Sudan University of Science and Technology

College of Graduate Studies

Use of Factor Analysis Model to Study and Analyze the Livestock in Kordofan Region 2011 – 2012

إستخدام الأسلوب العاملي لدراسة وتحليل الثروة الحيوانية في أقليم كردفان

2012 - 2011

A thesis Submitted in fulfillment of the Requirements for the Degree of PH.D in

Statistics

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1435 – 2014

بسم الله الرحمن الرحيم

(وَلَمْ يَرَوْا أَنَّا خَلَقْنَا لَهُمْ مِمَّا عَمِلَتْ أَيْدِينَا أَنْعَاماً فَهُمْ لَهَا مَالِكُونَ)

صدق الله العظيم

سورة يس الآية (71)

Acknowledgment

First, I pray and thank my God ‘‘ALLAH‘‘ for his uncountable gifts to me. Without his assistance I could not be able to do any thing, much more thanks is to him.

I would like to express my sincere appreciation and gratitude to Dr. Adil Musa, department of Applied Statistics, University of Sudan, for his valuable supervision, helpful guidance, offered facilities, valuable advices, and continuous encouragement through performing this thesis.

Thanks to professor Dr. Faisal, thanks due to Dr. Sabine and Dr. Brain S.Everitt, Reader in Statistics, for his invaluable comment.

In addition, thanks are also, due to all who’s offered him any help in completing this thesis.

Dedication

I have the honor and the privilege to dedicate this humble effort which I hope to be a significant contribution and a useful tool in the development of the animal resources in Sudan therefore I would like first of all to dedicate it to soul of my father and to my mother and brothers and to my wife and to my son.

Abstract

The one of the important aspect affected supported Sudan economy in the livestock sector north Kordofan state play a major role in this field.

This research conducted during 2011 - 2012 and covers the factors affected livestock. The Objective of the research is to examine the underling structure of the animal resources in North Kordofan State.A sample size of 758. The data was collected using simple random sample (SRS). The collected data was statistically analyzed using factor analysis by SPSS, after the literature background was stated and the data was analyzed the researcher explained and discussed the results of analysis and come to some results as follows: Twelve factors were extracted for animal resources; which explain 63.14% of the total variance, the first factor is health of animal resources, which consists of three manifest variables. Second factor is type of farm, which contains two variables the third, is owner which contains two variables. Also there is some recommendations as follows: Increment of the vaccination campaigns, arise of the community wariness, and improve the animal health care, Provision water resources.

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مستخلص البحث

من أهم القطاعات المؤثرة في دعم الاقتصاد الوطني الثروة الحيوانية والتي تلعب ولاية شمال كردفان دور كبير فيها.

صمم هذا البحث في الفترة 2011 – 2012 وأشتمل علي العديد من العوامل المتعلقة بالثروة الحيوانية تهدف هذه الدراسة إلي معرفة أهم العوامل التي تؤثر علي الثروة الحيوانية في الولاية، جمعت عينة مكونة من 758 من ملاك الثروة الحيوانية باستخدام العينة العشوائية البسيطة وتم استخدام الطرق العلمية باستخدام برامج SPSS وتوصلنا إلي عدد من النتائج وهي ، تم استخلاص أثني عشر عامل تفسر 63.14% من جملة التباين الكلي ، العامل الأول هو صحة الحيوان ويحتوي علي ثلاثة متغيرات والعامل الثاني هو نوع المرعي ويحتوي علي متغيرين والعامل الثالث هو ملكية المرعي وتحتوي علي متغيرين، كما خرجت الدراسة بعدد من التوصيات وهي زيادة الحملات التطعيمية وزيادة الوعي بأهمية الثروة الحيوانية بالنسبة للمجتمع وتحسين صحة الحيوان وزيادة مصادر المياه.

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CHAPTER ONE

Introduction

1.0 Preface:

The one of the important aspect affected supported Sudan economy in the livestock sector Kordofan region state play a major role in this field. In recent years, livestock have taken on an increasing national importance because the increasing recognition of the contribution of livestock production to the national economy and exports.

1.1 problem of the research

What are the real features of Animal Resources in North Kordofan State?

What is the underlying Structure of the Animal Resources in North Kordofan State?

To what extent the Animal Resources variables could be reduced?

Many observed variables affect Animal Resources. But the real feature of the Animal Resources is scientifically unknown.

The animal resources in north kordofan need scientific study to solve many problems suffering from it.

1.2 Objective of research

There are many factors affected the population of the livestock in North Kordofan, taking consideration the quality and quantity, these factors are

1- Water Resources.

2- Animal Health Care.

3- Grazing and Pastures.

4- Education of live stock owner.

5- Nutrition

6- Animal Typing.

7- Female Salutary and Export.

8- Others factors related to livestock.

To use the factor analysis method to reduce the several variables affect the Animal Resources in North Kordofan State.

To examine the underling structure of Animal Resources in North Kordofan State.

To give recommendation, that helps.

1.3 Important of research

Due to the separation of the country and its possible consequence on the country economic in term of national income as a result of missing a significant part of income based on oil exports that went to southern part of the country according to the comprehensive peace agreement that led to session, its necessary to search for effective useful alternatives to fill the gap caused by the lost of oil which was one of the major sources of the hard currency.

Animal resources and agriculture was being the backbone of the country economy before oil explores therefore it can raise again as a strong alternatives if we know the good position of the country in this field beside the adequate factors that can easily lead to success this sector specially if we recognize the raising demand on animal products.

This research aims to contribute in finding and promoting the main factors

Those can affect the on development of animals in North Kordofan State through a statistical model to determine the most important factors using the Factor analysis model.

1.4 Justification of research

There are no enough, deep statistical studies about the animal resources in the state, and people who deal with statistics do not use any kind of statistical tools. Therefore this field lack information which of course help in making good decisions and develop the sect

1.5 Hypotheses of research

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the water resources?

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the vaccination?

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the diseases?

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the food?

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the export?

Are the main factors affect the situation of animal resources in north Kordofan state; relate to the slaughter?

(1) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the water resources.

(2) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the vaccination.

(3) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the diseases.

(4) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the food.

(5) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the export.

(6) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the slaughter.

(7) Main factors affect the situation of animal resources in north Kordofan state; do not relate to the compound variables.

1.6 Methodology of the research

The descriptive and analytic procedures will be used to analyze the data of animal resources variables, collected from ministry of agricultural, animal resources department, IFAD organization agricultural research also questionnaire was used to collected primary data from animal resources. Statistical packages such as SPSS will be used to analyze the data.

1.7 Geographical and time limits

The area of study is North Kordofan State. The year of studying 2011 - 2012.

1.8 Review studies:

The purpose of the literature review is to give the reader and overview of the animal resources in north kordofan.

Title of research: Studies on genetic and environmental factor affecting the milk production of the Egyptian buffaloBy: Rabie Ragab Sadek (1984) Gairo university faculty of agricultureNote that seven factors affecting of the milk production explain 53.8 of the total variance.

Other research: Studies on some factors affecting acquired immunity in chickensBy: Ahmed Hassan Mohamed Haridy , Doctor of philosophy on agriculture sciences (poultry sciences) Department of animal production , faculty of agriculture, Gairo university Egypt (2010).

Also research title: A confirmatory factor analysis of the core self-evaluation's construct and exploratory factor

Analysis of the Abercrombie self-evaluation construct measure and Epstein (2001) constructive thinking inventory

By

Ethan M. Abercrombie

A Dissertation Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy Capella University September 2005.

Budaev, S. 2010: Using principal components and factor analysis in animal behavior

Research: Caveats and guidelines. Ethology 116, 472-480.

APPLICATION OF MULTIVARIATE PRINCIPAL COMPONENT ANALYSIS TO MORPHOLOGICAL CHARACTERIZATION OF INDIGENOUS GOATS IN SOUTHERN NIGERIA

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Received July 22, 2011; accepted September 15, 2011

1.9 Organization of research

This thesis consists of five chapters:

The first chapter is the introduction which includes the methodological framework.

The second chapter is the literature review about previous study and animal resources in North Kordofan state; including historical background, the situation of animal resources achievement

The third chapter is the methodology, factor analysis, which represents the literature review of the research

The fourth chapter is about study and analyzes the data of animal resources

The last chapter about discussion it includes interpreting the results of a factor analytic procedure recommendation of the study.

CHAPTER TWO

KORDOFAN REGION

RANGE AND LIVESTOCK IN KORDOFAN REGION

2.0 Overview: The Greater Kordofan region (North Kordofan and South Kordofan) compromises an area of 380,000 Km^2 and has three main climatic zones: desert in the north, dry savannah in the central part and wet savannah to the south. Despite its environmental and ecological sectors diversity, the region represents an agro-ecological entity, where the different forms of resources management are strongly complementary. The region is linked to several parts of neighboring States and its borders are permeable to allow the complementarities mainly dictated by extensive livestock industry that represents the major activity for the rural population. Generally, the region cannot be isolated from the complex ecosystems puzzle of which Sudan is composed.

The climate of the region ranges from desert to semi-humid. It is hot throughout the year with maximum temperatures ranging from 42oC in May to 31oC in January. Minimum temperatures range from 24oC in May to 13oC in January. Rainfall is highly seasonal and erratic, decreasing from more than 750 mm in the south to less than 200 mm in the north. High temperatures and relative high winds characterize the area (Table 3.1). Drought is a frequent occurrence, averaging one year in ten in the higher rainfall areas of the south, but in recent times three years out of ten in the north.

2.1Natural range types in Kordofan region

a. Sparse vegetation: (Map1, Land cover), this range type covers an area of 3,479,314.6 ha (15% of the range area o Kordofan). Majority of this range type is found in North Kordofan in the Desert and semi desert ecological zone. Smaller areas of this range types also found in Rashad and the western parts of Dilling and Kadugli. The vegetation scanty and its cover is in the range of 5 – 15% (photo R1). Range productivity is in the range of 5 – 60 gm/m2 with a mean of 30 gm/m2. Trees density is in the range of 0 – 40 trees/ha with a mean of 7 trees/ha. Woody cover includes the following species: Acacia radiana, Acacia mellifera, Commiphora Africana Leptadenia pyrotechnica. Herbaceous cover includes: Aristida mutablis, Schoenofeldia gracilis, Tetrapogon spathaceus, Panicum turgidum, Chrysophora aucheri, Indegofera spp

2.1.1 Open grassland:

This is the smallest range type in Kordofan,covering an area of 1,975,827.5 ha (8%). Most of this range type is found in Mahaliyat El-Salam, smaller areas found at the wadies in Mahaliyat Sodary. The vegetation is dense (15 – 65%) with few shrubs sparsely distributed (photo R2). Range productivity is in the range of 10 – 165 gm/m2 with a mean of 75 gm/m2. Trees density is in the range of 5 – 302 trees/ha with a mean of 95 trees/ha. Woody cover includes the following species: Acacia radiana, Acacia mellifera, Commiphora Africana Leptadenia pyrotechnica, Acacia senegal, Combretum glutinosum, Guiera senegalensis, Adansonia digitata Acacia nubica Herbaceous cover includes: Aristida mutablis, choenofeldia gracilis, Tetrapogon spathaceus, Panicum turgidum, Chrysophora aucheri, Indegofera spp, Cenchrus biflorus, Ergrostis tremula, Aristida pallida, Aristida mutablis, Crotolaria spp

2.1.2 Trees and shrubs savanna: This range type represents the bulk of rangeland in Kordofan. It covers an area of 10,671,847.2 ha (44% of the range area). In North Kordofan it is found in the Semi-desert and Low-rainfall savanna on sand, in South Kordofan it is found in smaller areas in Low-rainfall savanna on clay in Abu Gibeiha and Abyei. Trees and shrubs cover ranges between 15 – 40% and the grass cover ranges between 15 – 65% (photo R3). Range productivity is in the range of 15 – 210 gm/m2 with a mean of 100 gm/m2. Trees density is in the range of 5 – 650 trees/ha with a mean of 120 trees/ha. Woody cover includes the following species: Combretum cordofanum, Dalbergia melanoxylon, Albizzia sericocephala, Guiera senegalensis, Scleorcaria birrea, Commiphora pedunculata, Lannea senegal, Terminalia brownie. Herbaceous cover includes: Eragrostis tremula, Cenchrus biflorus, Arsitida pallida, Ctenum elegans, Andropogon gayanus, Pennisetum pedicellatum, Blepharis linariifolia, Zornia glochdiata, Monechma hespidum, Brachiaria xantholeuca.

2.1.3 Woodland: Woodlands cover an area of 7,902,719.2 ha (33%) and most of it found in South Kordofan, with very small areas in wadies in Mahaliyat Sodary. This range types characterized by dense trees and shrubs, where the trees/shrubs cover exceed 65% (photo R4). Range productivity is in the range of 5 – 94 gm/m2 with a mean of 50 gm/m2. Trees density is in the range of 24 – 1750 trees/ha with a mean of 720 trees/ha. Woody cover includes the following species: Boswellia papyrefera, Combretum hartmannianum, Dichiostachys glomerata, Acacia mellifera, Cadaba spp, Boscia senegalensis, Acacia seyal, Balanites, Terminalia laxiflora, Sclerocarya birrea, Anogeissus schimberi, Prosopis african Herbaceous cover includes: Brachiaria obtusiflora, Cymbopogon nervatus Hyperrhenia spp, Setaria incrassate, Vetivera nigritana, Andropogon gayanus, Pennisetum ramosum, Loudetia hordieformis.

Table 2-1: Size of natural range types in Kordofan and their productivity.

Range Type	**Area (Ha)**	**Area (%)**	**Grass Prod. (gm/m^2)**	**Trees dens. (trees/ha)**
Open grassland	1,975,827.5	08.22	30	7
Sparse vegetation	3,479,314.6	14.48	75	95
Trees and shrubs savanna	10,671,847.2	44.41	100	120
Woodland	7,902,719.2	32.89	50	720
Total	**24,029,708.5**	**100**	**-**	**-**

Source: Ministry of Animal Wealth and Fishery

2.2 Feed balance in Kordofan

2.2.1 Livestock population: Kordofan region encounters huge numbers of livestock. According to season 2006/2007 total numbers of cattle is 7.9 millions, sheep is12.5 millions, goats is 7.9 millions and camels is 3 millions. All these animal population together is equivalent to 12.7 million animals units (AU). Table1 illustrates the distribution of animal population throughout different Mahaliyas of Kordofan.

2.2.2 Sources of animal feed: Kordofan is a unique region in its natural range resources. According to the range survey which was conducted by Range and Pastures Administrations in both States (North/South Kordofan) and El-Obied Agricultural Research Station for season 2006/2007, total amount of forage produced from natural rangeland (grasses and trees/shrubs browse) was estimated at 18.6 million tons and the crops residues were estimated at 2.9 million tons. Thus total feed available for livestock was estimated at 21.4 million tons. Table2 illustrates sources of animal feed at different Mahaliyas.

2.2.3 Situation of feed balance: Total livestock feed requirement was estimated at 23.2 million tons, when we subtract this from total available feed (21.4 million tons), there is gab of almost 1.7 million tons (11% of Kordofan herds feed requirement). Table3 indicates situation of feed balance in Kordofan.

Table2-2: Animal population and their equivalent animal units (AU) at different Mahaliyas of Kordofan.

Locality	Cattle	Sheep	Goats	Camels	AU[1]
Shikan	261,880	1,334,866	432,056	351,460	879,651.60
Bara	4,263	1,023,105	630,308	227,144	529,508.45
Um Ruwaba	343,488	619,132	556,602	179,358	644,290.70
Sodari	548	658,651	254,156	359,594	529,858.60
Gabra	1,217	711,002	294,821	213,913	401,249.30
Gubeish/WadBanda	143,920	1,877,400	573,650	725,040	1,294,507.50
Nahud/AbuZabad	71,960	2,461,480	1,335,040	130,910	877,432.00
Kadugli	758,240	377,128	474,689	72,849	788,157.95
Dilling	505,343	236,177	394,563	64,559	549,986.10
Rashad	534,343	326,177	43,063	81,559	554,011.10
Abu Gibeiha	675,793	396,402	496,002	72,819	733,344.45
Talodi	857,240	458,628	533,436	88,609	903,280.00
ElSalam	1,465,116	798,888	721,707	233,325	1,600,195.65
Abyei	1,625,116	548,888	489,707	110,225	1,512,295.65
Lagawa/Keilak	713,488	665,184	637,609	104,533	868,327.15
Total	**7,961,955**	**12,493,108**	**7,867,409**	**3,015,897**	**12,666,096.20**

Source: Ministry of Animal Wealth and Fishery (2007). [1]AU is equivalent to 0.75 cow, 1.0 camel, 0.2 sheep and 0.15 goat (FAO, 1991)

Table2-3: Sources of animal feed at different Mahaliyas.

