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In title:

بعنوان:

Use of Plot Size in Estimation of Crops Yield per feddan In Traditional Rain-fed Sector (Sorghum) at period 2015/2016

إستخدام حجم الحوض في تقدير إنتاجية الفدان للمحاصيل في القطاع التقليدي (الذرة) خلال الفترة 2016/2015

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الآيـة

بسم الله الرحمن الرحيم

قال تعالى:

أفرأ يتم ما تحرثون (63) أأنتم تزرعونه أم نحن الزارعون (64)

سورة الواقعة ألآيات (63 – 64):

DEDICATION

This thesis is dedicated to soul of my parents who were emphasized the importance of education and worked very hard and exert efforts to educate me and my brothers and sisters throughout their life. The dedication extends to my wife and children.

I dedicate this Master΄s dissertation to all who have been and still fighting to promote and improve their knowledge and skills of statistics.

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However, apart from all the valuable academic knowledge and practical skill I have gained during my studies, I feel that the most valuable thing I am taking with me is to dare to think.

ABSTRACT

The rain-fed traditional represent a big share of area cultivated in the Sudan and characterized by a very complicated situation leads to numbers of problems in agricultural statistics, in respect to area enumeration and yield estimation and poses serious threats to quality and reliability of area and production estimates. Due to these problems it is essential to pay more attention to this important sector.

The study was carried out to study the effect of plot sizes on the three different types of soils (sandy, loam and clay soils) on the estimation of sorghum yield in the traditional rain-fed sector. The estimation was obtained by using crop-cutting technique and multi-stage stratified sampling. The primary data obtained from different plot sizes namely 5x5m, 6x7m and 10x10m on each type of soil. Equal sample size allocation was used. The village was considered as primary sampling unit and the field as secondary sampling unit and the plot as third sampling unit. Sample size of twenty for each plot size and on each soil type was used, with the following hypothesis;

1-There is a direct relationship between plant density and plot size.

2-The margin of error reflects the required sample size and there is a direct correlation between the level of accuracy required and the cost of conducting survey.

3-Increase of plot size has no effect on either the precision or the accuracy.

Analysis of variance table was used to analyze the effect of sample sizes on the estimation of sorghum yield in traditional rain-fed sector. The coefficient of variation was used to identify the best stable crop yield according to the plot size. The multiple comparison method was used to detect the significant differences between means in each soil type according to the plot size by using statistical package SPSS.

The results shows and according to the conclusions of the study the plot size had not shown any effect on the yield in the different types of soils, but there was slight effect of plots size in case of plants density estimation. There seem other factors affecting the level of yields. These

factors should be planting spaces, seed rate, adequate re-sowing, thinning and optimum sowing dates.

Two recommendations were recommended:

1- If the main objective of the survey is to estimate the crop yield, then the small size plots are better and recommended to use in all types of soils to save time and to save resources.
2- If the objective of the survey is to estimate the plant density then the medium plots size are better in estimation and recommended to be used.

المستخلص

يمثل القطاع التقليديالجزء الاكبر من المساحة المزروعة في السودان ويتصف بوضعه المعقد مما نجمت عنهمشاكل كبيرة فى الاحصاءات الزراعية, تتمثل فتحديد المساحات المزروعة والانتاجية الشئ الذى اثر كثيرا علي جودة ومصداقية المعلومة مما يجعل من الاهمية بمكان الالتفات الي هذا القطاع الهام.

هدفت الدراسة الي دراسة اثر حجم الاحواض في ثلاثة انواع من الترب الزراعية علي تقدير انتاجية الذرة فى القطاع المطري التقليدى. توصلنا الي التقدير باستخدام طريقة قطع المحصول واستخدام العينة الطبقية متعددة المراحل.

البيانات الاولية حصلنا عليها باستخدام ثلاثة احواض مختلفة المساحة وهي تحديدا 5*5 متر, 6*7 متر و10*10 متر في كل نوع من انواع الترب الزراعية الثلاث. اعتبرت القرية كوحدة احصائية اولية والمزرعة كوحدة احصائة ثانية والاحواض كوحدة احصائية ثالثة.

عشرون عينة لكل حجم حوض فى كل نوع من انواع الترب الزراعية وهي التربة الرملية والتربة الطينية الخفيفة والتربة الطينية الثقيلة قد تم استخدامها. وكانت فرضيات البحث كالاتى:

1- هنالك علاقة مباشرة بين الكثافة النباتية وحجم الحوض.
2- هامش الخطا يعكس حجم العينة المطلوب وهنالك علاقة بين مستوى الدقة المطلوب وتكلفةتنفيذ المسح.
3- حجم الحوض لبس له اثر علي الدقة والجودة

تم استخدام جدول تحليل التباين لتحليل اثر حجم الحوض علي تقدير الانتاجية فى القطاع التقليدى. معامل الاختلاف تم استخدامه لمعرفة الاستقرار فى تقدير الانتاجية حسب مساحة الحوض. ايضا تم استخدام طريقة المقارنات المتعددة لتحديد الفروقات المعنوية بين المتوسطات فى كل نوع من انواع الترب الزراعية حسب حجم الحوض وذلك باستخدام البرنامج الاحصائى SPSS.

اظهرت نتائج الدراسة انه لا اثر لحجم الحوضعلي تقدير الانتاجية في الترب الثلاث. لكن هنالك اثر طفيف لحجم الحوض في حالة تقدير الكثافة النباتية. وقد يعود ذلك لابعاد الزراعة وكميات التقاوى للفدان, الرقاعة, الشلخ وتاريخ الزراعة المناسب.

خرج البحث بتوصيتين:

1- لتقدير الانتاجية حجم الحوض الصغير هو الافضل وعلى جميع انواع الترب الزراعية لتوفير الزمن والموارد.
2- لتقدير الكثافة النباتية الافضل استخدام حجم الحوض المتوسط.

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Chapter One

Introduction

1-1 Preface:

Sudan is basically an agriculture-dominated country, where cultivation is usually carried out in three main sectors, namely irrigated sector, mechanized rain-fed sector and traditional rain-fed sector.

The agriculture activities are governed by agro climatic conditions having divergent features spread over the length and broads of the country. Number of food and nonfood crops is sown in different areas of the country depending on climatic conditions and other environmental factors.

2-1 Research problem:

The traditional rain-fed sector cultivation is carried out as a household enterprise and because of its large contribution in the national economy and of the different crops sown in this sector a reliable statistics becomes of a very importance .One of the most important factors for the production used in growing crops, raising livestock or any other farming activity is land. In traditional sector the pattern of land use usually varies by seasons or by different regions of the country. Thus apart from being used in the estimation of agricultural production, accurate data on area used for agricultural purposes is important aspect of agricultural planning.

The total land operated by the holder [i.e. the agricultural holding] is a crucial variable for the analysis of agricultural data. The area of a holding may vary from time to time; a holder may sell or leave part of his holding or may buy or rent from others. Thus the proportion of the holding under crop also varies from season to season or from year to year.

This very complicated situation in traditional sector leads to numbers of problems in agricultural statistics, in respect to area enumeration and poses serious threats to quality and reliability of area estimates

There are three types of errors that may occur if we depend on fieldworker's reports of area cultivated to be used as a frame for sample selection. These errors are:

1- Non-reporting of crops actually grown in the field
2- Reporting of crops not grown.
3- Incorrect reporting of area under crops

3-1 Research Importance:

Agriculture plays a dominant role in the Sudan economyas more than 70% of the populations are engaged directly or indirectly in this activity. Despite its diminishing contributions in the overall exports earnings, after the discovery and export of oil in the late 90s yet agriculture share in GDP still represents about 45%. Such an essential activity needs an efficient information system that provides decision makers, planers, researchers and data users with appropriate, accurate and timely data. The agricultural information system must fulfill the following:-

1- Identify the information required for the most important and public decisions and specify the kinds of information that deserve highest priority.
2- Utilize methods and means of collecting, processing, analyzing, and presenting data that meet reasonable standards of accuracy, coverage and timeliness, while at the same time try to minimize financial and human costs.
3- Have institutional structure which brings users and suppliers of information in a continuous dialogue and which is able to adapt itself to the changing demands of information and modern methodologies for generating it.

Despite the general perception and understanding of the importance of information system by decision maker, politicians, planners, and most categories of data users, but still there is a wide gap between the understanding and adoption and application reality, and in fact the standard of agricultural statistics is even deteriorating in recent years.

4-1 Objectives of the research:

1/is to estimate the average yield per feddan and consequently estimate the total production of sorghum.

2/ is to estimate harvested area depending on response from the selected farmers identifying planted and harvested areas.

3/ the same sample or a sub sample can be used to collect information on cost of the production and marketing of agricultural products.

5-1 Hypothesis of the Study:

1- Relationship between population size and sample size is not directly proportional
2- The margin of error impacts the required sample size and there is a direct correlation between the level of accuracy required and the cost of conducting survey.
3- Increase of plot size has no effect on either the precision or the accuracy.

6-1 The ResearchMethodology:

Attempt which aim at finding and recommending the most accurate and practicable method to be use in traditional sector to:

1- Introducing measures for improvement in the system of data collection relate to timely reporting to reduce the time lag between the completion of sowing and the availability of the estimates of area sown in respect to importance of crops
2- Estimate the area cultivated under different crops to be used as a frame for productive area and yield estimation compare different sizes of plots used in crop-cutting surveys for the estimation of average yield per feddan and recommending the best and most accurate one

The research sampling design for check on area enumeration and crop yield estimation to be use for comparison of different plot sizes are by using crop-cutting as follows:

Stratified three stages random sampling of equal allocation, with three identified strata in the locality [namely loam soil, sandy soil and clay soil] as main domain of research, villages within the stratum as first stage units and survey numbers [household] within villages as second stage units and plots within the farms as the ultimate sampling units, following simple random sampling without replacement.

The analysis is carried out using SPSS packages for the manipulation and statistical analysis of data to get descriptive statistics and inferences of research results.

7-1 The research area of the study:

The study should be carried out in Dilling locality in South Kordofan state. The locality found in the middle of the north part of South Kordofan state. It was characterized by its diversity in soil and crops and considered as traditional cultivation dominated locality, although there are large areas under mechanized rain-fed sector

8-1previous studies:

The previous studies carried out in the Sudan using crop cutting methodology are mainly on the mechanized rain-fed sector and to some extend on the irrigated sector. The design was stratified two stage random sample with uniform sampling fraction (proportionate allocation). The producing centres of the mechanized rain-fed sectors were considered as a domain area of the study and a sampling error of 5% of the average yield was contemplated. For the specified degree of accuracy, it was decided that and after many years of surveys,500 sample size to be conducted in Gedaref, 300sample in Blue Nile, and same in Sennar and White Nile. Blocks were considered as the main strata and section within blocks as sub strata. All the first stage of sampling and number of farms (selection) is selected randomly from each section within each block. This number is proportionate to the size area sown in that section. In this second stage of selection, two plots are randomly selected within each selected farm, the size of plot being 5*5 meters = 1/168 feddans but in the irrigated the plot size being 3x3 meters = 1/667 feddans. The selected plots were harvested, the number of heads recorded, weighted set and dry, threshed and the grain weighted simple weighted averages together variance and sample errors were computed to calculate the average yield per feddan and confidence limits forthe total production expected for each section and block, and accordingly the weighted average together with the maximum and minimum yield expected at the level of the producing center.

9-1 Research Structure:

This study includes five chapters, Chapter one consists the introduction**,** research problem, objective of the study, area of the study, research hypotheses, & research methodology. Chapter two provides an overview of rain-fed traditional sector and historical background of agricultural statistics in the Sudan. Chapter three presents literature review of survey sampling and methods of assessment.Chapter four provides research analysisand results discussion. Chapter five focuses on the findings, conclusion & recommendation of the research.

CHAPTER TWO - Rain-Fed Traditional Sector

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Chapter Two
Rain-fed traditional sector

1-2 Preface:

Sudan is endowed with a diversified natural resources base, both renewable and nonrenewable, including vast agricultural land, water and minerals. Oil and gold mining are both have a limited future because these resources are not renewable. However the use of land for traditional rain-fed crop farming and traditional rain-fed livestock production has also been careless and extractive with obvious damage to the natural resources on which these production systems depend. Like oil and gold, the land and forest resources are in danger of being destroyed and exhausted unless their management is substantially improved.

Economic growth in Sudan has been driven by oil since 1999. Oil accounted for nearly 40% of domestic revenue and 90% of export earnings and 15% of industrial value added. During this period, agriculture has been on a relative decline in terms of its importance to the Sudanese economy dropping from about 46% of GDP in 1997 to around 30% of GDP in 2011, due to the absolute decline of crop production and productivity. However, the negative trend in agriculture contribution has been partially mitigated by improvement in the traditional livestock production (SDTRA).The country soon faced the consequences of depending on unsustainable production system. This was mainly brought about by the secession of the South in 2011 when 75% of the oil earnings was lost, due to oil fields being in the South. This resulted in the loss of 26 % in overall value added, 90% (12.9% of GDP) loss of exports revenues and 6% of GDP loss in total revenues (SDTRA).

In the wake of this worsening economic situation, Sudan was fortunate, that gold revenues relieved some of the pressures on the balance of payments created by the loss of oil revenues and thus averted economic collapse. The sharp increase in gold production accompanied by unprecedented increases in international prices encouraged the government to depend on gold to partially offset the loss of oil revenue. However, by the time Sudan turns to the rain-fed agriculture, assuming the continuity of the present system, natural resources and their productivity may have deteriorated further.

2-2 Traditional Rain-fed Agriculture: The dismal performance of the sector indicates that the contribution of the rain-fed sector is far below its potential. The average growth rate of crops in the sector fell from a solid 24.6 percent in the 1990s to 2.4 percent during the period 2000 to

2008 basically due to lower yields. In general rapid expansion in the areas cultivated was behind the entire growth of output in rain-fed agriculture whenever it happens rather than yields. Yield of sorghum, the major rain-fed crop increased from 248 kg/feddan during 1990/91-2002/2003 to 259 kg/feddan during 2004/2005-2014/2015. The production of sesame, a predominantly rain-fed crop which has been a dominant export crop in the past, has increased dramatically. Its yearly average yield was increasedfrom an average of 73 kg/feddan during 1990/91-2002/2003 to 100 kg /feddan during 2004/2005-2014/2015.

Table (2-1) Area harvested, Production and average yield of Sorghum and Sesame(90/91-2014/2015)

Season	Sorghum			Sesame		
	Havrvested Area	Production	Yield	Havrvested Area	Production	Yield
1990-1991	6570	1176	179	1104	80	72
1991-1992	11109	3581	322	1280	97	76
1992-1993	14761	4042	274	3208	266	83
1993-1994	11152	1990	178	2931	176	60
1994-1995	15303	3648	238	3206	170	53
1995-1996	12007	2480	207	3586	313	87
1996-1997	15603	4089	262	4427	416	94
1997-1998	12646	2871	227	3766	281	75
1998-1999	15024	4143	276	3766	281	75
1999-2000	10780	2347	218	5382	348	65
2000-2001	10008	2491	249	4477	282	63
2001-2002	13683	4394	321	3780	296	78
2002-2003	12667	2825	223	1866	122	65
Period Average	**12409**	**3083**	**248**	**3291**	**241**	**73**
2003-2004	16867	2663	158	3783	401	106
2004-2005	10079	2678	266	3627	277	76
2005-2006	10505	4327	412	4339	400	92
2006-2007	15655	4999	319	2672	242	91
2007-2008	15753	3869	246	3544	350	99
2008-2009	16293	4320	265	2962	317	107
2009-2010	13364	2630	197	3031	248	82
2010-2011	17341	4605	266	3529	363	103
2011/2012	9559	1882	197	1953	187	96
2012/2013	16991	4524	266	5137	562	109
2013/2014	10372	2249	217	1911	205	107
2014/2015	20944	6169	295	6330	721	114
Period Average	**14477**	**3743**	**259**	**3568**	**356**	**100**

Source: Calculated from Department of Agricultural Statistics Data.

