APPLICATION OF NEW STATISTICAL METHODS TO STUDY THE ATTITUDE OF FARMERS IN AKAKI DISTRICT, ETHIOPIA

BY

BERHANE WOLDEMARIAM

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Berhane Woldemariam

Department of Statistics

Addis Ababa University

Approved by the Examining Board

Prof. A. Taube
External Examiner

Dr. Alemayehu Melaku
Internal Examiner

Dr. G. Sadasivan
Advisor

To my Parents and

Zelekash Shibeshi

A C K N O W L E D G E M E N T S

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ABSTRACT

Since attitudes are subjective and illusive, scaling techniques for quantifying attitudes are most important and hence receive a considerable amount of attention in our literature. Likert scales and factor analysis are the scaling techniques used in this survey research to study the attitudes of farmers in Akaki District towards three major characters; viz improved agricultural practices, education and farming, that affect the development of agriculture. The importance of these scaling techniques, in measuring attitudes, is discussed and comments regarding their suitability are made from the results of the actual survey. Since attitudes toward the stated characters may differ for farmers who live far apart and may be similar for those who live nearby, the design used is a stratified random sample with multiple characters. The District was subdivided into three convenient strata according to geographical contiguity to exploit the gain in efficiency due to stratification. Data collection was made through face-to-face interviews made with a stratified sample of 1000 farmers. The sample size in this case was determined from a pilot survey. The interviews were conducted through carefully constructed questionnaires which were divided into three major sections, each pertaining to a list of questions corresponding to a major character.

In addition, an attempt is made to link this study to the newly developing methods of solution for a stratified multicharacter sample allocation problem. Effectiveness of the methods to determine the optimum sample numbers in each stratum are empirically checked up by considering compromise, linear, nonlinear, and dynamic programming techniques. A comparative study of these techniques is made from the survey by computing the variances of the sample means and their computational efficiencies. Lastly a possible sample design for Ethiopia for the study of the attitudes of farmers, with several major characters is proposed and concluding remarks and recommendations, based on the empirical findings, are suggested.

Chapter I

INTRODUCTION

1.1. Back Ground

Ethiopia's economy, like many developing countries, is heavily dependent on agriculture. Due to this reason, it is essential that studies concerning the agricultural sector are to be made in order to enhance its development. Attitude surveys in this sector are important in this specific situation because agricultural development is directly linked with the farmers adoption of improved agricultural practices. If they have a negative attitude towards innovative practices, it will hamper the development of agriculture in the country. Social mobility of farmers into more advanced groups is also desirable from the view point of economic development of the country. This depends on the attitude of farmers towards education and farming. As far as we know no work has been done in this area in Ethiopia.

From the statistical methodology point of view there are many scaling techniques for quantifying attitudes. In this project an attempt is made to practice some of the methods. Quantification of attitudes has two advantages:

a) Numerical indices make it possible to report results in finer details than would be the case with personal judgments.

b) Without powerful methods of analysis, such as factor analysis, it would be all but impossible to assess the results of the research.

Further a stratified random sampling design for the survey is adopted since such a design would reduce the errors of the estimates, which are scores in this case. As far as we know allocation of sample numbers to different strata on the basis of multiple character has never been tried with scaled values in actual surveys. Thus there is a need to try the effectivness of some of the allocation techniques developed for multiple characters in this project. A pilot survey was beforehand conducted in Akaki district in Shoa Administrative region and four multiple character stratified random sampling allocation techniques using linear, nonlinear, and dynamic programming techniques are chosen for comparative study in this survey.

1.2. Objectives

The objectives of our research project are to design a suitable sampling scheme:

(i) for the study of attitudes of farmers towards

a) improved agricultural practices;

b) education; and

c) farming

(ii) to check up the effectivness of certain scaling techniques for measuring the attitude of the farming community in Akaki District towards the above factors.

(iii) to find the effectivness of certain methods in multi-character (multi-variate) optimum allocation in stratified surveys.

1.3. Preparation of Questionnaire

In any survey research that operate through the use of questionnaires, the questions should be written to produce the most complete and valid information from each respondent. Much care has to be taken to both the mode of administration of the questionnaire and type of sample questioned because their wording and content will be affected. Unlike sampling and data processing, questionnaire design is not a science or technology but remains an art. All researchers know that when they start analyzing the data they are sure to find that some of the questions are useless, whereas those that are sorely needed were somehow omitted from the design.

There are no clear or simple rules for questionnaire construction. In this research project we have started by looking at the general purposes that any questionnaire is designed to serve, that is the questionnaire should:

(i) meet the objectives of the research ;

(ii) obtain the most complete and accurate information possible; and

iii) do this within the limits of available time and resources.

Nevertheless none of us is omniscient. Indeed, the very fact that we are studying farmer's attitudes means we do not know it all and thus cannot conceive all possibilities. But the questionnaire has been pretested in Akaki District after which some improvements were made in the items selected so as to minimize these problems. The questionnaire has been

organized and worded, as much as possible,to encourage respondents to provide the most accurate and complete information they can.

Finally, we would like to note that a good survey is the product of hard intellectual effort over a sustained period, and of simple trail and error. Experience also helps, but none of these can substitute for the others.

1.4. Data Collection

Apart from our attention to survey design and analysis, the quality of the research can be no better than the quality of the data collected. Whether one decides to conduct all the interviews, hire a few enumerators to do the job, etc., the objective of the survey interview remain the same- to facilitate the collection of information about the population under study, viz. Akaki District farmers, in a uniform and reliable way. We have tried to complete the data collection so as to accomplish the objectives of uniformity and reliability using the funds and time available.

The data were collected from March 31, 1988 to April 19, 1988. The data collection was the most labour intensive part of the survey, and therefore, accounts for the greatest proportion of expenditure of the fund available. Ten interviewers were hired from the office of the Ministry of Agriculture. Most of the individuals are graduates from agriculture colleges in the country. It was believed that they will be able to communicate with the farmers very easily since they are working with the farmers. To achieve uniformity the interviewers were properly oriented and close instructions, supervision and follow up were carried out in order to check their

activities.

1.5. The Frame

Probably the most difficult task in sampling from the district is finding the appropriate list. Fortunately, an up to date (1988) list of 66 Farmers Assocation (FA) along with names and number of farmers was obtained from the documents of Inland Revenue Office of Akaki District. These FA's were alloted to three strata by means of geographical contiguity where a simple random sample of farmers were selected from each stratum independently.

1.6. The Sample Design

The sample design is multi-character stratified random sampling where three strata were formed for the 66 FAs with regard to their geographical contiguity. First a pilot sample survey of 60 farmers (20 farmers from each stratum) was conducted, the stratum variance for each character in each stratum were computed and the sample sizes for each stratum obtained using compromise allocation for the main survey.

1.7. The Problems of the Survey Research

i) **Time and Cost:-** Time and cost affect all aspects of survey research, of course they have special importance to questionnaire design because they impose a limit on the number of questions the researcher can ask. The

allocated budget was not sufficient . Apart from this the data collection was started very late from the time it was planned in the proposal especially due to the unavailability of a field vehicle. Due to time and cost constraints we faced several difficulties.

ii) Location of the farmers:- The farmers we were interviewing were a simple random sample in each stratum which fell in all the 66 FAs with no exception in the district. Due to this reason there was a need for guides to locate them. In this respect the Districts Ministry of Agriculture personnels and officials of the Districts FAs helped us a lot.

iii) Problems faced in encountering the farmers:- The farmers were highly suspicious of considering us as state officials empowered to do something else that will endanger them. We had at our best tried to convince them that this study focuses attention to their improvement and that we have no other objective than a research study for recommendations regarding the development of agriculture.

iv) Problems encountered in using computers:- Data analysis and processing, by the methods we adopted, needed computers. Lack of computer packages in the University had forced us to do part of the work with simple electronic hand Calculators. Apart from this, the time demanded by the computer center (saying "we are busy...") of Addis Ababa university to process the data, was completely against the time left for us to complete the thesis.

By and large, the survey research work, data processing and analysis demanded a lot of effort, effective coordination, supervision, money from our pockets, and great patience.

CHAPTER II

SCALING TECHNIQUES

2.1. INTRODUCTION

Survey research is frequently confronted with the problem of scaling the responses of attitudes. Much of the literature on the measurement of attitudes concerns different methods for developing such scales. At the present time, most measures of attitudes are based on self-report, and- and from what evidence there is concerning the validity of - approaches to the measurement of attitudes, self report offers the most valid approach currently available (Nunally, 1967).

This chapter reviews two principal scaling techniques used in the social research : Likert scales and factor scaling in factor analysis for the designed questionnaire on attitudes.

The simplest form of attitude measurement is based on a single item that elicits a simple response. The scale may be only nominal categories or, we may treat the categories as ordered, or even as interval level or above; although this may be presumptuous. Whenever the attitude toward a single object is measured on the basis of a single response, the scale is called single item measurement. For some types of measurement in survey research, single item measures are adequate. However, if the information can not be

assessed as directly, the difficulties increase. For variables such as attitudes, single item measuring device is a risky venture (Rossi, Wright, and Anderson, 1983). Due to this reason, this measure is not used in this survey.

2.2. Likert Scales

Likert scales, also called summated scales , are amongst the most commonly used scaling methods. The procedure is relatively easy to use which has intuitive appeal. A set of statements is selected each of which reflects favorably or unfavorably on the attitude object. After each statement there is an agreement scale. Respondents are asked to indicate on the scale to which extent they agree or disagree with each statement. Five categories are commonly used (example: strongly agree, agree, neutral, disagree, strongly disagree), although some applications omit the neutral category and some add even more categories to permit finer distinctions to be drawn.

It is usually recommended that an equal number of positive and negative statements be used. In our attitude survey we have adopted a five category scale for each statement. For positive statements the categories are scored 1,2,3,4,5 with 1 indicating strongly disagree and 5 indicating strongly agree. We should note that if the statement is unfavorable toward the subject, the scoring is reversed. The respondents attitude score is then the sum of the scores on the separate items; i.e., linear combination of the items with weight unit. High total scores represent favorable attitudes toward the object and low scores represent unfavorable attitudes.

Assumptions of Likert scale:

i) There is a continuous underlying attitude dimension and that each item is monotically related to that continuum. The exact form of the relationship is not important but a more favorable attitude should produce a higher expected score on any particular item.

ii) The sum of the item scores is monotically related to the attitude.

iii) A simple common factor prevails. In general this is equivalent to the assumption that we are measuring only one underlying common attitude.

The scores of Likert scales, like other attitude measurement techniques depends heavily on the original set of statements used. If these are bad items, it is unlikely that any mathematical mastication will produce good measurements. Even if good items are chosen and even if high reliability is attained, unidimensionality is not guaranteed. Other work, factor analysis, usually is needed. Another criticism of Likert scales is that the same total scores can be attained in a variety of ways. In the extreme case it is possible for two respondents, both having the same scores to have disagreed with each other on every item on an n item scale. If this occurred over many pairs of respondents, the items would be found to be bad and would be discarded.

2.3. Factor Analysis

Factor analysis can be viewed as consisting of a broad set of techniques(models) that encompass several related procedures such as principal components, principal factor analysis, and maximum likelihood factor methods. The immediate objective of factor analysis is to reduce a set of intercorrelated responses (variables) or alternatively a set of respondents (the individuals), to a smaller set of unobserved "factors" or latent variables which presumably give rise to the observed data and correlation (covariance) matrix.

In our survey we have a series of attitude statements to which subjects indicate the degree to which they agree or disagree. Each item can be considered a variable and the matrix of intercorrelations among these variables can be obtained. Here we are interested in knowing if the responses to the attitude can be accounted for by placing respondents on a few underlying attitude dimensions. If we obtain these dimensions and each respondents location (score) on each dimension we will have constructed measurements, fewer in number, that can be used in data analysis. In this way factor analysis provides us with summery, empirical, multidimensional indices or measurements that are not observed directly but may be used as variables in statistical analysis.