Locality	From Rangeland (ton)1	Crop residues (ton)2	Total forage Production (ton)
Bara	645,576.15	544,241.00	1,189,817.15
Gabra	1,270,450.11	32,134.96	1,302,585.07
Gubeish/WadBanda	683,240.11	49,652.57	732,892.68
Nahud/Abu Zabad	1,060,948.60	587,338.12	1,648,286.72
Shiekan	446,912.20	85,742.98	532,655.18
Sodary	846,552.20	42,415.34	888,967.54
Um Ruwaba	625,615.76	609,586.80	1,235,202.56
Abyei	2,604,761.60	254,371.00	2,859,132.60
El Salam	2,139,404.10	62,861.70	2,202,265.80
Lagawa/lKeilak	687,417.60	41,458.50	728,876.10
Kadugli	1,676,747.12	55,154.68	1,731,901.80
Dilling	2,426,972.07	184,244.71	2,611,216.78
Rashad	381,767.76	84,836.75	466,604.51
Abu Gibeiha	2,464,245.26	194,606.45	2,658,851.71
Talodi	602,972.01	57,313.38	660,285.39
Total	18,563,582.65	2,885,958.94	21,449,541.59

1Forage from rangeland includes grasses and trees browse.

2Crop residues production (ton/ha): Millet 0.517, sorghum 0.800, sesame 0.452, groundnut 0.500, watermelon 0.175, roselle 0.230 and cowpea 0.712 (El-Hag et. al, 2003)

Table2-4: Situation of feed balance in Kordofan (season 2006/2007).

Locality	Forage Production (ton)	Forage Requirement (ton)	Balance (Surplus/ shortage)	% Surplus/ shortage
Bara	1,189,817.15	900,164.37	289,652.78	32.18
Gabra	1,302,585.07	778,358.97	524,226.10	67.35
Gubeish/WadBanda	732,892.68	2,200,662.75	1,467,770.07	-66.70
Nahud/Abu Zabad	1,648,286.73	1,491,634.40	156,652.33	10.50
Shiekan	532,655.18	1,495,407.72	-962,752.54	-64.38
Sodary	888,967.65	900,759.62	-11,791.97	-1.31
Um Ruwaba	1,235,202.56	1,095,294.19	139,908.37	12.77
Abyei	2,859,132.70	2,570,902.61	288,230.09	11.21
El Salam	2,202,265.80	2,720,332.61	-518,066.81	-19.04
Lagawa/lKeilak	728,876.00	1,476,156.16	-747,280.16	-50.62
Kadugli	1,731,901.80	1,339,868.52	392,033.28	29.26
Dilling	2,611,216.78	1,329,626.64	1,281,590.14	96.39
Rashad	466,604.51	941,818.87	-475,214.36	-50.46
Abu Gibeiha	2,658,851.71	1,760,026.68	898,825.03	51.07
Talodi	660,285.39	2,167,872.00	1,507,586.61	-69.54
Total	21,449,541.71	23,168,886.11	1,719,344.40	-11.32

2.3 Land Use and Farming Systems

According to the Land Settlement and Registration Act (LSRA) of 1925, all land unregistered prior to that date is government land. Also, the Unregistered Land Act (URLA) of 1970 stated that all unregistered land is State-owned, but local peoples have usufructuary rights on it. Accordingly, all lands in West Kordofan, apart from that of urban centers, fall under the LSRA. The usufructuary right is recognized and legalized through customary laws "Aruf". Native administrations at different levels are the ones who are responsible for land allocation and management of land resources.

Pastoral and agro-pastoral systems are the mainstay of the economy. Livestock production systems in the State could be classified into:

2.3.1 Transhumant system: Transhumants migrate seasonally along traditional grazing routes. Cropping activities play relatively minor roles in the system. Crops grown include millet, sorghum, sesame, groundnut, watermelon. Transhumants usually raise sheep, goats and cattle. Messeriya and Hawzma Arab groups are good examples of this subsystem.

2.3.2 Sedentary system: This system includes both agronomic and livestock components and is dominated by cropping activities. Sheep are the predominant animal raised with considerable numbers of goats. The Hamar ethnic group is an example of this system. This system is distinguished and characterized by:

- **a.** Intensive use of areas around settlements or small favorable sites,
- **b.** Relative immobility of residence.
- **c.** Short growing season depending on rains.
- **d.** Frequent migration during the slack season.
- **e.** Some animals are kept in the household for frequent use.
- **f.** Subsistence and cash crops are grown.

2.3.3: Greater Kordofan total livestock wealth is estimated at around 12 million heads (Table 3.3). The animal wealth comprises cattle, sheep, camels and goats. Climatic features and soils are characterizing each ecological sector and rangeland type. Also other factors, like diseases and parasites, govern the management of flocks and the rangeland utilization. Pastoralism is the most dominant production system in this area. Large flocks are used to move from south to north during the rainy season (July-October) and vice-versa in the dry season (October-June).

Hawazma groups migrate at the same rhythm but from west to east within the southern parts of south and west Kordofan States. This grazing pattern is modified during drought periods, when large herds of camels migrate to browse on forage trees in central and southern parts of south and west Kordofan States. Sheep migrate during the dry season but do not move as far south as camels.

2.4 Migration patterns: There are 20 main stock routes in greater Kordofan States, 6 in S.Kordofan, 5 in N. Kordofan and 9 in west Kordofan. Many stock routes are shared by at least two States, which reduces the number to 11 tracks. Due to civil strife, some stock routes have been abandoned and nomads opened instead new ones such as between El liri-Kalogi-Dalami. In addition, some mechanized farms as well as traditional farming have been established across or too close to many stock routs, and resulted to frictions between several groups and disturbance of the whole migration pattern. The average length of stock route is about 180 Km in either direction. Along each stock route there are about 10 camping or resting stations called Makhta, where stock and men stop for one or two days before moving again.

The seasonal one-way journey takes about six weeks depending on the availability of water and grazing along the stock route. Therefore, nomads and their flocks spend about three months on move. Whatever trend and regardless of the length of the stock route, it seems that the magnitude and the direction of the migratory flocks are dictated by mutual interests and alliances/conflicts between groups. Nomads move from north to south and vice-versa i.e. in dry season they migrate southwards to the higher rainfall regions and as far as Bahr Elarab, when security is not an obstacle, and during the wet season they retreat north wards to escape Tsetse flies and muddy conditions.

In normal rainfall year, most of the nomads go towards the north to stay in their wet season for about three months before returning south. In years of poor rainfall, they usually reduce the magnitude of traveling and they often return south earlier, within four to six weeks. Utilization of stock routes obeys the basic rules well known by each groups using the same routes. Before moving, the scout "known as Mandoub, Rawwag" of the group inspects the whole route, evaluate suitability of forage resources and water and lifts any encountered major social problems.

2.5 ANIMAL FEED RESOURCES

National herd at different ecological zones under traditional pastoral production system depends mainly on grazing and browsing. In the drier areas where Acacias are predominant, fruits (seed pods), twigs, flowers and leaves are main browse materials. In the wetter areas to the south where broad-leafed plants are dominant, livestock depend heavily on tree foliage. The most important feature of the forest fodder is availability during dry season when all other types of grasses are already exhausted. In Sudano-Sahelian countries, browsing represents at least 20 % of livestock diet during dry season (Table 3.4).

Table 2-5: Some trees and shrubs in the study area.

Species	Utilizable part*			Animal type**					
	L	F	FS	C	S	G	CM	W	B
Haraz	+	5	+	5	+	+	+	+	5
Kitter	+	+	+	5	+	+	+	+	+
Sunt	+	5	5	5	+	+	+	0	0
Sayal	+	5	+	5	+	+	+	+	+
Tabaldi	+	5	0	+	+	+	0	0	0
Hajlag	+	0	+	+	+	+	+	+	0
Tundub	5	0	0	0	+	+	0	5	0
Gafal	+	-	-	0	5	+	+	0	-
Ushar	5	-	5	-	-	5	-	-	0
Karot	+	5	+	+	0	+	+	5	0
Godeem	+	-	5	5	+	+	+	5	0
Gubish	+	+	5	5	5	+	+	0	0
Marikh	+	+	5	+	+	+	5	+	5
Sarih	5	+	+	5	+	+	0	0	+
Sider	5	5	5	5	5	5	5	5	5

Utilizable part*: L=leaves, F=flowers, FS= fruits, seedpods
Animal type**: C = cattle, G=goats, S= sheep, CM= camel, W= wild animals, B=bees

Palatability: (+) = palatable very important, (5) = less important, (-) = not palatable not important, (0) =No available data

Table 2-6: The Hamari sheep numbers at Dar Hamar area, Western Kordofan.

Location (Mahalia)	Number
EnNhud	1,650,000
Gubeish	2,100,000
Total	3,750,000

Source: Ministry of Agriculture, Western Kordofan State Report 2004.

2.6 Husbandry System(s)

2.6.1 Herding: Sheep farming is practiced under both pastoral and agro-pastoral systems, together with other cash and food crops, on communal open rangelands. During the rainy season (July- October) sheep graze the lush in the southern parts. When the time comes for the flowering of "shilini"; a dominant grazing leguminous grass (Zornia spp.), and multiplication of mosquitoes, sheep breeders move further north to avoid the bloat (mortality rate of 4-5%) caused by shilini and mosquito bites and mud. The early rain showers in June and July produce the lush vegetation, commonly called "Shogara". Animals are rapidly gaining weight and recover soon enough, a condition known as compensatory growth. The heavy rainfalls in mid July generate abundant vegetation in the south for early grazing. Afterward, the north migration starts steadily to escape vectors, flies and predators. It is generally believed that the northern ranges are better in quality compared to the southern ranges.

2.6.2. Night Grazing: Night grazing is a common practice particularly during the dry seasons. It starts usually at 6:00 pm up to 2:00 am using one shepherd while the other is sleeping. The other shepherd takes over herding up to 10:00 am next morning. By this time, the animals are taken to shade. Thus, heat stress is avoided, feed intake is improved and the ovulation rate is expected to increase as well. Shade for the animals during the daytime is of paramount importance. Grazing areas that are without some tree cover to be used as shade are left underutilized.

Prolonged camping in a certain grazing area is not recommended. Frequent shifting of camps and night bedding areas (3-4 days) is essential for the animals to forage on uncontaminated sites. Generally, the Hamari sheep are not adapted to long confinement and tethering. Nevertheless, any transfer of Hamari sheep from their normal habitat areas is usually associated with high mortality rates.

2.6.3 Watering: During the rainy season (July-October), the animals' requirements are met by total dependence on green grass as source of both water and energy/protein. Other than the water collected on the natural and artificial ponds, animals are not systematically provided with water during the rainy season. However, monthly watering is the general norm during the rainy and 15 days interval during the winter (November-February) seasons, respectively. Lignifications of the grass cover take place in summer (March-June) due to the transformation of nutrients to the seeds or root system. The available rangelands for grazing are coarse and poor in quantity and quality. Phosphorus and Vitamen A deficiency are not uncommon in these rangelands. Therefore, summer is the most critical period for sheep production in Western Sudan. Not only that the range nutritive value drops, but also the drinking water become scarce and problematic and the ambient temperatures become intolerable. As a result, mortality rates increases to the peak. The harsh climatic conditions of the summer season have forced sheep owners to spend the season near the watering points (7-10 km) and the watering interval reduces to 3-5 days interval. However, longer watering intervals during summer in the range of 6-7 days are also common. These areas are already denuded and the good grazing areas are becoming beyond reach. Towards the end of the summer season, animals become more emaciated and the mortality rates reach 30-35% to the total flock.

2.6.4. Salt Provision: Common salt "Atron" or "Dirairi" is supplied every 3-4 days ad libitum or in drinking water; the former practice is most common. Frequent provision of salt in summer may not be recommended because it increases water requirement, which is both expensive and scarce. Salt is provided to meet the requirements for minerals

2.6.5. Breeding: Breeding season is controlled in such away that lambing coincides with the availability of nutritious grass cover on the open ranges. Through the use of "Kinan" (Plate 4.III)., the breeding rams are allowed to serve the ewes only in winter (February first to 15th) to have the lambing season begins with the onset of the rainy season in July.

The "Kinan" is a double-looped string attached to the upper part of the scrotum and extended to the front of the prepuce, preventing the penis from emerging. Thus, off-season breeding of ewes is minimized. In spite of the "Kinan", however, some ewes get served in September-October to lamb during the dry season. Carefulness has to be exercised otherwise deaths in both lambs and ewes are expected. The "Kinan" is released and rams are set free in February for 30 to 40 days. The mating process is cumbersome due to the hindrance of the flabby base tail of the ewes. To ensure successful breeding season, mating progression is usually assisted by a shepherd by holding the ewe's tail while the ram stands by to mount. Therefore, extra shepherds are required to be hired for the mating assistance. Generally, the conception rate and the flock twinning rates are 70-80% and 12-15%, respectively, (Table 4.3) and are mainly depend on herding and grazing conditions.

Table 2-7: Production and reproductive performance of the Hamari in Western Kordofan State.

Parameter	Male	Female
Birth weight (kg)	3.6	3.4
Weaning weight (kg)	28.5	25.0
Weaning age (months)	3.0	4.0
Age at first lambing (months)	--	24.0
Average No. of services/ conception	--	3.0
Flock lambing rate (%)1	--	70.0-80.0
Twinning rate (%)2	--	65.0-70.0
Abortion rate (%)	--	12.0-15.0
Adult mortality rate (%)	--	10.0

Lamb mortality rate (%)	10.0	25.0
Marketing weight (kg)	45.0	40.0
Culling age (years)	5.5	7.0

[1] Flock lambing rate is the numbers of ewe lambed/flock/year.

[2] Twinning rate is the number of ewes that born twin lambs/breeding season.

2.6.6 Conception Rate: The females in the flock are allowed to mate up to three times if they keep returning to oestrus. The average conception rate is around 80%. The ewes that missed conception (20%) are treated as infertile in the flock and are fattened and culled.

The low conception rates and the high return rates to oestrus are affected by body condition at breeding, level of ram's semen quality, heat stress and the level of assistance during mating period. The breeders believed that poor semen quality and ram infertility are associated with exposure of breeding rams to heat stress.

2.6.7 Lambing: Lamb crops are delivered in July, the effective beginning of the rainy season. About 70% of the ewes in the flock lambed a year. The lambing period is called "Bahla" and like the breeding season, additional assistance is also required to help in delivery, new born collection and assist in suckling of the colostrums. Close grazing of mothers to the camp is desirable during the lambing period. To reduce lamb refusal, particularly in the first lambing ewes, mothers are kept with their young for 2 to 3 days to develop the mother/young bonds (imprinting). The newly born lambs are separated from their dams during the day, guarded and herded to nibble on the lush around the camp with the purpose to initiate development of an earlier rumen function. The orphan lambs and those refused by their dams are taken care off by allowing them to nurse on good milking ewes or on dams that lost their lambs. Before sunset, the returned ewes from grazing are allowed to nurse their young and stay together until next morning. The young lambs are herded to develop rumen micro-organisms and at one month old, the lambs are allowed to join their dams on a permanent basis.

2.6.8 Twinning Rate: Twinning in the flock is directly related to flushing status before and after breeding. Good pasture condition and/or two weeks supplementation before mating should increase twinning rate tremendously. Generally, in the traditional system of Hamar rearing, the twinning rate is about 12.0-15.0%. Triplets might occur but at a very low rate. Nonetheless, the majority of producers interviewed during the course of this study stated that twinning is rare and never exceeds 5.0%.

2.6.9.Weaning: At about three months old, the male lambs are weaned and the females are weaned at 4-6 months of age or till next breeding time of their dams in some management systems. Occasionally, the weaned lambs (28.5 kg) are preferentially taken to graze on crop aftermath. The fields are sold from crop farmers: a ten "Mukhamas" field is purchased for about SD13500.

2.6.10 Castration: Castration is done when the breeder wishes to sell his produce late i.e. the marketing age would be at 4-5 years old for export or for local consumption. In recent years, the marketing age is reduced to about 7-8 months old. The young animals "called Hadi" are taken to Saudi Arabia during El-Haj time and Eid El-Adha to be slaughtered as sacrifice animals by the pilgrims.

2.6.11 Culling: Generally, ewes are culled after the 4th lambing season i.e. at age of seven years old. During the fifth season, the designated culled ewes are left open and sold for slaughter. Skip breeding is a sort of fattening process. However, the replacement rate is about 20-25% in most flocks. Animals that are sick and/or deformed that are low milk producers and of low twinning rate are culled from the flock and sold. The breeding rams are culled at age of six years; sometimes castrated and sold

The female lambs that are born in July may reach puberty at seven months of age and they can breed with their dams in February the same year of the breeding season. However, this best scenario may not always be the preferred existing case. Most female lambs breed the first time at about 19 months of age. Both breeding ages are influenced by range condition. Generally, unfavorable conditions delays puberty and hence, shorten lifetime productivity.

2.7 Flock Size and Management: Flocks are generally smaller in size; they contain about 100 breeding ewes. Larger flock sizes are associated with difficulties such as mating, lambing and general herd management. The usual herd size ranges from 100 to 300 heads per individual flock. An owner may maintain more than 1000 heads but must be divided into small manageable sub-flocks.

