DOI: DOI: 10.36253/jaeid-13548

Assessment of indigenous farming practices of Nilotic Nuer farmers in Gambella region, south-west Ethiopia

CHUOL BOR CHUOL[1,*], KHAT GACH GER[2]

[1]*Department of Rural Development and Agricultural Extension, College of Agriculture and Natural Resources, Gambella University, Ethiopia*

[2]*Department of Horticulture, College of Agriculture and Natural Resources, Gambella University, Ethiopia*

**Correspondence detail: dengKol2021@gmail.com*

Submitted on: 2022, 13 November; accepted on 2025, 9 April. Section: Research Papers

Abstract: Indigenous farming practices in the Gambella region are deeply rooted in local knowledge and traditions passed down through generations. One of the most important aspects of indigenous farming is the cultivation of diverse, drought-resistant crops such as sorghum, maize, and cassava. The primary objective of the study was to identify the indigenous farming practices of Nilotic Nuer farmers in the Gambella region, southwest Ethiopia. This study employed a mixed research method that integrated both qualitative and quantitative approaches. To ensure comprehensive data collection, a combination of simple random, systematic, purposive, and stratified sampling techniques was used to select the study areas, which included, Lare, Jekow, and Makuey districts, as well as Palbol, Kuachthiang, and Gier kebelles. Data were collected from both the primary and secondary sources. For data analysis, descriptive statistics, such as frequency distributions, percentages, means, standard deviations, and charts, were used. Inferential statistics, including t-tests and chi-square tests, were used to test relationships and differences. Additionally, an econometric model–the binary logistic regression model–was employed for further analysis. All analyses were conducted using the Statistical Package for Social Sciences (SPSS) software. The findings of this study indicated that most sample respondents strongly agreed on the role of increased crop and livestock yields (52%), while the majority strongly disagreed on the conservation of natural resources through agroforestry and crop rotation (47%). The majority of respondents agreed on the role of indigenous farming practices in minimizing soil erosion (32%), while most strongly agreed on the role of minimizing pollution (32%). The binary logit results showed that extension contact ($p=0.042$) and access to water ($p=0.052$) significantly and positively influenced Nuer farmers. However, household size ($p=0.097$) was significant and negatively influenced Nuer farmers.

Keywords: Farming practices, Farmers, Gambella, Indigenous knowledge, Nilotic, Nuer

Introduction

In the majority of African nations, agriculture is an important economic sector. The traditional sector has the ability to appraise the potential of indigenous knowledge for boosting agricultural productivity (Mushi, 2008). Simultaneously, research suggests that the more indigenous people experiment with external technology, the stronger their indigenous knowledge and behaviors become (Lemma & Hoffman, 2005). External knowledge is critical for enhancing small-scale cultivation and connecting greater output to viable markets, which results in enhanced agricultural income and yield, food availability, and the country's economy (Asaba, 2006). As a consequence, a system that incorporates both foreign and indigenous knowledge systems may benefit the long-term expansion of agriculture.

Agriculture is the principal economic sector and source of income for Ethiopian households, especially in rural areas, with 84% of the country's population now involved in various agricultural activities. The sale and export of agricultural commodities overseas account for the vast majority of the country's foreign currency profits. Currently, the industry produces 42% of Ethiopia's gross domestic product and is regarded as the principal source of inputs to various sectors, playing a vital role in ensuring the country's long-term economic growth (Central Statistical Agency, 2020).

Indigenous knowledge is an organized set of information that local people have gathered through experience, informal experimentation, and an awareness of their environment. Indigenous agricultural production knowledge systems represent farmers' acquired knowledge, evolving over generations of cultural and biological evolution. Farmers grow local crops by recognizing environmental conditions and seasonal variations without recourse to foreign inputs, finance, or current scientific knowledge (Maroyi, 2012). After millennia of cultural and biological development, communities have developed sophisticated agricultural systems suited to their regions, helping them manage diverse settings and meet subsistence needs. Indigenous crop production provides essential food resources to rural communities (Netting, 1993; Zhou, 2001). This knowledge is a significant asset, serving as social capital and a major source of income. Farmers in underdeveloped nations use indigenous knowledge to plan agricultural output, ensuring food security and long-term agricultural productivity (Mascarenhas, 2003).

According to Azam (2007), indigenous crop production is the backbone of Sub-Saharan Africa's subsistence agriculture. Cereals, legumes, groundnuts, millet, sorghum, gourds, melons, and pumpkins are produced on subsistence farms and in home gardens as a plentiful food supply. Sigot (2001) found that small pieces of land near homesteads are widely used as home gardens across Africa's 63 countries, growing diverse plants to provide agricultural food to households. Wyk (2011) noted that indigenous cereals contribute to food and nutrition security for small-scale farmers due to their drought and poor soil tolerance.

Preserving subsistence farming techniques is essential when linked to cultural diversity and the economic sustainability of local farming communities. Indigenous farming practices include zero tillage, minimum tillage, crop rotation, cover crops, contour bunds, and intercropping with leguminous plants, all tailored to specific localities (Food and Agriculture Organization, 2005; Ajani *et al.,* 2013). Akinola *et al.* (2020) emphasized that indigenous crop production systems are highly adapted to local environmental conditions, playing a key role in food security. Despite challenges such as unpredictable rainfall, these systems show resilience, allowing farmers to manage crops effectively in variable climates. Zuza *et al.* (2024) demonstrated that traditional systems successfully manage crops under difficult conditions, providing stable food production even in irregular weather patterns.