The way in which business is conducted under the three major sub sectors of rain-fed agriculture (namely; semi mechanized, traditional and nomadic/transhumant livestock) threatens the existence of the whole rain-fed traditional agriculture. Due to lack of secured land ownership (or long term tradable leases) and inadequate inputs, the current managerial practices that are based on a short term perspective, disregard the social costs of damage to the environment. Traditional farmers expand horizontally by increasing area planted to compensate for the low yields.

The increasing pressure on land resulting from the increasing number of animals and a withdrawal rate less than the ideal rate, and increased demand for land investment; all these factors led to unprecedented pressure for land uses, locked the livestock routes and weakened their development. Moreover, the secession of South Sudan in turn led to the loss of pasture available for grazing space and locked livestock routes. All attempts to open and expand the stock routes have been met with resistance by local and foreign investors and traditional farmers who found themselves prey to land dispossession process that is regularly widening its circle under the auspices of the government.

Semi-mechanized agriculture occupies large parts of the clay plains in the high rainfall savannah belt and has considerably increased from around 8.9 million feddans in 1980-85 to 14.5 million feddans in 2006-2012, extending from Al Fashaga in Eastern Sudan to Southern Kordofan in central Sudan and to South Darfur (Um Ajaj) in the far west. Farm sizes for individuals vary from 500 to 1500 feddan un-demarcated semi-mechanized areas (where land is not surveyed) are more than the demarcated areas (SDTRA). Land is allocated to officials and private investors to produce grains. In this process semi-mechanized farming crowded out traditional small producers, intruded into livestock routes and created conflicts between small traditional farmers, livestock herders and large investors. This production system has left behind millions of feddans of desert. If thispractice continued, then it will only be a matter of time before most parts of the country are turned into a big"Dust Bowl". Annual dust storms (*haboubs*) in Khartoum are advance warnings of the complete destruction of the farming system.The traditional rain-fed agriculture has in the past relied on a relatively more sustainable traditional system of rotation and inter-cropping on farms that are typically about 20 feddans on average. This system started to break down since the early seventies due to pressures from drought, desertification, population increase, introduction of semi-mechanized agriculture, poor and inefficient transfer of technology and low input use and above all lack of incentives associated with the land tenure system. Demographic, political, and technical challenges are now upsetting this balance.

2-3 Traditional sector:

The traditional rain-fed sector is the most important in terms of area cultivated, aggregate production, contribution to food security and livelihood of the rural poor, employment opportunities, provision of raw material to the processing sector and mobilization of the whole economy through its forward and backward linkages. The share of the sector in the country's Gross Domestic Product (GDP) increased on average from 12.5% during the period 1991/92-99/2000 to almost 15% during the period 2000-2008. The sector is the main contributor to the country's non-oil export earnings (livestock, sesame, groundnuts, and Gum Arabic, hibiscus and watermelon seeds). The share of the sector in the total agricultural exports earnings in 2011 was US$550 million representing about 75% (SDTRA).

Western Sudan has 91% of the rain-fed area under cultivation (54 % of total area in Greater Kordofan and 37% in Greater Darfur) and rain-fed production in this region constitutes 81% of total rain-fed output (47% in Greater Kordofan and 33% in Greater Darfur) Livestock is the largest subsector of the Sudanese domestic real economy and is a growing contributor to exports. The great bulk of all livestock production – possibly 90% of the total, – comes from small holders and migratory producers (SDTRA).

Despite this overwhelming importance of the traditional rain-fed sector, and its potential for growth, food security and poverty reduction, insufficient attention has been paid to and treated as a residual sector in terms of supporting policies and budget allocation for development.

2-4 Contribution of the sector to export value

Like most developing countries, Sudan exerts continuous efforts to promote its foreign exchange earnings and to bridge frequent gaps in trade and current account balances. Sector contributions to export earnings gain paramount importance. Export values of the traditional sector have been derived from single commodity export values specific to the sector (including processed vegetable oils) after netting out commodity values that are shared with other sectors (e.g., sesame and groundnuts) in proportion to the amounts produced. Fluctuating as it was, the share of the traditional sector remained relatively high. The sector's trend value can be derived to show a decreasing annual trend of $10.216 million since 2004 (compared to $25.934 million for the agricultural sector). Most of the deterioration in the sector's value of exports in later years is attributable to a weakening in the export values of Gum Arabic, 'karkadeh' and melon seed in addition to fluctuating exports of sorghum and decreasing returns from camel exports. On the other hand, sesame and sheep exports have witnessed discernible improvements. To conclude, although the share of the sector in total agricultural export earnings remained high, it is more or less stagnant and far away from the potential of the sector (SDTRA).

2-5 Traditional Rain-fed Agriculture Subsistence Oriented

Nonetheless it assumes an important role in economic development and poverty reduction in the Sudan, as depicted by the following parameters:

1. Thearea it occupies.
2. The size of the population engaged.
3. Contribution to the food needs of the country.
4. Share in commodity export, and in foreign exchange earnings.

It is extensively practiced in both sandy and clay areas, covering most states of Sudan receiving average annual rainfall within ranges of 300 to 400 mm and it coalesces with other forms of production: livestock raising (sedentary and nomadic), and hashab tapping for (Gum Arabic) production. Farming in the rain-fed traditional sector occupies an estimated 24.5 million feddan (10.3 million hectare), representing slightly less than two thirds of the total cultivated area in the country (SDTRA). The sector is vital to the country's food security and export crops. The sector is the main contributor (57%) in the total area devoted to the five major food crops of sorghum, sesame, millet, groundnuts and wheat (traditional wheat is grown in Jebel Marra). The greater states of Darfur and Kordofan, Blue Nile, Sinnar, and White Nile occupy the most important traditional rain-fed areas. The traditional rain-fed agriculture derives its essence from the many traits describing its existence, as revealed by the following features:

2-6 Performance of the Traditional Rain-fed Sector:

The rapidly growing demand for food products and the recurrent food shortages resulted in a serious food production gap. The situation has been exacerbated by the secession of South Sudan and loss of most of oil earnings. These domestic and international variables have induced policy makers of late to recognize the importance of the sector. The traditional rain-fed farming areas that produce a wide variety of products recorded the largest decline in performance. **2-7Historical background of agricultural statistics in Sudan:-**

Agricultural data collection in the agricultural sector started as early as the beginning of the 20th century, with the establishment of department of agriculture and veterinary services, followed by department of irrigation. The department of statistics evolved as a division in 1903 and developed into department in 1953 & into a central bureau of statistics in the late 80s.

The first agricultural economics and statistics section within the ministry of agriculture was established in 1958. It started with a very limited numbers of officials with economic and agricultural background.

In the early 60s, the division received a technical support in the field of agricultural statistics, and international expert was employed to assist the division to develop and adopt objective methods of data collection, analysis and publication. Theoretical and practical training courses were conducted in area measurement and crop cutting experiments. Sudan in considerate are of the very early countries in Africa and the Arab countries with applied crop cutting experiment to estimate yield of sorghum. The first specialized agricultural statistics bulletin was published 1960/1961, containing information on area, production and average yield of the main crops by centre of production, administrative set up and type of irrigation. Also rain fall data was included in this bulletin. This series of annual bulletins continued till 1969/1970. In 1970/1971, it was substituted by the agricultural your book, which was on the same line as the bulletin, but included more detailed information of the main crops, rainfall and some livestock data,. In mid 80s other publications were issued as the current agricultural statistics bulletin (CAS) and agricultural situation and outlook. These publications were meant to give supplemented information to data included in the yearbook or to bridge the gap between two successive issues of the agricultural yearbook. Since the late 80s and animals the only the publication issued by the admin of agricultural statistics admin is the agricultural statistics and outlook.

The agricultural division was up graded to administration of agricultural economics and statistics, under the umbrella of the general administration of agricultural planning and economics. During the period 1990/1991 the administration received financial and technical support through the agricultural planning and statistics project financial by USAID. The administration benefited from the project in building capacities in form of training at all levels and a formof equipment and transport facilities. Also this period witnessed advanced trials for constructing an area sampling frame.

In 1993, the agricultural statistics got autonomies status as evolved as our independent administration.

On 1996 within the new structural set up in the ministry of agriculture, a general admin of information and statistics was established comprising three administrations, namely agricultural statistics, computer and documentation and agricultural economics. But in 2001, due to the institutional reform undertaken by the ministry of agriculture, the agricultural statistics administration again reformed to the general directorate of planning.

After the implementation of the federal system in Sudan, data collection, analysis and publication was entrusted to the state ministries of agriculture, while the national agricultural schemes(Gezira, Rahad, New Halfa and Suki) were responsible for producing their own agricultural data. The role of agricultural statistics at the federal level was confined to training, technical support, co-ordination and publication of the agricultural data at the country level.

Methods of collecting current agricultural statistics:

As methods of data collection may differ from agricultural sector to another it is better to have an idea about the different agricultural sectors in the country. According to type of irrigation, agriculture in Sudan can be divided into two main sectors:

The irrigated sector:

This sector includes areas irrigated from the River Nile and its attributers by pumps, or gravity or flood even from seasonal streams other than the River Nile. Also areas irrigated by pumps from bore (Mataras) are considered as a part of this sector.

Rain fed sector:

In this sector the source of irrigation is rains. The rain fed sector is further sub divided into mechanized rain fed sector which is categorized by using machinery land preparation and harvest whether fully or partially and also large size of holdings is a category of this sub sector. A sizable portion of the mechanized sector is demarcated into schemes of regular shape of 1000 and 1500feddans.Part of this sub sector is un-demarcated and the size of holding can range from less than 100feddans to a few thousands (up to 5000). The other sub sector is thetraditional rain fed sector. This category includes areas mainly in western and southern Sudan where no machinery is applied and traditional methods of cultivation (agric. tools) are adopted, but besides this, small holdings(roughly up to50feddans) while use machinery in land preparation and partial harvest are considered as part of the traditional sector.

2-8 Methods of collection agricultural data in the irrigated sector:

National schemes:

The national schemes follow a proper crop rotation, where each crop is planted in a separate piece of land known as number with a definite size of feddanage and usually includes tenancies with equal sizes. Also the lay-out of the canalization system facilitates the estimation of planted areas under each crop. Accordingly, the statistics of area planted are accurate and reliable. The estimation of yield is based on sample survey were crop-cutting is conducted, an example is Gazira scheme, the statistics division of the agricultural planning administration carries an annual survey to estimate yields of the main crops (sorghum, wheat, groundnuts and cotton). As the administration is interested to have information at the level of the block, all blocks are included, as the first stage of selection starts at the tenancy level. In scheme, 36 tenancies were selected from each block resulting 3.2% according for the planted area, in a sample size of 40032 tenancies. The sample design adopted is a multi-stage random sample.

In the first stage applying systematic random selection, three canals (Turaa) are selected from each block, representing the start, the middle and the tail of the major canal. In the second stage, from each selected canal three numbers are selected applying simple systematic random selection, also representing the start, the middle and the tail of each number. At the 3rd stage, 3farmers are randomly selected from each selected number, one at the start, one at the middle and one at the tail. At the last stage, 3plots of 2*2 meters are randomly selected at the beginning, the middle and the end of the tenancy. Then the heads are cut dried, threshed and weighted, and the weighted average is calculated to estimate the yield of crop. All the same time paroled estimation which is mainly base on weekly records of the agricultural inspectors is prepared by the agricultural administration. Both estimates are mode available to the top administration. Of the scheme I think so as to avoid duplication and sometimes contradiction, it is better to depend on the objective method adopted by the planning administration and tosupply with more facilities and financial capabilities to improve this job. The other national schemes (Rahad, New Halfa, Suki) are using more or less similar procedures of estimation, but Gezira scheme is more experienced in the aspect and its coverage and persistence is better.

Other irrigated agricultural schemes:

The state ministries of agriculture are responsible for generating the agricultural statistics of the irrigated sector in that state. Although these schemes are having their own agricultural rotation and somewhat similar canalization like the national scheme, but they rarely follow objective method of estimation. The data of area planted and area harvested as fairly good degree of accuracy, and as usually there is a plan for targeted area and a close follow up at area planted and areas to be harvested. An early stage where crops are at maturing stage yields depend on eye estimates, and then refined from acetous records of threshers or combine harvesters at harvest time as crops like sorghum, wheat, broad bean are harvested either fully or partially by combine harvesters or threshers. The accuracy of yield figures in this sub sector can be considered acceptable, as an example we will considered this procedure adopted for collecting agricultural data mainly for food crops in River Nile state. According to the administrative division in the state, they are six localities, at each locality there is an agricultural inspector, assisted by new graduates of agriculture, who are located at administrative unites under the locality. Each locality has an average of about 10basic units. Each assistant inspector is responsible to collect data from their units by interviewing farmers plus his own observations, weekly reports are submitted from each locality from the time land preparation till the time of harvest, giving information about areas, performance of the crop yields and factor affecting the crop type, rain fall, number of irrigation, application of fertilizer, number of weeding, pests, and diseases etc …. At time of harvest, the inspectors try to record the production by following the combine harvester's threshers in the field. The agricultural planning administration within the ministry of agriculture at River Nile state is responsible to prepare a weekly report reflecting the agricultural station at state level.

2-9 Rain- fed mechanized sector:

Estimation of planted area:

The preliminary estimates of area depend to a large exert on the records of the annual renewal of the schemes as the farmers are supposed to pay laud rent before the start ofthe season. This information is supplemented and refined information of rain fall, prices, and information from farmers. Usually in September team from mechanized farms co-operation (MFC) tour all schemes from door to door to estimate the planted area either by interviewing the farmers or the manager of the scheme or by eye estimation by the members of the team. In November and December, depending on the availability of funds and transportation facilities, the teams estimate the areas to be harvested and the expected yield by subjective methods (eye estimation).The federal administration of agricultural statistics of the ministry of agriculture in calibration with state ministries of agriculture used to carry crop cutting surveys to estimate the yield of sorghum. The intensity of coverage and timeliness of these surveys depend considerably on the availability of financial resources. The coverage of the surveys in season05/2006 was the best during the last 15 years as it covered Gedaref, Damazin, S.Kordofan, Sennar, White Nile and Gedaref being the largest area is chosen as an example to explain the sampling procedure of the crop cutting survey.

CHAPTER THREE – Literature review

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Chapter Three

Literature Review

1-3Preface:

Broadly sampling stand for selection of a part of [sample] from some whole [population] observing selected part with respect to some property of interest and then drawing some conclusion [inference]about the whole (**Tore Dalenius 1985**) .

Sampling is used as a mean of attaining knowledge in two ways:

sampling in everyday life:

For example a housewife tastes a spoonful of soup to see the level of salt, a physician draws a few milliliters of blood from a patient to determine the ratio of white cells to red cells and an archaeologist excavates an ancient burial ground to find some objects to form an opinion about the culture which produce these objects.

Statistical sampling:

It is also called scientific sampling. It denotes selection of a sample from some population observing that sample with respect to some property of interest, and making inference about the population, throughout using procedures based on statistical theory.

Statistical sampling is used in different areas, as an examples, experiments and survey sampling. The difference is that, experiment is carried out to measure the effect of treatments, and the study is said to be based on experimental data, while survey sampling is based on observational data as generated by nature. This difference is of decisive importance with respect to the validity of inference.

