

Research methods in plant science

(plsc 3103)

Teaching material on:
Concepts, Principles and Processes of agricultural researches

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PREFACE

We humans always need to have a healthy environment which is capable of providing all the basic requirements (air, water, food, Shelter, cloth, medications and so on) for our potential sustainability on planet earth. And in assuring all these staffs, advancements of the agricultural science has no doubt. However, its advancement and betterment of life surely depend on the practical and theoretical knowledge of the agricultural and other related scientists. Surprisingly everything depends on research starting from observation which might be checked by trying and error then being modified through deep investigation and reasoning. And, in this research oriented and dynamic world, it is really indispensable to provide formal training in research methods not only for academic and research purposes but also to enhance the capability of the society in his/her day to day life.

At higher educational institutes, the research requirements are obligatory and all the working staffs are expected to internalize the research process and develop loyalty to the research ethics and its application. Basically, research is an integral part of the teaching - learning process. Without research, it becomes sterile and fails to serve the intended purpose of university education. It can be argued that students are both the reasons and instruments of research in a university setting. In this context, the objectives of conducting research in universities are stated as follows:

- ✓ To improve and ensure the quality of education for the satisfaction of a nation by producing a qualified and competent graduate. In this respect, university research activities are expected to:
 - Upgrade the quality of the teaching-learning process with the use of current information drawn from research findings;
 - Equip students with research skills and ethics to promote desirable scientific attitudes and behavior like integrity, objectivity and most of all honesty in all sort of research undertakings;
- ✓ To produce improved technologies and solutions for current and potential socio-economic problems
- ✓ To advance or extend the horizons of knowledge and through the process deepen the cultural levels of society.

Universities address these objectives in three ways:

- ✓ **Formal course offerings:** practical oriented courses contribute a lot towards building up research competence.
- ✓ **Staff research:** the instructors are expected to carry out research and related activities for updating their professional competence and solving sound problems.
- ✓ **Student research:** instruct students to use scientific knowledge, statistical tools and research methods in class, laboratories and on the field.

Thus, this material on research methods in plant science mainly gives a clue to the basic concepts, principles and processes of agricultural researches and make students aware of the research methodology as applied to plant science and/ or horticulture; understood how to formulate a research project and how to execute it; had a general idea about farming research; been able to layout and conduct field experiments, and to write research reports and to present it. Moreover, it deals with scientific approach; research and its types; a brief history of Ethiopian research in plant sciences and its organization; principles of research planning; methods of gathering information for formulation of research questions, their prioritization; research proposal and its preparation; farming systems research (FSR) and on farm research- introduction and methodology; the use of formal and informal methods of FSR approaches; laying out and conducting field and laboratory experiments - principles and practices; scientific reports types and their characteristics; styles commonly used; principles of writing research papers; styles used by common scientific journals; presentations of research results.

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CHAPTER 1

INTRODUCTION

1.1. Definitions and Scope of Research

Research is a term loosely used in daily life and it consists two syllables (re + search) implying that dealing carefully with some fields of knowledge again and again. However, in a scientific sense it reflects a way of thinking and conducting about a given phenomena/ situation and its governing principles to gain a deeper understanding.

The whole process of research follows scientific procedures and methods of analysis. It involves inter-related activities starting with the formulation of a researchable problem and ending with conclusions and recommendations based on the analysis and interpretation of data from the findings of the study. Mean that, the researcher can get knowledge on the specific topics as aimed that will be organized in applicable manner for creating technologies to solve development problems of humanity.

Therefore, Research is defined as a systematic and intended analysis and recording of controlled observations that may lead to the development of generalizations, principles, theories and facts for prediction and control of events. Moreover, it is

- ✓ More than compiling, counting and tabulating of data. But it involves deducing/ reasoning of hypotheses through careful observation and application of accurate analytical tools and logic.
- ✓ Often a team work than individual activity. Researchers working in groups solve problems in different ways by sharing their knowledge, ideas and experiences.
- ✓ A process which takes a great deal of time, energy and intensive application of logical thinking. Great discoveries rarely happen by accident.

Research results undergo a process of review for confirmation and updating. The truth of scientific finding is relative and temporary. As knowledge expands and research tools are refined what has been held may even be nullified. Thus, the review process is a powerful inducement for researchers to be critical of their own conclusions.

Researchers are specialists rather than generalists and they are disciplined and dedicated individuals who search the true facts. The ability to pursue research is largely depends on one's capacity like;

- ✓ *Reasoning power*: the researcher must have capacity to solve problems deductively (general to specific) and inductively (specific to general).
- ✓ *Originality*: Have creative, imaginative, initiative and fertility of rational ideas.
- ✓ *Memory*: Have extensive, logical and ready command of facts.
- ✓ *Alertness*: Have quick, incisive/ sharp and responsive observation, thought and feeling.
- ✓ *Accuracy*: Have precise, keen/ devoted, regular, reliable observation, thought and feeling.

- ✓ *Application*: Have power of concentration, sustained attention, relevant and well regulated effort.
- ✓ *Cooperation*: Have the capacity for intellect/ understand, companionship, teamwork orientation and leadership qualities.
- ✓ *Moral attitude*: intellectual mind, good ideals, etc.
- ✓ *Health*: Have nervous stability, good endurance, vitality/ strong,
- ✓ *Zeal*: Have deep interest of passion for original creative work.

1.2. Purpose of Research

Why do we pursue scientific research? Obviously, it is satisfy our **intellectual curiosity**. Because, we human by nature are curious being that always seek to understand and predict future circumstances. For example; farmers have a stock of indigenous knowledge passed from generation to generation for predicting **when** and **how** to perform their farm activities. But often they do this without understanding which only comes from simple observation of **patterns of regularities**.

Scientific research helps to predict and understand patterns of regularity. For instance, agricultural scientists intend to ensure food security by finding better ways of producing high quantity, good quality and preferable variety of food items.

So that, the main purposes of scientific research are to:

- ✓ Review about the existing knowledge
- ✓ Investigate current situations and potential problems
- ✓ Provide solutions for the sound problems
- ✓ Explore and analyze more general issues
- ✓ Construct new procedures or systems
- ✓ Explain new phenomenon
- ✓ Generate new knowledge

1.3. Types and Characteristics of Research

1.3.1. Types of Research

Research can be categorized into three broad types as disciplinary, multidisciplinary and interdisciplinary research.

1.3.1.1. Disciplinary Research

It is a logical system of finding knowledge about a particular set of objects and processes with a set of typical theories which is supported by appropriate methods and analysis tools. There are two broad types, namely basic (fundamental) and applied research.

a) Basic or Fundamental Research

- Pursued with the aim of discovering or creating new knowledge regardless of its immediate application. It has little concern for the immediate application of findings to actual problems.

- The primary purpose of the researcher and his/ her institution is to advance the knowledge through developing theories from broad generalizations or principles.
- The most important factors are the researchers' commitment and devotion to their field of specialization and the ability of the institution to facilitate and create conducive conditions for basic research.
- Example, in developing countries like Ethiopia, basic research can largely be justified through university teaching. The underlying reason is the desire to enrich quality teaching and learning process.

b) Applied Research

- Any research directed towards the generation of knowledge with the aim of solving predetermined problems. It is more important than basic research in contributing to development and the immediate welfare of the people.
- It is generally concerned with the adaptation, conversion and/or processing of knowledge from basic research to develop useful innovation or technology. In other words, it adapts the theories developed through fundamental research to the solution of practical problems.
- With the current state of knowledge explosion around the world and the emerging socio-economic problems in poor and developing countries, the greatest attention and priority are given to applied research.
- It normally follows basic research and attempts to determine and expand the potential use of new knowledge obtained from basic research.
- The results of applied research are used for the generation and improvement of technology, materials, processes, methods, devices and techniques.
- Example. Research findings by the domain of national research organizations like EARO and industrial establishments.

1.3.1.2. Multidisciplinary Research

- It involves several disciplines working independently in a given study carried by a team of researchers. There is no real or assumed integration b/n the disciplines.
- The team works mainly in parallel with regular communication coordinated by team leader who deal with plans, budgets, etc., in consultation with team members.

1.3.1.3. Inter-disciplinary Research

- It aims at integration of the different disciplines with the assumption of working together under similar theoretical perspectives and procedures. Mean that, it removes disciplinary boundaries to address a given research question.
- Obviously, it is difficult to organize and run this research because of differences in concepts, definitions, principles, etc., inherent to individual disciplines and personal biases.
- The coordinator is expected to resolve such restrictions through addressing questions like:
 - How will the team members communicate?

- Whose disciplinary language will be used and whose values will be adopted?
- Whose knowledge will count more in that setting?

Note: Action Research is an emerging research process.

- It may be described as type of applied research methodology which pursues action (or change) and research at the same time.
- In most of its forms, it is a participatory and interdisciplinary process which generates a better understanding of the events and cases under investigation.
- In short it produces knowledge through doing rather than only conceptualization.
- It involves interaction between local people and outside facilitators to develop appropriate technologies that give priorities and fit to the specific situations and circumstances of the local peoples.

1.3.2. Characteristics of Research

Generally a research is expected to have the following essence:

- ✓ Should be original and rigorous (strong)
- ✓ Free of factors affecting the outcome (controlled)
- ✓ Is directed toward the solution of a problem with the development of generalizations, principles or theories that would be helpful in predicting future occurrences.
- ✓ Systematic: must have flexible procedures with logical sequence that depend on observable experiences or empirical evidence.
- ✓ Demands accurate observation and description valid data gathered through efficient and accurate procedures.
- ✓ Empirical: Being a scientific process applying every possible test to validate the procedures employed, the data collected and the conclusions reached.
- ✓ Requires qualified and experienced expertise

1.4. Classification of Research

There are three classes of research depending on the purposes of research, i.e. to **explore**, to **describe**, and to **explain**. These are exploratory research, descriptive research and experimental research. Practically, all studies fall under one or a combination of these classes of research.

1.4.1. Exploratory Research

- Its main purpose is to investigate the general situation of a particular field for identifying and formulating researchable problems. It is a useful technique to acquire general information for identifying meaningful problems and hypotheses for future research.

- A great deal of exploratory research is done for the following purposes: (i) a desire for better understanding of a situation; (ii) to test the feasibility of undertaking a more rigorous study; (iii) to develop methods to be employed in a more careful study; and (iv) to make quick suggestions for tackling development problems.
- Since less is known about the environment and the structure of the traditional farming systems, it is used in agricultural and rural development research to obtain qualitative information and to quickly learn about farmers and their circumstances.
- Such a study is best conducted during the growing season, and preferably one or two months before the harvest period when most crops are fully developed. The duration of the study depends on the specific purpose and the size of the target area
- The chief shortcoming of exploratory studies is that they seldom provide answers to research questions. The methods of data collection are informal using largely unstructured interviews combined with limited observations. No statistical analysis is possible.
- On the positive side, they can help to raise research questions and provide insights into the research methods that yield answers to research questions.
- Two examples of exploratory studies conducted in agricultural and rural development studies are (a) Rapid Rural Appraisal and (b) Participatory Rural Appraisal. It is useful to examine the distinctive features RRA and PRA.

