TRENDS IN ECOLOGY AND ENVIRONMENTAL BIOLOGY RESEARCH METHODS: A REVIEW

Article · June 2017

CITATIONS
0

READS
2,496

2 authors, including:

Umar Aminu Mohammed
Bauchi State University, Gadau. Bauchi State, Nigeria.
15 PUBLICATIONS **13** CITATIONS

SEE PROFILE

BEST JOURNAL 14(1): 34 - 43
Date received: March 27, 2017
Date accepted: June 03, 2017
Printed in Nigeria

TRENDS IN ECOLOGY AND ENVIRONMENTAL BIOLOGY RESEARCH METHODS: A REVIEW

Mohammed, U. A*[1]. Ibrahim, S[2]. and Hayatu, M[3].
[1]Department of Biological Sciences, Bauchi State University, Gadau.Bauchi State, Nigeria. P.M.B. 65.
[2]Department of Biological Sciences and [3]Plant Biology,Bayero University, Kano, Nigeria.
*Correspondence author: farukamohammed@gmail.com

ABSTRACT
Environmental sciences are made up of disciplines such as Environmental Biology, which is regarded as an Applied Ecology. Ecology and Environmental Biology are related areas of specialization, thus the reason why students study it as a discipline. Ecology is the study of the relationship between living organisms and their environment, while environmental biology is an Applied Ecology that studies the holistic relationship between man and the physical and biological environment. This paper is based on the review of the some relevant work in the subject matter. Research methods is an important aspect of science and it denotes the procedure the researchers utilize in carrying out research processes. These include methods or techniques applied by the researcher throughout the period of studying his research problem. This paper highlighted eleven steps involved in ecological research process which are : Research problem formulation; Extensive literature survey; Developing the hypothesis; Research design preparing; Determining sample design; Collecting the data; Project execution; Analysis of data; Hypothesis testing; Interpretation and generalisation, and Report preparation. A research design is required after formulating the research problem, which deals with organising ideas within which research would be conducted. The research design preparation enables efficient and maximal information yielding. These can all be achieved subject to the research purpose, which is organized into four,viz: Exploration, Description, Diagnosis, and Experimentation. There are several research designs, such as, non-experimental and experimental hypothesis testing. Experimental designs can be either informal designs, such as before-and-after without control, after-only with control, before-and-after with control or formal designs, such as completely randomized design, randomized complete block design, Latin square design, simple and complex factorial designs, out of which the researcher must select one for his own project. Experimental research can also be grouped in to three categories; Controlled observation, Mensurative experiment and Manipulative experiment.After analysing the data based on the experimental design usedby the researcher, he is expected to test the hypothesis using various testssuch as Chi square test, t-test, F-test and drawing conclusion based on the outcome of the test.

Key words: Ecology, Environmental Biology and Research Methods.

INTRODUCTION

Trends are usually used to describe prevailing styles or general direction people are heading to in terms of techniques. It is always regarded as the best or most accepted way of doing things. This paper intends to review the methods and techniques used in carrying out ecological and environmental biology research.

Ecology and Environmental Biology are highly related areas of specialization, thus this motivated the students to study it as a discipline. Ecology is the study of the relationship between living organisms and their environment, while Environmental Biology is an Applied Ecology that studies the holistic relationship between man and the physical and biological environment (Allaby, 2010).

Ecologists usually illustrate ecological science as dynamic. 'Ecology is a scientific discipline in transition'(Holling, 1998). This changeover is described by numerous important shifts in prominence and perception(Wallington, Hobbs, & Moore, 2005; Carmel *et al*., 2013). Almost in the entire 20th century, a significant number of ecologists conceptualized ecological systems atequilibrium or as moving back to such equilibrium naturally following exceptional disturbances (Scoones, 1999). In recent years, there has been a movein the direction of accepting ecological systems as nonlinear, regularly changing, and random in space and time(Pickett, Shachak, Ostfeld, & Likens, 1997; Botkin, 2012).Subsequently equilibrium concept was substituted by additional concepts, for instance, the non- equilibrium change concept, where the system is usually characterised as revolving among different states (Noy-Meir, 1975). Ecologists have two opinions on the question of whether the fluctuation in ecological science signifies a Kuhnian 'paradigm shift' (Pickett, Parker, & Fiedler, 1992; Graham & Dayton, 2002; Naeem, 2002; Botkin, 2012), or, alternatively, a slow accumulation of changes, better described as 'evolution' instead of 'revolution'(Paine, 2002; Wallington *et al*., 2005).

Though some ecologists still believe that progress in ecology is inadequate(O'Connor, 2000; Bolnick *et al*., 2011;Carmel *et al*., 2013).

Research methods is an important aspect of science and it denote the procedure the researchers utilize in carrying out research processes. That is all those methods or techniques applied by the researcher throughout the period of studying their research problem are known as research methods(Kothari, 2004). Research methodology is not the same as research methods, because it uses systematic procedure to decipher the research problem. It could be regarded as a science of studying how research can be executed scientifically. It is logic the researcher use in solving his research problem, on the other hand ……. Therefore the researcher needs to know all the techniques/methods essential including the methodology(Kothari, 2004).