Two shepherds, plus the owner or otherwise, are required to manage a flock or sub-flock. One could be a teenager to be able to take more responsibilities and the other could be younger. Shepherds are hired on yearly basis on kind or monthly salary. The common practice is to give 10-15 lambs of new crop per shepherd per year plus supplementation of the necessary food items and clothing. For transportation, camp-water carrying and for emergencies, two donkeys or one donkey and a camel are required per flock.

2.8 **Flock Health and Disease Control:** A healthy animal is the most important factor for the producer to ensure high productivity and production efficiency. In order to have that healthy animal, diseases and disease problems that affect the animal should be prevented and controlled. Disease can be defined simply as any abnormality in the functions and tissues of the animal body.

2.8.1 Disease causing organisms: These diseases can be classified into five major categories as follows:

i. Viral Diseases: These are minute transmissible particles, which multiply only inside the living cells of specific host. This process sometimes damages the cells and causes disease.

ii. Bacterial Diseases: Single celled organisms found everywhere but only some are pathogenic. They cause disease by secreting toxins. It is classified as part of the vegetable kingdom; the pathogenic types include internal cellular bacteria (rickettsia) such as heart water, mycoplasms such as contagious agalactia of sheep and goat, branching and spiral bacteria such as leptospirosis, vibriosis and the true bacteria such as anthrax.

iii. Fungi: Members of vegetable kingdom but do not contain chlorophyll. They possess a differentiated body. Most of them that cause disease in animals are known as fungi imperfecti.

iv. End parasitic Protozoa: These include the whole parasites that live within the animal body. They can be divided into two groups; mainly the flat warms that include flukes and tape warms, and the round warms or the so called nematodes.

v. Ectoparasitic Protozoa: These include the insects (flies and mosquitoes, lice and fleas) and the accari (mites and ticks)

2.8.2 Common Diseases of Sheep: The number of diseases reported among tropical sheep is generally less than that for cattle. The greatest total loss in sheep is due to diseases of debilitating sort that causes reduced productivity rather than death. Most common diseases in sheep (Table 4.4) need proper diagnosis for their prevention and control.

Table 2-8: Common Diseases of sheep

No	Disease	Causative agent	Major symptoms sickness	Treatment
1	Haemorrhagic septicaemic	Virus, but chiefly pastureland multocida .	Fever, depression, cough, rapid breezing and seeing death sometimes after24hours.	Prevention, treatment &vaccination.
2	Anthrax	Bacillus anthracis	Sudden death, blocdy discharges from body opening .	Preventive vaccination .
3	Blackleg	Clostridium chewoei	High fever, off focd, characteristic swelling under skin that crackles to the touch.	Preventive vaccination
4	Brucellosis	Brucella melitensis.	Abortion and uterus infection orchitis in male.	Good hygiene and preventive vaccination
5	Tetanus	Clostridium tetani	Rigidity of muscles ,especially these of head ,stillness.	Antitoxins, musde relaxent, penicillin.
6	Mastitis	Various types of bacteria.	Swelling of udder, abnormal secretion of milk.	Antibiotic injection, udder infusion.
7	Navel infection	Various types of bacteria.	Weak lambs.	Antibiotic injection.
8	Pneumonic tike	Viral, bacteria	Various from of suppurative pleura	Good overall management,

	conditions	and protozoan.	pneumonia to chronic progressive pneumonia.	antibiotic.
9	Foot rot	Fungi and other pus formers.	Lameness caused by pus formation between heef &underlying tissues.	Application of antiseptics.
10	Blue tongue	Virus, 16 antigenic strains.	Fever, depression, lack of appetite, ulceration of mucous membranes tongue swollen and blue.	Preventive vaccination
11	Foot mouth disease	Virus, 7serotypes.	Eruption of vesicles in mucous membranes of mouth and on skin of digit.	Vaccination
12	Sheep pox	Filterable virus.	High fever, loss of appetite, blister like formations on the mouth between hind legs &udder	Vaccination and good care.
13	Rinderpest tick disease p.p.k.	Virus .	High fever, diarrhoea and death.	Vaccination
14	Heart water	Cowdria rumination	Fever, laboured respiration, anorexia, tremors convulsion death	Antibiotic, control of ticks.
15	Anaplasmosis.	Anaplasmosis species	Fever, anaemia jaundice ad debility.	Broad spectrums antibiotics .

2.9 Health Status and Common Diseases in West Kordofan State: Reference to the agricultural census for the year 2003 of the Ministry of Agriculture and Animal Resources of West Kordofan State, 70% of sheep in the area was reported to be in a good health. Mortality rate was about 3%

in lambs and about 2% in adult sheep. However, 75% of deaths were reported to be due to heat stress lack of drinking water at the proper time.

Many diseases were mentioned by the interviewed farmers in the area. These included endoparasites and various levels of pneumonias (Table 4.5). However, some of the problems mentioned might be symptoms of certain diseases; especially abortion may be due to Brucellosis which needs confirmation. Nonetheless, the low incidence of disease in the area indicated that the cost of treatment of one sheep could be very cheap if proper management and veterinary care were carried out properly.

Table2-9: Common diseases reported in Kordofan State.

No	Disease	Local Name	Arabic Name
1	Haemorrhagic		تسمم دموى
2	Anthrax		الحمى الفحمية
3	Feet &mouth	Abu Reyallah	ابو لسان / ابو ريالة
4	Heart water	Abu merare	الخدر /ابو مرير
5	Sheep pox	Nammah	الجدرى /نامه
6	Blackleg	Abu tataa	ابو زقاله / ابو تعتاع
7	Pneumonia	AbuFehayfeesh	التهـــاب رئـــوى /ابـــو قشيفيش
8	Internal & external parasites	Holla	ديدان /هلاع
9	Bloat (disease symptom)	Elsumt	نفاخ /السمت
10	Abortion	Torah	إجهاض / طراح
11	Foreign bodies	Umdraidmat	جســـم غريـــب / ام دريدمات

Furthermore, The field visit to the area reveals that diseases and problems that face producers' sheep flocks are these caused by internal and external parasites together with different types of pneumonia and sheep pox. These diseases can be easily controlled by proper management and effective use of the disease control programmes with well trained staff, supplied with proper and necessary equipment for routine diagnosis, prevention and vaccination.

2.10 Veterinary Services in West Kordofan: Veterinary services in the area are very few and located far away form sheep producing areas (Table 4.6). Private services are available near market places and governmental services in the main towns. However, these services are available on call.

Table 2-10: Veterinary Services in North Kordofan State.

	Vet. Unit	NO	Area
1	Vet. Hospital	5	EnNhud, Gubeish, ElKhewi, Abu Zabad, Elfala.
2	Mobile Vet. Clinic	3	Elnuhud, Gubeish, Elfula.
3	Vet. Dispensary	4	Foga, Wad. Banda, Elsugu, Elodaga.
4	Vet. Pharmacy	15	EnNhud, Gubeish, ElKhewi, Elfula, Abzabad.
5	Drug store	10	EnNhud, Gubeish, ElKhewi. Abu Sabad, Foga, Wadbanda, Elsugu, Ayal Bakheet.

2.11 Size rangeland in Kordofan

To calculate size of natural rangeland, FAO-AFRICOVER dataset was adopted. This dataset is a spatially re-aggregated version of the original national Africover Land cover multipurpose database. The land cover has been produced from visual interpretation of digitally enhanced LANDSAT TM images (Bands 4,3,2). The land cover classes have been developed using the FAO/UNEP international standard LCCS classification system. The table below shows the various land cover/ Land classes in the State and their acreages at locality level

Table 2-11: Size of Land cover/Land use types in the Localities of Kordofan state

State	Locality	Land cover/use type	**Area (Ha)**
North Kordofan	Sodary	Agriculture	87,635.00
		Rangeland	3,137,121.78
		Woodland	574,988.95
		Bare areas	3,614,707.20
		Settlement	4,305,.93
		Total	**7,418,758.86**
	Bara	Agriculture	1,124,464.89
		Rangeland	1,420,309.88
		Woodland	302,314.20
		Bare areas	2,610.48
		Settlement	21,027.86
		Total	**2,870,727.29**
	Sheikan	Agriculture	177,154.92
		Rangeland	493,475.57
		Woodland	110,377.72
		Bare areas	-
		Settlement	5,137.85

		Total	**786,146.06**
	Nahud/ Abu Zabad	Agriculture	1,213,508.52
		Rangeland	1,976,308.01
		Woodland	117,710.45
		Bare areas	12,006.43
		Settlement	5,814.83
		Total	**3,325,348.29**
	Gubeish/ Wad Banda	Agriculture	102,587.96
		Rangeland	1,331,154.75
		Woodland	416,482.69
		Bare areas	3,739.69
		Settlement	514.04
		Total	**1,854,479.16**
	Gabra	Agriculture	66,394.54
		Rangeland	2,280,917.80
		Woodland	356,111.40
		Bare areas	2,465,010.90
		Settlement	1,341.86
		Total	**6,169,776.51**
	Um Ruwaba	Agriculture	1,259,476.83

		Rangeland	707,587.67
		Woodland	338,457.60
		Bare areas	1,092.31
		Settlement	4,145.35
		Total	**2,310,759.76**

Table 2-12: Size of Land cover/Land use types in the Localities of South Kordofan State

State	Locality	Land cover/use type	Area (Ha)
South Kordofan (East Section)	Dilling	Agriculture	380,670.89
		Rangeland	679,721.67
		Woodland	789,663.52
		Bare areas	12,488.32
		Settlement	2,230.06
		Total	1,864,774.46
	Kadugli	Agriculture	113,955.96
		Rangeland	314,661.18
		Woodland	675,484.55
		Bare areas	49,284.28
		Settlement	2,676.07
		Waterbodies	669.02
		Total	1,156,731.06
	Abu Gibeiha	Agriculture	402,079.45
		Rangeland	955,133.82
		Woodland	898,713.35
		Bare areas	0.0
		Settlement	1,338.03
		Total	2,257,264.65

	Rashad	Agriculture	175,282.55
		Rangeland	444,450.54
		Woodland	229,249.69
		Bare areas	1,115.03
		Settlement	0.0
		Total	850,098.08
	Talodi	Agriculture	118,416.08
		Rangeland	233,710.08
		Woodland	1,420,323.90
		Bare areas	5,352.14
		Settlement	0.0
		Total	1,777,802.20

Continues

South Kordofan (West Section)	Lagawa Keilak	Agriculture	85,658.01
		Rangeland	339,969.08
		Woodland	660,448.33
		Bare areas	12,617.14
		Settlement	00.0
		Waterbodies	142.45
		Total	1,048,835.01
	Abyei	Agriculture	525,560.07
		Rangeland	701,713.77
		Woodland	1,876,027.20
		Bare areas	00.0
		Settlement	1,672.04
		Waterbodies	00.0
		Total	3,104,973.08
		Agriculture	129,879.52
	El Salam	Rangeland	1,091,532.70
		Woodland	499,272.87
		Bare areas	00.0
		Settlement	1,286.46
		Waterbodies	369,45
		Total	1,722,341.00

Source: AFRICOVER Project (2004)

CHAPTER THREE

Factor Analysis

3.1 The history of factor analysis can be traced back into the latter half of the nineteenth century to the efforts of the British scientist Francis Gatton (1869-1889) and other scientists to discover the principles of the inheritance of manifest characters (Mulaik , 1985-1987).

3.1.1 Hypothesis evaluated with test:

The primary hypothesis evaluated within the framework of procedures described the determination with respect to whether or not each of the derived components or factors makes a significant contribution in explaining the total variability in the data.

Factor analysis is a statistical method used to describe variability among observed variables Statistics is the science of the collection, organization, and interpretation of data. It deals with all aspects of this, including the planning of data collection in terms of the design of surveys and experiments...

3.1.2 Model Definition and Assumptions

Factor analysis is basically a one-sample procedure [for possible applications to data with groups, see Rencher (1998, Section 10.8)]. We assume a random sample $y_1, y_2, \dots, y_n$ from a homogeneous population with mean vector and covariancematrix .

The factor analysis model expresses each variable as a linear combination of underlying common factors f1, f2, . . . , fm, with an accompanying error term to account for that part of the variable that is unique (not in common with the other variables). For $y_1, y_2, \dots, y_p$ in any observation vector y, the model is as follows:

$$y1 - \mu1 = \lambda11\ f1 + \lambda12\ f2 + \cdots + \lambda1m\ fm + \varepsilon1$$
$$y2 - \mu2 = \lambda21\ f1 + \lambda22\ f2 + \cdots + \lambda2m\ fm + \varepsilon2$$
$$\dots \qquad \dots \qquad (3.1)$$
$$yp - \mu p = \lambda p1\ f1 + \lambda p2\ f2 + \cdots + \lambda pm\ fm + \varepsilon p.$$

a simple expression for the variance

of y_i,

$$\text{var}(y_i) = \lambda_i^2 1 + \lambda_i^2 2 + \cdots + \lambda_i^2 m + \psi i, \quad \ldots \quad (3.2)$$

which plays an important role in our development. Note that the assumption
$\text{cov}(\varepsilon i, \varepsilon k) = 0$ implies that the factors account for all the correlations among
the y's, that is, all that the y's have in common. Thus the emphasis in factor analysis
is on modeling the covariances or correlations among the y's.
Model (13.1) can be written in matrix notation as:

$$\mathbf{Y} - \mu = \wedge \mathbf{f} + \varepsilon \quad \ldots \quad (3.3)$$

where $\mathbf{y} = (y_1, y_2, \ldots, y_p)'$, $= (\mu 1, \mu 2, \ldots, \mu p)'$, $\mathbf{f} = (f_1, f_2, \ldots, f_m)'$, $\varepsilon = (\varepsilon_1, \varepsilon_2, \ldots\ldots \varepsilon_P)$, and

$$\wedge = \begin{pmatrix} \lambda 11 \; \lambda 12 \cdots \lambda 1m \\ \lambda 21 \; \lambda 22 \cdots \lambda 2m \\ \ldots \\ \ldots \\ \ldots \\ \lambda p1 \; \lambda p2 \cdots \lambda pm \end{pmatrix} \quad \ldots \quad (3.4)$$

The assumptions listed between (3.1) and (3.2) can be expressed concisely using vector and matrix notation: $E(f_j) = 0$, $j = 1, 2, \ldots, m$, becomes

$$E(\mathbf{f}) = \mathbf{0}, \quad \ldots \quad (3.5)$$

$$\text{var}(f_j) = 1, j = 1, 2, \ldots, m, \text{ and } \text{cov}(f_j, f_k) = 0, j \neq k, \quad \ldots \quad (3.6)$$

$E(\varepsilon_i) = 0$, $i = 1, 2, \ldots, p$, becomes

$$E(\varepsilon) = \mathbf{0}, \quad \ldots \quad (3.7)$$

ORTHOGONAL FACTOR MODEL

$$y_1 - \mu_1 = \lambda_{11} f_1 + \lambda_{12} f_2 + \varepsilon_1$$
$$y_2 - \mu_2 = \lambda_{21} f_1 + \lambda_{22} f_2 + \varepsilon_2$$
$$y_3 - \mu_3 = \lambda_{31} f_1 + \lambda_{32} f_2 + \varepsilon_3 \qquad \ldots \qquad (3.8)$$
$$y_4 - \mu_4 = \lambda_{41} f_1 + \lambda_{42} f_2 + \varepsilon_4$$
$$y_5 - \mu_5 = \lambda_{51} f_1 + \lambda_{52} f_2 + \varepsilon_5.$$

var$(\varepsilon_i) = \psi_i$, $i = 1, 2, \ldots, p$, and cov$(\varepsilon_i, \varepsilon_k) = 0$, $i \neq k$, become

$$\text{cov}(\varepsilon) = \psi = \begin{pmatrix} \psi_1 & 0 & \cdots & 0 \\ 0 & \psi_2 & \cdots & 0 \\ & & \vdots & \\ 0 & 0 & & \psi_2 \end{pmatrix} \qquad \ldots \qquad (3.9)$$

and cov$(\varepsilon_i, f_j) = 0$ for all i and j becomes

$$\text{cov}(\mathbf{f}, \varepsilon) = \mathbf{O}. \qquad \ldots \qquad (3.10)$$

In matrix notation as in (3.3), this becomes

$$\begin{pmatrix} y_1-\mu_1 \\ y_2-\mu_2 \\ y_3-\mu_3 \\ y_4-\mu_4 \\ y_5-\mu_5 \end{pmatrix} \begin{pmatrix} \lambda_{11} & \lambda_{12} \\ \lambda_{21} & \lambda_{22} \\ \lambda_{31} & \lambda_{32} \\ \lambda_{41} & \lambda_{42} \\ \lambda_{51} & \lambda_{52} \end{pmatrix} = \begin{pmatrix} f_1 \\ f_2 \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \end{pmatrix} \quad \ldots \quad (3.11)$$

3.2 Type of factor analysis

Exploratory factor analysis (EFA) is used to uncover the underlying structure of a relatively large set of variables. The researcher's a priori assumption is that any indicator may be associated with any factor. This is the most common form of factor analysis. There is no prior theory and one uses factor loadings to intuit the factor structure of the data.