2.4. Statistical Significance Testing in Factor Analysis

When the response variable consist of observations for the entire population, the only source of randomness is due to error of measurement

(unreliability) and to unique factors (individual effects). However the purpose of conducting sample surveys generally is to obtain accurate estimates of population parameters, since it is usually expensive to conduct population censuses. Factor analysis models are therefore more often computed from random samples than populations, and this introduces a second source of randomness-that due to sampling. Since the random sampling effects are of no substantive interest, the factor parameters (loadings, scores, and latent roots) must be subjected to statistical tests to decide whether which are insignificant in the population. The nature of the test will depend on the type of factor model used. Usually significance testing is conducted for principal components and factor analysis. Maximum likelihood factor analysis is now widely available in standard packages such as SPSS and BMD and no longer presents computational difficulties. It is important to keep in mind that factor analysis differs from the principal component model in that factor analysis is covariance (rather than variance) oriented; that is factor analysis embodies a definite hypothesis that the observed p variables have been generated by precisely $m < p$ common factors. It is this hypothesis that is tested in the maximum likelihood factor model, where it is assumed that $x \sim N(\mu, \Sigma)$. Examination of the testing procedures could be referred to Morrison (1967).

2.5. Constructing Factor Scales

Factor analysis contains two sets of numbers: the factor loadings, which measure correlation between the observed measurements and the factors; and the factor scores, which indicate the relative position of each individual on that factor. The first step in factor analysis consists

in identifying the factors by means of rotations. Depending on the nature of the data, optimal identification of factors in terms of observed measurements (variables) is usually achieved in terms of oblique (correlated) factors. Once the factors have been identified in terms of substantive behaviour (attributes), the factor scores can be considered as measuring the relative location of the individuals on the factors. The factors in effect, becomes latent variables on which the individuals are scaled or measured. Here we wish to

i) uncover, if possible, a relatively small number of continuous factors which result in the attitudes; and

ii) scale each individual along one of continuous but an observed factors.

It is assumed that although the response is measured by discrete numbers(1, 2, 3, 4, 5), the latent attitudes are continuous. It is these latent attitudes which we wish to measure using the questionnaire.

The principal recommendation for factor scaling is that it provides a method of measuring dimensions that cannot be observed with accuracy. Since only common factors are scaled, the resultant measurement are largely free of measurement error and other individual differences among the respondents. Note that factor scales are only uncorrelated when the variables indicate that an orthogonal structure is relevant. Lack of orthogonality between the factors need not present major difficulties since latent attitudes may in reality be correlated. At last we should note that the factors depend on the variables included (and excluded) from the factor analysis and hence cannot be theory free. The predictive and explanatory

ability of the factor scales will therefore depend on the relevance of the questionnaire designed.

Finally a distinctive feature of factor scaling is that it does not assume each item (question) to be of equal value when determining the individual's scores. Thus items with low loadings are given small weight, and those with very small magnitude are omitted from the calculations altogether. What constitutes a small loading is that are statistically insignificant loadings rather than loadings which are deemed to be small.

CHAPTER III

General Theory of Stratified Random Sampling

Among the different types of sampling procedures, stratified random sampling will be discussed herein after.

3.1. Notations and Terminology

Let L be the number of strata and the suffix h =1, 2,...,L denote the hth stratum.

N_h = The number of sampling units in the h^{th} stratum

$N = \sum N_h$ = Total number of sampling units in the population

$W_h = N_h/N$ = stratum weight in the h^{th} stratum

n_h = The number of sampling units selected with simple random sampling from the h th stratum.

$n = \sum n_h$ = Total sample size for all strata

Let Y_{ihj} = The value of the i th unit in the h th stratum of the jth character (j = 1,2,...,p)

(i = 1,2,...,N_h) and (h = 1,2,...,L)

$Y_{hj} = \sum_{i=1}^{N_h} Y_{ihj}$ = true total of the hth stratum of the jth character.

$\bar{Y}_{hj} = Y_{hj}/N_h$ = true mean of the hth stratum of the jth character.

$\hat{Y}_{hj} = N_h \bar{y}_{hj}$ = unbiased estimate of the population total of the hth stratum for the jth character.

$\bar{y}_{hj} = \left(\sum_{i=1}^{n_h} y_{ihj} \right) / n_h$ = sample mean of the hth stratum for jth character.

$\bar{Y}_{jst} = \sum W_h Y_{hj}$ = unbiased estimate of the population mean for the jth character

$Y_{jst} = N y_{jst}$ = unbiased estimate of the population total of the jth character.

3.2 Description

Stratification means division into layers. Past data or some other information related to the character under study may be used to divide the population into various groups such that

(i) units within each group are as homogeneous as possible and

(ii) the group means as widely different as possible.

Thus a population consisting of N sampling units is divided into the L subgroups, termed as strata, of sizes N_h. If a random sample of size n_h is drawn from each strata independently, the sample is termed as stratified

random sample of size $n = \sum n_h$ and the technique of drawing such a sample is called stratified random sampling.

It should be noted that with a multicharacter study one faces the difficulty of choosing an appropriate way of stratification. In such a situation one can use

i) intuition

ii) judgement of subject matter specialists,

iii) geographical contiguity

Further optimum points of stratification for multicharacter surveys can effectively be used.

After construction of the strata, the next important point is a suitable sample number allocation in each stratum.

3.3. Introduction to the Determination of Sample Size

In planning any sample survey, the first problem that is faced is how to determine the size of the sample so that the required population parameters (totals, means, etc.) may be estimated in the best manner as to the kind of sampling method to be taken with the degree of precision required.

In stratified multi-character random sampling, we need the values of the population strata variances or else they should be estimated in order to apply optimum allocation. There are at least three ways of estimating population variance:

(i) by previous sampling of the same or a similar population;

(ii) by the results of a pilot sample survey; and

(iii) by guess- work about the structure of the population, assisted by some mathematical results.

The most serious limitation of optimum allocation is the absence of the knowledge of S_{hjs} in advance. In order to overcome this problem a pilot sample of size 60 has been taken in order to produce estimates of S_h (h= 1,2,3)

In most surveys information is collected from more than one character. In our attitude survey of Akaki District farmers, their attitude towards improved agricultural practices, education, and farming are regarded as the three most vital characters. One method of determining sample size is to specify margins of errors for the characters that are regarded as most vital to the survey. An estimation of the optimum sample size is first made separately for each of the desired characters. As Cochran (1977) noted, the best allocation for one character may not in general be best for another, and hence some compromisation or other alternatives must be reached.

3.4. Methods of Optimum Allocation in Multicharacter Stratified Surveys

With a single character under study and for a given sampling procedure, optimum allocation is well defined. It is that which minimizes the cost of the survey for a desired precision, or the variance of the sample estimate

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When a number of characters are simultaneously understudy in a sample survey, there is no single optimality criterion for the allocation of the sample numbers. The problem is attacked by many known statisticians using compromise, linear, nonlinear, and dynamic programing techniques.

Kokan (1963) has defined "optimum allocation" in multicharacter surveys as follows:

A vector $n = (n_1,\ldots,n_L)$ of sample numbers will be referred as " optimum allocation" if it minimizes the cost of the survey subject to the conditions that the variance V_j $(j = 1,2,\ldots,p)$ of the estimate of the jth character does not exceed a given positive quantity v_j at confidence level $1-\alpha_j$ $(0 \leq \alpha_j \leq 1)$, $(j = 1,2,\ldots,p)$, where p is the number of characters under study.

This optimality criterion, together with certain other considerations, will lead us to the linear, nonlinear and dynamic programming techniques for the determination of the vector n. Dalenuis (1953) was the first to suggest the use of linear programing in sample surveys to determine sample number allocations when several characters are under study. Nordbtten (1956) illustrated this approach by a numerical example. Delenuis (1957) had further mentioned that nonlinear programing techniques can also be used to solve the problem. We shall now try to brief the different methods and procedures for the allocation problem in multicharacters.

3.4.1 Compromise Allocation

As Cochran (1977) put it, if good previous data are available, we can compute the optimum allocation for each character separately and see to what extent there is disagreement. In survey of specialized type, as he put it, the correlations among the items may be high and the allocations may differ relatively little. Hence the average of the optimum sample size (m_h) for the characters would provide a satisfactory compromise allocation. The expected variance for it is given by the formula

$$V_{com} = \sum [W_h S_h]^2 / n_h$$

If the allocations are made from established variances, the precision of the compromise will be overestimated.

3.4.2. Linear Programming

The allocation problem has been formulated as a linear programing problem and then solved using linear algorithms (Nordbotten, 1956; Dalenius, 1957; Marshall and Nautiyal, 1980; Mitchel and Bare, 1981). Among the works presented by the different authors, we shall here present that of Nordbotten (1956).

The production of the estimate of the population total will be

associated with a cost function C $(n^1,\ldots,n_L)$. The quality of this estimate is expressed by the variance. The allocation problem is equivalent to the constrained minimization problem

$$C\ (n_1,\ldots,n_L) = \text{Min.}$$

subject to

$$\text{Var } Y\ (n_1,\ldots,n_L) = V_0$$

where v_0 is the variance corresponding to the predescribed quality. Here the average sampling cost per element may as well depend on n_h. A small n_h may perhapes correspond to a higher cost per element than a large n_h.

The cost function has the following form.

$$C = c_0 + \sum b_h n_h^1, \qquad \ldots\ldots\ldots(3.4.2.1)$$

where the parameters b_h are supposed to be nonpositive.

The problem is to estimate p totals ought to be done as cheaply as possible subject to the following conditions.

i) $0 \leq n_h \leq N_h \quad (h = 1,\ldots,L) \qquad \ldots\ldots\ldots(3.4.2.2)$

ii) $\sum N_h (N_h - N_h) \cdot S^2_{hj} \cdot n_h^{-1} \leq v_j \quad (j=1,\ldots,p) \qquad \ldots(3.4.2.3)$

$C = c_0 + \sum b_h Y_h \qquad \ldots\ldots\ldots\ldots(3.4.2.1)$

subject to

$$\sum N_h(N_h - n_h)S^2_{hj}y_h \leq v_j \qquad (j=1,2,\ldots,p) \qquad \ldots(3.4.2.5)$$

and $\quad 1/N_h \leq y_h \leq 0 \qquad (h = 1,2,\ldots,L) \qquad \ldots\ldots\ldots(3.4.2.6)$

Therefore, (3.4.2.4) to (3.4.2.6) are linear in y_h's and hence appropriate linear programming solution techniques could be applied.

3.4.3. Nonlinear programing

The allocation problem has been formulated as a nonlinear programing problem and solved using nonlinear algorithms (Kokan, 1963; Jaganathan, 1965; Kokan and Khan, 1967; Chatterjee, 1968; Sö1and, 1968; Huddleston et al., 1970; Arivantis and Afanja, 1971). Similarly as before among the works presented by the different authors, we shall present that of Kokan (1963) and Kokan and Khan (1967).

Kokan has formulated the problem as follows: Let $C = \phi(n)$ where C is the total cost and $n = (n_1,\ldots,n_L)$ a vector of sample numbers. The allocation problem is

$$\text{minimize } C = \phi(n) \qquad \ldots\ldots\ldots \text{(3.4.3.1)}$$

subject to

$$V_j \leq v_j \quad (j=1,2,\ldots,p) \qquad \ldots\ldots\ldots\ldots \text{(3.4.3.2)}$$

and $0 \leq n_h \leq M_h \quad (h=1,2,\ldots,L) \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3.4.3.3)}$

where M_h is a function of the population number of units in the hth class (depending up on the sampling procedure used).

If a vector n satisfying the (p+2L) constraints (3.4.3.2) and (3.4.3.3) exists, we call it a "feasible solution". Further, if a feasible solution also minimizes the objective function (3.4.3.1) it is called "locally optimum". The objective function can be transformed to a convex function and the constraints as linear in their variables. By the property of

convex function, if a feasible solution exists, an optimum solution also exists.

Without loss of generality, assume the characters under study are the population means Y_j under stratified random sampling. Let $\bar{Y}_{jst}$ be unbiased estimate of $\bar{Y}_j$ which has the sampling variance

$$V_j = \text{Var}\ (\bar{y}_{jst}) = \sum a_{hj} x_h \qquad (3.4.3.4)$$

where $a_{hj} = w^2_h\, S^2_{hj}$ $(h = 1,\ldots,L;\ j = 1,2,\ldots,p)$ (3.4.3.5)

and $x_h = 1/n_h - 1/N_h$ $(h = 1,2,\ldots,L)$ (3.4.3.6)

Let C_h be the cost of enumerating all the p characters on a single sampling unit in the h_{th} stratum. The total cost of the survey is

$$C = c_0 + \sum c_h n_h \qquad (3.4.3.7)$$

where c_0 is the overhead cost. Using (3.4.3.6), (3.4.3.7) can be reduced to

$$C = c_0 + \sum N_h C_h \,/\!/\, n + N_h X_h)$$

Further the following constraint is also needed.