2-3Survey Sampling:

There is no accepted definition of survey, and hence survey sampling, many definitions of survey is written, but the most two often quoted definitions are:

1- An examination of an aggregate units, usually human beings or economic or social institutions. Strictly speaking perhaps "survey should relate to the whole population under consideration but it is often used to denote a sample survey i.e., an examination of a sample in order to draw conclusions about the whole"

2- "Many research problems require the systematic collection of data from population or samples of populations through the use of personal interviews or other data gathering devices. These studies are usually called Surveys, especially when they are concerned with large or widely dispersed groups of people"

Classes of Survey Populations:

Three classes of populations are identified as objects of survey sampling, the first is the process in the plane, the plane may be total land of a country, and the process may be biological. Secondly, a process in time, the time may be a calendar year, and the process may be births and deaths. Thirdly, a finite set of objects of some kind, such as individuals.

The Necessary Basis for Survey Sampling:

Sampling survey must be measureable and control the uncertainty of the estimates, and sampling survey design must meet certain efficiency conditions; it must accommodate cost-reducing procedure for data collection and control various sources of non-sampling errors. The development of new methods and theory of survey sampling make it feasible to meet the above mentioned conditions.

Bases for planning a Sample Survey:

The decision:

The decision to consider statistical study, there must be a problem or group of problems to the solution of which the study is expected to contribute. Such a problem is called a user's problem, which is to be well understood by the user as well as by statistician who is to be in charge of the statistical study. Once the user's problem has been carefully formulated, the next step is to translate it into a statistical problem, to provide the information the user needs as a basis for tackling the problem. So, the decision is made to plan a sample survey.

The population of interest:

The information needed for tackling the user's problem concern a finite set of individually identifiable objects, which are refer to as elements and a set of elements refer to as a population.

The information of interest:

Sample surveys are used to provide estimate of numerical characteristics describing the population of interest. For each one of several properties, there is specific measurement procedure, which may apply in a uniform manner to all elements in the population. This would generate data, represent by data matrix with one column for each element. The data matrix is typically a conceptual entity, defined with reference to the measurement procedures.

The needed accuracy of the estimate:

The uses to be made of the estimates determined the necessary accuracy of the estimates. $\hat{y}$ is an approximation of $\hat{Y}$. So the users naturally expect, $\hat{y}$ to be a good approximation. Such an approximation must, however be started more precisely. If the users prime consideration is that $\hat{y}$ is sufficiently close to $\hat{Y}$; regardless it is under or over estimate, then the needed accuracy may be then expressed as follows: The error of the estimate must be less than [plus or minus a critical value ά, specified in advance of making the survey. In other hand if the user are concerned about the direction of the error; an under estimate by a certain amount may be more serious than an equally large estimate. Then the needed accuracy may be expressed as above but more detailed.

Criteria for Survey Sampling:

The statistician in search for survey sampling to be adopted uses some means which help to focus on good design. An important class of such means is criteria for survey sampling.

The Measurability Criterion:

Measurability should be a distinct criterion, rather than one to be included in the definition of probability sampling and second in importance to probability selection, add to that the measurability of complex samples need codes for ultimate clusters and strata (**Steven Heeringa& Graham Kalton 2003**).

To provide estimate having the needed accuracy, it must be possible to measure how well the estimates approximate the corresponding parameters. The measure needs not to be exact; it may be in the nature of an approximation. Themeasurability is to be achieved by means of probability sampling; this means that the elements selected for a survey must be selected with known probabilities. This criterion is supplemented by the pre-requite that the design be reasonably self-contained [possible to measure the accuracy on the basis of the survey itself, the design and data] without to resort to strong assumption about the population.

The Efficiency Criterion:

The efficiency calls for a reasoned balance between the accuracy of the estimates aimed at, and the cost of achieving that accuracy. This means that the design should yield estimates of maximum accuracy for a fixed cost or required accuracy at minimum cost.

The Simplicity Criterion:

This Criterion calls for using a design which is simple enough to be carried out in a way faithful to the design.

3-3 Observational Accesses to the Population:

Preparing Sampling Frame:

Efficiency Considerations:

Sample survey means creating some means of getting observational accesses to the population of elements, for short a sampling frame. The data collection would call for observing the sample elements with respect to the properties of interest and possibly also some supervision to assure the accuracy of the data collected. This would be prohibitively inefficient on grounds of the cost of creating the frame and the cost of data collection.

The cost of preparing a sampling frame:

Instead of preparing a list of the N individual elements of the population O we may prepare a list of M identifiable units of some other, to be denoted by:

$[U_I | I = 1\dots M] = [U_{1\dots} U_{I\dots} U_M]$ ………….. [1-3]

Where M< N, M = N or M > N, as the case may be. When there is no need to specify the individual units, we will denote this set by (U), in analogy with use of (O) to denote the population of elements. (U) must be such that there is association between the M units in (U) and the N elements in (O). It is this association which provides the observational access to (O) through (U); a sample of elements may be selected from (O) by selecting a sample of units from (U). Hence these units will be referred to as sampling units and (U) will be referred to as a sampling frame. The cost of preparing (U) may be muchsmaller than the cost of making a list of elements in (O). We will denote the cost of preparing (U) by $C_{U.}$

The cost of data collection:

This cost will reflect the spatial distribution of the elements selected for the survey; and this in turn depend on the spatial distribution of the sampling units selected: if the elements selected are scattered over a large area, the cost of field work will be higher than if the elements are located in a possibly small number of administrative units. We will denote the cost of data collection by $C_{D.}$

General function:

The general cost function for getting observational access to the population suggested as follow:

$$C = C_U + C_D \ldots\ldots\ldots\ldots [2\text{-}3]$$

This simple cost function plays a key role in the choice of sampling system.

Four basic rules of association:

To present the four rules of association we will consider the following situation. Thus there is a population of N elements: $(O) = (O_1 \ldots O_{J\ldots} O_{N)},$ and a frame with M sampling units: $(U) = (U_{1\ldots} U_{I\ldots} U_M)$.

Basic rule No. 1:One-to-One:

Each unit in (U) is associated with one and only one element in (O) and every element in (O) is associated with one and only one unit in (U); hence M = N.

Rule No.1 may be symbolized by: $U_J \Longrightarrow O_{J,}$ $J = 1 \ldots N$.

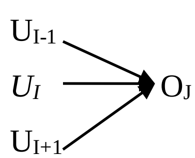
Example: The population of elements consists of all inhabitants in a country. (U) is a list of these inhabitants, say population register.

Basic rule No. 2: Many-to-One:

Each unit in (U) is associated with one and only one element in (O), but an element in (O) may be associated with more than one unit in (U). In this case we denote the frame by:

$$(U) = (U_{1\ldots} U_I \ldots U_M) \text{ with } M>N$$

Rule No. 2 may be symbolized by:



I = 1... M

The rule implies that the O_J is selected if U_{I-1} or U_I or U_{I+1} is selected.

Example: The population of elements consists of all households in a city and (U) is a list of all members of these households.

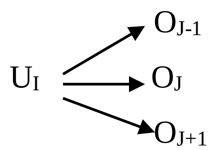
Basic rule No. 3 One-to-Many:

Each unit in (U) is associated with several elements in (O); no element is associated with more than one unit in (U).

The frame is denoted by (U) = ($U_1 \ldots U_I \ldots U_M$), With M < N.

The units in (U) are typically referred to a cluster. The i^{th} unit is a cluster of N_I elements, I =1..M

Rule No. 3 may be symbolized by:

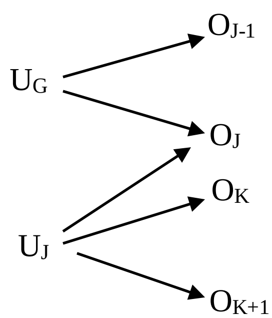


, Where one unit is associated with a cluster comprising three elements.

Example: Population of elements consists of all frames in a country, while (U) is a list of administrative units, into which the country is divided.

Basic rule No, 4: Many-to-Many:

This rule – the basis for network sampling, may be symbolized by:



We will not elaborate on this rule; it is merely presented here for making the list of rules complete.

An Important distinction:

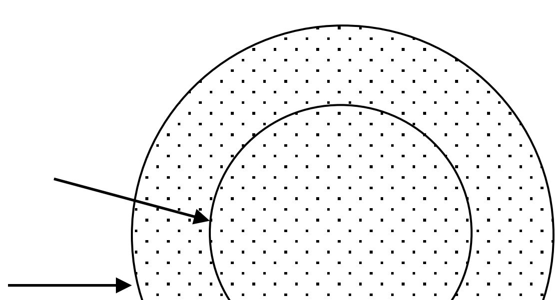
As a preliminary to the discussion of important and desirable properties of frame, we will introduce the distinction between the target population of elements and the sampled population of elements.

The target population:

This is the population of elements which we want to investigate by means of a sample survey. It may be symbolized by $(O)_{T.}$

The sampled population:

This is a population of elements, to which we have observational access by means of frame. It may be symbolized $(O)_{S.}$



Sampled population

Target population

It is important to realize that the sampled population often is not identical with the target population as shown in the above figure.

4-3Important and desirable properties of a frame:

The frame construction must be tackled in a way that reflects the survey situation with respect to the following aspects:

1: The kind of population of elements.

2: The geographic distribution of the target population.

3: The survey operation to be carried out, and notably the data collection.

In order to arrive at a good solution to the problem of frame construction, it is helpful to consider the technical properties in term of which alternative frames may be assessed. These properties cover important properties and desirable properties.

Important properties:

1: The frame must make it possible to compute estimates concerning a population of elements (complete).

2: The frame must serve to yield a sample of elements, which can be unambiguously identified.

3: The frame must be such that it is impossible to determine how the units in the frame are associated with the elements in the (sampled) population.

Desirable properties:

1: The frame should be simple to use.

2: The frame must be organized in a systematic fashion, as an example, units in (U) may be ordered by geography or size.

3: The frame includes auxiliary information.

4: The frame should be reasonable stable in time.

Techniques for frame construction:

There are two types of fames to be considered, list frame (directory type) and lists in the form of processed maps (map type).For directory type the general format is a list, and for the map type the general format is a map of some area which has been divided into (non-overlapping) smaller areas, which serve as sampling units.

Three special problems are to be considered:

1: The problem of multiple lists, this problem arises when there are two lists of elements; the rule of association is one-to-one in both cases. Some elements are on both lists; other elements, however, are on only one of the lists. The fact that some elements may be accessed by means of both lists is a problem which has to be addressed. Three options are to be considered, first one calls for eliminating from one of the list those elements which are on the other list. The second option calls for select samples independently from list number one and list number two. Then delete from the sample from list number two any element, which is also a member of list number one. The last and the third option calls for selection of two independent samples one from each list. When computing estimates, we must take into account that some elements in the population have probabilities of being selected which reflect this situation.

2: The problem of empty units, this problem occur when there is one or more units in (U), not associated with an element in (O). The population of elements may be the families in a city as of today. (U) is a list of dwelling units in that city. For some of the dwelling units in (U), it holds true that no elements are associated with them; we will say that these units are empty.

3: The problem of incomplete lists, for some populations, a list of the elements may be available, but this list is incomplete; it does not comprise all elements in the population.

Survey Sampling:

Survey sampling is the process of selecting a probability-based sample from a finite population according to a sample design. You then collect data from these selected units and use them to estimate characteristics of the entire population.

A *sample design* encompasses the rules and operations by which you select sampling units from the population and the computation of sample statistics, which are estimates of the population values of interest. The drawing of random samples cannotbe left to subjective discretion but must be the result of objective and preferable mathematical methods (**Robert G.**

D. Steel & James H. Torrie 1981).The objective of your survey often determines appropriate sample designs and valid data collection methodology. A complex sample design often includes stratification, clustering, multiple stages of selection, and unequal weighting. There are two types of sampling are to be distinguished, the probability sampling and non-probability sampling.
A probability sampling is one in which every unit in the population has a chance (greater than zero) of being selected in the sample, and this probability can be accurately determined. The combination of these traits makes it possible to produce unbiased estimates of population totals, by weighting sampled units according to their probability of selection.

Non-probability sampling is any sampling method where some elements of the population have *no* chance of selection (these are sometimes referred to as 'out of coverage'/ 'under covered'), or where the probability of selection can't be accurately determined. It involves the selection of elements based on assumptions regarding the population of interest, which forms the criteria for selection. Hence, because the selection of elements is nonrandom, non-probability sampling does not allow the estimation of sampling errors.

Sampling Systems:

There are three basic systems, which are element sampling, cluster sampling and multi-stage sampling. In specific application, one of these systems or possibly a combination of them will be chosen as the sampling system on the basis of the kind of efficiency considerations.

Element sampling:

This term denotes sampling from a frame (U) which is associated with the population of elements (O) according to basic rule No. 1: one-to-one and basic rule No. 2: many-to-one. Under element sampling come simple random sampling, stratified sampling and sampling with unequal probabilities of selection.

5-3Simple Random Sampling:

Simple random sampling is a method of selecting n units out of N such that every one of the ${}_{N}C_{n}$ distinct samples has an equal chance of being drawn (**William G. Cochran 1977**). The theory dates back more than a century. It plays a minor role in applications. The reason for its nonetheless prominent place in account of theory of survey sampling is that SRS allows a simple, yet informative discussion of some important topics. The rule of association is one-to-one. With each element we associate Y-,X-,and A- data. A number of parameter is to be defining for these data, expressed in term of the Y-, X- and A- data, respectively.

Y- parameters:

The mean per element, we write as:

The total we w

$$\hat{Y} = \frac{1}{N} \sum Y_J \qquad \ldots\ldots\ldots\ldots\ldots [3\text{-}3]$$

The population variance among the Y - data is:

$$\sigma^2 = \frac{1}{N} \sum (Y_J - \hat{Y})^2 \qquad \ldots\ldots\ldots [4\text{-}3]$$

Simple random sampling is g schemes, namely sampling without replacement and sampling with replacement.

SRS without replacement:

The sample is selected at random from (U) in n consecutive draws: At the first draw, each element has a probability 1/N of being selected. The element is not replaced into (U). In the second draw each remaining element has a probability 1/ (N-1) of being selected. Again, the element is not replaced into (U). This procedure is continued until n elements have been selected. The outcome is a sample of n distinct elements which may be represented by:

$$\{O_j \mid j = 1 \ldots n\} = \{O_{1 \ldots}\, O_{j \ldots}\, O_n\}$$

The use of lower case ,j, for the index signifies that $O_j$is the jth element selected for the sample, to be distinguished from O_J which is the Jth element in the population. The corresponding different combinations of n elements out of N, is:

$$C_n^N = \frac{N!}{(N-n)!\,n!} \quad \ldots\ldots\ldots.. [5-3]$$

Each of these C_n^N samples has thesame probability $\mathbf{1}/C_n^N$ of being selected**.** This mechanism is obliviouslynot practical**.** Two alternative mechanisms of practical interest are to be identified (**Tore Dalenius 1985**) .

Alternative mechanism No.1: This makes use of a table of random numbers for selecting n elements from a population of N elements.

Alternative mechanism No. 2: If the population of elements is ordered at random (thoroughly mixed) a random sample of n elements may be selected by:

I: Selecting the n first elements in the sequence.

II: Selecting every Kth element from a random start, this is properly referred to as systematic sampling.

SRS with replacement:

In this case, n draws are made from (U); after each draw, and hence before the next draw; the selected element is replaced into (U). The sampling may make use of a table of random numbers.

The Estimation of Sample Size:

In planning of a sample survey a decision must be made about the size of the sample. The decision is important. Too large a sample implies a waste of resources, and too small a sample diminishes the utility of the results. The decision cannot always be made satisfactory; often we do not possess enough information to be sure that our choices of sample size are the best one. Sampling theory provides a framework within which to think intelligently about the problem. We cannot absolutely guarantee accuracy within 5% except by measuring everyone. To make a rough of n the fpc (finite population correction) is ignored, and the sample percentage p is assumed to be normally distributed. In technical terms, p is to lie in the range (P ± 5), except for a 1 in20 chance. Since p is assumed normally distributed about P, it will lie in the range (P ± $2\sigma_p$), apart from a 1 in 20 chance. Furthermore,

$$\sigma_p = \sqrt{PQ/n} \quad \ldots\ldots..[6-3]$$

Hence, we may put $2\sqrt{PQ/n} = 5$ or $n = \frac{4PQ}{25}$ ………. [7 − 3]

At this point a difficulty appears that is common to all problems in the estimation of sample size. A formula for n has been obtained, but n depends on some property of the population that is to be sampled (**William G. Cochran 1977**).

