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An assessment of rural households' perceptions and self-reported attitudes towards the adverse effects of traditional biomass energy use on deforestation, land degradation, agricultural productivity, and food security in Ada'a woreda, Oromia, Ethiopia

Abstract: This article was aimed at assessing rural households' perceptions and self-reported attitudes towards the negative effects of traditional biomass energy use on deforestation, land degradation, agricultural productivity, and food security in Ada'a woreda, Oromia regional state, Ethiopia.

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A mixed approach design was deployed with quantitative and qualitative designs to collect the data using a survey questionnaire, interview guide, and observation checklist. Data was collected from 366 sample households and analyzed using SPSS version 20 and Stata Version 14 software. The study, in the course of analysis, deployed the Mann-Whitney U test, the Kruskal-Wallis H test, and an Ordered Logistic Regression. Gender is revealed as an influencing factor determining perceptions on traditional biomass energy use as a cause of deforestation, land degradation, negative effects on agricultural productivity, and food security. In this regard, males' perception increases by 66, 88, 61, and 55% respectively than females. Considering the level of education, as the reference category, households with no formal education and primary school had a perception decrease of 80%. The participants with secondary school attendance showed a 70% decrease in the belief that traditional biomass energy use causes deforestation. For land degradation, the participants with no formal education showed a decrease by 62%, and those with primary and secondary school attendance reflected the decrease by 70 and 74%, respectively. Agricultural productivity decreases by 60% in connection to biomass energy use for those with no formal education, by 77 and 63% respectively for primary and secondary school attendees. The effect of biomass energy use was revealed to negatively affect food security, decreasing by 84% for those with no formal education and by 79 and 80% respectively for primary and secondary school attendees. The use of traditional biomass energy is a significant driver of deforestation. Mixed farmer households have experienced a 178% increase in deforestation, while small business households have seen an increase of 111%. This environmental damage has a severe impact on agricultural productivity.

Keywords: attitude, Ethiopia, rural household, traditional biomass

Introduction

Biomass refers to material of biological origin, excluding material embedded in geological formations and transformed into fossils (Rettenmaier et al. 2010). Global biomass energy production has increased substantially, but its ecological and social effects remain uncertain. Perceptions of bioenergy's influence on overall living conditions are more prevalent than on personal spaces, with notable statistical links between bioenergy, life satisfaction, and ecological factors (Venghaus and Hoffmann 2016). In most developing countries, biomass is the main source of energy for cooking and heating (Okello et al. 2013). Traditional biomass energy dominates national energy statistics in many developing countries, particularly in Sub-Saharan Africa, with serious adverse effects on the environment and human health (Benti et al. 2021). Where demand for traditional biomass energy is growing at a rate of 3.3% annually, and over 27% of wood fuel is often used in an unsustainable way, over 3.5 million hectares of forest are lost or degraded each year (Namaswa et al. 2022). The most often used types of biomass are woody biomass, agricultural wastes, and animal dung (Tolessa 2023).

Ethiopia's energy consumption is also heavily skewed toward biomass energy due to several factors, including severe poverty, limited access to renewable energy sources, and outdated technology (Guta 2012). Currently, almost 80% of Ethiopians reside in rural areas where grid power is not readily available, and traditional biomass remains the primary source of energy for cooking (Assefa 2021). Firewood accounts for 77% of the country's annual energy needs, while other notable biomass energy sources include cow dung cake (13%), crop residue (9%), and charcoal (1%) (Hailu and Kumsa 2020).

Biomass is a renewable energy source. Heavily skewed toward biomass energy due to several factors, including severe poverty, limited access to renewable energy sources, and outdated deforestation, land degradation, and reduction in the ecological services provided by forests, woodlands, and bushes, increased soil erosion, loss of biodiversity, job losses, increased suffering, particularly for women searching for household energy, increased food insecurity as a result of limited biomass for cooking, and increased household income diverted to purchase wood fuel for energy are just a few of the broader effects of unsustainable extraction of biomass for energy (Mugo and Gathui 2010). Energy is required for the most fundamental necessities, such as heating, lighting, cooking, and boiling water. However, the rapid population growth in rural areas has put significant pressure on biomass resources, resulting in desertification and deforestation in some areas (Felix and Gheewala 2011). Ethiopia's rural population depends on biomass for all of its daily energy requirements, except for lighting. The traditional way of biomass energy utilization wastes a significant amount of energy, particularly during cooking. The system is known to have a substantial impact on the depletion of natural resources, unpleasant health risks, and negative economic outcomes (Amare et al. 2015). Ethiopia has an abundance of renewable energy resources that can help realize its goal of electrifying the entire country but, despite all of its promise, the country's energy industry is still in its infancy, because the majority of Ethiopians live in remote areas, where they lack access to modern energy sources and are completely dependent on traditional biomass energy sources (Hailu and Kumsa 2020).

Biomass energy use aggravates the risk of exposing conservation areas, contaminating water sources, and lowering food security (Field et al. 2007). The majority of the rural population relies on the unrestricted gathering of animal dung, agricultural waste, and woody biomass; therefore, they rely on traditional biomass energy sources, such as burning wood, dung, and agricultural waste for cooking, heating, and lighting, which leads to health problems and low agricultural productivity (Benti et al. 2021). According to a study by Hakizimana et al. (2020), biomass energy utilization negatively affects the environment and is extremely inefficient, wasting a lot of the available energy.

According to a study conducted by Amare et al. (2015), enhancing biomass energy efficiency in rural households of Ethiopia, the findings supported the fact that homes using energy-efficient stoves may conserve more than 33% and 20% of the wood biomass, respectively, compared to households using typical open traditional stoves. According to Wassie (2020), household size, proximity to a wood source, geography, and income level are statistically substantially correlated with the principal cooking fuels used in rural households. The negative impact has challenges to society's development in terms of food security in the northern highlands of Ethiopia. Based on the challenges identified by scholars, this article aims to assess the perceptions of households towards the effects of traditional biomass energy use on deforestation, land degradation, agricultural productivity, and food security in rural areas of Ada'a woreda, Oromia regional State, Ethiopia.

1. Materials and methods

The researcher deployed a mixed study design for this study. The convergent parallel research design was simultaneously deployed under which the quantitative and qualitative components of the studies (Roomaney 2018). A mixed-methods research design allows researchers to construct, confirm, and theorize, addressing the need to study complex social phenomena to comprehend their complexities. Furthermore, combining data from multiple sources yields more reliable findings that can support study conclusions and implications (Dawadi et al. 2021).

