusive research where we rely on quantitative techniques the objective is to express in numeric terms the difference in responses. Hence, a *scale* is used to represent the item being measured in the spectrum of possibilities. The values assigned in the measuring process can then be manipulated according to certain mathematical rules. There are four basic types of scales which range from least to most sophisticated for statistical analysis.

- nominal

- ordinal
- interval
- ratio

## Data Analysis

After questionnaire development, pretesting the instrument and designing the sample, fieldwork – or the actual gathering of the required data – must be undertaken. However, we will not be discussing the complex and expensive tasks associated with fieldwork as part of this course.

Once the results start to come back from the field, the information needs to be prepared for input in order to be tabulated and analyzed. Before the questionnaires are given to someone for data-entry, they must be edited and coded. There should be no ambiguity as to what the respondent meant and what should be entered.

So is it their first trip or not? And what do you instruct the data-entry person to do? In spite of clear instructions, this type of confusing response is not as rare as we might think, particularly in self-administered surveys.

If the questionnaire was not pre-coded, this will be done at the same time as the editing by the researcher. Coding involves assigning a label to each question or *variable* and a number or value to each response category .Sometimes, people will write in a response such as "can't remember" or "unsure", and the editor must decide on what to do. This could either be ignored or a new code and/or value could be added. All of these decisions as well as the questions and their codes are summarized in a "codebook" for future reference. SPSS have prepared some basic guidelines for preparing for data entry, that you should be sure to read.

Even in a structured questionnaire, you may have one or two *open-ended questions*, which do not lend themselves to coding. This type of question needs to be content analyzed and hopefully grouped into categories that are meaningful. At this point, they can be either tabulated manually or codes can be established for them.

Once the data has been input into the computer, usually with the assistance of a statistical package such as SPSS, it needs to be 'cleaned'. This is the process of ensuring that the data entry was correctly executed and correcting any errors. There are a number of ways for checking for accuracy:

- Double entry: the data is entered twice and any discrepancies are verified against the original questionnaire;
- Running frequency distributions and scanning for errors in values based on the original questionnaire (if only four responses are possible, there should be no value "5", for instance); and
- Data listing refers to the printout of the values for all cases that have been entered and verifying a random sample of cases against the original questionnaires.

The data is now ready for tabulation and statistical analysis. This means that we want to do one or more of the following:

- Describe the background of the respondents, usually using their demographic information;
- Describe the responses made to each of the questions;
- Compare the behavior of various demographic categories to one another to see if the differences are meaningful or simply due to chance;
- Determine if there is a relationship between two characteristics as described; and
- Predict whether one or more characteristic can explain the difference that occurs in another.

In order to describe the background of the respondents, we need to add up the number of responses and report them as percentages in what is called a *frequency distribution* (e.g. "Women accounted for 54% of visitors."). Similarly, when we describe the responses made to each of the questions; this information can be provided as a frequency, but with added information about the "typical" response or "average", which is also referred as measure of central tendency (e.g. "On average, visitors returned 13 times in the past five years".)

In order to compare the behaviour of various demographic categories to one another to see if the differences are meaningful or simply due to chance, we are really determining the statistical significance by tabulating two or more variables against each other in a cross-tabulation e.g. "There is clear evidence of a relationship between gender and attendance at cultural venues. Attendance by women was statistically higher than men's".).

If we wish to determine if there is a relationship between two characteristics as described; for instance the importance of predictable weather on a vacation and the ranking of destination types, then we are calculating the correlation. And finally, when trying to predict whether one or more characteristic can explain the difference that occurs in another, we might answer a question such as "Are gender, education and/or income levels linked to the number of times a person attends a cultural venue?

## Drawing Conclusions

While your data analysis will need to analyze every questions asked, discussing such things as statistical significance and correlations, when you are ready to draw conclusions, you will have to determine what the main findings of your report really are. Not everything is worthy of being re-discussed when drawing conclusions. It is quite likely that the reader or readers of the final report have not spent much time thinking about the research, but want to understand quickly without having to read every last bit of analysis and data manipulation.

The final chapter of the research report must bring the research together and provide an interpretation of the results, written in language that is commonly understood even by managers who may not be well versed in statistical analysis, a summary of the critical conclusions of which management or any other specific audience needs to be aware, and strategic recommendations based on the findings of the research.

In more commercial reports the analysis of the data and the interpretation of the results may well go hand in hand, with only those findings directly relevant to the study objectives being discussed. Only summary tables and charts are part of the write-up. In these cases, the detailed analysis and a comprehensive set of tables and charts are usually confined to a technical report.

## Interpreting Results

In the Data Analysis, the results for each question in the survey were discussed along with the appropriate statistical analysis and an illustration in the form of a table or chart. As part of the interpretation of the results, you need to go back to the findings previously discussed and interpret them in light of the sub problems you posed as part of your research question. This sub problem interpretation is based on the results of each research item. Whereas in the data analysis you only identify the results without editorializing or commenting on them, now we are ready to draw conclusions about the data.

As part of the interpretation, you will want to place your results in the context of your literature review. That is to say, to what extent do you have an explanation why other researchers might have reached different conclusions, or even what the implications are of your data pointing to similar results. Since your literature review drove the development of your hypotheses, it is logical that you would discuss whether hypotheses tested positive or negative as part of your interpretation.

## Summarizing Conclusions

Summarizing conclusions is a two-step process, whereby

1. You review the conclusions of all the hypotheses, and from these conclusions
2. You draw overall conclusions for the research question itself.

These conclusions are usually listed numerically, and then further discussed one by one. The reasoning followed to reach the conclusions and the data that supports the statements made are incorporated into a brief editorial comment with respect to the global interpretation.

It is absolutely critical at this point not to cede to temptation to make concluding statements that would apply the study's results beyond the parameters established for the study under the problem definition. Indeed, you may even want to incorporate a statement warning the reader not to interpret the results in such a way that generalizations beyond the study's parameters are made.

## Making Recommendations

No matter how complete your study was, there will always be further research that will be required to shed more light on the research question, particularly if there is an interest in generalizing the findings beyond the study's parameters. You will also have found areas within the literature itself that have considerable gaps that should be addressed, and to which your study may or not have contributed. Therefore, a summary section regarding recommendations for further study is appropriate.

If the research was undertaken on behalf of a client, then it is also important to provide the manager with a set of recommendations that directly address the management situation that led to the research being commissioned in the first place. However, as much as the manager may want far reaching recommendations, care has to be exercised that they are indeed anchored in the findings of the study and do not exceed its parameters.

**In short:**

**Outline of a Research Proposal**

Title of the study

Should contain key words to give a clear and concise description of the scope and nature of work

Avoid words like: a study of …; an investigation …; a survey of

- Introduction
  - - Statement of the problem
  - -- Review of literature
  - - - Objectives/research questions and/or hypothesis
  - - - Definition of terms
  - -- Limitation of the study
- Review of literature
- Methodology

-Research design

-Subject selection

-Instrument development

  - Data collection
  - Data analysis
- Time schedule and budget
  - Time schedule
  - Budget
- Bibliography
- Appendices

**Introduction**

- Background setting
  - Provide reader with necessary background and setting to put the problem in proper context
  - Lets reader see the basis for the study
  - Justify the reader that the study is needed
  - Be factual
  - provide a logical lead in to a concise statement of the problem
- Objectives of the study
  - Best located after the statement of the problem
  - Make clear the direct connection between specific objectives and hypothesis
- Definition of term
  - Provide operational definition
- Limitation of the study
- Review of literature
  - Indicate the theory on which the study is based
  - Review of literature is a continuous process, it could continue till report is prepared
- Methodology
  - First identify the population to be studied
  - How the sampling frame will be developed?
  - Sampling procedure
- Instrument development

- Validity (Does the instrument measure what it suppose to measure?)
- Reliability (Whatever the instrument measures does it do so consistently?)
- Suitability
- The instrument should be pilot and field tested

**Literature Review**

- The main purpose of literature review is to get ideas for dimensions of general problem that should be investigated. Review of literature is helpful in
  - Identifying a problem area for your research
  - Developing the significance of the problem area
  - Identifying variables to be investigated
  - Formulating the conceptual framework for your study
  - Formulate research questions or hypothesis to be tested
  - Locating data collecting instruments
  - Aiding in interpreting and reporting research findings
- It is essential for researcher to know how to find previous work in their areas. To do this one should know
  - The source of previous work
  - What agency collects such information and organize it into database
  - What form these database take
  - Efficient ways of finding the information one needs

**Organizing the Related Literature**

- Literature should lay a systematic foundation for the study. The literature should be presented in such a way as to justify carrying out one's study by showing what is known and what remains to be investigated
- Tips for literature review
  - Begin with the most recent studies in the field and then work backward
  - Read abstract or summary section of a report first to determine whether it is relevant to the research questions
  - Before taking notes, skim the report quickly to find those section that are related to the question
  - Write out a complete bibliographic reference for each work
  - If online database searching has been conducted, keep the search strategies on file

**Problem Identification**

- Selecting or formulating a problem is one of the most important aspects of doing research. There is no way to do research until a problem is recognized. Selection of problems involved:
  - Decisions on the general problem area
  - General subjects is narrowed down to a specific statement of research problem
  - The statement of problem should clearly indicate what is to be investigated
- Sources of research problems
  - Desire to know for the satisfaction of knowing
  - Desire to know in order to do something better or more efficiently
  - How to find a research problem?
    - Experience
    - Deductions from theory
    - Related literature
- Locating a problem for research
  - Begin with a general problem area
    - Specific problem do not come well defined
    - Usually begin with a broad area and narrow down with a very narrow issue

  - Activities indicating possible problems
    - Have special interest in your filed
    - Read critically (concepts, articles and thesis)
    - Talk with faculty about related research
    - Be alert to possible problem from seminar/courses
- Factors to be considered in choosing a problem
  - Select a problem area in which you have a high degree of professional interest
  - Problem area should be of some significance to the profession
  - Accomplishments of the research study
    - Researcher knowledge and skill
    - Financial resource available
    - Time frame is suitable
  - Are data available to the researcher
  - Will physical or psychological harm come to anyone as a result of the proposed research?
  - Ethical principles to follow include:
    - Protecting participants from harm
    - Ensuring confidentiality of research data
    - Do not deceive the subjects

Writing the Proposal for Dissertation

- Orient yourself to the process – know your audience, read requirement, re-read, know your subjects your goals, and capacity
- Master the basics of your disciplines, your field, your area
- The first approach – identifying the concept
  - Write the precise question on paper
  - Revise and revise
  - State the expected solution to the questions
  - Write a title that clear, interesting, and accurate
  - Write a synopsis of the research
    - Purpose
    - Methods
    - Rationale
    - What new knowledge
    - Significance
- Outline the major section of the proposal

## UNIT 4: RESEARCH DESIGN

### Introduction

A research design is the plan or arrangement of methods and procedures for obtaining the information needed to solve the problem. It is the conceptual structure within which research is conducted.

Research design provides the glue that holds the research project together. A design is used to structure the research, to show how all of the major parts of the research project -- the samples or groups, measures, treatments or programs, and methods of assignment -- work together to try to address the central research questions

There are different definitions about Research Design;

*Research design is a plan, structure and strategy of the investigation conceived so as to obtain answer to research questions and to control variance……F.N. Kerlinger*

*Research Design is a logical, systematic planning and directing of a piece of research……P.V.Young*

- **A good research design ensures that**

–The information obtained are relevant to the research problem.
–They were collected by purposely and economical procedure.
–The research is conducted efficiently.
–The reliability and validity is not questioned.