6-3 Stratified Sampling:

In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratification is the process of dividing members of the population into homogeneous subgroups before sampling. These subpopulations are non-over-lapping, and together they comprise the whole of the population, so that

$N_1 + N_2 + \ldots + N_L = N$. …… [8-3] (**William G. Cochran 1977**).

The strata should be mutually exclusive: every element in the population must be assigned to only one stratum. The strata should also be collectively exhaustive: no population element can be excluded.

So, we can say stratified sampling is another example of a classical sampling scheme and the theory was developed almost a century ago. Stratified poses four design problems:

1: Stratification variables.

2: The number L of strata.

3: The mode of stratification that is how to group the elements into the L strata.

4: The sample sizes in the strata that is the sample allocation problem.

Due to the importance of the sample allocation problem, the focus will be on this problem.

The stratified sample allocation problem:

The population of N elements, (O), is grouped into L mutually exclusive subpopulations, called strata with N_H elements in the Hth stratum, H = 1…..L. For each stratum, there is a stratum frame (U_H), the units of which are the elements; hence the rule of association is one-to-one.

The population mean per element is:

$$\bar{Y} = \frac{1}{N}\sum_{H}\sum_{J} Y_{HJ} = \frac{1}{N}\sum_{H} N_H \bar{Y}_{H=} \sum_{H} W_H \bar{Y}_H \quad \dots\dots..[9-3]$$

Where $W_H = N_H/N$.

The population variance is:

$$\sigma_Y^2 = \frac{1}{N}\sum_{H}\sum_{J}(Y_{HJ} - \bar{Y})^2 = \frac{1}{N}\sum_{H}\sum_{J} Y_{HJ} - \bar{Y}_H + \bar{Y}_H - \bar{Y})^2 \quad \dots\dots..[10-3]$$

$$= \frac{1}{N}\sum_{H} N_H . \frac{1}{N_H}\sum_{J}(Y_{HJ} - \bar{Y})^2 + \frac{1}{N}\sum_{H} N_H\,(\bar{Y}_H - \bar{Y})^2 \quad \dots\dots\dots[11-3]$$

$$= \quad \sum_H W_H \sigma_{HY}^2 \; + \; \sum_H W_H (\bar{Y}_H - \; \bar{Y})^2 \quad \dots\dots..[12-3]$$

= Within stratum variance + between stratum variance

There are two assumptions in discussing the theory of different sample allocations.

Assumption one: The sample selection from each stratum is carried out by SRS. Both sampling with replacement and without replacement are to be considered.

Assumption two: The sample selection from any stratum is independent of that from any other stratum. This will allow us to apply simple theory for linear combination of estimator for the different strata.

Stratified sampling theory:

In stratification sampling there are special theories adopted in sampling.

Proportional allocation: This theory calls for making n_H proportional to N_H. This may be written as:

$$n_H = \frac{N_H}{N} n = W_H n \quad \text{………} [13\text{-}3]$$

The sample is representative of the population, in the sense that

$n_H/n = N_H/N$ ……… [14-3]

For proportional allocation the estimator:

$$\bar{Y} = \sum_H W_H \bar{Y}_H \quad \text{……….} [15\text{-}3]$$

Simplifies to:

$$\bar{Y} = \frac{1}{n} \sum_H \sum_j Y_H \ldots \ldots [16-3].$$

This means the sample is self weighted

For sampling without replacement:

$$\sigma^2(\bar{Y}) = \sum_H W_H^2 \, \sigma^2(\bar{Y}_H) \quad \text{……….} [17\text{-}3]$$

Becomes:

$$\sigma^2(\bar{Y}) = \sum_H W_H^2 \frac{N_H - n_H}{N_H - 1} \cdot \frac{1}{W_H} \sigma_{HY}^2 \ldots \ldots \ldots . [18-3]$$

$$\sigma^2(\bar{Y}) = \frac{1}{n} \sum_H W_H \frac{N_H - n_H}{N_H - 1} \cdot \sigma_{HY}^2 \ldots \ldots \ldots [19-3]$$

While for sampling replacement the variance becomes:

$$\sigma^2(\bar{Y}) = \sum_H W_H^2 \cdot \frac{1}{W_H n} \sigma_{HY}^2 \quad \text{………..} [20\text{-}3]$$

$$\sigma^2(\bar{Y}) = \frac{1}{n} \sum_H W_H \sigma_{HY}^2 \quad \text{………} [21\text{-}3]$$

When comparing this variance with the variance when using SRS with replacement from a population which is not stratified, in that case:

$$\bar{Y} = \frac{1}{n} \sum_j Y_j \quad \text{…….} [22\text{-}3]$$

Has the variance:

$\text{Var}\bar{Y} = \frac{1}{n} \sigma_Y^2$ ……….. [23-3]

Which, if σ_Y^2 is expressed as in above, becomes:

$$\text{Var. } \bar{Y} = \frac{1}{n} \left[\sum_H W_H \sigma_{HY}^2 + \sum_H W_H (\bar{Y}_H - \bar{Y})^2 \right] \quad \text{………..} [24\text{-}3]$$

This expression shows that the gain (= reduction of variance) from using stratified sampling with proportional allocation is:

$$G = \frac{1}{n}\sum_{H} W_H(\bar{Y}_H - \bar{Y})^2 \dots\dots\dots[25-3]$$

In general, G> 0; G would be zero, if all stratum means $(\bar{Y}_H)$ were equal.

Optimum allocation:

Optimum allocation is used for two different but related ways of allocation, namely minimum variance allocation and optimum allocation proper. Here are present for the case of sampling with replacement, and estimating $(\bar{Y})$ by:

$$\bar{y} = \sum_{H} W_H \bar{y}_H \dots\dots[26-3]$$

Minimum variance allocation:

Gains from using stratified sampling may be especially large if large sampling fractions $n_H/n = N_H/N$ are used in strata with large stratum variances, and small sampling fractions are used in strata with small stratum variances. If n_H is made proportional to the product of W_H and σ_{HY}

The variance $\sigma^2(\bar{y})$ becomes a minimum for a fixed sample size; the variance is:

$$\sigma^2(\bar{y}) = \frac{1}{n}[\sum_H W_H \sigma_{HY}]\dots\dots\dots [27\text{-}3]$$

While the sample is not self-weighted and hence not "representative", the estimator $(\bar{y})$ yields a more representative estimate than proportional allocation. The gain from using minimum variance allocation is especially large, when sampling from highly skewed populations, that is populations which comprise a small number of elements which contribute heavily to the total T_Y, and hence a heavy impact on$(\bar{Y})$.

Optimum allocation proper:

This allocation takes into account three quantities: W_H, σ_{HY} and the cost C_H of collecting the data. Assuming the following simple cost function:

$$C = \sum_H C_H n_H \dots\dots [28\text{-}3]$$

Where C_H is the cost per element included in the sample from the Hth stratum, and assuming the total cost of collecting the data is fixed to be C_0. Then the optimum allocation proper calls for making

$$n_H \sim \frac{W_H \sigma_H}{\sqrt{C_H}} \quad …….. [29\text{-}3]$$

Which is allocation minimizes the variance$\sigma^2(\bar{y})$.

Probabilities of selection:

While for SRS and also for stratified sampling using proportional allocation, every element in the population has the same probability of being selected for the sample, this does not hold true for stratified sampling using minimum variance allocation(except for the case where $\sigma_{IY} = \dots = \sigma_{HY} = \dots = \sigma_{LY}$) nor for stratified sampling using optimum allocation proper (except for the case where $\sigma_{IY} = \dots = \sigma_{HY} = \dots = \sigma_{LY}$ and CI = …… = C_H = …… = C_L). The probabilities of being selected for the sample differ between the strata: there are typically L classes of probabilities of selection, which are unequal among themselves.

Post-stratified sampling:

There is stratum frame for stratum (U_H). If this condition is not justified, but the stratum sizes $W_{H,}$ H = 1……L, are known the following approach may be considered;

- A sample is selected by simple random sampling without replacement.

- These elements are observed with respect to the Y-property and also their respective stratum affiliations; assuming that the number of elements selected from the Hth stratum is $n_H > 0$ – if no element has been selected from the some stratum, this stratum is merged with an adjacent stratum;

- For each stratum, $\bar{Y}_H$ is estimated by $\bar{y}_H$.

- Finally, $(\bar{Y})$ is estimated by:

$$\bar{y} = \sum_H W_H \bar{y}_H \quad …….. [30\text{-}3]$$

In situations where stratified sampling with proportional allocation performs well, post- stratified sampling may be expected to perform better.

Two- phase sampling:

The use of two-phase sampling for the purpose of using stratified in a situation where there is no stratification information available about the elements, prior to sample selection.

Phase No. 1: A large sample of elements is selected and observed with respect Z, stratification variable. The selected elements are grouped into L strata. The sizes of these strata are estimated by $W_{H,}$ H = 1…….L.

Phase No. 2: these calls for selecting samples from each stratum and collecting the Y-data

Finally, $(\bar{Y})$ is estimated by:

$$\hat{y} = \sum_{H} W_H \bar{y}_H \quad \ldots\ldots [31-3]$$

Where$\bar{y}_H$, H = 1……. L, is based on the second-phase sample.

Two phase sampling for stratification is efficient in a situation, where the cost of collecting the Z-data is low, and at the same time, the gain from using stratified sampling is large.

Cut-off sampling:

Cut-off sampling is occasionally used to estimate a total T_Y for a markedlyskew population.

The choice of stratification variables:

The elements in (O) are to be grouped into strata on the basis of the values of a specific stratification variable Z, to distinguish it from the estimation variables Y and X. If one set is comprised by qualitative data and the other set by quantitative data, it is advantageous to use the qualitative data for stratification and the quantitative data for estimation.

The number L of strata:

The variance $Var_L(\bar{y})$ when using L strata, may be expected to be smaller than the variance $Var_{L-1}(\bar{y})$ when using L-1 strata.

The gain from increasing the number of strata from L-1 to L will in practice, be a decreasing function of L in the context of element sampling. A few well chosen strata will produce a gain close to the maximum gain possible

The mode of stratification:

For the stratification variable Z, the range of Z has to be partitioned into L intervals (strata) by points:

$Z_0 < Z_1 < \ldots\ldots < Z_H < \ldots\ldots < L-1 < L$, no Z-value is larger than Z_L

The strata should be internally homogeneous as possible: the within strata variances should be small.

Sampling with unequal probabilities of selection:

The idea here is the same as in stratified sampling using optimum allocation; the probabilities of selection are unequal to all N elements. For population of N elements ((O) = $(O_{1,\ldots,}O_{J,}\ldots,O_N)$) and a frame of (U), the rule of association is One-to-One. With these elements we associate Y- and n-values which are subject to the following conditions in preparation for developing the sample selection plan:

$O < n_J < 1$

And

$\sum_J n_J = 1$ ………. [32-3]

These n-values will serve as the basis of sampling schemes.

The sampling scheme calls for making n draws with replacement, using the n-values as the probabilities of selection. The procedure of making a draw may use a table with cumulative n-values and a table of random numbers.

7-3 Cluster Sampling:

There are two main reasons for application of cluster sampling, first no reliable list of elements in the population is available and that it would be expensive to construct such a list. Secondly there are no complete and up-to-date lists (**William G. Cochran 1977**).

Cluster of Unequal sizes:

Cluster comprises different numbers of elements. For a frame (U), the units of which are clusters; the rule of association is One-to-Many. The clusters may be compact, that is clusters are made up of contiguous elements, as an example a block in a city, the elements being households residing there; or non-compact, that is cluster made up of non-contiguous elements, as an example the elements numbered 1, 12, 21, ….. in a list of elements, such as a directory of retail stores.

The population and the parameters:

The population (O) of elements is grouped into M clusters, the set of which constitutes the frame:

$$(U) = (U_{1,\ldots,}U_{I,\ldots\ldots,}\ U_M).$$

The different elements in each M reflect the fact that the clusters are of unequal sizes. The cluster totals:

$$T_{1,\ldots,}T_{I,\ldots\ldots,}\ T_M$$

Where

$T_I = \sum_J Y_{IJ}$ ………… [33-3]

The overall total:

$T = \sum_I Y_I$ ……… [34-3]

The mean of the cluster totals:

$\overline{T} = \frac{1}{M}\sum_I T_I$ ……….. [35-3]

The mean number of elements per cluster:

$\overline{N} = \frac{1}{M}\sum_I N_I$ ……… [36-3]

The means per element within clusters:

$$\overline{Y_1}, \dots, \overline{Y_I} \dots., \overline{Y_M} \quad \dots\dots.. [37-3]$$

Where $\overline{Y_I}$ = T_I/N_I ……. [38-3]

The overall mean per element:

$$\overline{Y} = \frac{T}{N} = \frac{1}{N}\sum_I T_I = \frac{1}{N}M\overline{T} \quad \text{……… [39-3]}$$

The population variance:

$$\sigma_Y^2 = \frac{1}{N}\sum_I\sum_J(Y_{IJ} - \overline{Y}_I)^2 + \frac{1}{N}\sum_I N_I(\overline{Y}_I - \overline{Y})^2 \quad \text{……….. [40-3]}$$

The expression for the population variance is equivalent with the corresponding expression for stratified population:

$$\sigma_Y^2 = \frac{1}{N}\sum_H N_H \cdot \frac{1}{N_H}\sum_J(Y_{HJ} - \overline{Y}_H)^2 + \frac{1}{N}\sum_H N_H(\overline{Y}_H - \overline{Y})^2 \quad \text{……. [41-3]}$$

= within stratum variance + between stratum variance.

A sample of m < M clusters is selected by means of SRS without replacement.

Estimation of $(\bar{y})$:

Two estimator of overall mean per element to be consider:

$\overline{Y} = \frac{T}{N} = \frac{1}{N}\sum_I T_I = \frac{1}{N}M\overline{T}$ ….. [42-3]

Estimator No. 1: This estimator is of the following type:

$\overline{Y} = \frac{1}{N}$(Estimator of T = $M\overline{T}$) …. [43-3]

$$= \frac{1}{N} \cdot M \cdot \frac{1}{m}\sum_i T_i \quad \text{……. [44-3]}$$

The variance of $(\bar{y})$ is

Var$(\bar{y})$ = Var $\{\frac{1}{N} \cdot M \cdot \frac{1}{m}\sum_i T_i\}$ …….. [45-3]

which can be written as:

$var\overline{Y} = \frac{M-m}{M-1}\frac{1}{m}\frac{1}{M}\sum_I\left[\frac{N_1}{\overline{N}}\overline{Y}_I - \overline{Y}\right]^2$ [46-3]

The variance may be large. This occurs when the sizes of clusters vary greatly, and hence the factors $N_I/\bar{N}$ by which $\bar{Y}_I$ is multiplied vary greatly.

Estimator No. 2: This estimator which calls for estimating both T = $M\bar{T}$ and N.

$\overline{Y_r} = \frac{estimator\ of\ T}{estimator\ of N} = \frac{M.\frac{1}{m}\Sigma_i T_i}{M.\frac{1}{m}\Sigma_i N_i}$ ………… [47-3]

which simplified to:

$\overline{Y_r} = \frac{\Sigma_i T_i}{\Sigma_i N_i}$ ………. [48-3]

This is a ratio-type estimator, both the numerator and the denominator is a random variable. Hence, in general, the $(\bar{y})$ is biased, but if the correlation between the cluster totals and their sizes is positive, the bias may be negligible.