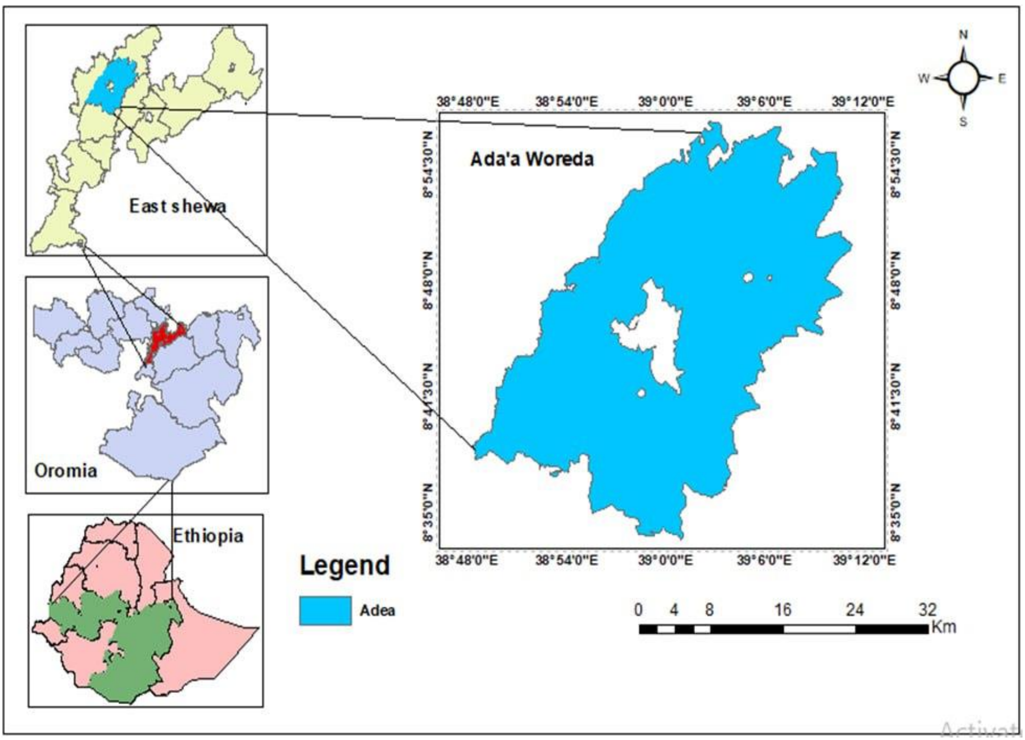


Fig. 1. Location map of the study area
Source: sketched by authors using Arc, GIS, 10.4.1 (November 2024)

Rys. 1. Mapa lokalizacji obszaru badań

2. Study population, sample size, and sampling procedure

According to the report from the Ada'a woreda administration office in 2023, the woreda encompasses 15 rural kebeles, which collectively total 12,894 households. To conduct a thorough and representative study, the researcher employed a systematic sampling technique. From the total of 15 kebeles, five were chosen based on a systematic interval calculated using the formula $i = N/n$, where N represents the total number of kebeles and n indicates the number of kebeles to be sampled. This calculation resulted in an interval of 3, derived from dividing 15 by 5. As a result, every third kebele was selected as a sample for the study, ensuring a methodical and structured approach to data collection. Accordingly, 3rd, 6th, 9th, 12th, and 15th kebeles were selected among the 15 kebeles in the study target woreda.

According to the woreda administration office report in 2023, the total number of households living in those 5 sample kebeles was 4298. To select a representative sample, the researcher applied the Taro Yamane formula of 1967, which provides a simplified formula for calculating sample size assuming a 95% confidence level (.05 significance level).

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

$$N = 4298/1 + 4298(0.05)^2 = 366$$

$$N = 4298/1 + 4298 \cdot 0.0025 = 4298/11.745 = 366$$

where:

n – the sample size,

N – the population size,

E – the level of precision (.05).

3. Methods of data collection

This study relied on both primary and secondary data. The primary data was collected through a survey using a questionnaire, while articles and books served as secondary sources. Closed-ended questionnaires were carefully prepared and distributed to 366 selected household respondents across five kebeles.

4. Results and discussion

4.1. Mann-Whitney U test

The Mann-Whitney U test is appropriate for comparing two independent groups when the dependent variable is continuous or ordinal, and it can effectively be used with gender as the independent variable (Shier 2004).

Table 1. Mann-Whitney U test for ranking male and female household heads' responses

Tabela 1. Test U Manna-Whitneya do klasyfikacji odpowiedzi mężczyzn i kobiet będących głowami gospodarstw domowych

Ranks				
	Gender	N	Mean Rank	Sum of Ranks
Traditional biomass energy utilization causes deforestation.	Female	197	170.65	33618.50
	Male	169	198.48	33542.50
	Total	366		
Traditional biomass energy utilization causes land degradation.	Female	197	167.40	32977.50
	Male	169	202.27	34183.50
	Total	366		
Traditional biomass as an energy source negatively affects agricultural productivity.	Female	197	172.28	33939.50
	Male	169	196.58	33221.50
	Total	366		
Traditional biomass energy utilization negatively affects food security.	Female	197	171.44	33773.50
	Male	169	197.56	33387.50
	Total	366		

Source: survey data result (March 2025).

4.2. Rank sums and observations

As revealed in Table 1, Female (gender = 1) observation 197 with ranks of sum 33618.50, 32977.50,33939,33221.50 for traditional biomass energy utilization causes deforestation and land degradation, negatively affecting agricultural productivity and food security, respectively. Male (gender = 2) observation 169 ranks of sum 33542.50, 34183.50,33221.50, and 33387.50 for traditional biomass energy utilization causes deforestation and land degradation, negatively affecting agricultural productivity and food security, respectively.