The Nuer people not only rely on cattle for many of their lives but also consider land to be a valuable asset with multiple uses. Cattle are their most prized possession, and they go to great lengths, even risking their lives, to protect them. Their deep connection to cattle and farmland shapes their attitudes toward and relationships with neighboring communities. This strong attachment to livestock and land reflects Nuer's reliance on traditional agricultural practices (Resilient Landscape and Livelihood Project, 2018).

Agriculture has been a source of income for the Nuer for thousands of years, since they transitioned from hunting and gathering to settled farming. Nuer farmers possess a strong understanding of the improved farming practices that they have adapted to local environmental conditions (Zionist Organization of America, 2016).

Research on the integration of indigenous practices with modern technologies for sustainable land management has been conducted in specific Ethiopian regions, such as Debremitimak Kebele in East Gojjam (Adimew, 2014) and the Gonder and Gojam areas (Bishaw & Wubshet, 2020). However, there is a gap in documented evidence on the indigenous farming practices of Nilotic Nuer farmers. The present study aims to fill this knowledge gap by conducting an in-depth analysis of indigenous farming practices specific to Nilotic Nuer farmers in selected districts. Using both qualitative and quantitative research methods, this study will examine the roles of indigenous Nuer farming practices and the factors influencing them. By collecting primary data from local farmers and combining it with secondary sources, the study will contribute valuable insights into sustainable agricultural practices and provide recommendations for improving food security and agricultural productivity in the region.

Materials and Methods

Description of the Study Areas

This study was conducted in the Nuers zone, which is distinct from the other two zones in the Gambella Regional State. This zone is bounded to the south, west, and north by South Sudan, and to the east by the Anuak zone, which defines the border on the south and west, while Baro defines the border in the north. Ethiopian Nuer in the Gambella region reside in the districts of Akobo, Jekow, Wanthow, Makuey, Lare, and Itang They also reside in the city of the Gambella Regional State. Tirgol, Matar, Nyinenyang, Kuachthiang, and Kuergeng are among the towns in the zone. It is located in the Ethiopian lowlands and is flat, with an elevation of 400–430 m above sea level. The zone is composed of grasslands, marshes, swamps, and forests (Central Statistical Agency, 2022).