$0 \leq x_h \leq 1 - (1/N_h)$ (3.4.3.8)

Our objective is to choose $n_1,\ldots,n_L$, such that C is minimum (-C is maximum) subject to the constraints $V_j \leq v_j$. Hence we maximize

$$\phi = -\sum N_h C_h \,/\, [1 + N_h X_h] \qquad (3.4.3.9)$$

subject to

$$\sum a_{hj} X_h < v_j \quad (j = 1,2,\ldots,p) \qquad (3.4.3.10)$$

and $0 \leq x_h \leq 1 - 1/N_h$ $(h = 1,2,\ldots,L)$ (3.4.3.11)

The objective function in (3.4.3.9) is nonlinear and convex, and the restrictions (3.4.3.10) and (3.4.3.11) are linear in X_h's. Because (3.4.3.9)is a convex function, if a solution $x = (x_1,...,X_L)$ exists, an optimum solution will exist. For the solution the following method was adopted:

Form the function

$$L = \alpha + \lambda_j (\sum a_{hj}X_h - v_j)$$

where α is a constant.

Differentiate L parcially with respect to X_h's (h = 1,2,...,L) and λ_j, first for j=1, and equate the results to zero and solve for λ_j and X_{hs}. Check whether these values satisfy the constraints (3.4.3.10) and (3.4.3.11). If these satisfy the constraints they are feasible solutions and are also optimum. If these values do not satisfy, then proceed as above with j = 2 to find a solution and and soon until an optimum solution is found. Thus, by a process of trial and error, the methed is to find which constraints are irrelevant and which are essential and therefore have to be introducedinto the objective function with a language multiplier.

Later in 1967 Kokan and Khan presented an analytical solution for the problem as follows:

Neglecting the overhead cost, the allocation problem

$$\text{Maximize } K = \sum C_h n_h \qquad (3.4.3.12)$$

subject to

$$\sum a_{hj}x_h \leq v_j \quad (j = 1,2,...,p) \qquad (3.4.3.13)$$

and $0 \leq x \leq 1 - 1/N_h \qquad (h = 1,2,\ldots,L) \qquad \ldots\ldots(3.4.3.16)$

putting $1/n_h = X_h$ (3.4.3.12) to (3.4.3.14) reduce to

$$k(x) = \sum c_h/x_h \,, \qquad x = (x_1,\ldots,x_L)$$

The upper limit in the last inequalities is defined for integral values of n_h. Since the value of X_h be continous the upper limit of X_h is fixed at m, where m is a positive finite real number >1. Thus we have

$$1/N_h \leq X_h \leq m \qquad (h = 1,2,\ldots,L) \qquad (3.4.3.17)$$

Equation (3.4.3.15) represents a hypersurface in L dimensions and (3.4.3.16) with equality signs are hyperplanes of L-1 dimensions. The existence and uniqueness of the solution to the allocation problem and the analytical dimensions of the solution is given by Kokan and Khan (1967). For the procedures to the solution also refere to the same reference above.

3.4.4 Dynamic Programming

Omule (1985) had found a way to the solution of allocation problem through ther use of dynamic programming. The problem is attacked by considering the process as a multi-stage decision process through dynamic programing. The advantage is that dynamic programing can more easily handle, problems involving several starata and/or characters (or variables).

Omule had expressed the allocation problem as a multistage decision process

as follows:

The stratified sampling design allocation problem can be stated as follows:

Find n_h ($h = 1,2,\ldots,L$) such that

$$C = c_0 + \sum c_h n_h$$

is minimized and such that the sampling variance of each character j ($j = 1,2,\ldots,p$) is no more than a specified tolerance level v_j.

The determination of the n_h can be regarded as a stage process in which we select n_1, units from stratum 1, n_2 units from stratum 2, and so on untill we have selected n_L units from stratum L.

Mulltistage Decision Model

Let the hth stratum be the h^{th} stage and n_h be the decision variable at the hth stage . At each stage h, define the amount of variance of the variables remaining to be accounted for (from v_j) prior to the selection of n_h units as state x_{jh}. Further define state $x_{j,h-1}$ as the amount of variance of the variable remaining to be accounted for, subsequent to the sampling decesion of n_h. These two states are related through the following state transition functions.

$$x_{jh} = x_{j,h^{-}1} + W^2_h S^2_{jh} [1/n_h - 1/N_h] \quad (j = 1,2,\ldots,p) \qquad (3.4.4.1)$$

The cost of the sampling decision at stage h is $c_h n_h$. Since c_h is constant it can be disregarded.

Solution by Dynamic Programming

First restate the problem as follows:

Find n_h ($h = 1,2,\ldots,L$) such that the objective (cost) function C is minimized and subject to the constraints.

$$\sum W^2_h S^2_{hj} [1/n_h - 1/N_h] \leq v_j$$

$$(j = 1,2,\ldots,p)$$

and $2 \leq n_h \leq N_h$ so as to ensure at least one degree of freedom and to ensure the sample is not larger than the population.

Stages of the Solution

i) Separate the objective functions into stage components - functions of n_h independent of each other for all $h = 1,2,\ldots,L$.

ii) Decompose the L-decision variable problem into L problems corresponding to the L stages of the model n_h. Thus at stage h, the decision problem is to find the optimum sample size n^*_h such that

$f_h(X_h)$ = minimum § $c_h n_h + f_{h-1}(X_h)$† $2 \leq n_h \leq N_h$ for feasible values of ,

$X_h = [0 \leq x_{h1} \leq v_1 \ , \ 0 \leq X_{h2} \leq v_2, \ldots, \ 0 \leq X_{hp} \leq v_p]$

Note that X_{h-1} is predicted from (3.4.3.41) and, in particular $f_0(x_0) = 0$. The above equations are solved recursively for stages $h = 1,2,\ldots,L$ using calculus or simple search procedures such as complete enumeration.

CHAPTER 4

ANALYSIS AND RESULTS FROM THE SURVEY DATA

4.1 Introduction

We shall base our study on the 1000 farmer's responses to the 33 items which relate to the attitude of farmer's toward improved agricultural practices, education, and farming. The first 17 items were on improved agricultural practices. The next 10 items were on education, and the last 6 items were on farming. Based on the methods discussed in chapters 2 and 3, the survey have been analysed and presented, For conveneence we have adapted the following symbols:

All are attitudes toward ....

X_1 = Using fertilinzers for farming teff
X_2 = Using fertilizers for farming wheat
X_3 = Using fertilizers for farming chick-pea
X_4 = Using fertilizers for farming others
X_5 = Using insecticides, pesticides, and weedicides for farming teff
X_6 = Using insecticides, pesticides, and weedicides for farming wheat
X_7 = Using insecticides, pesticides, and weedicides for fatming chick-pea
X_8 = Using insecticidse, pesticides, and weedicides for farming others
X_9 = Using improved machines for harvesting cereal crops
X_{10} = Storing excess produce in improved bins
X_{11} = Adoption of new high zield varieties of teff
X_{12} = Adoptionof new high zield varieties of wheat
X_{13} = Adoption of new high zield varieties of chick-pea
X_{14} = Adoption of new high varieties of others

X_{15} = Adoption of better marketing practices -by polythene packets

X_{16} = Adoption of better marketing practices- distant better market

X_{17} = Adoption of better marketing practices- staring and marketing when price goes up.

X_{18} = Agricultural education given by M.O.A

X_{19} = Participation in agricultural education given by M.O.A

X_{20} = Satisfaction in the agricultural education

X_{21} = The intention to practice the education received

X_{22} = Children's agricultural education in agricultural schools or Universities

X_{23} = The opening of agricultural schools in the country

X_{24} = Sending children to conventional schools

X_{25} = Education of farmers in agricultural education

X_{26} = Education of farmers in general education

X_{27} = The extent of satisfaction that agricultural education is helping in the profession

X_{28} = The work as a farmer

X_{29} = Sulf-sifficiency by the agricultural products

X_{30} = Cultivation of vegetable, plantation, and ornamental crops.

X_{31} = Adoption of mixed farming

X_{32} = Income in the general farming

X_{33} = Income in the animal husbandary.

M.O.A = Ministry of Agriculture.

I = Improved agricultural practices.

E = Education

F = Farming

4.2 Preliminary Estimation of Variances and Means

From the pilot sample surey we had first estimated the stratum means and variances and had taken a total sample size of 1000 of which 540,310 and 150 were allocated to stata 1,2 and 3 respectively based on compromise allocation. Then the main servey was conducted and a better estimate of the means and standard devications were obtained based onLikert (unweighted) scale scores. The following results were obtained. From the main survey.

Table 4.2.1

Charactors

		I		E		F	
Stratum	N_h	$\bar{y}_{h_I}$	S_{h_I}	$\bar{y}_{h_E}$	S_{h_E}	$\bar{y}_{h_F}$	S_{h_F}
1	4751	72.15	9.6909	45.92	8.4329	23.46	7.3149
2	5127	63.54	4.7138	44.68	4.0209	23.61	5.3182
3	3124	63.79	3.1776	42.31	2.9713	25.09	2.0593
$\bar{y}_{jst}$	13002	66.75		44.56		23.91	

Table 4.2.2

$a_{hj} = W_h^2 S_{hj}^2$

j \ h	1	2	3
I	12.539	3.455	0.583
E	9.475	2.514	0.510
F	7.144	4.398	0.245

4.3 Estimation of Factor Loadings, Identification and Interpretation of Factors

The data matrix obtained from the main survey was of order 1000 farmers by 33 items of whom the first 17 items were on improved agricultural practices (charatcterI), the next 10 items on education (character E), and the last 6 items on farming (character F): By the use of P-stat computer packages factor analysis were performed for each character in each stratum separately. From the analysis, the latent factors, factor loadings and the communalities were obtained for each character in each stratum. The next logical step is to relate the latent factors to the originally observed responses by examining the pattern and magnitudes of the loadings. From the examination of the factor loadings in the initial solution,* Factor identificationis found to be difficult. Some factors are bi-polar, i.e., they load positively on some items and negatively on others. Usually the interpretation of the bi-polar factor is not readily apparent and hence a need for a factor solution, that makes interpretation easier. Thus the next step is to rotate the acis to get a simpler and/or more easily interpretable solution. Hence we have adopted a varimax (orthogonal) rotation that simplifies identification of the common factors. The results are given through the nine tables tiven in appendes C.

* The initial solutions are given in Appendex B.

based on the tables above (Table 4.3.1 to table 4.3.9) a possible interpretation of each latent factor is given below:

(i) for improved agricultural practices (Character I)

Table 4.3.10

Stratum 1

Factor	Group items	identification as attitude toward ....
1	$x_{10}, x_{11}, x_{13}, x_{14}, x_{14}$	improved varieties and improved l for all crops
2	x_7, x_8, x_{16}	plant protection* measures for minor crops and distant better market
3	x_3, x_4, x_{17}	minor agricultural innovations
4	x_5, x_6, x_9, x_{12}	plant protection measures for major crops and improved harvesters
5	x_1, x_2	fertilizers use for major crops

(i) for improved agricultural practices (Character I)

Table 4.3.1

Stratum 1

Factor	Group items	identification as attitude toward ....
1	$x_{10}, x_{11}, x_{13}, x_{14}, x_{14}$	improved varieties and improved I for all crops
2	x_7, x_8, x_{16}	plant protection* measures for minor crops and distant better market
3	x_3, x_4, x_{17}	minor agricultural innovations
4	x_5, x_6, x_9, x_{12}	plant protection measures for major crops and improved harvestors
5	x_1, x_2	fertilizers use for major crops

* means the use of pesticides, herbicides and weedcides

Table 4.3.2

Stratum 2

Factor	Grouped items	Identification as attitude toward ...
1	$x_1, x_4, x_7, x_8, x_{15}$	fertilizers use and plant protection measures for minor crops
2	$x_9, x_{12}, x_{13}, x_{14}$	improved varities of crops and improved harvestors
3	x ,x ,x ,x	improved varieties of teff, beans and marketing practice
4	x_2, x_6	fertilizers use and plant protection measures for wheat
5	x_5	teff protection measures
6	x_1	fertilizers use for teff