- **A research design appropriate for a particular research problem, usually involves the consideration of the following factors**.

–The resources of obtaining information
–The availability and skills of the researcher & his staff, if any.
–The objective of the problem to be studied.
–The nature of the problem to be studied.
–The availability of time & money for research work.

**A Research Design involves the following tasks**:

- Define the information needed
- Design the exploratory, descriptive, and/or causal phases of the research
- Specify the measurement and scaling procedures
- Construct and pre-test a questionnaire (interviewing form) or an appropriate form for data collection
- Specify the sampling process and sample size
- Develop a plan of data analysis

**Major functions of research design**

●The most important function of the research designs is that they provide the researcher with the blue print or outline for studying research questions.
●Research designs dictate boundaries of research activity and enable the investigator to guide his/her energies in specific directions.
●A third function of research design is that it enables the investigator to expect potential problems in the implementation of the study.

**Types of Research Designs**

- Exploratory / Formulative Research design
- Descriptive Research Design
- Experimental Research Design

**Exploratory / Formulative Research Design**

- Exploratory research is conducted without a formal research design and is flexible and open to all possible ideas to solve the problem. It investigates all alternatives until a better idea is formed.

**Characteristics of Exploratory Research**

- Gain insights and ideas
- Helps to break down a big vague problem into smaller more specifics.
- Develop hypotheses
- Helps to clarify concepts
- Appropriate when little is known
- Primary data are qualitative in nature

**●The main purpose of exploratory research is**

-Identification of the problem
-Formulation of the hypothesis/problem
-Formulation of the alternative courses of action to solve the problem

●In exploratory research design, the researcher is involved in investigating the subject in which he/she has not sufficient knowledge to formulate the hypothesis about the problem.
In other words, Exploratory research is preliminary study of an unfamiliar problem about which the researcher has little or no knowledge.

**●Methods of exploratory research design**

-Study of secondary sources of information/The survey of concerning literature
-Pilots survey/experience survey/survey of individuals with ideas
-Analysis of selected cases/analysis of *insight stimulating* (near interesting) examples
Under this method cases are identified to find out the following three factors.
-Features common to all cases in the general group
-Features not common to all cases but common to certain sub-groups
-Features common to specific case
Hypothesis is then formulated on the basis of comparison similarities and dissimilarities

**Descriptive Research design**

●Descriptive research design provides information that helps the decision maker to take a decision. This types of research design should include
-Arrangement of the methods for selecting the sources of information – the sample, sampling method.
-Method of collecting data –observation, personal interview, questionnaire etc.

●Descriptive research involves the description of the extent of association between two or more variables. The prediction is based upon the nature of the relationship between the variables.

●It provides the sound basis for the solution of the problems.
●Descriptive research is characterized by a prior formulation of the hypothesis or research questions. The researcher has to gain substantial knowledge about the problem through exploratory research before he /she initiate the descriptive research.

●Before conducting the descriptive research, the researcher should be able to clearly spell out what he/she wants to measure and how he/she is going to measure.

●Descriptive research attempts to obtain a complete and accurate description of the situation for which the formal research is required. It includes the accurate statement of the problem.

**Characteristics of Descriptive Research**

- Used to describe a phenomenon (market characteristics or functions)
- It assumes that the researcher has much prior knowledge about the problem situation
- It is preplanned and structured
- Based on large representative samples
- Requires a clear specification of the who, what, when, where, why and way. (the six Ws)

**Types of Descriptive Research Design**

**●Historical Research Design**

-Studies past phenomenon by collecting, verifying, analyzing and synthesizing past evidences.
- Based upon the study documents, letters, stones and metal, personal interviews who have seen, heard, experienced the past events.

- **Developmental Research Design**

–Studies the changes over key variables over time and cross-section of the society

- Developmental Research Design may be of three types

**1. Longitudinal Research Design**

–Measure change upon certain variables over two period of time on the same sample

**2. Cross-sectional Research Design**

–Study upon the phenomena or variables on two or more cross-section of the society

**3. Trend research Design**

–Generally based upon the secondary data at a regular time interval

- **Case study research design**

–Study detailed upon a case

–More than five cases are needed in order to draw the conclusion

–Case may be an individual, a family, an organization, a community or a country

- **Survey research design**

–Based upon gathering information from the field

–Need more planning and preparation than any other research design

The difference between two research designs in tabular form:

| **Research design** | Types of study | |
|---|---|---|
| | **Exploratory /Formulative** | **Descriptive/diagnostic** |
| **Overall Design** | Flexible design ( design must provide opportunity for considering different aspects of the problem) | Rigid design ( design must make enough provision for protection against bias and must maximize reliability) |
| **Sampling design** | Non-probability sampling design(purposive or judgment sampling) | Probability sampling design( Random sampling) |
| **Observational design** | Unstructured instruments for collection of data | Structured or well thought out instruments for collection of data |
| **Statistical design** | Non pre-planned design for analysis | Pre-planned design for analysis |
| **Operational design** | No fixed decisions about the operational procedures | Advanced decisions about operational procedures |

Differences between Exploratory and Conclusive Research

| | Exploratory /Formulative | Conclusive(Descriptive) |
|---|---|---|
| Objective | ▪ To provide insights and understanding. | ▪ To test specific hypotheses and examine relationships. |

| | | |
|---|---|---|
| Characteristics | ▪ Information needed is defined only loosely<br>▪ Research process is flexible and unstructured<br>▪ Sample is small and non-representative.<br>▪ Analysis of primary data is qualitative. | ▪ Information needed is clearly defined.<br>▪ Research process is formal and structured.<br>▪ Sample is large and representative.<br>▪ Data analysis is quantitative |
| Findings Results | ▪ Tentative | ▪ Conclusive |
| Outcome | ▪ Generally followed by further exploratory or conclusive research | ▪ Findings used as input into decision making |

**Experimental Research design**

The Experimental Research design is a plan & layout of the experiment. This is necessary in order to ensure a valid statistical analysis of the data & also to have more efficient estimate of treatment effects. Here researcher tests the hypothesis of casual relation between variables. This type of design not only reduces bias & increase reliability but will permit drawing inferences about causality. Usually experiments meet this requirement.

Experiments are of two types, laboratory experiments & field experiments. Most of the experiments in physical sciences are done in laboratories. Many of dues experiments in social & managerial sciences are performed in field.

Experimental research design is broadly divided in two categories,

- Informal Experimental Research design
  - Before & after without control design
  - After only with control design
  - Before & after with control design
- Formal Experimental Research design
  - C.R. Design
  - R.B. Design
  - L.S. Design
  - Factorial Design etc.

**Informal Experimental Research designs**

- **Before & after without control design**

In such a design a single test group or test area is selected & the dependent variable is measured before the introduction of the treatment. Then treatment is introduced & the dependent variable is measured again after the treatment has been introduced. The treatment effect is the difference between these two levels of phenomena.

Test area: Level of phenomena Before treatment (X) — treatment introduced → level of phenomena after treatment (Y)

Treatment effect = Y-X

iations may be

- **After only with control design**

In this design test area & control area are selected & the treatment is introduced in to the test area only. The dependent variable is then measured in both the area at the same time

| | | |
|---|---|---|
| Test area: | Treatment introduced → | level of phenomena after treatment (Y) |
| Control area: | No treatment → | level of phenomena without treatment (Z) |
| Treatment effect = (Y – Z) | | |

The basic assumption in such a design is that the two areas are identical with respect to their behavior towards the phenomena considered.

- **Before & after with control design**

In this design two areas are selected & the dependent variable is measured for both the areas in identical time period. Then the treatment is introduced into the test area only. The treatment effect is determined by subtracting the change in dependent variable in the control area from the change in dependent variable in test area: shown as follows:

| | Time period I | | Time period II |
|---|---|---|---|
| Test area: | level of phenomena Before treatment(X) | treatment introduced → | level of phenomena after treatment (Y) |
| Control area: | level of phenomena With out treatment (A) | no treatment → | level of phenomena without treatment (Z) |
| | Treatment effect = (Y- X) – (Z – A) | | |

...eous variation

...racteristics and

- Formal, non- restriction, single factor design experimental design.
- Treatments are assigned completely at random so that each experimental unit has the same chance of receiving any one treatment.
- Here any difference among the experimental units receiving the same treatment is considered as the "*experimental error*".
- CRD is one in which all the experimental units are taken in a single group which is homogeneous as far as possible. For example, the entire field plots constituting the group having the same soil fertility, soil depth, soil texture, soil moisture etc. All the cows forming a group are of the same breed, same age, same weight, and same lactation etc.
- Commonly used when experimental units are homogeneous or an experimental area happens to be homogeneous**.**
- Involves only two principles of experimental design, they are replication & randomization.

**Randomization & layout**

- Whole experimental material is divided into n number of experimental units.
  $n = r \times t$, r is number of replication, t is number of treatments for equal replication
  $n = \sum r_i$, for unequal replication
- Assign the plots from 1 to n
- Assign the treatment to the experimental plots randomly

Let us take an example of CRD with four treatments A, B, C& D each replicated five times look like this.

| | | | |
|---|---|---|---|
| A | D | A | B |

| | | | |
|---|---|---|---|
| C | B | C | A |
| D | A | C | B |
| C | B | D | C |
| D | B | D | A |

Lay out of CRD (with equal replication)

Similarly, four treatments T1, T2, T3& T4 each are replicated 4,3,3,5 times respectively then layout of CRD have been 15 plots (units) as shown below:

| | | |
|---|---|---|
| T2 | T2 | T2 |
| T3 | T4 | T3 |
| T1 | T1 | T1 |
| T4 | T4 | T1 |
| T3 | T4 | T4 |

Layout of CRD (Unequal replication)

**Mathematical model & statistical analysis**

Its mathematical model & statistical analysis is analogous to the ANOVA of one-way classified data.

The linear model is,

$$y_{ij} = \mu + \alpha_i + e_{ij} \ldots\ldots\ldots\ldots(1) \quad i = 1,2,\ldots\ldots\ldots t.$$

$$j = 1,2\ldots\ldots\ldots r_i$$

$y_{ij}$ = yield or response from the $j^{th}$ unit receiving the $i^{th}$ *treatment*

$\mu$ = general mean effect

$\alpha_i$ = effect due to $i^{th}$ treatment

$e_{ij}$ = error effect due to chance

$n = \sum r_i$ = total no. of experimental units

**Assumptions**

- All the observations are independent
- Different effects are additive in nature
- $e_{ij}$ are identically & independently distributed $N(0, \sigma_e^2)$
- $\sum \alpha_i = 0$, or $\alpha_i \sim N(0, \sigma_\alpha^2)$

**Hypothesis**

$H_0 : \mu_1 = \mu_2 = \mu_3 = \ldots\ldots\ldots\ldots\ldots\ldots = \mu_t = \mu$

i.e. $\alpha_1 = \alpha_2 = \alpha_3 = \ldots\ldots\ldots\ldots\ldots\ldots = \alpha_t = 0$

$H_1 : \mu_1 \neq \mu_2 \neq \mu_3 \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \mu_t$

i.e. $\alpha_1 \neq \alpha_2 \neq \alpha \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \alpha_t \neq 0$

**Advantages**

- Simple & easy layout
- Utilization of whole experimental material
- Complete flexible
- Simple analysis
- Missing data create no problem in analysis
- Specially suitable even some units are destroyed or failed to respond
- Mostly used in laboratory or green house experiment
- Gives maximum degrees of freedom for experimental error

**Disadvantage**

- Only suitable for small number of treatments
- Homogeneous experimental units can rarely obtained
- Less informative for heterogeneous fields
- Seldom suitable for field experiments
- All extraneous variations included in the error variation (residual variation)

**Randomized Block Design (RBD)**

- Most widely used experimental designs in forestry & biological research.
- Especially suitable for field experiments where the number of treatments is not large and there exists a remarkable factor based on which homogeneous sets of experimental units can be identified.
- The primary distinguished feature of the RBD is the presence of block of equal size each of which contains all the treatments.