Table 2. Statistics test result with grouping variable "Gender"

Tabela 2. Wyniki testu statystycznego ze zmienną grupującą „Płeć"

Test Statistics a				
	Traditional biomass energy utilization causes deforestation	Land degradation	Negatively affects agricultural productivity	Negatively affects food security
Mann-Whitney U	14,115.500	13,474.500	14,436.500	14,270.500
Wilcoxon W	33,618.500	32,977.500	33,939.500	33,773.500
Z	–2.718	–3.334	–2.426	–2.445
Asymp. Sig. (2tailed)	.007	.001	.015	.014

Source: survey data result (March 2025). Grouping variable: Gender

Table 2 shows that the Z-values (–2.718, –3.334, –2.426, and –2.445) reflect the magnitude and direction of the differences between the groups. The p-values (0.007, 0.01, 0.015, and 0.014) indicate the probability that traditional biomass energy use contributes to deforestation, land degradation, and impacts on agricultural productivity and food security, respectively.

4.3. Kruskal-Wallis H test

The Kruskal-Wallis test and one-way ANOVA are widely used statistical analyses. ANOVA is a parametric test that assumes a normal distribution, interval data, and homogeneity of these assumptions. The Kruskal-Wallis test is more appropriate when the assumptions of ANOVA are not met (Ostertagová et al. 2016). The test statistic is calculated using the formula for the group (Hecke 2015).

According to McClenaghan (2024), the Kruskal-Wallis test has several key assumptions: each group of data must be independent of the others, and each group should consist of at least five observations. In addition, the observations within each group should originate from populations that have the same distributional shape. The analyzed variable should be ordinal or continuous, indicating a hierarchical structure. Finally, the data should be randomly selected from independent samples.

4.4. Hypothesis

According to Lomuscio (2021), the Kruskal-Wallis H test has the following hypothesis:

H 0: The median test scores are equal among groups.

Ha: Not all of the medians are equal among groups.

4.5. Test for education level groups

This Hypothesis Test Summary box is given for the Kruskal-Wallis test. As $p < 0.001$, there is evidence to suggest a difference between at least one pair of groups, and which pair(s). To find out, double-click on the Hypothesis Test Summary box to open the Model Viewer.

On the figure below, change the "Independent Samples Test View" to "Pairwise comparisons" in the bottom right corner.

Figure 2 below illustrates that perceptions of traditional biomass energy use vary notably with education levels. The research highlights significant correlations between educational attainment and its effects on deforestation, land degradation, farming productivity, and food security concerns. Specifically, attitudes towards the impact of traditional biomass energy on food security, defined as an access to sufficient, nutritious food, differ across educational demographics. The findings support the rejection of the null hypotheses across all four examined variables, indicating significant discrepancies in perceptions regarding the implications of traditional biomass energy use among distinct educational strata.

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Traditional biomass energy utilization causes for deforestation. is the same across categories of Educational status .	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
2	The distribution of Traditional biomass energy Utilization causes land degradation. is the same across categories of Educational status .	Independent-Samples Kruskal-Wallis Test	.003	Reject the null hypothesis.
3	The distribution of Traditional biomass as energy utilization negatively affects agricultural productivity. is the same across categories of Educational status .	Independent-Samples Kruskal-Wallis Test	.027	Reject the null hypothesis.
4	The distribution of Traditional biomass energy utilization negatively affects food security. is the same across categories of Educational status .	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Fig. 2. Hypothesis testing
Source: survey data result (March 2025)

Rys. 2. Testowanie hipotez

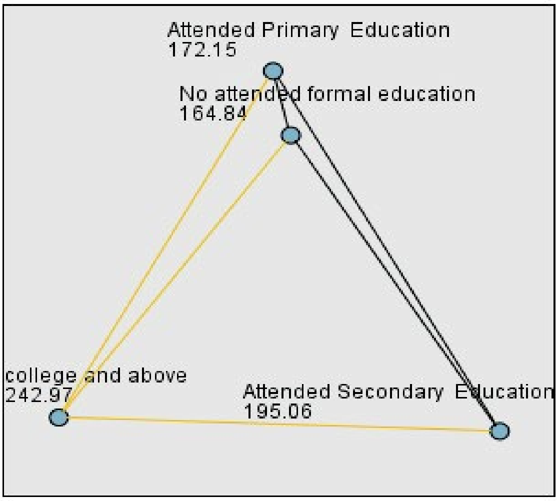
Based on Figure 2 and the hypothesis testing results, Dunn's post hoc tests have been applied meticulously to all pairwise comparisons. Given the extensive number of comparisons, SPSS implements a rigorous adjustment to the p-values to enhance statistical precision. Specifically, the Bonferroni correction is used, which entails multiplying each Dunn's p-value by the total number of tests to mitigate the risk of Type I errors. The paragraphs that follow will present a detailed pairwise comparisons that succinctly show the results of the Dunn-Bonferroni tests for each group pairing, offering a clear and comprehensive summary of the findings.

4.6. Post-hoc testing

Various post-hoc tests exist for different scenarios, such as the Kruskal-Wallis test, which indicates significant differences among groups but doesn't specify which ones. To clarify these differences, we can use a post-hoc test like the Dunn-Bonferroni test (Basterretxea et al. 2024).

As illustrated in Figure 3 below, different educational groups are analyzed in pairwise comparisons. The comparisons are as follows: no formal education vs. primary education, no formal education vs. secondary education, no formal education vs. college and above, primary education vs. secondary education, primary education vs. college and above, and secondary education vs. college and above. The orange lines indicate significant differences between pairs. The "Adj. Sig" column reflects adjustments made for multiple tests using the Bonferroni correction method. Notably, the p-value for the comparison between individuals with no formal education and those with a college degree or higher is significant ($p < 0.001$). Similarly, the comparison between those with attended primary education and individuals with a college degree or above is also substantial ($p < 0.001$), and the comparison between those with attended secondary education and those with a college degree or higher is significant ($p < 0.05$). An orange line highlights significant differences by connecting the two groups on the diagram, showing their mean ranks. A Kruskal-Wallis test indicated strong evidence of a difference ($p < 0.001$) in the mean ranks among at least two pairs of groups. Subsequently, Dunn's pairwise tests were performed for the four pairs of groups. The results show that $p < 0.001$ (adjusted using the Bonferroni correction) of a significant difference between individuals who did not attend formal education and those who attended college or higher, as well as between those who completed primary education and those who attended college or higher. In contrast, a significant difference was found between individuals who completed secondary education and those who attended college or higher ($p < 0.05$).

Pairwise Comparisons of Educational status



Each node shows the sample average rank of Educational status .