Table 4.3.3

Stratum 3

Factor	Grouped items	Identification as attitude toward
1	x, x, x, x, x, x, x ,	improved agricultural practices in general
2	x, x, x	plant protection measuresfor minor crops and distant better market
3	x, x, x	wheat protection measures and improved varieties of wheat
4	x, x	fertilizers use and plant protection measures for teff
5	x, x	fertilizers use for minor crops and improved marketingby polythene packets

(ii) Education (Character E)

Table 4.3.4

Stratum 1

Factor	Grouped items	Identification as attitude toward ....
1	x, x, x, x	agricultural education given by MOA
2	x x, x, x	agricultural and conventional education in general
3	x x	farmers education

Table 4.3.5

Stratum 2

Factor	Grouped item	identification asattitud toward...
1	x, x, x, x	agricultural education given by MOA
2	x, x, x, x	education in general
3	x, x	farmers education

Table 4.3.6

Stratum 3

Factor	Grouped item	identification as attitude toward ...
1	x, x, x x	agricultural education given by MOA and its satisfaction in occupation
2	x, x, x,	widespread of agricultural schools and childrens education
3	x x,	composition of agricultural education and

general education of the farmers

(iii) Farming (character F)

Table 4.3.7

Stratum 1

factor	group items	identification as attitude toward ...
1	x x x x x	Farming insecurity
2	X_{30}	cultivation of crops other than cereal crops insecurity

Table 4.3.8

Stratum 2

factor	Grouped item	Identification as attitude toward ...
1	x x x x x	farming insecurity
2	x_{29}	self-sufficiency by the agricultural products

Table 4.3.9

Stratum 3

factor	Grouped item	Identification as attitude toward ....
1	x x x	agricultural income
2	x x	general farming
3	x	being a farmer

4.4. Constructing Factor scales

In this section factor scores, which indicate the relative position of each farmer in that factor, are obtained as follows. Consider the factor loadings in Table 4.3.9 as an example. We have seen that items x_{29},x_{32}, and x_{33} are intended to measure attitude toward agricultural income, x_{30} and x_{31} are intended to measure attitude towards general farming, and X_{26} is intended to measure attitude toward farming as occupation. To scale (measure) each of the 1000 farmers along these dimensions we adopt the following procedure. Consider the farmer who responded as given below on items concerning the character farming.

Table 4.4.1

Observed response score for farmer 1, in stratum 3

Question	Observed response
x28	5
x_{29}	2
x_{30}	3
x_{31}	5
x_{32}	5
x_{33}	4

To compute this farmer's total score for factor 1 we first reverse the negative loadinds (if any) for the large loadings and make adjustments for the observed responses with corresponding negative loadings. Then this total score for factor 1 is [.716843(2) + .773062(5) + .793615(4)]/3 = 2.8245 indicating an almost neutral average attitude toward the agricultural income. Similar calculations give us the total scores for each farmer in each stratum for each character which are given in Appendix D

4.5 Results obtained From the Factor Scales

Based on the factor scale scores (see Appendix D) of the Farmers in each stratum for each character the following results are obained.

Table 4.5.1
Average Total Scores and percent of Farmers with Favourable Attitude Toward the Larent Factors on CharacterI.

stratum(1)	Latent Factor (2)	average total score(3)	interpretation for (3)	% of farmers having favourable attitude for (2)
1	1	3.3319	Not far from neutral	63.2
	2	3.3207	Not far from neutral	65.8
	3	2.7756	almost neutral	7.9
	4	2.8483	almost neutral	none
	5	3.9785	strong agreement	97.4
2	1	2.1997	strong dis agreement	none
	2	2.6731	almost neutral	none
	3	2.3698	strong dis agreement	none
	4	3.3933	not far from neutral	70
	5	4.0673	strong agreement	96
	6	5	very strong agreement	100
3	1	2.0922	strong disagreement	none
	2	1.3740	very strong disagreement	none
	3	2.9694	almost neutral	none
	4	3.8284	strong agreement	100
	5	2.6493	almost neutral	none

Table 4.52

Average Total Scores and Percent of Farmers with Favourable Attitude Toward the Latent Factors on Character E.

stratum (1)	Latent Factor (2)	average total score(3)	interpretation for (3)	% of farmers having favourable attitude for (2)
1	1	3.9945	strong agreement	89.5
	2	3.0432	not far from neutral	none
	3	3.8177	strong agreement	81.6
2	1	3.9610	strong agreement	86.7
	2	2.6162	almost neutral	none
	3	3.1193	not far from neutral	13.3
3	1	3.4510	strong agreement	71.4
	2	3.0960	not far from neutral	28.6
	3	2.6079	almost neutral none	none

Table 4.53

Average Total Scores and Percent of Farmers with Favourable Attitude Toward the Latent Factors on character F.

stratum (1)	Latent Factor (2)	average total score(2)	interpretation for (3)	% of farmers having favourable attitude for (2)
1	1	1.3914	very strong disagr.	none
	2	1.5376	strong disagreement	none
2	1	1.3958	very stron disagr.	none
	2	2.8846	almost neutral	16.7
3	1	2.9413	almost neutral	14.3
	2	2.9704	almost neutral	14.3
	3	4.5373	very strong agreement	100

From the above tables, we observe that there is a strong favourable attitude toward the use of fertilizers and plant protection measures (i.e.,pesticides, herbicides, etc. For the major crops (teff and wheat) unlike the minor crops (chick pea and others). But there is no favourable attitude toward the adoption of new varieties of crops and other improved agricultural practices (like the use of improved bins, improved harvestors, etc.). On the other hand there is a strong favourable attitude toward the agricultural education (as demonstration trials) given by the M.O.A. in which about 90%,82%, and 71% of the farmers in stratum 1,2,and 3 strongly approve of it respectively. Unlike stratum 2 and 3, 82% of the farmers in stratum 1 strongly approve of farmers' education (both agricultural and others) in general. Except a small proportion of farmers which approve of the opening of agricultural schools in the country and childern's education in stratum 3, the general attitude of farmers towards the proliferation of agricultural schools and children's education is on the average, neutral. Further there is a very strong favourable attitude towards general farming in stratums 1 and 2 unlike the average neutral attitude towards farming in stratum 3. In all the strata there is a very strong facourable attitude towards farming as an occupation.

4.6 Application of the Different Methods of Allocation.

In the sample allocation problem the characters are attitudes towards improved agricultural practices (I), education (E), and farming (F). First we consider information given in Table 4.4.1 and 4.2.2 of section 4.2. we base Ourserlves on the allocations techniques, compromese, linear, nonlinear, and dynamic programming techniques, discussed in chapter III. We take all C_h 's ($h = 1,2,3$) as constants.

4.6 Application to Unweighted Likert Scale Scores

i) Linear Programming Solution

The linear programming technique, that of Nordbotten (1956), given in Chapter III, has no practical relevance in this survey. The cost function defined is rather very special and cannot be applied, especially, in this kind of attitude surveys. The cost function by Nordbotten assumes the parameters b_h to be non positive which implies at least one b_h is negative and hence

$$\sum_{h=1}^{L} b_h n_h^{-1} < 0 \text{ follows. But this, in turn,}$$

implies

$$C - \sum_{h=1}^{L} b_h n_h^{-1} = C_o > C$$

which indicate total cost C is less than C_o. Hence such an ideal cost function is far from reality unless the purpose is to show that there is a way to formulate the allocation problem as a linear programming technique.

ii) Nonlinear Programming Solutions*

Kokan's (1963) allocation problem is to (ignoring C_o), maximize =

$$\phi = -\left\{\frac{4751}{1+4751x_1} + \frac{5127}{1+5127x_2} + \frac{3124}{1+3124x_3}\right\} \quad (4.6.1.1)$$

subject to

$$12.539x_1 + 3.455x_2 + 0.583x_3 \leq 2.900 \quad (4.6.1.2)$$

$$9.475x_1 + 2.514x_2 + 0.510x_3 \leq 1.292 \quad (4.6.1.3)$$

$$7.144x_1 + 4.398x_2 + 0.245x_3 \leq 0.372 \quad (4.6.1.4)$$

and,

$$0 \leq x_1 \leq 0.9997895,\ 0 \leq x_2 \leq 0.999805,\ 0 \leq x_3 \leq 0.9996799 \quad (4.6.1.5)$$

Applying the method adopted in Chapter III we found:

$\lambda = -199.530204$, $X_1 = 0.026276041$, $X_2 = 0.033562282$ and $X_3 = 0.142705121$ which gives the optimum sample numbers $n_1 = 38$, $n_2 = 30$ and $n_3 = 7$ with a total sample size of 75 farmers.

Further applying the analytical solution method developed by Kokan and Khan (1967) to the allocation problem

$$\text{minimize} \sum_{h=1}^{3} C_h n_h$$

subject to the above constraints, we found the following results. By taking the upper confidence limits as

$$v_j = \left[\frac{.05\bar{y}_{jst}}{1.96}\right]^2, \quad (j=1,2,3\ldots) \text{ we have}$$

$$k_j = v_j + \sum_{h=1}^{3} a_{hj}/N_h \text{ which gave } k_1 = 2,971,\ k_2 = 1.295$$

and $k_3 = 0.374$. Thus we have

Values of Intercepts (k_j/a_{hj})

j \ h	1	2	3
J	.237	.860	5.097
E	.137	.515	2.541
F	.052	.085	1.528

The first row strictly dominates the others. Hence our set contains only (E,F). Next we compute the least cost allocations for different characters. Costs are constant in our survey. Therefore we compute the quantities

$$X_{hj}^{-1} = [\sqrt{a_{hj}} \sum_{h=1}^{3} \sqrt{a_{hj}}]/k_j \quad (j= E,F).$$

Hence the least cost allocations are given below:

Least Cost Allocations

j \ h	11	2	3	Total
E	13	7	3	23
F	38	30	7	75

The total sample size is maximum for $j_1 = F$. This solution satisfies the other requirements also. Hence the optimum allocations are those corresponding to j=F, that is $n_1=38$, $n_2=30$, and $n_3=7$ which are the same as Kokan's solution showing the difference is only in the way they are solved.

iii) Dynamic Programming Solution

The allocation problem, by Omule (1985), is to handle the problem as a multistage decision process. The decision problem at stage h (stratum h) is to find n_h^* such that

1) $f_h(X_{Ih}, X_{Eh}, X_{Fh}) = \text{minimum } \{C_h n_h + f_{h-1}(X_{h-1})\}$, $n_h \geq 2$

where $f_o(X_{io}, X_{Eo}, X_{Fo}) = 0$, and h = 1,2,3

we solved the three equations stated by (1) recursively

by complete enumeration method. We set X_{I3}= 2.900, X_{E3}=1.292, and X_{F3} = 0.372 and for all feasible values of $n_2 \geq 2$ and $n_3 \geq 2$ we computed f_3 as follows:

$$f_3(X_{I3}, X_{E3}, X_{F3}) = \{C_3 n_3 + C_2 n_2 + \max\left[\frac{W_1^2 S_{j1}^2}{X_{j1}}\right]\}, \quad j=I,E,F$$

where

$$X_{j1} = X_{j2} - W_2^2 S_{j2}^2 \left(\frac{1}{n_2} - \frac{1}{N_2}\right)$$

$$X_{j1} = X_{j3} - W^2 W_{j3}^2 \left(\frac{1}{n_3} - \frac{1}{N_3}\right)$$

which implies

$$X_{j1} = X_{j3} - W_3^2 S_{j3}^2 \left(\frac{1}{n_3} - \frac{1}{N_3}\right) - W_2^2 S_{j2}^2 \left(\frac{1}{n_2} - \frac{1}{N_2}\right),$$

for all

$$j = I,E,F.$$

The solutions are found to be n_1=38, n_2=29, and n_3=7 with a slight difference from the nonlinear sample number allocations.

iv) Solution by Compromise Allocation

The individual characterstic allocations are given below:

Optimum n_h for each character in each stratum (n=75)

h \ j	I	E	F
1	43	43	38
2	23	22	30
3	9	10	7

Here for the purpose of comparison, we consider compromise allocation by averaging the stratum sampling fractions

over the individual characterstic allocations and multiply by Kokan's (1963) total sample size (i.e. 75) equal to that of optimum allocation based on convex programming technique. By so doing we found the optimum allocation solutions as

$$n_1=41,\ n_2=25 \text{ and } n_3=9.$$

4.6.2 Application to Weighted Likert Scale Scores

Here we have adopted a new technique to get better scores for the Likert Scales in order to overcome some of the disadvantages of Likert Scaling technique discussed in Chapter II. We took high factor leadings as weight to each item for each character and then applied the Likert scaling technique. In other words we took the sum of the factor scale scores on all the latent factors for each item. The following information is obtained

