Asian Journal of Advances in Agricultural Research

14(2): 18-28, 2020; Article no.AJAAR.60898
ISSN: 2456-8864

Analysis of Environmental Factors Determining the Adoption of Land Management Practices in Guinea Savanna Agro-Ecological Zone of Kaduna Using Principal Component Analysis (PCA)

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Authors' contributions

This work was carried out in collaboration among all authors. Author TAA designed the study. Author JOA performed the statistical analysis and wrote the protocol. Authors JOE and OO wrote the first draft of the manuscript. Authors JAO and OWB managed the analyses of the study. Author RAJ managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2020/v14i230127
Editor(s):
(1) Dr. Saad Farouk Mohamed Hussiien Gadalla, Mansoura University, Egypt.
Reviewers:
(1) Somanath Sarvade, Jawaharlal Nehru Krishi Vishwavidyalaya, India.
(2) Nasim Ahmad, Dr. Rajendra Prasad Central Agricultural University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60898

Original Research Article

Received 06 July 2020
Accepted 10 September 2020
Published 21 September 2020

ABSTRACT

This study analyzed the various determinants of land management practices in Chikun LGA of Kaduna State and determined most sustainable practice(s), with the specific focus on: Socio-economic characteristics of farmers; types of land management practices in relation to the determinant factors; effects of land management practices on the farm productivity; determine the most sustainable land management practice in the study area. A purposive sampling technique was adopted in collecting data from three hundred and eighty (380) rural farmers with structured questionnaires administered in Buruku, Chikun Local Government area of Kaduna State, Nigeria. Five land management practices showed positive effects on the farm productivity as compared to the mean of 3 points; these were cover crop, crop rotation, irrigation, organic manure and fertilizer application. Two land management practices as perceived to have good effects on farm productivity of respondents were agro-forestry and bush fallow as shown in the component one of

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the result of Principal Component Analysis (PCA). It was concluded that the farming population was ageing and was adversely affected the choice of best practices due to lack of education and knowledge to adopt the best land management practice. Sustainable land management practices has the potential to reverse the trend of food scarcity and environmental disasters, help to improve local livelihoods, restore natural ecosystems and also contribute significantly to climate change adaptation and mitigation. There is clear evidence that the productivity of soils in Buruku Village will continue to decline if strategic measures are not put in place to manage soil fertility in different soil units to support agricultural land.

Keywords: Land management; environmental factors; productivity; agro-ecological zone and principal component analysis.

1. INTRODUCTION

Land management is the systems that through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources [1].

Land degradation is clearly a cause for concern – the productive potential and the well being of communities are at risk. Degradation has resulted in a significant reduction in the economic, social and ecological benefits of land for crop, livestock and tree production purposes. It also negatively affects the inland and coastal fisheries, availability of natural products (for food, fuel and medicines) and opportunities for ecotourism [2].

The extention of land degradation in Nigeria is presently alarming, it occurs on different scales and dimensions and experiences in all part of the country. Also, compared with some other African countries, the country is blessed with abundant land resources, which are capable of indefinite regeneration over a given period of time if the prevailing management practices are conducive [3,4].

Moreover, poor incentives for natural resource conservation, among other socio-economic problems, have subjected the soils' nutrients to serious exploitation and depletion. Nigerian policy makers have now come to understand that sustainable management of land is a prerequisite for providing enabling environment for agricultural development, which is pivotal towards ensuring that the basic needs of human being is adequately available, accessible and affordable for the growing populations [3,5].

It is against the backdrop where this study examined various factors that push farmer to adopt certain land management practices in Buruku, Chikun Local Government Area of Kaduna State, Nigeria. The study has following specific objectives, such as examine socio-economic characteristics of farmers; identify the various types of land management practices in relation to the determinant factors; examine the effects of each of the land management practices on the farm productivity; determine the most sustainable land management practice.