3.2.1 Confirmatory factor analysis

In statistics, confirmatory factor analysis is a special form of factor analysis. It is used to test whether measures of a construct are consistent with a researcher's understanding of the nature of that construct. In contrast to exploratory factor analysis, where all loadings are free to vary,

(CFA) seeks to determine if the number of factors and the loadings of measured (indicator) variables on them conform to what is expected on the basis of pre-established theory. Indicator variables are selected on the basis of prior theory and factor analysis is used to see if they load as predicted on the expected number of factors. The researcher's a priori assumption is that each factor (the number and labels of which may be specified a priori) is associated with a specified subset of indicator variables. A minimum requirement of confirmatory factor analysis is that one hypothesizes beforehand the number of factors in the model, but usually also the researcher will posit expectations about which variables will load on which factors. The researcher seeks to determine, for instance, if measures created to represent a latent variable really belong together.1

3.2.2 Exploratory factor analysis (EFA) could be described as orderly simplification of interrelated measures. EFA, traditionally, has been used to explore the possible underlying factor structure of a set of observed variables without imposing a preconceived structure on the outcome (Child, 1990). By performing EFA, the underlying factor structure is identified.

CFA and EFA are powerful statistical techniques. An example of CFA and EFA could occur with the development of measurement instruments, e.g. a satisfaction scale, attitudes toward health, customer service questionnaire. A blue print is developed, questions written, a scale determined, the instrument pilot tested, data collected, and CFA completed. The blueprint identifies the factor structure or what we think it is. However, some questions may not measure what we thought they should. If the factor structure is not confirmed, EFA is the next step. EFA helps us determine what the factor structure looks like according to how participant responses. Exploratory factor analysis is essential to determine underlying constructs for a set of measured variables.2

Since its inception a century ago 9Speaman, 1904, 1927), factor analysis has become one of the most widely used multivariate statistical procedures in applied research endeavors across a multitude of domains (e.g., psychology, education, sociology, management, public health). The fundamental intent of factor analysis is to determine the number and nature of latent variables or factors that account for the variation and co variation among a set of observed measures, commonly referred to as indicators.3

3.3 Types of factoring

Principal component analysis (PCA): The most common form of factor analysis, PCA seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this

[1] http:// **www.absluteastronomy.com / topics / Conirmatory_factor_analsis**

[2] Paper 200-31 Exploratory or Confirmatory Factor Analysis? Diana D. Suhr, Ph.D.University of Northern Colorado

[3] David A. Kenny, Series Editor, Methodology in the Social Sciences, p(13)

variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. This is called the principal axis method and results in orthogonalOrthogonality

Orthogonality occurs when two things can vary independently, they are uncorrelated, or they are perpendicular.-Mathematics:In mathematics, two vectors are orthogonal if they are perpendicular, i.e., they form a right angle.

3.3.1 (Uncorrelated) factors.

Canonical factor analysis , also called Rao's canonical factoring, is a different method of computing the same model as PCA, which uses the principal axis method. CFA seeks factors which have the highest canonical correlation with the observed variables. CFA is unaffected by arbitrary rescaling of the data.

Common factor analysis, also called principal factor analysis (PFA) or principal axis factoring (PAF), seeks the least number of factors which can account for the common variance (correlation) of a set of variables.

Image factoring: based on the correlation matrix of predicted variables rather than actual variables, where each variable is predicted from the others using multiple regression.

Alpha factoring: based on maximizing the reliability of factors, assuming variables are randomly sampled from a universe of variables. All other methods assume cases to be sampled and variables fixed.

Factor regression model: a combinatorial model of factor model and regression model; or alternatively, it can be viewed as the hybrid factor model , whose factors are partially known.4

3.3.2 Purposes and Advantages of CFA

Although both EFA and CFA are based on common factor model and often use the same estimation method (e.g., maximum likelihood), the specification of CFA is strongly driven by theory

[4] http:// www.absluteastronomy.com / topics / Orthogonality

or prior research evidence. Thus, unlike the approach in EFA in which the researcher can only prespecify , the number of factors, the CFA researcher usually tests a much more parsimonious solution by indicating the number of factors, the pattern of factors loadings (and cross- loadings, which are usually fixed to zero), and appropriate error theory (e.g., random or correlated indicator error).

EFA, CFA allows for the specification of relationship among the indicator uniqueness's (error variance), which may have substantive importance (e.g., correlated errors due to method effects).

Similarly, another advantage of CFA and SEM is the ability to estimate the relationships among variables adjusting for measurement error.5

In probability theory and statistics, the variance is used as a measure of how far a set of numbers are spread out from each other. It is one of several descriptors of a probability distribution, describing how far the numbers lie from the mean . In particular, the variance is one of the moments of...

In mathematics, a variable is a value that may change within the scope of a given problem or set of operations. In contrast, a constant is a value that remains unchanged, though often unknown or undetermined. The concepts of constants and variables are fundamental to many areas of mathematics and...
in terms of a potentially lower number of unobserved variables called factors. In other words, it is possible, for example, that variations in three or four observed variables mainly reflect the variations in a single unobserved variable, or in a reduced number of unobserved variables. Factor analysis searches for such joint variations in response to unobserved latent variable

[5] David A. Kenny, Series Editor, Methodology in the Social Sciences, p(49- 50)

Factor analysis includes both component analysis and common factor analysis. More than other statistical techniques, factor analysis has suffered from confusion concerning its very purpose. This affects my presentation in two ways. First, I devote a long section to describing what factor analysis does before examining in later sections how it does it. Second, I have decided to reverse the usual order of presentation. Component analysis is simpler, and most discussions present it first. However, I believe common factor analysis comes closer to solving the problems most researchers actually want to solve. Thus learning component analysis first may actually interfere with understanding what those problems are. Therefore component analysis is introduced only quite late in this chapter.

Factor analysis is a statistical method for studying processes---psychological, mathematical, and economic---where there appear to be dozens or even hundreds of variables affecting operations. By analyzing and studying the variables statistically, factor analysis can separate out a few core variables, known as factors that control the rest. Concentrating on the factors makes analyzing the process much simpler.

3.4 The Goal: Understanding of Causes

Many statistical methods are used to study the relation between independent and dependent variables. Factor analysis is different; it is used to study the patterns of relationship among many dependent variables, with the goal of discovering something about the nature of the independent variables that affect them, even though those independent variables were not measured directly. Thus answers obtained by factor analysis are necessarily more hypothetical and tentative than is true when independent variables are observed directly. The inferred independent variables are called factors. A typical factor analysis suggests answers to four major questions:

How many different factors are needed to explain the pattern of relationships among these variables?

What is the nature of those factors?

How well do the hypothesized factors explain the observed data?

How much purely random or unique variance does each observed variable include?

3.5 **Absolute Versus Heuristic Uses of Factor Analysis**

A heuristic is a way of thinking about a topic which is convenient even if not absolutely true. We use a heuristic when we talk about the sun rising and setting as if the sun moved around the earth, even though we know it doesn't. "Heuristic" is both a noun and an adjective; to use a heuristic is to think in heuristic terms.

The previous examples can be used to illustrate a useful distinction--between absolute and heuristic uses of factor analysis. Spearman's g theory of intelligence, and the activation theory of autonomic functioning, can be thought of as absolute theories which are or were hypothesized to give complete descriptions of the pattern of relationships among variables. On the other hand, Rubenstein never claimed that her list of the seven major factors of curiosity offered a complete description of curiosity. Rather those factors merely appear to be the most important seven factors--the best way of summarizing a body of data. Factor analysis can suggest either absolute or heuristic models; the distinction is in how you interpret the output.

3.6 Factor Analysis Objective

The concept of heuristics is useful in understanding a property of factor analysis which confuses many people. Several scientists may apply factor analysis to similar or even identical sets of measures, and one may come up with 3 factors while another comes up with 6 and another comes up with 10. This lack of agreement has tended to discredit all uses of factor analysis. But if three travel writers wrote travel guides to the United States, and one divided the country into 3 regions, another into 6, and another into 10, would we say that they contradicted each other? Of course not; the various writers are just using convenient ways of organizing a topic, not claiming to represent the only correct way of doing so. Factor analysts reaching different conclusions contradict each other only if they all claim absolute theories, not heuristics. The fewer factors the simpler the theory; the more factors the better the theory fits the data. Different workers may make different choices in balancing simplicity against fit.

A similar balancing problem arises in regression and analysis of variance, but it generally doesn't prevent different workers from reaching nearly or exactly the same conclusions. After all, if two workers apply an analysis of variance to the same data, and both workers drop out the terms not significant at the .05 level, then both will report exactly the same effects. However, the situation in factor analysis is very different. For reasons explained later, there is no significance test in component analysis that will test a hypothesis about the number of factors, as that hypothesis is ordinarily understood. In common factor analysis there is such a test, but its usefulness is limited by the fact that it frequently yields more factors than can be satisfactorily interpreted. Thus a worker who wants to report only interpretable factors is still left without an objective test.

A similar issue arises in identifying the nature of the factors. Two workers may each identify 6 factors, but the two sets of factors may differ--perhaps substantially. The travel-writer analogy is useful here too; two writers might each divide the US into 6 regions, but define the regions very differently.

Another geographical analogy may be more parallel to factor analysis, since it involves computer programs designed to maximize some quantifiable objective. Computer programs are sometimes used to divide a state into congressional districts which are geographically contiguous, nearly equal in population, and perhaps homogeneous on dimensions of ethnicity or other factors. Two different district-creating programs might come up with very different answers, though both answers are reasonable. This analogy is in a sense too good; we believe that factor analysis programs usually don't yield answers as different from each other as district-creating programs do.

3.6 Factor Analysis Versus Clustering and Multidimensional Scaling

Another challenge to factor analysis has come from the use of competing techniques such as cluster analysis and multidimensional scaling. While factor analysis is typically applied to a correlation matrix, those other methods can be applied to any sort of matrix of similarity measures, such as ratings of the similarity of faces. But unlike factor analysis, those methods cannot cope with certain unique properties of correlation matrices, such as reflections of variables. For instance, if you reflect or reverse the scoring direction of a measure of "introversion", so that high scores indicate "extroversion" instead of introversion, then you reverse the signs of all that variable's correlations: -.36 becomes +.36, +.42 becomes -.42, and so on. Such reflections would completely change the output of a cluster analysis or multidimensional scaling, while factor analysis would recognize the reflections for what they are; the reflections would change the signs of the "factor loadings" of any reflected variables, but would not change anything else in the factor analysis output.

Another advantage of factor analysis over these other methods is that factor analysis can recognize certain properties of correlations. For instance, if variables A and B each correlate .7 with variable C, and correlate .49 with each other, factor analysis can recognize that A and B correlate zero when C is held constant because .72 = .49. Multidimensional scaling and cluster analysis have no ability to recognize such relationships, since the correlations are treated merely as generic "similarity measures" rather than as correlations.

We are not saying these other methods should never be applied to correlation matrices; sometimes they yield insights not available through factor analysis. But they have definitely not made factor analysis obsolete. The next section touches on this point.

3.7 Rotation

In the opening example on curiosity, I mentioned individual factors that Rubenstein described: enjoyment of reading, interest in science, etc. Rotation is the step in factor analysis that allows you to identify meaningful factor names or descriptions like these.

3.8 Linear Functions of Predictors

To understand rotation, first consider a problem that doesn't involve factor analysis. Suppose you want to predict the grades of college students (all in the same college) in many different courses, from their scores on general "verbal" and "math" skill tests. To develop predictive formulas, you have a body of past data consisting of the grades of several hundred previous students in these courses, plus the scores of those students on the math and verbal tests. To predict grades for present and future students, you could use these data from past students to fit a series of two-variable multiple regressions, each regression predicting grade in one course from scores on the two skill tests.

In common factor analysis the process of rotation is actually somewhat more abstract that I have implied here, because you don't actually know the individual scores of cases on factors. However, the statistics for a multiple regression that is most relevant here--the multiple correlation and the standardized regression slopes--can all be calculated just from the correlations of the variables and factors involved. Therefore we can base the calculations for rotation to simple structure on just those correlations, without using any individual scores.

A rotation which requires the factors to remain uncorrelated is an orthogonal rotation, while others are oblique rotations. Oblique rotations often achieve greater simple structure, though at the cost that you must also consider the matrix of factor intercorrelations when interpreting results. Manuals are generally clear which is which, but if there is ever any ambiguity, a simple rule is that if there is any ability to print out a matrix of factor correlations, then the rotation is oblique, since no such capacity is needed for orthogonal rotations.

3.9 Comparing Two Factor Analyses

Since factor loadings are among the most important pieces of output from a factor analysis, it seems natural to ask about the standard error of a factor loading, so that for instance we might test the significance of the difference between the factor loadings in two samples. Unfortunately, no very useful general formula for such a purpose can be derived, because of ambiguities in identifying the factors themselves. To see this, imagine that "math" and "verbal" factors explain roughly equal amounts of variance in a population. The math and verbal factors might emerge as factors 1 and 2 respectively in one sample, but in the opposite order in a second sample from the same population. Then if we mechanically compared, for instance, the two values of the loading of variable 5 on factor 1, we would actually be comparing variable 5's loading on the math factor to its loading on the verbal factor. More generally, it is never completely meaningful to say that one particular factor in one factor analysis "corresponds" to one factor in another factor analysis. Therefore we need a completely different approach to studying the similarities and differences between two factor analyses.

Actually, several different questions might be phrased as questions about the similarity of two factor analyses. First we must distinguish between two different data formats:

1. Same variables, two groups. The same set of measures might be taken on men and women, or on treatment and control groups. The question then arises whether the two factor structures are the same.

2. One group, two conditions or two sets of variables. Two test batteries might be given to a single group of subjects, and questions asked about how the two sets of scores differ. Or the same battery might be given under two different conditions.

The next two sections consider these questions separately.

3.10 Comparing Factor Analyses in Two Groups

In the case of two groups and one set of variables, a question about factor structure is obviously not asking whether the two groups differ in means; that would be a question for MANOVA (multivariate analysis of variance). Unless the two sets of means are equal or have somehow been made equal, the question is also not asking whether a correlation matrix can meaningfully be computed after pooling the two samples, since differences in means would destroy the meaning of such a matrix.

The question, "Do these two groups have the same factor structure?" is actually quite different from the question, "Do they have the same factors?" The latter question is closer to the question, "Do we need two different factor analyses for the two groups?" To see the point, imagine a problem with 5 "verbal" tests and 5 "math" tests. For simplicity imagine all correlations between the two sets of tests are exactly zero. Also for simplicity consider a component analysis, though the same point can be made concerning a common factor analysis. Now imagine that the correlations among the 5 verbal tests are all exactly .4 among women and .8 among men, while the correlations among the 5 math tests are all exactly .8 among women and .4 among men. Factor analyses in the two groups separately would yield different factor structures but identical factors; in each gender the analysis would identify a "verbal" factor which is an equally-weighted average of all verbal items with 0 weights for all math items, and a "math" factor with the opposite pattern. In this example nothing would be gained from using separate factor analyses for the two genders, even though the two factor structures are quite different.

Another important point about the two-group problem is that an analysis which derives 4 factors for group A and 4 for group B has as many factors total as an analysis which derives 8 in the combined group. Thus the practical question may be not whether analyses deriving m factors in each of two groups fit the data better than an analysis deriving m factors in the combined group. Rather the two separate analyses should be compared to an analysis deriving 2m factors in the combined group. To make this comparison for component analysis, sum the first m eigenvalues in each separate group, and compare the mean of those two sums to the sum of the first 2m eigenvalues in the combined group. It would be very rare that this analysis suggests that it would be better to do separate factor analyses for the two groups. This same analysis should give at least an approximate answer to the question for common factor analysis as well.

Suppose the question really is whether the two factor structures are identical. This question is very similar to the question as to whether the two correlation or covariance matrices are identical--a question which is precisely defined with no reference to factor analysis at all. Tests of these hypotheses are beyond the scope of this work, but a test on the equality of two covariance matrices appears in Morrison (1990) and other works on multivariate analysis.

3.11 Comparing Factor Analyses of Two Sets of Variables in a Single Group

One question people often ask is whether they should analyze variable sets A and B together or separately. My answer is usually "together", unless there is obviously no overlap between the two domains studied. After all, if the two sets of variables really are unrelated then the factor analysis will tell you so, deriving one set of factors for set A and another for set B. Thus to analyze the two sets separately is to prejudge part of the very question the factor analysis is supposed to answer for you.