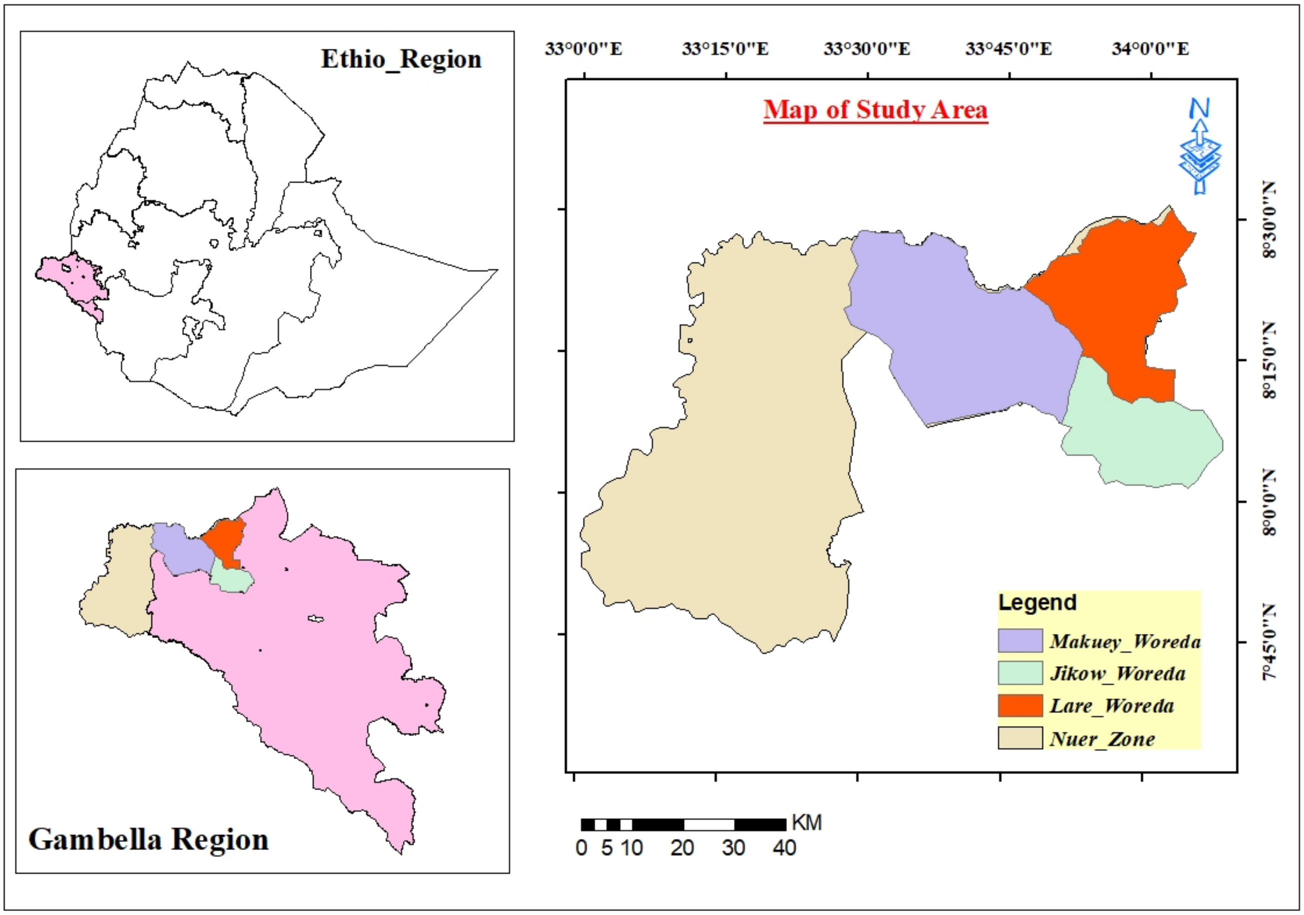

Figure 1: Map of the study areas

Demographic and socio-economic characteristics

According to Ethiopia's Central Statistical Agency (2022), population density by region, zone, and woreda, this zone has a total population of 167,759, with 90,440 men and 77,319 women. There were 67,419 urban and 100,340 rural residents. The Ethiopian Nuer in the Gambella region primarily lived agrarian-pastoral lifestyles, which are typical of Nilotic cattle complexes. Agropastoralism served as the foundation or backbone of the economy. They lived a nomadic existence in the search for water and vegetation and moved seasonally in search of land for this type of livelihood. In search of better grazing land, other sections had to migrate seasonally over distances of several kilometers (Tasew, 2017).

They also had a pattern of mostly farmed sorghum and maize, with tiny plots of tobacco, groundnuts, and other minor crops. Furthermore, fisheries aided the Nuer economy. They were able to capture fish as an alternate source of sustenance because of their residence along rivers and in marshy areas. Fish abound in the Baro salient, which is linked to rivers and streams within the Ethiopian territory (Intergovernmental Authority on Development, 2022).

Research Design

This study aimed to assess the indigenous farming practices of Nilotic Nuer farmers. This study employed mixed research, both quantitative and qualitative, that is more useful for understanding the complex roles and factors that influence the indigenous farming practices of Nilotic Nuer farmers, which require a detailed understanding of the processes involved.

For a quantitative approach, a structured questionnaire was administered to a representative sample of farmers. The questionnaire included both closed- and open-ended questions to gather data on farming techniques, crop selection, seasonal practices, and environmental factors. This helped quantify the key aspects of farming practices and identify patterns across the community.

Furthermore, a qualitative approach, key informant interviews, and focus group discussions (FGDs) were conducted with community elders, experienced farmers, and local agricultural leaders as well as field observation. These methods provide rich contextual insights into the cultural and historical significance of farming practices, knowledge transmission, and adaptive strategies used by Nuer farmers. Field observations were also conducted to witness the implementation of various practices during different agricultural cycles.

Sampling Techniques and Sample Size Determination

A multi-stage sampling procedure was employed to draw a sample from indigenous farmers. Firstly, the Nuer zone was selected by a simple random sampling procedure from three (3) regional zones. Secondly, from the Nuer zone, three districts such as Lare, Jekow, and Makuey were selected by systematic sampling procedures due to the researcher's easier access to the districts. Thirdly, three kebelles (the smallest administrative division or unit of Ethiopia), namely Palbol, Kuachthiang, and Gier, from each district were selected purposively because of the high level of farmers' out-dated farming practices. Finally, the sample respondents were selected by stratified sampling technique to increase the reliability and accuracy of the obtained information depending on the strata at which farmers were categorized based on their farming practices for the last two or more years in the districts. Then, after this stage, the rural farmers were classified as indigenous farmers or non-indigenous farmers.

Additionally, the sample size from this study included the Palbol, Kuachthiang, and Gier kebelles, respectively. The total number of households in the study areas was 390, of which Palbol accounted for 117, Kuachthiang for 125, and Gier for 148 households, respectively. The sample size of this study was determined based on Yamane (1967) at a 95% confidence level and a 5% margin of error.

$$\mathrm{n} = \frac{N}{1 + N(e)2}$$

$$\mathrm{n} = \frac{390}{1 + 390(5\%)2} = 197$$

$$\text{Palbol Kebelle} = \frac{117 * 197}{390} = 59$$

$$\text{Kuachthiang Kebelle} = \frac{125 * 197}{390} = 63$$

$$\text{Gier Kebelle} = \frac{148 * 197}{390} = 75$$

Where n represents the total sample size, N represents the total household, and e represents the sampling error.

Types, Sources and Methods of Data Collection

The sample respondents provided the primary data, which included both qualitative and quantitative information. Focus group discussion, key informant interviews, an interview schedule, and field observation were all used to collect primary data. Documents from district agricultural and rural development offices, agriculture projects, reports, journals, the internet, and books can also be used to collect secondary data.

Methods of Data Analysis

To collect the necessary information, this study used descriptive, inferential, and econometric models with the Statistical Package for Social Sciences version 24. Charts, frequency, percentage, mean, and standard deviation were used to analyze the data for descriptive statistics. The inferential statistics included chi-square and t-tests for qualitative and quantitative data, respectively. Furthermore, the econometric analysis in this study used a binary logistic model to analyze factors that influence the indigenous farming practices of Nilotic Nuer farmers in the study areas. The information from focus group discussions and key informant interviews was analyzed qualitatively and will be used in the text to boost the information from the Statistical Package for Social Sciences analysis. Therefore, the relationship among these independent variables and the farmer's indigenous farming practices are presented in Table 1.