Research Process

Research process is made up of sequentialstagesneeded to efficiently carry out the research. The order below provides an important step by step guide as regards to the research process(Ratti & Garton, 1994; Kothari, 2004).

1. Research problem formulation;
2. Extensive literature survey;
3. Developing the hypothesis;
4. Research design preparing;
5. Determining sample design;
6. Collecting the data;
7. Project execution;
8. Analysis of data;
9. Hypothesis testing;
10. Interpretation and generalisation, and
11. Report preparation.

Research Problem Formulation:

Research problem is the fuel that plots the scientific process. It is the base of any research method. Two research problems are widely recognised, which include those relate to states of nature and those relate to relationships between variables. From the word go the researcher must identify the problem he wants to study, i.e., he needs to decide the general area of interest relating to the subject-matter he wishes to look into. In the Initial stage the problem could be stated in a general and broad way and then other related problems will be resolved if any. Then, the practicability of the solution need to be considered before a problem working formulation can be set up. The conceptualisation of a broad topic into a particular research problem, is the first step in a scientific enquiry. fundamentally two steps are required in formulating the research problem, and that includes, thoroughly understanding the problem, and rewording the same into substantive terms from a logical point of view(Ford, 2004; Kothari, 2004; Olsen, 2004).

One can best understand the problem by discussing it with his colleagues or experts in the area. It is very common in an academic institution for a researcher to seek the help of anexperience guide that has several research problems in mind. Usually, the guide shade light on the problem in general terms, then it is up to the researcher to bottleneck it and phrase the problem in operational terms(Ford, 2004; Kothari, 2004).

The researcher required to examine as many accessible literature as possible to familiarise himself with the problem selected. Two types of literature are usually reviewed, which are the conceptual literature that deals with concepts and theories, and the empirical literature that is made up of studies done earlier which are similar to the proposed one. The rudimentary outcome of this review is the knowledge on the available data materials for operational purposes that will enable the researcher to define his own research problem meaningfully. The researcher will then reword the problem into operational and analytical terms i.e., to ensure the problem resented in a specific terms. This task of defining or formulating, a research problem is a very significant step in the whole research process. The problem the researcher is investigating must be specified unambiguously in order to help identifying relevant data from ones that are irrelevant. However care must be taken to corroborate the validity and objectivityof the background facts relating to the problem. Pertinent terms if present should be clearly explained along with the task of problem formulation. In fact, problem formulation often follows a successive pattern where some formulations are put in place, each formulation should be more specific than the preceding one, each more realistic in terms of the available resources and data, and each one phrased in more analytical terms(Ford, 2004; Kothari, 2004).

Ecological research involves defining, then continuously redefining, ideas and objectives as new results are obtained. Experienced researchers debate the meanings of the terms they use, the significance or interpretation of results obtained, what should be done next, and how it should be carried out. They engage in each of these activities over an extended period as their research proceeds. However, when you start research your process of questioning and debate is intense as you make a detailed analysis of a research problem(Carmel *et al*., 2013; Ford, 2004).

Literature Review:

As soon as the problem is formulated, a short summary of it should be scripted. At this point the researcher is obliged to carry out an extensive literature survey/review associated with the problem. In order to do that, the researcher needs indexing and abstracting journals and unpublished or published materials such as, academic journals, books, proceedings from conferences and government reports. Here one source will lead to another. Studies done earlier, if any, relating to the study in hand should be meticulously studied.

A good library will be a great help to the researcher at this stage. The researcher is expected to know the extent of knowledge in an area of the earlier studies after identifying the research problem. The is expected to identify the area of weakness, areas without weaknessand areas of controversy in order to make the review rich (Pearl, 2000; Kothari, 2004).

Working Hypotheses Development:

Hypotheses are mere assumption or some suppositionto be proved or disproved.As soon as the researcher has an extensive literature survey, theresearcher should clearly state statethe working hypothesis or hypotheses.Working hypothesis is a provisional supposition made with a specific end goal to draw out and test its coherent or observational outcomes. Thusly the way in which research hypotheses are created is especially critical since they give the point of convergence for research. They additionally influence the way in which tests must be directed in the investigation of information and indirectly the quality of information which is required for the analysis. In many sorts of ecological research, the improvement and development of working hypothesis assumes an imperative role. Hypothesis ought to be certain and constrained to the bit of research close by in light of the fact that it must be tried. The role hypothesis plays is to manage the specialist by delimiting the region of research and to keep him on tract. It hones his reasoning and concentrates consideration on the more imperative facets of the issue. It additionally demonstrates the sort of data required and the kind of techniques for data analysis to be utilized(Deacon *et al*., 1998). One needs to engage experts and colleagues as well as examining the records available when formulating hypothesis. Example; Heavy metals contamination in soil is not the function of soil microbes. This is a negative statement and it is known as null hypothesis. The opposite of the above statement could be; Heavy metals contamination is the function of soil microbes, this statement is known as alternative hypothesis. (Kothari, 2004).