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
No attended formal education-Attended Primary Education	-7.311	12.876	-.568	.570	1.000
No attended formal education-Attended Secondary Education	-30.223	13.900	-2.174	.030	.178
No attended formal education-college and above	-78.132	15.970	-4.893	.000	.000
Attended Primary Education-Attended Secondary Education	-22.912	15.172	-1.510	.131	.786
Attended Primary Education-college and above	-70.821	17.089	-4.144	.000	.000
Attended Secondary Education-college and above	-47.909	17.873	-2.681	.007	.044

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Fig. 3. Pair comparisons of educational status
Source: survey data result (March 2025)

Rys. 3. Porównania par statusu edukacyjnego

4.7. Test for occupation groups

Figure 4 shows households' perceptions on the effects of traditional biomass energy use on deforestation, land degradation, agricultural productivity, and food security. For instance, opinions on how biomass energy contributes to deforestation and land degradation differ significantly by occupation. Similarly, beliefs about its impact on agricultural productivity and food security are not uniform across professions.

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Traditional biomass energy utilization causes for deforestation. is the same across categories of Occupation .	Independent-Samples Kruskal-Wallis Test	.024	Reject the null hypothesis.
2	The distribution of Traditional biomass energy Utilization causes land degradation. is the same across categories of Occupation .	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
3	The distribution of Traditional biomass as energy utilization negatively affects agricultural productivity. is the same across categories of Occupation .	Independent-Samples Kruskal-Wallis Test	.004	Reject the null hypothesis.
4	The distribution of Traditional biomass energy utilization negatively affects food security. is the same across categories of Occupation .	Independent-Samples Kruskal-Wallis Test	.016	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Fig. 4. Hypothesis testing
Source: survey data result (March 2025)

Rys. 4. Testowanie hipotez

4.8. Post-hoc testing

As indicated in Figure 5 above, the adjusted p-values from Dunn's post-hoc test revealed no significant differences among the groups of small private business owners, livestock farmers, pensioned individuals, and crop farmers. Specifically, the comparisons yielded the following p-values: small private business owners and livestock farmers ($p = 1$), small private business owners and pensioned individuals ($p = 1$), small private business owners and crop farmers ($p = 0.779$), livestock farmers and pensioned individuals ($p = 0.641$), livestock farmers and mixed farmers ($p = 1$), livestock farmers and crop farmers ($p = 0.117$), pensioned individuals and mixed farmers ($p = 1$), pensioned individuals and crop farmers ($p = 1$), and finally, mixed farmers and crop farmers ($p = 1$).

As revealed in Figure 5 above, there were no connecting lines or asterisks between the groups, indicating a lack of significant pairwise differences. These findings suggest that the treatments do not significantly differ from one another in their effects on the measured outcome. In summary, Dunn's post-hoc analysis did not reveal significant differences among the treatment groups, indicating that all treatments may have similar effects or that further research is needed to identify any potential differences.

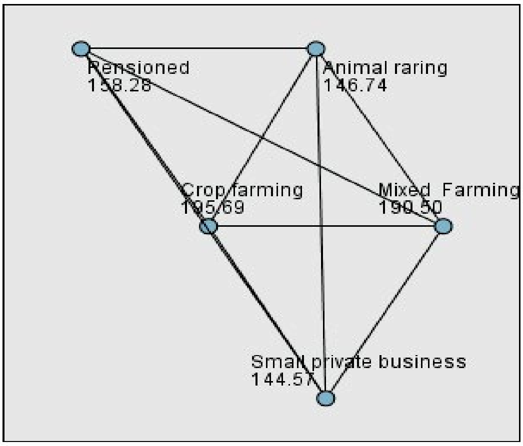
4.9. Ordinal logistic regression model

The pseudo R^2 values reported in the ordered logistic regressions are typically low, 5%. It is also important to transparently acknowledge any omitted variables. Our models do not include all potentially relevant factors that could influence attitudes toward traditional biomass energy use. Elements such as household income, household size, access to alternative energy sources, media exposure, and local policy environments were excluded from this analysis because they were found to be insignificant, with p-values greater than 0.05. The ordinal logistic regression model analyzed households' perceptions of how traditional biomass energy use contributes to deforestation, land degradation, agricultural productivity, and food security, in terms of gender, occupational differences, and educational levels.

Ologit. Traditional biomass energy use causes deforestation: Gender, Education and Occupation

Ordered logistic regression	Number of obs	=	366
	LR chi2(3)	=	34.49
	Prob > chi2	=	0.0000
Log-likelihood = –467.26593	Pseudo R2	=	0.0356

Pairwise Comparisons of Occupation



Each node shows the sample average rank of Occupation .

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Small private business-Animal raring	2.177	29.884	.073	.942	1.000
Small private business-Pensioned	-13.708	33.346	-.411	.681	1.000
Small private business-Mixed Farming	45.938	26.057	1.763	.078	.779
Small private business-Crop farming	51.127	27.614	1.852	.064	.641
Animal raring-Pensioned	-11.532	27.096	-.426	.670	1.000
Animal raring-Mixed Farming	43.761	17.353	2.522	.012	.117
Animal raring-Crop farming	48.950	19.613	2.496	.013	.126
Pensioned-Mixed Farming	32.230	22.805	1.413	.158	1.000
Pensioned-Crop farming	37.418	24.569	1.523	.128	1.000
Mixed Farming-Crop farming	-5.189	13.062	-.397	.691	1.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Fig. 5. Pair comparisons of occupation
Source: survey data result (March 2025)

Rys. 5. Porównania par zawodów

Table 3 shows the results of an ordered logistic regression based on 366 observations. The likelihood value is –467.26593. The likelihood ratio chi-squared statistic (LR Chi^2) is 34.49, with a p-value of 0.0000, demonstrating that the model is statistically significant. The Pseudo R^2 is 0.0356, indicating that about 3.6% of the variance in the dependent variable is accounted for by the independent variables. Our analysis examined how gender influences perceptions of traditional biomass energy use and its role in contributing to deforestation, using "Female" as the reference category. The coefficient for gender is reported as 0.5088756 (SE = 0.2041042, z = 2.49, p = 0.013). This suggests that being male (coded as 1) is associated with a 66% increase in the log odds that traditional biomass use contributes to deforestation (exp (0.5088756) ≈ 1.66) compared to being female. The 95% confidence interval spans from 0.1088388 to 0.9089125, highlighting a statistically significant positive effect of gender on attitudes toward traditional biomass energy use and deforestation.