Table 1. Definition of the variables. Source: Review of Related Literatures (2022).

Variable name	Measurement	Nature	Expected outcome
Dependent variable			
Household indigenous farming practices	0=Non-indigenous farmer,1=Indigenous farmer	Dummy	+/-
Independent variables			
Gender	0=Male, 1=Female	Dummy	+/-
Age	Number of age in year	Continuous	+
Household size	Total family members	Continuous	+
Farmland ownership	0=No, 1=Yes	Dummy	+
Livestock holding size	Tropical Livestock Unit	Continuous	+
Fertilizer utilization	0=No, 1=Yes	Dummy	-
Extension contact	0=No, 1=Yes	Dummy	+
Pasture access	0=No, 1=Yes	Dummy	+
Water access	0=No, 1=Yes	Dummy	+

Results

Sample Households Characteristics

Descriptive analysis for discrete variables

These variables were gender, farmland ownership, fertilizer utilization, extension contact, pasture access, and water access. Table 2 lists the significant and insignificant variables. Among non-indigenous farmers, 49% did not own farmland and 51% owned farmland. Similarly, 46% did not own farmland and 54% of Nuer farmers owned farmland. The result obtained from the chi-square test revealed that the associated p-value was less than 0.01, which is ($\chi2$= 200.1; p = 0.000). This means that there was a statistically significant association between farmland ownership and Nuer farmers' indigenous farming practices. Likewise, 41% said no to non-indigenous farming practices and 59% said yes to pasture access. Equally, 39% had no access to pasture and 61% had access to pasture through indigenous farming. The chi-squared test revealed that the associated p-value was less than 0.1, which was $\chi2$= 3.496 (p = 0.062). This means that there was a statistically significant association between pasture access and Nuer farmers' indigenous farming practices. Gender, fertilizer utilization, extension contact, and water access for non-indigenous and indigenous farmers showed non-significant values at ($\chi2$= 0.101, p = 0.750, $\chi2$= 0.396, p = 0.650, $\chi2$= 0.039, p = 0.884, and $\chi2$= 1.473, p = 0.225), respectively.

Table 2. Descriptive analysis for discrete variables. Source: Own Field Survey (2022).

		Household farming practices					
		Non-indigenous		Indigenous			
Variables		Frequency	Percentage	Frequency	Percentage	x2	Sig
Gender	Male	21	54	85	54	0.101	0.750
	Female	18	46	73	46		
Farmland ownership	No	19	49	73	46	200.1	0.000*
	Yes	20	51	85	54		
Fertilizer utilization	No	21	54	92	58	0.396	0.650
	Yes	18	46	66	42		
Extension contact	No	12	31	83	53	0.039	0.844
	Yes	27	69	75	47		
Pasture access	No	16	41	62	39	3.496	0.062***
	Yes	23	59	96	61		
Water access	No	11	28	79	50	1.473	0.225
	Yes	28	72	79	50		
Total		39	100	158	100		

& * represent significant at 1% & 10% level of precision.*

Descriptive analysis for continuous variables

These variables were age, household size, and livestock holding size for the sample households. The mean differences are listed in Table 3. The average age for non-indigenous farmers was 41.03 years, while it was about 43.58 years for indigenous farmers. The t-test for non-indigenous and indigenous people was found insignificant. This indicates that there were no statistically significant differences in age. Similarly, the total average household income of farm household heads for non-indigenous farmers was 7.00 Ethiopian Birr, while it was 6.25 Ethiopian Birr for indigenous farmers. The t-test for household income between non-indigenous and indigenous households was found to be statistically insignificant, as shown in Table 3. This means that there was no statistically significant difference between non-indigenous and indigenous farmers in terms of total household income. Finally, the average livestock holding size for non-indigenous farmers was 20.95 Tropical Livestock units and 20.01 Tropical Livestock units for indigenous farmers. The t-test for livestock holding size between non-indigenous and indigenous farmers was found to be statistically insignificant at any probability level, as shown in Table 3. This shows that there was no statistically significant difference between non-indigenous and indigenous farmers in terms of livestock holding size.

Table 3. Descriptive analysis for continuous variables. Source: Own Field Survey (2022).

	Household farming practices					
	Non-indigenous		Indigenous			
Variables	Mean	Standard deviation	Mean	Standard deviation	t-test	Sig
Age	41.03	19.26	40.78	15.99	0.081	0.936
Household size	7.00	5.45	6.25	4.42	0.901	0.369
Livestock holding size	20.95	17.14	20.01	19.04	0.280	0.780

Roles of Indigenous Farming Practices

As indicated in Figure 2, 13% of the sample respondents strongly disagree on the role of indigenous farming practices in increasing crop and livestock yields: 5% disagree, 15% are neutral, 20% agree, and 52% strongly agree on the importance of traditional farming practices in increasing crop and livestock yields. This indicated that the majority of the sample respondents (52%) strongly agreed with the valued role of this practice.