The variance of $(\bar{y})$ is approximately:

$$var\bar{Y}_r = \frac{M-m}{M-1}\frac{1}{m}\frac{1}{M}\sum_I(N_H/\bar{N})^2\,(\bar{Y}_1\,.\bar{Y})^2 \text{ …… [49-3]}$$

Clusters of Equal sizes:

In this case all the clusters are of the same size:

$$N_{1} = \ldots\ldots = N_I \ldots\ldots = N_M = N_0.$$

Hence N = MN_0. The cluster may be compact or non-compact.

The population and the Parameters:

The population (O) of elements is grouped into M clusters, the set of which constitutes the frame:

$$(U) = (U_{1,\ldots,}U_{I,\ldots,}U_M). \text{ …….. [50-3]}$$

The clusters have the same number of elements

The means per element within clusters:

$$\overline{Y_1}, \ldots, \overline{Y_I} \ldots., \overline{Y_M}$$

Where:

$\overline{Y_I} = T_I/N_0$. ………. [51-3]

The overall mean per element:

$\bar{Y} = \frac{T}{N} = \frac{1}{N}\Sigma_I T_I = \frac{1}{N}M\bar{T}$ ………… [52-3]

The population variance:

$$\sigma_Y^2 = \frac{1}{N}\Sigma_I\Sigma_J\left(Y_{IJ} - \bar{Y}_I\right)^2 + \frac{1}{N}\Sigma_I N_I\left(\bar{Y}_I - \bar{Y}\right)^2 \text{ …….. [53-3]}$$

A sample of m < M clusters is selected by means of SRS without replacement, just as in that of unequal sizes.

Estimation of $(\bar{y})$: We consider the two estimators presented in clusters of unqual sizes.

Estimator No. 1:

$$\bar{y} = \frac{1}{N_0}\frac{1}{m}\sum_i T_i \quad \text{………} \ [54\text{-}3]$$

Estimator No. 2: $\bar{y} = \frac{M.\frac{1}{m}\sum_i T_i}{M.\frac{1}{m}.\ m.N_0}$ ……..... [55-3]

$$\bar{y} = \frac{1}{N_0}\frac{1}{m}\sum_i T_i \quad \text{……..} \ [56\text{-}3]$$

This is identical with estimator No. 1.

$$var\bar{Y} = \frac{M-m}{M-1}\frac{1}{m}\frac{1}{M}\sum_I[\bar{y}_I - \bar{Y}]^2 \quad \text{…….} \ [57\text{-}3]$$

Which is written as

$$var\bar{Y} = \frac{M-m}{M-1}\frac{1}{m}\sigma^2_{B_0} \quad \text{…………} \ [58\text{-}3]$$

8-3Systematic Sampling:

The systematic sampling is scheme for element sampling, in which we selecting every kth element. In other hand the systematic sampling is regard as special case of cluster sampling. The selection of m = 1 cluster from a set of M clusters of equal size (**Tore Dalenius 1985**).

The Population and Parameters:

The population and parameters will be identical with those of the clusters of equal sizes. We assume that M = k, as used in every kth element.

The sampling scheme:

The sampling is done as follows:

1- One of the cluster is selected at random
2- This selected cluster identifies the starting element in the first of the N_0 rows.
3- The sample is composed of the starting elements and every kth following element.

Estimation of $(\bar{y})$:

$\bar{y} = \frac{1}{N_0}\frac{1}{m}\sum_i T_i$ ……. [59-3]

In the cluster of equal sizes becomes

$\bar{y} = \frac{1}{N_0}T_s = \frac{1}{N_0}\sum_J Y_{sJ}$ …….. [60-3]

And the variance

$$var\bar{Y} = \frac{M-m}{M-1}\frac{1}{m}\frac{1}{M}\sum_I[\bar{y}_I - \bar{Y}^{-}]^2 \quad \text{.......... [61-3]}$$

$var\bar{Y} = \frac{M-m}{M-1}\frac{1}{m}\sigma^2_{B_0}$ .... [62-3]

becomes

$$var\bar{Y} = \sigma^2_{B_0} \quad \text{......... [63-3]}$$

In terms of intra-class correlation$\S_0$, this variance is written as:

$$var\bar{Y} = \frac{\sigma^2_Y}{N_0}\ (1 + \S_0(N_0\ - 1) \quad \text{......... [64-3]}$$

F_1 x F_2

Where: $F_1 = \frac{\sigma^2_Y}{N_0}$ is the variance of SRS (with replacement) of N_0 elements, and F_2 is the factor reflecting the impact of cluster sampling.

Characteristics of Systematic Sampling:

Systematic sampling has certain characteristics, which make attractive for applications:

1- Simple to execute the sampling scheme.
2- Simple to check that the execution is faithful to the plan.
3- It describes the sample of elements evenly over the population, which leads to favorable effect on the accuracy of the estimates.

For these characteristics, systematic sampling has become widely used in sample surveys. And often used as a selection mechanism in a framework such as stratified sampling.

9-3Estimating the variance:

The sample that comprises m = 1 cluster means that it is impossible to estimate the variance on the basis of the data collected. One way to address the problem is to use replications. Thus rather than using one starting element and the skipping interval 1/k, r starting elements are used in combination with the skipping interval 1/rk; this scheme referred to as the Tuckey plan (**Tore Dalenius 1985**). The mean $(\bar{y})$ per element would then be estimated by the pooledestimator

$\bar{y} = \frac{1}{r}\sum_i \bar{y}_i$ .... [65-3]

i = 1 ……, r, and variance $(\bar{y})$ would be estimated by:

$\bar{y} = \frac{1}{r}\frac{1}{r-1}\sum_i(\bar{y}_i - \bar{y})^2$ …….. [66-3]

10-3Non-sampling Error:

It is sources of error other than the use of sampling will operate. In principle every operation of a survey is a potential source of non-sampling error. These errors can be grouped into three major categories as follows:

1- Error due to non-response.

2- Measurement errors.

3- Processing errors.

For two different reasons, non-sampling errors represent problems which have to be addressed in the design and analysis of a survey.

1-Non-sampling errors may account for a major part of the total error in a survey, sometimes much more than the sampling error.

2-It is difficult to measure the error of a survey in the presence of a large contribution from non-sampling errors.

Special steps have to be taken to address the problems that non-sampling errors pose. Using sample survey rather than a total survey make it feasible to use measurement, since results of sample survey may be more valuable to the users than the results of a total survey. The size of a survey is of importance for a second reason. Thus if the size is small it may easier to control the sources of non-sampling error than if the size is large.

11-3Agricultural Surveys:

Under the estimation theory title a doctrinal body is collected which treats to solve a problem with very simple formulation given a set of observations from reality to guess the value a magnitude has taken is under consideration departing from those observations. Obliviously we have got no access to that magnitude but it has some functional relationship with the obtained observation.

If the obtained observation taken from reality have not got any degree of uncertainty , the unknown magnitude would be determined without no error from solving , in favor of that magnitude , the functional relationship mentioned before hard .as many times as the experiment being repeated ,us many time the some value would be obtained , However , the nature do not behave like that ,let repeat any measurement of any magnitude several time and surely different values will be obtained .The functions shall be with higher or lower amplitude depending on the random factors which affect the problem, and thus averaging all those measurements , fluctuation will decrease as the number of averaged measurements increase .

12-3Measurement of estimator quality:-

An estimator is a function of the observations, what gives rise that the estimator results in a random available, for that reason, the estimator quality can only are given in probabilistic terms.

The quality criticism commonly adopted for a parameter estimator is the minimum mean squared error criticism. Scalar parameter Q, and denoting the estimator with Q^, the achieved error would be equal to $E = Q - \hat{Q}$ and its mean squared error would be, $E\{E^2\} = E\{(Q-\hat{Q})^2\}$.

Standard deviation and standard error are perhaps the two least understood statistics commonly shown in data tables. Both statistics are typically shown with the mean of a variable, and in a sense, they both speak about the mean. They are often referred to as the standard deviation of the mean and standard error of the mean.

13-3Standard deviations:

It's a measure that summarizes the amount by which every value within dataset varies from the mean. Effectively it indicates how tightly the values in the dataset are bunched around the mean value, It takes account every variable in the dataset. When the values in a dataset are pretty tightly bunched together the standard deviation is small, and vice versa.

The standard deviation is usually presented in conjunction with the mean and is measured in the same units.

14-3Standard errors:-

It is statistical term that measures the accuracy with which a sample represents a population in statistic, a sample mean deviates from actual mean of the population, this deviation in standard error. The small standard error and more representatives the sample will be over all population. The standard error is also inversely proportional to sample size, the lager sample size, the smaller standard error because the statistic will approach the actual value.

15-3Coefficient of variation:

The Coefficient of Variation [CV] also known as" relative variability "equal the standard deviation divided by the mean. C.V is often presented as a given ratio multiplied by 100, C.V for a single variable aims to describe the dispersion of the variable in a way that does not depend on the variables measurement unit, the higher the C.V the greater the dispersion in the variable. The

C.V for a model aims todescribe the model fit in the term of the relative size of squared residuals and outcome values, the lower the C.V the smaller the residual relative to the predicated value.

16-3The estimation of the production:

Two major factors affecting directly the production estimate, normally the harvested area (productive area) and the yield per area unit.

Production = Harvested area x Average yield per area unit.

Area Estimation:-

Area estimated either by actual form measurement or by Eye estimation accompanied by some techniques to justify the estimation like quantity of seeds sown or number of plowing hours and selection of small sub-sample the from the survey sample to reach a correction factor to minimize error percentage in this estimation.

Yield estimation:

Many ways used to estimate yield, but the most used are the following:

Complete harvest:-This method is summarized in the following:-Selection of random sample from the targeted crop farmers.

-The farms of selected farmers are completely harvested.

-Determining the total production of the selected sample.

-Estimate the yield of the crop by dividing the total production by the total area of the sample.

This method theoretically logic but practically and because it depend on complete harvest, it needs time & and for some extend tired some. Due to that it is not practiced, but it good estimation especially in small farm and farmers responded to the enumerators.

Sampling Harvest units: - **I**n this method the following steps are used

-Selected random sample from farmers of the targeted crop (sorghum).

-choose sample from the harvesting units from each selected farmer.

-weighed each selected unit, and then estimate the average weight of the harvesting units.

-total production is calculated by multiply the average weight of harvesting unit by the total numbers of the units.

-The yield is estimated by dividing the total production on the harvested area.

Although this method is good but many constrained are found:

A-Enumerators must be available at harvesting time of the selected farm.

B- Impossible to choose in case of transportation some of harvesting unit from the farm.

c- This method not applicable in case of crops that are harvested many times in the same season.

-It is clear that this method depend on three factors, normally, the cultivated area, the weight of harvesting unit and number of production units. If this is done accurately, then the yield should be more accurate at farm level.

Crop Cutting Survey:-

This method is widely used to estimate the yield of the area unit, so it is valid to measure the variation in yield between the different producing centers or the different seasons. It is achieved by selecting random sample from farmers or farms and determined randomly by objective method two plots from each selected farmer.

The size of the plots:

The size and shape of the plots are given much attention in most of the countries. The food and agricultural organization recommended that the size of the plot to be proportional to the intensity of agriculture. In irrigated land is small size between 1–5 meters while in rain-fed agriculture size between 10 – 25 square meters and could be extended to 100 square meters (FAO 1981). For Sudan, the plot size has been 100 square meters for some time then became 42 square meters. Now from the experience of agricultural statistics, reach to optimum size of 25 square meters for rain-fed mechanized and 9 square meters for irrigated.

Form of the plots:

Form of the plot can lead to an error in the estimate due to an error in determining the length of the plot or an error due to plant on the border will be calculated within or outside the plot. To reduce this error the optimum shape of the plot is that who gives us the lower circumference of the specific area. Generally the circular shape is better than square shape and the square shape is better than triangle (India Experience). The square shape has been selected for practical reason.

Location of the plot:

The location of the plot in the selected farm according to the following:

-Reach the selected farm and make sure it is the selected farm.

-Collect the primary information about the farm (cultivated area, harvested area, sowing date and the variety sown).

-Measure the length and width of each selected farm.

-Choose the random length and the random width using the table of random numbers.

-start measuring the random length, usually the start from the south-west corner of the farm.

-From end point of the random length working towards the width up to the end point of the random width.

-The joint point of the random length and the random width is the south-west corner of the first plot

-Put the pole in the south-west corner of the plot and then measure the required meters to determine the other pole point using the cross- stuff, then determine the third pole and the fourth pole points by the same way to make square shape as required.

-Measure the diagonal to assure that plot measurements are correct.

-Do the same to determine the second plot.

17-3Some sampling surveys in Sudan:

The National irrigated schemes:

The national schemes follow a proper crop rotation, where each crop is planted in a separate piece of land known as number with a definite size of feddanage and usually includes tenancies with equal sizes. Also the lay-out of the canalization system facilitates the estimation of planted areas under each crop. Accordingly, the statistics of area planted are accurate and reliable. The estimation of yield is based on sample survey were crop-cutting is conducted, an example is Gazira scheme, the statistics division of the agricultural planning administration carries an annual survey to estimate yields of the main crops (sorghum, wheat, groundnuts and cotton). As the administration is interested to have information at the level of the block, all blocks are included, as the first stage of selection starts at the tenancy level. In scheme, 36 tenancies were selected from each block resulting 3.2% according for the planted area, in a sample size of 40032 tenancies. The sample design adopted is a multi-stage random sample.

In the first stage applying systematic random selection, three canals (Turaa) are selected from each block, representing the start, the middle and the tail of the major canal. In the second stage, from each selected canal three numbers are selected applying simple systematic random selection, also representing the start, the middle and the tail of each number. At the 3rd stage, 3farmers are randomly selected from each selected number, one at the start, one at the middle and one at the tail. At the last stage, 3plots of 2*2 meters are randomly selected at the beginning, the middle and the end of the tenancy. Then the heads are cut dried,threshed and weighted, and the weighted average is calculated to estimate the yield of crop. All the same time paroled estimation which is mainly base on weekly records of the agricultural inspectors is prepared by the agricultural administration. Both estimates are mode available to the top administration. Of the scheme I think so as to avoid duplication and sometimes contradiction, it is better to depend on the objective method adopted by the planning administration and to supply with more facilities and financial capabilities to improve this job.The other national schemes (Rahad, New Halfa, Suki) are using more or less similar procedures of estimation, but Gezira scheme is more experienced in the aspect and its coverage and persistence is better.

Other irrigated agricultural schemes:

The state ministries of agriculture are responsible for generating the agricultural statistics of the irrigated sector in that state. Although these schemes are having their own agricultural rotation and somewhat similar canalization like the national scheme, but they rarely follow objective method of estimation. The data of area planted and area harvested as fairly good degree of accuracy, and as usually there is a plan for targeted area and a close follow up at area planted and areas to be harvested. An early stage where crops are at maturing stage yields depend on eye estimates, and then refined from acetous records of threshers or combine harvesters at harvest time as crops like sorghum, wheat, broad bean are harvested either fully or partially by combine harvesters or threshers. The accuracy of yield figures in this sub sector can be considered acceptable, as an example we will considered this procedure adopted for collecting agricultural data mainly for food crops in River Nile state. According to the administrative division in the state, they are six localities, at each locality there is an agricultural inspector, assisted by new graduates of agriculture, who are located at administrative unites under the locality. Each locality has an average of about 10basic units. Each assistant inspector is responsible to collect data from their units by interviewing farmers plus his own observations, weekly reports are submitted from each locality from the time land preparation till the time of harvest, giving information about areas, performance of the crop yields and factor affecting the crop type, rain fall, number of irrigation, application of fertilizer, number of weeding, pests, and diseases etc …. At time of harvest, the inspectors try to record the production by following the combine harvester's threshers in the field. The agricultural planning administrationwithin the ministry of agriculture at River Nile state is responsible to prepare a weekly report reflecting the agricultural station at state level.