Table 4.6.1: Estimated Means and S_h's

	Character					
	I		E		F	
Stratum	$\bar{y}_{Ih}$	S_{Ih}	$\bar{y}_{Eh}$	S_{Fh}	$\bar{y}_{Fh}$	S_{Fh}
1	16.274	2.2010593	10.945	1.1668333	2.955	.7652068
2	19.661	.66772186	9.904	.8704726	4.299	.5869863
3	12.690	1.2414092	9.155	1.6939919	10.450	.791268
$\bar{y}_{jst}$	16.748		10.104		5.286	
$v_j=[\frac{.05\bar{y}_{jst}^2}{1.96}].1825$			.0664		.0182	

Table 4.6.2: $a_{jh} = w_h^2 S_{jh}^2$

j \ h	1	2	3
I	.6469	.0713	.0890
E	.1818	.1179	.1657
F	.0782	.0536	.0365

Based on the above tables, similar calculations as in section 4.6.1, the following optimum sample numbers for each stratum are found

Solution Method by	Stratum Optimum 1	2	3	Total Sample
Kokan (1963	11	9	7	27
Kokan and Khan (1967)	11	9	7	27
Omule (1985)	11	9	7	27
Compromise	12	9	7	27

4.7 Comparative Study of the Methods

Empirical comparisons of the methods will be given based on the results found in subsections 4.6.1 and 4.6.2. For the purpose, the variances of the estimated means are given below

Table 4.7.1: Variances of the Estimated Means Based on the Weighted Likert Scale Scores

Solution Technique	Character I	Character E	Character F	Total Sample
Non linear programming	.0793	.0532	.0182	27
Dynamic programming	.793	.0532	.0182	27
Compromise	.0754	.0534	.0184*	27

Table 4.7.2: Variances of the Estimated Means Based on the Unweighted Likert Scale Scores

Solution Technique	Character I	Character E	Character F	Total Sample
Nonlinear programming	.5249	.4034	.3672	75
Dynamic programming	.5289	.4062	.3722	74
Compromise	.5053	.3854	.3750*	

For all characters the variances of the estimated means are highly efficient in case of the weighted Likert Scale scores than the unweighted ones. Moreover the costs and total sample number are reduced. In the case of the unweighted Likert Scale scores, dynamic programming technique is slightly less efficient than the nonlinear programming technique but equally efficient in the weighted ones. Compromise allocation, based on the same total sample size as the optimal convex programming allocation, satisfies the variances specified for characters I and E in both cases. In any case the

*Violates the variance restriction.

non linear programming solutions are far better in terms of efficiencies and fulfillment of variance restriction conditions. Dynamic programming, in both cases, gave results similar to those obtained by using other methods (except the linear programming) and did not violate any variance restriction. The advantage of dynamic programming is that it can handle optimization problems involveng several strata and/or characters. Thus for complex sample surveys that involve several strata and/or characters, dynamic programming is more preferable to the allocation problem.

4.8 Estimation from a Sample of the Gain due to Stratification

When a stratified random sampling has been taken, it may be of interest, as a guide to the conduct of future syrveys, to appraise the gain in precision relative to simple random a sampling (Cochran, 1977).

Due to the stated reason above, the necessary computations are made and the following results are found.

Notation: Vran = variance of simple random sample

deff = design effect

Table 4.8.1 Values of Variances and Deff for the Likert Scale Scores (Unweighted)

(1) Character (j)	(2) $Var(y_{jst})$	(3) Vran	(2)÷(3) =deff	Appraised Sample Design
I	.5249	.8128	.6458	Stratified
E	.4034	.4726	.8536	Stratified
F	.3672	.4182	.8780	Stratified

Table 4.8.2 Values of Variances and deff for the Likert Scale Scores (Weighted)

(1) Character (j)	(2) $Var(y_{jst})$	(3) Varn	(2)÷(3) = deff	Appraised Sample Design
I	.0793	.3536	.2243	Stratified
E	.0532	.0688	.7733	Stratified
F	.0182	.3414	.0633	Stratified

In both, weighted and unweighted Likert scale scores the deff values justify:

i) stratified random sampling design is superior to that of simple random sampling design and

ii) all the deff values for the weighted Likert scale scores are much less than the unweighted ones and hence stratified random sample design with differentially weighted Likert scores are much preferable to study the attitudes of farmers towards multi-item characters of interest.

4.9 Proposed Sample Design for Ethiopia for the Study of The Attitudes of Farmers'

In this specific situation it is easy to get the frame needed concerning attitude surveys in rural Ethiopia due to the reason stated by Asmerom (1985). Due to the conclusion reached by Asmerom (1985), we propose that cluster sampling design is not appropriate to study attitude surveys in rural Ethiopia. We propose a possible sample design as follows.

Let R be the total number of administrative regions in Ethiopia and R_h (h=1,2,...,R) be the h^{th} administrative region. Thus we propose a stratified random sample design where the strata are the R administrative regions and R_h is the h^{th} stratum.

The study of the attitudes of farmers' could proceed as we made, in the thesis, for Akaki District.

D I S C U S S I O N A N D C O N C L U S I O N

In the preceding chapters we have found that factor analysis is an appropriate statistical method to study the attitudes of farmers toward major characters that can describe their attitudes towards the overall agricultural and economic development in the rural section. Since many of our concepts are subjective and illusive scaling techniques are most important and hence have received a special attention in our litrature and data analysis. Choosing a scaling technique often is a matter of finding which computer programs are available, easy to use, etc. A better test of the dimensionality is provided by the various factor analytic techniques. If the scale is composed of items measuring two (or more) attitude dimensions, factor analysis will reveal the dimensions and will indicate which items belong to which dimensions and how they should be weighted to compose the scales.

The items in Likert scale must not be weighted equally in attitude suveys, We may a priori assign different weights to different items in order to increase the reliability ot the estimates, or, empirical results can be used to differentially weight the items. Factor analysis can be used to obtain weights so that the correlation of total score of each respondent to the latent factors could be maximized. The factor analysis and hence our work in general, cannot be theory free since at least the predictive and explanatory ability of the factor analysis depend on the relevance of the questionnaire designed.

On the other hand we have observed, from the empirical study that the differentially weighted Likert scales have less variances of the estimated means. Optimum allocation in multi-character attitude survey based on these scores are highly effecient with reduced costs than the unweighted ones. The comparative study of the allocation methods showed that nonlinear and dynamic programming techniques are more efficient and appropriate. The choice of these methods could be done according to the complexity of the survey and available computer programs for the computations.

Finally, we suggest the following in order to conduct attitude surveys of farmers towards agriculture:

i) The questions should be written to produce the most complete and valid information.

ii) Use a multicharacter stratified random sampling.

iii) Use differentially weighted Likert scale scores for the allocation problem.

iv) Use nonlinear programming or dynamic programming techniques according to the complexity of the survey and availible computer programs for the computations.

APPENDIX A.

SAMPLING FRAME

STRATUM I

S.N	Name of PA	Number of Farmers
1.	Bole Kotebe	227
2.	Bole Lemi	224
3.	Bole Bulbula	308
4.	Bole Weregenu	157
5.	Weredena Arabso	182
6.	Bole Arabso	154
7.	Genda Selula	229
8.	Kilinto	251
9.	Gelan Edero	210
10.	Kersa Tulu Mute	145
11.	Gelan Gura	161
12.	Koyi	222
13.	Wedensona Werebo	144
14.	Dengura Dikosdin	136
15.	Tulu Dimotuna Fechi	213
16.	Yerer Abay	253
17.	Gelan Selto	155
18.	Buli	241
19.	Chefi Buki	228
20.	Necho	153
21.	Enselale Lale	185
22.	Enselale Finch Wuha	206
23.	Abay and Silto	228
24.	Gimachi	139

APPENDIX A.

SAMPLING FRAME

STRATUM II

S.N	Name of PA	Number of Farmers
1.	Kaliti	301
2.	Seriti	175
3.	Salon Gora	154
4.	Hechu	215
5.	Endodi	186
6.	Were Jarsa	181
7.	Aba Samuel	155
8.	Dewera Tino	264
9.	Tengego	219
10.	Dufa	211
11.	Bilibilo	161
12.	Kurivo	194
13.	Sidamo Awash	164
14.	Denbina Geradera	177
15.	Debre Gelan	192
16.	Geradona Sakalo	255
17.	Merena Sakalo	182
18.	Dewera Gudo	202
19.	Boretema Gurgi	184
20.	Golena Koticha	217
21.	Dimotu	241
22.	Dalota Guebriel	255
23.	Gogecha	102
24.	Dalota Kota	166
25.	Wolisona Dir Geła	208
26.	Mendelo Tulu Gurecha	172

STRATUM III

S.N	Name of PA	Number of Farmers
1.	Abu Kombolcha	232
2.	Koffu	170
3.	Abu Gerbi	182
4.	Abu Serkema	173
5.	Abu Kobo	193
6.	Abu Achero	141
7.	Amuyena Lera	269
8.	Abu Dedela	200
9.	Abu Lugna	178
10.	Abu Chiri	153
11.	Luya Lugna	210
12.	Luya Wajetu	234
13.	Abu Koticha	245
14.	Abu Edero	151
15.	Abu Dera	201
16.	Abu Oda	192

APPENDIX B.

B.1. Common Factor Loadings a_{ij} in stratum 1.
On Improved Agricultural Practices.

Respons items	Common Factors				
	F_1	F_2	F_3	F_4	F_5
X_1	-.167104	-.199927	-.506733	.201593	.637635
X_2	-.248850	-.327406	-.612403	.148430	.297868
X_3	-.641650	-.016904	-.306945	.320679	-.359159
X_4	-.568148	.170950	-.392197	.428997	-.346176
X_5	-.374360	-.259877	-.477046	-.333612	.130264
X_6	-.459024	-.356809	-.347220	-.322510	-.208928
X_7	-.517573	-.726978	.250292	-.024566	-.092639
X_8	-.559500	-.597474	.282116	.029705	-.140516
X_9	-.389487	-.336376	-.037260	-.281306	-.243029
X_{10}	-.480451	.527238	-.086664	-.032644	-.176044
X_{11}	-.716609	.478782	.283223	-.002515	.185643
X_{12}	-.433403	.244691	-.061369	-.581069	.062702
X_{13}	-.804907	.273443	.265113	-.125506	.197494
X_{14}	-.816489	.281198	.263337	-.077650	.188082
X_{15}	-.579634	.108751	.328876	.360235	.101433
X_{16}	-.427454	-.879081	.450880	.177568	.197295
X_{17}	-.501673	+.326081	-.447584	.014961	-.032836

B.2. Common Factor Loadings a_{ij} in stratum 1.
On Education

Response items	Common Factor		
	F_1	F_2	F_3
X_{18}	-.820856	-.132577	-.228671
X_{19}	-.837396	-.005370	-.344388
X_{20}	-.853104	.061534	-.329419
X_{21}	-.799476	-.025269	-.282820
X_{22}	-.725379	.362169	.161702
X_{23}	-.638886	.259590	.041642
X_{24}	-.511711	.339034	.539072
X_{25}	-.522153	.256872	.405058
X_{26}	-.539633	-.557454	.454912
X_{27}	-.556987	-.636138	.191205

B.3. Common Factor Loadings a_{ij} in stratum 1.
On Farming

Response items	Common Factors	
	F_1	F_2
X_{28}	-.680603	.461049
X_{29}	-.831680	.267406
X_{30}	-.455364	-.739577
X_{31}	-.546769	-.196214
X_{32}	-.800789	.194259
X_{33}	-.650985	-.380483

B.4. Common Factor Loadings a_{ij} in stratum 2.
On Improved Agricultural Practices.