Research Design Preparation:

The researcher will need to prepare a research design after formulating the research problem. He will have to organize his ideas within which research would be conducted. The research design preparation enablesefficient and maximal information yielding. These can all be achieved subject to the research purpose. Research purposes can be organised into four, viz., (i) Exploration (ii) Description (iii) Diagnosis and (iv) Experimentation. An adaptable research design which gives chance to considering a wide range of parts of an issue is viewed as fitting if the reason for the research study is that of investigation.Be that as it may, when the reason happens to be a precise depiction of a circumstance or of a relationship between variables, the appropriate plan will be one that limits bias and amplifies the unwavering quality of the data gathered and analysed(Ratti and Garton, 1994).

There are several research designs, such as, non-experimental and experimentaldesign. Experimental designs can be either informal designs (such as before-and-after without control, after-only with control, before-and-after with control) or formal designs (such as completely randomized design, randomized block design, Latin square design, simple and complex factorial designs), out of which the researcher must select one for his own project(Ratti and Garton, 1994).

Studies on Ecology and Environmental Biology use the following formal designs to test hypotheses:

I. Completely Randomised Design (CRD):
This is used if the experimental units are homogeneous or similar in their reaction to same treatment stimulus. If there are no restrictions on allocation of treatments to experimental units(Ratti and Garton, 1994).

II. Randomised Complete Blocks Design (RCBD):
This design adds power to the statistical methods by blocking or comparing treatments within homogeneous groups(Olsen, 2004).

III. Latin Squares (LS):
This design is the most useful in areas where the direction of heterogeneity is bidirectional in the soil fertility. With this type of soil fertility, it is not advisable to use RCBD because the blocking will take care of only one gradient while the other gradient will be confounded (or added) to the treatment effect. As a result, the variation observed among treatments cannot be attributed to the effect of the treatment alone because part of the variation may be due to differences in fertility gradient. Latin Square is the more appropriate design because the two-directional blocking, commonly referred to as row-blocking and column-blocking, is accomplished by ensuring that every treatment occurs only once in each row-block and once in each column-block. As such, LS design is considered more powerful than RCBD in that aside from detecting differences due to treatments, it also detects differences due to rows and columns and not due to blocks alone(Olsen, 2004).

IV. Split Plot, Split Split Plot:
In this design the main plot is assigned to either the whole experimental area (in CRD) or in each block (in RCBD) while the subplots are assigned and randomized in each main plot. With the randomization of the subplot in each main plot, the interaction (Main Plot x Sub Plot) is also created (therefore, the size of the subplot is always the same as that of the interaction).

The size of the subplot (and the interaction) will always be smaller than the main plot. With this design, the subplot and the interaction between the main plot and the subplot have higher degree of precision than the main plot(Olsen, 2004; Oehlert, 2010).

V. Factorial Arrangements:

Factorial, whether in CRD or RCBD, is applicable when an experiment is dealing with two factors to be evaluated at the same time. The other assumption is that both factors (A and B) and the interaction between the two (A x B) are of equal importance. Factorial can also be considered as simple CRD or RCBD if the factor combination will be considered as single treatment. After analysis, the treatment effect is partitioned into three meaningful components: due to A, due to B and due to AxB(Olsen, 2004).

Ecological research design preparation typically includes the following:

(i) The methods for data collection;
(ii) The accessibility and abilities of the researcher and his staff (assuming any);
(iii) Explanation of the path in which chose methods for acquiring data will be sorted out and the thinking prompting to the determination;
(iv) The time and resources available for the research; and
(v) The cost factor relating to the research, i.e. the finance available for the purpose(Kothari, 2004).

Determining Sample Design:

All the items into account in any field of inquiry represent a 'universe' or 'population'. A whole enumeration of all the samples within the 'population' is thought as a census inquiry. It will be plausible that in such an inquiry when all the items are covered no element of chance is left and highest accuracy is obtained. But in practice this may not be true. Even the slightest element of bias in such an inquiry will get larger and larger as the number of observations increases. Moreover, there's no manner of checking the component of bias or its extent except through a survey or use of sample checks. Besides, this kind of inquiry involves a good deal of your time, money and energy. Not only this, census inquiry is not possible in practice under many circumstances. For instance, soil testing is done only on sample basis. Hence, quite often we select only a few items from the universe for our study purposes. The things thus chosen represent what's technically known as a sample(Ford, 2004).