(a) Rapid Rural Appraisal (RRA)

- It is a systematic but semi - structured activity which carried out in the field by a multidisciplinary team and designed to acquire quickly new information and hypotheses about rural life.
- There is no standardized methodology or analytical framework for RRA. It depends on the objectives, local conditions, skills, resources and knowledge of its users.
- It looks at the same problem from different angles. It uses several information gathering techniques like interview with farmers and resource persons, group interviews, direct observation on the farm, secondary sources of information, etc.
- Interviews are carried out by the researchers using a check list rather than a questionnaire, so that more complicated issues can be explored. And the samples are chosen purposively rather than randomly.

(b) Participatory Rural Appraisal (PRA)

- It is a technique in which rural people are involved, not only as sources of information, but also in analysis, planning and dissemination.
- The participants consist of groups of rural people carefully selected to work together and create a pictorial representation of some process or set of circumstances with readily available materials.
- Its strength is to offer the local peoples a good opportunity for creating and owning data that remains with the community.
- Participating investigators can also build a high level of rapport/ link with local people concerning the study at hand and for future opportunities.

- Regarding its weaknesses; the participating farmers may not be representative of the community because they are not usually selected at random. Also, it is unlikely that PRA would yield information on sensitive issues such as sexual behavior, religious matters and the like.

1.4.2. Descriptive research

- It is conducted to precisely measure and report the characteristics of some population or phenomenon under study.
- The researcher first observes deeply to understand all the conditions/ relationships that exist, opinions that are held, processes that are going on, effects that are evident or trends that are developing then records/ measures, analyzes, describes and interprets all what has been undertaken.
- A descriptive research contributes to science primarily by building a foundation of facts upon which hypotheses may be tested. Good descriptive studies can go beyond the description of variables. They attempt to predict, test or arrive at hypotheses regarding the relationship between variables included in the study.
- The serious limitation of descriptive research is that it cannot describe cause and effect relationship because the lack of control measures. This is the domain of experimental research where control mechanisms are in place to offset the influence of other extraneous factors.
- However, it is possible to make comparisons or contrasts and attempt to discover relationships between existing non-manipulated variables.
- Has two phases. These are:
 - a) Descriptive phase:** where the researcher merely describes the variables or events relevant to a given problem; example crop surveys, geographical descriptions, etc.
 - b) Analytical phase:** it includes the study of association between different variables. It indicates what happens when two or more factors interact in a given situation.
- Moreover, it is characterized with the following points:
 - It is non-experimental, so it deals with the relationships between non-manipulated variables in a natural rather than artificial setting.
 - It involves hypothesis formulation and testing.
 - It uses the logical methods of inductive-deductive reasoning to arrive at a generalization.
 - It often employs methods of randomization so that error may be estimated when inferring population characteristics from observations of samples.
 - The variables and procedures are described as accurately and completely as possible so that the study can be replicated by other researchers.

There are about four kinds of descriptive research.

I. Formal Surveys

- By definition a formal survey is a questionnaire based study of a sample of respondents who are representative of a particular population.

- The sample should be sufficiently large to allow valid statistical inferences to be drawn. They have the advantage of providing quantifiable data which can be subjected to statistical inference.
- Its main objective is to portray accurately the incidence, distribution and characteristics of a group or situation. It may or may not begin with a specific hypothesis.
- It has to be properly designed and carried out. The findings have to be analyzed and reported on time.
- It may involve a single visit, multiple visit or repeated regular visits. The purpose of the study determines the number of visits.
- Good rapport or affinities should be established in order to achieve desirable level of accuracy. Example, human and livestock population census, agricultural sample survey, etc.

II. Case Studies

- It is an empirical enquiry that investigates phenomena within their real life context when the factors relevant to these phenomena are not clearly evident. It probes deeply and analyzes interactions between the factors that explain present status.
- It examines a unit as a whole. The unit may be a person, a family, a social group, or a community.
- It is conducted not to draw broad generalizations but to understand the life cycles of units and explain their status and factors that influence their behavior, change or growth.
- It is a detailed study of a single or small number of units selected as representative of groups relevant to the issue under considerations, but not necessarily representative of the population as a whole.
- This kind of study is appropriate where a detailed understanding of complicated relationships is considered more important than ensuring representativeness of the data. Such studies are usually conducted at a certain point in time. Example: Reduction of the income of farmers in Sidama Zone due to fluctuation of coffee price in the world market.

III. Historical Studies

- History is a meaningful account of human achievements, the relationships between persons, events, times and places. Historians draw their data from observations and experiences of others to understand the past, and to try to the present and predict the future.
- Since they have not been at the scene of the event, they must use logical inferences to supplement what is probably an incomplete account. Thus, historical research describes what it was?

- The process involves investigation, recording, analyzing and interpreting the events of the past for the purpose of discovering generalizations that are helpful in understanding the present, and to a limited extent, in anticipating the future.

IV. Farming Systems Research (FSR)

- It is an applied problem solving approach to the generation and diffusion of technologies appropriate to farmers' circumstances.
- It addresses the objectives/ interests of farmers through understanding what and why they do. It investigates deeply the constraints they faced as well as the possible opportunities for improvement their livelihood.
- It involves experimental trials to test research recommendations from on station studies such as rate of fertilizer application, use of improved seeds, etc.
- It begins with the analysis of whole farming systems and identification of particular or set of problems associated with the farming system through a variety of data collection methods that elicit farmers' priorities and concerns.
- The stages involved in FSR include the following:
 1. Description and diagnosis, when the main characteristics of the actual farming systems are analyzed.
 2. Design relevant strategies based on information from on-station and on-farm experiments, and from farmers as to their technical economic and social feasibility and acceptability.
 3. Testing a few promising strategies on-farm.
 4. Dissemination of accepted strategies to farmers

1.4.3. Experimental Research

- A type of research in which variables are manipulated and their effects on other variables are observed. Here, the intension is to find the relationships between variables under study through deliberate manipulation of the study variables.
- It provides a systematic and logical method for answering the question, "***If this is done under carefully planned and controlled conditions, what will happen?***" In other words, experimental research shows what will be the outcome when certain variables are carefully controlled or manipulated.
- It allows researchers to deduce the cause and effect relationship of the study by setting an appropriate experimental design which specifies the following requirements;
 - The set of treatments selected for comparison.
 - The arrangement of plots to which the treatments will be applied.
 - The rules by which the treatments are going to be allocated to each plot.
 - The condition at which measurements or other records to be made.

- The tasks that the researchers need to perform to design an experiment are:
 - Identify all non-experimental variables that might contaminate the experiment and determine how to control them.
 - Select a research design and sample of subjects to represent a given population
 - Assign subjects and experimental treatments to the groups.
 - Select, construct and validate instruments to measure the outcomes of the experiment.
 - Outline procedures for collecting the data and possibly conduct a pilot study or trial run test to perfect the instruments or research design.
 - State the statistical or null hypothesis.
- Most experiments in natural and social sciences involve three major components.
 - Independent and dependent variables.
 - Experimental and control groups.
 - Pre-testing and post-testing.

1.5. Research Ethics

- It is not possible to say that every scientific research come up with good things through right and ethical manner. Because, it is common to see/ hear about some scientific findings conducted and used for beneficial destructive purposes.
- Moreover, there is no sure way of saying all scientists are engaged in findings guided by ethical concerns and even sometimes it is difficult to be ensure their findings are put for serving the best interests of the society.
- Generally, there are a set of agreements and standards established by the scientific community to safe guard against immoral research activities and proper conduct of scientific investigations.
- There are core values that researchers are required to respect in any of their scientific work. These core values relate to the norms of the society and their personal behaviors like honesty, fairness, collegiality, and openness.
- Unintentionally performed mistakes due to the state of past knowledge or methodology understood to be appropriate could be tolerated and need to be corrected with the discovery and growth of further knowledge and information. But, intentional violations of the norms and mistakes due to negligence, haste or deception are shameful and unacceptable ethics of research.
- The more serious and inexcusable practice in scientific research is deception/ cheating. This may involve fabrication of data, falsification/ distortion (change or misreport) of data and plagiarism (copying and using the ideas or words of another person without giving appropriate credit).
- Other ethical concern relate to anonymity and confidentiality of people studied as well as the importance of insuring the voluntary participation of research subjects. Also, researchers should insure that no harm is done to the subjects physically or psychologically or in any other form.

- Hence, scientific knowledge and methods are continually examined with critical mind for possible genuine errors and/ or misconduct in making observations and interpretations by researchers.

1.6. The Tools of Research

1.6.1. The Library and Computer Technology

- The library is an important ally of any researcher. It offers information resources that serve diverse academic and personal needs. A well established and stocked library holds books and publications covering most subjects of interest.
- Generally, libraries have sections including the circulation desk, the card catalog cabinets, or the Public Access Catalog (PAC) where computerized, the reference room, and the stacks.
- Since different information resources exist inside and outside the library, the customers (students, instructors, researchers...) are need to develop and have the skills to detect, use and act accordingly.
- Technological advancements are making library services to become simple and efficient. For example, computerization of library's facility and resources creates a great opportunity to hold and recall vast amounts of information easily and shortly. Additionally, libraries having computers with internet access provide more and recent information sharing.
- There are two sources of information known as primary and secondary sources.
 - Primary sources lead to original works and enable the researcher to get closer as much as possible to actually happened historical event. For example, the following materials are considered as primary sources:
 - a. Interviews, diaries, speeches, letters, memos, manuscripts and other papers in which individuals describe events in which they were participants or observers.
 - b. Memoirs and autobiographies. These may be less reliable than diaries or letters since they are usually written long after events occurred and may be distorted by bias, dimming memory or the revised perspective that may come with hindsight. On the other hand, they are sometimes the only source for certain information.
 - c. Records of or information collected by government agencies that are directly reported without further interpretation or analysis. Many kinds of records (births; deaths; marriages; permits and licenses issued; census data; etc.) documents conditions in the society.
 - d. Records of organizations. The minutes, reports, correspondence, etc., of an organization or agency serve as an ongoing record of the activity and thinking of that organization or agency.
 - e. Photographs, audio records and moving pictures or video recordings, documenting what happened.
 - f. Materials that document the attitudes and popular thought of a

historical period. Example, public opinion polls taken at the time of interest.

g. Artifacts of all kinds: physical objects, buildings, furniture, tools, appliances and household items, clothing, and toys, among other things.

- A secondary source is a work that interprets or analyzes a historical event or phenomenon. It is generally at least one step removed from the event. Textbooks and encyclopedias are examples of secondary sources.

