

Impact of Livelihood Diversification on Income of Smallholder Farmers in Lemo Woreda, Hadiya Zone, Central Ethiopia

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ABSTRACT

Introduction: Livelihood diversification is increasingly recognized as a strategy to enhance household income and resilience among smallholder farmers in developing countries. This study evaluates the impact of livelihood diversification on household income and identifies the key determinants influencing farmers' engagement in diversified livelihoods in the study area.

Objectives: The study aims to analyze the determinants of livelihood diversification among smallholder farmers and evaluate its impact on household income in the study area.

Methods: A multistage sampling procedure was used to select 364 smallholder household heads from four randomly chosen kebeles. Both primary and secondary data were collected using structured interviews, key informant interviews, focus group discussions, and personal observations. Descriptive statistics, binary logistic regression, and propensity score matching (PSM) techniques were employed for data analysis.

Results: Findings revealed that 29.67% of the respondents engaged in livelihood diversification, while 70.33% remained non-diversified. Binary logistic regression identified education level, landholding size, frequency of extension contact, livestock ownership, and access to credit as significant factors influencing livelihood diversification. The PSM results demonstrated that diversified households earned 61% more in total annual income compared to their non-diversified counterparts.

Conclusions: Livelihood diversification significantly enhances household income and economic stability. To promote diversified livelihoods, government and development partners should create enabling environments through improved access to education, extension services, credit, and asset accumulation support for smallholder farmers in the region.

Keywords: Livelihood diversification, smallholder farmers, income, logistic regression, propensity score matching

1. INTRODUCTION

In developing countries, agriculture is an important sector for majority of the rural populations' livelihood as it is a source of income, employment and foreign exchange (Larsen and Lilleør, 2014). Ethiopia is one of the Sub-Saharan Africa countries where majority of the population lives in the rural areas mainly depending on agriculture for their livelihoods. Agriculture is the backbone of Ethiopian economy contributing about 32.4 percent of Gross Domestic Product, 74.9 percent of foreign exchange earnings and 67 percent of the population living in the rural areas depending on agriculture for their livelihood (NBE, 2022; WB, 2019). Despite its high contribution to the overall economy, Farming as a principal source of income has failed to assure sufficient livelihood for most smallholder farmers in Ethiopia. This is due to the agricultural sector's highly distinctive characteristics, including shrinking farm sizes, out-dated production techniques, small-scale, irregular rainfall patterns, rising soil erosion, land degradation, aridity in some regions and pervasive tropical diseases in others, and low levels of output per farm (Mota *et al.*, 2019). Consequently, smallholder farmers partake in a number of strategies including livelihood diversification which enable them to fulfil livelihood requirement.

Livelihood diversification is a process by which household members construct a diverse portfolio of off-farm and/non-farm activities in their struggle for survival and to improve their income (Ellis, 2000). It strengthens farmers' resistance to climate shocks and acts as a risk insurance mechanism. It also contributes to closing the poverty gap between farm households (Martin & Lorenzen, 2016; Simtowe *et al.*, 2016). Sources stated that farm households can increase food security, have higher incomes, and be more resilient to environmental stresses by diversifying their income-generating strategies (Kassa, 2019). According to Diiro (2013), Farmers' purchasing power for agricultural inputs (such as improved seeds and inorganic fertilizers) and the application of mechanization techniques to boost productivity is increased by the income generated through diversification of livelihoods.

In this study, livelihood diversification refers to non-farm and/off-farm income generating activities that smallholder farmers engaged in to increase their income levels (Losch *et al.*, 2010). Naturally, smallholder farmers diversify their sources of income to escape extreme poverty and also to improve their income. Therefore, the impact of livelihood diversification on the smallholder farmers' income needs to explore. Governments and policy makers should be aware of the breadth of livelihood diversification practices and how much they contribute to the income of farm households, as this information influences the formulation and execution of policies (Abimbola and Oluwakemi, 2013).