The researcherneeds to choose the method for choosing a sample or what is prominently known as the sampledesign. At the end of the day, a sampledesign is an unequivocal plan decided before any data are really collected for getting asample from a given population. In this manner, the plan to choose 12 of a city's 200 drugstores absolutely constitutes a sample design. Samples are either probability samples or non-probability samples. In probability samples every member of the population has equal chance of being incorporated into the sample yet the non-probabilitysamples don't permit the researcher to decide this likelihood. Probability samples are those based on simple random sampling, systematic sampling, stratified sampling, cluster/area sampling whereas non-probability samples are those based on convenience sampling, judgement sampling and quota sampling techniques. A short say of the critical sample designs is as per the following(Kothari, 2004):

(i) Deliberate Sampling:

Deliberate sampling is also known as purposive or non-probability sampling. This sampling technique involves the purposive or deliberate selection of specific units of the universe for constituting a sample that represent the universe. At the point when population components are chosen for incorporation in the sample base on the easiness of access, it can be called convenience sampling. On the off chance that the researcher wishes to secure information from, say, anglers, he may choose a settled number of water bodies and may lead interviews at these areas. This would be a case of convenience sample of anglers. Now and again such a procedure may give extremely one-sided comes about especially when the population is not homogeneous(Ford, 2004).

(ii) Simple Random Sampling:

This sort of sampling is otherwise called chance sampling or probability sampling where every item in the population has an equivalent chance of consideration in the sample and every one of the possible samples, in the event of limited universe, has a similar likelihood of being chosen. For instance, in the event that we need to choose a sample of 300 items from a population of 15,000 items, then we can put the names or numbers of all the 15,000 items on pieces of paper and carryout a lottery. Using the random number tables is another method of random sampling. To select the sample, each item is assigned a number from 1 to 15,000. Then, 300 five digit random numbers are selected from the table. To do this we select some random starting point and then a systematic pattern is used in proceeding through the table. We may begin in the fourth line, second segment and continue down the section to the base of the table and afterward move to the highest point of the following segment to one side.


At the point when a number surpasses the limit of the numbers in the frame, for our situation more than 15,000, it is just passed over and the next number selected that does fall within the applicable range. Since the numbers were set in the table in a totally irregular manner, the subsequent resulting sample is considered random(Kothari, 2004).

(iii) Systematic Sampling:

In a few occurrences the most handy method for sampling is to choose each 15th name on a list, each 10th house on one side of a road etcetera. Sampling of this sort is known as systematic sampling. A component of arbitrariness is normally brought into this sort of sampling by utilising irregular numbers to get the unit with which to begin. This technique is valuable when sampling frame is accessible in the form of a list. In such an outline the selection procedure begins by picking some arbitrary point in the rundown and after that each nth component is chosen until the coveted number is secured(Ader*et al.*, 2008Kothari, 2004).

(iv) Stratified Sampling:

In the event that the population from which a sample is to be drawn does not constitute a homogeneous gathering or group, then stratified sampling strategy is used in order to get a sample that is representative. In this method, the population is stratified into various non-overlaping strata or subpopulations and sample items are chosen from every stratum. On the off chance that the selected items from each stratum are based on simple random sampling in the entire procedure, i.e. stratification and then simple random sampling, is known as stratified random sampling(Kothari, 2004).

(v) Quota Sampling:

In stratified sampling the cost of taking random samples from individual strata is usually so costly that interviewers are just offered quota to be filled from various strata, the real determination of items for sample being left to the interviewer's judgment. This is termed quota sampling. The measure of the amount for every stratum is by and large proportionate to the extent of that stratum in the population. Quota sampling is therefore an imperative type of non-probability sampling. Quota samples for the most part happen to be judgment samples as opposed to random samples(Ader*et al.*, 2008Kothari, 2004).

(vi) Cluster Sampling and Area Sampling:

Cluster or bunch Sampling involves grouping the population and after that choosing the clusters or the groups as opposed to individual components for consideration in the sample. Assuming some game reserve wishes to sample its guests in a specific period. It has issued its cards to 15,000 guests. The sample size is to be kept say 450. For cluster sampling this rundown of 15,000 guests could be framed into 100 clusters of 150 guests. Three cluster may then be chosen for the sample randomly. The sample size should frequently be bigger than the sample random sample to guarantee a similar level of precision on the grounds that in cluster sampling procedural potential for order bias and different wellsprings of mistake is generally highlighted. The clustering methodology can, be that as it may, make the sampling procedure generally less demanding and increment the productivity of field work, particularly on account of personal interviews(Kothari, 2004).

(vii) Multi-stage Sampling:

This is a further advancement of cluster sampling. This method is implied for enormous request stretching out to an extensively substantial geological territory like a whole nation. Under multi-stage sampling the main stage might be to choose vast primary sampling units, for example, states, then regions or districts, then towns lastly certain families inside towns. On the off chance that the random sampling is used at all stages, the sampling methodology is depicted as multi-stage random sampling(Kothari, 2004).

(viii) Sequential Sampling:

This is somewhat a complex sample design where the ultimate size of the sample is not fixed in advance but is determined according to mathematical decisions on the basis of information yielded as survey progresses. This design is usually adopted under acceptance sampling plan in the context of statistical quality control(Kothari, 2004).

By and by, a lot of the strategies for sampling depicted above may well be utilized as a part of a similar review in which case it can be called mixedsampling. It might be brought up here that ordinarily one ought to turn to randomsampling with the goal that inclination can be disposed of and samplingerror can be estimated. In any case, purposive sampling is viewed as attractive when the universe happens to be little and a known characteristic of it is to be considered seriously.