1.6.2. Statistical Tools

- Statistics is a body of mathematical techniques or processes for gathering, organizing, analyzing, and interpreting numerical data.
- Statistical tools are used to describe, analyze and predict the outputs of a research from a mass of data collected by researchers.
- The kind of data collected and the goal of the researcher determine the choice for the right type of statistical procedure or test.
- The statistical results are expected to be interpreted by one who can understand the statistical methods and the applied subject matter.
- There are two families of statistics; namely parametric and nonparametric statistics.
 - Parametric statistics makes the assumption that the data are secured from a sample drawn from a population that fairly reflects normal distribution (Gaussian distribution).
 - Nonparametric tests are those which do not make such assumption.

CHAPTER TWO

RESEARCH PLANNING

2.1. General principles in research planning

The success of a given research project depends on the quality of planned activity and its full and right implementation. Because, properly planned activity involves detailed description of key processes to be undertaken, creates chances to fulfill the required manpower, facilities and other resources and provides appropriate methods of monitoring and evaluating the research project.

Research planning is particularly important for developing countries like Ethiopia where the resources are severely limited. Even, many programs and projects compete for the limited resources and sometimes they use it unwisely. These limited resources have to be used as judiciously as possible so as to enhance the pace of economic development of the countries.

2.2. Levels of Research planning

The choice for a type of research planning depends on the level at which the research is expected to be undertaken in a time bounded manner. Planning research can be considered at five different levels: country, research institution, research program, project and individual study levels.

The first step for research planning is the identification, definition and selection of problems and decision making on the areas of research focus. The next step is identification of key activities, facilities and resources to be used in the proposed research. The third step deals with arrangement and fulfillment of every possible condition for the realization targeted outcomes. Finally, it is provision of accurate means for coordinating, monitoring and evaluating the implementation of the program and its outputs.

2.3. Situation and Models in Undertaking Research

To undertake a research, the researcher has to assess the current condition (which determines the existing problem) and decide on the type of possible solutions through determining steps that lead to the solution. In this process the researcher will go from one working model to another depending on conditions considered. There are three models;

- Current situation (problems and opportunities)
- Preferred situation (intended targets)
- Action plan (strategy to have final result)

The first model (current situation) describes conditions at the beginning of the experiment. Everything is not known about the existing situation and the blind spot indicates the presence of knowledge gap that has to be bridged. Here, the researcher is try to identify the main problem and assess every possible opportunities for having solution on the problem.

The second model, the preferred situation, is about the way of attaining the researcher's intended target. In this model, the amount of blind spot decreased due to improvements on the previous situation. The third model is the action plan which elaborates the methodology on how the researcher is going to have a final solution.

2.4. Steps in the planning process

There are six important sequential steps in planning research process.

1. Problem identification
2. Ranking (prioritization) of problem
3. Identification of causes
4. Analysis of interrelations among problems and causes
5. Identification solutions
6. Evaluations of solutions

In many developing countries like Ethiopia, the problems affecting the agriculture sector are fairly well known. For instance, lack of improved varieties, soil degradation, genetic erosion, lack of improved agronomic practices, post harvest losses, diseases and insect pest incidences, and so on.

Depending on the scope of the research, it is important to decide the level at which the research should be carried out. However, prior to formulate the research problem and set objective should given for the client and the discussion should reveal the client's view concerning the beneficiaries of research results. It may sometimes happen that the client does not have well defined objectives which are vital for proper formulation of the problem. Under such circumstances, the initial task of researcher is to assist the client in clarifying the objectives. The objective of the client should be known to delimit the scope of the research. Once this is done, the next most important step is to identify the alternate pathways for realizing the objectives. Then, the more important pathways should be selected by comparing the alternative pathways and ranking them according to their appropriateness in reaching the objectives. Based on the nature of causes, two general types of problems can be identified. These are:

- Problems related to biological limiting factors such as deficiency of nutrients, moisture stress, pests and diseases, adaptation, etc., and
- Problems related to inefficient use misuse of resources such as over or under application of fertilizers, irrigation water pesticides, timing of operation, varietal or species use, etc.,

The first group of problems occurs as a result of natural phenomena in which man has no direct involvement. For instance, in the case of disease and insect outbreak, it is the environmental conditions, which trigger these outbreaks. The second group of problems is related to the way resources are managed. As these are basically man-made, they are easier to solve than the former ones.

Analysis of the existing state of affairs may suggest several researchable problems. But it is difficult to conduct all because of different resource limitations. Therefore, it is important to prioritize the problems that compete for limited resources by ranking them based on some predetermined criteria. Once the criteria are set, various calculations and comparisons will be made (input and benefit analysis, time factors as short, medium and long term problems) to give priority for a problem with large availability of the necessary resources and whose solution benefits a wide range of clients. For instance, ranking of agricultural problems may be done based on:

- Distribution and severity of the problem; the extent and number of target groups affected, and seriousness of the problem
- Importance of crop in question; importance may be in terms of yield quality and quantity, market value, socio-cultural acceptance, etc.

In Table below there is a guide for understanding the concept of ranking problems:

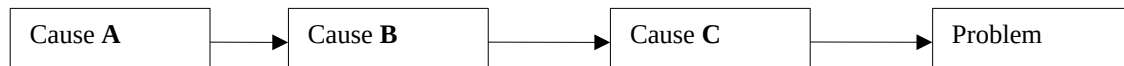
No	Type of problem	Distribution problem	Importance of crop	Seriousness of problem	Priority level
1	Nitrogen deficiency in coffee	Most farmers ***	Coffee ***	***	1
2	Phosphorus deficiency in wheat	Several farmers **	Wheat ***	**	3
3	Drought stress in maize at ear filling	Much of drought prone north **	Maize **	***	2
4	High cost of weeding Teff	Some farmers **	Teff ***	*	3
5	Manganese deficiency in coffee	Few farmers *	Coffee ***	*	5
6	Anthrachnose attack on bean pods (about one year in three)	Some farmers **	Beans *	*	4

Where: *** very important, ** somewhat important and * not so important. The same approach is used regarding the distribution and the seriousness of the problem. The total number of * determines the rank to be allocated to the problem. Since problems number 2 and 4 are of equal priority level, some additional criterion may be required to assign independent ranks.

Giving attention to the causes of a problem is an important stimulus for identification of solutions. When attempting to identify the root causes of a problem, the first thing that has to be done is to list all possible causes and working towards eliminating the less important ones. It may help to prepare a diagram of causes and problems by using arrows to lead from causes to problems. Sometimes a chain of cases may lead to a particular problem or several causes may contribute to a problem. It is important to elucidate the difference between the two types of causes.

A. Chain of Causes

In some cases a single factor will be responsible for causing a problem or several causes follow one another result in a problem. A factor can be considered as an effect as regards the factor immediately preceding it and a cause to the one, which follows it. The idea is shown schematically below.



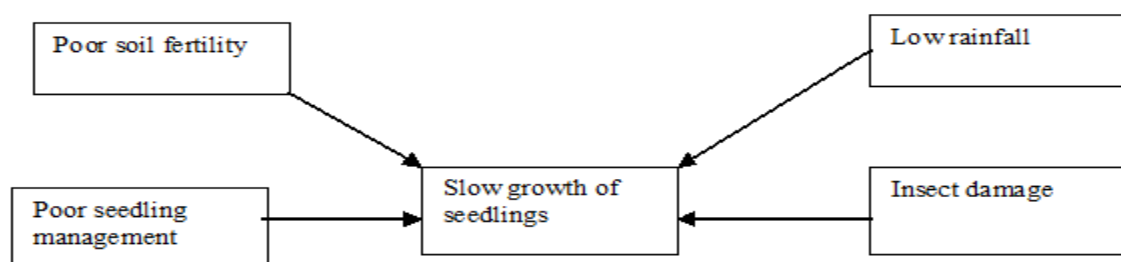
Here we have a chain of causes in which cause **A** results in cause **B** and cause **B**, in turn, results in cause **C** which, in turn, results in the **problem**.

For example, assume that because of drought there is not sufficient grass to feed animals and farmers remove crop residue to be used as cattle feed. The removal of crop residue causes loss of organic matter. This, in turn, causes nutrient deficiency in the soil the effect of which is low yield. In this example, cause A is drought, cause B is shortage of grass, or fodder cause C is removal of crop residue, cause D is loss of organic matter and cause E is nutrient deficiency. This chain of causes results in low crop yields, which is the problem of concern to the farmer.

As a second example, assume that the farmer does not have adapted arable land to grow cash as well as food crops. To overcome the difficulty, the farmer cleared his forestland and used it for cultivation. This exposed the land to wind and water erosion, which, in turn, drastically reduced the productivity of the land. There are three causes, which work as a chain to result in yield decline. Had he left some trees on his farm the trees would have protected his soil against the harsh effects of environmental conditions. The problem of interest here, as in the previous, is reduction in crop yield.

B. Multiple causes

This is a situation in which more than one cause may be identified for a single problem. All the cause of the problem has to be addressed in order to obtain a realistic solution to the problem. For example, consider slow growth of seedlings in the field which probably assumed due to simultaneous action of Poor soil fertility, Poor seedling management, Low rainfall and Insect damage.



It is possible to have multiple and chain of cause working together to generate a problem. Let us say that in the above example poor soil fertility is caused by lack of fertilizer, poor

seedling management is caused by low level of personal education, and insect damage is caused by lack of insecticides and low rainfall by the EL-Nino Effect.

Analysis of interrelations among problems and cause

In order to establish a meaningful solution one has to clearly understand every possible interrelation between problems and cause. So as to get an indication of the interrelation between problems and causes connecting links should be established between the individual diagrams. Example; **Chart-1 Interrelation between problems and causes**