Response items	Common Factors					
	F_1	F_2	F_3	F_4	F_5	F_6
X_1	.000000	.000000	.000000	.000000	.000000	1.000000
X_2	-.185681	-.518106	.229825	.535435	.059313	.000000
X_3	-.612827	.175759	.057727	-.138524	.356822	.000000
X_4	-.668931	-.07641	.180700	.193253	.330423	.000000
X_5	-.114559	-.582867	.205568	-.547252	-.028209	.000000
X_6	-.233127	-.729139	.382547	.014028	.011679	.000000
X_7	-.623487	.285203	-.056080	-.037416	.359453	.000000
X_8	-.562818	.043103	.277504	.326622	.206260	.000000
X_9	-.392036	-.021399	.227515	-.358183	-.432396	.000000
X_{10}	-.736827	-.272279	-.311847	-.167494	-.262000	.000000
X_{11}	.153539	.399438	.626109	.162278	-.313944	.000000
X_{12}	-.373228	-.068784	.103835	.291261	-.456883	.000000
X_{13}	-.697839	.389303	-.174762	-.100122	-.232094	.000000
X_{14}	-.673817	.294726	.105577	.185469	-.303434	.000000
X_{15}	-.558055	.082057	.233785	-.387497	.187233	.000000
X_{16}	.320130	.015136	.687329	-.195848	.064928	.000000
X_{17}	-.251941	-.559317	-.375207	.133394	-.090726	.000000

B.5. Common Factor Loadings in stratum 2.
On Education.

Response items	Common Factors		
	F_1	F_2	F_3
X_{18}	-.778690	.335288	.102470
X_{19}	-.880031	.222709	.032974
X_{20}	-.884934	.193802	.176102
X_{21}	-.872503	.085326	.096213
X_{22}	-.402130	-.601187	-.058495
X_{23}	-.425775	-.528601	-.241988
X_{24}	-.319601	-.624310	+.208219
X_{25}	-.252361	-.162333	-.773017
X_{26}	-.129780	-.413592	-.058816
X_{27}	-.135104	.429046	.625839

B.6. Common Factor Loadings in stratum 2.
On Farming.

Response items	Common Factors	
	F_1	F_2
X_{28}	-.561522	-.047362
X_{29}	-.388557	772664
X_{30}	-.731186	217249
X_{31}	-.624663	220106
X_{32}	-.816153	-.269068
X_{33}	-.656746	-.533500

B.7. Common Factor Loadings in stratum 3.
On Improved Agricultural Practices.

Response items	Common Factors				
	F_1	F_2	F_3	F_4	F_5
X_1	.022389	-.435028	.329084	.546073	.335212
X_2	.259435	-.584172	.104760	-.185191	.148853
X_3	-.737697	-.102932	.350911	.081053	-.089934
X_4	-.041340	-.503921	.160891	-.166985	-.582227
X_5	-.372182	-.631780	.261010	.195022	.244246
X_6	-.067463	-.549654	-.498225	-.253997	.290599
X_7	-.727186	-.077539	.297167	-.298584	.112692
X_8	-.648872	-.270325	.134579	-.381649	.004252
X_9	-.553196	.011679	-.222511	.404694	.136995
X_{10}	-.117946	-.156005	-.762442	.303419	.008638
X_{11}	-.785492	.112672	-.083015	-.010697	-.061045
X_{12}	-.169430	-.358234	-.520645	.012108	-.195609
X_{13}	-.833845	.225988	-.081712	.074749	-.109060
X_{14}	-.852214	.191998	-.166278	.130312	-.135175
X_{15}	.116358	-.508301	-.026240	.209334	-.491192
X_{16}	-.490377	-.031580	-.273774	-.457899	.230844
X_{17}	.664114	-.041998	-.164958	-.215048	.028008

B.8. Common Factor Loadings in stratum 3.
On Education.

Response items	Common Factors		
	F_1	F_2	F_3
X_{18}	-.859595	-.012287	.112062
X_{19}	-.960522	-.083103	.053262
X_{20}	-.954837	-.070515	.072842
X_{21}	-.904748	-.046168	.071926
X_{22}	-.017988	-.703960	-.227287
X_{23}	-.118383	-.548944	-.575753
X_{24}	.231314	-.658730	-.154135
X_{25}	.323209	-.580938	.435382
X_{26}	-.035119	.399325	-.817725
X_{27}	-.606786	-.136519	-.118211

B.9. Common Factor Loadings in stratum 3.
On Farming.

Response items	Common Factors		
	F_1	F_2	F_3
X_{28}	.069122	-.378162	.852725
X_{29}	.662943	-.451417	-.200554
X_{30}	-.039242	.849439	-.012112
X_{31}	.362227	.513186	.474984
X_{32}	.805796	.156358	.064256
X_{33}	.779825	.060082	-.192720

APPENDIX C.

C.1. Common factor loadings a_{ij} and their Communalities h_i^2 for 17 Response variables on Improved Agricultural Practices in stratum 1. (after varimax rotation).

Response variable(i)	a_{ij}'s for common Factors					h_i^2
	F_1	F_2	F_3	F_4	F_5	
X_1	.033441	.005718	.013204	-.011317	.877743	.772
X_2	-.116983	.091852	.237299	.212235	.726996	.655
X_3	.177294	.217464	.787917	.169932	.098117	.736
X_4	.186414	.025799	.870160	.044781	.122912	.810
X_5	.058881	.066147	.085993	.604442	.427700	.564
X_6	-.005323	.249664	.248286	.678647	.146857	.606
X_7	.034874	.881668	.052404	.291695	.042592	.868
X_8	.119165	.827481	.132863	.230323	-.024478	.770
X_9	.040612	.355713	.127383	.595350	-.068142	.404
X_{10}	.529939	-.240604	.416470	.131869	-.137162	.548
X_{11}	.006967	.054206	.170691	-.034576	-.039774	.857
X_{12}	.510474	-.150612	-.080814	.549509	-.035867	.593
X_{13}	.875686	.214496	.115336	.145674	.017928	.848
X_{14}	.877716	.222369	.152944	.112879	.022427	.856
X_{15}	.555208	.374430	.269856	-.272578	.020971	.596
X_{16}	.184378	.850873	-.107011	-.081970	.125069	.792
X_{17}	.363449	-.238940	.495494	.256883	.242779	.560
Sum of squares ...	3.4771	2.8121	2.1157	1.7970	1.6357	
Percent of variance ...	20.5	16.5	12.4	10.6	9.6	
average squared loadings ...		.696				

Note that the total communality h_i^2 of the five common factors remains unchanged so that the statistical explanatory power of the original and new factor locations is constant.

C.2. Common Factor Loadings a_{ij} and their communalities h_i^2 for 10 response variables on Education in stratum 1.

Response variable(i)	Common Factors F_1	F_2	F_3	h_i^2
X_{18}	0.781127	0.181410	0.31716	.744
X_{19}	0.870014	.185326	.169090	.820
X_{20}	.875308	.240823	.126206	.840
X_{21}	.801475	.195830	.197667	.720
X_{22}	.481062	.671124	.040733	.683
X_{23}	.484118	.491103	.041765	.477
X_{24}	.078990	.800714	.141442	.677
X_{25}	.167416	.671120	.155781	.503
X_{26}	.123001	.252004	.854556	.809
X_{27}	.297271	.042354	.813203	.751
sum of squares	3.3792	2.0120	1.6234	
percent of varoance ...	33.8	20.1	16.2	
avarage squared loadings ...		0.701		

C.3. Common Factor Loading a_{ij} and their communalities h_i^2 for 6 response variables on farming in stratum1.

Response variables (i)	Common Factors F_1	F_2	h_i^2
X_{28}	-.680603	.461049	.676
X_{29}	-.831880	.267406	.763
X_{30}	-.455364	-.739577	.754
X_{31}	-.546769	-.196214	.337
X_{32}	-.800789	.194259	.679
X_{33}	-.650985	-.380483	.569
sum of squares ...	2.7263	1.0521	
persent of variance ...	45.4	17.5	
average squared loadings		0.629	

C.4. Common Factor Loading a_{ij} and their communalities h_i^2 for 17 response variable on improved Agricultural practies in stratum 2. (after varimax rotation)

Response Variables(i)	Common Factors F_1	F_2	F_3	F_4	F_5	F_6	h_i^2
X_1	.000000	.000000	.000000	.000000	.000000	1.000000	1.000
X_2	.011377	.042452	.081983	.798299	-.001753	0.000000	.646
X_3	.735185	.067509	.068350	-.042243	.089123	0.000000	.556
X_4	.678141	.123935	.087536	.386173	.021331	.000000	.632
X_5	-.011664	-.081767	.098178	.091195	.818911	.000000	.695
X_6	.031795	.0095869	.048800	.643111	.561772	.000000	.733
X_7	.749439	.096851	.123846	.083386	-.102446	.000000	.604
X_8	.561713	.212795	-.079648	.405829	-.114057	.000000	.545
X_9	.106384	.526629	-.083275	-.121753	.459083	.000000	.521
X_{10}	.298341	.516124	.593099	.034603	.320370	.000000	.811
X_{11}	-.110296	.310691	-.757229	.033347	-.129720	.000000	.700
X_{12}	-.013856	.602949	.041180	.286594	-.028513	.000000	.448
X_{13}	.483722	.614936	.187372	-.284051	-.070973	.000000	.733
X_{14}	.414402	.696986	-.019933	.056419	-.130739	.000000	.679
X_{15}	.619234	.136169	-.065902	-.110609	.373483	.000000	.558
X_{16}	-.082472	-.199369	-.690305	.070386	.299461	.000000	.618
X_{17}	-.084773	.094441	.630132	.328112	.149275	.000000	.543
sum of squares ..	2.7922	2.0209	1.9000	1.6897	1.6195	1.000	
Percent of variance	16.4	11.9	11.2	9.9	9.5	5.9	
avarage squared loadings		0.648					

C.5. Common Factor Loadings a_{ij} and their communalities h_i^2 for 10 response variable on Education in stratum 2. (After Varimax Rotation)

Response Variables(i)	Common Factors F_1	F_2	F_3	h_i^2
X_{18}	.850192	-.038927	.070236	0.729
X_{19}	.891657	.108972	.134945	0.825
X_{20}	.914531	.123434	-.008676	0.852
X_{21}	.850661	.227353	.049649	0.778
X_{22}	.154995	.708623	.019626	0.527
X_{23}	.164662	.668278	.216822	0.521
X_{24}	.123662	.673894	-.256587	0.535
X_{25}	.025280	.318014	.765389	0.688
X_{26}	-.032166	.436154	.009756	0.191
X_{27}	.146533	-.287107	.700074	0.594
sum of squares ..	3.1674	1.8570	1.2150	
present of variance	31.7	18.6	12.1	
avarage squared loadings		0.624		

C.6. Common Factor Loading a_{ij} and their communalities h_i^2 for 6 response variables on farming in stratum 2.

Response variables(i)	Common Factors F_1	F_2	h_i^2
X_{28}	-.561522	-.047362	.318
X_{29}	-.388557	.772664	.748
X_{30}	-.731186	.217219	.582
X_{31}	-.624663	.220106	.439
X_{32}	-.816153	-.269068	.739
X_{33}	-.656746	-.533500	.716
sum of squares ...	2.4885	1.0519	
percent of variance ...	41.5	17.5	
avarage squared loadings		0.5901.	