Additionally, there are conditions under which sampledesigns other than randomsampling might be viewed as better for reasons like convenience and low expenses. The sample design to be utilised must be chosen by the researchertaking into consideration the nature of the inquiry and other related factors(Ader*et al.*, 2008Kothari, 2004).

Collecting the Data:

In dealing with any real life problems it is often found that data at hand are inadequate, and hence, it becomes necessary to collect data that are appropriate.

There are several ways of collecting the appropriate data which differ considerably in context of money costs, time and other resources at the disposal of the researchers.

Observations and experiments are known to be the two dominant tools of ecological research. The researcher is expected to identify an increase in the frequency of models, for two reasons: (1) The ecosystem has increasingly been described as 'complex', and models are often the only tools available for the study of complex systems, and (2) Due to the substantial increase in the availability of modelling tools during the last three decade (Carmel *et al.*, 2013). An increase in the proportion of meta-analysis studies is expected, for two major reasons: (1) a growing awareness of the incapacity of single studies of specific systems, conducted under narrow ranges of conditions, to provide insights on broader ecological issues, and (2) the increased access to information and data in the age of the Internet(Belovsky *et al.*, 2004).

In the past, ecologists have been reluctant to engage in applied research (Lindenmayer *et al.,* 2015). Applied science was considered inferior to basic, 'pure' science (Ludwig *et al.*, 2001). Some applied ecological issues, such as conservation, are emotionally charged (Wallington *et al.*, 2005), and perceived by some ecologists as 'advocacy' (Levin, 1999). More recently, ecologists have become increasingly concerned about the implications of their work to society's problems(Ludwig *et al.*, 2001; Belovsky *et al.*, 2004), while environmental agencies have expressed an increased demand for ecological solutions to environmental problems (Sutherland *et al.*, 2006).

Primary data are mostly collected either through experiment or non-experimental proceduresuch as survey. If the researcher conducts an experiment, he observes some quantitative measurements, or the data, with the help of which he examines the truth contained in his hypothesis(Ludwig *et al.*, 2001; Belovsky *et al.*, 2004).

Dredging of data

Dredging of data is a non- experimental research, it happens when examining data sets that are usually collected for other purposes (Smith & Ebrahim, 2002). If a hypothesis and ahypothesis test are stated prior to the examination of the data, and the results of the test, regardless of the outcome are reported, then dredging of data can be useful and result in a considerable savings in effort. In the preliminary stages of study for a new topic it may be a useful process in formulating a new hypothesis and to validate critical hypothesis tests. But, when the topic has been the subject of much study, a specific hypothesis should be available for testing earlier. One should be careful when engaging in three other types of dredging of data (Smith & Ebrahim, 2002).

i. Snooping: It is testing a large set of hypotheses. The problem arises since some tests are expected to be significant by chance alone and because the hypotheses may not be independent. These problems also occur with experimenter generated data sets(Keppel, 1982).
ii. Fishing: This is choosing test variables based on an examination of the data rather than because of their importance toa*priori*hypothesis. Also, by relegating variables to two classes, those chosen and those discarded, the interpretation of the results are clouded. In the absence of a specific *a priori* hypothesis, report the tests for all variables(Keppel, 1982).
iii. Hunting: This is the process of searching through many data sets to find some relationships worth testing. One can never know how many data sets were found not to display the desired relationship since negative results are seldom reported(Keppel, 1982).

Experimental research

Experimental research involves collecting of data by the experimenter for the express purpose of answering a particular question or to test a particular hypothesis. This does not mean that all experimental evidence is created equal as a source for causal inferences. In fact, several kinds of experiments that in the order to be present andrepresent an increasing degree of intervention on the part of the experimenter into the workings of nature. And it is believed a growing ability to connect intimately cause an effectExperimental research can be grouped in to three categories; (1) Controlled observation (2) Mensurative experiment and (3) Manipulative experiment(Ford, 2004; Kothari, 2004).

1. Controlled Observations

Controlled observations aremostly collected by design to test a specific hypothesis. The design incorporates samples under the experimental conditions of intrigue and under putative control conditions, which means without the experimental treatment. In any case, the perceptions are gotten from a sampling program that includes nature just latently. The main action of the experimenter is to make the observations, analyze the data, and interpret the result(Schulze *et al.*, 2005).

2. Mensurative Experiments

Mensurative is a kind of experiment where the experimenter does not control the experiment. It involves the experimenter and a part of nature a bit more actively inthe hypothesis test*,* but only to passively measure another part of nature(Pearl, 2000).

3. Manipulative Experiments

In a manipulative experiment, the experimenter possess a total control over a portion of nature to create all the desired experimental and control conditions.