2. METHODOLOGY

2.1 The Study Area

The study was conducted in Chikun Local Government Area which is one of the local government areas located in northern guinea savanna of agro-ecological zone of Kaduna state, Nigeria. It is geographically located between latitude 10° 33'N to 10° 37'N and Longitudes7° 10' E to 7° 14' E (see Fig. 1). It is situated some 50 km north west of Kaduna Township along Kaduna-Lagos express way. The area is bounded by Igabi Local Government Area to the east, Kaduna metropolis to the South east and north and Birnin-Gwari to the west [4]. The area is being located in the interior part of Nigeria experiences continental climate. It is characterized by wet and dry seasons orchestrated by the movement of the inter-tropical Convergence Zone [5]. The dry season in the area begins in early November and lasts till April while the wet season starts from May and ends in September. The length of rainfall varies from 150 days to 190 days with an annual rainfall ranging between 1500 mm and 2000 mm. The temperature is high throughout the year with the peak in March and April (37°C), while the mean annual temperature varies between 24°C and 28°C. Humidity is constantly high (above 60%) at mid-day and close to 100% at night during the rainy season, relative humidity is low ranging between 20% and 40% in January rising to between 60% and 80% in July [5].

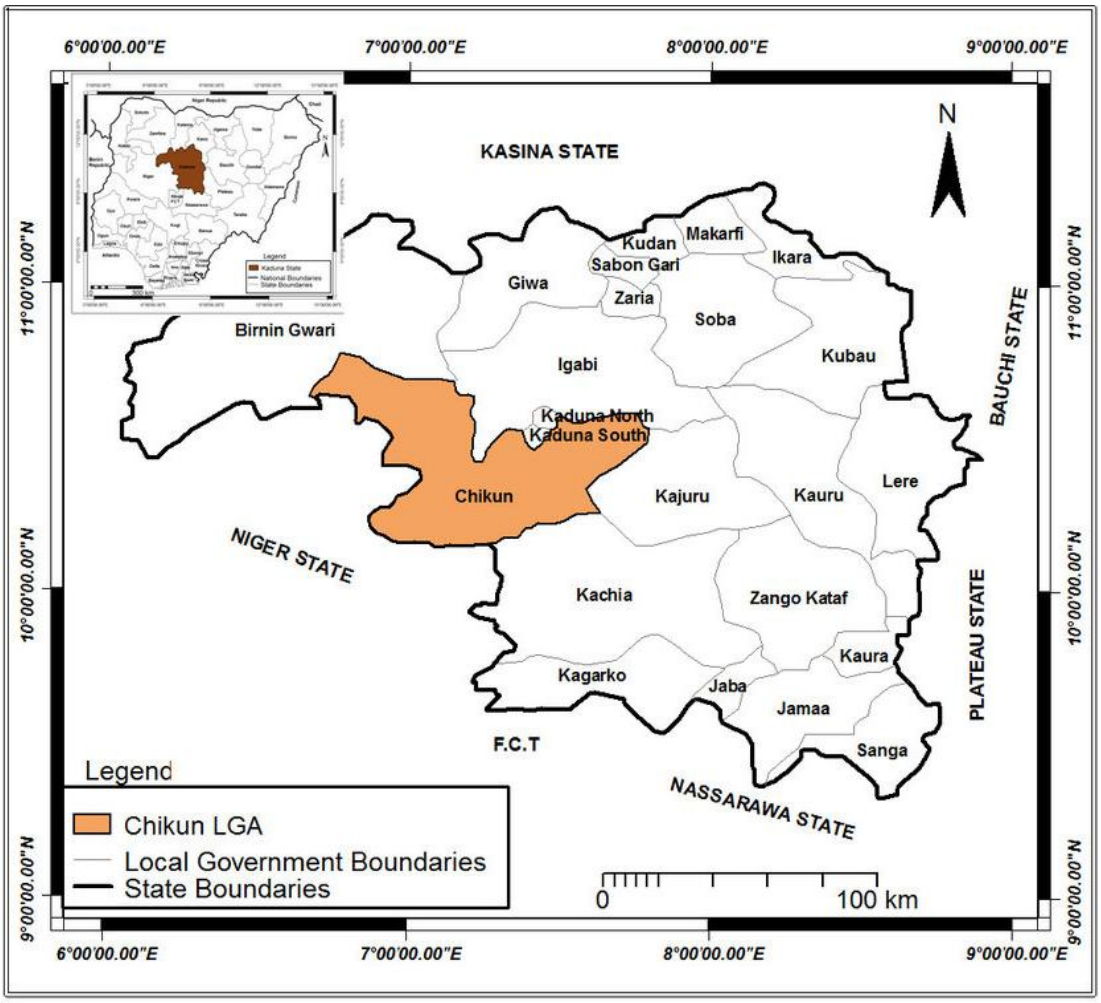

Fig. 1. Map of Kaduna state showing the study area
Source: Modified from Administrative Map of Kaduna State

The study area falls within the basement complex of central Nigeria and soil type is derived from weathering of the rocks. The area consists mainly of lateritic rocks, the soil of the area can be classified as ferruginous tropical soil [4]. Soils are typically red-brown to red-yellow tropical ferruginous soils. Some areas are richer in kaolinitic clay and organic matter, very heavy and poorly drained which are characteristics of vertisols [6]. The modified vegetation zone on the northern Guinea savannah is a land described as wood land vegetation with relatively interspaced and short scattered trees within which are thick bushes and shrubs. The vegetation cover consists of the following native or indigenous species of *Isoberlina doka, Monotes kerotingu, Vapaca togoensis, Parimarie curratelli folia* etc. Some of the exotic species include; *Eucalyptus rudis, Mangifera Indica, Pinus cocara.* Some of these species grown in agroforerstry practices which is one of land management practices in the study area.