According to Sugiharto (2020), diversification away from relying solely on subsistence methods for livelihood families can boost their production, improve their financial situation, and deal with shock and stress from the environment rather than depending on farming alone. Non-farm earnings across the developing world account for 35 to 50 percent of smallholder farmer's income. Non-farm activities not only absorb a large quantity of surplus agricultural labor, but also improve the rural standard of living (Yenesew and Masresha, 2019). Landless and near-landless households in the rural area depend heavily on non-farm income for their survival (Aziz *et al.*, 2017). The presence of off-farm income may also relax the budget constraints of the farm households. Additional positive impacts of off-farm income would be expected under better wage rate and improved employment opportunities (Gebreyesus, 2016). Farm households who depend only on farm income have to use a larger proportion of farm profit to satisfy the consumption demands of the household. In households where additional income is present, the budgetary constraints are relaxed thereby making more of the farm profit available for reinvestment (Zakaria *et al.*, 2019). These show that rural non-farm and off-farm activities are contributing significantly to food security, poverty alleviation, and to improved rural household income. Thus, the expansion of non-farm and/off-farm rural activities and diversification of income are desirable policy objectives since they give individuals and households more options to improve their livelihood security and living standards. This is because, in addition to increasing income, it causes farmers' behavioral changes like risk taking behavior (Gebreyesus, 2016).

The study area (Lemo Woreda), in particular, and the Hadiya zone, in general, are home to smallholder farmers who cultivate cereal crops with low economic returns and rely on rain-fed agricultural production systems. The major cereal crops produced in the study area include wheat, barley, peas, and beans. Enset is a strategic crop that significantly contributes to the food security of the woreda (LWOAARD, 2022). Numerous important questions remain unanswered in this area, which are relevant to understanding the situation and guiding policy making. These include the impact of non-farm and/or off-farm activity diversification on the income of smallholder farmers. Therefore, focusing on the smallholder farming households of the woreda, this study aims to address the fundamental question of whether non-farm and/or off-farm diversification activities influence overall income inequality among smallholder farmers in the study area.

2. OBJECTIVES

2.1. General Objective

The general objective of this study is to evaluate the impact of livelihood diversification on the income of smallholder farmers in Lemo Woreda, Hadiya Zone, Central Ethiopia

2.2. Specific Objectives

- i. To analyze the determinants of livelihood diversification among smallholder farmers in the study area
- ii. To evaluate the impact of livelihood diversification on smallholder farmers' income in the study area

3. METHODS

3.1. Description of the Study Area

Lemo Woreda is a study area in the Central Ethiopia National Regional State. It shares borders with the Kembata Tembaro Zone to the south, Duna and Soro to the southwest, Gomibora to the west, Misha to the northwest, Ana Lemo to the northeast, and Shashogo to the southeast. It contains the towns of Belesa and Lisana, and it encircles Hossana. The topography consists of rocky highlands and hilly regions with slopes ranging from 2 to 30% (LWOAARD, 2022).

The "Woina Dega" agro-climatic zone, where the Woreda is situated, has an altitudinal range of 1950–2400 masl and an average annual rainfall of 1150 mm. It has seasonal streams and rivers that provide water for drinking and hygienic needs, and the Bilate River, one of the rivers, is used for small-scale irrigation (LWOAARD, 2022).

The total population of the Woreda is 118,594, 58,666 of whom are men and 59,928 of whom are women. Protestants make up 74.07% of the population, Muslims 12.37%, Ethiopian Orthodox Christians 7.2%, and Catholics 6.14% (Census, 2007).

Farmers find it challenging to grow enough food solely from farm activity because of land fragmentation and soil is overly cultivated in the study area. Consequently, they were engaged in different off-farm and/non-farm activities to raise their income such as wage work, petty trading and handy craft are among the activities introduced. However, the intensity and dimension of such activities differ within the community due to differences in factors affecting the community members to engage in such activities (LWOAARD, 2022).

3.2. Sample and Sampling Techniques

The representative sample for this study was chosen using a multistage sampling technique. In the initial phase, 4 kebeles were randomly selected from a total of 33 kebeles that exist in the Woreda. Moreover, selection of the 4 kebeles is possible because of the total distributions of the farm households of the area are socioeconomically, culturally and institutionally similar for all kebeles in the Woreda. In addition to this, the administration, livelihood diversification strategies and plans of development by the leaders are almost the same for all kebeles and so any household from any kebeles can be representative of each other. In the second stage, the farmers in each randomly selected kebeles were stratified into diversified and non-diversified categories based on the diversification status of sample respondents as reported by administrators of selected kebeles. In the third and last stage, from the total population of the selected kebeles 364 (108 from diversified and 256 from non-diversified groups) sample respondents were selected by using simple random sampling technique.

3.3. Methods of Data Collection

In this study, both qualitative and quantitative data were used. These quantitative and qualitative data types were gathered using both primary and secondary sources. Focus group discussion, observations, key informant interviews, structured sample household head interviews, and other primary data collection techniques were used. Reviewing research journals, books, and these published and unpublished as well as evaluating various records and reports from the agriculture and rural development office were used as secondary methods of data collection.