But in the case of a survey, data can be collected by any one or more of the following ways:

(i) By observation: This method implies the collection of information by way of investigator's own observation, without interviewing the respondents. The information obtained relates to what is currently happening and is not complicated by either the past behaviour or future intentions or attitudes of respondents or other organisms as the case may be. This method is no doubt an expensive method and the information provided by this method is also very limited. As such this method is not suitable in inquiries where large samples are concerned(Ford, 2004).
(ii) Through personal interview: The investigator follows a rigid procedure and seeks answers to a set of pre-conceived questions through personal interviews. This method of collecting data is usually carried out in a structured way where output depends upon the ability of the interviewer to a large extent(Kothari, 2004).
(iii) Through telephone interviews: This method of collecting information involves contacting the respondents on telephone itself. This is not a very widely used method in ecology and environmental biology but it plays an important role in industrial surveys in developed regions, particularly, when the survey has to be accomplished in a very limited time(Kothari, 2004).
(iv) By mailing of questionnaires: The researcher and the respondents do come in contact with each other if this method of survey is adopted. Questionnaires are mailed to the respondents with a request to return after completing the same. It is the most extensively used method in various environmental economic and ethno medicinal surveys. Before applying this method, usually a Pilot Study for testing the questionnaire is conduced which reveals the weaknesses, if any, of the questionnaire. Questionnaire to be used must be prepared very carefully so that it may prove to be effective in collecting the relevant information. Questionnaires are either open ended, which requires more explanation or closed ended, which requires a simple yes or no (Ader*et al.*, 2008Kothari, 2004).
(v) Through schedules: Under this method the enumerators are appointed, given training and then provided with schedules containing relevant questions. The enumerators meet the respondents with the schedules, data thereby would be collected by filling up the schedules by enumerators on the basis of replies given by respondents. Much depends upon the capability of enumerators so far as this method is concerned. Some occasional field checks on the work of the enumerators may ensure sincere work. The researcher should select one of these methods of collecting the data taking into consideration the nature of investigation; objective and scope of the inquiry, financial resources, available time and the desired degree of accuracy. Though the researcher needs pay attention to all these factors but much depends upon the ability and experience of the researcher(Kothari, 2004).

7. Project Execution:
Execution of the project is an imperative stride in the research process. In the event that the execution of the project continues on right direction, the data to be gathered would be sufficient and dependable. The researcher ought to see that the project is executed in a deliberate way and on time. In the event that the study is to be directed by methods for structured questionnaires, information can be promptly machine-handled. In such a circumstance, inquiries and additionally the conceivable answers might be coded. On the off chance that the information are to be gathered through interviewers, courses of action ought to be made for appropriate choice and preparing of the interviewers. The preparation might be given with the assistance of guideline manuals which clarify unmistakably the job of the interviewers at each progression. Periodic field checks ought to be made to guarantee that the interviewers are doing their doled out jobs truly and proficiently. A cautious watch ought to be kept for unexpected factorsin order to keep the survey however much practical as could reasonably be expected. This, at the end of the day, implies that means ought to be taken to guarantee that the study is under measurable control so that the gathered data is as per the pre-characterized standard of exactness. In the event that a portion of the respondents do not cooperate, some reasonable techniques ought to be designed to handle this issue. One strategy for managing the non-response issue is to make a list of the non-respondents and take a small sub-sample of them, and after that with the assistance of specialists incredible endeavours can be made for securing response(Kothari, 2004).

8. **Analysis of Data**:
After the information have been gathered, the researcher swings to the task of analysis it. The analysis of information requires various firmly related operations, like establishment of categories, the use of these categories to crude information through coding, organization and after that drawing statistical inferences. The cumbersome information ought to essentially be consolidated into a couple of reasonable gatherings and tables for further investigation. In this way, specialist ought to order the crude information into some deliberate and usable classifications. Coding operation is typically done at this phase through which the classifications of information are changed into images that might be arranged and tallied. Altering is the methodology that enhances the nature of the information for coding. With coding the stage is prepared for classification. Organization is a piece of the specialized system wherein the ordered information are placed as tables. The mechanical gadgets can be made utilization of at this point. A lot of information, particularly in extensive request, is organized by computers. Computers spare time as well as make it conceivable to study huge number of factors influencing an issue at the same time (Oehlert, 2010).

Analysis work after tabulation is generally based on the computation of various percentages and coefficients, by applying various well defined statistical formulae. In the process of analysis, relationships or differences supporting or conflicting with original or new hypotheses should be subjected to tests of significance to determine with what validity data can be said to indicate any conclusion(s). For instance, if there are two samples of weekly refuse dump, each sample being drawn from agencies in different parts of the same city, giving two different mean values, then the problem may be whether the two mean values are significantly different or the difference is just a matter of chance. Through the use of statistical tests one can establish whether such a difference is a real one or is the result of random fluctuations. If the difference happens to be real, the inference will be that the two samples come from different universes and if the difference is due to chance, the conclusion would be that the two samples belong to the same universe. Similarly, the technique of analysis of variance can help in analysing whether three or more varieties of seeds grown on certain fields yield significantly different results or not. In brief, the researcher can analyse the collected data with the help of various statistical measures(Kothari, 2004; Oehlert, 2010).