2.2 Method of Data Collection

The study was carried out through field observation, personal contact with the rural farmers by means of standard questionnaire. Purposive sampling was employed for sample population, to obtain the 380 respondents in the study area. Data were derived from the survey was statistically analyzed through the use of both descriptive and inferential statistical method such as Principal Component Analysis (PCA) through the application of Statistical Package for the Social Sciences (SPSS).

3. RESULTS AND DISCUSSION

3.1 Socio-Economic Characteristics of the Respondents

Gender distribution of the farmers depicted more male (100%) than female (Table 1). This result confirmed with the cultural settings in the study area, an area which is predominantly Muslims and women are in Purdah (their religious beliefs make them to be indoors more often).

It was discovered from the Table 1 that 88% of the farmers were between the age of 20 – 60 years old, this implied that majority of the respondents were in the active age brackets. The mean age was 44 years and this showed that there was availability of family labour and productivity of the labour because age has direct bearing on the availability of farm labour and the ease with which sustainable land management practices were adopted. This fact was in agreement with Raufu and Adetunji that age bracket was in direct bearing on the availability of farm labor and the ease with which improved sustainable land management practices are adopted [7].

Most of the farmers (65%), have Quranic education. Those with primary and secondary education are 12% and 19% respectively. The remaining 4% have post secondary education. This is expected to have significant impact and ability of farmers to effectively adopt better land management practices. This result is in agreement with the findings of Abdulazeez et al. [8] that, the education influences adoption of land management practices positively [9].

Majority (92%) of the respondents are married, while the remaining 8% being single and no respondents are widowed or divorced.

Years of farming experience is one of major factors that contribute to the effective land management in this type of occupation. From Table 1, most of the farmers sampled have been in farming practice for more than 20 years, (67%). While 18% have between 6 – 10 years of farming knowledge, 9% have between 11 – 15 years of farming experience. Only 2% have just spent less than 5 years on the farm which indicated the mean farming experience to be 18.8 years.