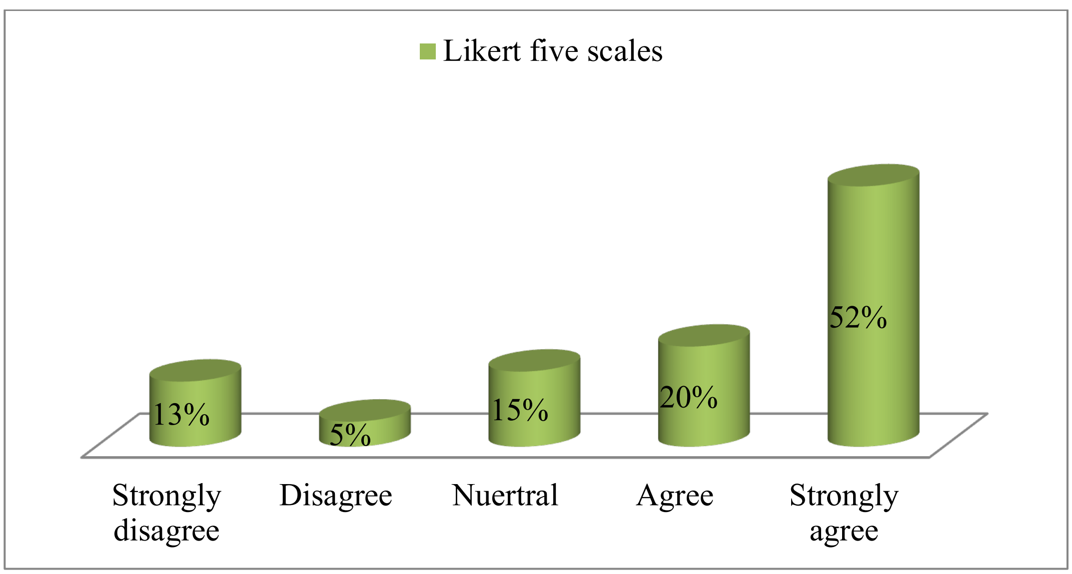

Figure 2: Increasing of crop and livestock yields. Source: Own Field Survey (2022).

Regarding the roles of indigenous knowledge in natural resource conservation through agroforestry and crop rotation, 47% of the sample respondents strongly disagree, 34% disagree, 4% neutral, 9% agree, and 6% strongly agree on the roles of indigenous farming practices in these techniques. This result indicates that the majority of the sample respondents (47%) strongly disagree with the roles of indigenous farming practices, as shown in Figure 3.

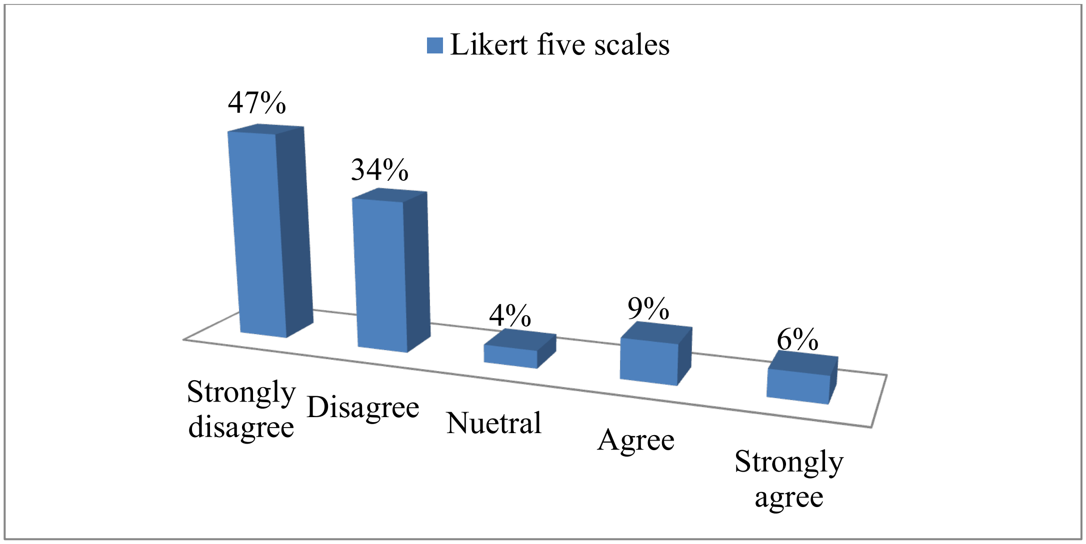

Figure 3: Conservation of natural resources through agroforestry and crop rotation. Source: Own Field Survey (2022).

The role of indigenous farming practices in minimizing soil erosion indicated that 14% strongly agreed, 17% disagreed, 13% neutral, 32% agreed, and 24% of sample respondents strongly agreed. The results show that the majority of the sample respondents (32%) agree on the role of indigenous farming practices in minimizing soil erosion, as indicated in Table 4.

Furthermore, the role of indigenous farming practices in minimizing pollution revealed that 14% of the sample respondents strongly disagreed, 20% disagreed, 14% neutral, 20% agreed, and 32% strongly agreed. This shows that the majority of sample respondents (32%) strongly agreed on the role of indigenous farming practices in minimizing pollution, as indicated in Table 4 below.

Table 4. Minimization of soil erosion and chemical pollution. Source: Own Field Survey (2022).

	Roles		
S.No	Likert five scales	Minimize soil erosion	Minimize pollution
1.	Strongly disagree	27(14%)	28(14%)
2.	Disagree	33(17%)	39(20%)
3.	Neural	26(13%)	28(14%
4.	Agree	63(32%)	40(20%)
5.	Strongly agree	48 (24%)	62(32%)
	Total	197(100%)	197(100%)

Determinant Factors that Influence Indigenous Farming Practices

It is hypothesized that indigenous farming practices are influenced by various factors. Based on the binary logit model, only three out of the eleven explanatory variables influenced indigenous farming practices. These include extension access, pasture access, and household size, as shown in Table 5.