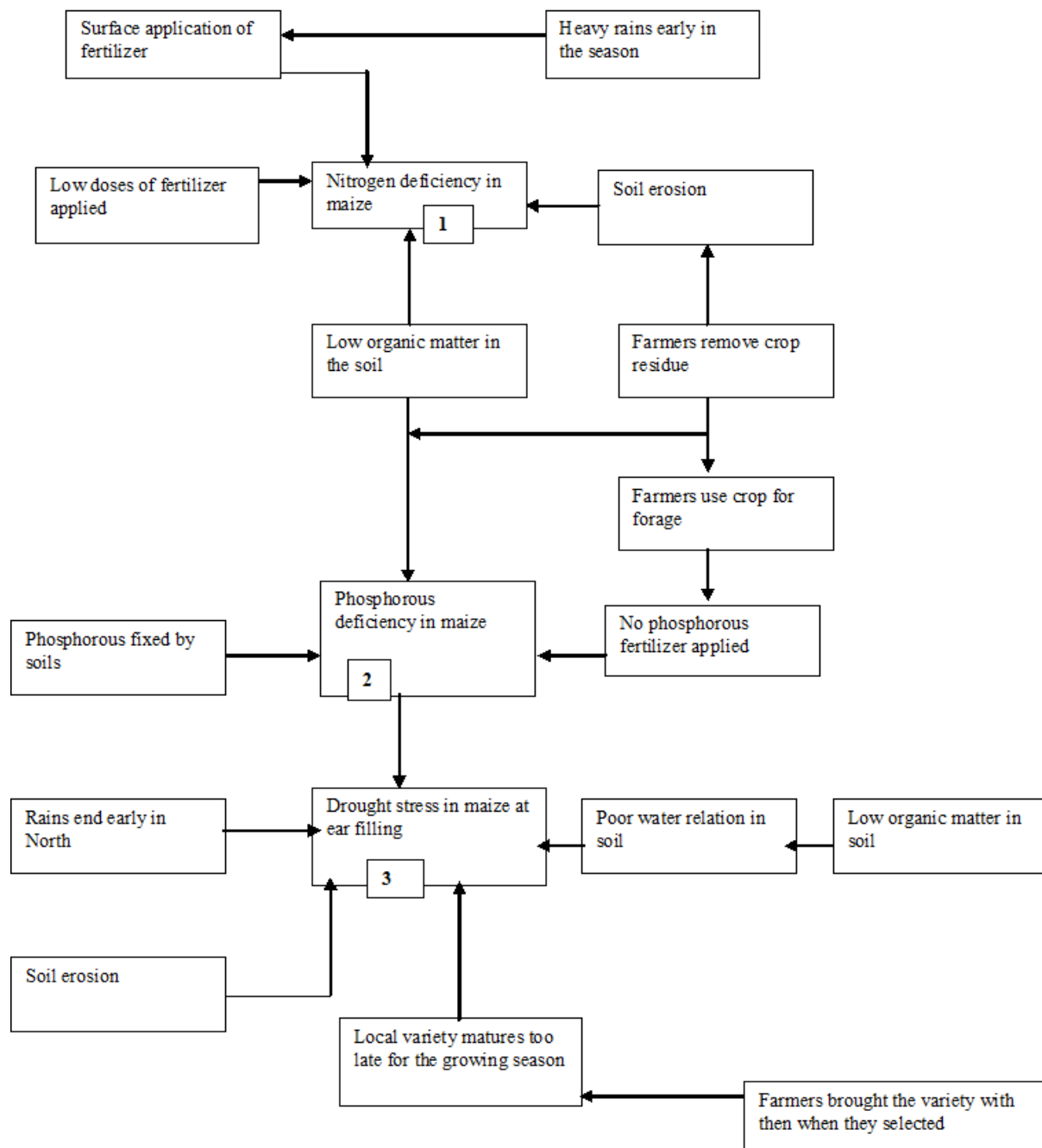
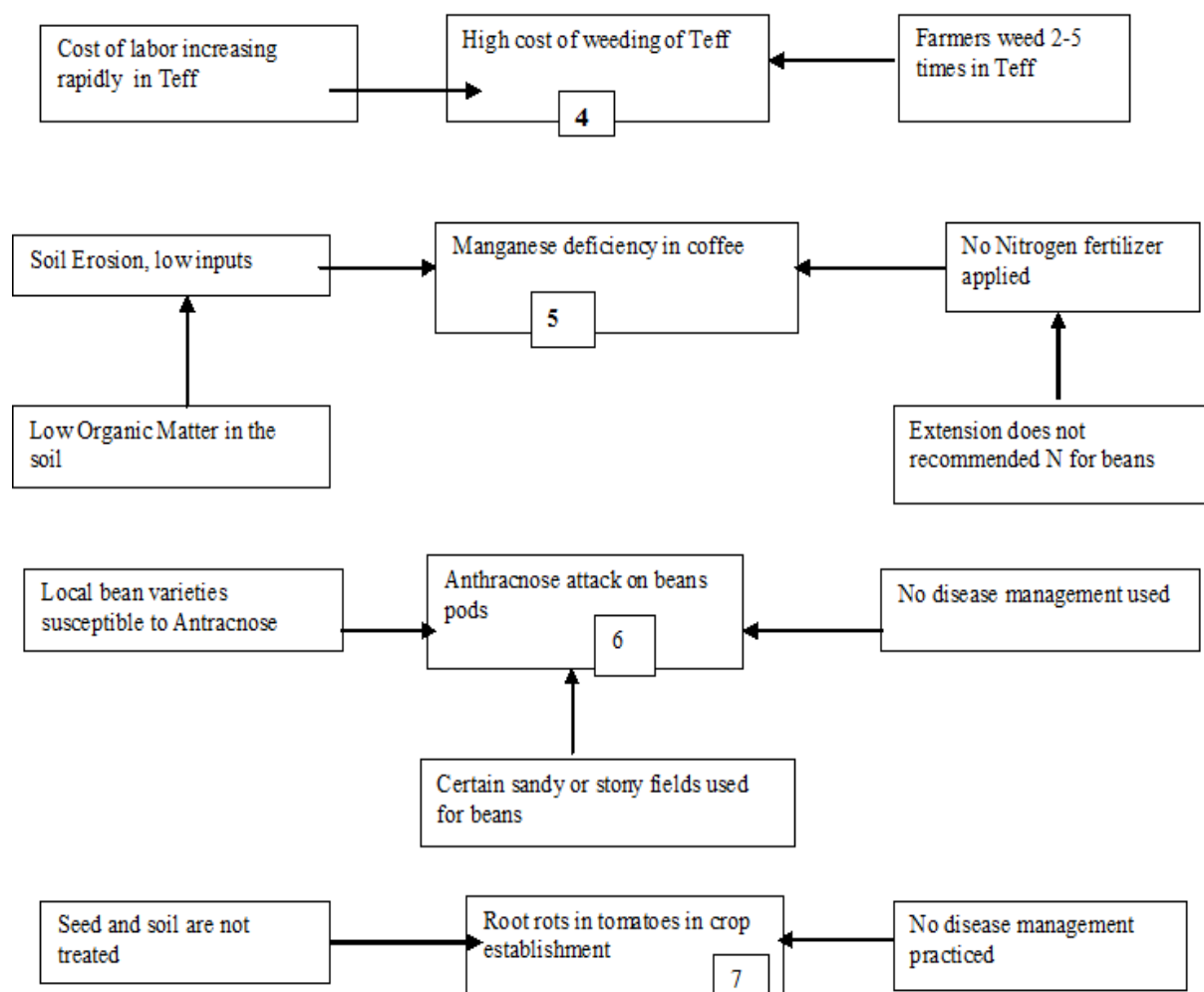


Chart 1 Continued



2.5. Research problems and Questions

Before an attempt is made to identify a problem and look for solutions, it is necessary to have a question on the detected problem.

2.5.1. Research Problem

It is an intellectual challenge, difficulty, doubt, etc. that a person faces when an undesirable situation arises. That means, it is a declarative statement of what has gone wrong or what is unsettling. For instance statement such as:

- Rural family incomes are very low as compared to urban family incomes
- Agricultural production systems in Southwest of Ethiopia are conducive for environmental degradation.
- Forest genetic resources of the country are decreasing at an alarming rate.

However, they are too broad to formulate a reasonable research plan. The aforementioned problems cannot be solved without further analysis by asking relevant questions.

2.5.2. Research Questions

A research problem cannot be solved unless it is analyzed further. Hence, it is a statement that inquires about a given problem to bring out the salient points. The questions asked have to be relevant and mature in order to formulate an adequate plan for properly investigation of problems which lead to a solution. For illustration, suppose the problem related to the decline of forest genetic resources. To analyze this problem, the researcher will have to ask some related questions like,

- What is the existing situation of genetic resources in the forest?
- How is the rate of decline?
- Which plant species are more endangered?
- Which agro-ecologies are more affected?
- What are the causal agents?
- Which of the agents are more serious?
- How could situation be reversed?

2.6. Problems, causes and solutions

- **Problem:** Undesirable state of affairs/ interactions that has taken place. Mean it is something has gone wrong with the existing situation or it is an effect, function or result of a given factor. For instance, coffee trees died and withered out at the time when the farmers expect some fruits.
- **Causes:** Are factors or reasons responsible for the creation of problem. Example, in the coffee example, a researcher found out a presence of hard clay pan at the depth of 30 cm as a cause. Here, the researcher has uprooted some of the drying trees and observe stunted taproots curved upward.
- **Solution:** A strategic action done to overcome the causes and resolve the difficulty. In the coffee example, a farmer identified the existence of hard pan should not continue to use the land for coffee production. It should be used either for growing shallow rooted plants or for grazing purposes.

CHAPTER THREE

RESEARCH PROPOSAL WRITING

- Research proposal is an important step in the research process and it is defined as a **written document** requesting for authorization and funding to undertake a specific project in laboratory, library, field etc.
- Well designed proposal serves as a **systematic plan of procedure** that leads the researcher towards solution and provides a basis for the **evaluation of the research project**.
- There is **no a hard and fast format** in scientific research proposal writing. It varies from one organization to another, from one country to another. Though the format varies, **the essence expressed in different formats remains the same**.
- What matters is
 - To convince others how the proposed research is worth to be undertaken
 - To enable the researcher to demonstrate his expertise (knowledge and skill) and competency (ability/ potential) in the particular area of study
 - To serve as a planning tool for the researcher
 - To get fund for undertaking the research
- The major components (the essence) of a scientific research proposal are:-
 - Title
 - Introduction
 - Review of Literature
 - Materials and Methods
 - Work Plan
 - Logistic (Budget Plan)
 - References/ bibliography

TITLE

- A project title should be **descriptive, clear and short**. It should **contain and reflect the content of the research proposal** that enable the readers to **understand the concepts, methodologies and outputs** of the study.
- It must include the **subject matter** (crop, pest, soil, animal, disease, etc.), **the line of investigation** (breeding for disease resistance, evaluation of agronomic characteristics, selecting for adaptability, economic fertilizer rate, yield evaluation, irrigation requirement, biology studies, chemical control, stoking rate evaluation), and **location** (place of study)
- If a research activity contains more than **three factors** (lines of investigation), it will be better to **split each** so as to **easily find the suitable experimental designs** for meeting the intended objectives.
- Apart from activities specifically designed to be multinational (e.g. survey, national yield trials), it is better to treat them as a **unit at single locations**. Example, yield trial, it is

better to treat activities by single locations. This is particularly true for agronomic and soil fertility trials, which are influenced by the peculiarities of the environment unless such locations are similar in their environmental characteristics.