Majority of the respondents have farm sizes ranging between 2 and 7 hectares per farmer. A total of 44 of the respondents have their farmlands ranging between 2 and 4 hectares, while 17% of the people have theirs between 5 and 7 hectares. Seventeen percent (17%) have total farm land between 8 and 10 hectares, 16% have above 10 hectares and 6% of the farmers have below 2 hectares of land. This value gives a mean farmland size of respondents to be 5.9 hectares of land per farmer. This corroborates with Abdulazeez et al. [8], who observed that this factor is necessary because the farmland size determines the types of land management practiced [9].

Several land management practices such as fallowing are known to require more land area. Inadequate land area may therefore pose a problem in the adoption of such practices.

Table 1 shows the type of land ownership system among the respondents. About 48% of the farmers personally owned the land while 34% hired the land, and only 18% of the farmers were either rented the land or borrowed from the community head. The ownership structure conforms to the findings of Abdulazeez et al. [8], which is important as farmers may not be willing to expend effort towards sustainable land management practices on land temporarily held by them [9]. This group of people are those whose farmlands are not quite productive or those with large number of families, whose farmlands are not large enough to support their food requirement.

3.2 Determinants of Land Management Practices in the Study Area

The study tried to elicit some factors considered as the determinants in adopting different land management practice by the respondents. This is contrary to the study of Raufu and Adetunji that only considered socio-economic factors to determine land management practices [7]. The determinant factors in this study were derived under different categories of problems associated with environment, economic and social factors on land and agricultural activities in the study area. These factors include erosion, strong wind, drought and flood, bush fire, crop pests, natural hazards, sustain land, financial cost, adoptability and farm productivity [10].

The result is presented in Table 2 observed that most farmers (51%) practiced application of fertilizer, application of organic manure (40%), agroforestry (6%), while 2% of the respondents

practiced irrigation and mulching to control erosion respectively.

Another environmental problem is strong wind which is a peculiar problem to the farmers of the study area, fertilizer and organic manure which top the group with 42% and 32% respectively, were applied to reduce the effects of strong wind on their farms, while agroforestry and irrigation were adopted by 13% of respondents each to solve the problem. The remaining respondents, 2% made use of other methods like cover crops and bush fallow to checkmate the problem.

Table 1. Socio-economic characteristics of the respondents

Variable	Variable	Percentage (%)
Gender		
Male	380	100
Female	0	0
Total	380	100
Age group		
21 – 30	53	14
31 – 40	118	31
41 – 50	95	25
51 – 60	68	18
Above 60	46	12
Total	380	100
Educational level		
Primary	12	46
Secondary	72	19
Post –Secondary	15	4
Q/Education	247	65
Total	380	100
Marital status		
Married	350	92
Single	30	8
Widow	0	0
Total	380	100
Year of farming experience		
< 5	8	2
6 – 10	68	18
11 – 15	34	9
16 – 20	15	4
> 20	255	67
Total	380	100
Farm land size (Ha)		
< 2	23	6
2 – 4	166	44
5 – 7	65	17
8 – 10	65	17
> 10	61	16
Total	380	100
Farm ownership		
Personally Owned	182	48
Community	0	0
Hired	129	34
Rent	69	18
Total	380	100

Source: Field Survey, 2019

Table 2. Determinants of the choice of land management practices by the respondents