Extension contact: This is an institutional factor that influences indigenous farmers in the study area. Extension contact had a positive influence on Nuer indigenous farmers at the 5% level (p = 0.042), as expected. This means that an increase in extension contact would increase indigenous farming practices in the study area. The estimate shows that as extension contact increases, the probability of Nuer indigenous farmer's increases by 2.302.

Water access: This is an environmental factor that influences Nuer farmers in the study area. As expected, water access had a positive impact on indigenous Nuer farmers at the 10% level (p = 0.052). This means that the decrease in water access would also mean the end of indigenous farming practices in the study area. The estimate shows that, as water access decreased, the probability of Nuer indigenous farming practices also decreased by 2.266.

Household size: Household size is one of the demographic factors that influence Nuer indigenous farmers in the selected districts. Unexpectedly, the model result showed a 10% (p = 0.097) negative significant association between family size and indigenous farming practices. This shows that a decrease in household size affects Nuer indigenous farming practices. The estimate indicates that decreasing the number of households by one person would also decrease the probability of Nuer farmers by 0.897.

Table 5. Binary logit model result for explanatory variables. Source: Software Output (2022).

Variables	B	SE	Sig	Exp(B)
Gender	-.118	.392	.764	.889
Farmland ownership	-.327	.397	.410	.721
Fertilizer utilization	.249	.386	.519	1.282
Extension contact	.834	.411	.042**	2.302
Pasture access	-.144	.398	.717	.866
Water access	.818	.422	.052***	2.266
Age	.026	.019	.163	1.026
Household size	-.109	.065	.097***	.897
Live stockholding size	-.001	.010	.922	.999

*** &*** represent significant at 5% & 10% level of precision.*

Discussion

Indigenous farming practices play a significant role in improving crop yield and sustainable agriculture. Studies show that Traditional methods, such as rotating fallow-based systems for livestock herding and soil enrichment in Senegal, increased millet yields compared to conventional farming (Faye *et al.,* 2020). In Ethiopia, indigenous land management practices such as organic manure application, crop rotation, and agroforestry improve soil fertility and crop productivity (Demissie, 2019). These findings highlight the importance of supporting indigenous practices and creating integrated approaches to sustainable agricultural development. Durán *et al.* (2023) stated that traditional farming practices minimize soil erosion and the loss of nutrients, which are by-products of modern agricultural practices. Furthermore, traditional knowledge plays a major role in natural resource management and agroforestry practices in numerous countries. In Ethiopia, traditional practices like "Sera" are used to manage natural resources, with 98.6% of respondents acknowledging its importance (Alemu, 2019). In Nepal, farmers utilize indigenous knowledge for agroforestry promotion, with 91% practicing agri-silviculture and home-gardening (Sharma *et al.,* 2023). Similarly, in Nigeria's southeast agro-ecological zone, farmers employ various indigenous farm management practices to sustain their environment, including organic manure (15%), intercropping (15%), and crop rotation (14%) (Odoemelam & Ajuka, 2015; Okpara, 2015). These practices can contribute to soil conservation, biodiversity preservation, and sustainable resource management. Similarly, Takale and Waykar (2020) proposed that traditional farming could be used to promote sustainable agriculture by minimizing chemical pollution. They stated that traditional forming practices are environmentally friendly and provide desirable habitats that support biodiversity. Indigenous farming practices play a pivotal role in minimizing soil erosion in various regions. Studies conducted in Vietnam, Sudan, Rwanda, and the Democratic Republic of Congo have highlighted the effectiveness of traditional soil conservation techniques. These include crop rotation, intercropping, contour ridges, stone bunds, and zero tillage (Ahmed *et al.* 2020; Bapfakurera and Nduwamungu, 2020). Farmers' awareness of soil erosion and adoption of adaptation measures are influenced by factors such as indigenous knowledge, farm location, and participation in farmers' associations (Chuma *et al.,* 2022). Indigenous farming practices play crucial roles in sustainable agriculture and environmental conservation. Studies have shown that local farmers perceive these practices as effective for climate change resilience and are cost-effective and environmentally friendly (Odoemelam & Ajuka, 2015). Common indigenous techniques include organic manure use, intercropping, crop rotation, cover cropping, and shifting cultivation (Okpara, 2015). These methods are less harmful than modern farming systems and significantly contribute to climate change adaptation.

Engida *et al.* (2021) stated that extension contact is significant and positively contributes to increasing farm enterprise options. This demonstrates the importance of providing farmers with advice, information, and other support services to help them improve the productivity of their crop and animal production, and thus their farm and non-farm incomes. Moreover, improving water access for indigenous communities can lead to better health outcomes, increased agricultural land use, and highlights the importance of incorporating cultural and social factors into sustainable water service models (Shahraki *et al.,* 2023). Sustainable water service models that prioritize water as a service and incorporate indigenous communities' culture, experiences, knowledge, and practices can effectively address water-related challenges (Behailu *et al.,* 2016). Food and Agricultural Organization (2016) also stated that ensuring equitable access to water is critical for improving the resilience of dry land production systems and agro-pastoral communities. A previous study by Nigussie *et al.* (2017), Saguye (2017) and Kansanga *et al.* (2021) found that the number of productive family members has a significant effect on the successful adoption and maintenance of indigenous land management practices.