As in the case of two separate samples of cases, there is a question which often gets phrased in terms of factors but which is better phrased as a question about the equality of two correlation or covariance matrices--a question which can be answered with no reference to factor analysis. In the present instance we have two parallel sets of variables; that is, each variable in set A parallels one in set B. In fact, sets A and B may be the very same measures administered under two different conditions. The question then is whether the two correlation matrices or covariance matrices are identical. This question has nothing to do with factor analysis, but it also has little to do with the question of whether the AB correlations are high. The two correlation or covariance matrices within sets A and B might be equal regardless of whether the AB correlations are high or low.

Darlington, Weinberg, and Walberg (1973) described a test of the null hypothesis that the covariance matrices for variable sets A and B are equal when sets A and B are measured in the same sample of cases. It requires the assumption that the AB covariance matrix is symmetric. Thus for instance if sets A and B are the same set of tests administered in years 1 and 2, the assumption requires that the covariance between test X in year 1 and test Y in year 2 equal the covariance between test X in year 2 and test Y in year 1. Given this assumption, you can simply form two sets of scores I'll call A+B and A-B, consisting of the sums and differences of parallel variables in the two sets. It then turns out that the original null hypothesis is equivalent to the hypothesis that all the variables in set A+B are uncorrelated with all variables in set A-B. This hypothesis can be tested with MANOVA.

Rotation methods

Rotation serves to make the output more understandable and is usually necessary to facilitate the interpretation of factors.

Varimax rotation

In statistics, a varimax rotation is a change of coordinates used in principal component analysis and factor analysis that maximizes the sum of the variances of the squared loadings...is an

Orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor. Each factor will tend to have either large or small loadings of any particular variable. A varimax solution yields results which make it as easy as possible to identify each variable with a single factor. This is the

most common rotation option.

Quartimax rotation is an orthogonal alternative which minimizes the number of factors needed to explain each variable. This type of rotation often generates a general factor on which most variables are loaded to a high or medium degree. Such a factor structure is usually not helpful to the research purpose.

Equimax rotation is a compromise between Varimax and Quartimax criteria.

Direct oblimin rotation is the standard method when one wishes a non-orthogonal (oblique) solution – that is, one in which the factors are allowed to be correlated. This will result in higher eigenvalues but diminished interpretability.

Interpretability

In mathematical logic, interpretability is a relation between formal theories that expresses the possibility of interpreting or translating one into the other.-Informal definition: Assume T and S are formal theories... of the factors. See below.

Promax rotation is an alternative non-orthogonal (oblique) rotation method which is computationally faster than the direct oblimin method and therefore is sometimes used for very large datasets.

Criteria for determining the number of factors

Using one or more of the methods below, the researcher determines an appropriate range of solutions to investigate. Methods may not agree. For instance, the Kaiser criterion may suggest five factors and the scree test may suggest two, so the researcher may request 3-, 4-, and 5-factor solutions discuss each in terms of their relation to external data and theory.

Comprehensibility: A purely subjective criterion would be to retain those factors whose meaning is comprehensible to the researcher. This is not recommended.

Kaiser criterion: The Kaiser rule is to drop all components with eigenvalues under 1.0 – this being the eigenvalue equal to the information accounted for by an average single item. The Kaiser criterion is the default in SPSS

SPSS is a computer program used for survey authoring and deployment, data mining, text analytics, statistical analysis, and collaboration & deployment... and most computer program

Computer program

A computer program is a sequence of instructions written to perform a specified task for a computer. A computer requires programs to function, typically executing the program's instructions in a central processor. The program has an executable form that the computer can use directly to execute the...

s but is not recommended when used as the sole cut-off criterion for estimating the number of factors as it tends to overextract factors .

Variance explained criteria: Some researchers simply use the rule of keeping enough factors to account for 90% (sometimes 80%) of the variation. Where the researcher's goal emphasizes parsimony (explaining variance with as few factors as possible), the criterion could be as low as 50%

Scree plot: The Cattell scree test plots the components as the X axis and the corresponding eigenvalues

Eigenvalue, eigenvector and eigenspace

The eigenvectors of a square matrix are the non-zero vectors that, after being multiplied by the matrix, remain proportional to the original vector. For each eigenvector, the corresponding eigenvalue is the factor by which the eigenvector changes when multiplied by the matrix...

as the Y-axis. As one moves to the right, toward later components, the eigenvalues drop. When the drop ceases and the curve makes an elbow toward less steep decline, Cattell's scree test says to drop all further components after the one starting the elbow. This rule is sometimes criticized for being amenable to researcher-controlled "fudging". That is, as picking the "elbow" can be subjective because the curve has multiple elbows or is a smooth curve, the researcher may be tempted to set the cut-off at the number of factors desired by his or her research agenda.

Horn's Parallel Analysis (PA): A Monte-Carlo based simulation method that compares the observed eigenvalues with those obtained from uncorrelated normal variables. A factor or component is retained if the associated eigenvalue is bigger than the 95th of the distribution of eigenvalues derived from the random data. PA is one of the most recommendable rules for determining the number of components to retain, but only few programs include this option.
Before dropping a factor below one's cut-off, however, the researcher should check its correlation with the dependent variable. A very small factor can have a large correlation with the dependent variable, in which case it should not be dropped.

Types of factoring

Principal component analysis (PCA): The most common form of factor analysis, PCA seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. This is called the principal axis method and results in orthogonal

Orthogonality occurs when two things can vary independently, they are uncorrelated, or they are perpendicular-Mathematics: In mathematics, two vectors are orthogonal if they are perpendicular, i.e., they form a right angle. (Uncorrelated) factors.

Canonical factor analysis, also called Rao's canonical factoring, is a different method of computing the same model as PCA, which uses the principal axis method. CFA seeks factors which have the highest canonical correlation with the observed variables. CFA is unaffected by arbitrary rescaling of the data.

Common factor analysis, also called principal factor analysis (PFA) or principal axis factoring (PAF), seeks the least number of factors which can account for the common variance (correlation) of a set of variables.

Image factoring: based on the correlation matrix of predicted variables rather than actual variables, where each variable is predicted from the others using multiple regressions.
Alpha factoring: based on maximizing the reliability of factors, assuming variables are randomly sampled from a universe of variables. All other methods assume cases to be sampled and variables fixed.
Factor regression model: a combinatorial model of factor model and regression model; or alternatively, it can be viewed as the hybrid factor model, whose factors are partially known.

Terminology
Factor loadings: The factor loadings, also called component loadings in PCA, are the correlation coefficients between the variables (rows) and factors (columns). Analogous to Pearson's r

In statistics, the Pearson product-moment correlation coefficient is a measure of the correlation between two variables X and Y, giving a value between +1 and −1 inclusive. It is widely used in the sciences as a measure of the strength of linear dependence between two variables...

, the squared factor loading is the percent of variance in that indicator variable explained by the factor. To get the percent of variance in all the variables accounted for by each factor, add the sum of the squared factor loadings for that factor (column) and divide by the number of variables. (Note the number of variables equals the sum of their variances as the variance of a standardized variable is 1.) This is the same as dividing the factor's eigenvalue by the number of variables.

Interpreting factor loadings: By one rule of thumb in confirmatory factor analysis, loadings should be .7 or higher to confirm that independent variables identified a priori are represented by a particular factor, on the rationale that the .7 level corresponds to about half of the variance in the indicator being explained by the factor. However, the .7 standard is a high one and real-life data may well not meet this criterion, which is why some researchers, particularly for exploratory purposes, will use a lower level such as .4 for the central factor and .25 for other factors call loadings above .6 "high" and those below .4 "low". In any event, factor loadings must be interpreted in the light of theory, not by arbitrary cutoff levels.

In oblique rotation, one gets both a pattern matrix and a structure matrix. The structure matrix is simply the factor loading matrix as in orthogonal rotation, representing the variance in a measured variable explained by a factor on both a unique and common contributions basis. The pattern matrix, in contrast, contains coefficient

Coefficient

In mathematics, a coefficient is a multiplicative factor in some term of an expression; it is usually a number, but in any case does not involve any variables of the expressions.

Which just represent unique contributions? The more factors, the lower the pattern coefficients as a rule since there will be more common contributions to variance explained. For oblique rotation, the researcher looks at both the structure and pattern coefficients when attributing a label to a factor.

Communality: The sum of the squared factor loadings for all factors for a given variable (row) is the variance in that variable accounted for by all the factors, and this is called the communality. The communality measures the percent of variance in a given variable explained by all the factors jointly and may be interpreted as the reliability of the indicator.

Spurious solutions: If the communality exceeds 1.0, there is a spurious solution, which may reflect too small a sample or the researcher has too many or too few factors.

Uniqueness of a variable: That is, uniqueness is the variability of a variable minus its communality.

Eigenvalues:/Characteristic roots: The eigenvalue for a given factor measures the variance in all the variables which is accounted for by that factor. The ratio of eigenvalues is the ratio of explanatory importance of the factors with respect to the variables. If a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. Eigenvalues measure the amount of variation in the total sample accounted for by each factor.

Extraction sums of squared loadings: Initial eigenvalues and eigenvalues after extraction (listed by SPSS as "Extraction Sums of Squared Loadings") are the same for PCA extraction, but for other extraction methods, eigenvalues after extraction will be lower than their initial counterparts. SPSS also prints "Rotation Sums of Squared Loadings" and even for PCA, these eigenvalues will differ from initial and extraction eigenvalues, though their total will bet he same.

Factor scores: Also called component scores in PCA, factor scores are the scores of each case (row) on each factor (column). To compute the factor score for a given case for a given factor, one takes the case's standardized score on each variable, multiplies by the corresponding factor loading of the variable for the given factor, and sums these products. Computing factor scores allows one to look for factor outliers. Also, factor scores may be used as variables in subsequent modeling.

Advantages

Reduction of number of variables, by combining two or more variables into a single factor. For example, performance at running, ball throwing, batting, jumping and weight lifting could be combined into a single factor such as general athletic ability. Usually, in an item by people matrix, factors are selected by grouping related items. In the Q factor analysis technique, the matrix is transposed and factors are created by grouping related people: For example, liberals, libertarians, conservatives and socialists, could form separate groups.

Identification of groups of inter-related variables, to see how they are related to each other. For example, Carroll used factor analysis to build his Three Stratum Theory

Three Stratum Theory

In 1993 John Carroll published "Human cognitive abilities: A survey of factor-analytic studies", which outlined his hierarchical, Three-Stratum Theory of cognitive abilities.

. He found that a factor called "broad visual perception" relates to how goodan individual is at visual tasks. He also found a "broad auditory perception" factor, relating to auditory task capability. Furthermore, he found a global factor, called "g" or general intelligence, that relates to both "broad visual perception" and "broad auditory perception". This means someone with a high "g" is likely to have both a high "visual perception" capability and a high "auditory perception" capability, and that "g" therefore explains a good part of why someone is good or bad in both of those domains.

Disadvantages

"...each orientation is equally acceptable mathematically. But different factorial theories proved to differ as much in terms of the orientations of factorial axes for a given solution as in terms of anything else, so that model fitting did not prove to be useful in distinguishing among theories." (Sternberg, 1977). This means all rotations represent different underlying processes, but all rotations are equally valid outcomes of standard factor analysis optimization. Therefore, it is impossible to pick the proper rotation using factor analysis alone.

Factor analysis can be only as good as the data allows. In psychology, where researchers often have to rely on less valid and reliable measures such as self-reports, this can be problematic.

Interpreting factor analysis is based on using a “heuristic”, which is a solution that is "convenient even if not absolutely true" (Richard B. Darlington). More than one interpretation can be made of the same data factored the same way, and factor analysis cannot identify causality.

CHAPTER FOUR

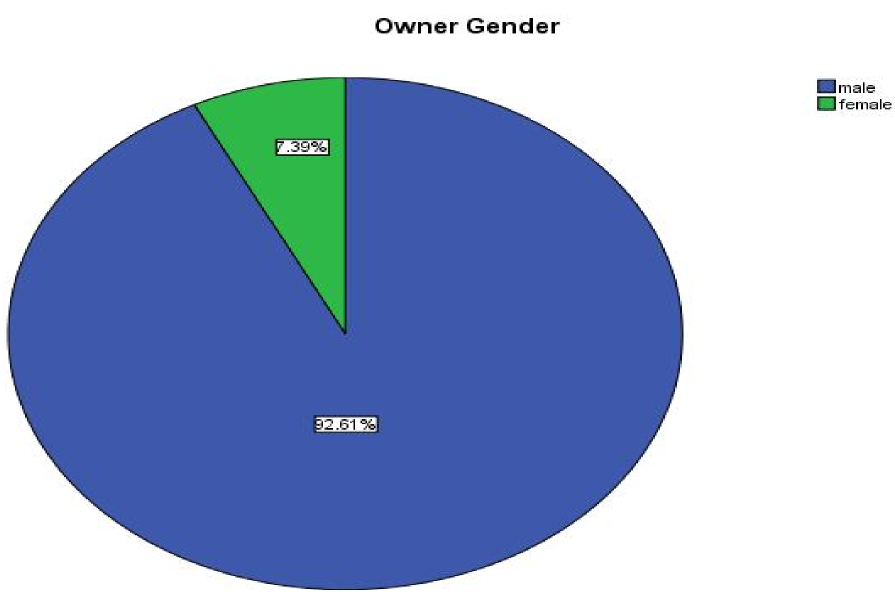
APPLICATIONS

4.1 Null versus Alternative hypothesis

For each component or factor the null hypothesis is that the component or factor in question does not make a significant contribution in explaining the total variability in the data. The alternative hypothesis is that the component or factor in question does make a significant contribution in explaining the total variability in the data.

Descriptive statistics

Figure (1-4)



The source: Prepared by researcher depending on SPSS output

Shows the sex of the respondents, 92.61% males and 7.39% were females

The: 4-1 the owner age

owner age		Frequency	Percent
Valid	15 -35	284	37.5
	35 – 55	277	36.5
	Over 55	197	26.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS outpu

Shows owner age distribution of the respondents

Table: 4-2 the owner family member

owner family member		Frequency	Percent
Valid	3 – 5	51	6.7
	6 – 8	254	33.5
	Over 8	453	59.8
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the numbers families   of the respondents

Table: 4-3 the breeding type

breeding type		Frequency	Percent
Valid	Settled in farms	249	32.8
	Special farms	7	.9
	Semi nomads	347	45.8
	nomads	155	20.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows breeding type distribution of the respondents

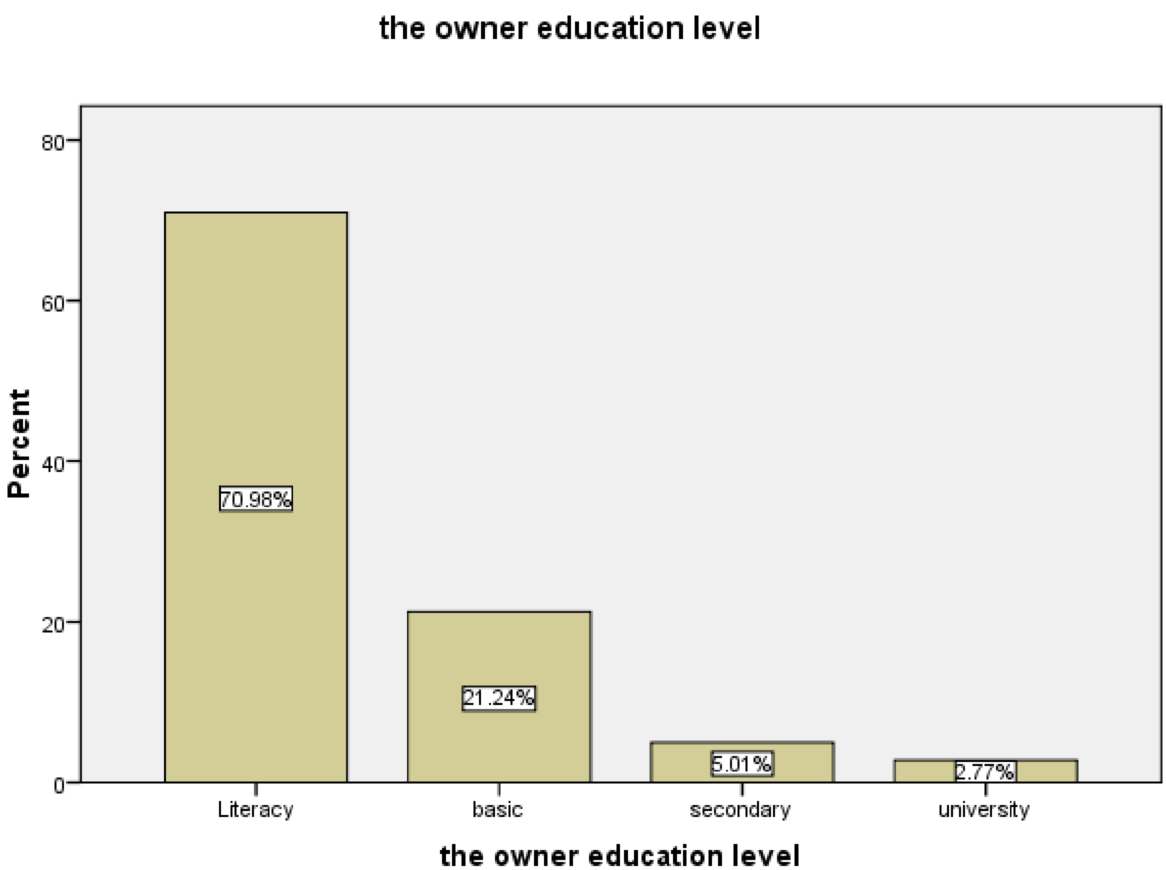
Table: 4-4 the breeding purpose

breeding purpose		Frequency	Percent
Valid	For export	408	53.8
	For local sales	287	37.9
	For salutary	55	7.3
	For show	8	1.1
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows breeding purpose distribution of the respondents

Figure (2-4)



The source: Prepared by researcher depending on SPSS output

Shows the education levels of the respondents, it's clear that most of them concentrate in the low levels and illiterate.