C.7. Common Factor Loading a_{ij} and their communalities h_i^2 for 17 response variable on improved Agricultural practies in stratum 3. (after varimax Rotation)

Response variables(i)	Common Factors F_1	F_2	F_3	F_4	F_5	h_i^2
X_1	-.012621	-.196563	-.027653	.817936	-.004844	.709
X_2	-.448275	.284153	.042532	.361591	.248469	.476
X_3	.704576	.232206	-.214472	.253474	.178853	.693
X_4	-.010678	.134762	-.035999	.017220	.792800	.648
X_5	.213049	.279195	.051322	.734415	.195287	.703
X_6	-.221311	.513023	.598933	.179831	.024968	.704
X_7	.551946	.584330	-.248850	.128394	.021659	.725
X_8	.423540	.652885	-.064825	.089533	.200068	.658
X_9	.583126	-.056137	.336235	.221246	-.181721	.538
X_{10}	.114905	-.124315	.824067	-.021494	-.059104	.712
X_{11}	.744168	.268089	.096065	-.068005	-.030128	.640
X_{12}	.002285	.127535	.602920	-.041703	-.279600	.467
X_{13}	.848181	.166587	.077860	-.115303	-.063248	.771
X_{14}	.873139	.134758	.178887	-.109072	-.040174	.826
X_{15}	-.074779	-.193612	.209072	-.164755	.666146	.558
X_{16}	.249795	.647005	.209402	-.152497	-.176795	.579
X_{17}	-.888508	-.070195	.066765	-.183221	-.007015	.517
sum of squares ...	4.2136	1.9140	1.7723	1.6254	1.3979	
precent of variance ..	24.8	11.3	10.4	9.6	8.2	
average squared loadings		64.3				

C.8. Common Factor Loading a_{ij} and their communalities h_i^2 for 10 response variables on Education in stratum 3. (After Varimax Rotation)

Response variables(i)	Common Factors F_1	F_2	F_3	h_i^2
X_{18}	.862549	-0.086720	.010017	.752
X_{19}	.964818	-0.000727	.038392	.932
X_{20}	.959585	- .021213	.027120	.922
X_{21}	.907305	- .039349	.033478	.826
X_{22}	.072622	.720333	-.152933	.548
X_{23}	.124529	.758668	.236135	.647
X_{24}	-.172578	.656092	-.225717	.511
X_{25}	-.229341	.295291	-.705889	.638
X_{26}	-.080514	.068799	.904517	.829
X_{27}	.604945	.148802	.112688	.401
sum of squars ...	3.8945	1.8485	1.4627	
percent of variance ...	31.7	18.6	12.1	
average squared loadings		0.701		

C.9. Common Factor Loading a_{ij} and their communities h_i^2 for 6 response variable on farming on stratum 3. (After Varimax Rotation)

Response variables(i)	Comon Factors F_1	F_2	F_3	h_i^2
X_{28}	-.034175	-.033316	.934153	.875
X_{29}	.716843	-.407401	.060418	.683
X_{30}	-.098694	.775945	-.333767	.7236
X_{31}	.247331	.690671	.286316	.620
X_{32}	773062	.267660	.092809	.678
X_{33}	.793615	.0822729	-.110555	.649
sum of squeres ...	1.8134	1.3247	1.0905	
percent of variance ...	30.2	22.1	18.2	
average squared loadings		0.705		

APPENDIX D.

D.1. Factor scales of 38 randomly selected farmers in stratum 1 on improved Agricultural practices

serial number of the Farmer	Farmer's total score on F_1	F_2	F_3	F_4	F_5
1	3.7455	4.2667	2.9269	2.9224	4.0169
2	3.7455	4.2667	2.9269	2.9224	4.0169
3	3.6345	4.2667	2.9269	2.9224	4.0160
4	3.7455	4.2667	2.9269	2.9224	4.0169
5	3.7455	4.2667	3.5893	2.9224	4.0169
6	3.0773	4.2667	2.8714	2.6587	4.0169
7	3.7455	4.2667	2.9269	2.9224	4.0169
8	3.6345	3.7073	2.8714	2.6477	4.0169
9	3.5335	3.9728	2.9269	2.9224	4.0169
10	3.7455	4.2667	2.9269	2.9224	4.0169
11	3.7455	4.2667	2.9269	2.9224	4.0169
12	3.7455	4.2667	2.9269	2.9224	4.0169
13	3.7455	4.2667	3.3267	2.9224	4.0169
14	3.3013	1.9567	1.3785	2.9224	2.5589
15	3.3013	2.5806	1.2980	2.9224	4.0169
16	3.4589	3.0912	2.2487	2.9224	4.0169
17	2.3533	3.9909	2.0561	2.9224	4.0169
18	3.7455	4.2667	2.9269	2.9224	4.0169
19	3.7455	4.2667	3.5893	2.9224	4.0169
20	3.7455	4.2667	3.5893	2.9224	4.0169
21	3.7455	4.2667	3.5893	2.9224	4.0169
22	3.7455	4.2667	3.9269	2.9224	4.0169
23	2.4710	0.8533	2.3462	2.2871	4.0169
24	3.7455	4.2667	2.5113	2.9224	4.0169
25	3.7455	4.2667	2.9269	2.7961	4.0169
26	3.7455	4.2667	2.9269	2.9224	4.0169
27	3.7455	4.2667	2.9269	2.9224	4.0169

....CONTD

serial number of the Farmer	Farme's total score on				
	F_1	F_2	F_3	F_4	F_5
28	3.7455	4.2667	2.7465	2.9224	4.0169
29	3.2134	0.8533	2.7465	2.9224	4.0169
30	2.2372	1.9928	2.5113	2.7961	4.0169
31	3.7455	1.4231	2.4831	2.7961	4.0169
32	2.6814	1.4206	2.9269	2.7961	4.0169
33	2.4593	1.4206	2.4839	2.5434	4.0169
34	3.3013	0.8533	2.9269	2.9224	4.0169
35	2.4593	1.4206	2.4839	2.6698	4.0169
36	2.3122	0.8533	2.5387	2.4171	4.0169
37	2.2372	1.9747	2,7740	2.9224	4.0169
38	2.0353	4.2667	2.6088	2.9224	4.0169

D.2. Factor scales of 38 randamly selected Farmer's in stratum 1 on Education

serial number of Farmer	Farmer's total score on F_1	F_2	F_3
1	4.1599	3.0924	4.1694
2	4.1599	3.2926	4.1694
3	4.1599	3.2926	4.1694
4	4.1599	3.2926	4.1694
5	4.1599	3.2926	4.1694
6	4,1599	3.0924	4.1694
7	4.1599	3.0924	4.1694
8	3.7223	3.0924	4.1694
9	4.2599	3.0924	4.1694
10	4.1599	3.0924	4.1694
11	3.7223	2.8018	4.1694
12	4.1599	3.0924	4.1694
13	4.1599	3.2926	4.1694
14	4.1599	3.2926	4.1694
15	4.1599	3.2926	4.1694
16	4.1599	3.2926	4.1694
17	4.1599	3.1248	4.1694
18	4,1599	3.2926	4.1694
19	4.1599	3.2926	4.1694
20	4.1599	3.2926	4.1694
21	4.1599	3.2926	4.1694
22	4.1599	3.2926	4.1694
23	3.5232	3.1248	2.0537
24	4.1599	3.1248	4.1694
25	3.7407	3.0924	4.1694

.... CONTD

Serial number of Farmer	Farmer's total score on		
	F_1	F_2	F_3
26	4.1599	3.0924	4.1694
27	4.1199	3.2926	4.1694
28	4.1599	3.0924	4.1694
29	4.1599	3.2926	3.7628
30	4.1599	2.5567	2.5016
31	3.3279	2.6341	2.5016
32	4.1599	3.2926	3.7628
33	4.1599	3.2926	3.7628
34	3.9646	2.9246	2.9082
35	3.3279	2.5891	2.9082
36	3.3279	2.4339	2.5016
37	2.4959	2.7244	2.0744
38	4.1599	3.2926	3.7628

D.3. Factor seales of 38 Randomly selected Farmers in stratum 1 on Farming

Serial number of the Farmer	Farmer's Total Score on	
	F_1	F_2
1	1.4492	1.4792
2	1.7155	1.4792
3	0.8324	0.7396
4	0.9626	1.4792
5	1.4193	2.2187
6	1.5494	2.2187
7	1.4193	2.2187
8	1.4193	2.2187
9	1.1227	2.2187
10	1.2529	2.2187
11	1.4193	2.2187
12	1.5794	2.2187
13	1.2529	0.7396
14	1.1227	1.4792
15	1.5794	1.4792
16	1.1227	1.4792
17	1.8128	0.7396
18	1.1589	0.7396
19	0.9925	0.7396
20	1.2529	0.7396
21	1.4193	0.7396
22	1.0928	0.7396
23	0.9925	2.2187
24	1.4193	2.2187
25	1.7457	2.2187

..... CONTD

Serial number of the Farmer	Farmer's Total Score on	
	F_1	F_2
26	1.5794	2.2187
27	0.7022	0.7396
28	1.7457	1.4792
29	1.2891	1.4792
30	2.0121	1.4792
31	2.0420	0.7396
32	1.3890	1.4792
33	1.3890	1.4792
34	1.5794	2.2187
35	1.7217	0.7396
36	1.5286	2.2187
37	2.1722	2.2187
38	1.6155	0.7396

D.4. Factor Scales of 30 Randomly selected Farmers in stratum 2 on Improved (Agricultural Practices.)

Serial Number of the Farmer	F_1	F_2	F_3	F_4	F_5	F_6
1	2.3691	3.0544	1.9210	2.8828	4.0946	5
2	2.5047	3.0544	1.9361	2.8828	4.0946	5
3	2.2397	3.0544	1.9511	2.8828	4.0946	5
4	1.3025	2.2767	2.6632	3.6035	4.0946	5
5	1.7267	2.1341	2.9598	3.2820	4.0946	5
6	0.9164	2.5942	2.4254	3.6035	4.0946	5
7	2.0059	2.7259	2.0802	3.6035	4.0946	5
8	2.4010	2.5942	1.9320	2.8828	4.0946	5
9	1.7295	2.3974	2.5980	2.8828	4.0946	5
10	2.5366	3.0544	2.4087	2.8828	4.0946	5
11	0.6687	2.5942	2.7705	3.6035	4.0946	5
12	3.0815	2.5752	2.0635	3.6035	4.0946	5
13	2.8793	2.3309	2.7705	3.2044	4.0946	5
14	2.0554	2.1150	2.2361	3.6035	4.0946	5
15	2.4990	2.3974	2.2695	3.6035	4.0946	5
16	2.5511	2.5942	2.0635	2.8828	3.2756	5
17	2.2371	2.3974	2.6147	3.6035	4.0946	5
18	1.7210	2.5752	2.5812	3.6035	4.0946	5
19	1.5167	2.5752	2.7705	3.6035	4.0946	5
20	2.8793	2.3974	2.9598	3.6035	4.0946	5
21	3.0582	3.0544	1.8909	3.6035	4.0946	5
22	2.5427	2.5752	2.2528	3.6035	4.0946	5
23	1.8336	2.5752	2.5812	3.6035	4.0946	5
24	2.6236	2.5752	2.7705	2.6035	4.0946	5
25	2.7240	1.9403	2.0802	3.6035	4.0946	5
26	2.4533	3.0544	2.5812	3.6035	4.0946	5
27	2.4184	2.5752	2.0635	3.6035	4.0946	5
28	2.5598	2.5752	2.2528	3.6035	4.0946	5
29	1.7181	2.9227	2.5812	3.6035	4.0946	5
30	2.2368	3.0544	2.0635	3.6035	4.0946	5

D.5. Factor Scales of 30 Randomly Selected Farmers in Stratum 2 on Education

Serial Number of the Farmer	Farmer's Total Score on		
	F_1	F_2	F_3
1	4.3838	2.6725	3.6637
2	4.3838	2.4474	3.6637
3	2.1684	2.4446	2.9636
4	3.9483	2.9996	2.9636
5	3.5070	2.5450	2.5809
6	3.5070	2.8312	3.3136
7	4.3838	2.8906	2.9636
8	4.3838	2.8906	2.9636
9	3.9483	2.9996	2.9636
10	4.3838	3.1086	3.6637
11	2.6303	2.2689	2.5809
12	4.1713	2.7221	3.3136
13	4.3838	2.8312	3.3136
14	4.1713	2.8312	2.9309
15	4.3838	2.9996	2.9309
16	3.9426	2.7221	3.6637
17	4.1713	2.7221	3.3136
18	3.5070	3.1086	3.3136
19	4.3838	2.7816	2.9636
20	2.8690	2.6131	3.3136
21	4.3838	2.9996	3.3136
22	3.7140	2.9996	3.3136
23	4.3838	2.8312	2.6135
24	4.3838	2.9996	3.3136
25	4.3838	2.9996	3.3136
26	4.3838	2.8906	2.9636
27	4.3838	2.9996	2.9636
28	3.9483	2.9996	2.5809
29	2.8690	2.8312	2.9309
30	4.3838	2.7221	2.9309

D.6. Factor Scales of 30 Randomly Selected Farmers in stratum 2 on Farming

Serial number of the Farmer	Farmer's Total Score on F_1	Farmer's Total Score on F_2
1	0.9726	2.3180
2	1.0657	1.5453
3	1.5023	3.8633
4	1.4599	3.0907
5	2.0406	1.5453
6	1.3965	3.0907
7	1.4939	3.0907
8	1.7969	2.3180
9	1.5278	3.0907
10	0.8094	3.8633
11	1.7828	2.3180
12	1.3986	2.3180
13	1.3986	2.3180
14	1.1040	3.8633
15	1.3965	3.0907
16	1.2353	3.8633
17	1.3816	3.0907
18	1.2353	3.8633
19	1.5448	3.0907
20	1.2353	3.0907
21	1.5448	2.3180
22	1.2502	3.0907
23	2.3691	2.3180
24	0.9726	3.8633
25	1.5278	2.3180
26	1.6571	2.3180
27	1.6720	3.0907
28	1.5448	2.3180
29	1.1189	3.0907
30	0.9726	3.0907