9. Hypothesis-testing:

After analysing the data as stated above, the researcher is in a position to test the hypotheses, formulated earlier if any. The facts support the hypotheses or they happen to be contrary? This is the usual question which should be answered while testing hypotheses. Various tests, such as Chi square test, t-test, F-test, have been developed by statisticians for the purpose(Kothari, 2004; Oehlert, 2010).

The hypotheses might be tested using at least one of such tests, depending on the nature and question of research request. Hypothesis testing will bring about either accepting the hypothesis or rejecting it. On the off chance that the researcher had no hypotheses to begin with, generalisations established on the basis of data may be stated as hypotheses to be tested by subsequent researches in times to come(Kothari, 2004; Oehlert, 2010).

10. Interpretation and Generalisations:

If a hypothesis is tested and upheld several times, it may be possible for the researcher to arrive at generalisation, i.e., to build a theory. As a matter of fact, the real value of research lies in its ability to arrive at certain generalisations. If the researcher had no hypothesis to start with, he might seek to explain his findings on the basis of some theory. It is known as interpretation. The process of interpretation may quite often trigger off new questions which in turn may lead to further researches(Pearl, 2000; Kothari, 2004).

11. Report Preparation:

Finally, the researcher has to prepare the report of what has been done. Writing of report must be done with great care keeping in view the following: (i) The preliminary pages; (ii) The main text, and (iii) The end matter.

In its preliminary pages the report should carry title and date followed by acknowledgements and foreword. Then there should be a table of contents followed by a list of tables and list of graphs and charts, if any, given in the report(Kothari, 2004).

The main text of the report should have the following parts:

(a) Introduction: It should contain a clear statement of the objectives of the research and an explanation of the methodology adopted in accomplishing the research. The scope of the study along with various limitations should as well be stated in this part.

(b) Summary of Findings: After introduction there would appear a statement of findings and recommendations in non-technical language. If the findings are extensive, they should be summarised.

(c) Main Report: The main body of the report should be presented in logical sequence and broken-down into readily identifiable sections.

(d) Conclusion: Towards the end of the main text, the researcher should again put down the results of his research clearly and precisely. In fact, it is the final summing up.

At the end of the report, appendices should be enlisted in respect of all technical data. References/Bibliography, i.e., list of all sources cited such as books, journals and reports should also be given in the end. Index should also be given specially in a published research report(Pearl, 2000; Ford, 2004; Olsen, 2004; Carmel *et al*., 2013).

CONCLUSION

It is important for a researcher to choose the right method and follow the systematic and logical steps in conducting the research. Latest techniques largely attract more attention most especially in highly reputable journals, but it is equally important to follow the above mentioned research process.

REFERENCES

Adèr, H. J., Mellenbergh, G. J., & Hand, D. J. (2008).Advising on research methods: a consultant's companion.Huizen: Johannes van Kessel Publishing. ISBN978-90-79418-01-5

Allaby, M. (2010). *A Dictionary of Ecology Oxford Reference*. *Oxford University Press, USA; 4 edition (July 15, 2010)*. https://doi.org/10.1093/acref/9780199567669.001.0001

Belovsky, G. E., Botkin, D. B., Crowl, T. a., Cummins, K. W., Franklin, J. F., Hunter, M. L., … Scott, J. M. (2004). Ten Suggestions to Strengthen the Science of Ecology. *BioScience*, 54(4), 345.

Bolnick, D. I., Amarasekare, P., Araujo, M. S., Burger, R., Levine, J. M., Novak, M., … Vasseur, D. A. (2011). Why intraspecific trait variation matters in community ecology. *Trends in Ecology and Evolution*, *26*(4), 183–192. https://doi.org/http://dx.doi.org/10.1016/j.tree.2011.01.009

Botkin, D. (2012). *The Moon in the Nautilus Shell: Discordant Harmonies Reconsidered*. Oxford: Oxford University Press.

Carmel, Y., Kent, R., Bar-Massada, A., Blank, L., Liberzon, J., Nezer, O., … Federman, R. (2013). Trends in Ecological Research during the Last Three Decades - A Systematic Review. *PLoS ONE*, *8*(4). https://doi.org/10.1371/journal.pone.0059813

Deacon, R. T., Kolstad, C. D., Kneese, A. V., Brookshire, D. S., Scrogin, D., Fisher, A. C., … Wilen, J. (1998). Research Trends and Opportunities in Environmental and Natural Resource Economics. *Environmental and Resource Economics*, *11*(3–4), 383–397. https://doi.org/10.1023/A:1008247412458

Ford, E. D. (2004). *Scientific Method for Ecological Research*. *Cambridge University press* (Vol. 1). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781107415324.004

Graham, M. H., & Dayton, P. K. (2002). On the evolution of ecological ideas: Paradigms and scientific progress. *Ecology*, *83*(6), 1481–1489. https://doi.org/10.1890/0012-9658(2002)083[1481:OTEOEI]2.0.CO;2

Hoffmann, H., Platzer, C., Winker, M., & Von Muench, E. (2011). Technology review of constructed wetlands Subsurface flow constructed wetlands for greywater and. *Transport*, 36. Retrieved from http://www.indiaenvironmentportal.org.in/files/technology-review-constructed-wetlands.pdf

Holling, C. S. (1998). Two cultures of ecology. *Conservation Ecology*, *2*(2), 4. Retrieved from http://www.ecologyandsociety.org/vol2/iss2/art4/%5Cnhttp://www.consecol.org/vol2/iss2/art4

Keppel, G. (1982). *Design and Analysis: A Researcher ′ s Handbook.* Englewood Cliffs, NJ.: Prentice-Hall.