Table: 4-5 the owner main professional

owner main professional		Frequency	Percent
Valid	farmer	91	12.0
	raisins livestock	667	88.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the main professional distribution of the respondents

Table: 4-6 the owner secondary professional

owner secondary professional		Frequency	Percent
Valid	farmer	590	77.8
	raisins livestock	84	11.1
	others	84	11.1
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the secondary professional distribution of the respondents

Table: 4-7 the owner professional experience

owner professional experience		Frequency	Percent
Valid	10 - 20	86	11.3
	20 -30	211	27.8
	over 30	461	60.8
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the years of owner professional of the respondents

Table: 4-8 the Breeding Farm Area

Breeding Farm Area		Frequency	Percent
Valid	12 – 14	213	28.1
	14 – 16	113	14.9
	over 16	432	57.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the breeding farm area of the respondents

Table: 4-9 the vaccinated animal per year

vaccinated animal per year		Frequency	Percent
Valid	80 - 150	686	90.5
	150 -320	60	7.9
	Over 440	12	1.6
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the vaccinated animal per year of the respondents

Table: 4-10 the male slaughtering animal per year

	Age per month	Frequency
Valid	6 - 12	633
	12 - 18	106
	Over 18	19
	Total	758

The source: Prepared by researcher depending on SPSS output

Shows the male slaughtering animal per year of the respondents

Table: 4-11 the female slaughtering animal per year

	Age per month	Frequency	Percent
Valid	6 – 12	551	72.7
	12 – 18	93	12.3
	over 18	114	15.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the female slaughtering animal per year

Table: 4-12 the died of livestock

	age per month		Percent
Valid	2 – 12	315	41.6
	Over 30	443	58.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the died of animal per year

Table: 4-13 the export animal

export animal		Frequency	Percent
Valid	100 – 500	152	20.1
	500 – 1000	482	63.6
	Over 1000	124	16.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the export animal per year

Table: 4-14 the animal commercial domestic

animal commercial domestic		Frequency	Percent
Valid	30 – 70	217	28.6
	70 - 110	150	19.8
	110 - 140	140	18.5
	Over 140	251	33.1
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the animal commercial domestic per year

Table: 4-15 the grazing hours/day

grazing hours/day		Frequency	Percent
Valid	4 – 8	214	28.2
	Over 8	544	71.8
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the animal grazing hours/day

Table: 4-16 the animal labor personnel

animal labor personnel		Frequency	Percent
Valid	1 – 3	146	19.3
	3 – 5	415	54.7
	Over 5	197	26.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Table: 4-17 the others reasons for animal decrement

animal decrement		Frequency	Percent
Valid	1- 2	327	43.1
	3 – 4	259	34.2
	Over 4	172	22.7
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Table: 4-18 the vaccination against diseases

vaccination against diseases		Frequency	Percent
Valid	100 - 500	300	39.6
	500 - 1000	379	50.0
	Over 1000	79	10.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the numbers of animal vaccinated against diseases

Table: 4-19 the vaccinated animals

vaccinated animals		Frequency	Percent
Valid	yes	569	75.1
	no	189	24.9
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the animals vaccinated or not of the respondents

Table: 4-20 the livestock water resource

the livestock water resource		Frequency	Percent
Valid	Boreholes	515	67.9
	Stream - dam	150	19.8
	More than one source	93	12.3
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the source of drink water of the respondents

Table: 4-21 does owner have a farmer?

does owner have a farmer?		Frequency	Percent
Valid	yes	732	96.6
	no	26	3.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows does owner have a farm or not

Table: 4-22 annual animal leather of respondents

annual animal leather of respondents		Frequency	Percent
Valid	176 – 376	527	69.5
	376 – 576	110	14.5
	over 576	121	16.0
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the annual animal leather of respondents

Table: 4-23 the farm area/fadan

farm area/fadan		Frequency	Percent
Valid	5 – 25	280	36.9
	25 – 45	342	45.1
	45 – 65	110	14.5
	Over 65	26	3.4
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the farm area of respondents

Table: 4-24 do animals contribute in daily living requirements?

do animals contribute in daily living requirements?		Frequency	Percent
Valid	yes	726	95.8
	no	32	4.2
	Total	758	100.0

The source: Prepared by researcher depending on SPSS output

Shows the animal contribute in daily living requirements

4.2 Rotated Component Matrix

1- First factor includes these variables (Livestock Water Resource, Vaccinated Animal).

2- Second factor includes these variables (Owner Farm, farm Area).

3- Third factor includes these variables (Owner Main Professional, Owner Gender).

4- Fourth factor includes these variables (female Slaughtering Animal per Year, Breeding Type and. Animal Commercial Domestic).

5- Fifth factor includes these variables (Breeding Farm Area, animal Health).

6- Sixth factor includes these variables (Export Animal, Owner Education Level).

7- Seventh factor includes these variables (Animal labor Personnel, annual Animal leather).

8- Eights factor includes these variables (Vaccinated Animals, Reasons for Animal Decrement).

9- Ninth factor includes these variables (lost of animal, grazing hours/day).

10- Tenth factor includes these variables (Owner Professional Experience, Vaccinated Animals).

11- Eleventh factor includes these variables (Slaughtering male Animal/year, Owner Professional Experience).

12- Twelve factor includes the twelve factors cal includes the variables (Slaughtering).

4.3 Analyzing the data of study

The SPSS program has been used to analyze the data of livestock, after the correlation matrix was checked; twenty six variables – the others were excluded – as suitable variables for factor analysis. First we look for the correlation matrix as a preliminary analysis to make some decisions.

4.3.1The KMO and Bartlett's Test

Then we have to check the fit of sample size, the KMO was used to do that as in the table 4-26.

Table 4:25 The KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.518
Bartlett's Test of Sphericity	Approx. Chi-Square	1.911E3
	df	325
	Sig.	.000

The source: Prepared by researcher depending on SPSS output

The Table (4-25) shows the Kaiser – Meyer – Olkin measure of sampling adequacy and Bartletts test of sphericity (Bartlett(1954)) (which evaluates the null hypothesis that all of the correlations in a correlation matrix are zero), SPSS obtained the result $\chi^2(325) = 1911$, p = .000 (which indicates a probability less than .0005) for Barrtletts test of sphericity. Note that is greater than χ^2 tabulated, the null hypothesis can be rejected at the .01 and .05 level. The value of KMO is o.518 , which indicates that the samples size is mediocre , so the sample size is sufficient. The Barrtletts test P- value is highly significant (0.000) , thus it tells us that the correlation matrix is not identity matrix; therefore , the underlying population from which the sample was derived.

Correlation Matrix

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24	x25	x26
x1		.000	.019	.071	.001	.000	.000	.036	.489	.103	.015	.338	.017	.179	.081	.193	.250	.000	.000	.000	.000	.089	.072	.099	.480	.401
x2	.000		.170	.113	.070	.268	.020	.312	.029	.371	.238	.143	.004	.030	.374	.119	.437	.064	.135	.061	.088	.140	.000	.015	.049	.161
x3	.019	.170		.264	.186	.001	.130	.374	.348	.052	.153	.379	.429	.315	.006	.469	.016	.395	.189	.040	.218	.118	.282	.102	.127	.020
x4	.071	.113	.264		.192	.074	.003	.400	.256	.377	.109	.376	.000	.410	.026	.005	.268	.190	.047	.188	.001	.151	.364	.206	.174	.010
x5	.001	.070	.186	.192		.031	.399	.129	.277	.067	.331	.407	.378	.004	.283	.361	.412	.008	.000	.409	.006	.000	.323	.374	.031	.129
x6	.000	.268	.001	.074	.031		.006	.065	.060	.000	.327	.249	.338	.069	.000	.042	.009	.464	.231	.015	.004	.001	.010	.041	.319	.088
x7	.000	.020	.130	.003	.399	.006		.013	.274	.210	.032	.208	.000	.340	.061	.117	.338	.000	.422	.468	.024	.122	.246	.098	.058	.016
x8	.036	.312	.374	.400	.129	.065	.013		.305	.165	.006	.011	.001	.087	.000	.008	.094	.127	.459	.322	.458	.046	.082	.156	.297	.237
x9	.489	.029	.348	.256	.277	.060	.274	.305		.288	.225	.371	.053	.201	.448	.047	.016	.274	.303	.000	.233	.203	.286	.117	.456	.068
x10	.103	.371	.052	.377	.067	.000	.210	.165	.288		.342	.443	.181	.381	.083	.011	.358	.029	.002	.138	.151	.180	.080	.000	.405	.482
x11	.015	.238	.153	.109	.331	.327	.032	.006	.225	.342		.283	.074	.493	.062	.021	.053	.000	.292	.001	.431	.347	.378	.475	.498	.207
x12	.338	.143	.379	.376	.407	.249	.208	.011	.371	.443	.283		.413	.249	.411	.481	.338	.070	.255	.310	.046	.014	.196	.103	.192	.357
x13	.017	.004	.429	.000	.378	.338	.000	.001	.053	.181	.074	.413		.484	.235	.000	.058	.050	.294	.000	.044	.068	.029	.000	.053	.456
x14	.179	.030	.315	.410	.004	.069	.340	.087	.201	.381	.493	.249	.484		.209	.157	.000	.363	.478	.447	.102	.252	.003	.042	.001	.399
x15	.081	.374	.006	.026	.283	.000	.061	.000	.448	.083	.062	.411	.235	.209		.298	.000	.496	.005	.019	.133	.418	.164	.004	.005	.478
x16	.193	.119	.469	.005	.361	.042	.117	.008	.047	.011	.021	.481	.000	.157	.298		.500	.035	.143	.480	.005	.051	.336	.004	.276	.037
x17	.250	.437	.016	.268	.412	.009	.338	.094	.016	.358	.053	.338	.058	.000	.000	.500		.150	.199	.147	.003	.032	.069	.320	.000	.112
x18	.000	.064	.395	.190	.008	.464	.000	.127	.274	.029	.000	.070	.050	.363	.496	.035	.150		.304	.000	.181	.311	.301	.001	.096	.221
x19	.000	.135	.189	.047	.000	.231	.422	.459	.303	.002	.292	.255	.294	.478	.005	.143	.199	.304		.109	.094	.071	.045	.231	.132	.041
x20	.000	.061	.040	.188	.409	.015	.468	.322	.000	.138	.001	.310	.000	.447	.019	.480	.147	.000	.109		.013	.005	.009	.003	.325	.031
x21	.000	.088	.218	.001	.006	.004	.024	.458	.233	.151	.431	.046	.044	.102	.133	.005	.003	.181	.094	.013		.000	.242	.000	.078	.006
x22	.089	.140	.118	.151	.000	.001	.122	.046	.203	.180	.347	.014	.068	.252	.418	.051	.032	.311	.071	.005	.000		.241	.005	.294	.018
x23	.072	.000	.282	.364	.323	.010	.246	.082	.286	.080	.378	.196	.029	.003	.164	.336	.069	.301	.045	.009	.242	.241		.141	.000	.138
x24	.099	.015	.102	.206	.374	.041	.098	.156	.117	.000	.475	.103	.000	.042	.004	.004	.320	.001	.231	.003	.000	.005	.141		.268	.418
x25	.480	.049	.127	.174	.031	.319	.058	.297	.456	.405	.498	.192	.053	.001	.005	.276	.000	.096	.132	.325	.078	.294	.000	.268		.180
x26	.401	.161	.020	.010	.129	.088	.016	.237	.068	.482	.207	.357	.456	.399	.478	.037	.112	.221	.041	.031	.006	.018	.138	.418	.180	

The source: Prepared by researcher depending on SPSS output

4.3.2 Correlation Matrix

The top half of the table contains the Pearson correlation coefficient matrix (between all pairs of variables). Where as the bottom half of the table contains the one tailed significant. This correlation matrix could be used check the pattern of relationships. There are no coefficient greater than 0.9; while some significance values are less than .o5; others are not. The determinant of the R – matrix is 0.078, which is greater than the necessary value (.00001) to perform factor analysis. Therefore singularity and multi – co linearity are not problems for these data.

Principal components analysis requires that there be some correlations greater than 0.30 between the variables included in the analysis.

For this set of variables, there are 71 correlations in the matrix greater than 0.30, satisfying this requirement. The correlations greater than 0.30 are high lighted in Brown.

The researcher uses the principal component as method of extraction; and Kaiser Criterion (Eigen values equal one or greater) for the number of factors. For rotation the Varimax method was chosen. The data have missed values, so it will be replaced with the means in order to keep the sample size as it's.

SPSS was requested to suppress the values of loading less than absolute value of (0.35).

The final analysis was run and the results of factor analysis at as below:

4.3.3 Factor extraction

The table shows the communalities before and after extraction. The second column shows the initial assumption (that principal components works on) that all variance is common, therefore before extraction communalities are all one. The last column shows the communalities after extraction, which reflect the common variance in the data structure; means that it is the proportion of variance explained by the underlying factors, for instance that about 63% of the variance associated with the owner gender is common, or shared variance, and about 82% of the variance associated with owner professional experience, and so on.

Table: 4-26 The Total Variance Explained

Component	Initial Eigen-values		
	Total	% of Variance	Cumulative %
1	2.144	8.245	8.245
2	1.720	6.614	14.860
3	1.611	6.197	21.057
4	1.518	5.839	26.896
5	1.364	5.248	32.144
6	1.328	5.107	37.251
7	1.305	5.018	42.269
8	1.197	4.606	46.874
9	1.112	4.278	51.153
10	1.096	4.216	55.369
11	1.017	3.910	59.279
12	1.003	3.859	63.138
13	.938	3.608	66.746
14	.916	3.524	70.270
15	.882	3.393	73.662
16	.876	3.368	77.030
17	.782	3.008	80.039
18	.755	2.903	82.942
19	.728	2.801	85.742
20	.702	2.702	88.444
21	.690	2.654	91.098
22	.576	2.216	93.314
23	.553	2.128	95.442
24	.497	1.911	97.353
25	.427	1.643	98.997
26	.261	1.003	100.000

The source: Prepared by researcher depending on SPSS outputExtraction Method: Principal Component Analysis.

The eigen-value associated with each factor represents the variance explained by that particular linear component.

Also the eigenvalues were displayed in terms of percentage of variance explained (column 3), so factor one explains 8% of total variance and factor two explains about 6.6% and so on.

It could be noticed that the first few factors explain relatively large amount of variance.

According to Kaiser Criterion only the factors with eigenvalues greater than one is extracted, so just eleven factors that have eigenvalues greater than one were retained, which displayed in table (4-29) represents the extraction sums of squared loadings. In this table the eigenvalues associated with the eleven factors and the percentages of variance explained are again displayed.