**Blocking Technique**

- Grouping the experimental units into blocks such that variability within a block is minimized & variability among the blocks is maximized**..**

Two important points should be kept in mind while blocking

- Selection of the source of variability
- Block shape
  - ✓ Unidirectional – use long & narrow
  - ✓ Two directional – ignore the weaker one
  - ✓ Equally strong – square blocks

"**Randomization & layout**

The randomization process for RBD is applied separately & independently to each block. For example let us take a field experiments with 6 treatments A, B, C, D, E & F and 3 replications.

Gradient →

| Block I | Block II | Block III |
|---|---|---|
| C | A | F |
| D | E | D |
| F | F | C |
| E | C | A |
| B | D | B |
| A | B | E |

**Layout of RCBD**

**Mathematical model & statistical analysis**

Its mathematical model & statistical analysis is analogous to the ANOVA of two-way classified data.

The linear model is,

$$y_{ij} = \mu + \alpha_i + \beta_j + e_{ij} \ldots\ldots\ldots\ldots (1) \quad i = 1,2,\ldots\ldots t.$$
$$j = 1,2\ldots\ldots r$$

$y_{ij}$ = yield or response from the $j^{th}$ block receiving the $i^{th}$ treatment

$\mu$ = general mean effect

$\alpha_i$ = effect due to $i^{th}$ treatment

$\beta_j$ = effect due to $j^{th}$ block

$e_{ij}$ = error effect due to chance

**Assumptions**

- All the observations are independent
- Different effects are additive in nature
- $e_{ij}$ are identically & independently distributed $N(0, \sigma_e^2)$
- $\sum \propto_i = 0$, $\sum \beta_j = 0$, or $\propto_i \sim N(0, \sigma_\propto^2)$ ,$\beta_j \sim N(0, \sigma_\beta^2)$

**Hypothesis**

$H_{0\propto}$ : $\mu_{1.} = \mu_{2.} = \mu_{3.} = \ldots\ldots\ldots\ldots\ldots = \mu_{t.} = \mu$

i.e. $\propto_1 = \propto_2 = \propto_3 = \ldots\ldots\ldots\ldots\ldots = \propto_t = 0$

$H_{1\propto}$ : $\mu_{1.} \neq \mu_{2.} \neq \mu_{3.} \neq \ldots\ldots\ldots\ldots\ldots \neq \mu_{t.} \neq \mu$

i.e. $\propto_1 \neq \propto_2 \neq \propto \neq \ldots\ldots\ldots\ldots\ldots \neq \propto_t \neq 0$

$H_{0\beta}$ : $\mu_{.1} = \mu_{.2} = \mu_{.3} = \ldots\ldots\ldots\ldots\ldots = \mu_{.t} = \mu$

i.e. $\beta_1 = \beta_2 = \beta_3 = \ldots\ldots\ldots\ldots\ldots = \beta_t = 0$

$H_{1\beta}$ : $\mu_{.1} \neq \mu_{.2} \neq \mu_{.3} \neq \ldots\ldots\ldots\ldots\ldots \neq \mu_{.t}$

i.e. $\beta_1 \neq \beta_2 \neq \beta_3 \neq \ldots\ldots\ldots\ldots\ldots \neq \beta_t \neq 0$

**The principle advantage of RBD**

- Blocking reduce error variance and provides more accurate result.
- Any number of treatments & any number of replication may be included. This is the most popular design in view of simplicity, flexibility & validity. No other design has been used as frequently as RBD
- Control treatments can easily be included without causing any complication in the analysis of the data.

**Disadvantages**

- If the blocks are not homogeneous the error term will be large
- It cannot accommodate large number of treatment since in this situation the homogeneity of blocks or groups is always in danger or hazard.

In many situations the criteria for blocking or grouping is not easily selectable.

**Latin Square Design (LSD)**

- Balanced two-way classification scheme with two superimposed blocking systems rows & columns.
- The number of rows and the number of columns must both be equal to number of treatments and each treatment occurs once in each row & once in each column.
- The principle use of LSD in forestry research is in nursery & glass house experiments
- Specially used when the variations are in two direction & perpendicular to each other. For example, if a forest researcher wants to estimate the effect of 4 different fertilizers (say) A, B, C & D in the growth of nursery seedlings of 4 different species (row) & 4 different age groups (column), he has to use the design LSD.

**Randomization & layout**

The process of randomization & layout for LSD is shown below for the experiment with four different treatments A, B, C & D cited above. In this experiment the researcher has to divide the total experimental land in 4×4 = 16 experimental units.

**Step 1**: The whole experimental area is divided into $4^2 = 16$ experimental units arranged in a square so that each row as well as each column contains 4 units.

**Step 2**: The 4 treatments are then allocated to these rows & columns in such a way that every treatment comes once & only once in each column. The randomization can be shown follows:

Gradient ⟶

| | | Columns (age of seedlings) | | | |
|---|---|---|---|---|---|
| | | 1(3month) | 2(4month) | 3(5month) | 4(6month) |
| Rows (species) | 1 | A | B | C | D |
| | 2 | B | C | D | A |
| | 3 | C | D | A | B |
| | 4 | D | A | B | C |

Layout of LSD

**Mathematical model & statistical analysis**

$$y_{ij} = \mu + \alpha_i + \beta_j + \gamma_k + e_{ijk} \quad \ldots\ldots\ldots(1) \quad i = 1,2,\ldots\ldots t$$

$$j = 1,2\ldots\ldots t$$

$$k = 1,2,\ldots\ldots t$$

$y_{ijk}$ = yield or response of the $k^{th}$ treatment in $i^{th}$ row & $j^{th}$ column

$\mu$ = general mean effect

$\alpha_i$ = effect due to $i^{th}$ row

$\beta_j$ = effect due to $j^{th}$ column

$\gamma_k$ = effect due to $k^{th}$ treatment

$e_{ijk}$ = error effect due to chance

**Assumptions**

- All the observations are independent
- Different effects are additive in nature
- $e_{ijk}$ are identically & independently distributed $N(0, \sigma_e^2)$
- $\sum \alpha_i = 0$, $\sum \beta_j = 0$, $\sum \gamma_k = 0$, or $\alpha_i \sim N(0, \sigma_\alpha^2)$, $\beta_j \sim N(0, \sigma_\beta^2)$, $\gamma_k \sim N(0, \sigma_\gamma^2)$

**Hypothesis**

$H_{0\alpha}$ : $\mu_{1..} = \mu_{2..} = \mu_{3..} = \ldots\ldots\ldots\ldots\ldots\ldots = \mu_{t..} = \mu$
i.e. $\alpha_1 = \alpha_2 = \alpha_3 = \ldots\ldots\ldots\ldots\ldots\ldots = \alpha_t = 0$
$H_{1\alpha}$ : $\mu_{1..} \neq \mu_{2..} \neq \mu_{3..} \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \mu_{t..}$
i.e. $\alpha_1 \neq \alpha_2 \neq \alpha \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \alpha_t \neq 0$

$H_{0\beta}$ : $\mu_{.1.} = \mu_{.2.} = \mu_{.3.} = \ldots\ldots\ldots\ldots\ldots\ldots = \mu_{.t.} = \mu$
i.e. $\beta_1 = \beta_2 = \beta_3 = \ldots\ldots\ldots\ldots\ldots\ldots = \beta_t = 0$
$H_{1\beta}$ : $\mu_{.1.} \neq \mu_{.2.} \neq \mu_{.3.} \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \mu_{.t.}$
i.e. $\beta_1 \neq \beta_2 \neq \beta_3 \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \beta_t \neq 0$

$H_{0\gamma}$ : $\mu_{..1} = \mu_{..2} = \mu_{..3} = \ldots\ldots\ldots\ldots\ldots\ldots = \mu_{..t} = \mu$
i.e. $\gamma_1 = \gamma_2 = \gamma_3 = \ldots\ldots\ldots\ldots\ldots\ldots = \gamma_t = 0$
$H_{1\gamma}$ : $\mu_{..1} \neq \mu_{..2} \neq \mu_{..3} \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \mu_{..t}$
i.e. $\gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \ldots\ldots\ldots\ldots\ldots\ldots \neq \gamma_t \neq 0$

**Advantages**

- Because of the two way blocking or stratification LSD controls more of the variations than CRD & RBD.
- Greater sensitivity – row & column variation is removed from error
- Easy analysis
- Several LSD of the same size may be combined and it is suitable for 5-9 no. of treatments

**Disadvantages**

- To obtain equal number of row, column & treatment is often difficult.

When number of treatment is large, design become impracticable because of the large number of replication required and when number of treatment is small, design gives few error degrees of freedom.

**Factorial Experiment (multiple -factor Experiment)**

An experiment in which the treatment consists of all possible combinations of the selected levels in two or more factors is referred to as factorial experiment.

They are especially important in several economic and social phenomena where usually a large no. of factors affect a particular problem. In this design the treatments consist of combination of different levels of two or more factors. A fully factorial experiment is a highly efficient way of obtaining information on each of the treatment factor & on the extent to which they interact with each other.

**$2^2$ Factorial designs:**

For example, suppose we want to find out the effect of two different fertilizer (factors) nitrogen (N) & potash (K) on the production of certain crop by using the two different amount of each fertilizer as 20 & 25kg.Here we can use factorial experiment.

Let each level of each factor is denoted as $N_0$, $N_1$, $K_0$, $K_1$ then we obtain four-treatment combination as shown below;

| Factor K | | Factor N | |
|---|---|---|---|
| | | 20kg( $N_0$) | 25kg($N_1$) |
| | 20kg($K_0$) | $N_0K_0$ | $N_1K_0$ |
| | 25kg ($K_1$) | $N_0K_1$ | $N_1 K_1$ |

These 4 treatment combinations can be compared by laying out the experiment in

(i) R.B.D., with r replicates (say), each replicate containing 4 units, or (ii) 4x4 L.S.D., and ANOVA can be carried out accordingly. In the above cases, there are 3 d.f. associated with the treatment effects.

In factorial experiment our main objective is to carry out separate tests for the main effects N, K and interaction NK.

| Replication I | Replication II | Replication III |
|---|---|---|
| $N_0K_0$ | $N_1K_0$ | $N_0K_0$ |
| $N_0K_1$ | $N_1$ $K_1$ | $N_1$ $K_1$ |
| $N_1K_0$ | $N_0K_1$ | $N_1K_0$ |
| $N_1$ $K_1$ | $N_0K_0$ | $N_0K_1$ |

A sample layout of 2x2 factorial experiment in a RCBD with 3 replications

Similarly, ANOVA of a two- factor experiment on bamboo involving two levels of spacing (Factor A) and three levels of age at planting (Factor B) laid out in RCBD with three replications is given below

| Age at planting (month)(FactorB) → Levels ↓ | Spacing (m)(Factor A) | |
|---|---|---|
| | 10 mx10 m (a1) | 12m x 12m (a2) |
| 6 (b1) | a1b1 | a2b1 |
| 12 (b2) | a1b2 | a2b2 |
| 24 (b3) | a1b3 | a2b3 |

**The 2x3 factorial treatment combinations of two levels of spacing and three levels of age**

**Advantages:**

- Flexibility- any number of factors as well as any number of levels can be used subject to the available resources.
- Factorial treatments may be used in any experimental design
- Interaction of the treatments can be investigation
- In the absence of interaction number of replication increases.