Conclusion

The finding concluded that the majority of sample respondents strongly agree on the valued role of indigenous farming practices increasing crop and livestock yields. Regarding the roles of indigenous farming practices in natural resource conservation through agroforestry and crop rotation, it's revealed that most of the sample respondents strongly disagree with the valued roles of this practice. Similarly, when it came to the roles of indigenous farming practices in reducing soil erosion, the majority of sample respondents agreed with the practices. Similarly, the majority of sample respondents strongly agree on the role of indigenous farming practices to minimize pollution in the study districts. Nevertheless, based on the binary logit model, it is indicated that extension contact and water access were significant and positively influences the Nuer indigenous farming practices. Furthermore, the model also showed that household size was significant and negatively influenced the rural household's indigenous farming practices in the selected Nuer zone districts.

As for strategies and policies makers, farmers should be educated on the values of indigenous farming practices and be encouraged to improve food security and natural resource conservation.

This will help in reducing the food insecurity starvation level and will have an environmental benefit for the farmers in the study areas. Similarly, the district governments should motivate the local farmers about the importance of indigenous practices to reduce soil erosion, nutrient loss, and environmental pollution.

Furthermore, extension program should be organized for the farmers in selected districts in order to educate and inform them on the benefits of blending indigenous knowledge with scientific knowledge in agricultural production. The government districts should also train the farmers about the benefits of family size by indicating that population is an opportunity, not a curse when it comes to indigenous farmers. This means households with a greater number of people are likely to farm land more intensively than those with fewer household members. Finally, the districts government and donor's agencies should enhance and promote all efforts towards the efficient, equitable, and optimum utilization of the available water resources for significant socio-economic improvement of local farmers.

References

Adimew, A. (2014). Assessing Integration Indigenous Practices with Modern Technologies for Sustainable Land Management; the Case of Soil Conservation and Fertility Improvement in Debremitimak Kebele, East Gojjam. http://thesisbank.jhia.ac.ke/id/eprint/8332

Ahmed, A., Eldoma, I., Elaagip, E., & Hou, F. (2020). Effects of Indigenous Cultivation Practices on Soil Conservation in the Hilly Semiarid Areas of Western Sudan. Water. https://doi.org/10.3390/w12061554

Ajani, E.N., Mgbenka, R.N., & Okeke, M.N. (2013). Use of Indigenous Knowledge as a Strategy for Climate Change Adaptation among Farmers in Sub-Saharan Africa: Implications for Policy. *Asian Journal of Agricultural Extension, Economics and Sociology* 2(1):23-40.

Akinola, R., Pereira, L., Mabhaudhi, T., De Bruin, F., & Rusch, L. (2020). A Review of Indigenous Food Crops in Africa and the Implications for more Sustainable and Healthy Food Systems. *Sustainability*, 12. https://doi.org/10.3390/su12083493

Alemu, M. (2019). Farmers' Perception and Indigenous Knowledge for Natural Resources Management, Abo-Wonsho Woreda, Southern Ethiopia. *Agricultural Sciences*. https://doi.org/10.4236/as.2019.1011103

Asaba, E.B. (2006). Bridging the information and knowledge gap between urban and rural communities through rural knowledge centre: Cases studies from Kenga and Uganda. *International Association of Agricultural Information Specialists (IAALD) Quarterly Bullentin*, 51 (3-4).

Azam, A.S. (2007). Agricultural diversification: the potential for underutilised crops in Africa's changing climates. *Riv Biol*. 2007 Jan-Apr; 100(1):27-37.

Bapfakurera, E., & Nduwamungu, J. (2020). The Role of Indigenous Knowledge Systems on Soil and Water Conservation in Musanze and Nyabihu Districts, North-Western of Rwanda.

Behailu, B., Pietilä, P., & Katko, T. (2016). Indigenous Practices of Water Management for Sustainable Services. SAGE Open, 6. https://doi.org/10.1177/2158244016682292

Bishaw, B., & Wubshet, T. (2020). The role Indigenous Knowledge in Agricultural Farming practices: the case of Gonder and Gojam area, Amhara regional state, Ethiopia. *International Journal of Advanced Research in Biological Sciences*: DOI: 10.22192

Chuma, G. B., Mondo, J., Ndeko, A. B., Bagula, E., Lucungu, P. B., Bora, S. F., Karume, K., Mushagalusa, G., Schmitz, S., & Bielders, C. (2022). Farmers' knowledge and practices of soil conservation techniques in smallholder farming systems of Northern Kabare, East of D.R. Congo. *Environmental Challenges*, 7, 100516. https://doi.org/10.1016/j.envc.2022.100516

CSA. (2020). Report on Area, Production, and Farm Management Practice. Adiss Ababa.

CSA. (2022). Population Size by Sex, Area and Density by Region, Zone and Woreda: July 2022.

Demissie, S. (2019). The Role of Indigenous Land Management Practices to Improve Crop Productivity in Abobo District, Gambella, Ethiopia. *Journal of Environment and Earth Science.* https://doi.org/10.7176/jees/9-6-04

Durán, Y., Gómez-Valenzuela, V., & Ramírez, K. (2023). Socio-technical transitions and sustainable agriculture in Latin America and the Caribbean: a systematic review of the literature 2010–2021. *Frontiers in Sustainable Food Systems*. https://doi.org/10.3389/fsufs.2023.1145263

Engida, G., Agegnehu, W., & Kusse, H. (2021). Determinants of sorghum crop commercialization the case of Southwest Ethiopia. https://doi.org/10.1016/j.heliyon.2021.e07453

FAO. (2005). 31st Session of the Committee on World Food Security. Special Event on Impact of Climate Change, Pests and Diseases on Food Security and Poverty Reduction. Rome, Italy.