3.4. Methods of Data Analysis

The household's personal, demographic, economic, institutional, and psychological factors related to the non-farm and off-farm livelihood diversification activities were evaluated using descriptive statistics. In order to determine the factors that influence smallholder farmers to diversify their income source into non-farm and/or off-farm activities in the study area, the logit model was used in this study.

The propensity score matching (PSM) technique was used to generate estimates for paired treatment (diversified sample household) and control (non-diversified sample household) groups based on the similarity of observable characteristics in order to evaluate the impact of non-farm and/or off-farm activities diversification on the income of smallholder farmers. The researcher used this technique because it can reduce the dimensionality of the covariates,

making it easier to balance them across the treatment and control groups. Additionally, PSM can avoid model misspecification, as it does not rely on a functional form of the outcome equation.

4. RESULTS AND DISCUSSION

4.1. Demographic and Socio-economic Characteristics of the Household Head

The results of the survey data indicated that 48 (13.19%) were females, and 316 (86.81%) of the respondents were males. According to a comparison based on diversification status, out of 108(29.67%) diversified households 94(25.82%) is headed by male participants and the corresponding figure for non-diversified is about 14(3.85%). Based on the available data, 40.11% (146) of farmers were credit users, while 218 (59.89%) of farmers were not. Of the respondents who used credit services, 89 (or 24.5%) had a diverse portfolio, while 57 (15.66%) did not. 19 (52.2%) of the respondents who did not use credit services were diversified, while the remaining 199 (54.67%) were not. Data revealed that 23 respondents (6.32%) had no crop risk, while 341 (93.68%) of the respondents faced crop risk. 107 households were diversified out of the respondents who face crop risk, while 234 households were not diversified. Of the respondents who weren't exposed to crop risk, 1 household was diversified, and the other 22 were non-diversified.

Table 1: Summary of frequency of categorical variables

Variables		LivDiv						χ^2 (chi2)
		Diversified	Non-diversified	Total				
		Frequency	Percent	Frequency	Percent	Frequency	Percent	
SexHH	Female	14	3.85	34	9.34	48	13.19	
	Male	94	25.82	222	60.99	316	86.81	0.007
AcCreSe	Yes	89	24.45	57	15.66	146	40.11	
	No	19	5.22	199	54.67	218	59.89	114.370
CrRisk	Yes	107	29.49	234	64.28	341	93.68	
	No	1	0.27	22	6.04	23	6.32	7.5444

Source: Own survey, 2024

The average age of the sample household head was 47.77 years, with a range of 26 to 67 years. The average age of households participating in off-farm and/non-farm diversification activities was 48.01 years, whereas the average age of households solely engaged in on-farm activities was 47.20 years. The sample households' diversification groups had a mean age difference 0.81 year that was less than 1. The average education enrollment level of the household head for all sample observations was 3.06 years of schooling, as indicated in table 6 below. The household's enrollment level for education was set at 0 years for the minimum and 18 years for the maximum. Furthermore, the results showed that the average education enrollment for the heads of diversified households was 4.71 years of schooling, while the average education level of non-diversified households was 2.36, or roughly 2 years of schooling. The average family size of the household head for all sample observations was 3.60 units, as table 6 below illustrates. The household's minimum and maximum family sizes were 1 and 12.1 units respectively. In households that were not diversified, the average family size was 3.52 units, while in diversified households it was 3.80 units. However, there was an absolute -0.28 unit mean difference in average family size between diversified and non-diversified.

The sample household's land holding ranges from 0.25 hectares to 2 hectares. The land holding is 0.99 hectares on average. The treated group's mean land holding is 0.98 hectares, while the control group's corresponding figure is 1.00 hectares. The average walking distance to the closest market, measured in walking distance for the combined

sample of observations, was 5.81 kilometers, as shown in table 6 below. The minimum and maximum walking distance for farmers in the study area was between 0.5 and 12 kilometers, respectively. Additionally, the results showed that, on average, household heads who were diversified took 5.50 walking kilometers to the closest market, while non-diversified household heads took 5.94 kilometers. Table 2 below shows that, on average, during the cropping season, farmers in all sample households received extension services from development agents 3.55 times, or roughly four times a year. Farmers in the study area had extension contacts at minimum and maximum frequencies ranging from 0 to 12 units. For farmers who diversify their sources of income, the average frequency of extension contacts with development agents was 5.25, or roughly five times a year, compared to 2.84, or roughly three times a year, for households without such diversification. Table 6 below illustrates that all sample households had an average of 4.54 tropical livestock units (TLU) in livestock holding. In the study area, farmers' tropical livestock holding ranged from 0 to 13.34 TLU at the lowest and maximum, respectively. While respondents who did not diversify their source of income held an average of 4.63 tropical livestock units, diversified households held an average of 4.32 TLU.