Kothari, C. R. (2004). *Research Methodology Methods and Techniques*. *Statewide Agricultural Land Use Baseline* (Vol. 1). New Delhi: New Age International (P) Ltd. https://doi.org/10.1017/CBO9781107415324.004

Levin, S. A. (1999). Towards a Science of Ecological Management. *Conservation Ecology*, *3*(2). Retrieved from http://www.consecol.org/vol3/iss2/art6/

Lindenmayer, D., Messier, C., Paquette, A., & Hobbs, R. J. (2015). Managing tree plantations as novel socio-ecological systems: Australian and North American perspectives. *Canadian Journal of Forest Research*, *1433*(June), 150615144134009. Retrieved from http://www.nrcresearchpress.com/doi/abs/10.1139/cjfr-2015-0072#.VYZOnUaAmHQ

Ludwig, D., Mangel, M., & Haddad, B. (2001). Ecology, conservation, and public policy. *Annual Review of Ecology and Systematics*, *32*(1999), 481–517.

Naeem, S. (2002). Ecosystem consequences of biodiversity loss: The evolution of a paradigm. *Ecology*, *83*(6), 1537–1552. https://doi.org/10.2307/3071972

Noy-Meir, I. (1975). Stability of grazing systems: an application of predator-prey graphs. *The Journal of Ecology*, *63*(2), 459–481. https://doi.org/10.2307/2258730

O'Connor, R. J. (2000). Why Ecology Lags Behind Biology. *The Scientist*, *14*(20), 35.

Oehlert, G. W. (University of M. (2010). *A First Course in Design and Analysis of Experiments* (1st Editio). Minnesota: Library of Congress Cataloging-in-Publication Data. Retrieved from http://users.stat.umn.edu/~gary/book/fcdae.pdf

Olsen, B. R. (2004). *Research Methodology in the Medical and Biological Sciences*. (P. Laake, H. B. Benestad, & B. R. Olsen, Eds.). London: Elsevier. Retrieved from http://store.elsevier.com/Research-Methodology-in-the-Medical-and-Biological-Sciences/isbn-9780080552897/

Paine, R. T. (2002). Advances in ecological understanding: By Kuhnian revolution or conceptual evolution? *Ecology*, *83*(6), 1553–1559. https://doi.org/10.1890/0012-9658(2002)083[1553:AIEUBK]2.0.CO;2

Pearl, M. C. (2000). Research Techniques in Animal Ecology Methods and Cases in Conservation Science. *The Journal of Wildlife Management*, *65*(3), 594–599. https://doi.org/10.2307/3803113

Pickett, S. T. A., Parker, V. T., & Fiedler, P. L. (1992). The new paradigm in ecology: implications for conservation biology above the species level. In *Conservation Biology The Theory and Practice of Nature Conservation Preservation and Management* (pp. 66–88). Chapman and Hall.

Pickett, S. T. A., Shachak, M., Ostfeld, R. S., & Likens, G. E. (1997). Towards a comprehensive conservation theory. In *The ecological basis of conservation: heterogeneity, ecosystems, and biodiversity* (pp. 384–399).

Ratti, J., & Garton, E. (1994). Research and experimental design, *2004*, 1–31. Retrieved from http://www.esg.montana.edu/biol525/ratti.pdf

Schulze, E.-D., Beck, E., & Müller-Hohenstein, K. (2005). *Plant Ecology*. (H. Dieter Czeschlik, Ed.), *Stress: The International Journal on the Biology of Stress*. Berlin: SPRINGER HEIDELBERG. https://doi.org/http://dx.doi.org/10.1093/aob/mcj018

Scoones, I. (1999). New Ecology and the Social Sciences: What Prospects for a Fruitful Engagement? *Annu. Review of Anthropology*, *28*, 479–507.

Smith, G. D., & Ebrahim, S. (2002). Data dredging, bias, or confounding. *BMJ (Clinical Research Ed.)*, *325*(7378), 1437–1438.

Sutherland, W. J., Armstrong-Brown, S., Armsworth, P. R., Brereton, T., Brickland, J., Campbell, C. D., … Watkinson, A. R. (2006). The identification of 100 ecological questions of high policy relevance in the UK. *Journal of Applied Ecology*, *43*(4), 617–627.

Wallington, T. J., Hobbs, R. J., & Moore, S. A. (2005). Implications of current ecological thinking for biodiversity conservation: A review of the salient issues. *Ecology and Society*, *10*(1), 1–15narrowavailable. Retrieved from http://www.ecologyandsociety.org/vol10/iss1/art15/