Table 3. Perceptions of traditional biomass energy use causes deforestation using "Female, college+ and pensioned" as reference categories for gender, education and occupation groups

Tabela 3. Postrzeganie tradycyjnego wykorzystania energii z biomasy powoduje wylesianie, przy czym jako kategorie odniesienia dla płci, wykształcenia i grup zawodowych przyjęto kobiety, osoby z wyższym wykształceniem i emerytów

Traditional biomass energy use causes deforestation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Gender	.5088756	.2041042	2.49	0.013	.1088388	.9089125
Male	.5455807	.2003123	2.72	0.006	.1529757	.9381856
Female	0	(omitted				
Education	.440993	.0987607	4.47	0.000	.2474255	.6345605
No Education Attended	–1.801645	.3986306	–4.52	0.000	–2.582947	–1.020343
Primary Education	–1.719574	.418165	–4.11	0.000	–2.539162	–.8999856
Secondary Education	–1.315953	.4365657	–3.01	0.003	–2.171607	–.4603004
College and above	0	(omitted)				
Occupation	–.1722145	.0830963	–2.07	0.038	–.3350803	–.0093486
Mixed Farming	.4337994	.408537	1.06	0.288	–.3669183	1.234517
Crop farming	.5840023	.4512197	1.29	0.196	–.300372	1.468377
Animal raring	–.3458662	.4876856	–0.71	0.478	–1.301712	.6099801
Small private business	–.1734333	.5960637	–0.29	0.771	–1.341697	.99483
Pensioned	0	(omitted)				

Source: survey data result (February 2025).

The effect of educational status on the perception of traditional biomass energy use as a cause of deforestation was considered using "College and above" as the reference category. The results indicate the following: For individuals with no formal education, the coefficient was –1.801645 (SE = 0.3986306, z = –4.52, p = 0.000), with a 95% confidence interval for this coefficient of [–2.582947, –1.020343]. exp (–1.801645) ≈ 0.20. This suggests that lacking formal education is associated with an 80% decrease in the odds of believing that traditional biomass energy use contributes to deforestation. Those with primary education showed a coefficient of –1.719574 (SE = 0.418165, z = –4.11, p = 0.000), with a 95% confidence interval of [–2.539162, –0.8999856]. Exp (–1.719574) ≈ 0.20. This indicates that having attended primary school is also linked to an 80% decrease in the odds of holding the belief that traditional biomass energy causes deforestation. For individuals with secondary education, the coefficient was –1.315953 (SE = 0.4365657, z = –3.01, p = 0.003), with a 95% confidence interval of [–2.171607, –0.4603004]. exp(–1.315953) ≈ 0.30.

The effect of occupation on the perception of traditional biomass energy utilization as a cause of deforestation, coefficient –.1722145 (SE =.0830963, Z = –2.07, P = 0.038) with [–.3350803 –.0093486] a 95% confidence interval exp (–.1722145) ≈ 0.84 with an increase in the log odds of believing that traditional biomass energy use causes deforestation. In terms of using "Pensioned" as the reference category, mixed farmers, crop farmers, livestock farmers, and small private business owners did not show statistically significant results as their p-values were greater than 0.05.

Ologit. Traditional biomass energy use causes land degradation: Gender, Education and Occupation

Ordered logistic regression	Number of obs	=	366
	LR chi2(3)	=	13.32
	Prob > chi2	=	0.0040
Log-likelihood = –448.72737	Pseudo R2	=	0.0146

In Table 4 below, the total number of observations used in the model is 366. Log-likelihood –448.7273: the log-likelihood value at the estimated parameters. Higher values (closer to zero) indicate a better fit. The likelihood ratio chi-squared statistic LR chi^2 is 13.32, accompanied by a p-value of 0.0040. Pseudo R20.0146 suggests that approximately 1.46% of the variance in the dependent variable is explained by the independent variables. We examined the effects of gender on perception towards traditional biomass energy use causing land degradation, with "Female" as the reference category. Males with a coefficient of 0.6308879 (SE =.1977144, Z = 3.19, P = 0.001), with exp (0.6308879) ≈ 1.88, suggesting that being male is associated with an increase in the log odds of perceiving traditional biomass energy use as causing land degradation by about 88% compared to being female.

We examined the effects of educational status on attitudes toward the use of traditional biomass energy and its cause of land degradation, using "College and above" as the reference category. The results indicate that individuals with no formal education had a coefficient of –0.9713 (SE = 0.3458, Z = –2.81, p = 0.005), with a 95% confidence interval of [–1.648955, –2935807] (Exp (–0.9713) ≈ 0.38) indicates that the log-odds of perceiving traditional biomass energy use as contributing to land degradation decreases by about 62% compared to the reference group. For

Table 4. Perceptions towards traditional biomass energy use and its contribution to land degradation using "Female, college+ and pensioned" as the reference category for gender, education and occupation groups

Tabela 4. Postrzeganie tradycyjnego wykorzystania energii z biomasy i jego wpływu na degradację gleby przy użyciu kategorii „Kobiety, osoby z wyższym wykształceniem i emeryci" jako kategorii odniesienia dla płci, wykształcenia i grup zawodowych

Traditional biomass energy use causes land degradation	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Gender	.2738733	.2043835	1.34	0.180	–.1267109	.6744576
Male	.6308879	.1977144	3.19	0.001	.2433749	1.018401
Female	0	(omitted)				
Education	.1332347	.0925049	1.44	0.150	–.0480716	.314541
No formal education	–.9712678	.3457651	–2.81	0.005	–1.648955	–.2935807
Primary Education	–1.237078	.3628756	–3.41	0.001	–1.948301	–.5258544
Secondary Education	–1.352367	.3781213	–3.58	0.000	–2.093471	–.611263
College and above	0	(omitted)				
Occupation	–.2770112	.0842294	–3.29	0.001	–.4420977	–.1119246
Mixed Farming	.6932061	.4314015	1.61	0.108	–.1523252	1.538737
Crop farming	1.01824	.4736404	2.15	0.032	.0899223	1.946559
Animal raring	–1.187193	.5116907	–2.32	0.020	–2.190088	–.1842972
Small private business	.3822768	.602569	0.63	0.526	–.7987368	1.56329
Pensioned	0	(omitted)				

Source: survey data result (March 2025).

those who completed primary education, the coefficient was –1.2371 (SE = 0.3629, Z = –3.41, p = 0.001), with a 95% confidence interval of [–1.948301, –5258544]. The Exp (–1.2371) ≈ 0.30) shows that the log-odds of seeing traditional biomass energy use as causing land degradation decreases by 70% compared to the reference group. Individuals with secondary education had a coefficient of –1.3524 (SE = 0.3781, Z = –3.58, p = 0.000), with a 95% confidence interval of [–2.093471, –611263]. The exponential of –1.3524 (Exp (–1.3524) ≈ 0.26) indicates that in the log-odds of perceiving traditional biomass energy use as contributing to land degradation, the likelihood decreases by 74% compared to the reference group.