Table: 4-27 The Rotation Sums of Squared Loadings

Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	1.805	6.944	6.944
2	1.573	6.048	12.992
3	1.539	5.919	18.911
4	1.499	5.767	24.678
5	1.498	5.762	30.440
6	1.349	5.187	35.628
7	1.301	5.005	40.633
8	1.241	4.774	45.406
9	1.194	4.591	49.998
10	1.157	4.450	54.448
11	1.150	4.424	58.872
12	1.109	4.266	63.138

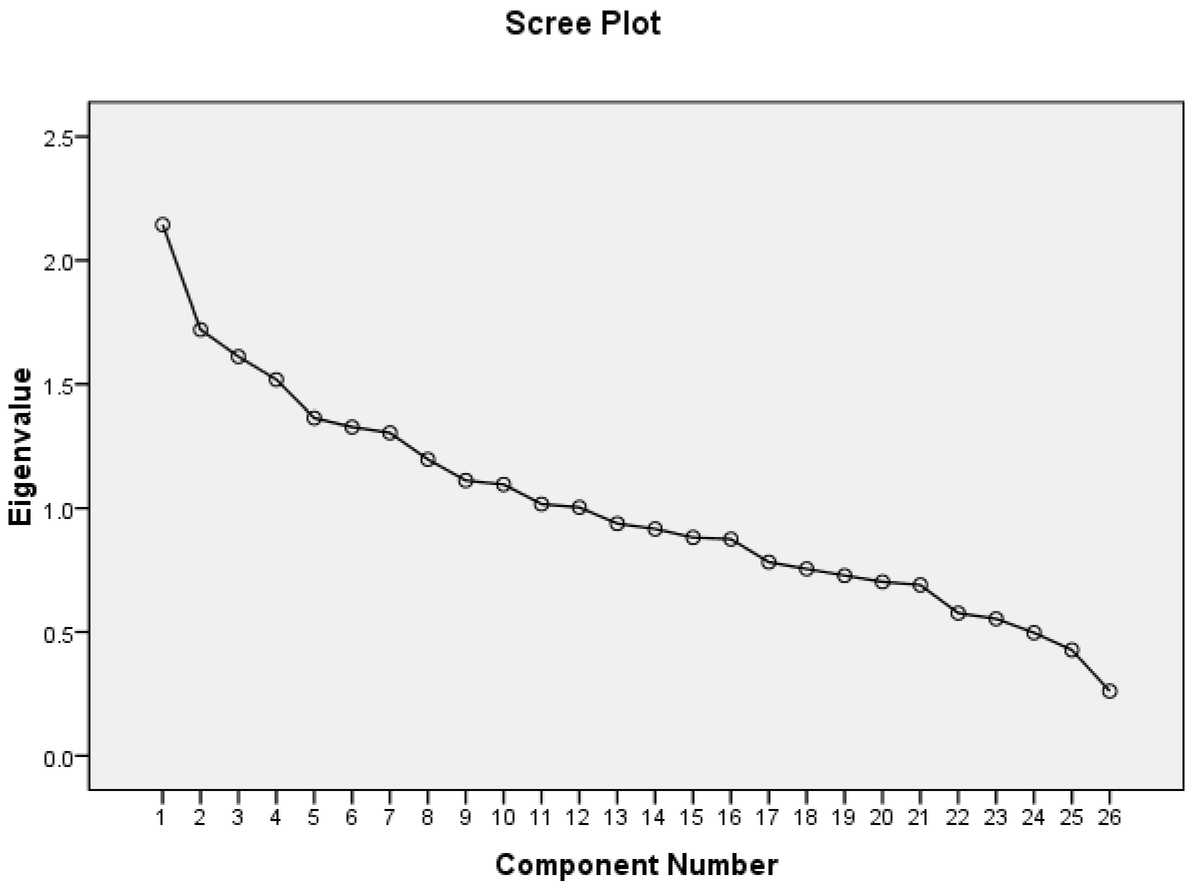
The source: Prepared by researcher depending on SPSS output

Table (4-30) represents the rotation sums of squared loading. The eigen-values after rotation are displayed in column two, the percentage variance column three and the cumulative percentage of variance in column four.

Rotation In actuality there are number of different potential solutions which might result from factor analytic procedure. An operation referred to as rotation is commonly employed in order to allow a researcher to discriminate more clearly between factors.

Rotation enables us to interpret the factor structure easily, and one of the consequences for these data is that the variances of the eleven factors were distributed. For the instance, before rotation the first two factors accounted for

Figure (3-4)



The source: Prepared by researcher depending on SPSS output

Screen plot of principal components and Eigen values

Values levels off to the right of the plot. Using this criterion, 12 PCs were retained in the analysis of this study. The different factors extracted represented different patterns affecting of animal resources.

Each PC was considered a weighted linear combination of the variables and was written with the heavy loadings and given the most descriptive names. Principal Component 1 (PC1) contributed 6.944 percent to the variation with an Eigen value of 29.419 in the variables included and represented.

4.4 Interpreting the results of a factor analytic procedure

The results of the factor analysis for the data of animal resources in north Kordofan state show the underlying structure in below table. Twelve factors are extracted, which explain 63.12% of the total variance.

Note that a set of numerical values is recorded in the columns for factor 1 and factor 2 up to factor 12. These values are called factor loading. A factor loading can interpreted as a correlation coefficient (and thus it will always fall within the range +1 to -1) that tells the researcher how much each of the variables (in this case, each of tests) correlates with each of the factor. As is also the case with a correlation coefficient, the absolute value of a factor loading indicates the strength of the relationship between that factor and given variable. The higher the absolute of factor loading, the purer measure that variable is of that factor.

And eignvalues is a numerical index that indicates the relative strength of each of the derived factors. On a more technical level, Kachigan (1986) notes that an eigenvalue (also known as a characterstic or latent root) is equivalent number of variables a factor represents. Thus the higher the eigenvalue associated with a factor, the larger the role that factor plays in explaining variability in the complete set of data.

Thus, (table 4-31)

Table: 4-28 The Structure of Factor one

No.	Variable	Loading
1	Vaccinate against diseases	0.896
2	Livestock water resource	0.896
3	Owner education level	-0.168
4	Breeding	0.225
5	Grazing hours/ day	-0.135
6	Do animal contribute in daily living requirements	-0.156

The source: Prepared by researcher depending on SPSS output

$$\text{Factor } 1 = a'_1 y = 0.896y_1 + .896y_2 - 0.168y_3 + 0.225y_4 - 0.135y_5 - 0.156y_6$$

The table (4-31) shows that this factor explained 6.944 of the total variance in animal resources in the state. It contains six variables.

Table: 4-29The Structure of Factor two

No.	Variable	Loading
1	Do owner have a farm	0.852
2	Breeding farm area	.837
3	Breeding	0.131
4	Died of livestock	0.109
5	Owner age	0.249

The source: Prepared by researcher depending on SPSS output

Factor 2 = $a'_1 y = 0.852y_1 + .837y_2 + 0.131y_3 + 0.109y_4 + 0.249y_5$

Factor two explained 6.048 of the total variance according to the results of factor analysis with orthogonal rotation as demonstrated in table (4-32). However, this factor is loaded five variables.

Table: 4-30 The Structure of Factor three

No.	Variable	Loading
1	Owner gender	-0.730
2	the owner secondary professional	0.691
3	Breeding purpose	0.230
4	Number after vaccination	0.114
5	Owner educational level	-0.241
6	the vaccinated animal per year	0.724
7	Animal labor personal	0.176
8	Annual animal leather	0.212
9	Vaccination animal	0.213
10	Breeding type	-0.197
11	Grazing hours /day	0.116

12	Owner age	0.331
13	Do animal contribute in daily living requirements	0.210
14	Owner secondary professional	0.167

The source: Prepared by researcher depending on SPSS output

Factor 3 = $a'_1 y$ =- $0.730y_1 + 0.691y_2 + 0.230y_3 + 0.114y_4 – 0241y_5 + 0.724y_6 + 0.176y_7 + 212y_8 + 0.213y_9 - 0.197y_{10} +0116y_{11} + 0.331y_{12} + 0.210y_{13} + 0.167y_{14}$

Factor three explained 5.919 of the total variance

Table: 4-31 The Structure of Factor four

No.	Variable	Loading
1	Female slaughtering animal per year	0.70
2	Breeding type	0.609
3	Animal commercial domestic	0.529
4	Owner main professional	0.136
5	Export animal	0.151
6	Owner education level	-0.230
7	Annual animal leather	0.314
8	the vaccination against diseases	-0.112
9	Grazing hours per day	-0.138
10	Owner age	-0.151
11	Owner secondary professional	0.167

The source: Prepared by researcher depending on SPSS output

Factor 4 = $a'_1 y = 0.70y_1 + 0.609y_2 + 0.529y_3 + 0.136y_4 + 0.151y_5 - 0.230y_6 + 0.314y_7 - 112y_8 - 0.138y_9 - 0.151y_{10} +0167y_{11}$

Factor four explained 5.767 of the total variance

Table 4-32 The Structure of Factor five

No.	Variable	Loading
1	Farm area	0.805
2	the vaccination against diseases	0.802
3	Female slaughtering animal per year	-0.199
4	Animal commercial domestic	0.151
5	Owner educational /year	-0.132
6	Animal labor personal	0.109
7	Annual animal leather	-0.153
8	the vaccination against diseases	0.113
9	Grazing hours /day	0.110
10	Owner age	0.111
11	Owner family member	0.132
12	Do animal contribute in daily living requirements	-0.105

The source: Prepared by researcher depending on SPSS output

Factor 5 = $a'_1y = 0.805y_1 + 0.802y_2 - 0.199y_3 + 0.151y_4 - 0.132y_5 + 0.109y_6 - 0.153y_7 + 113y_8 + 0.110y_9 + 0.111y_{10} +0132y_{11} - 105y_{12}$

Factor five explained 5.762 of the total variance

Table: 4-33 The Structure of Factor six

No.	Variable	Loading
1	Animal commercial domestic	0.751
2	Owner education level	0.421
3	Grazing hours /day	0.478
4	Owner family member	0.214
5	Animal commercial domestic	-0.122
6	Others reasons for animal decrement	0.149
7	the vaccination against diseases	0.278
8	Breeding	-0.187
9	Owner secondary professional	-0.345

The source: Prepared by researcher depending on SPSS output

Factor 6 = $a'_1y = 0.751y_1 + 0.421y_2 + 0.478y_3 + 0.214y_4 - 0.122y_5 + 0.149y_6 + 0.278y_7 - 187y_8 - 0.345y_9$

Factor six explained 5.187 of the total variance

Table: 4-34 Structure of Factor seven

No.	Variable	Loading
1	Animal labor personal	0.748
2	Annual animal leather	0.465
3	the vaccination against diseases	0.408
4	Owner main professional	0.157
5	Breeding	0.245
6	Number after vaccination	0.162
7	Female slaughtering animal /year	0.223
8	Male slaughtering animal per year	0.141
9	Owner secondary professional	0.181
10	Owner age	-0.282
11	Animal commercial domestic	-.0174

The source: Prepared by researcher depending on SPSS output

Factor 7= $a^{/}_{1}y = 0.748y_1 + 0.465y_2 + 0.408y_3 + 0.157y_4 + 0.245y_5 + 0.162y_6 + 0.223y_7 + 0.141y_8 + 0.181y_9 - 0.282y_{10} - 0.174y_{11} +0167y_{12}$

Factor 7 explained 5.005 of the total variance

Table: 4- 35 The Structure of Factor eight

No.	Variable	Loading
1	Others reasons for animal decrement	0.795
2	Breeding	0.544
3	Owner gender	0.252
4	Do animal contribute in daily living requirements	0.236
5	Animal commercial domestic	-0.159
6	Breeding type	0.195
7	Annual animal leather	-0.188
8	Owner family member	-0.188
9	Owner secondary professional	0.199

The source: Prepared by researcher depending on SPSS output

Factor 8= $a^{/}_{1}y = 0.795y_1 + 0.544y_2 + 0.252y_3 + 0.236y_4 - 0.159y_5 + 0.195y_6 - 0.188y_7 - 0.188y_8 + 0.199y_9$

Factor eight explained 4.774 of the total variance

Table 4- 36 The Structure of Factor nine

No.	Variable	Loading
1	Died of livestock	0.764
2	Grazing hours /day	0.526
3	Owner age	0.336
4	Breeding	0.195
5	Animal commercial domestic	0.214
6	Breeding farm area	0.101
7	Number after vaccination	0.130
8	Owner education level	-0.202

9	Annual animal leather	0.130
10	Farm area	-0.111

The source: Prepared by researcher depending on SPSS output

Factor 9 = $a'_1y = 0.764y_1 + 0.526y_2 + 0.336y_3 + 0.195y_4 + 0.214y_5 + 0.101y_6 + 0.130y_7 - 0.202y_8 + 0.130y_9 - 0.111y_{10}$

Factor nine explained 4.591 of the total variance

Table: 4- 37 Structure of Factor ten

No.	Variable	Loading
1	Owner family member	0.697
2	Do animal contribute in daily living requirements	0.596
3	Owner education level	0.265
4	Owner main professional	0.163
5	Owner age	-0.121
6	Number after vaccination	-0.404

The source: Prepared by researcher depending on SPSS output

Factor10 = $a'_1y = 0.697y_1 + 0.596y_2 + 0.265y_3 + 0.163y_4 - 0.121y_5 - 0.404y_6$

Factor ten explained 4.450 of the total variance

Table: 4- 38 The Structure of Factor eleven

No.	Variable	Loading
1	Owner professional experience	0.893
2	Annual animal leather	0.352
3	Animal commercial domestic	0.309
4	Owner education level	0.149
5	Other reasons for animal decrement	0.137
6	Owner secondary professional	0.185
7	Animal labor personal	-0.111
8	Breeding	-0.120

The source: Prepared by researcher depending on SPSS output

$Factor11 = a^{/}_{1}y = 0.893y_1 + 0.352y_2 + 0.309y_3 + 0.149y_4 + 0.137y_5 + 0.185y_6 - 0.111y_7 - 0.120y_8$

Factor eleven explained 4.424 of the total variance

Table: 4- 39 The Structure of Factor twelve

No.	Variable	Loading
1	Male slaughtering animal /year	0.820
2	Owner secondary professional	-0.536
3	Animal commercial domestic	0.105
4	Animal labor personal	0.138
5	Annual animal leather	-0.156
6	Breeding…	-0.134
7	Number after vaccination	-0.140
8	Owner family member	-0.145
9	Do animal contribute in daily living requirements	0.116

The source: Prepared by researcher depending on SPSS output

$Factor12 = a^{/}_{1}y = 0.820y_1 - 0.536y_2 + 0.105y_3 + 0.138y_4 - 0.156y_5 - 0.134y_6 - 0.140y_7 - 0.145y_8 + 0.116y_9$

Factor 12 explained 4.266 of the total variance

The most important three factors are the health of live stock, farm area and experience of owner.

First factor includes these variables (Livestock Water Resource, vaccinated Animal), which explains 8.25% about of the total variance.

Second factor includes these variables (Owner Farm, farm Area), which explains 6.6% about of the total variance.

Third factor includes these variables (Owner Main Professional, Owner Gender), which explains 6.2% about of the total variance.

Fourth factor includes these variables (female Slaughtering Animal per Year, Breeding Type and animal Commercial Domestic), which explains 5.8% about of the total variance.

Fifth factor includes these variables (Breeding Farm Area, animal Health), which explains 5.25% about of the total variance.

Sixth factor includes these variables (Export Animal, Owner Education Level), which explains 5.12% about of the total variance.

Seventh factor includes these variables (Animal labor Personnel, annual Animal leather), which explains 5% about of the total variance.

Eights factor includes these variables (Vaccinated Animals, Reasons for Animal Decrement), which explains 4.61% about of the total variance.

Ninth factor includes these variables (lost of animal, grazing hours/day), which explains 4.28% about of the total variance.

Tenth factor includes these variables (Owner Professional Experience, Vaccinated Animals), which explains 4.22% about of the total variance.

Eleventh factor includes these variables (Owner Professional Experience and animal Commercial Domestic), which explains 3.9% about of the total variance.

Twelve factor includes these variables (Slaughtering male Animal/year Owner Professional Experience), which explains 3.8% about of the total variance.

The principal components were given as follows:

$$\text{Factor } 1 = a'_1 y = 0.896y_1 + .896y_2 - 0.168y_3 + 0.225y_4 - 0.135y_5 - 0.156y_6$$

$$\text{Factor } 2 = a'_1 y = 0.852y_1 + .837y_2 + 0.131y_3 + 0.109y_4 + 0.249y_5$$

$$\text{Factor } 3 = a'_1 y = - 0.730y_1 + 0.691y_2 + 0.230y_3 + 0.114y_4 - 0241y_5 + 0.724y_6 + 0.176y_7 + 212y_8 + 0.213y_9 - 0.197y_{10} + 0116y_{11} + 0.331y_{12} + 0.210y_{13} + 0.167y_{14}$$

$$\text{Factor } 4 = a'_1 y = 0.70y_1 + 0.609y_2 + 0.529y_3 + 0.136y_4 + 0.151y_5 - 0.230y_6 + 0.314y_7 - 112y_8 - 0.138y_9 - 0.151y_{10} + 0167y_{11}$$

Factor 5 = $a^{/}_{1}y = 0.805y_1 + 0.802y_2 - 0.199y_3 + 0.151y_4 - 0.132y_5 + 0.109y_6 - 0.153y_7 + 113y_8 + 0.110y_9 + 0.111y_{10} +0132y_{11} - 105y_{12}$

Factor 6 = $a^{/}_{1}y = 0.751y_1 + 0.421y_2 + 0.478y_3 + 0.214y_4 - 0.122y_5 + 0.149y_6 + 0.278y_7 - 187y_8 - 0.345y_9$

Factor 7= $a^{/}_{1}y =0.748y_1 + 0.465y_2 + 0.408y_3 + 0.157y_4 + 0.245y_5 + 0.162y_6 + 0.223y_7 + 0.141y_8 + 0.181y_9 - 0.282y_{10} - 0.174y_{11} +0167y_{12}$

Factor 8= $a^{/}_{1}y =0.795y_1 + 0.544y_2 + 0.252y_3 + 0.236y_4 - 0.159y_5 + 0.195y_6 - 0.188y_7 - 0.188y_8 + 0.199y_9$

Factor 9 = $a^{/}_{1}y =0.764y_1 + 0.526y_2 + 0.336y_3 + 0.195y_4 + 0.214y_5 + 0.101y_6 + 0.130y_7 - 0.202y_8 + 0.130y_9 - 0.111y_{10}$

Factor10 = $a^{/}_{1}y =0.697y_1 + 0.596y_2 + 0.265y_3 + 0.163y_4 - 0.121y_5 - 0.404y_6$

Factor11= $a^{/}_{1}y =0.893y_1 + 0.352y_2 + 0.309y_3 + 0.149y_4 + 0.137y_5 + 0.185y_6 - 0.111y_7 - 0.120y_8$

Factor12 = $a^{/}_{1}y =0.820y_1 - 0.536y_2 + 0.105y_3 + 0.138y_4 - 0.156y_5 - 0.134y_6 - 0.140y_7 - 0.145y_8 + 0.116y_9$

Factor 1 explained	6.944	of the total variance
Factor 2 explained	6.048	of the total variance
Factor 3 explained	5.919	of the total variance
Factor 4 explained	5.767	of the total variance
Factor 5 explained	5.762	of the total variance
Factor 6 explained	5.187	of the total variance
Factor 7 explained	5.005	of the total variance
Factor 8 explained	4.774	of the total variance
Factor 9 explained	4.591	of the total variance
Factor 10 explained	4.450	of the total variance
Factor 11explained	4.424	of the total variance
Factor 12 explained	4.266	of the total variance

CHAPTER FIVE

RESULTS AND RECOMMONDATION

5.1RESULTS:

The results of the factor analysis for the data of animal resources in north Kordofan state showed the underlying structure.