**Disadvantages**

- More complex if any observation is missing
- If interaction is present, the results are more difficult to interpret
- If the number of factors & the levels are large, the size of the experiment is large

## Unit 5: Methods of data collection

### 5.1:Sampling techniques

**Population (or universe):A** population or universe is an aggregate of objects (units), animate or inanimate under study. In other words, population means the large group from which the samples are drawn or the group of individuals under study is known as population or universe.

The population may be **finite** or **infinite**.

**Sample :**A finite subset of the population selected from it for the purpose of investigation is called a sample & the no. of units included in the sample is called "sample size" For e.g. If 10 trees are selected out of 50, the 10 selected trees are called sample & no. of items in the sample is called sample size (n).

**Sampling units :**The population is divided into suitable units for the purpose of sampling & these are called sampling units. In other words, before selecting the sample, the population must be divided into parts that are called "sampling units".

**Types of sampling units in forest surveys are:**

- Compartments
- Topographical sections
- Strips of a fixed width
- Plots of definite shape and size

**Types of sampling units in socio-economic surveys are:**

- Geographical units : ecological regions, districts, cities, wards
- Structural units : a house, a flat
- Social group units : a family, a school, a club
- Individuals

**Sampling Frame: The** list of sampling units from which the sample units are to be selected is called sampling frame.

**Parameters**:The statistical constants, which are taken from population, are called parameters. The population mean, variance, C.V. etc. are parameters. The problem in sampling theory is to estimate the parameters from a sample by a procedure that makes it possible to measure the precision of the estimates.

**Statistic**:The statistical constants that are taken from sample are called statistic. For example, sample mean, sample variance etc.

Census & sampling

**Definition**: For any statistical investigation, we need statistical data. These types of data can be collected by two methods.

(i) Census method
(ii) Sampling method

**(i)Census Method**

In this method, the information is collected from each & every unit of the population that makes the subject matter under study. It is complete enumeration method.

**Merits**

(i) Complete information about population is obtained.
(ii) Result accurate, reliable.
(iii)Suitable for if area under study is not so vast.

**Demerits**

(i) More time
(ii) More labours
(iii)Expensive
(iv)Not suitable for destructive testing
(v) Not suitable for infinite / hypothetical population

**(ii) Sampling Method**

In this method, the information is obtained only from a part of the population assuming that it is the representative of the whole. A part is studied & on that basis, the conclusion is drawn for the entire population.

**Scope of sampling**

1) Less time
2) Reduced cost
3) Administrative convenience
4) Better supervision
5) Checks result of census method
6) Suitable for infinite / hypothetical population
7) Suitable for destructive testing

**Steps in sampling**

The following are the 6 some basic steps in sampling;

1) Defining the population to be covered
2) Defining sampling units
3) Acquiring frame / list of the population elements (Sampling units)

4) Deciding about the size of the sample.
5) Deciding about the type of the sample to be used.
6) Testing the reliability of the sample

**Sampling errors & Non-sampling errors**

The errors involved in the collection, processing & analysis of data may be broadly classified under the following two heads.

(i) Sampling errors (ii) Non-sampling errors

**i. Sampling errors:**

Sampling errors have their origin in sampling & arise due to the fact that only a part of the population has been used to estimate population parameters & draw inferences about the population. As such the sampling errors are absent in a census.

**Sampling errors** are mainly due to the following reasons:

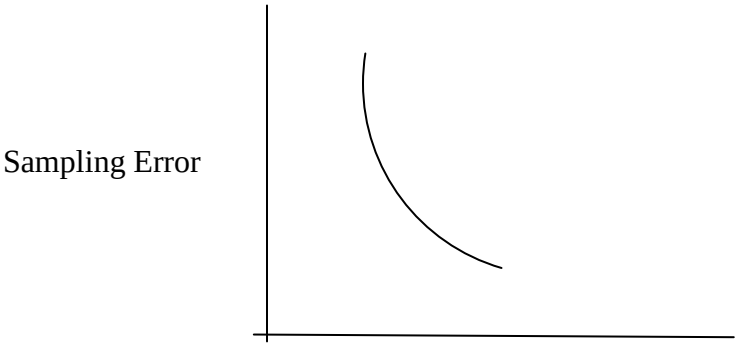
(1) Faulty selection of the sample:
Some of the bias is introduced by the use of defective sampling technique for the selection of a sample

(2) Substitution:
If difficulties arise in enumerating a particular sampling unit included in the random sample, the investigators usually substitute a convenient member of the population.

(3) Faulty demarcation of the sampling units
Bias due to defective demarcation of sampling units is particularly significant in area surveys such as agriculture experiments in the field or crop cutting survey.

(4) Constant error due to improper choice of the statistics for estimating the population parameter.

Increases in the sample size (i.e. no. of units in the sample) usually results in the decrease in sampling error.




## ii. Non-sampling Errors

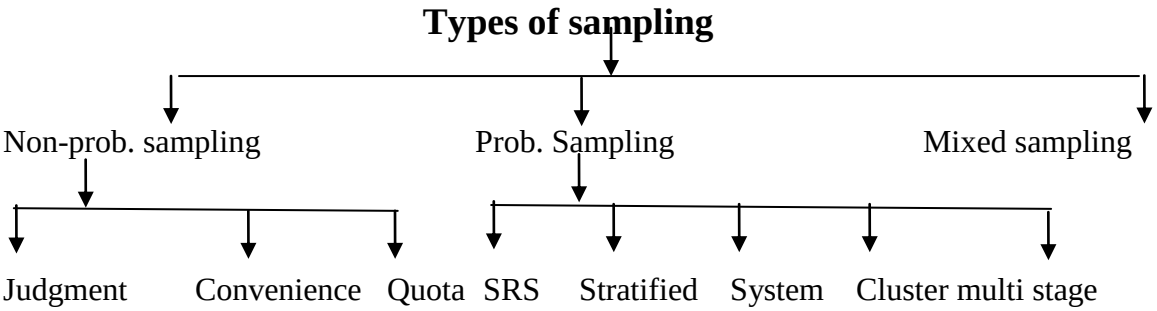
These errors can occur at every stage of the planning or execution of census or sample survey. Some of the more important non-sampling errors arise from the following factors:

**(1) Faulty planning or Definitions :** Here, non-sampling errors are due to
(a) Data specification being inadequate & inconsistent with respect to the objectives of the survey.
(b) Error due to location of the units & actual measurement of the characteristics, errors in recording the measurements, errors due to ill designed questionnaire etc.
(c) Lack of trained & qualified investigators & lack of adequate supervisory staff.

**(2) Response Errors**
These errors are introduced as a result of the responses furnished by the respondents & may be due to any of the following reasons:
(i) Response errors may be accidental

(ii) Prestige bias
(iii) Self-interest
(iv) Bias due to interviewer
(v) Failure of respondent's memory

**(3) Non-response Bias**
**(4) Errors in coverage**
**(5) Compiling Errors**
**(6) Publication Errors**




**(1) Non-Probability Sampling**

These are such methods which do not provide every item in the universe with a known chance of being included in the sample. The selection process is, at least, partially subjective.

**Types of Non-Probability sampling**

**(a) Judgment (Purposive, deliberate or subjective)**

In this method of sampling, the investigator exercises his judgment in the choice & includes those items in the sample which he thinks are most typical of the universe with regard to the characteristics under investigation.

**Merits**

(i) When only a small no. of sampling units is in the universe, simple random selection may miss important elements, whereas judgement selection would certainly include them in the sample.

(ii) When we want to study some unknown traits of a population, some of whose characteristics are known, we may then stratifying the population according to these known properties & select sampling units from each stratum on the basis of judgment.

This method is used to obtain a more representative sample.

(iii) Judgment sampling is then the only practical method to arrive at solutions to their urgent problems.

**Limitations**

(i) Not scientific because the population units to be sampled may be affected by the personal prejudice (opinion) or bias of the investigator.
(ii) There is no objective way of evaluating the reliability of sample results.

**(b) Convenience Sampling**

A. Convenience sample is obtained by selecting convenience population units. In this sampling, that fraction of population being investigated which is selected neither by probability nor by judgment but by convenience. A sample obtained from such as telephone directories etc. is a convenience sample.

**Merits**

(i) Suitable for project report establishment.
(ii) Useful for making pilot studies.

(iii)Questions may be tested& preliminary information may be obtained by this method before the final sampling design is decided upon.

**Demerits**

(i) Hardly be representative of the population.

(ii) Generally biased & unsatisfactory.

**c. Quota Sampling**

It is most commonly used non-probability sampling. In a quota sample, quotas are set up according to some specified characteristics such as income, age, political, or religious group etc. Each interviewer is then asking to interview a certain no. of persons which constitutes his quota. Within the quota, the selection of sample items depends on personal judgment. Opinion surveys are mostly conducted by using this method.

**d. Accidental Sampling**

A form of non-probability sampling in which one takes available samples at hand. This form of sampling should not be used at all.

**e. Self-selected sampling**

Sometimes a sample is not actually selected but people themselves are to be included in the sample. E.g. Inquiry about the people likes a particular TV program. Here the sample is not fixed. Those who care to reply forms the part of the sample. Such a sample is called a self selected sample.

This type of sampling relies on previously identified members of a group to identify other member of the population. As newly identified members name others, the samples snowballs. This technique is useful when a population listing is unavailable. To obtain secrete information, it is also useful.

**2. Probability Sampling**

It is the scientific method of selecting samples according to some laws of probability /chance. Types of probability sampling are:

(1) Simple random sampling

(2) Stratified random sampling

(3) Systematic sampling

(4) Cluster sampling

**(1)Simple random sampling**

It is the technique of drawing a sample in such a way that each unit of the population has an equal & independent chance of being selected in the sample. From theoretical considerations, SRS is the simplest form of sampling and is the basis for many other sampling methods. It is most applicable for the initial survey in an investigation and for studies that involve sampling from a small area where the sample size is relatively small.

SRS may be with or without replacement.

(i) SRS with replacement (SRSWR)

(ii) SRS without replacement (SRSWOR)

In SRSWR, a chosen element is always replaced before the next selection is made but not replaced in SRSWOR.