The study examined the influence of occupation on the perception of traditional biomass energy use as a cause of land degradation. Occupation with a coefficient of –.2770112 (SE.0842294, Z = –3.29, P = 0.001), with a 95% confidence interval of [–.4420977 –.1119246]. Using "Pensioned" as a reference. Crop farming exhibits a significant positive coefficient of 1.01824 (SE = 0.4736, Z = 2.15, p = 0.032) and a 95% confidence interval of [0.0899, 1.9466]. Exp (1.01824) ≈ 2.78, suggests that the odds of perceiving biomass energy as contributing to land degradation are 178% higher for crop farmers compared to the reference group. In contrast, animal rearing has a significant negative coefficient of –1.187193 (SE = 5116907, Z = –2.32, P = 0.020). With a 95% confidence interval of [–2.190088 – 1842972], the exponential of the coefficient (–1.187193) ≈ is 0.31. This indicates that the odds of perceiving biomass energy as contributing to land degradation decrease by 69% for animal rearing compared to the reference group.

Ologit Traditional biomass energy use negatively affects agricultural productivity: Gender, Education and Occupation

Ordered logistic regression	Number of obs	=	366
	LR chi2(3)	=	14.75
	Prob > chi2	=	0.0020
Log-likelihood = –434.76756	Pseudo R2	=	0.0167

Table 5 shows that our ordinal logistic regression model is based on a total of 366 observations. The log-likelihood is –434.76756, with higher values (closer to zero) indicating a better fit. The LR chi-squared statistic is 14.75, with a corresponding p-value of 0.0020. This low p-value (typically considered significant if less than 0.05) suggests that the model fits significantly better than a null model. Additionally, the pseudo-R-squared value is 0.0167, which measures the goodness of fit similarly to R-squared in linear regression, indicating that approximately 1.67% of the variance in the dependent variable is explained by the independent variables while holding other variables constant.

With reference to Table 5, an ordered logistic regression analysis investigating the impact of gender attitudes towards traditional biomass energy use on agricultural practices is presented, with “Female” defined as the reference category. Males coefficient .4774987 (SE =.2054048, Z = 2.32, P = 0.020). The 95% confidence interval for this coefficient ranges from .0749127 to .8800847 Exp (.4774987) ≈ 1.61, suggesting that being male is associated with a 61% increase in the log-odds of perceiving that the use of traditional biomass energy negatively affects agricultural productivity when compared to females.

Educational status and perception of traditional biomass energy use negatively affect agricultural productivity, with “College+ education level” as the reference category. For the households with no attendance of formal education, the coefficient of –.9286386 (SE =.3666906, Z = –2.53, P = 0.011) prevailed, with a 95% confidence interval for this coefficient is [–1.647339, –.2099382]. Exp (–.9286386) ≈ 0.40, suggesting that having not attended formal education is associated with a decrease in the log-odds of having an attitude towards traditional biomass energy use, negatively affecting agricultural productivity by 60% than the reference group.

On the other hand, primary education attendance with coefficient –1.123488 (SE =.3848232 Z = –2.92 P = 0.004) and with a 95% confidence interval for this coefficient is [–1.877728, –.3692486]. Exp (–1.123488) ≈ 0.33, suggesting that having attended primary education is associated with a decrease in the log odds of having the attitude towards traditional biomass energy use, which affects agricultural productivity by 77% compared to the reference group. Secondary education with coefficient –.9913787 (SE = .4024106, Z = –2.46, P = 0.014) and the

Table 5. Perception of traditional biomass energy use negatively affects agricultural productivity using "Female, college+ and pensioned" reference categories for gender, education and occupation groups

Tabela 5. Postrzeganie tradycyjnego wykorzystania energii z biomasy negatywnie wpływa na wydajność rolnictwa w odniesieniu do kategorii referencyjnych „Kobiety, osoby z wyższym wykształceniem i emeryci" w podziale na płeć, wykształcenie i zawód

Traditional biomass energy utilization negatively affects agricultural productivity.	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Gender	.5227595	.2096315	2.49	0.013	.1118894	.9336296
Male	.4774987	.2054048	2.32	0.020	.0749127	.8800847
Female	0	(omitted)				
Education	.1777618	.097062	1.83	0.067	–.0124763	.3679999
No formal education	–.9286386	.3666906	–2.53	0.011	–1.647339	–.2099382
Primary education	–1.123488	.3848232	–2.92	0.004	–1.877728	–.3692486
Secondary education	–.9913787	.4024106	–2.46	0.014	–1.780089	–.2026685
College and above	0	(omitted)				
Occupation	–.1484583	.0866521	–1.71	0.087	–.3182933	.0213767
Mixed farming	.7457574	.4309039	1.73	0.084	–.0987987	1.590314
Crop farming	.7252286	.4693766	1.55	0.122	–.1947326	1.64519
Animal raring	–.273275	.503483	–0.54	0.587	–1.260083	.7135335
Small private business	1.684332	.7073544	2.38	0.017	.2979424	3.070721
Pensioned	0	(omitted)				

Source: survey data result (March 2025).

95% confidence interval for this coefficient is [–1.780089, –.2026685]. Exp (–.9913787) ≈ 0.37, suggesting that having attended secondary education is associated with a decrease in the log odds of having the attitude towards traditional biomass energy use, which affects agricultural productivity by 63% when compared to the reference group.

Occupation, "Pensioned" as the reference category, the results indicate that small private business owners had a coefficient of 1.684332 (SE = .7073544, z 2.38, p 0.017). The 95% confidence interval for this coefficient is [.2979424, 3.070721]. Exp (1.684332) ≈ 2.11, suggesting that being a small private business owner is associated with an increase in the log-odds of having an attitude towards the use of traditional biomass energy, which negatively affects agricultural products by 111% compared to the reference group.

Ologit Traditional biomass energy utilization negatively affects food security: Gender, Education and Occupation.