⇩ ⇨	Mulching	Cover crop	Crop rotation	Irrigation	Organic manure	Fertilizer	Bush fallow	Agroforestry	Total
Erosion	8 (1.7%)	0	0	11 (2.3%)	190 (39.7%)	243 (50.7%)	0	27 (5.6%)	479 (100%)
Strong Wind	0	4 (0.9%)	0	53(12.6%)	133 (31.5%)	177 (41.9%)	2(0.5%)	53 (12.6%)	422 (100%)
Drought& Fl	4 (0.9%)	4 (0.9%)	8 (1.9%)	99(23.2%)	106 (24.9%)	189 (44.4%)	5(1.2%)	11 (2.6%)	426 (100%)
Bush Fire	0	0	4 (0.9%)	65(15.4%)	129 (30.6%)	220 (52.1%)	0	4 (0.9%)	422 (100%)
Crop Pest	4 (1.0%)	0	27 (6.5%)	8 (1.9%)	129 (31.2%)	243 (58.7%)	0	4 (1.0%)	415 (100%)
Natural Ha	0	0	4 (1.0%)	11 (2.7%)	133 (32.1%)	243 (58.6%)	4(1.0%)	19 (4.6%)	414 (100%)
Sustain Land	4 (1.0%)	0	4 (1.0%)	4 (1.0%)	297 (76.5%)	60 (15.5%)	0	19 (5.0%)	388 (100%)
Less Exp	15 (3.8%)	0	0	0	304 (77.7%)	53 (13.6%)	0	19 (4.9%)	391 (100%)
Adoptable	11 (2.5%)	4 (0.9%)	0	8 (1.8%)	304 (69.6%)	99 (22.7%)	0	11 (2.5%)	437 (100%)
Productivity	0	0	0	8 (1.9%)	170 (39.9%)	240 (56.3%)	0	8 (1.9%)	426 (100%)
Total	46 (1.1%)	12 (0.4%)	47 (1.1%)	267(6.3%)	1895 (44.9%)	1767(41.8%)	11(0.3%)	175 (4.1%)	4220 (100%)

Sources: Field Survey, 2019

Key: Fl- Flood, Ha- Hazard, Exp- Expensive, ⇨ Land Management ⇩ Determinant Factors

It was also revealed that about 44% of the farmers applied fertilizer to solve the problem of drought and flood, while organic manure and irrigation were applied by 25% and 23% respectively. Eleven farmers, representing 3% believed that trees (agroforestry) could also be used to reduce the effect of drought and flood in the area [11]. Crop rotation was practiced by 2% while mulching, bush fallow and cover crops were practiced by 1% each. About 52% and 31% adopted fertilizer application and organic manure, respectively to prevent bush fire, while the remaining 17% adopted other methods like irrigation, crop rotation and agroforestry.

Moreover, very few of farmers knew the significance of trees on their farm in preventing other natural hazards and climate change, with about 59% practicing application of fertilizer, followed by application of organic manure being practiced by 32% of farmers while the rest of them adopted irrigation, crop rotation or agroforestry.

Among the other factors that determined the choice of land management practice was cost of practice,78% adopted organic manure followed by fertilizer application (13%), while agroforestry, irrigation, mulching, crop rotation were adopted by very few of respondents. A huge percentage of the respondents, (77%), adopted Organic Manure of sustainability while 16% adopted fertilizer application. For adoptability socially and culturally in the study area, 70% applied organic manure and only 23% applied fertilizer for that purpose, the remaining land management practices were adopted by less than 3% for these factors. On the area of the land management practices that increased the farm productivity, more than half of the respondents, 56% applied fertilizer, while 40% applied organic manure. Irrigation and agroforestry were practiced by 2% each, while mulching, cover crop, crop rotation and bush fallow were not applied by any of the respondents for this purpose [12].

Generally, from Table 2 it can be concluded that 45% of the farmers in Buruku in Chikun Local Government Area of Kaduna state apply organic manure, followed by fertilizer with 42%, next is irrigation with 6%, agroforestry was also practiced by 4% of the farmers, whereas mulching and crop rotation were practiced by almost the same number of farmers, with 1% each. Cover crop and bush fallow were practiced by less than one percent of the respondents.