18-3Rain- fed mechanized sector:

Estimation of planted area:

The preliminary estimates of area depend to a large exert on the records of the annual renewal of the schemes as the farmers are supposed to pay laud rent before the start of the season. This information is supplemented and refined information of rain fall, prices, and information from farmers. Usually in September team from mechanized farms co-operation (MFC) tour all schemes from door to door to estimate the planted area either by interviewing the farmers or the manager of the scheme or by eye estimation by the members of the team. In November and December, depending on the availability of funds and transportation facilities, the teams estimate the areas to be harvested and the expected yield by subjective methods (eye estimation).The federal administration of agricultural statistics of the ministry of agriculture in calibration with state ministries of agriculture used to carry crop cutting surveys to estimate the yield of sorghum. The intensity of coverage and timeliness of these surveys depend considerably on the availability of financial resources. The coverage of the surveys in season05/2006 was the best during the last 15 years as it covered Gedaref, Damazin, S.Kordofan, Sennar, White Nile and Gedaref being the largest area is chosen as an example to explain the sampling procedure of the crop cutting survey.

19-3Some surveys in Egypt and Inbdia:

Study made by AbdElshahid (1973) to estimate the average yield per feddan of cotton in Egypt. The experimental data for this study was obtained from crop cutting surveys made on cotton in the season of 1969 and 1971 to estimate the mean yield of cotton per feddan. The sampling design for these surveys was stratified multi-stage sampling. The study is carried out for different governorates in Egypt through use of crop cutting technique. In each governorate, the number of cluster was calculated for a given number of fields per cluster with different percentage standard errors. Also the optimum numbers of clusters and experimental plots per cluster and with a minimum cost were calculated. The result indicated that sampling two or three fields per cluster with plot per each selected field is about the optimum distribution for estimating the average yield.

Ghazi and Sallib conducted a survey on wheat in (1960) in Dakhaliya to compare economical wise between sampling two plots in the same field or samplingtwo fields and sampling one plot in each selected field. The result showed that tge mean square error between fields is highly significant. Thus the variance in yield rate between fields is far greater than that within the same field.

They concluded that it is disadvantageous to sample more than one plot per field. Further they concluded that selecting two fields per cluster and conducting one crop cutting experiment in each selected field for crop sampling in Egypt is adequate.

Suktame (1947) reported some results of the investigation on different crops. He indicated that there was a definite risk of obtaining over- estimate of the average yield with small plots. The first was in Morad Abad district (1945). He selected eight villages. In each selected village two were marked at random. The field results showed that the average yield for the district decreases and the decreasing rate diminishes with increase in size. This implies that when the plot size is sufficiently large, the estimate attains a stable value.

20-3 Research Type:

It is estimation of sorghum yield in rain-fed traditional sector, using crop cutting method by using multi-stage sampling.

Design of multi-stage sample:

Stratification is the process of dividing members of the population into homogeneous subgroups before sampling. These subpopulations are non-over-lapping, and together they comprise the whole of the population.These are used as primary sampling unit; sometimes a sample is drawn from this primary sampling unit. The sample is then done through other additional stages can be added to constitute what we call the multi-stage sampling. The last sampling unit in the final of sampling is called the listing (ultimate) sampling unit.

Where our study is carried out the area is divided into two strata namely the sandy soil strata and clay soil strata. Three administrative units are defined on those strata namely Dalami (clay soil), Fershaya and debaibat (sandy soil). Three villages are selected from these administrative units are taken as first stage sampling, the households as second stage sampling and ultimately the plots as the third stage sampling.

Location and marking of crop cutting plot:

1-Make a list of farms in each selected village, and this represents the secondary sampling units (SSU).

2-Random number of farms is selected from each selected (SSU)

3-Two plots are selected from each selected farm (third sampling unit)

The location of the plot in the selected farm according to the following:

-Reach the selected farm and make sure it is the selected farm.

-Collect the primary information about the farm (cultivated area, harvested area, sowing date and the variety sown).

-Measure the length and width of each selected farm.

-Subtract the plot length and width from the farm length and width to make sure that the plot is inside the farm.

-Choose the random length and the random width using the table of random numbers.

-start measuring the random length, usually the start from the south-west corner of the farm.

-From end point of the random length working towards the width up to the end point of the random width.

-The joint point of the random length and the random width is the south-west corner of the first plot

-Put the pole in the south-west corner of the plot and then measure the required meters to determine the other pole point using the cross- stuff, then determine the third pole and the fourth pole points by the same way to make square shape as required.

-Measure the diagonal to assure that plot measurements are correct.

-Cut the crop heads (sorghum) inside the plot and count the heads number and put them in separate sack with a label of farm and plot number and the sector or the locality and heads No:

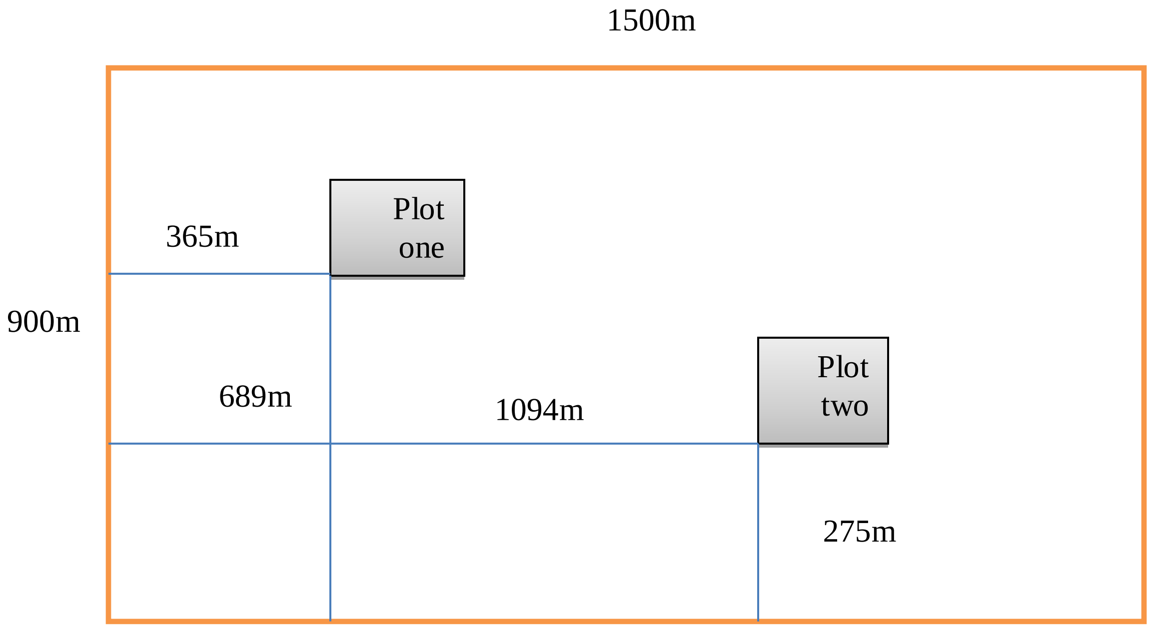
-Do the same to determine the second plot.

-This exercise is done to all the samples

In the last stage come digging, and threshing weighing to all samples separately and write the weight of each plot on its label, this is done in the field and the data is put in special sheet designed for this purpose,

The data entered to the computer for analysis to determine the yield of the crop per unit area to be used in farther analysis

Figure (1): Farm map:



Actual length 1500m

Random lengths 1500-5 for plot one 365m and1094 m for plot two.

Actual width 900m

Random widths 900-5 for plot one 689 and 275m for plot two.

21-3Assessment methodology:

Two stage estimation:

At first stage we select a number of farmers and from each selected farmer two plots are selected randomly. The data is prepared for analysis as follows:

Table (1-3) Two stage estimation:

No.	Plot production		Sum of two plots	Square of the Sum of two plots
	Plot1	Plot2		
1	Y_{11}	Y_{12}	$Y_{1.}$	$Y^2_{1.}$
2	Y_{21}	Y_{22}	$Y_{2.}$	$Y^2_{2.}$
3	Y_{31}	Y_{32}	$Y_{3.}$	$Y^2_{3.}$
-	-	-	-	-

-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
n	Y_{n1}	Y_{n2}	$Y_{n.}$	$Y^2_{n.}$
Total			$\sum_{i=1}^{n} y_{i.}$	$\sum_{i=1}^{n} y_{i.} = k$

Source: Mukhtar (2005)

1-Plot average production equal to: $= \frac{\sum_{i=1}^{n} Yi.}{2n} = \frac{\sum_{i=1}^{n} Yi.}{nm}$ …….. [67-3]

2- The correction factor (CF): $= \frac{[\sum_{i=1}^{n} Y_{i.}]^2}{2n}$ …….. [68-3]

3 – Sum of squares between farmers: $= \frac{K}{2} - CF = B^2$ ….. [69-3]

4 – Total sum of squares: $= \sum_{i=1}^{n} \sum_{j=1}^{2} y_{ij}^2 - CF = TSS$ ……. [70-3]

5 – Sum of squares within farmers: = TSS - B2 ….. [71-3]

Table (2-3) two stage estimation analysis of variance [ANOVA]:

Source of variation	DF	Sum of Squares	Mean of Squares	E[M.S]
Between farmers	n-1	$2\sum_{i=1}^{n} [\bar{y}_i - \bar{y}_{..}]^2 = B^2$	$\frac{B^2}{n-1} S_1^2$	$S_w^2 + 2S_b^2$
Between plots within farmers	n	TSS - SST	$\frac{TSS - SST}{n} = S_0^2$	S_w^2
Total	2n-1	$\sum_{i=1}^{n} \sum_{j=1}^{2} [Y_{ij} - Y_{..}]^2$		

Source: Mukhtar (2005)

6 – The variance:

$$V(\bar{Y}_{..}) = \frac{S_b^2}{n} + \frac{S_w^2}{2n} = \frac{S_1^2}{2n} \quad \text{….. [72-3]}$$

Where: $S_w^2 = S_0^2 S_6^2 = \frac{S_1^2 - S_0^2}{2}$ ……... [73-3]

7 – The sample Error:

$$S.E\,(\bar{Y}_{..}) = [V(\bar{Y}_{..})]^{\frac{1}{2}} \quad \text{……. [74-3]}$$

8 – The coefficient of variation:

$$C.V.\,(P) = \frac{S.E\,(\bar{Y}_{..})}{\bar{Y}_{..}} * 100 = \sqrt{\frac{\frac{S_b^2}{n} + \frac{S_w^2}{2n}}{\bar{Y}_{..}}} * 100 \quad \text{……. [75-3]}$$

$$\text{Or,} \quad \left[\frac{P\bar{Y}}{100}\right]^2 = \frac{S_b^2}{n} + \frac{S_w^2}{2n} \quad \text{…….. [76-3]}$$

By this we give estimation for yield of the plot along with the variance, In case the sample error is small. Otherwise the variance decreased by $\frac{S_1^2}{N}$.

The Estimation of the Overall Yield:

The estimation of the overall yield is calculated from the yields of different strata by using the weights of strata as shown in the following table:

Table (3-3) The estimation of the overall yield:

Stratum	W = $\frac{A_t}{A_0}$	$\bar{Y}_t$	$W_t\bar{Y}_t$	$V(\bar{Y}_t)$	W_t^2	$W_t^2 V(\bar{Y}_t)$
1						
2						
3						
-						
-						
-						
	100		$\bar{Y}_0$			$V(\bar{Y}_0)$

Source: Mukhtar (2005)

Where:

A_t = Area cultivated in stratum t.

A_0 = Total cultivated area in the whole locality.

1 – Average yield of plot in the locality:

$\bar{Y}_0 = \sum_{t=1}^{l} w_{t\bar{Y}_t}$ …….. [77-3]

2 - Sample Error: = $[V(\bar{Y}_0)]^{\frac{1}{2}}$ ……. [78-3]

3 - Coefficient of variation: = $\frac{[V(\bar{Y}_0)]^{\frac{1}{2}}}{\bar{Y}_0}$ …… [79-3]

4 – 95% confidence limit: = $\bar{Y}_0 \pm 1.96 * SE$ …… [80-3]

Three stages sampling:

In this case we select a number of village's, **n** and from the selected village we select a number of farmers, m and ultimately we select two plots from the selected farmer, **q**.

The analysis of variance table for three stages sampling as follows:

Table (3-4) Three stage estimation analysis of variance (ANOVA):

Source of variation	DF	Sum of Squares	Mean of Squares	E[M.S.]
Between blocks	n-1	$mq\sum_{i=1}^{n}[\overline{y_{i..}} - \overline{y_{...}}]^2$	S_2^2	
Between tenants within blocks	n(m-1)	$q\sum_{i=1}^{n}\sum_{j=1}^{m}[\overline{y_{ij.}} - \overline{y_{i..}}]^2$	S_1^2	
Between plots within tenants	nm(q-1)	$\sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{q}[\overline{y_{ijk}} - \overline{y_{ij.}}]^2$	S_0^2	
Total	nmq-1	$\sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{q}[\overline{y_{ijk}} - \overline{y_{...}}]^2$		

Source: Mukhtar (2005)

Where:

1 - $V(\overline{Y_{...}}) = \frac{S_2^2}{n} + \frac{S_b^2}{nm} + \frac{S_w^2}{nmq} = \frac{S_z^2}{nmq}$ …… [81-3]

$S_w^2 = S_0^2$ ………… [82-3]

$S_b^2 = \frac{S_1^2 - S_0^2}{q}$ …… [83-3]

$S_z^2 = \frac{S_2^2 - S_1^2}{mq}$ …… [84-3]

2 - S.E $(\bar{Y}_{...}) = [V(\overline{Y_{...}})]^{\frac{1}{2}}$ ….. [85-3]

3 – C.V. $= \frac{\text{S.E }(\bar{Y}_{...})}{\overline{Y_{...}}} * 100$ …… [86-3]

23-3Multiple comparison of the means procedure:

Preface:

When the computed value of the F statistic in a single factor ANOVA is not significant, the analysis is terminated because no differences among the μ_i's have been identified. But when H_0 is rejected, the investigator will usually want to know which of the μ_i's are different from one another. A method for carrying out this further analysis is called a multiple comparisons procedure. **(Jay L. Devore)**

Several of the most frequently used procedures are based on the following central idea:

First calculate a confidence interval for each pairwise difference, $\mu_i - \mu_j$ with i< j. Thus if I=4, the six required CIs would be for $\mu_1 - \mu_2$ [but not also for $\mu_2 - \mu_1$], $\mu_1 - \mu_3$, $\mu_1 - \mu_4$,$\mu_2 - \mu_3$, $\mu_2 - \mu_4$ and $\mu_3 - \mu_4$.

Then if the interval for $\mu_1 - \mu_2$ does not include 0, conclude that μ_1 and μ_2 differ significantly from one another, if the interval does include 0; the two µ's are judged not significantly different.

Following the same line of reasoning for each of the other intervals, we end up being able to judge for each pair of µ's whether or not they differ significantly from one another.

The procedures based on this idea differ in how the various confidence intervals [CLs] are calculated.

Here I present a popular method that controls the simultaneous confidence level for all I (I-1)/2 intervals.

Tukey's procedure:

Tukey'sprocedure involves the use of another probability distribution called the student zed range distribution. The distribution depends on two parameters. A numerator df**m** and a denominator, df**v**.