If sampling units =N

No. of sample size = sample units = n

Then, In SRSWR, probability of each draw = 1/N

But In SRSWOR, Prob. of $1^{st}$ draw = 1/N& other are 1/N-1, 1/N-2, ……..1/N – n-1

But in actual practice, SRSWOR is done

(SRSWR is generally done for an infinite population)

**Mean & variance**

In SRS,

*Sample mean,* $\overline{x_n} = \frac{\sum x}{n}$

Sampling variance, $s^2 = \frac{1}{(n-1)} \sum \left(x - \bar{x}\right)^2$

$$= \frac{\sum x^2 - \frac{\left(\sum x\right)^2}{n}}{n-1}$$

**2 conditions**

(i) When sampling is done without replacement (SRSWOR) from a finite population (N)

Then, variance of mean

Variance $(\overline{x_n}) = s^2/n \quad (1\text{-}n / N)$ - (i)

(ii) When sampling is done with replacement (SRSWR) from infinite population

Then, variance $(\overline{x_n})$ = var $(\overline{x_n}) = s^2/n$ - (ii)

From above (i) & (ii) expressions, we see that the variance of the sample mean in SRSWR is more than that of SRSWOR. This means SRSWOR provides on more efficient estimator of the sample mean relative to SRSWR.

**Selection of SRS by (SRSWOR)**

(1) Lottery method - Lotto

(2) By random no. table method - Bingo

**Advantages**

(1) SRS is a scientific method & there is no possibility of personal bias.
i.e. the sample mean is an unbiased estimate of population mean.

$E(\overline{x_n}) = \mu$

(2) Estimation methods are simple & easy.

**Disadvantages**

(1) If sample chosen is widely spread, takes more time & cost.

(2) A population frame or list is needed.

(3) For a given precision, SRS usually requires larger sample size as compared to stratified random sampling.

The irregular distribution of the sampling units in the forest area in SRS may be of great disadvantage in forest areas where accessibility is poor & costs of travel & locating the plots are considerably higher than the cost of enumerating the plot.

When to use

- If the population is not widely spread geographically.
- If the population is more or less homogenous w.r.t. the characteristics under study.

SRS is most applicable for the initial survey in an investigation & for studies that involve sampling from a small area where the sample size is relatively small.

**(2) Stratified random sampling**

In this sampling, total population **(**heterogeneous) is divided into sub-populations called strata of same or different size in such a way that characteristics within the strata are homogenous but between the strata is heterogeneous. Then samples are taken from each stratum by SRS or any other methods regarding to optimum or proportional allocation methods. For e.g. the yield rate of rice is different (heterogeneous) with geographical regions of our country, then, we use stratified random sampling.

**(i) Proportional allocation**:

When information regarding the relative variances within strata and cost of operations are not available, the allocation in the different strata may be made in proportion to the number of units in them or the total area of each stratum.

If N be the total number of sampling units in the population, Ni be the number of sampling units in the ith stratum (i=1,2,3…….k), ni be the no. of sample units selected with srswor from the ith stratum, k be the no. of strata and n be the total sample size from all the strata, then

sample size selected from each stratum in proportional allocation method is as follows,

$n_1 = (N_1/N) \times n$

$n_2 = (N_2/N) \times n$

.

.

$n_j = (N_j/N) \times n$

In general,

$N_i = (N_i/N) \times n$

Where i = 1, 2 ……. k

This means larger size strata receive large size sample values.

Then, we can say , $\mathbf{n_i \propto N_i}$

**(ii)Neyman's optimum allocation**:

It is the determination of the ni's is to choose them so as to

I. Minimize the variance (i.e. Maximize the precision) of the estimate for

√(a) Fixed sample size n (b)Fixed cost

II. Minimize the total cost for fixed desired precision

**(a) Fixed sample size n**

Other things being equal, a larger sample may be taken from a stratum with a larger variance so that the variances of the estimates of strata means get reduced. The application of the above principle requires advance estimates of variation within each stratum. These may be available from a previous survey or may be based on pilot surveys of a restricted nature. Thus if this information is available, the sampling fraction in each stratum may be taken proportional to the standard deviation of each stratum.

Under this allocation, Sample size for each stratum is given by

$\mathbf{n_i \propto N_i S_i}$ **where $S_i^2$=Population mean square of the ith stratum**

$$\mathbf{n_i = \frac{n N_i S_i}{\sum N_i S_i}}$$

This suggests that greater the value of $N_iS_i$ for a given stratum, greater is the number of sample units to be selected from the stratum in order to obtain the most precise estimate of the population mean.

**(b)For fixed cost** :In case the cost per unit of conducting the survey in each stratum is known and is varying from stratum to stratum, an efficient method of allocation for minimum cost will be to take large samples from the stratum where sampling is cheaper and variability is higher. To apply this procedure one needs information on variability and cost of observation per unit in the different strata.

$$\mathbf{n_i \propto \frac{N_i S_i}{\sqrt{Ci}}}$$

$$\mathbf{n_i = \frac{n N_i S_i/\sqrt{Ci}}{\sum (N_i S_i/\sqrt{Ci})}}$$ **Where Ci=Cost per unit in the stratum**

This leads to the following important conclusion:

A larger sample would be required from a stratum if

i. Stratum size (Ni) is large

ii. Stratum variability (Si) is large

iii. Sampling cost per unit is low in the stratum

Criteria of stratification of forest area
(i) Topographic features
(ii) Forest type
(iii) Density classes
(iv) Volume classes
(v) Height classes
(vi) Age classes
(vii) Site classes etc.

**Advantages (Merits)**
(i) More representatives than SRS & SYS
(ii) Greater accuracy (more efficient) than SRS
(iii) Administrative convenience

**Demerits (Disadvantages)**
(i) More time & cost due to wide geographical area.
(ii) Sampling units for each stratum is necessary or separate frame is needed for each stratum.
(iii) Need prior & additional information about population & its subpopulation. For eg. The volume estimates obtained at a previous inventory of the forest area may be used for stratification of the problem.

**When to use:**
(i) When the sampling units (population units) are heterogeneous w.r.t. Characteristics under study.
(ii) If the sampling problems differ in various sections of the population.

**(3) Systematic Sampling (SYS)**

Sys is a commonly employed technique if the complete & up to date list of the sampling units is available. This consists in selecting only the $1^{st}$ unit at random, the rest being automatically selected according to some predetermined patterns involving regular spacing of units. Let us suppose that N sampling units are serially numbered from 1 to N in some order & a sample of size n is to be drawn such that

$N = nk \longrightarrow K = N/n$

Where, K = Sampling interval (an integer)

Systematic sampling consists in drawing a random number say $i \leq k$ & selecting the unit corresponding to this number & every $k^{th}$ unit subsequently. Thus the systematic sample of size n will consists of the units.

i, i+k, i+2k …… i+ (n-1) k

The random no, "i" is called the random start & its value determines the whole sample.

For e.g., let there are 195 trees (whose diameters are needed) & we have to select 10 trees from these 195 trees.

Then, Sampling fraction K = N/n = 195/10 = 19.5 ~ 20

Then, say $1^{st}$ random start i = $8^{th}$ tree (say)

Then, sample selected tree no. are i, i+k i+2k i+ (n-1) k

8 28 188

Tree diameter recorded on a systematic sample of 10 trees from a plot

| **Selected tree no** | Diameter at breast height (cm)x |
|---|---|
| 8 | 100 |
| 28 | 110 |
| 48 | 120 |
| 68 | 115 |

| | |
|---|---|
| 88 | 120 |
| 108 | 110 |
| 128 | 100 |
| 148 | 120 |
| 168 | 110 |
| 188 | 115 |

Measure of every kth tree along a certain compass bearing is an example of systematic sampling. A common sampling unit in forest surveys is a narrow strip at right angles to a base line and running completely across the forest. If the sampling units are strips, the scheme is known as systematic sampling by strips. Another possibility is known as systematic line plot sampling where plots of fixed size and shape are taken at equal intervals along equally spaced parallel lines. In the latter case, the sample could as well be systematic in two directions.

Notice that the precision increases with the number of independent systematic samples. A theoretically valid method of using the idea of systematic samples and at the same time leading to unbiased estimates of the sampling error is to draw a minimum of two systematic samples with independent random starts.

**Advantages (Merits)**

(i) This method is simple, administrative easier, cheaper & quicker or, It is very easy to operate & checking can be done quickly.

(ii) It is possible to select a sample in the field without as sampling frame.

**Disadvantages (Demerits)**

(i) If the population is not in random order, one cannot validly estimate parameter of the population.

(ii) Not suitable for more heterogeneous data.

(iii) Not suitable for infinite population

**When to use**

(i) If the complete & up to date lists of the sampling units are available, it is suitable.

(ii) Suitable for chronological (classification according to time), alphabetical or numerically ordered data for e.g. Names in a telephone directory, Hospital records etc.

(iii). When we wish to draw documents from a file, particularly if the file is in chronological order.

## 4. Cluster Sampling

The population is divided into non-overlapping groups called clusters. A sample of clusters are selected.

The clusters are the primary units of sampling. The members of the

clusters are the secondary units.

**Cluster sampling** refers to a sampling method that has the following properties.

- The population is divided into $N$ groups, called **clusters**.
- The researcher randomly selects $n$ clusters to include in the sample.
- The number of observations within each cluster $M_i$ is known, and $M = M_1 + M_2 + M_3 + ... + M_{N-1} + M_N$.
- Each element of the population can be allocated to one, and only one, cluster.

Two types of **cluster sampling** methods.

- **One-stage cluster sampling**. All of the elements within selected clusters are included in the sample.
- **Two-stage cluster sampling**. A subset of elements within selected clusters are randomly selected for inclusion in the sample.

## Cluster Sampling: Advantages and Disadvantages

Assuming the sample size is constant across sampling methods; cluster sampling generally provides less precision than either simple random sampling or stratified sampling. This is the main disadvantage of cluster sampling.

Given this disadvantage, it is natural to ask: Why use cluster sampling? Sometimes, the cost per sample point is less for cluster sampling than for other sampling methods. Given a fixed budget, the researcher may be able to use a bigger sample with cluster sampling than with the other methods. When the increased sample size is sufficient to balance the loss in precision, cluster sampling may be the best choice.

## When to Use Cluster Sampling

Cluster sampling should be used only when it is economically justified - when reduced costs can be used to overcome losses in precision. This is most likely to occur in the following situations.

- Constructing a complete list of population elements is difficult, costly, or impossible. For example, it may not be possible to list all of the customers of a chain of hardware stores. However, it would be possible to randomly select a subset of stores (stage 1 of cluster sampling) and then interview a random sample of customers who visit those stores (stage 2 of cluster sampling).

- The population is concentrated in "natural" clusters (city blocks, schools, hospitals, etc.). For example, to conduct personal interviews of operating room nurses, it might make sense to randomly select a sample of hospitals (stage 1 of cluster sampling) and then interview all of the operating room nurses at that hospital. Using cluster sampling, the interviewer could conduct many interviews in a single day at a single hospital. Simple random sampling, in contrast, might require the interviewer to spend all day traveling to conduct a single interview at a single hospital.
- Even when the above situations exist, it is often unclear which sampling method should be used. Test different options, using hypothetical data if necessary. Choose the most cost-effective approach; that is, choose the sampling method that delivers the greatest precision for the least cost.

### The Difference between Strata and Clusters

Although strata and clusters are both non-overlapping subsets of the population, they differ in several ways.

- All strata are represented in the sample; but only a subset of clusters are in the sample.

- With stratified sampling, the best survey results occur when elements within strata are internally homogeneous. However, with cluster sampling, the best results occur when elements within clusters are internally hetergeneous.

**MULTISTAGE CLUSTER SAMPLING**

The population is divided in non-overlapping groups called clusters. A sample of clusters are selected.

The clusters are the primary units of sampling. The memebrs of the clusters are the secondary units. If all the members of each selected cluster are included in our sample (of secondary units), the method is called a one-stage cluster sampling. If we take a random sample of each selected cluster, the method is called a two-stage cluster sampling. The secondary units may themselves be groups of tertiary units, and we carry on into subsampling tertiary units from the selected secondary unit, etc. this is called a multi-stage cluster sampling scheme.