- **Generally, a good title:**

- contains few words (should not longer more than 20);
- describes the contents of the paper accurately;
- revolves around the subject as much as possible;
- avoids abbreviations, formulas and jargon (terminological) words;
- easy to understand;
- not exaggerated (overstated) and fake

Note:

- Avoid **waste of words** and **unnecessary information or words** like: "A Study of ...," "Observation of ...", "Examination of...", "A note on...", "Investigation on..." etc. For example, take the following titles that were submitted by 3rd year students in 2006
 - Impact assessment of improved varieties adaptation practices in Aleta wondo Woreda, SNNPR.
 - o This is a wrong title because there is no need to put both impact and assessment at once. The student may use impact of...
 - A study of the effect of Moringa supplementation on the performance of Goat fed grass hay.
 - o A study of is not necessary for this title. The effect of...
 - Influence of N fertilizer effects on growth performance, tuber yield and yield components of potato varieties. It is waste of words. The effect of nitrogen fertilizer on tuber yield and yield components of potato varieties

INTRODUCTION

- Its purpose is to introduce about the research topic and it has to
 - convince the reader how the research is worthwhile (useful, valuable and meaningful)
 - be attractive and informative
- often it is written in present tense and should have the following common sections:
 - Background and justification
 - Statement of the problem
 - Objectives of the study
 - Significance of study

a) Background and Justification

- ✓ It is also called problem situation, problem description or problem context. It gives a **general descriptions** and the **need for conducting the research**. Here, the researcher **problematises his/ her case**, and **consider how and why he/ she want to use** the different theories, sets of concepts and methodologies in the research.
- ✓ The reader should be guided in a **logical way towards the subject or problem** to be studied. It also used as **Literature Review** if the researcher fails to include

separately in the structure of the proposal. **Because**, this section is concerned with the **review of previous work to reveal what is known of subject** (gaps in knowledge and current trends).

b) Statement of the problem

- ✓ The **most important section** of proposal; because it **shows why the researcher has selected** the concerned variables in the expected research and **the extent (how far or deep) to which the research problem is going to be addressed**. Research problem is a **concisely formulated sentence** which indicates **what, why and from whose perspective** is the particular situation has problematised.
- ✓ Should provide readers with a **logical flow** from the background and the conceptual framework and also provide a **clear and delimited** core of focus for the research.
- ✓ Should be written in **clear language** which holds the reader's attention from the outset and let him know what is going to done.
- ✓ Some leading questions that help you to formulate a research problem are:
 - What do you want to know?
 - Where do you want to do the research?
 - How is the situation?
 - What state of affairs or processes do you want to describe?
 - When? What time span you will study?
 - Why will you study this? To what purpose?
 - What consequences will the new knowledge have?
- ✓ Rules in defining a research problem:
 - Be sure that the topic chosen is neither too vague nor too broad in scope.
 - To make the problem clearer and more understandable, state it as a question which will require a definite answer
 - Carefully state the limits of the problem, eliminating all aspects and factors which will not be considered in the study.
 - Define any special term that must be used in the statement of the problem or throughout the study proposal.

c) Objectives of the Study:

- ✓ Is a section which indicates what the researcher **intends to accomplish**. Mean that it is a statement indicates what will the research contribute, what will be expected from the research outcomes and what products will the research aims to bring forward
- ✓ It should demonstrate why this research is important and makes it clear to the reader what is presently lacking in the body of research or literature and for what particular piece of research there is thus a great need
- ✓ Generally, research objectives:
 - What is to be achieved by the proposed investigation has to be stated plainly and concisely?

- Should be
 - ✗ Cohesive (well organized) and logically arranged,
 - ✗ specified in short-term,
 - ✗ relevant to the problem statement,
 - ✗ state the target of the research activity, i.e., what kind of results are expected or sought from conducting research,
 - ✗ the wording of the title and objectives must be clearly stated
 - ✗ Not too many.

d) Significance of the study

- ✓ This section addresses the likely contribution of the research (knowledge, applications, solutions, etc)
- ✓ The researcher describes the value of specific applications of knowledge to be gained and the potential importance of these applications. He/she also describes the gaps that the proposed research is intended to fill.

LITERATURE REVIEW

- The importance of literature review can be indicated in the following saying “Research starts in the library and ends in the library.” Review means see again, examine, or study again examine critically or deliberately, to give critical evaluations
- In the context of literature review: it means locating literature in a variety of sources, reading it carefully and thoroughly, evaluating the content, breaking down and reorganize it into theme (topics) along the line of investigation.
- Literature review is a continuous process that cuts across all stages of the research process in a dynamic way.
- What are the purposes and importance of literature review?
 - ✓ **Benefit from previous findings**
 - Reduce the dimensions of problem
 - Increase your potential;
 - Reduce difficulties in the area of investigation
 - Provide unique contextual contribution to the research project
 - ✓ **Review may lead to :-**
 - Either changing the study topic
 - Reshaping the cover gap that others did not cover or overlooked
 - To avoid sterile problem areas where research has failed
 - To provide any meaningful results
 - To avoid duplications
 - ✓ **Improve method logical and procedural matters**
 - ✓ **Development of a theoretical framework**
 - ✓ **Evaluate previous studies**
 - ✓ **Avoid duplications**
 - ✓ **Argue a case for the present study**

- Sources of literature: Original documents, Books and original articles and Secondary sources
- **Types of Literature**
 - ✓ Theoretical works and review
 - ✓ Methodological review
 - ✓ Original finding and review of them
- **How to obtain relevant literature:** Almanac (manual), Books, Abstracts, Journals, Encyclopedia and Handbooks, Personal communications, Gray literature(files found in offices and research), Newspapers and magazines, Oral literature, Specialized agencies, Visits, Modern technologies; electronic data bases (CD-ROM), E-mail (internet) and Electronic Journals (TEAL, AGORA)

MATERIALS AND METHODS (METHODOLOGY)

- This section shows how the research objectives/hypotheses will be answered / tested in the most rigorous way. It describes in detail the specific methods and the materials needed to accomplish the research
- It explains the procedures to be followed. It provides clear and complete descriptions for all experimental, analytical, and statistical procedures
- The section should include enough information so that another researcher can repeat the procedures and expect to get similar results
- In writing this section it is very useful to consider questions such as:
 - **Where:** Important to describe where the study will explicitly takes place.
 - **How:** provide a detailed description of what will occur from the time the project starts until it ends, i.e., how you will do the research
 - **When:** present the methods in a logical sequence of activities in a time frame.
 - **Why:** justify the chosen methods, especially if they are new or unique.
- The major components are:
 - a) **Description of the study area;** mainly by giving emphasis to the following information depending upon the nature of the study
 - Location and topography
 - Climate
 - Geology and soils
 - Production systems
 - b) **Target population;** The population from which the sample will be drawn, the method of sampling and the rationale for the sampling method should be explained or described in the proposal
 - c) **Research design and Treatment;**
 - The design element of a proposal should indicate how the research setting will be arranged in order to yield the desired data with the least possible contamination by irrelevant variables.

- The proposal should carefully identify these variables that might affect the results and it should specify how the variables will be controlled.
- Specifically, this section must include:
 - ✗ A description of the investigations and/or experiments proposed in the sequence in which the investigations or experiments are to be performed
 - ✗ Techniques to be used in carrying out the proposed project; including the feasibility of the techniques
 - ✗ The factors being used as independent and dependent variables should be identified.
- This is the most important part of your proposal.
 - ✗ Be sure to incorporate appropriate controls in your experiments whenever necessary.
 - ✗ You do not need to give details about common procedures since these can be referenced.
 - ✗ Basic protocols that are integral to the proposed work should be detailed.
 - ✗ Reviewers will look for indications that you have carefully thought out every step in the proposed procedure
- The experimental design/research design is the plan, structure and strategy of the investigation:
 - ✗ The **plan** is the overall scheme to be followed in conducting the research
 - ✗ The **structure** is the more specific outline of how the variables are operationalized.
 - ✗ The **strategy** is a description of details such as methods to be employed in collecting and analyzing the data.
 - ✗ The design of planned experiments or the sampling protocol of surveys should be conveyed clearly and concisely.
- Do not forget to describe clearly and carefully your experimental subjects, numbers, treatments, environmental conditions, measurements, field layout and statistical models.
- It will often be dictated by the necessary and appropriate **statistical tests** or other evaluation tools that can dictate the hypothesis.

d) Data collection methods

- The proposal should include a description of the instruments and procedures to be used for collecting the data including who will collect the data when it will be collected and how.
- If observers, interviewers or enumerators are to be used, specify the criteria that will be used in their selection.

e) Data analysis procedures

- Data analysis involves the ordering and reduction of the data so that they can be related directly to the research problem.
- All statistical procedures to be used in analyzing the data should be described.
- One way of organizing the data is to state each hypothesis and to follow it with a description of the statistical tests to be used.

WORK PLAN

- It shows how you plan to deal with constraints such as time, transport and accommodation
- **Time Schedule/ Research Calendar:** Commonly three phases are shown these are starting, implementation and final phases.
- There are three steps in formulation of work plan
 - Analysis of tasks
 - Time estimates of each tasks
 - Synthesis of the plan

Example

Activity	May	June	July	Aug	Sept	Oct	Nov.	Dec.	Jan	Feb	Mar
Literature search	X	X	X	X	X	X	X	X	X	X	X
Develop proposal		X									
Research designing			X	X							
Pilot study				X							
Field work					X	X					
Data collection					X	X	X				
Data analysis								X			
Write up								X	X		
Report circulation for comments									X	X	
Dissemination workshop										X	X

Table 1: time schedule

LOGISTICS (BUDGET PLAN)

- It shows how you are going to organize the research in logistic terms (research equipment, transport, accommodation, etc) and deal with language problems (use of interpreters).
- The steps in presentation of budget should proceed in the following manner
 - Study the sequence of research activities or work plan
 - Estimate the cost of each activity

- Group similar expenditure items together
- Allow for inflation
- Present a detailed periodic budget; and
- Present a budget summary covering all years of the project

Examples

Table 1: Personnel cost

Qualification	Quantity	Duration (in days or months)	Payment rate (per day/per month)	Total cost
Junior researcher				
Technical asst.				
Field asst.				
Daily laborer				
Guard				
Sub total				

Table 2: Equipment and supplies

Item	Unit	Quantity	Unit cost (birr)	Total cost
Seed				
Pesticides				
Fertilizers				
Glassware				
Meters				
Barrels				
Subtotal				

Table 3: Stationery

Item	Unit	Quantity	Unit cost (birr)	Total cost
Record books				
Lined paper				
Typing paper				
Diskette				
Computer and accessories				
Printer				
Subtotal				

Table 4: Travel cost and per diem

Description	Rate per day	Total days	Total costs
Researcher			
Technical asst.			
Field asst.			
Enumerators			
Driver			

Subtotal			
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Table 5: Fuel & Lubricants

Description	Rate per day	Total days	Total costs
Subtotal			

Table 6: Field offices and laboratories

Description	Area in M ²	Cost per m ²	Total cost
Field offices			
Laboratory			
Greenhouse			
Subtotal			

Table 7: Human resource development and training

Description	Number	Budget per person	Total cost
Ph. D			
M.sc			
B.sc			
Development agents			
Farmers			
Subtotal			

Table 8: Budget Summary

Item	Sub-total
Personnel cost	
Equipment and supplies	
Stationery	
Travel cost and per diem	
Fuel & lubricant	

Field offices and laboratories (infrastructure)	
Human resource development and training	
Miscellaneous expense	
Total	
Contingency (15%)	
Grand total	

References (Bibliography)

- A bibliography is an alphabetical or numerical list with complete source of relevant information about a given subject.
- This use of the work of others has to be acknowledged in the bibliography section. Failure to credit someone else's work is to plagiarism.
- Plagiarism is the act of presenting the words, Ideas, images, sounds, or the creative expression of others as your own. Plagiarism is therefore a form of theft and will be taken seriously in the academic setting.
- There are three things to remember when referencing. These are
 - The 'Elements' to remember when referencing (name of the author, title of the book or article, date of publication, volume (If any) and name of publisher.
 - House style (of publisher of course of study).
 - Choice of referencing system (There are two common systems for referencing: the Harvard (author- date) system and the Vancouver (Numerical) system.
- Examples:
 - **Books = Author (s) name (s). Date. Title. Publisher, place.** → Bues A M and Sacher G A. 1952. Mineral cycling in south-eastern eco-systems. Prentice Hall, NJ, USA.
 - Forget reprint dates, if any, and use first publication date. → Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures of agricultural Research. 2nd ed. John wiley and sons., inc., New York.
 - In case of revised editions, use the date of revised edition and indicate next to the title which edition you used. → Mesfin Woldemariam. 1984. Rural vulnerability to famine in Ethiopia; 1958-1977. Vikas publishing Hous, New delhi.
 - **Chapter in a book = Author's name. Date. Title of chapter. Pp. In: Name (s) of ed (s). Title of book. Publisher, city.** → Singh G B. 1987. Agro forestry in the Indian subcontinent: past, present and future. Pp 117-40. *In: Steppler HA and Nair PKR (eds.). Agro forestry, a decade of development. Nairobi, ICRAF.* → Melaku worede, Tesfaye Tesema, and Regassa Feyissa 2000. Keeping diversity alive: an Ethiopian perspective. *IN: Genes in the field; on farm*

conservation of crop diversity, B. Stephen and brush B. (eds.) Lewis publishers, USA.