3.3 The Effects of Land Management Practices on Farm Productivities

The effects of land management practices on farm productivity is presented in Table 3 the effects of land management practices on the farmers' products, fertilizer application had very good effects on the farm yield of farmers with mean point of 4.81, the application of fertilizer over the years on the farm has been having tremendous improvement on their farm yields, which means it has not had any negative effects to the farmers on their produce [13]. The next land management practice was Organic Manure with mean of 3.92 as shown in Table 3, this also has very good effect on the farm yields, followed by crop rotation with average mean of 3.39, this also shows a good effect, while the practices of cover crop and irrigation also have positive effect on the farm produce with mean of 3.21 and 3.20 respectively. However, the other three practices were considered to have poor effect on the productivity, these are agroforestry, mulching and bush fallow with mean of 2.16, 2.04 and 1.81 respectively.

Table 3. The effects of land management practices on farm productivity

Land management	Frequency	Mean	Remarks
Mulching	380	2.04	Poor
Cover crop	380	3.21	Good
Crop rotation	380	3.39	Good
Irrigation	380	3.20	Good
Organic manure	380	3.92	Good
Fertilizer	380	4.81	Good
Bush fallow	380	1.81	Poor
Agroforestry	380	2.16	Poor

Sources: Field Survey (2019)

3.4 Most Sustainable Land Management Practice

A method was adopted to determine the sustainable land management is the use of Principal Component Analysis (PCA). The principal components are used as predictors or criterion variables in this study to determine the most sustainable land management practices.

The variables used in this section are data derived from farmers' perception on the effect of land management practices on farm productivity.

The eigenvalue from Table 4 shows that the first three components combined account for approximately 60% of the total variance (this variance value can be observed at the intersection of the row headed "Cumulative" and column headed "3"). According to the "percentage of variance accounted for" criterion, this suggests that it may be appropriate to retain three components (Table 4).

The scree plot from this solution appears on the graph. This scree plot shows that there are several breaks in the following three components number 1, 2 and 3 and also are the components that fall above eigenvalue 1.0 and then the line begins to flatten out beginning with component 4. The last large break appears after component 3, suggesting that only components 1–3 account for meaningful variance (Fig. 2). This indicates that only these first three components should be retained and interpreted.

So far, the results from the eigenvalue-one criterion, the variance accounted for criterion and the scree plot have converged in suggesting that a three-component solution may be appropriate. It is from these that the rotated component pattern is reviewed to see if such a solution is interpretable.

The significant number of retained components could been seen from rotated component matrix pattern table, using the critical value of 60% of the land management practices that has value above 60% in each of the components which are three (Table 5 and Table 6). The solution is now cleaner, in the sense that two items are now loads on each of the three components. In this regard, the current results demonstrate a somewhat similar and simpler structure in land management practices.

Table 4. Total variance explained

Component	Initial Eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.285	28.557	28.557	2.285	28.557	28.557	2.110	26.380	26.380
2	1.446	18.081	46.637	1.446	18.081	46.637	1.358	16.969	43.349
3	1.052	13.149	59.786	1.052	13.149	59.786	1.315	16.437	59.786
4	.995	12.433	72.219						
5	.726	9.070	81.289						
6	.609	7.607	88.896						
7	.506	6.319	95.215						
8	.383	4.785	100.000						

Extraction Method: Principal Component Analysis

Table 5. Component matrix[a]

	Component		
	1	2	3
Mulching	.636	.254	-.215
Cover Crop	.448	.298	.608
Crop Rotation	.376	.503	.492
Irrigation	.149	.411	-.444
Organic Manure	.009	-.629	.342
Fertilizer	-.517	.656	-.052
Bush Fallow	.800	-.049	-.106
Agroforestry	.780	-.207	-.257