For example, in surveying the performance of school children, the country may be divided into areas (which form the primary units), schools within the areas form the secondary units, the classes within the schools form the tertiary units and the children within the classes form the main objects of the study population.

Reasons for cluster sampling

1. It may be very expensive to compile a list of all the members of the population we want to interview, but relatively cheap to form a list of all the clusters, e.g. all the schools.
2. The cost is reduced, if the cost increases as the distance between the members increases.

## Size of the sample (different Formulas)

The no. of sample units in the sample is known as sample size. In sampling analysis one question is always arise "What should be the size of the sample or how large or small should be "n"? If n is too small, it may not serve to achieve the objectives & if it is too large, we may face huge cost & waste resources.

As a general rule, sample must be of an optimum size ie it should neither be excessively large nor too small. With this optimum sample size one can achieve reliable, efficient & representatives of the estimation of the population.

**Factors affecting the size of the sample**

(1) Nature of population (Universe)
   If the items of the population are homogenous, a small sample can fulfill the objective but if heterogeneous, a large sample is necessary.
(2) No. of classes. The larger the no. of classes (or sub classes), larger should be the size of the sample.
(3) Nature of the study
   For intensive & continuously studying, sample should be small. For a general survey, the size of the sample should be large.
   For extensive & not repeated nature – large sample gives good result.
(4) Type of sampling
   For SRS, large sample size
   But for stratified & sys RS, small sample size gives good result.
(5) Standard of accuracy (or precision) required

If the standard of accuracy or the level of precision is to be kept high, we shall require relatively large sample.

(6) Other considerations

Nature of units, size of population, availability of finance, size of questionnaire, availability of trained investigators, the conditions under which the sample is being conducted, the time available for completion of study are other considerations to which a researcher must pay attention while selecting the size of the sample

There are some methods to determine the optimum sample size for a given level of Significance.

**FORMULA I**

**1. Sample size for large population (z-test)**

**i. For infinite population**

We have, $z_\alpha = (\bar{x} - u) / \sigma/\sqrt{n}$

$Z_\alpha = e /(\sigma/\sqrt{n})$

$$\mathbf{n = (\sigma.z_\alpha)^2 / e}$$

Where, $\sigma$ = Standard deviation of the population (to be estimated from past experience or on the basis of a trial sample)

$z_\alpha$ = z value at $\alpha$ level of significance

error = $e = (\bar{x} - \mu)$ = acceptable error (the precision)

**ii.For finite population**

$$\mathbf{n = z_\alpha^2.N.\sigma^2 / \{(N-1)\, e^2 + z^2\, \sigma^2\}}$$ N = size of population

**Table**

| Critical $z_\alpha$ value | | Level of significance $\alpha$ | |
|---|---|---|---|
| | | 1% (99% confidence) | 5% (95% confidence) |
| Two-tailed test | Right | +2.58 | +1.645 |
| | Left | -2.326 | -1.645 |

**2.Sample size for estimating proportion**

**i. For infinite population**

$$\mathbf{n = z_\alpha^2 p.q / e^2)}$$

**ii.For finite population**

$$\mathbf{n = z_\alpha^2.p.q.N / \{e^2(N-1) + z^2_\alpha.p.q\}}$$

Where, p = Sample proportion (May be on the basis of our experience or past data or pilot survey)

q = 1-p

**FORMULA II** :

Sample size determination

$$\mathbf{n = \frac{1}{1/no + 1/N}}$$

**Where, no = {Zα/2 *σ / d}2**

**And d = Zα/2 * SE of mean**

**$= Z\alpha/2 * [( N-n)/Nn]½ * \sigma$**

**All other symbols have their usual meanings**

## FORMULA III :Size of the sample

Sample size is More or less independent of population size

Formula for determining sample size (Krejcie and Morgan, 1970).

**Sample size** $n = \frac{\chi^2 NP(1-P)}{C^2(N-1)+\chi^2 P(1-P)}$

Where $\chi^2$ is the chi-square value for 1 degree at some desired probability level;N is the population size(which gets more important as N gets smaller);P is the population parameter of a variable;and C is the **level of significane** you choose.
Since P is what we want to estimate with a sample, we will always set P to 0.5 in this formula. The chi-square value for 1 degree of freedom at the .05 level of significance is 3.841.

**Size of the sample required for various population sizes at 5% level of significane**

| Population size | Sample size |
|---|---|
| 50 | 44 |
| 100 | 80 |
| 150 | 108 |
| 200 | 132 |
| 250 | 152 |
| 300 | 169 |
| 400 | 196 |
| 500 | 217 |
| 800 | 260 |
| 1,000 | 278 |
| 1,500 | 306 |
| 2,000 | 322 |
| 3,000 | 341 |
| 4,000 | 351 |
| 5,000 | 357 |
| 10,000 | 370 |
| 50,000 | 381 |
| 1,000,000 | 384 |

*Source: Krejcie and Morgan (1970)*

## FORMULA IV

**Sample size formula by solvin (1970)**

**$n = \frac{1}{}$**

**$1+Ne^2$, Where P= population size and e is margin of error.**

## 5.2:Social Survey

The basic procedure in survey is that people are asked a number of questions on that aspect of behavior which the sociologist is interested in. A number of people carefully selected so that their representation of their population being studied are asked to answer exactly the same question so that the replies to different categories of respondents may be examined for differences. One type of survey relies on contacting the respondents by letter and asking them to complete the questionnaire themselves before returning it. These are called Mail questionnaires. Sometimes questionnaires are not completed by individuals separately but by people in a group under the direct supervision of the research worker. A variation of the procedure can be that a trained interviewer asks the questions and records the responses on a schedule from each respondent.

These alternate procedures have different advantages and disadvantages. Mail questionnaires are relatively cheap and can be used to contact respondents who are scattered over a wide area. But at the same time the proportion of people who return questionnaires sent through post is usually rather small. The questions asked in main questionnaires have also to be very carefully worded in order to avoid ambiguity since the respondents cannot ask to have questions clarified for them. Using groups to complete questionnaires means that the return rate is good and that information is assembled quickly and fairly. Administrating the interview schedules to the respondents individually is probably the most reliable method. Several trained interviewers may be employed to contact specific individuals. The questionnaires and schedules can consist of both close-ended and open-ended questions. Also a special attention needs to be paid to ensure that the questionnaires are filled in logical order.

Where aptitude questions are included, great care must be exercised to ensure the proper words are used. In case of schedules, emphasis and interactions may also be standardized between different individuals and from respondents to respondents. Finally proper sampling techniques must be used to ensure that the sample under study represents the universe of study. In order to enhance the reliability of data collected through questionnaires and schedules, these questionnaires and schedules must be pretested through pilot studies.

**The Survey Method of Research**

Surveys are used to measure people's:

- Opinion
- Attitudes
- Beliefs
- Behaviors
- Reactions
- And attributes in response to specific questions.

Surveys can provide distribution of characteristics in a population and can accomplish this through surveying only a portion of the people (or units) in that population.

Some qualitative methods such as focus group interviews, in-depth case studies and ethnography cannot do the job which surveys can.

**Advantages of Survey**

- Relatively moderate in cost

- Relatively easy to large numbers
- Allow for anonymity of response
- Researchers can ask complex questions about respondents attitudes and behaviors.
- Data can be requested from records and other sources
- Allow time for respondents to reflect on events and report changes and feelings
- The success of survey is enhanced if combined with other methods
    1. Observation
    2. Case study, etc.

**Methods of Survey Research**

- Using mail technique
- Telephone
    - Mixed-mode

  Both mail and telephone technique

Administered under a group setting

- Workshops
- Classroom setting

Each has its own advantages and disadvantages

**Mail method of Survey Research**

- Mail is the method of choice when:
- Size of sample is large
- Visual display of questions is needed
- Educational level of respondents is high
- Respondents are dispersed in a large geographical area
- The budget is low (cost effective to use mail)
- If designed properly, mail can generate valid and reliable information
- Mail method should be avoided when:
- Target population has low education
- Survey questions are open-ended
- Sampling frames are inadequate or not available

Recommended steps in conducting a mailed survey

- Mail a pre-card
- Informing respondents of forthcoming questionnaire
- Mail first packet

First Packet should include:

- Cover letter
- Appropriately constructed letterhead, cosigned (If joint research project), individually signed, etc.
- Questionnaire
- Booklet, saddleback stapled, figure on front page, back page blank, etc.
- Pre-addressed, stamped return envelope

**First Packet should include**:

- Incentive - as appropriate
- "Return card", mailed flat, commemorative stamp, etc.

Recommended steps in conducting a mailed survey

- Postcard reminder - with rationalization
- First follow-up
- Second complete packet with new cover letter
- Postcard reminder - with rationalization

- Phone call reminders
- Other follow-ups if deemed appropriate
- Control non-response error (bias)

**Telephone method of Survey**

- Telephone is the method of choice when:
- Respondents are widely dispersed geographically
- Speed in data collection is essential
- Sample size is small
- Cost is not a big factor
- Telephone surveys may yield a higher response rate than mail surveys
- Interviewers can explain questions not understood by respondents
- Telephone surveys should be avoided when:
- We need to ask long and complex questions and/or bias from people without telephones cannot be tolerated
- Low budget (cost may be higher than mail)
- Telephone surveys require good interviewing skills
- There is a natural bias in favor of those with listed numbers and who are usually at home.
- Telephone surveys require clear and simple questions
- If respondent is unfamiliar with a caller, it may cause indifference and poor cooperation

**Mixed-Mode Survey Method of Research**

- Mixed-Mode survey is the method of choice when:
- One method won't get an adequate response rate
- Faced with sampling problems
- Mixed-mode surveys should be avoided when:
- Key evaluation question involve attitude and/or social desirability

### 5.3: Questionnaire method

It is a most popular and widely used technique in which information is obtained with the help of a questionnaire, which is prepared exclusively for the purpose. In the other words with the help of asset of questions, all the required data is collected. In this method, the investigator doesn't go to any respondents for the collection of information.

There are various definitions about questionnaire methods which are given below:

In general, the word **questionnaire** refers to a device for securing answers to questions by using a form which the respondent fills in him/herself. ---------- Goode and Hatt

A **questionnaire** is a list of questions sent to a numbers of persons for them to answers. It secures standardized result that can be tabulated and treated statistically. ------Bogardus

A **questionnaire** is generally sent through the mail to the informants to be answered as specified in a covering letter. --- P.V. Young

From above definitions, one can trace the following uniqueness (individuality) of questionnaire:

- It is an indirect technique of primary data collection.
- Mailing process is essentials in questionnaire technique.
- Questionnaire technique is self –administered.
- Respondents must be literate to use this technique.
- Larger number of respondents can be included.
- Wide area can be covered by questionnaire technique.
- It is a quantitative technique rather than qualitative.