- **Reports**

- EARO (Ethiopian agricultural research organization). 1999. National research strategy for pulses. EARO, Addis Ababa, Ethiopia
- IAR (Institute of Agricultural Research). 1995. Jimma Research centre progress report for the period 1996. IAR, Jima, Ethiopia.

- **Journal articles = Author (s) name (s). Date. Title. Journal name in full, volume number: beginning and ending page numbers.**

- Haymanot Awgchew., Heluf Gebrekidan. and Adamu Molla. 2015. Nutrient status of potato (*Solanum tuberosum* L.) tubers and lettuce (*Lactuca sativa* L.) leaves produced along the bank of River Beressa. *Journal of Horticulture and Forestry*, 7(8), 179-185.
- Hailay Gebremedhin., Bizuayehu Tesfaye., Ali Mohammed. and Dargie Tsegay. 2013. Influence of preservative solutions on vase life and postharvest characteristics of rose (*Rosa* hybrid) cut flowers. *International Journal for Biotechnology and Molecular Biology Research*, 4(8), 111-118.
- Frew Mekbib. 1997. Farmer participation in common bean genotype evaluation: the case of eastern Ethiopia. *Experimental agriculture* 33: 399-408.
- Singh, M.R., P.R. Sharma, and L.I. singh. 1999. Genetic divergence among rice bean cultivars of Manipur hills. *Indian journal of genetic* 59(2): 221-225

- **Entire proceedings = Name (s) of ed (s) (sponsoring institution, if there is no editor). Date of publication. Title of proceedings, date of conference, place of conference. Publisher, total pages.**

- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1975. Proceedings of the international workshop on grain legumes, ICRISAT, 18 Jan 1974, Hyderabad, India. ICRISAT Patancheru, A.P., India.
- Amsalu Nebiyu. 2004 Genetic diversity of cassava in Ethiopia; its implication for food security and the need for biotechnology research. Pp. 39-42. In the six international scientific meeting of the cassava biotechnology net work, 8-14 march, 2004, CIAT, Cali, Colombia.

- **Papers in proceedings = Author of paper. Date of publication. Title of paper. Pages. In: Proceedings (name of workshop), name of editor (s), if any, sponsor, date of workshop, place held, publisher's address.**

- Saxena M C and Yadav D S. 1975. some agronomic considerations of pigeonpeas and chickpeas. Pp31-61. In: Proceedings of the

International Workshop on Grain Legumes, ICRISAT, 18 Jan 1974, Hyderabad, India. ICRISAT, Patancheru A.P., India.

- Amsalu Nebiyu. 2004. Explorations and collection of root and tuber crops in southwestern Ethiopia; its implication for conservation and research. In: proceedings of the 11th annual conference of the crop science society of Ethiopia, 26-28 April 2004, Addis ababa, Ethiopia (In press).
- **Thesis or dissertation**
 - Mulubrhan, Haile. 2004. The effects of nitrogen, phosphorus, and potassium fertilization on the yield and yield components of potato (*solanum tuberosum* L.) Grown on vertisols of Mekelle area, Ethiopia. M.Sc. Thesis. Alemaya University, Ethiopia.
 - Mesfin abebe. 1975. Ecophysiology of 'Noug' (*Guizotia Abyssinica* casis). PhD dissertation, University of California, USA.

Chapter 4

Scientific Research Report Writing

IV.1. Preparing Research Report

- **Effective communication** of research findings, both to scientist and to the general audiences, is a **very important component** of the research process. So decisions on **writing style and method of presentation** must depend on the **intended purposes** of the research and **prospective readers/ audiences**.

- Any researcher who hopes to do an effective report should have some idea about **the needs, interests and capability** his/ her probable readers or audiences which will help him/ her to decide on main points of presentation.
- All research works are carried out with some specific purpose and beneficiaries in mind. The purpose may be to solve a given problem that a society is facing, or broaden the prospect of knowledge of mankind in general. Whatever the purpose, the outputs of the works should be made **available or submitted** for the end users who could be scientific community, agricultural managers, farmers, development agents, policy makers, donors or academics.
- Most research reports require a certain amount of **substantiation** from sources other than the research findings at hand. Sometimes, the researcher may want to make comparisons of the results with those obtained from other sources. All of the sources are assembled in a bibliography to accompany the report. The style and form of a research report are based upon **clarity of organization and presentation as practiced** in academic circles.
- Effective writing is a tool that helps to
 - Insure better understanding and use of the results of the study.
 - Outline a work with in prepared research report.
 - Hold down repetition and guard against omissions of works.

IV.2. The Nature of Scientific Writing

- Writing is first and foremost step for **analyzing, revising and editing** the text in a given research. Because, it is unusual for a researcher to have and produce a **ready-made** but he/ she learns from his/ her mistakes through **comments and advices made by peers, reviewers or supervisor**. i.e. writing a research report is not something left to the end of the research work.
- Nevertheless, the writer must **assume responsibility** and **keep his/ her confidence** (experience and knowledge about the problem being studied). **No one else can know better than him/ herself about the work he/ she did accomplish.**
- The keys to scientific writing are:
 - ⇒ Use only clear, simple, short and coherent/ logical sentences. Minimize the use of jargons and imprecise words
 - ⇒ Avoid personal pronouns like I, we, you, my, our, us, etc.
 - ⇒ Sufficiently described concepts and definitions depending on the type and capability of the target audience.
 - ⇒ Use past or past perfect tense in describing research procedures that have been completed.
- Generally, a researcher has the obligation to make **some comments as to what the findings mean**. Whenever results are **not conclusive**, some explanation should be made. Data do not “speak for themselves” but must be analyzed and interpreted.
- Researchers must **draw conclusions from the analysis and finally make**

recommendations. Conclusions and recommendations must be made on the basis of the data at hand. The limitations of the study should also be pointed out, in all fairness to the reader.

- List of some checklist for reviewing a scientific report:
 - ⇒ Are concepts and definitions described sufficiently?
 - ⇒ Are the main points/ results clearly spelled out and described?
 - ⇒ Has the text a clear focus?
 - ⇒ Is the text well organized?
 - ⇒ Are the different chapters well connected?
 - ⇒ Is the text written in clear terms with adequate explanations?

IV.3. Types of Scientific Publication

- Universities, research organizations and donors require research reports that have been prepared in terms of the **objectives and/ or hypotheses** of the study using **their own format** for progress, annual and terminal reporting.
- Basically, there are different means for reporting research findings; these are:

❖ **Research journal**

- ⇒ It is the **most common organs of communication in science** and its purpose is to publish scientific papers that **communicate new and original information** to other scientists.
- ⇒ The research paper takes hypothesis that has been **tested by experimental methods** that come to conclusions.
- ⇒ There are two major types of research paper readers. One is the **specialist** in the field who wants to read the entire paper to partake of all its information. The other is the **casual reader** who is interested mainly in the experimental methodology, results and recommendations.

❖ **Research review**

- ⇒ It is like an **extended version of the discussion** in a research article and its essential feature is that the reader is led to the **cutting edge** of a given area of research.
- ⇒ A good review gathers to **all important work of a given topic**, but it is not simply a catalogue of facts rather it **analyses and interprets** the existing facts and theories within a particular field.

❖ **Conference paper**

- ⇒ A paper **delivered orally** at a conference and necessarily **short** which confines itself to be brief in presenting the **objectives, interpreting the methods and the results of the work.**
- ⇒ It clearly state main points that can be brought out in the discussion and its **revised version made for publication of the proceedings.**

❖ **Thesis or dissertation**

- ⇒ The telling characteristic of a thesis or dissertation is its **length and depth.**

- ⇒ A work of this type is the **written evidence of sustained research** done over a considerable period, usually 2-4 years.
- ⇒ It generally contains an **extensive review of the literature** as well as the results of several experiments, **all of which were aimed at testing a single hypothesis**.
- ❖ **Book chapter**
 - ⇒ It is **rarely sets out a fundamental hypothesis** but it tends to synthesize information about a particular subject.
- ❖ **Annual report**
 - ⇒ It describes works completed in any 12- month period.
 - ⇒ The intent is **not so much to conclusively prove a hypothesis** rather it is to **spell out objectives, describe activities and justify budget expenditure** for a piece of research undertaken in the year.
- ❖ **Newsletters**
 - ⇒ Its purpose is to **disseminate information of interest** to its readers **quickly** and in a **readily digestible format**. i.e. it gives a little emphasis on justification or methodology of the research.
 - ⇒ Mostly it addresses a **general readership** and should not be used as substitute for publication of research results as refereed journals.

Audiences and intent of a research communication

- ⇒ Readers of agricultural and related research fall in to different groups. The most common audience groups include:
 - ✓ Researchers in a specific field of research activities
 - ✓ Researchers with a peripheral/ minor interest
 - ✓ University teachers and other working staffs like lab and field assistances, and students
 - ✓ Research managers
 - ✓ Extension agents
 - ✓ Farmers
 - ✓ Policymakers
 - ✓ Donor agents
 - ✓ Members of government and research communities
 - ✓ Commercial business people

IV.4. Format of the Research Report

- Before starting to write a scientific paper or report, ask yourself:
 - ✓ Has this research work advanced enough to be reported
 - ✓ Is this to be a progress or final report of the research publication
 - ✓ To who this paper or report is going to be submitted (is it for a donor or institution)
- The main reasons why scientists write research papers are;
 - ✓ Helping advance knowledge in a particular field

- ✓ Supporting the progression of a professional career.
- ✓ Satisfying the donor who provided the funding for research.
- ✓ Becoming famous.
- The characteristics of good scientific paper should
 - ✓ Present an accurate account of the research investigation
 - ✓ Be clearly written and easily understood
 - ✓ Follow the particular style of the scientific discipline
 - ✓ Be free of jargon and local slang
 - ✓ Have appropriate and adequate illustrative material, all of which should be relevant to the subject of the report.
 - ✓ Not contain any plagiarized material (Plagiarism is a serious offence and is a serious charge against an author.