Let $Q_{\alpha,\, m,\, v}$ denote the upper tail $\boldsymbol{\alpha}$ critical value of the student zed range distribution with **m** numerator df and **v** denominator df [analogous to $F_{\alpha,\, v1,\, v2}$]. Values of $Q_{\alpha,\, m,\, v}$ are given in the table of critical values for student zed range distributions. **(Jay L. Devore)**

With probability 1- α,

$$\bar{X}_{i.} - \bar{X}_{j.} - Q_{\propto, I, I(J-1)}\sqrt{\frac{MSE}{J}} \leq \mu_{i.} - \mu_{j.} \leq \bar{X}_{i.} - \bar{X}_{j.} + Q_{\propto, I, I(J-1)}\sqrt{\frac{MSE}{J}} \quad \text{.........} \quad [87\text{-}3]$$

For every i and j (i = 1,........,I and j = 1, ..., I) with i< j.

The numerator df for appropriate Q_α critical value is the number of population or means being compared, and not I-1 as in the F test. When the computed $\bar{\boldsymbol{X}}_{\boldsymbol{i.}}, \bar{\boldsymbol{X}}_{\boldsymbol{j.}}$ and MSE are substituted into the upper proportion, the result is a collection of confidence intervals with simultaneous confidence level 100(1 – α) % for all pairwise differences of the form $\mu_{i.} - \mu_{j.}$ with **i<j.** Each interval that does not include 0 yields the conclusion that the corresponding values of $\mu_{i.}$ *and* $\mu_{j.}$ differ significantly from one another.

Since we are not really interested in the lower and upper limits of the various intervals but only in which include **0** and which do not, much of the arithmetic associated with the above proposition can be avoided.

The differences can be identified visually using an “underscoring pattern” as shown in the following the T method for identifying significantly different μ_j , s :

Select α, extract$Q_{\propto,I,I(J-1)}$ from the table and calculate $w = Q_{\propto,I,I(J-1)}\sqrt{\frac{MSE}{J}}$. Then list the sample means in increasing order and underline those pairs that differ by less than w. Any pair of sample means not under scored by the same line corresponds to a pair of population or treatment means that are judged significantly different.

Fortunately these very complicated calculations are simply reached using statisticalsoftware’s developed for these purposes. Here I used SPSS packages’ in analysis of my experiments.

CHAPTER FOUR

1-4 The Analysis and Results Discussion

Chapter Four

Analysis and Results Discussion

1-4 The analysis and results discussion:-

Number of heads per feddan:-

An experiment was carried out in three different areas to compare three different plot sizes and their impact on estimation of the number of heads per feddan. Let μ_i denotes the average number of heads given by plot i, filters (i = 1… 3). A sample of 22 farmers for each plot size was used, resulting in the following sample means:

Fershaya Area (First stratum – loam soil):

A sample of twenty two farmers for each plot size was used, resulting in the following sample means:Plot size 5x5 = 4418, plot size 6x7 = 9302 and plot size 10x10 = 6585, while the highest standard deviation shown by using plot size 6x7 meters (4543.546) followed by plot size 5x5 meters (3127.879) and plot 10x10 meters (2107.397) and the highest standard error shown by using also plot size 6x7 meters (1015.968) followed by using 5x5 meters (699.415)and plot size 10x10meters (471.228), for the coefficient of variation the highest is shown by using plot size 5x5meters (15.8296) followed by plot size 6x7 meters (10.92145) and plot size 10x10 meters (7.155433) as shown in the table (1-4) below.

Table (1-4): Mean statistics for number of heads per feddan under different plot sizes:

Plot	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	4418.40	3127.879	699.415	15.8296
`plot size 6x7 meters	9302.50	4543.546	1015.968	10.92145
plot size 10x10 meters	6585.60	2107.397	471.228	7.155433
Total	**6768.83**	**3910.122**	**504.795**	**7.45763**

Source: Researcher data

Table (2-4): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.396E+08	2	1.198E+08	10.305	.000
Within Groups	6.625E+08	57	1.162E+07		
Total	9.021E+08	59			

Source: Researcher data

Since F = 10.305 and p-value = 0.000 as shown in table (2-4) above, H_0 is rejected decisively at level 0.05. Because the computed value of the F statistic in a single factor ANOVA is significant. We conclude that there are significant differences between means as judged by the mean under the control condition. We now use Tukey's procedure to look for significant differences among the μ_i's as shown in table (4-3) below.

Table (3-4): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05		CV
		1	2	
plot size 5x5 meters	20	4418.40		15.8296
plot size 10x10 meters	20	6585.60		7.155433
plot size 6x7 meters	20		9302.50	10.92145
Sig.		.119	1.000	

Source: Researcher data

Refer to the analysis output the above table (3-4) represent the differences among the μ_i's. The plot size 6x7 meters is significantly different from the other two namely plot size 5x5 meters and the plot size 10x10 meters in its true average content. On the other hand the plot size 5x5 meters and the plot size 10x10 meters are not significantly different from one another in their true average contents.

Debaibat (Second stratum – Sandy soil):

In Debaibat area a sample of twenty two farmers for each plot size was used, resulting in the following: sample means:Plot size 5x5 = 7404, plot size 6x7 = 4417 and plot size 10x10 = 9201heads per feddan while the highest standard deviation shown by using plot size 10x10 meters (4632.815) followed by plot size 5x5 meters (3128.110) and plot 5x5 meters (2187.275) and the highest standard error shown by using also plot size 10x10 meters (1035.929) followed by using 6x7 meters (699.467)and plot size 5x5meters (489.090), for the coefficient of variation the highest is shown by using plot size 6x7meters (15.83399) followed by plot size 10x10 meters (11.25869) and plot size 5x5 meters (6.605213)as shown in the table (4-4) below.

Table (4-4): Mean statistics for number of heads per feddan under different plot sizes:

Plot size	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	7404.60	2187.275	489.090	6.605213
plot size 6x7 meters	4417.50	3128.110	699.467	15.83399
plot size 10x10 meters	9201.15	4632.815	1035.929	11.25869
Total	**7007.75**	**3944.896**	**509.284**	**7.267437**

Source: Researcher data

Table (5-4): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.336E+08	2	1.168E+08	9.723	.000
Within Groups	6.846E+08	57	1.201E+07		
Total	9.182E+08	59			

Source: Researcher data

In the analysis of variance table (5-4) above F = 9.723 and p-value = 0.000, H_0 is rejected decisively at level 0.05. Because the computed value of the F statistic in a single factor ANOVA is significant. We conclude that there are significant differences between means as judged by the mean under the control condition. We now use Tukey's procedure to look for significant differences among the μ_i's as shown in table (4-6) below.

Table (6-4): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05		CV
		1	2	
plot size 6x7 meters	20	4417.50		15.83399
plot size 5x5 meters	20		7404.60	6.605213
plot size 10x10 meters	20		9201.15	11.25869
Sig.		1.000	.238	

Source: Researcher data

The analysis output in the above table (6-4) represent the differences among the μ_i's. The plot size 5x5 metersand plot size10x10 are not significantly different from one anotherin their true average contents. On the other hand the plot size 5x5 meters and the plot size 10x10 meters are significantly different from plot size6x7meters.

Dalami: (Third stratum – Clay soil)

In Dalami area a sample of twenty two farmers for each plot size was used, resulting in the following: sample means: Plot size 5x5 = 9739, plot size 6x7 = 7027 and plot size 10x10 = 3931heads per feddan, while the highest standard deviation shown by using plot size 5x5 meters (5003.058) followed by plot size 6x7 meters (2623.802) and plot 10x10 meters (2451.364) and the highest standard error shown by using also plot size 5x5 meters (1118.718) followed by using 6x7 meters (586.700)and plot size 10x10meters (548.142), for the coefficient of variation the highest is shown by using plot size 10x10 meters (13.94337) followed by plot size 5x5 meters (11.48604) and plot size 6x7 meters (8.348629) as shown in the table (7-4).

Table (7-4): Mean statistics for number of heads per feddan under different plot sizes:

Plot	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	9739.80	5003.058	1118.718	11.48604
plot size 6x7 meters	7027.50	2623.802	586.700	8.348629
plot size 10x10 meters	3931.20	2451.364	548.142	13.94337
Total	**6899.50**	**4235.539**	**546.806**	**7.925296**

Source: Researcher data

Table (4-8): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.379E+08	2	1.689E+08	13.364	.000
Within Groups	7.206E+08	57	1.264E+07		
Total	1.058E+09	59			

Source: Researcher data

In the analysis of variance table (4-8) above F = 13.364 and p-value = 0.000, H_0 is rejected decisively at level 0.05. Because the computed value of the F statistic in a single factor ANOVA is significant. We conclude that there are significant differences between means as judged by the mean under the control condition. We now use Tukey's procedure to look for significant differences among the μ_i's as shown in table (4-9) below.

Table (4-9): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05			CV
		1	2	3	
plot size 10x10 meters	20	3931.20			13.94337
plot size 6x7 meters	20		7027.50		8.348629
plot size 5x5 meters	20			9739.80	11.48604
Sig.		1.000	1.000	1.000	

Source: Researcher data

The analysis output in the above table (4-9) represent the differences among the μ_i's. The plot size 5x5 meters, plot size6x7 and plot size 10x10 are significantly different from one another in their true average contents. On the other hand the plot size 5x5 metersis higher followed by plot size 6x7meters.

4-1-2 The average yield per feddan:

4-1-2-1 Fershaya(First stratum – loam soil):

In the other experiment which was carried outto compare the effectof different plot sizeson average yield per feddan as judged by the controlled conditionLet μ_i denotes the average yield given by plot ifilters (i = 1… 3). A sample of 22 farmers for each plot size was used, resulting in the following sample means:Plot size 5x5 = 75.18, plot size 6x7 = 97.25 and plot size 10x10 = 94.07, while the highest standard deviation shown by using plot size 6x7 meters (72.364) followed by plot size 10x10 meters (71.783) and plot 5x5 meters (67.905) and the highest standard error shown by using also plot size 6x7 meters (16.181) followed by using 10x10 meters (16.051)and plot size 5x5meters (15.184), for the coefficient of variation the highest is shown by using plot size 5x5 meters (20.19694) followed by plot size 10x10 meters (17.06262) and plot size 6x7 meters (16.63914) as shown in the table (10-4) below.

Table (10-4): Mean statistics for average yield per feddan under different plot sizes:

Plot	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	75.18	67.905	15.184	20.19694
plot size 6x7 meters	97.25	72.364	16.181	16.63914
plot size 10x10 meters	94.07	71.783	16.051	17.06262
Total	**88.83**	**70.194**	**9.062**	**10.20111**

Source: Researcher data

Table (11-4): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5693.243	2	2846.622	.569	.569
Within Groups	285010.700	57	5000.188		
Total	290703.943	59			

Source: Researcher data

Since F = .569 and P-value = 0.569, H_0 is not rejected decisively at level 0.05. We conclude that there are no significant differences between means as judged by the mean under the control condition as shown in table(11-4) above. Because the computed value of the F statistic in a single factor ANOVA is not significant, the analysis is terminated because no differences among the μ_i's have been identified as shown in table (4-12)below.

Table (12-4): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05	CV
		1	
plot size 5x5 meters	20	75.18	20.19694
plot size 10x10 meters	20	94.07	17.06262
plot size 6x7 meters	20	97.25	16.63914
Sig.		.588	

Source: Researcher data

Refer to the analysis output in table (10-4) above represents the differentCV's, you can see thatplot size 6x7 has the lower CV (16.63914), followed by plot size 10x10 (17.06262) and plot size 5x5 (20.19694).We conclude that plot size 6x7 is better in estimation than the two other plots.

Debaibat (Second stratum – Sandy soil):

In Debaibat area the experiment which was carried outto compare the effectofdifferent plot sizeson average yield per feddan as judged by the controlled conditionLet μ_i denotes the average yield given by plot ifilters (i = 1… 3). A sample of 22 farmers for each plot size was used, resulting in the following sample means: Plot size 5x5 = 103.49, plot size 6x7 = 75.18 and plot size 10x10 = 97.25, while the highest standard deviation shown by using plot size 10x10 meters (72.364) followed by plot size 5x5 meters (67.961) and plot 6x7 meters (67.906) and the highest standard error shown by using also plot size 10x10 meters (16.181) followed by using 5x5 meters (15.196)and plot size 6x7meters (15.184), for the coefficient of variation the highest is shown by using plot size 6x7 meters (20.19704) followed by plot size 10x10 meters (16.63861) and plot size 5x5 meters (14.68426), as shown in the table (13-4) below.

Table (13-4): Mean statistics for number of heads per feddan under different plot sizes:

Plot size	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	103.49	67.961	15.196	14.68426
plot size 6x7 meters	75.18	67.906	15.184	20.19704
plot size 10x10 meters	97.25	72.364	16.181	16.63861
Total	**91.97**	**69.344**	**8.952**	**9.733662**

Source: Researcher data

Table (4-14): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8848.925	2	4424.463	.918	.405
Within Groups	274860.108	57	4822.107		
Total	283709.034	59			

Source: Researcher data

Since F = .918 and P-value = 0.405, H_0 is not rejected decisively at level 0.05. We conclude that there are no significant differences between means as judged by the mean under the control condition as shown in table (4-14). Because the computed value of the F statistic in a single factor ANOVA is not significant,the analysis is terminated because no differences among the μ_i's have been identified as shown in table (4-15)below.

Table (4-15): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05	CV
		1	
plot size 6x7 meters	20	75.18	20.19704
plot size 10x10 meters	20	97.25	16.63861
plot size 5x5 meters	20	103.49	14.68426
Sig.		.407	

Source: Researcher data

Refer to the analysis output in table (4-13) aboverepresents the differentCV's, you can see thatplot size 5x5 has the lower CV (14.68426), followed by plot size 10x10 (16.63861) and plot size 6x7 (20.19704).We conclude that plot size 5x5 is better in estimation than the two other plots.

Dalami (Third stratum – Clay soil):

In the other experiment which was carried out in Delami areato compare the effectof different plot sizeson average yield per feddan as judged by the controlled condition.Let μ_i denotes the average yield given by plot ifilters (i = 1… 3). A sample of 22 farmers for each plot size was used, resulting in the following sample means: Plot size 5x5 = 104.12, plot size 6x7 = 97.22 and plot size 10x10 = 65, while the highest standard deviation shown by using plot size 5x5 meters (70.662) followed by plot size 6x7 meters (70.028) and plot 10x10 meters (44.881) and the highest standard error shown by using also plot size 5x5 meters (15.801) followed by using 6x7 meters (15.659)and plot size 10x10meters (10.036), for the coefficient of variation the highest is shown by using plot size 6x7 meters (16.10616) followed by plot size 10x10 meters (15.44056) and plot size 5x5 meters (15.17502) as shown in the table (16-4) below.

Table (16-4): Mean statistics for number of heads per feddan under different plot sizes:

Plot size	Mean	Std. Deviation	Std. Error	CV
plot size 5x5 meters	104.12	70.662	15.801	15.17502
plot size 6x7 meters	97.22	70.028	15.659	16.10616
plot size 10x10 meters	65.00	44.881	10.036	15.44056
Total	**88.78**	**64.277**	**8.298**	**9.34692**

Table (17-4): Analysis of variance table (ANOVA):

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17447.703	2	8723.851	2.197	.120
Within Groups	226316.306	57	3970.462		
Total	243764.009	59			

Source: Researcher data

Since F = 2.197 and P-value = 0.120, H_0 is not rejected decisively at level 0.05. We conclude that there are no significant differences between means as judged by the mean under the control condition as shown in table (4-17) above. Because the computed value of the F statistic in a single factor ANOVA is not significant, the analysis is terminated because no differences among the μ_i's have been identified as shown in table (4-18)below.