**Advantages and Disadvantages of questionnaire method**

**Advantages**

- Through the help of post office and drop-and-collect technique a single researcher can gather data from a large and representative sample at a relatively low cost.
- Questionnaires ensure the anonymity (secrecy) of the respondents and provide sufficient time to the respondents to think, fill- up and sent it back.
- It is less expensive than other technique of primary data collection. The researcher can save his/her time, resources and efforts by proper handling of questionnaire.
- All the respondents get the same questions with a self –administered (self-managed or controlled) questionnaire; therefore there is no possibility of interviewer bias.
- Questionnaire stimulates free though and is convenient to fill up; it provides a chance for respondents to express feelings and opinions.
- Respondents report socially undesirable behaviour and traits (i.e. arrest records; alcohol dependency, family violence, premarital sexual experience etc.) more willingly in questionnaire than they do in face to face interviews.
- More complex questions can be raised in self administered questionnaire than in personal interview.
- One can put long array of items instead of questions, which is not possible to ask in personal interviews.

**Disadvantages**

- There is no control over how people interpret questions on a self administered instrument**.**
- There is possibility of low response rate in developing societies. It is difficult to draw conclusion with low response rate.
- In some cases, you may want respondents to answer a question without knowing what coming next. This is impossible in a self administered questionnaire.
- If a questionnaire is returned back, you can't be sure that the respondent who received it is the person who filled it out.
- Sometimes mailed questionnaires are prone to serious sampling problems. Sampling frames of addresses are almost always imperfect i.e. if you use a phone diary to select sample you may miss all those people who don't have phones or who choose not to list their numbers.
- The use of questionnaire is limited only up to literate respondents viz simply this is not useful for studying illiterate community/ society.
- Response is difficult if the response list is too long and sometimes response categories may be superficial or biased.
- The responses of questionnaire are totally dependent on respondent's recall and there is lack of response to help clarify the ambiguous questions.
- Hand written responses of respondents are difficult to understand.

**Types of questions**

Basically, two distinct type of questions are asked in a survey

1. **Closed ended questions**: Closed ended questionnaires are used when some sort of categorized data is required. In other words when the data needs to be put into definite classification.. In this the questions in the questionnaires are so worded that the replies can be found out from he alternative replies provided therein. For e.g.

i. Is the application of your employing agency policy consistent?

---Yes

--No

--I do not know

ii. How relevant to the requirements of your present job was your forestry training?

---Extremely relevant

----generally relevant

--- Not very relevant
---Not at all
2. **Open ended questions:** Open-ended questions allow respondents to answer in their own words rather than select from predetermined answers. For e.g.
i. What are the specific goals of your B.Sc. forestry program?
ii. What do you think should be done to improve this training program for next year?

**Characteristics of a good questionnaire**

1. It should appear professional (qualified, specialized)
2. It is short and easy to read.
3. It introduces respondents about the purpose of the evaluation, explains why their cooperation is needed, and provides clear direction to complete and return the questionnaire.
4. It is unambiguous and vocabulary used in the questionnaire should be easily understandable to the respondents.
5. The questions are organized in a logical order.
6. Branching is clear.
7. It uses capitalized key words to reduce the chance of misreading instructions.
8. A good questionnaire always provides alternatives, but doesn't use double- barreled questions.
9. It doesn't put false premises (grounds) into questions.
10. It asks both closed and open ended questions. Usually a good questionnaire ends with an open ended questions,``Are there any other comments or concerns you would like to mention?"
11. The title should reflect the content of the instruments.
12. It comes with a cover letter.
13. It has an attractive front cover.
14. The good questionnaire should end with`` thank you."

**Major processes in questionnaire**

- Constructing appropriate questionnaire
- Pre-testing and editing the questionnaire
- Covering letter
- Manage self -addressed envelop and stamped
- Dispatch(send out) by mail
- Follow up letters or telephone calls
- Collection/coding/ tabulation and reporting

**Avoiding bias and increasing responses**

It is said that there is relatively low response rate in this instrument. Therefore research should always be careful to increase the response rate of questionnaire. The main problem of questionnaire is unable to obtain adequate response rate. If less than 60% responses are obtained, the result of research cannot be generalized. More than 70% responses are adequate response rate in questionnaire.

**Factors affecting response**

A no. of factors are responsible for varying degree of response. Some of them are:

- Special characteristics of the respondent group
- Prestige of sponsoring agency
- Importance of the problem under study
- Nature of questionnaire
- Nature of reaction of the respondent
- Size of Questionnaire
- Sequence of questions

**Methods use for greater response**

The following methods are generally used for getting proper response:

- Appeal
- Inducement to reply
  --Monetary inducement
  ---Non –monetary inducement
- Follow up system
- Questionnaire sent through inter-mediators
- Time of sending the questionnaire-weekend days
- Certainty of reaching the address
-

**5.4: Interview method**

- It is oldest, common and mostly used device by researcher for data collection. It is a`` meeting" where the interviewer puts questions to the interviewee and records the responses. The meeting is always face to face.
- Communicate with each other not only through verbal interaction (words) but also through gestures, facial expressions and other visual interactions.
- Mostly interviews are pseudo conversation in nature (conversation with a purpose)

**Definitions**

- An interview can be defined as a meeting of persons face to face on some points. ----M. N .Bara
- Interview may be regarded as a systematic method by which one person enters more or less imaginatively into the inner life of another who is generally a comparatively stranger to him. -------P. V .Young
- The interview is, in a sense, an oral type of questionnaire .Instead of writing the response the subject or interviewee gives the needed information, verbally, in a face to face relationship---Best, john W.
- The interview is a face to face interpersonal sole situation in which one person being interviewed, the respondent questions to designed to obtain answers pertinent(relevant) to purpose of the research problem.----Kerlinger
- The interview is a piece of social interaction with one person asking another a no. of questions and the other person giving answer. ---T. L Baker

**Advantages of interview method**

1. Psycho- social study possible
2. Collection of manifold information
3. Study of non- visible abstract phenomena
4. Study of past events
5. Inter-stimulation interaction
6. Checking information easier
7. High response participation
8. Both inflow and outflow of ideas
9. Can be used in all types of persons
10. Possibility to explore/ study unknown events
11. Higher reliability of information

**Disadvantages**

1. Costly method
2. Faulty memory of informants
3. More time consuming
4. Value difference
5. Superiority/inferiority complex

6. Possibility of changing meaning
7. Possibility of bias of the interviewer as well as that of the respondents
8. Problem of trained interviewer
9. Problem of over stimulation (motivation)
10. Too much reliance on other
11. Problem of recording

**Kinds of interviews**

**1. Structured interview:** It is also known as control, guided and directive interview. In this type of interview, a complete schedule is used and also called schedule- cum- interview. The interview is asked to get the answer to those questions only. He/ she does not add any thing from his own side. The language too is not changed. He can only interpret or amplify the statement whenever necessary.

**2. Unstructured interview:** It is known as uncontrolled, unguided or non directive or free story method. Pre-determined questions are used in this type of interview. The field worker may be told certain broad topics upon which the information is to be collected. The subject is asked to narrate the incidents of his life, his own feelings and reactions and the research has to draw his own conclusions from it. It is generally used in the following types of inquires:

a. When pilot studies are undertaken in order to get an idea of the phenomena under study.
b.When reactions and feelings to the subject are to be studied pertaining some emotional incident.
c.When change in the mood and gesture are to be studied.

**3. Semi-structured interview:** It interviews with project participants and other key informants begin with an interview guide that lists topics to cover and open ended questions to ask. Probing (inquiring or questioning) techniques are used to solicit (seek) answers and raise new topics that reflect the people's perspective, beliefs, attitude and concerns.

**Advantages**

- It can be used in complex situations in which answers to questions cannot be predetermined.
- It can be used to generate hypothesis to guide an evaluation.
- Respondents are not confined by pre-selected choices when answering questions.
- The structure of the interview is not predetermined but develops as the interview unfolds.
- Additional questions can be asked to clarify issues or explore new ideas

## Main steps of interviews

1. **Preliminary information**

- Knowledge of problem
- Selection of interviewee
- Information of interviewee
- Fixation of time, place, date
- Construction of tools
  ----Interview guide
  ---Interview schedule

2. **Execution of interview**

- Contacting the informants
- Telling the purpose
- Appeal for co-operation
- Beginning of main interview
- Stimulation and recall
- Recording

3. **Closing of interview**

- Closing
- Vote of thanks
- Reporting

**Pre-requisites for successful interviewing**

- Providing encouragement
- Psychology of the interviewee
- Less talking and smile
- Proper dress up
- Conscious and careful
- Avoid boredom
- Be an analytical listener
- Record carefully as a trained researcher
- Avoid over reporting
- Do not impose personal values

**5.5:RRA/PRA**
**(Rapid Rural Appraisal/ Participatory Rural Appraisal)**
**Meaning**

- Rapid=Fast, Quick
- Appraisal
  The finding out of information about problems, needs, and potential in a village. It is the first stage in any project.
- **Rapid Rural Appraisal (RRA)**
  RRA is essentially a process of learning about rural conditions in an intensive, iterative, and expeditious manner.

It characteristically relies on small multidisciplinary (interdisciplinary) team that employ a range of methods, tools and techniques specifically selected to enhance understanding of rural conditions, with particular emphasis on tapping the knowledge of local inhabitants and combining that knowledge with modern scientific expertise. Many RRA tools and techniques were adopted to achieve increased accuracy at low cost, in terms of time and money.

- **Participatory Rural Appraisal (PRA**)

PRA is a label given to a growing family of participatory approaches and methods that emphasize local knowledge and enable local people to make their own appraisal, analysis, and plans. PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders. Although originally developed for use in rural areas, PRA has been employed successfully in a variety of settings. The purpose of PRA is to enable development practitioners, government officials, and local people to work together to plan context appropriate programs.

- PRA is a family of approaches and methods to enable local people to share, enhance, and analyse their knowledge of life and conditions, to plan and to act. ---Robert Chambers

## Brief Evolution of RRA/PRA Method

- RRA evolved in late 1970s as cost-effectiveness, timeliness, and quality of rural development-related research.
- Initially RRA was developed as a planning tool by development professionals after the second World War in developing countries which used to be "Top-Down" in early days.

- A workshop and conference on RRA were held at the Institute of Development Studies, University of Sussex England, in 1978 and 1979.
- A series of international conference and training/workshops on RRA were held in Khon Kaen Thailand in 1985, 1990, and 1992.
- The term "PRA" was probably first used in Kenya to describe village-level investigations, analysis, and planning undertaken by the National Environment Secretariat in association with Clark University, USA.
- PRA was evolved from RRA. The mode of RRA has been mainly "extractive". PRA grew out of biases of rural development tourism-the phenomena of the brief rural visit by the urban-based professionals-of the costs, inaccuracies, and delays of large scale questionnaire surveys.
- PRA has become more popular as an action research and planning tool since mid 1990s with the notion that people should have a basic right to be involved in decisions which directly affect them. This right is supported by the statements contained in the Agenda 21 Documents of the Rio Conference, 1992.
- Now a day, PRA has been widely used as a very useful method in Participatory Action Research and Development Planning in Natural Resource Management, Health and Nutrition, Education etc.

Difference between RRA and PRA

| | |
|---|---|
| ❖ In RRA, information is elicited and extracted by outsiders. In other words, people go to the rural areas, obtain information, and then bring it away to process and analyze. | ❖ In PRA, information is owned and shared by local peoples. Outsiders go to rural areas, but they facilitate rural people in collection, presentation and analysis by themselves |
| ❖ The information is owned by outsiders and often not shared with rural people | ❖ The information is owned by rural people but usually shared with outsiders |

Principles of PRA

1. Using optimal ignorance

This refers to the importance of knowing what it is not worth knowing. It avoids unnecessary details and irrelevant data. It does not measure precisely than is needed. It optimizes trade off between quality, relevance, accuracy, and timeliness.