FAO. (2016). Enhancing Equitable Access to Water Resources for Pastoral Communities. Djibouti City, Djibouti.

Faye, J., Hopple, A., & Bridgham, S. (2020). Indigenous farming practices increase millet yields in Senegal, West Africa. *Agroecology and Sustainable Food Systems*, 45, 159 - 174. https://doi.org/10.1080/21683565.2020.1815927

IGAD. (2022). Co-Management of Fisheries shared between Ethiopia and South Sudan (Baro-Sobat) transboundary river basin.

Kansanga, M., Luginaah, I., Bezner Kerr, R., Dakishoni, L., & Lupafya, E. (2021). Determinants of smallholder farmers' adoption of short-term and long-term sustainable land management practices. *Renewable Agriculture and Food Systems*, 36(265), 277. https://doi.org/10.1017/s1742170520000289

Lemma, M., & Hoffmam , V. (2005). The agricultural knowledge system in Tigray, Ethiopia: Empirical study about its recent history and actual effectiveness.

Maroyi, A. (2012). Enhancing food security through cultivation of traditional food crops in Nhema communal area, Midlands Province, Zimbabwe. *African Journal of Agricultural Research* Vol. 7(39), pp. 5412-5420/DOI: 10.5897

Mascarenhas, A. (2003). Indigenous knowledge. Livelihood and development: Is a High Rate of sustainable growth achievable? Paper Read at the Inaugural Tanzanian Biennial Development forum, Dares Salam Tanzania, 24-25 April.

Mushi, O. (2008). Improved seeds help Boost Crop Production Daily News Wednesday, August 20.

Netting, R.M. (1993). Smallholders, Householders Farm Families and the Ecology of Intensive, Sustainable Agriculture; Stanford University Press: Stanford, CA, USA.

Nigussie, Z., Tsunekawa, A., Haregeweyn, N., Adgo,E., Nohmi, M., Tsubo, M., Aklog, D., Meshesha, T.D., & Abele,S. (2017). Farmers' perception about soil Erosion in Ethiopia. Land Degrad. Develop.28: 401–411 (2017).

Odoemelam, L., & Ajuka, P. (2015). Indigenous farm management practices among rural farmers: implications for sustainable environment in South-East agro-ecological zone, Nigeria. , 3, 7-14.

Okpara, M. (2015). Indigenous Farm Management Practices among Rural Farmers: Implications for Sustainable Environment in South-East Agro-Ecological Zone, Nigeria.

RLLP. (2018). Sustainable Land Management Program: Updated Social Assessment.

Sauye, S.T. (2017). Determinants of adoption of sustainable land management (SLM) practices among small holder farmers' in Jeldu District, West Shewa Zone, Oromia Region, Ethiopia. *Global Journal of Science Frontier Research*. /

Shahraki, A., Panagopoulos, T., Ashari, H., & Bazrafshan, O. (2023). Relationship between Indigenous Knowledge Development in Agriculture and the Sustainability of Water Resources. *Sustainability.* https://doi.org/10.3390/su15075665

Sharma, S., Acharya, P., & Joshi, M. (2023). Indigenous knowledge in agroforestry promotion: a case from Bandegaun, Indrawati Rural Municipality, Sindhupalchok District, Nepal. *MOJ Ecology & Environmental Sciences*. https://doi.org/10.15406/mojes.2023.08.00288

Sigot, A.J. (2001). Indigenous food systems: Creating and promoting sustainable livelihoods. In Proceedings of the International Conference in Indigenous Knowledge Systems: African Perspectives, Thohoyandou, South Africa, 12–15 September.

Takale, D., & Waykar, A. (2020). Sustainable Agriculture through Organic Farming. , 40, 1384-1390.

Tasew, G. (2017). "Cross-Border Intergroup Conflicts in the Horn of Africa: A Case Study of Ethiopia-South Sudan Borderland People". Southern Voices Network for Peace building Scholar, November 2017. P. 39.

Wyk, B. (2011). The potential of South African plants in the development of new food and beverage products. *South African Journal of Botany*, 77, 857-868. https://doi.org/10.1016/J.SAJB.2011.08.003

Yamane, T. (1967). Statistics: An introductory analysis, 2nd ed, New York. Harper & Row.

Zhou, M. (2001). Plant genetic resources conservation and use in China: Proceedings of a National Workshop on Conservation and Utilization of Plant Genetic Resources, 25-27 October 1999, Beijing, China.

ZOA. (2016). Improving Food Security and Strengthening Community Cohesion in Gambella/https://aidstream.org/who-is-using/NL-KVK-41009723/2965

Zuza, E., Lambert, K., Macmillan, T., Chiyemura, F., Araya, Y., Bowskill, V., Oluseye, A., Ng'endo Kanui, M., Keding, G., Butler, G., Breman, E., King, I., Matumba, L., Heddenhausen, J., Nordin, S., & Bhagwat, S. (2024). Crop species diversity: A key strategy for sustainable food system transformation and climate resilience. *Food and Energy Security*. https://doi.org/10.1002/fes3.558