Table (18-47): Sub-set homogeneous:

Plot size	N	Subset for alpha = 0.05	CV
		1	
plot size 10x10 meters	20	65.00	15.44056
plot size 6x7 meters	20	97.22	16.10616
plot size 5x5 meters	20	104.12	15.17502
Sig.		.131	

Source: Researcher data

Refer to the analysis output in table (4-16) above represents the differentCV's, you can see thatplot size 5x5 has the lower CV (15.17502), followed by plot size 10x10 (15.44056) and plot size 6x7 (16.10616).We conclude that plot size 5x5 is better in estimation than the two other plots.

CHAPTER FIVE

1-5 Conclusion
2-5 Recommendation

Chapter Five

Conclusion and recommendations of the Research

Conclusion:

This study revealed that the:

1- The higher plant density obtained with medium plots size in stratum one(loam soils) with no significant difference between large and small size plots, while in stratum two (sandy soils) the higher estimation obtainedwith large plots size, but with no significant difference from medium size plots. In the third stratum (clay soils) the higher plant density estimation obtained with small size plots with no significant difference from medium size plots.

2- The standard deviation is lower for large size plots in the loam and clay soils while in sandy soils is lower for small size plots.

3- In the loam soils the large size plots had lower coefficient of variation while in the sandy soils the small size plots shows lower coefficient of variation and the medium size plots has the lower coefficient of variation in the clay soils.

4- The higher crop yield obtained with medium plots size in stratum one (loam soils) with no significant difference between all plots, while in stratum two (sandy soils) the higher Estimation of yield obtained with small plots size, but also with no significant difference. In the third stratum (clay soils) as in the second stratum the higher crop yield estimation obtained with small size plots with no significant difference between all plots.

5- The standard deviation is lower for large size plots in the loam and clay soils while in sandy soils is lower for small size plots.

6- In the clay soils the large size plots had lower coefficient of variation while in the sandy soils the medium size plots shows lower coefficient of variation but almost similar to that of small size plots and the small size plots has the lower coefficient of variation in the loam soils.

7- In case of plant density estimation the large size plots are better to use in clay and sandy soils while small is better in the sandy soils.

8- Since there is no significant difference between large and small plots in the first stratum and also no significant difference between large and medium plots in the second stratum, beside there is no significant difference small and medium size plots, we conclude that large size plots were better in the loam and sandy soils while medium size plots are better in the clay soils.

9- Since there was no significant difference between all plots sizes in estimation of yield in different soils types we conclude that any plot size may be use in estimation.

Therefore according to the conclusions of the study the plot size had not shown any effect on the yield in different types of soils, but there was slight effect of plots size in case of plants density estimation. There seem other factors affecting the level of yields. These factors should be planting spaces, seed rate, adequate re-sowing, thinning and optimum sowing dates.

Recommendation:

1- If the main objective of the survey is to estimate the crop yield, then the small size plots are better and recommended to use in all types of soils to save time and to save resources.
2- If the objective of the survey is to estimate the plant density then the medium plots size are better in estimation and recommended to be used.
3- Utilize methods and means of collecting, processing, analyzing, and presenting data that meet reasonable standards of accuracy, coverage and timeliness, while at the same time try to minimize financial and human costs.
4- Have institutional structure which brings users and suppliers of information in a continuous dialogue and which is able to adapt itself to the changing demands of information and modern methodologies for generating it.
5- General perception and understanding of the importance of information system by decision makers, politicians, planners and most categories of data users must followed of adoption and application reality to raise the standard of agricultural statistics.
6- Agricultural census must be conducted to provide skeleton data for efficient statistical list frames.
7- Crop cutting surveys must be adopted to cover all the other crops and in all agricultural sectors.
8- Crop cutting surveys must be used to estimate field base pre-harvest and harvest loss of crops.
9- Utilize modern technology to provide area sampling frame to substitute list frame.

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Annexes

Annex (1) Plot size, number of heads and weight per plot of the first stratum:

Farm No.	Plot size 5x5				Plot size 6x7				Plot size 10x10			
	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w
1	0	35	0	750	121	79	957	630	248	172	3200	2000
2	22	35	220	650	60	153	1260	1428	220	236	6200	6800
3	4	8	350	640	110	24	284	294	0	68	0	800
4	22	12	150	180	32	136	2100	2016	188	164	3800	3800
5	18	11	250	225	40	54	2076	1764	164	184	6800	5200
6	15	9	350	270	73	181	3360	2554	156	188	2200	1800
7	14	18	90	40	69	64	1596	1722	128	148	3600	4000
8	41	35	200	300	52	230	865	840	188	0	1800	0
9	9	22	70	170	128	114	1260	571	192	104	2600	2080
10	19	0	200	0	60	69	991	1428	124	100	2680	1600
11	22	0	750	0	146	150	1764	344	144	140	1000	1520
12	42	25	25	500	55	30	235	84	100	92	3000	1200
13	29	21	700	300	99	0	823	0	128	204	2800	540
14	12	8	200	190	0	5	0	17	352	72	4400	720
15	14	9	400	180	94	42	1092	252	192	256	219	680
16	38	33	1350	1100	138	82	252	521	40	344	114	660
17	62	63	1550	1600	55	123	269	680	112	316	400	3600
18	58	69	1550	750	77	168	991	722	24	248	720	840
19	32	39	250	300	193	220	882	706	44	216	220	1000
20	37	90	400	700	81	114	496	773	116	160	2600	2400

source: Field survey 2015/2016

Annex (2) Plot size, number of heads and weight per plot of the second stratum:

Farm No.	Plot size 5x5				Plot size 6x7				Plot size 10x10			
	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w
1	62	43	800	500	0	59	0	1260	288	188	2279	1500
2	55	59	1550	1700	37	59	370	1092	144	364	3000	3400
3	78	17	650	200	7	13	588	1075	162	56	676	700
4	47	41	950	950	37	20	252	302	76	324	5000	4800
5	41	46	1700	1300	30	18	420	378	95	128	4944	4200
6	39	47	550	450	25	15	588	454	174	432	8000	6080
7	32	37	900	1000	24	30	151	67	164	152	3800	4100
8	47	22	450	1200	69	59	336	504	124	548	2060	2000
9	48	26	650	520	15	37	118	286	304	272	3000	1360
10	31	25	670	400	32	0	336	0	144	164	2360	3400
11	36	35	250	380	37	0	1260	0	348	356	4200	820
12	25	23	750	300	71	42	42	840	132	72	560	200
13	32	51	700	135	49	35	1176	504	236	0	1960	0
14	88	18	1100	180	20	13	336	319	0	12	0	40
15	18	64	115	170	24	15	672	302	224	100	2600	600
16	31	86	110	165	64	55	2268	1848	328	196	600	1240
17	78	79	350	900	104	106	2604	2688	132	292	640	1620
18	60	62	180	210	97	116	2604	1260	184	400	2360	1720
19	11	54	55	250	54	66	420	504	460	524	2100	1680
20	29	40	650	600	62	151	672	1176	192	272	1180	1840

source: Field survey2015/2016

Annex (3) Plot size, number of heads and weight per plot of the third stratum:

Farm No.	Plot size 5x5				Plot size 6x7				Plot size 10x10			
	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w	PLt1h	PLt2h	PLt1w	PLt2w
1	72	47	700	750	104	72	1344	840	0	140	0	3000
2	36	91	750	850	92	99	2604	2856	88	140	880	2600
3	31	14	1300	175	0	29	0	336	16	32	1400	2560
4	91	81	1250	1200	79	69	1596	1596	88	48	600	720
5	43	32	1236	1050	69	77	2856	2184	72	44	1000	900
6	103	108	2000	1520	66	79	924	756	60	36	1400	1080
7	41	38	950	1025	54	62	1512	1680	56	72	360	160
8	18	137	515	500	79	0	756	0	164	140	800	1200
9	76	68	750	340	81	44	1092	874	36	88	280	680
10	36	41	590	850	52	42	1126	672	76	0	800	0
11	87	89	1050	205	60	59	420	638	88	0	3000	0
12	33	18	140	50	42	39	1260	504	168	100	100	2000
13	59	0	490	0	54	86	1176	227	116	84	2800	1200
14	0	3	0	10	148	30	1848	302	48	32	800	760
15	56	25	650	150	81	108	932	286	56	36	1600	720
16	82	49	150	310	17	144	48	277	52	132	2700	4400
17	33	73	160	405	131	133	588	1512	84	252	2200	6400
18	46	100	590	430	101	104	302	353	32	276	3200	3000
19	115	131	525	420	18	91	92	420	128	156	1000	1200
20	48	68	295	460	49	67	1092	1008	148	360	1600	2800

source: Field survey 2015/2016

Annex 4:**TABLE I ONE DIGIT RANDOM NUMBERS**

ROW NO	COLUM NO.													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2	9	7	9	3	7	8	0	4	8	9	3	8	5
2	1	5	4	7	3	4	7	6	3	4	7	6	6	4
3	7	9	8	1	5	5	1	7	4	5	1	2	7	2
4	1	9	4	7	3	1	7	6	3	9	7	9	4	6
5	4	0	5	2	8	7	6	3	0	5	2	0	1	3
6	7	5	4	7	2	9	4	8	2	6	7	4	8	5
7	2	4	4	5	4	9	6	8	1	3	5	7	9	6
8	8	0	2	2	5	0	7	2	7	4	2	1	9	9
9	8	9	9	2	8	6	7	9	9	0	9	1	8	6
10	2	5	2	3	4	2	6	8	9	9	2	7	1	7
11	4	9	6	4	3	1	8	6	1	0	6	6	8	3
12	9	0	2	8	2	3	4	1	0	8	2	5	5	1
13	2	1	3	6	8	2	7	4	5	0	8	8	3	0
14	6	0	4	3	7	3	1	6	9	9	4	5	5	9
15	8	3	6	1	1	0	8	1	9	6	0	7	3	3
16	6	2	1	6	2	5	8	9	7	6	1	3	9	1
17	7	2	8	0	8	5	7	1	3	1	2	8	0	5
18	7	2	6	7	5	2	5	3	3	3	6	4	8	5
19	7	7	5	2	6	2	4	7	5	8	5	6	3	2
20	5	4	5	0	3	8	7	1	1	1	5	3	8	2
21	3	2	3	7	0	5	7	1	9	6	3	3	4	0
22	1	8	8	3	2	3	8	2	2	0	0	3	8	8
23	2	9	4	9	6	8	5	8	0	7	4	6	1	2
24	2	4	3	2	4	9	0	9	4	5	3	9	3	4
25	3	5	9	9	6	0	6	2	5	5	2	2	6	7

Annex 5:**TABLE 11 –TWO DIGIT RANDOM NUMBERS**

ROW NO	COLUM NO.													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	57	60	10	15	10	49	75	78	18	90	03	40	29	32
2	35	34	56	09	88	41	86	70	53	37	28	23	31	99
3	27	72	79	98	56	31	90	21	44	36	14	72	56	19
4	33	52	77	60	53	60	68	94	09	63	11	51	41	63
5	72	82	21	16	27	70	24	47	42	32	30	39	85	95
6	24	21	30	03	59	42	64	16	72	08	79	35	47	73
7	53	15	27	03	33	38	16	12	00	58	20	76	04	76
8	64	65	12	18	35	06	35	38	06	37	69	22	66	63
9	94	20	09	87	72	45	51	64	79	40	22	42	08	89
10	09	33	49	00	67	18	46	43	79	13	40	92	72	44
11	41	29	22	42	47	64	61	59	68	68	98	96	72	44
12	10	94	23	31	77	84	87	98	47	97	95	11	57	99
13	76	71	62	57	34	73	39	98	22	87	17	83	59	50
14	47	11	36	90	55	31	12	77	00	64	82	44	13	48
15	91	15	93	12	45	65	85	87	35	81	06	80	82	67
16	44	91	89	02	70	52	94	68	55	07	53	34	43	26
17	04	29	41	07	08	53	57	07	31	83	31	68	80	43
18	95	12	26	23	18	37	29	91	51	02	51	35	46	18
19	49	03	29	47	27	97	16	51	51	17	10	48	15	46
20	66	61	70	37	38	15	92	67	00	79	96	77	33	40
21	39	96	83	17	90	12	09	62	63	18	46	33	26	66
22	50	48	63	31	16	96	84	44	22	05	92	42	61	44
23	04	95	51	54	95	88	38	40	55	12	06	40	70	52
24	50	03	99	08	86	17	76	98	40	59	88	90	04	91
25	81	07	74	01	70	31	22	05	76	52	07	60	77	36

Annex 6:**TABLE111 – A OF THREE DIGIT RANDOM NUMBERS**

ROW NO	COLUM NO .													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	102	947	440	753	752	759	802	448	988	211	962	801	396	161
2	753	662	739	760	120	872	972	973	373	906	665	921	386	954
3	962	118	554	665	277	105	078	550	150	068	002	239	308	626
4	371	934	342	484	778	020	472	034	410	129	684	653	582	970
5	505	214	344	083	916	324	353	299	694	364	552	663	558	573
6	436	257	339	275	916	174	903	864	768	284	386	707	947	515
7	235	025	286	775	843	797	441	760	183	624	763	745	220	333
8	431	919	115	608	187	815	924	921	171	791	475	855	562	187
9	048	189	181	257	368	651	571	077	633	676	475	061	011	287
10	298	784	354	029	676	923	092	885	025	146	832	741	726	374
11	041	803	168	009	961	486	370	953	745	025	478	339	571	860
12	412	003	620	779	342	018	700	115	866	510	432	252	080	822
13	150	309	286	080	588	255	712	266	773	128	092	230	000	981
14	926	805	890	637	989	513	389	256	430	501	631	533	579	301
15	782	246	748	302	960	312	279	907	734	643	347	602	513	065
16	547	770	055	859	506	916	431	044	184	362	484	064	919	144
17	472	078	091	855	595	362	485	866	426	897	565	934	748	838
18	841	497	453	355	794	063	114	674	897	855	582	887	726	759
19	506	508	905	685	294	441	723	106	329	899	651	361	648	329
20	188	746	117	340	936	942	876	616	770	672	769	737	097	068
21	648	618	520	017	240	178	862	570	961	252	659	198	117	773
22	527	177	163	439	899	550	154	221	648	762	000	150	284	747
23	201	232	015	597	643	972	353	256	400	324	286	429	975	845
24	883	382	991	330	564	764	143	888	694	703	574	189	172	560
25	363	821	762	199	771	516	659	759	477	645	571	045	699	084

Annex 7: The questionnaire:

Sudan University of Science and Technology
College of Post- Graduate Studies
Questionnaire for Estimation of Sorghum Yield
(Crop-cutting)

			General Information:
State	Locality	Admin Unit	
			Farmer Name :
Cultivated Area	( ) Fedd.	Harvested Area	( ) Fedd.

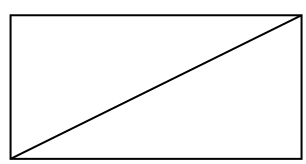
Field Diagram:

The Length ( ) Meter

The Width ( ) Meter

2 – Crop-cutting Results:

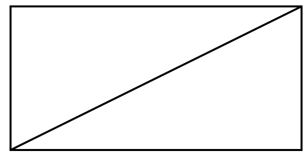
Plot Number (1):

Plot No. (1)	Page No.	Column No.	Row No.	The Random Number
Plot Selection:				
The Length (Field Length – Plot Length)				
The Width (Field Width – Plot Width)				
A = ------ Meter B = ------ Meter C = ------ Meter				

Plot (1) Crop cutting results:

Number of Heads	The weight (gram)	Empty sack weight	The net weight

Plot Number (2):

Plot No. (2)	Page No.	Column No.	Row No.	The Random Number
Plot Selection:				
The Length (Field Length – Plot Length)				
The Width (Field Width – Plot Width)				
A = ------ Meter B = ------ Meter C = ------ Meter				

Plot (2) Crop cutting results:

Number of Heads	The weight (gram)	Empty sack weight	The net weight