Structure and part of a research paper

- In general, a research report or paper is written using the **IMRAD logic** which is believed as a simple and universally accepted format. The acronym IMRAD is derived from – Introduction, Materials and Methods, Results and Discussion.
- There are two parts; preliminary and main body sections

A. Preliminary section

1. Title page:

- includes:
 - ✓ The title or topic name
 - ✓ The name of the authors
 - ✓ The relationship of the report to a course or degree requirement
 - ✓ The name of the institution where the report is submitted
 - ✓ The date and place of the presentation
- Any research title will almost certainly change before the research is completed and reported. It is very wise to think of an effective title that will be finally adopted.
- The title should **catch the readers' attention** while informing them about the main thesis/ view of the study and should be **concise** and **give a precise indication** of what is to come. It should **not claim more** than what the study actually delivers.
- The title should be typed in **capital letters**, **single spaced** and **centered** between the right and left margins of the page.

2. Acknowledgement (if any)

- An acknowledgement page is included if the writer has received **unusual assistance** in the conduct of the study.
- The author gives **credit** for external support received during the conduct of the study.
- Acknowledgement also expresses gratitude for the use of **copyrighted** or otherwise **restricted materials**.

3. Table of contents:

- A good table of contents serves as an important purpose in providing an **outline of the report content**.
- The relationship between principal and minor divisions is indicated by **capitalization of chapter numbers and titles**, with subheadings in small letters and with capitalized principal letters.

B. Main body of the report

1. Introduction

- It **presents the problem** addressed by the research and gives **sufficient background information** that allows readers to understand the results of the study.
- It is written in such a way that readers will know the current status of research conclusions on the topic, the theoretical implications associated with the results of previous research on the subject, and the statement of a hypothetical resolution of the issues to be tested by the research described.
- As in the proposal, the introduction should **describe the nature and purpose** of the study, **present the guiding research questions**, and **explain the significance of and justification for conducting the study**. Terms likely to be used throughout the paper should be defined in this section.

2. Review of Related literature

- It must be organized in relation to research topic you are developing.
- Synthesize results into a summary of what is and is not known, identify areas of controversy in the literature, formulate questions that need further research.

3. Materials and Methods (Methodology)

- It is used to describe what the researcher did and how the study was conducted.
- One important purpose is to enable others repeat the experiment and verify the results if they wish to. In doing so, you should summarize the procedures in the execution of each of the stage of your work.
- This section should build on the description of methods outlined in the proposal. You should label subsections similar to those in the proposal.
- It is done in the past tense or past perfect tense form and it should present the following:
 - Procedures used and kind of design
 - Sources of data
 - Methods of gathering data
 - Description of data gathering instruments used

4. Analysis of data/ Results

- This section summarizes the data collected and details the statistical treatment of that data.
- Present your results in a logical sequence using only observations pertinent to your stated objectives.
- After a brief statement of the main results or findings of the study, the data are reported in sufficient detail to justify the conclusions.

- Tables and illustrations may be used to report data when these methods are seen to present the data more clearly and economically.
- Do not replicate observations in your tables. Give only means and measures of variability.
- Use tables to present exact values and figures to show trends and relationships.
- All tables and illustrations should be mentioned in the text, with appropriate titles or captions and enough explanations to make them readily identifiable.
- Avoid repetition of numerical data from the tables and figures in the text.

5. Discussion

- This section should reflect the implications of the study and the researcher evaluates the data and interprets the findings in the context of the research questions or hypothesis. He or she is guided by questions like the following.
 - ⇒ What do my results mean and what are their implications?
 - ⇒ Should I interpret my results clearly, concisely and logically?
- The major results are picked or summarized, evaluate, and interpreted with respect to the original research questions and hypotheses and related with previous works.
- It includes the theoretical and practical consequences of the results and the validity of conclusions, the limitations of the study and suggestions for future work, and emphasizes on new results and suggests new lines of work or further research.

6. Conclusions and Recommendations

The researcher is expected to describe briefly what he/ she did, the main results and recommendations for further research or applicability.

7. References

- At the end of your report you need to list all the sources cited in the text.

8. Appendix

- It is a convenient place to put materials, which are relevant to the report, but would interrupt the flow of the next or would take too much space if placed in the main body of the report.
- Common things to be included in the appendix include:
 - ✓ Detail questionnaires and interview schedules
 - ✓ Maps and statistical procedures
 - ✓ Climatic information (Temperature, Rainfall etc)

Data presentation

- Data that have been collected and analyzed in a scientific investigation are presented in the results section of a scientific paper. These data represent the research findings and may be presented as tables, graphs, figures or photographs
 - ✓ Tables are good for presenting precise numerical data.
 - ✓ Graphs are best for illustrating trends and relationships among sets of variables.
 - ✓ Figures and photos give vivid/ colorful evidence of research findings.

Table

- Table is a **systematic arrangement** of data or information in a format that allows the reader to **observe variations or trends** and to **make comparisons**.
- It helps the reader **to spot on important details of observed relationship, get a brief overview of findings, grasp the significance of data much quickly and conveniently** than through along textual discussion.
- A table may be included as a **quantitative support statement** in the text to clarify a complex argument. Although the use of tables is **not recommended** simply to repeat information adequately covered in the text of the report, the text should contain sufficient detail to support the particular arguments being put forwards.
- The essential future of good table is its **simplicity and clarity**. i.e. don't put too much data in a single table b/c it **opens door for confusion**. It is desirable to concentrate on a limited number of ideas in a single table and so use **several tables for making several comparisons** of distinctly different kinds of data.
- If a table is large enough to cover more than half a page, it should be placed and centered on a page by itself. If it is short and occupies less than half a page, it may be placed on the page with the material of the text preferably, as closely as possible to the text than relates to it.
- All tables including those appear in the appendix should be **numbered** to permit **easy identification**. The usual practice is to use Arabic numerals and to number tables consequently throughout the report. If tables are included in the appendix, the numbering sequences should continue from the last table number in the text. The word table followed by its number is placed in the first line.
- Every table has title or heading. The title should be a **concise summary** of what is presented in the body of the table. If the title is more than one line, it is single spaced and centered like an **inverted pyramid**. The title of each table must correspond exactly with the given in the list of tables.
- It is **not advisable to fold tables larger than one page** and include it in the report. If such table is encountered an attempt should be made to **reduce the font and spacing** of the table so that it would fit in to the normal page.
- Column headings and box heading should be worded carefully and clearly, describing the nature and units of measurements of the data listed. Generally a table consists of most or all of the following elements:
 - ✓ Number and title
 - ✓ Column and row headings
 - ✓ Field or body of the table
 - ✓ Footnotes

Figures, charts and graphs

- Figures are used by the researcher for the purpose of presenting **data clearly and concisely**. When skillfully used they reveal trends or relationship that the reader might not grasp when examining complex statistical data presented in tables.

- Charts and graphs are **pictorial representation** of relationship between two or more variables. Generally, they serve three important purposes.
 - ✓ Illustration or communication
 - ✓ Analysis of relationship
 - ✓ Graphical computation
- Since charts and graphs **bring out the salient features** of a set of numerical information, they **attract the attention of the reader more easily as compared to tabular or verbal presentation**.
- Charts and graphs are very useful for **summarizing a large amount of data**. Relationship between variables and trends become more apparent when depicted graphically than when presented in a tabular form.
- An illustrative graph portrays information in such a way that it is **easy for the viewer to understand facts and arrive at conclusion**.
- Graphs should be **simple and clear, contain relevant legends, independent of the text, organized in the way they present data and not crowded**. They should be used only if they bring **significant ideas or relationship in to a sharp focus** for the reader more quickly and effectively than the other means of presentation.
- Examine the data carefully and decide what should be illustrated and which type of illustration best suits the data or the information you wish to present.

Examples;

- ✓ Choose a line graph if you wish to demonstrate the relationship between two data sets, or a dynamic comparison over time.
- ✓ Use a flow chart to explain a process or system.
- ✓ Use a pie chart to compare sizes or proportions of components of system.
- ✓ Use histograms/ bar charts to show frequency distributions of observations for each class of variable such as weights or crop yields.
- ✓ Use mathematic map to show the pattern of an experimental layout, or a geographic map to show the distribution on insect pests, for example, over a country or region.
- ✓ Use photographs to show the actual appearance of a specimen or something else you wish to describe.
- ✓ Use line drawings to illustrate objects or specimens or to present numerical data.

Note:

- A graph or a figure tells its own story. Do not repeat everything that you audience can see from the illustration just as if it were not there. But it is good to draw attention to important points that the graphs illustrates.

Oral presentation of research results

- There are major differences between a scientific article written for reading and one written to be present at scientific meeting. In **a written article**, the reader has the

luxury of lingering over the text to absorb the material, even going back to a previous paragraph or page to help grasp the significance of something later in the text. But in **oral presentation**, the listener may have only one chance to understand the material that is being presented; thus the speaker needs to present each idea **clearly** and perhaps even **repeat key points**.

- Some people argue that it takes about 3 minutes to put across a new idea, and therefore a speaker must repeat and expand on an idea several times for the audience to get the message.
- In most scientific meetings, each presenter is allowed only about **15 minutes** (about two minutes for an introduction, one minute for the conclusion and the rest 12 minutes for the methodology, results and discussion). This is a short time to present research work that took several times to complete.
- Here are some hints how to prepare and present a scientific report at meeting.
 - During preparation
 - ✓ Try to speak at a normal speed and loudly. For example, speakers can deliver about 400 words in 5 minutes.
 - ✓ Focus only on the major ideas and avoid citing references and acknowledgements that will waste your precious presentation time.
 - ✓ Prepare or select your illustrative material such as slides or overhead transparencies very carefully. Ensure that it is relevant to the subject and will reinforce what you say.
 - ✓ Double space the text, or use large letters if your computer printer can handle them, so that the text is easy to read.
 - ✓ Do not use too much data in to the visual materials.
 - ✓ Rehearse with a colleague so that you know your presentation will fit in to the allotted time.
 - ✓ Put your illustrations in the order you will use them and number them accordingly.
 - ✓ If you are using slides, mark them so you know which way they go into the projector tray.
 - At the conference room
 - ✓ Before your presentation, load your slides in to the projector and do a trial run to ensure that they are all loaded correctly in the right sequence. A preceding coffee or lunch break is a good time to try this.
 - ✓ If the projector is not working correctly, inform the conference organizers immediately so they can either fix it or bring in another one.
 - ✓ Check that the projector is sitting solidly on its stand.