2. Offsetting biases

Especially those of rural development tourism, by being relaxed and not rushing, listening not lecturing, probing instead of passing on to the next topic, being unimposing instead of important, and seeking out the poorer people and their concerns.

3. Triangulation

Using more than one, and often three, sources of information to cross-check answers/responses.

4. Learning from and with rural people

Directly, on the site, and face-to-face, gaining from indigenous physical, technical and social knowledge.

5. Learning rapidly and progressively

With conscious exploration, flexible use of methods, opportunism, improvisation, iteration, and cross-checking, not following a blueprint program but adapting through a learning process.

**Applications of PRA**

- Beneficiary Assessment
- Community Needs/Capacity Assessment
- Institutional Assessment
- Participatory Poverty Assessment
- Social Assessment
- Stakeholder Analysis

## Tools and Techniques of PRA

1. **Semi-structure Interview (SSI)**
   SSI is a PRA method that engages villagers in a conversation through a series of guide questions (not structured questionnaire) relevant to the villagers. Important information is generated by talking with villagers about topics that interest them. SSI can be used with individuals, key informants, interest groups or other small groups of villagers.

2. **Time Chart (Seasonal Calendar)**
   A time chart (seasonal calendar) is a PRA method that determines patterns and trends throughout the year in a certain village. It can be used for purposes such as rainfall distribution, food availability, agricultural production, income and expenditures, health problems, and others. The time chart can also be used to collect information on how villagers allocate their time as well as their labor in various activities within the village.

3. **Ranking**
   a) **Participatory Wealth Ranking (Wellbeing Ranking)**
      It determines the economic attributes of households in a village. It shows information on the relative wealth and well-being of households in a village. It helps in determining the social and economic status of households in a village. The information generated by the wealth ranking exercise helps in identifying the poor households in the village. Ranking is done by the villagers themselves, and as such gives the researchers insights on the actual economic conditions of the village through the eyes of the villagers.

   b) **Pair-wise Ranking**
      Helps villagers to set priorities (i.e. problems, needs, actions, etc.). Ranking can be undertaken with key informants or group of villagers that represents a good mixture of interests. It can also be conducted based on gender to determine different preferences between men and women. For simple issues (i.e. problems) villagers can rank them during the semi-structured interview. It also enables researcher to determine the villagers' preference

   c) **Mapping**

   d) **Social Mapping**

   Involves the sketching / drawing of houses and other social facilities and infrastructure (i.e. temple, schools, community center, store, rice mills, forests, farmland, commons, roads, water resources, recreation facilities, etc.) in a village. It helps to visualize and situate the location of households and other social facilities/infrastructure in a village.

   e) **Census Mapping**

   It provides more detailed information of the village with emphasis on individual households. It gives the villagers and the researchers a chance to take a closer look and better understanding of individual households in a village. It offers to as an opportunity for the villagers and the

researchers to identify indicators for planning, implementation, monitoring, and evaluation of village development activities.

4. **Venn Diagram**
   It shows the key institutions, organizations, or groups as well as influential individuals in a village and their relationships and importance in decision making. A Venn diagram can be prepared on the ground, large sheet of paper, or a blackboard. The villagers should draw their own Venn diagrams.
5. **Village Profiling**
   It provides basic information that helps both researcher and villagers to know more about a village. It provides information on the bio-physical and socio-economic condition of a village as well as its cultural and social organizations. It serves as a baseline for planning, implementation, monitoring, and evaluation of village development activities.

**Conclusion**

- A very powerful planning tools
- Empowers participants
- Users friendly
- Combinations and sequence of methods have proved powerful and practical.
- Visual sharing-Diagrams, Maps etc.
- Efficient, Participatory (Two-way), Rapid, and Relaxing.

## UNIT 6: Data analysis interpretation

**Selecting the appropriate statistical test: For differences ( 1 group)**

Key: N= Nominal I=Interval NP= non-parametric test
} Categorical data } Continuous data P=Parametric test
O= Ordinal R=Ratio

| One variable(s) scores are: | The other variable(s) scores: | Test type | Appropriate statistical test | Practical example | Typical null hypothesis |
|---|---|---|---|---|---|
| N | N | NP | Contingency coefficient | Colour preference by sex | There will be no significance relationship between Colour preference and sex of respondent. |
| N | O | NP | Contingency coefficient or Spearman's rho | Political preference by ranking in education | There will be no significance relationship between political preference and education. |
| O | O | NP | Spearman's rho | Math ranking by reading ranking within the 6th grade | There will be no significance relationship between Math ranking and reading ranking within the 6th grade. |
| O | R | NP<br><br>P | Spearman's rho<br><br>Pearson's r | Anxiety scores by self-esteem scores (Bivariate) | There will be no significance relationship between Anxiety scores and self-esteem scores |
| I | I | P | If2variables:Pearson's r/ 3 or more variables: Multiple Regression R | Anxiety scores by self-steem scores,alientation scores and IQ scores (Multi variate) | There will be no significance relationship in anxiety scores in regard to self- esteem,alientation and IQ scores |

| | | | | | |
|---|---|---|---|---|---|
| R | N | P | Discriminate analysis | Income, years in residence, years of schooling, age by respondent sex | There will be no significance relationship between respondent sex in regard to income, years of residence, years of schooling and age of respondent |
| I | N | P | Discriminate analysis | ‘’ | ‘’ |

**Selecting the appropriate statistical test: For differences (2 or more groups)**

Key:N= Nominal I=Interval NP= non-parametric test
} Categorical data } Continuous data P=Parametric test
O= Ordinal R=Ratio

| Scores are | Groups are | Test type | Appropriate statistical test | Practical example | Typical null hypothesis |
|---|---|---|---|---|---|
| N | N | NP | Chi-square | Political party preference by sex | There will be no significance difference between men and women regarding their political party preference. |
| O | N | NP | Mann-Whitney U or Chi-square | Ranking on English test by student sex | There will be no significance difference between girls and boys regarding their ranking on the English test. |
| O | O | NP | Chi- square | Grade point average rank by English achievement rank | There will be no significance difference in grade point average rank as compared to English achievement average rank. |
| I | N | P | If 2 means tested, t-test. If 3 means or more: ANOVA | Temperature by city | There will be no significance difference in mean temperature between Pokhara and Katmandu. |
| R | N | P | If 2 means tested: t-test. If 3 means or more: ANOVA | Math scores by student sex | There will be no significance difference in math scores between male and female students |

## REVIEW OF AVAILABLE STATISTICAL TESTS

To select the right test, ask yourself two questions: What kind of data have you collected? What is your goal? Then refer to below table:

Table 1. Selecting a statistical test

| | Type of Data |
|---|---|

| Goal | Measurement (from Gaussian/Normal Population) | Rank, Score, or Measurement (from Non-Gaussian Population) | Binomial (Two Possible Outcome) | Survival Time |
|---|---|---|---|---|
| **Describe one group** | Mean, SD | Median, interquartile range | Proportion | Kaplan Meier survival curve |
| **Compare one group to a hypothetical value** | One-sample *t* test | Wilcoxon test | Chi-square or Binomial test ** | |
| **Compare two unpaired groups** | Unpaired *t* test | Mann-Whitney test | Fisher's test (chi-square for large samples) | Log-rank test or Mantel-Haenszel* |
| **Compare two paired groups** | Paired *t* test | Wilcoxon test | McNemar's test | Conditional proportional hazards regression* |
| **Compare three or more unmatched groups** | One-way ANOVA | Kruskal-Wallis test | Chi-square test | Cox proportional hazard regression** |
| **Compare three or more matched groups** | Repeated-measures ANOVA | Friedman test | Cochrane Q** | Conditional proportional hazards regression** |
| **Quantify association between two variables** | Pearson correlation | Spearman correlation | Contingency coefficients ** | |
| **Predict value from another measured variable** | Simple linear regression or Nonlinear regression | Nonparametric regression** | Simple logistic regression* | Cox proportional hazard regression* |
| **Predict value from several measured or binomial variables** | Multiple linear regression* or Multiple nonlinear regression** | | Multiple logistic regression* | Cox proportional hazard regression* |

## PARAMETRIC and NONPARAMETRIC TESTS

Choosing the right test to compare measurements is a bit tricky, as you must choose between two families of tests: parametric and nonparametric. Many -statistical test are based upon the assumption that the data are

sampled from a Gaussian/Normal distribution. These tests are referred to as parametric tests. Commonly used parametric tests are listed in the first column of the table and include the t test and analysis of variance.
Tests that do not make assumptions about the population distribution are referred to as nonparametric- tests. All commonly used nonparametric tests rank the outcome variable from low to high and then analyze the ranks. These tests are listed in the second column of the table and include the Wilcoxon, Mann-Whitney test, and Kruskal-Wallis tests. These tests are also called distribution-free tests.

Your decision to choose a parametric or nonparametric test matters the most when samples are small for reasons summarized here:

| | Large samples (> 100 or so) | Small samples (<12 or so) |
|---|---|---|
| Parametric tests | Robust. P value will be nearly correct even if population is fairly far from Gaussian. | Not robust. If the population is not Gaussian, the P value may be misleading. |
| Nonparametric test | Powerful. If the population is Gaussian, the P value will be nearly identical to the P value you would have obtained from a parametric test. With large sample sizes, nonparametric tests are almost as powerful as parametric tests. | Not powerful. If the population is Gaussian, the P value will be higher than the P value obtained from a t test. With very small samples, it may be impossible for the P value to ever be less than 0.05, no matter how the values differ. |
| Normality test | Useful. Use a normality test to determine whether the data are sampled from a Gaussian population. | Not very useful. Little power to discriminate between Gaussian and non-Gaussian populations. Small samples simply don't contain enough information to let you make inferences about the shape of the distribution in the entire population. |

**Note:**
We can classify the types of variables that we might encounter, as different types of statistical procedures are appropriate depending on the type of variable.
One possible scheme is as follows:

**Two types Variable**
1. **Measurement Variable**: Two types; Continuous Variable, Discrete Variable
2. **Categorical Variable**: Two types: Ranked Variable, Attribute Variable

***1. Measurement Variable***: Values can be expressed in a meaningful numerical scale that can be measured. In biological terms these can be considered "quantitative traits".

----***Continuous Variable***: variable can (theoretically) have an infinite number of values, even over a restricted range.
**Examples**: plant height (cm); body weight (kg); soil pH
---***Discrete Variable***: restricted to certain values (with no intermediate ones). Usually, a discrete variable is a count ⇒ values of 0, 1, 2, 3, etc.
**Examples**: Number of leaves on plant; animal litter size, white blood cell counts on a Microscope slide.

***2. Categorical Variable***: Values cannot be expressed in a true numerical scale, but can be placed in categories. These can be termed "qualitative traits".

--***Ranked Variable***: The category values may be placed in a meaningful order.
**Examples**: calving ease (1 = "no intervention required", 2 = "some intervention required", 3 = "veterinarian required"); disease severity scores (e.g. 1-5). While in these cases a number has been assigned to each category, it is not a numerical measurement scale, as the difference between score 1 and 2 is not necessarily the same as the difference between score 2 and 3 etc.
--***Attribute Variable***: Values of variables are categories without any natural ordering.
**Examples**: genotype, blood cell type (basophils, eosinophils, lymphocytes etc.), lettuce variety.

## **Unit 7**: Report writing and presentation