Ordered logistic regression	Number of obs	=	366
	LR chi2(3)	=	25.59

Prob > chi2 = 0.0000
Log-likelihood = -527.653 Pseudo R2 = 0.0237

The presentation is based on 366 observations. The log-likelihood is –527.653, with higher values indicating a better fit. The LR chi-squared (3) statistic is 25.59, with a p-value of 0.0000, showing statistical significance. The Pseudo R-squared value is 0.0237, suggesting that about 2.37% of the variance in the dependent variable is explained by the independent variables. As revealed in Table 6, gender negatively affects perceptions of traditional biomass energy use with "Female" as the reference category. Male had a coefficient of 0.4355584 (SE = 0.1914907, z = 2.27, p = 0.023). The 95% confidence interval for this coefficient is [.0602434, .8108733]. (Exp (0.4355584) ≈ 1.55 suggests that being a male is associated with an increase in the log-odds of having a concept or knowing that traditional biomass energy use negatively affects food security by 55% compared to being female.

Households with no formal education attendance had a coefficient of –1.8227566 (SE = 0.3507788, z = –5.21, p = 0.000), with a 95% confidence interval for this coefficient being

Table 6. Perceptions of traditional biomass energy use negatively affect food security, using "Female, college+ and pensioned" as the reference category for gender, education and occupation groups

Tabela 6. Postrzeganie tradycyjnego wykorzystania energii z biomasy ma negatywny wpływ na bezpieczeństwo żywnościowe, przy czym jako kategorię odniesienia dla płci, wykształcenia i grup zawodowych przyjęto „Kobiety, osoby z wyższym wykształceniem i emeryci"

Traditional Biomass energy use has negative effects on food security.	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Gender	–.1593274	.1921102	–0.83	0.407	–.5358564	.2172016
Male	.4355584	.1914907	2.27	0.023	.0602434	.8108733
Female	0	(omitted)				
Education	.4128857	.0925961	4.46	0.000	.2314006	.5943707
No formal education	–1.827566	.3507788	–5.21	0.000	–2.51508	–1.140052
Primary education	-1.543978	.3686984	–4.19	0.000	–2.266614	–.8213422
Secondary education	–1.596406	.3809738	–4.19	0.000	–2.343101	–.8497111
College and above	0	(omitted)				
Occupation	–.1517353	.0858607	–1.77	0.077	–.3200191	.0165485
Mixed farming	.6002337	.4509122	1.33	0.183	–.283538	1.484005
	.5134141	.4823658	1.06	0.287	–.4320055	1.458834
Animal raring	–.4172404	.5229604	–0.80	0.425	–1.442224	.6077431
Small private business	1.053564	.6400092	1.65	0.100	–.2008309	2.307959
Pensioned	0	(omitted)				

Source: survey data result (March 2025)

[–2.266614, –.8213422]. Primary school with coefficient of -1.543978 (SE = 0.3686984, z = –4.19, p = 0.000), with a 95% confidence interval for this coefficient is [–2.266614 –.8213422]. Exp of (–1.543978) ≈ 0.21, suggesting that primary education attendance is associated with a decrease in the log-odds of having a perception towards the utilization of biomass energy, which negatively affects food security by 79% when compared to the reference group. Secondary education attendance had a coefficient of –1.596406 (SE = 0.3809738, z = –4.19, p = 0.000) and the 95% confidence interval for this coefficient is [–2.343101, –.8497111] Exp 0. 20, suggesting that secondary education attendance associated with a decrease in the log-odds of having an attitude towards the utilization of biomass energy that affects food security by 80% when compared to reference group.

5. Discussion

The study focused on the society's perceptions regarding the effects of traditional biomass energy utilization on deforestation, land degradation, and negative impacts on agricultural productivity and food security in rural areas. According to a study by Tofu et al. (2022), the use of biomass energy has resulted in several negative consequences, including environmental degradation, such as deforestation and land degradation, as well as issues related to food insecurity and health problems arising from smoke exposure and fuel handling. Accordingly, gender influence on perceptions of traditional biomass energy use causes deforestation, land degradation, and negatively affects agricultural productivity and food security, where males' perception increases by 66%, 88%, 61%, and 55% than females, respectively. Regarding gender studies by Anfinsen (2017), a gender perspective can improve energy studies and enhance mitigation efforts. Ignoring aspects of gender can, at worst, lead to unsatisfactory analysis. Researchers and satellite remote sensing indicate a trend of spontaneous dispersed afforestation. Converting about 10% of farmland to forest could halve food insecurity, especially benefiting ultra-poor households and those who burn crop residue (Morrow et al. 2024).

Using educational, "College and above" as the reference category, households with no formal education and who attended primary school had a perception that decreased by 80%. Those who attended secondary school experienced a 70% decrease in perception that traditional biomass energy use causes deforestation. In 2015/2016, consumption of four solid biomass fuels contributed 33,327 to 44,547 ktoe to total energy consumption, valued at 4.4–7.7% of GDP. Stationary combustion of these fuels resulted in 165–219 Mt of CO2eq emissions and could affect 730,000 ha of forest and woodlands (Yalew 2022). People primarily use traditional energy for cooking due to a lack of knowledge and their beliefs about food prepared using it. Many households rely on traditional biomass for cooking because of these misconceptions (Geremew et al. 2014). Regarding the causes of land degradation, perceptions of individuals with no formal education decrease by 62%, while perceptions of individuals who have attended primary and secondary school decrease by 70% and 74%, respectively. Reducing the unsustainable use of traditional biomass helps decrease land degradation and CO_2 emissions while providing social and economic benefits (Olsson et al. 2019).

The perception of negatively affecting agricultural productivity decreases by 60% for those with no formal education, and by 77% and 63% for primary and secondary school attendees, respectively, when compared to the reference group. The perceptions of negatively affecting food security decrease by 84% for individuals with no formal education and by 79% and 80% for primary and secondary school attendees compared to the reference group. Bioenergy has a notable negative impact on environmental conditions, as perceived by a portion of the population. While reduced satisfaction with environmental quality was evident, further social impacts of bioenergy could not be statistically established (Venghaus and Hoffmann 2016). Concerning perceptions of occupation on traditional biomass energy use causing deforestation, using pensioners as the reference category, the results indicate that the log odds for mixed farmers increase by 178% compared to the reference group. Small business households increase by 111% regarding perceptions that traditional biomass energy use negatively affects agricultural productivity. The large-scale implementation of biomass production for bioenergy presents an exciting opportunity to reimagine land use. However, it also calls for us to be mindful of the delicate balance between energy needs and the vital importance of food security and sustainable land management (Olsson et al. 2019). According to a study by Hitchner et al (2016), limited public understanding of bioenergy technologies has led to misconceptions and increased risk perceptions. This emphasizes the urgent need for education to improve social acceptance of bioenergy.