- ✓ Make sure that you know how to manipulate the projector, especially the remote control mechanism.
- During your presentation
 - ✓ Be relaxed and confident. Look at the audience, not at the floor or out the window, no matter how shy you may be.
 - ✓ Adopt a simple conversational style (speak clearly and somehow loudly to your audience) and do not shout at your audience.
 - ✓ Present a single idea or fact in a variety of ways by varying your construction and voice. Remember, present only one new idea every 3 minutes to permit your audience to pick up the idea.
 - ✓ Allocate your presentation time. For example for introduction = 35% methods = 40% and results and discussion = 25%
 - ✓ Pause after each new slider or transparency is projected to allow time for your audience to absorb the new material.
 - ✓ Do not distract you audience by pacing up and down the room, tripping over the microphone cord, or fiddling continuously with the microphone. If you have to use a microphone, do not place it too close to your mouth because the sound quality will be poor.
 - ✓ Get your message across clearly. Tell your audience what you are going to say (Introduction), say it (Methods, Results, Discussion), and then tell them what you have said (Conclusion).
 - ✓ If possible complete your presentation 2 minutes before your time is up. Do not get into a running battle with the chair, who will be struggling to stop your talk. Give other speakers affair chance to present their work.
 - ✓ At the end of you presentation, do not forget to thank the chair and the audience for their attention.

Chapter 5

On-farm Research

5.1. Overview of OFR

- On-farm research (OFR) is a **set of procedures on adaptive research** conducted on farmers' field in order to develop recommendations for representative groups of farmers.

- OFR is characterized by **farmers' participation** in identifying priorities, managing experimentation and evaluating results.
- Depending on the objectives of the study, the degree of farmer participation varies widely. It can range from traditional variety tests or fertilizer yield response trials (where the farmers' involvement is limited to giving permission for using their property and performing normal field operations) to farmer-initiated and managed trials (where the researcher becomes the collaborator)
- Groups identified as conducting on-farm research include: farmer organizations created specifically for this purpose; other grass-roots organizations that do agricultural research and hire staff that are not commercial farmers; agribusiness, and; publicly-funded research administered by colleges, universities and government agencies.
- OFR is most appropriate for:
 - ✓ Obtaining data on particular soil types or other physical conditions that are not available on the experiment station.
 - ✓ Studying phenomena that must be examined on a larger tract than the experimental station.
 - ✓ Analyzing systems that involve interactions among several individual enterprises or that essentially are of a whole-farm nature (eg. nutrient cycling, water quality impacts from surface runoff).
 - ✓ Comparing a system's performance under realistic farm conditions to its performance under experimental conditions.
 - ✓ Evaluating production techniques that are particularly sensitive to management skill.
 - ✓ Studying the long-term effects of a production method that has already been used on a farm for a long time (eg. long-term build up of soil nutrients or organic matter).
 - ✓ Analyzing a production method or management system that is already practiced by some farmers but has not received attention from researchers.

5.2. Stage of OFR

- Procedures for OFR can be divided into five stages, among which there is considerable overlap and feedback.
 - **Diagnosis:** Involves collecting and analyzing information in order to design on-farm experiments. Diagnostic activities may include a review of secondary data, interviews with local officials, informal farm surveys consisting of farmer interviews and field observations, and formal surveys with a questionnaire. The

purpose of the initial diagnostic activities is to gather enough information to describe the basic features of the research area, to identify problems that limit farmers' productivity, and to begin considering possible improvements in farmers' practices.

- **Planning:** It focuses on identification of experimental factors to be included in on farm experiments, as well as to suggest other research activities.
- **Experimentation:** On-farm experiments are planted on the fields of representative farmers and examine a small number of experimental variables. Most of the experiments progress from exploring production problems, to testing possible solutions, and then to verifying recommendations and demonstrating them with farmers.
- **Assessment:** The results of the on-farm experiments should be analyzed carefully and it requires assessment of farmers' reactions and opinions, systematic agronomic interpretation, and careful statistical and economic analysis. The results of the assessment are then used to plan future research and to make recommendations for farmers.
- **Recommendation and Diffusion:** When researchers are confident that they have enough information, they can formulate recommendations. In the system extension agents participate in the entire process and so are able to transfer recommendations to farmers with skill and confidence. When farmers are actively involved in the research process, they participate effectively in the diffusion of new technologies. By monitoring farmers' opinions and use of new technologies, researchers can improve their understanding of farmers' needs and preferences.

5.3. Characteristics of OFR

Issues Related to the Planning Stage of OFR

- The method of designing on-farm experiment is intended to develop technologies that can improve farmers' productivity in the short term (three to five years). This type of adaptive research relies heavily on technologies such as new crop varieties or management practices which have been developed through applied researches. However, longer term priorities for technology development can be suggested by information generated during OFR and agricultural development policy which often direct research toward particular regions, crops, or types of farmer. This planning method can be used to identify suitable issues to be pursued with officials responsible for implementing policy or for extension.
- Planning an experimental program requires an understanding of how farmers adopt innovations. Although in certain situations farmers may need to make simultaneous changes in a number of their practices, it is always advisable to consider offering farmers intermediate steps toward the adoption of a package of practices. Most

farmers are very cautious and tend to adopt one or a few new inputs or techniques at a time. This stepwise adoption behavior has important implications for planning an experimental program, because it may influence the number of factors that are tested at any one time and the order in which they are tested.

The Use of Diagnostic Data in the Planning Process

- Effective planning depends on the information developed during the initial diagnostic activities, the diagnosis that takes place afterward (supplementary surveys, observations, crop or soil samples, etc.) and the results of the experiments themselves.
- A diagnosis has four goals:
 - To describe the circumstances and practices of representative farmers;
 - To identify problems limiting the productivity of the resources available to farmers
 - To understand the causes of those problems; and
 - To begin to consider possible solutions.

Chapter 6

Farmer Participatory Research

6.1. Introduction to farmer participatory research

- It is defined as research in which farmers play the leading decision-making roles in identifying and designing researches as well as in implementing and evaluating it.

- It is active involvement and participation of beneficiaries (farmers) and other stakeholders in the agricultural research process. This approach is evolved as a response to earlier agricultural research methodologies (on-station research and Farming Systems Research) that were found to be unsatisfactory in producing appropriate and sustainable research results for the target beneficiaries.
- Participatory rural appraisal (PRA) can be described as a set of approaches and methods that enable local people to express and analyze their realities and conditions in order to plan, implement, monitor and evaluate their activities. PRA emphasizes processes that empower local people and employs a wide range of methods such as: matrix scoring to compare things; map drawing to show the location of important local features and resources; flow diagrams to indicate system linkages, and causes and effects; and seasonal calendars to illustrate annual variations in important factors, such as food availability and labor wages
- There are some common meanings used to identify the various types of participation in agricultural research:
 - **Contractual:** researchers contract with farmers to obtain land and services
 - **Consultative:** researchers consult farmers about their problems and then develop solutions for them
 - **Collaborative:** researchers and farmers collaborate as partners
 - **Collegiate:** researchers work to strengthen farmers' informal research and development systems, and where farmers are given scope to apply their initiative and specialized knowledge throughout the research process.
- FPR represents an attempt to move towards collegiate research, recognizing farmers as innovators and experimenters, and treating them as active and equal partners with researchers and extensionists (rather than merely passive end-users of technologies).

6.2. The aims and objectives of FPR include the following:

- ✚ Increase the understanding of the complexities and dynamics of local agricultural and socio-economic systems;
- ✚ Identify priority problems, constraints and opportunities;
- ✚ Identify, develop, test and implement new technologies and techniques (based on the knowledge and research capabilities of local communities and institutions; and
- ✚ Stimulate and strengthen the experimental capacity of farmers to analyze their situations and develop relevant, feasible and useful innovations;

- There are three main reasons for promoting FPR
 - ✓ **Pragmatic objectives:** to increase the efficiency and effectiveness of research through increased adoption rates of technologies and techniques, and reduced research and extension costs;
 - ✓ **Ethical objectives:** to increase equity and ensure that stakeholders, especially the resource-poor, play a role in activities that affect them; and
 - ✓ **Political objectives:** to empower the poor and strengthen their bargaining power.
- FPR is important to achieve the following outputs:
 - ✓ Create better linkages and understanding between farmers, researchers and extension staff;
 - ✓ Develop a better understanding of ways in which FPR can be conducted in developing countries such as Ethiopia
 - ✓ Enhance the capacity of GOs and NGOs that enable farmers to undertake FPR
 - ✓ Stimulate and encourage the incorporation by GOs and NGOs of FPR into their own organizational activities.
- Methods of Farmers' Participatory Research include:
 - ✓ Participatory on-farm trials
 - ✓ Group/ community meetings, workshops, discussions
 - ✓ Case studies with individual households/ farmers
 - ✓ Study tours (to other farmers' fields and research stations)/ exchange visits
 - ✓ Participatory Rural Appraisals (PRAs).
- The current popularity of the FPR approach represents a fundamental shift of attitudes and approach in the agricultural research and development process. Within an FPR approach, farmers' needs and demands become the driving forces, and the constraints of the systems are the ability of the support services (research, extension and input-supply) to respond effectively to these demands.
- It often requires a complete reversal of both the information and the staff incentive systems. For example, information systems have to become sensitive and responsive to variations (across space and time) in demand from below, and staff should be rewarded for their ability to listen to, and act on, farmers' demands, relaying these to their colleagues and superiors. The change in procedures and normal values required to implement this switch is formidable, and represents a considerable challenge to advocates and practitioners of FPR.

6.3. Planting and conduction participatory on-farm Experiment

- While planting and conducting participatory on farm research, farmers should be the main participates of the experiment. They should be participated from planting until analysis of the result. The degree of involvement varied from high intensity (involving a substantial amount of FPR staff time in the field) to low intensity (in

which FPR simply gave some advice on trial design or analysis of results to a collaborating GO or NGO).

- What is important for all of the above methods is the manner in which they are applied to a large degree depends on the nature of the dialogue that can be established between researchers/ extensionists and farmers.
- The use of participatory methods requires researchers to re-examine their own knowledge bases and attitudes and to cultivate a willingness to treat farmers as equals, with respect for their concepts, detailed technical knowledge and research capacity, and to acknowledge them as experimenters and innovators.
- The difference between participatory and conventional researches are given in the table below:

Criteria	Participatory research	Convectional research
What is the research for?	Action	Understanding with action later
Who is the research for?	Local people	Institutional, personal and professional interests scientists
Whose knowledge counts?	Local people's	Funding parities, institutional agendas, professional interests
Topic choice influenced by?	Local priorities	Disciplinary convections, objectives or truth
Methodology chosen for	Empowerment, mutual learning	Researcher
Problem identification	Local people	Researcher or enumerator
Data collection	Local people	Disciplinary concepts and frameworks
Analysis	Local concepts and	Researcher
Presentation of findings	Local people	By researcher by other academicians or funding body
Action on findings	Internal to the processes	Separate and may not happen
Who takes action	Local people with or without external support	External agencies
Who owns results	Shared	The researcher
What is emphasized	Process	Outcomes