- Twelve factors are extracted, which explain 63.12 of the total variance. The most important three factors are the health of live stock, farm area and experience of owner.
- The first factor which called (Animal health) includes the variables (Livestock, Water Resource, Vaccinated Animal), which explains 8.25% about of the total variance.
- The second factor called (Range) includes the variables (Owner Farm, farm Area), which explains 6.6% about of the total variance.
- The third factor called (Type of Owner) includes the variables (Owner Main Professional, Owner Gender), which explains 6.2% about of the total variance.
- The fourth factor called (Slaughter & Breeding) includes the variables (female Slaughtering Animal per Year, Breeding Type and animal Commercial Domestic), which explains 5.8% about of the total variance.
- The fifth factor called (Animal Husbandry) includes the variables (Breeding Farm Area, animal Health), which explains 5.25% about of the total variance.
- The sixth factor called (Animal Export) includes the variables (Export Animal, Owner Education Level), which explains 5.12% about of the total variance.

- The seventh factor called (Labor & Leather) includes the variables (Animal labor Personnel, annual Animal leather), which explains 5% about of the total variance.
- The eights factor called (animal mortality) includes the variables (Vaccinated Animals, Reasons for Animal Decrement), which explains 4.61% about of the total variance.
- The ninth factor called (Leathers) includes the variables (lost of animal, grazing hours/day), which explains 4.28% about of the total variance.
- The tenth factor called (Animal Safety) includes the variables (Owner Professional Experience, Vaccinated Animals), which explains 4.22% about of the total variance.
- The eleventh factor includes the variables (Owner Professional Experience and animal Commercial Domestic), which explains 3.9% about of the total variance.
- The twelve factors called (Animal Care) includes the variables (Slaughtering).
- The sex of the respondents, 92.6% males and 7.4% were females
- The education levels of the respondents, it's clear that most of them concentrate in the low levels and illiterate.
- the animals vaccinated against diseases per year 75.1% and 24.1% are not vaccinated.
- 95.8% for the respondents the animal contribute in daily living requirements

RECOMMONDATION:

1- Provision water resources

2- Increment of the vaccination campaigns

3- Arise of the community a wariness

4- Improve the animal health care

5- Giving priority to research that improvement the livestock

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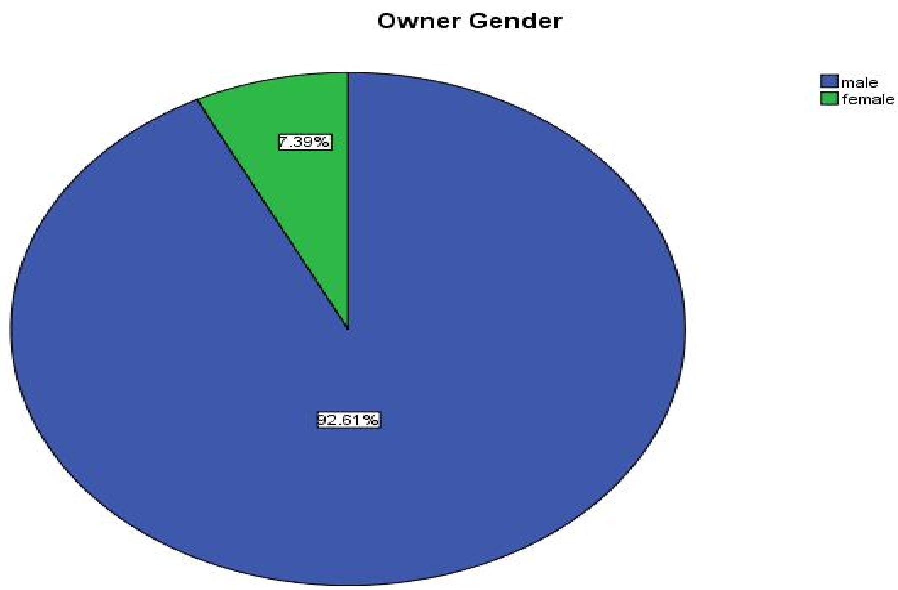
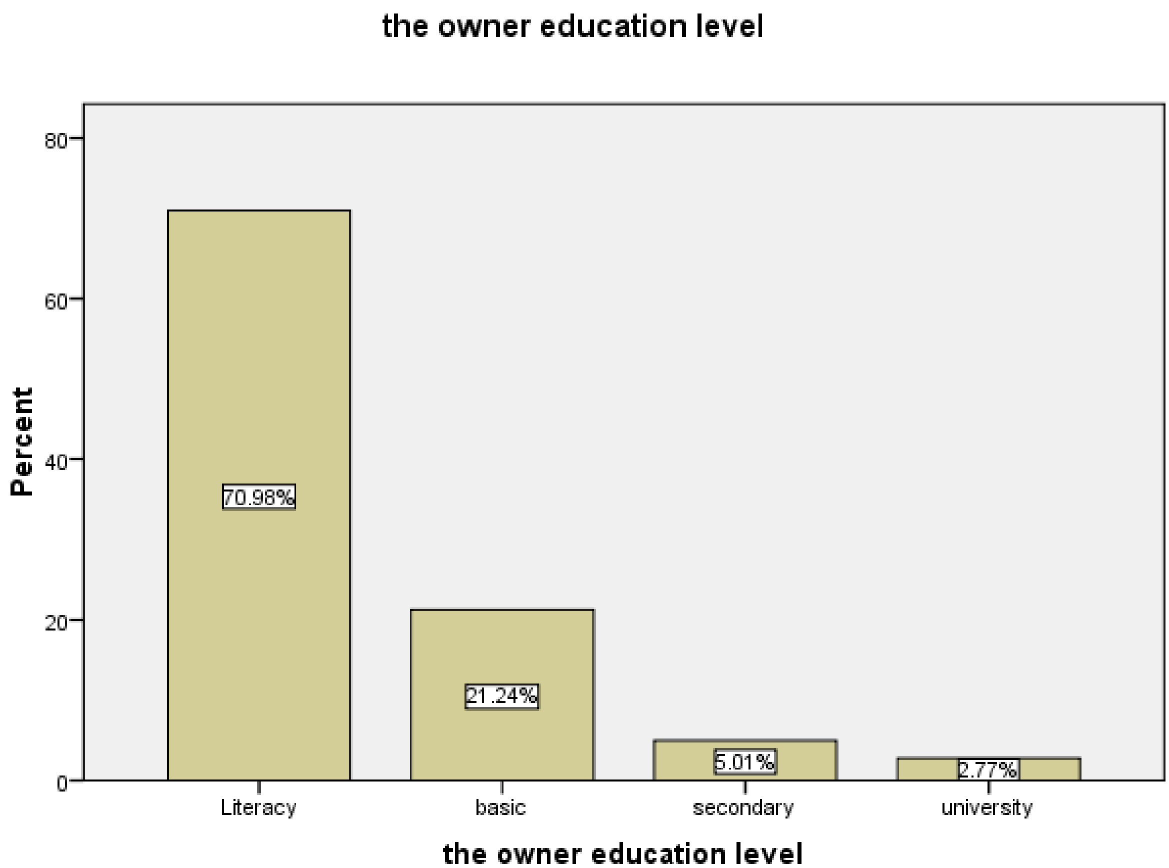
Appendix

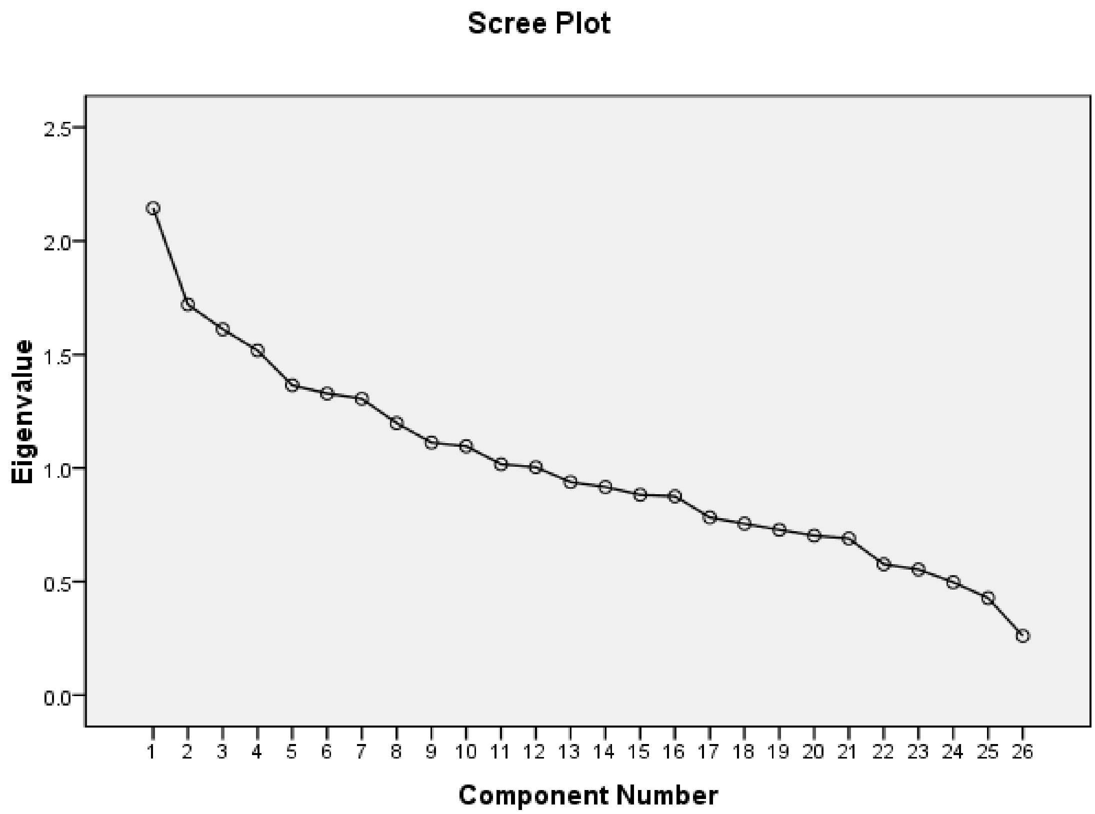




the owner education level
Percent
80
60
40
20
0
70.98%
21.24%
5.01%
2.77%
Literacy
basic
secondary
university
the owner education level

Correlation matrix

	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15	x16	x17	x18	x19	x20	x21	x22	x23	x24	x25	x26
x1		.000	.019	.071	.001	.000	.000	.036	.489	.103	.015	.338	.017	.179	.081	.193	.250	.000	.000	.000	.000	.089	.072	.099	.480	.401
x2	.000		.170	.113	.070	.268	.020	.312	.029	.371	.238	.143	.004	.030	.374	.119	.437	.064	.135	.061	.088	.140	.000	.015	.049	.161
x3	.019	.170		.264	.186	.001	.130	.374	.348	.052	.153	.379	.429	.315	.006	.469	.016	.395	.189	.040	.218	.118	.282	.102	.127	.020
x4	.071	.113	.264		.192	.074	.003	.400	.256	.377	.109	.376	.000	.410	.026	.005	.268	.190	.047	.188	.001	.151	.364	.206	.174	.010
x5	.001	.070	.186	.192		.031	.399	.129	.277	.067	.331	.407	.378	.004	.283	.361	.412	.008	.000	.409	.006	.000	.323	.374	.031	.129
x6	.000	.268	.001	.074	.031		.006	.065	.060	.000	.327	.249	.338	.069	.000	.042	.009	.464	.231	.015	.004	.001	.010	.041	.319	.088
x7	.000	.020	.130	.003	.399	.006		.013	.274	.210	.032	.208	.000	.340	.061	.117	.338	.000	.422	.468	.024	.122	.246	.098	.058	.016
x8	.036	.312	.374	.400	.129	.065	.013		.305	.165	.006	.011	.001	.087	.000	.008	.094	.127	.459	.322	.458	.046	.082	.156	.297	.237
x9	.489	.029	.348	.256	.277	.060	.274	.305		.288	.225	.371	.053	.201	.448	.047	.016	.274	.303	.000	.233	.203	.286	.117	.456	.068
x10	.103	.371	.052	.377	.067	.000	.210	.165	.288		.342	.443	.181	.381	.083	.011	.358	.029	.002	.138	.151	.180	.080	.000	.405	.482
x11	.015	.238	.153	.109	.331	.327	.032	.006	.225	.342		.283	.074	.493	.062	.021	.053	.000	.292	.001	.431	.347	.378	.475	.498	.207
x12	.338	.143	.379	.376	.407	.249	.208	.011	.371	.443	.283		.413	.249	.411	.481	.338	.070	.255	.310	.046	.014	.196	.103	.192	.357
x13	.017	.004	.429	.000	.378	.338	.000	.001	.053	.181	.074	.413		.484	.235	.000	.058	.050	.294	.000	.044	.068	.029	.000	.053	.456
x14	.179	.030	.315	.410	.004	.069	.340	.087	.201	.381	.493	.249	.484		.209	.157	.000	.363	.478	.447	.102	.252	.003	.042	.001	.399
x15	.081	.374	.006	.026	.283	.000	.061	.000	.448	.083	.062	.411	.235	.209		.298	.000	.496	.005	.019	.133	.418	.164	.004	.005	.478
x16	.193	.119	.469	.005	.361	.042	.117	.008	.047	.011	.021	.481	.000	.157	.298		.500	.035	.143	.480	.005	.051	.336	.004	.276	.037
x17	.250	.437	.016	.268	.412	.009	.338	.094	.016	.358	.053	.338	.058	.000	.000	.500		.150	.199	.147	.003	.032	.069	.320	.000	.112
x18	.000	.064	.395	.190	.008	.464	.000	.127	.274	.029	.000	.070	.050	.363	.496	.035	.150		.304	.000	.181	.311	.301	.001	.096	.221
x19	.000	.135	.189	.047	.000	.231	.422	.459	.303	.002	.292	.255	.294	.478	.005	.143	.199	.304		.109	.094	.071	.045	.231	.132	.041
x20	.000	.061	.040	.188	.409	.015	.468	.322	.000	.138	.001	.310	.000	.447	.019	.480	.147	.000	.109		.013	.005	.009	.003	.325	.031
x21	.000	.088	.218	.001	.006	.004	.024	.458	.233	.151	.431	.046	.044	.102	.133	.005	.003	.181	.094	.013		.000	.242	.000	.078	.006
x22	.089	.140	.118	.151	.000	.001	.122	.046	.203	.180	.347	.014	.068	.252	.418	.051	.032	.311	.071	.005	.000		.241	.005	.294	.018
x23	.072	.000	.282	.364	.323	.010	.246	.082	.286	.080	.378	.196	.029	.003	.164	.336	.069	.301	.045	.009	.242	.241		.141	.000	.138
x24	.099	.015	.102	.206	.374	.041	.098	.156	.117	.000	.475	.103	.000	.042	.004	.004	.320	.001	.231	.003	.000	.005	.141		.268	.418
x25	.480	.049	.127	.174	.031	.319	.058	.297	.456	.405	.498	.192	.053	.001	.005	.276	.000	.096	.132	.325	.078	.294	.000	.268		.180
x26	.401	.161	.020	.010	.129	.088	.016	.237	.068	.482	.207	.357	.456	.399	.478	.037	.112	.221	.041	.031	.006	.018	.138	.418	.180	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2.5
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