Conclusion

This article focuses on examining households' perceptions of the negative effects of traditional biomass energy utilization on deforestation, land degradation, agricultural productivity, and food security in rural areas. The assessment highlights the influence of gender on perceptions of how traditional biomass energy use causes deforestation, land degradation, and negatively impacts agricultural productivity and food security. It was found that males tend to be more aware of these consequences than females. Therefore, we recommend that females need to be educated about the negative effects of traditional biomass energy use. When it comes to educational levels and perceptions of traditional biomass energy use about land degradation, individuals with no formal education or only a primary or secondary school education tend to have lower perceptions compared to those with a college education or higher.

In terms of the perception of negative impacts on agricultural productivity, households with no formal education, as well as those with only primary or secondary schooling, are less aware of the detrimental effects of biomass energy use compared to the reference group, which consists of individuals with a college education or higher. Similarly, when it comes to awareness of food security issues, those without formal education and those with primary or secondary schooling tend to be less informed than the college-educated. Regarding the perception of traditional biomass energy use contributing to deforestation, the analysis shows that mixed farmers and small business owners have significantly higher log odds compared to pensioners, who serve as the reference category. Overall, we recommend implementing education-based interventions to increase community awareness about the health and environmental impacts of traditional biomass energy use. Addressing these issues could positively influence rural perceptions of the negative effects associated with biomass energy use.

Policy recommendation

The study found that societal perceptions of the negative effects of traditional biomass energy use vary by gender, education, and occupation. Based on these findings, we recommend specific actions for relevant authorities. The identified gap calls for multiple interventions by the governments, non-governmental actors, and private entities to raise awareness about the long-term impacts of traditional biomass energy use on deforestation, land degradation, agricultural productivity, and food security. Additionally, promoting awareness of the benefits of alternative energy sources is vital. Encouraging collaboration between the private sector and the government on modern renewable energy initiatives, as well as supporting the adoption of energy-saving technologies, are important policy measures. Establishing institutional and technological links between rural communities and renewable energy sources, such as solar and wind energy, along with efficient electricity systems, is crucial. At the local level in rural areas, clear national policies regarding forests and energy should be established to foster sustainable development. Investing in alternative energy technologies can lead to significant improvements in environmental conditions, enhance food security, and promote better health outcomes for communities. Incorporating gender- and education-based interventions can empower women, raise community awareness about the health and environmental effects of traditional biomass energy, and encourage sustainable practices. Addressing these issues can have broader implications for regional sustainability and improving the quality of life in rural areas. In general, Policy interventions should focus on empowering women and enhancing educational opportunities to improve outcomes in rural areas.

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Ocena postrzegania przez członków gospodarstw wiejskich negatywnych skutków tradycyjnego wykorzystania energii z biomasy dla wylesiania, degradacji gleby, wydajności rolnictwa i bezpieczeństwa żywnościowego i postaw wobec tego zjawiska w okręgu (woredzie) Ada'a, Oromia, Etiopia

Streszczenie

Celem niniejszego artykułu była ocena postrzegania przez członków gospodarstw wiejskich negatywnych skutków tradycyjnego wykorzystania energii z biomasy dla wylesiania, degradacji gleby, wydajności rolnictwa i bezpieczeństwa żywnościowego i postaw wobec tego zjawiska w okręgu (woredzie) Ada'a, w regionie Oromia, w Etiopii. Zastosowano podejście mieszane, łączące metody ilościowe i jakościowe, w celu zebrania danych za pomocą kwestionariusza ankietowego, przewodnika do wywiadów i listy kontrolnej do obserwacji. Dane zebrano od 366 gospodarstw domowych i przeanalizowano za pomocą oprogramowania SPSS w wersji 20 oraz Stata w wersji 14. W trakcie analizy w badaniu zastosowano test U Manna-Whitneya, test H Kruskala-Wallisa oraz uporządkowaną regresję logistyczną. Płeć okazuje się czynnikiem wpływającym na postrzeganie tradycyjnego wykorzystania energii z biomasy jako przyczyny wylesiania, degradacji gleby, negatywnego wpływu na wydajność rolnictwa i bezpieczeństwo żywnościowe. W tym zakresie postrzeganie mężczyzn wzrasta odpowiednio o 66, 88, 61 i 55% w porównaniu z kobietami. Biorąc pod uwagę poziom wykształcenia jako kategorię odniesienia, gospodarstwa domowe bez formalnego wykształcenia i z wykształceniem podstawowym odnotowały spadek postrzegania o 80%. Uczestnicy z wykształceniem średnim wykazali 70-procentowy spadek przekonania, że tradycyjne wykorzystanie energii z biomasy powoduje wylesianie. W przypadku degradacji gleby uczestnicy bez formalnego wykształcenia wykazali spadek o 62%, a osoby z wykształceniem podstawowym i średnim odnotowały spadek odpowiednio o 70 i 74%. Wydajność rolnictwa spada o 60% w związku z wykorzystaniem energii z biomasy w przypadku osób bez formalnego wykształcenia, odpowiednio o 77 i 63% w przypadku osób z wykształceniem podstawowym i średnim. Wykazano, że wykorzystanie energii z biomasy ma negatywny wpływ na bezpieczeństwo żywnościowe, zmniejszając je o 84% w przypadku osób bez formalnego wykształcenia oraz odpowiednio o 79 i 80% w przypadku osób z wykształceniem podstawowym i średnim. Wykorzystanie tradycyjnej energii z biomasy jest istotnym czynnikiem powodującym wylesianie. W gospodarstwach rolnych prowadzących działalność mieszaną odnotowano wzrost wylesiania o 178%, natomiast w gospodarstwach prowadzących działalność na małą skalę wzrost ten wyniósł 111%. Szkody środowiskowe mają poważny wpływ na wydajność rolnictwa.

Słowa kluczowe: postawa, Etiopia, gospodarstwo wiejskie, tradycyjna biomasa