D.7. Factor scales of 7 Randomly Selected Farmer's in Stratum 3 on Improved Agricultural Practices (Ater varimax Rotation)

Serial number of the Farmer	Farmer's Total Score on				
	F_1	F_2	F_3	F_4	F_5
1	2.5561	2.0810	2.2778	3.8809	2.5848
2	1.9560,	0.6281	2.9746	3.8809	2.0618
3	2.6419	1.4529	3.1769	3.8809	1.5223
4	1.4664	0.6281	2.7012	3.8809	3.2510
5	1.6217	1.2542	3.3765	3.8809	1.0625
6	2.1514	1.6666	2.9022	3.5137	3.2510
7	2.2521	1.9071	3.3765	3.8809	3.2510

D.8. Factor Scales of 7 Randomly Selected Farmer's in stratum 3 on Educarion (After Varimax Rotation)

Serial Number of the Farmer	Farmer's Total Score on		
	F_1	F_2	F_3
1	1.3438	3.5585	2.6142
2	1.9128	3.3538	2.0627
3	4.2992	3.3898	1.3568
4	3.9960	2.8810	2.9672
5	4.2992	3.5585	3.3201
6	4.0057	2.8810	2.9672
7	4.2992	3.0997	2.9672

D.9: Factor Scales of 7 Randomly Selected Farmers in stratum 3 On Farming (After Varimax Rotation)

Serial Number of the Farmer	Farmer's Total Score on		
	F_1	F_2	F_3
1	2.8245	2.8906	4.6708
2	2.2835	2.8906	4.6708
3	3.0703	3.3212	4.6708
4	3.5413	2.5453	4.6708
5	2.5412	3.6665	4.6708
6	3.0447	2.1999	3.7366
7	3.2836	3.2786	4.6708

Schedule for the survey entitled " APPLICATION OF NEW STATISTICAL METHODS TO STUDY THE ATTITUDES OF FARMERS IN AKAKI DISTRICT, ETHIOPIA"

1. Stratum Number _____
2. The serial number of the farmer in the stratum _____
3. Name of the farmer selected _____
4. Age of the farmer selected _____
5. Family size in the farmer selected _____
6. Educational level of the farmer _____
7. Educational level and age of each of this dependents _____

	Educational Level	Age
a)	_____	___
b)	_____	___
c)	_____	___
d)	_____	____
e)	_____	___
f)	_____	___
g)	_____	___
h)	_____	___
i)	_____	___
j)	_____	___

I. Improved Agricultural practices

1. What are the important crops you are raising in your holding? Give the relative importance of the crops in the relative order of their importance.

a) _____ d) _____
b) _____ e) _____
c) _____ f) _____

2. Do you think it necessary to use fertilizers for farming

teff	wheat	chick pea	others	
____	____	_____	_____	a) I think it very necessary (5) *
____	____	_____	_____	b) I think it necessary (4)

* all numbers in parentheses indicate positive responses.

Teff	Wheat	Chick pea	Others	
___	___	_____	_____	a) I am indifferent about it (3)
___	___	_____	_____	d) I do not think it necessary (2)
___	___	_____	_____	e) I do not think it necessary at all (1)

3. Do you think it worthwhile to use insecticides, pesticides and weedicides in farming

teff	wheat	chick pea	others	
___	___	_____	_____	a) I think it very necessary (5)
___	___	_____	_____	b) I think it necessary (4)
___	___	_____	_____	c) I am indifferent about it (3)
___	___	_____	_____	d) I do not think it necessary (2)
___	___	_____	_____	e) I do not think it necessary at all (2)

4. What is your attitude towards harvesting cerial crops with improved machines as harvestors rather than traditional practices.

_____ a) very favourable (5)
_____ b) favourable (4)
_____ c) indifferent (3)
_____ d) not favourable (2)
_____ e) deadly against it (1)

5. What is your attitude towords storing the excess produce in improved bins rather than the traditional ones?

_____ a) strongly approve of it (5)
_____ b) approve of it (4)
_____ c) indifferent (3)
_____ d) do not approve of it (2)
_____ e) strongly disapprove of it (1)

6. What is your attitude regarding adoption of new high yield varieties of

teff	wheat	chick pea	others	
___	___	_____	_____	a) strongly approve of it (5)
___	___	_____	_____	b) approve of it (4)
___	___	_____	_____	c) neutral (3)
___	___	_____	_____	d) do not approve of it (2)
___	___	_____	_____	e) strongly disapprove of it (1)

7. What is your attitude towards adoption of better marketing practices as selling in (i) polythene packets (ii) marketing at a distant better market, etc. (iii) storing for some time and marketing at a time when the price goes up, etc.?

(i)	(ii)	(iii)	
___	___	_____	a) strongly approve of it (5)
___	___	_____	b) approve of it (4)
___	___	_____	c) neutral (3)
___	___	_____	d) do not approve of it (2)
___	___	_____	e) strongly disapprove of it (1)

II. Education

1. What is your attitude towards the agricultural education, as demonstration trials, given by the Ministry of Agriculture?

_____ a) very necessary (5)
_____ b) fairly necessary (4)
_____ c) average (3)
_____ d) not necessary (2)
_____ e) very unnecessary (1)

2. What is your attitude towards the extent of participation in agricultural education given by the Ministry?

_____ a) very often (5)
_____ b) fairly often (4)
_____ c) average (3)
_____ d) seldom (2)
_____ e) very seldom (1)

3. What is your attitude regarding the satisfaction from the education you get from the Ministry?

_____ a) very much satisfied (5)
_____ b) satisfied (4)
_____ c) average (3)
_____ d) dissatisfied (2)
_____ e) very much dissatisfied (1)

4. What is your attitude regarding the intention to practice the education you get in your farm activities?

_____ a) very well (5)
_____ b) relatively well (4)
_____ c) neutral (3)
_____ d) unwilling to do it (2)
_____ e) do not practice it at all (1)

5. What is your attitude regarding your children getting agricultural education in agriculture school or universities?

_____ a) very much approve of it (5)
_____ b) approve of it to some extent (4)
_____ c) neither approve or disapprove of it (3)
_____ d) disapprove of it (2)
_____ e) very much disapprove of it (1)

6. What is your attitude regarding the opening of agricultural schools in the country?

_____ a) strongly approve of it (5)
_____ b) approve of it (4)
_____ c) neutral (3)
_____ d) do not approve of it (2)
_____ e) strongly disapprove of it (1)

7. Do you think it necessary to send your children to the conventional schools?

_____ a) I think it very necessary (5)
b) I think it necessary (4)
c) I am not concerned about it (3)
d) I do not think it necessary (2)
e) I do not think it necessary at all (1)

8. What do you think about educating the farmers in (i) agriculture (ii) general education?

(i) (ii)

_____ _____ a) very much approve of it (5)
_____ _____ b) approve of it to some extent (4)
_____ _____ c) neither approve not disapprove it (3)
_____ _____ d) disapprove of it to some extent (2)
_____ _____ e) very much disapprove of it (1)

9. What is your attitude towards the extent of satisfaction that agricultural education in general is helping you in your profession?

_____ a) sufficiently well (5)
_____ b) relatively well (4)
_____ c) average (3)
_____ d) poorly (2)
_____ e) very poorly (1)

II. Farming

1. What do you think of your work as a farmer?

_____ a) good for a life time (5)
_____ b) good for a while (4)
_____ c) neither good nor bad (3)
_____ d) reluctantly engaged in (2)
_____ e) very much dissatisfied (1)

2. Do you think that agricultural products are enough to self-sufficiency?

_____ a) I think that they are sufficiently well (5)
_____ b) I think it they are relatively well (4)
_____ c) I think that they are average (3)
_____ d) I think they are not enough (2)
_____ e) I think that they are very much below requirements (1)

3. What is your attitude regarding the cultivation of vegetable, plantation and ornamental crops?

_____ a) very much favorable (5)
_____ b) fairly favorable (4)
_____ c) neutral (3)
_____ d) fairly not favorable (2)
_____ e) very much not favorable (1)

4. Do you think it necessary to adopt mixed farming?

_____ a) I think it very necessary (5)
_____ b) I think it necessary (4)
_____ c) I am not concerned about it (3)
_____ d) I do not think it necessary (2)
_____ e) I do not think it necessary at all (1)

5. What do you think of your income in the general farming as an occupation?

_____ a) very much satisfied (5)
_____ b) satisfied (4)

_____ c) average (3)
_____ d) dissatisfied (2)
_____ e) very dissatisfied (1)

6. What do you think of your income in the animal husbandry as an occupation?

_____ a) very much satisfied (5)
_____ b) satisfied (4)
_____ c) average (3)
_____ d) dissatisfied (2)
_____ e) very much dissatisfied (1)

REFERENCES

1. Ahsan, M.J (1978). Allocation problem in Multivariate Stratified Random Sampling. JISA, Vol. 16, 1-5.

2. Ahsan, M.J. and Khan, S.U. (1977). Optium Allocation in Multivariate Stratified Random Sampling using prior Information. JISA, Vol. 15, 57-67.

3. Ahsan, M.J. and Khan, S.U. (1982). Optimum Allocation in Multivariate Stratified Random Sampling with Overhead Cost. Mctrika. Vol 29, 71-78

4. Bethal, James (1985). Optimum Allocation Algorithm for Multivariate Surveys. ASA Srvy. Rsr. 209-212.

5. Chatterjee, S. (1968). A Note on Optimum Allocation. Skand. AKtuar. Tedskr., Vol. 50, 40-44.

6. Chatterjee, S. (1968). Multivariate Stratified Surveys. JASA, Vol. 63, 530-534.

7. Chatterjee, S. (1972). Astudy of Optimum Allocation in Multivariate Stratified Surveys. Skand. Aktuar., Vol. 55, 73-80.

8. Cochran, G.W. (1977). Sampling Technigues. John Wiley and Sons, New York, third edition.

9. Dalenius, T. (1953). The Multivariate Sampling Problem. Skand. Aktuar. Tedskr., Vol. , 36, 92-102.

10. Folks, Jhon Leroy and Antle, Charles, E. (1965). Allocation of Sampling Units to Strata when threre are Responees of Interest. JASA, Vol. 60,225-233.

11. Huddleston, H.F., Claypool, P.L. and Hocking, R.R (1970). Optimum Sample Allocation to strata using Convex Programming. App. Stat. Vol., 19, 273-278.

12. Jae-on Kinsyl Muller, Charles W. (1978). Introduction to Factor Analysis. SAGE publications INC. USA.

13. Kalton, Graham (1983). Introduction to Survey Sampling. SAGE Publications Ine. USA.

14. Kidane, A. (1985). Sampling Error from Socio-Economic Baseline Survey in an Ethiopian Rural Setting. Social Science Research Review, Vol. I, No. 1, Jan. 1985. 69-78.

15. Kish, L. (1965). Survey Sampling. Jhon Wiley and DSons. New york.

16. Kokan, A.R. (1963). Optmum Allocation in Multivariate Surveys. JRSS, A126, 557-565.

17. Kohan, A.R. and Khan, S.U. (1967). Optimum Allocation in Multivariate Surveys: An Analytical Solution JRSS, B29, 115-125.

18. Morrison, D.F. (1967). Multivariate Statistical Methods. Mc Graw-Hill, New York.

19. Nordbotten, S. (1956). Allocation in Stratified Sampleing by means of Linear Programming. Skand. Aktuar. Tidskr.

20. Munnaly, Jum, C. (1967). Psychometric Theory. MCGraw-Hilly

21. Omule, S.A.Y. (1985). Optimum Design in Multivariate Stratified Sampling. Biom. J. Vol. , 26, 517-526.

22. Rao, T.J. (1984). Allocation of Sample Size to Strata and Related Problems. Biom. J. Vol , 26, 517-526

23. Rossi, Peter, H., Wright, James, D. and Anderson Andy, B. (1983). Handbook of Survey Research. Academic Press.

24. Yates, F. (1960). Sampling Methods for Census and Surveys. Charless Griffin and Co. London, third edition.

D E C L A R A T I O N

This thesis is my original work and has not been presented for a degree in any other university.

Berhane W.Mariam
3/6/88

This thesis has been submitted for examination with my approval as a university advisor.

Dr.G. Sadasivan
3/6/88