Extraction Method: Principal Component Analysis
a. 3 components extracted

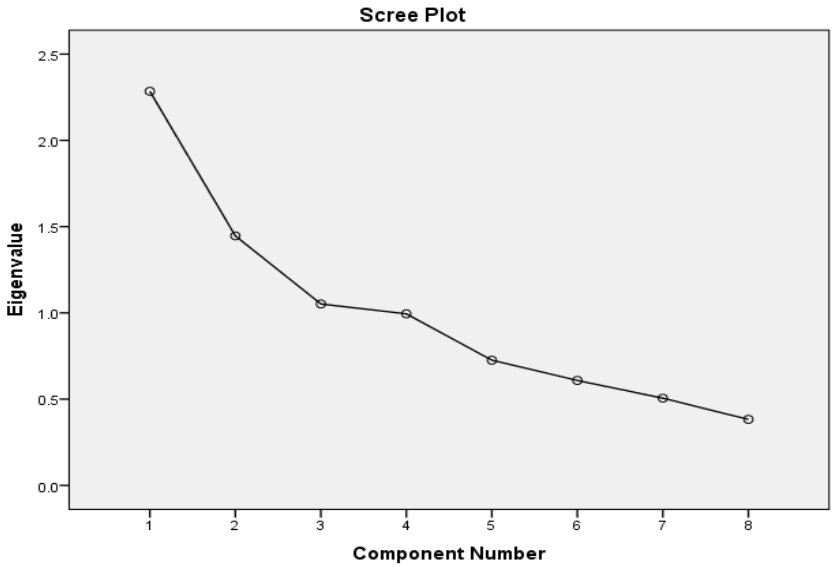

Fig. 2. Principal component analysis scree plot

Table 6. Rotated component matrix[a]

	Component		
	1	**2**	**3**
Mulching	.587	.226	.346
Cover Crop	.145	.792	-.099
Crop Rotation	.064	.784	.133
Irrigation	.174	-.060	.595
Organic Manure	.057	-.068	-.711
Fertilizer	-.620	.097	.554
Bush Fallow	.778	.216	.039
Agroforestry	.847	.011	-.003

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 5 iterations

4. CONCLUSSION AND RECOMMENDATIONS

The farmers' adoption of land management practices is motivated by several factors. Socio-economic characteristics such as age distribution, sex distribution, and educational status had bearing on the choice of land management practices adopted and sustainable land use.

The desktop review and limited consultations was undertaken for this study revealed that both profitability and business resilience influence farm decision-making. The main way these are influenced, is through adjustments in farm outputs and input use, that is, through changes in productivity. Sustainable land management practices in the study area are adopted by farmers as part of a package of measures usually aimed at interconnected objectives relating to business competitiveness, productivity and risk management.

Sustainable land management practices can contribute significantly to climate change adaptation and mitigation. There is clear evidence that the productivity of soils in Buruku Village will continue to decline if strategic measures are not put in place to manage soil fertility in different soil units to support agricultural land. Application of mineral fertilizers and crop residues are among strategies to be promoted. Based on findings a wider range of stakeholders needs to be involved in planning, promoting community based land use plans and

also a monitoring framework needs to be in place to ensure positive outcomes in terms of productivity.

Based on these findings of this study, the following recommendations were made:

- Agricultural extension activities in the study area should focus more on sustainable land management.
- The study revealed that the farming population in the study area is ageing and that is adversely affecting sustainable land use. Government needs to intensify efforts at integrating more young school leavers into agricultural production within the currently institutionalized poverty alleviation programs.
- There is need for government to subsidize or make available for free different tree seedlings to the famers to encourage practice of agroforestry, which is a very sustainable form of land management practices and also, has very good effects on the environment as a whole.
- Sustainable agricultural practices need to be stimulated by further emphasizing improved production and reduced costs. Production benefits are the primary interest of land users, and have direct consequences for livelihoods in small-scale subsistence farming.
- An enabling environment should be nurtured for sustainable land management to thrive best.
- There is a need for investment in documenting and evaluating SLM practices and in assessing their impact on ecosystem services.
- Many resource users, extensionists, researchers, policy-makers and decision-makers are insufficiently informed with respect to the causes, the context, and the impacts of inappropriate resource use. Major efforts in information and training will be necessary if SLM practices are to achieve a break-through.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60898