Table 2: Summary and mean comparison of continuous variables

Variables	Diversified (n=108)	Non-diversified (n=256)	Mean difference	Combined sample (n=364)	T- value
AgHH	47.20	48.01	0.80	47.77	1.27
EduLeHH	4.71	2.37	-2.35	3.06	-5.99
FamSize	3.80	3.51	-0.28	3.60	-0.28
LaSize	0.98	1.00	0.01	0.99	0.26
DistMkt	5.50	5.94	0.44	5.81	1.32
FreExtCon	5.25	2.84	-2.41	3.55	-6.28
TLU	4.32	4.63	0.31	4.54	1.00

Source: Own survey, 2024

4.2. Status of Non-farm and Off-farm Activities Diversification in the Study Area

The results of the descriptive statistics indicate that, out of all the sample households, 256 (or 70.33%) participated in on-farm activities only, such as crop production and livestock rearing, which involves a variety of agricultural products as their primary source of income. Various crops are grown in the study area, based on observations and focus group discussions. Teff, maize, wheat, beans, and barely are a few of the main cereals farmed in the study area. Additionally, fruits like oranges, avocados, coffee, and cabbage as well as vegetables like tomatoes, cabbage, carrots, and chillies are grown.

Descriptive statistics also reveal that, of those who diversified their income sources, 60 (16.48%) were involved in off-farm activities, whereas 83.52% of smallholder farmers did not take part in any off-farm activity. The key informants added that in times of food scarcity, wage labor is the most crucial source of income. Landless and smallholder rural farm households are frequently forced to work as wage laborers in other farms, performing tasks like crop weeding and harvesting.

In this study, "non-farm" activities are those that happen outside of the agricultural industry. Table 3 below shows that 296 (81.32%) of smallholder farmers were not involved in any non-farm activity, while 68 (18.68%) of them were involved in non-farm activities in addition to on-farm ones. The main non-farm activities in the study area were remittance transfers within and between countries, selling local beers (Tella and Areke), petty trading (trading grains, fruits, vegetables, and spices), and handy craft activities (like weaving, spinning, carpentry, poetry, and house mudding).

In addition to their on-farm activities, 16 (4.4%) smallholder farmers also engaged in both non-farm and off-farm activities, as indicated by the results of the descriptive statistics.

Table 3: Status of non-farm and off-farm activities diversification in the study area

Livelihood diversification	Frequency	Percent
Diversified	108	29.67
Non-diversified	256	70.33
ParOffAc	60	16.48
ParNonAc	68	18.68
ParOffNonAc	16	4.40

Source: Own survey, 2024

4.3. Determinates of Non-farm and/Off-farm Activities Diversification

To assess the factors that affect the diversification of livelihood in to different activities, this study used logistic regression model. The variables that significantly affected the diversification of income sources into non-farm and/or off-farm activities were the education level of the household head, land size, livestock holding in tropical livestock units, frequency of extension contact, and access to credit services, as table 4 below illustrates.

Education level of household head: The probability of livelihood diversification in to non-farm and/or off-farm activities was positively affected by the household head's education level, as it was predicted. The marginal effect result of the household head's education level in table 4 below shows that when all other factors remain constant, a one-year increase in the household head's schooling will increase the probability of the household head participating in to non-farm and/off-farm livelihood diversification by 1.8%. This result is consistent with the findings of Abera *et al.*, (2021), who found that a household's likelihood of engaging in livelihood diversification activities increases with its level of education.

Land size owned (landholding): The likelihood of engaging in non-farm and/or off-farm activities diversification was positively affected by a household's land size, as predicted, and this relationship was significant at the 5% level of significance. Table 4 below illustrates the marginal effect result of logistic regression, which showed that, while holding other factors constant, an extra hectare of land increases the probability of a household diversifying their livelihood into non-farm and/or off-farm activities by 14.85%. This finding is in line with a study by Derbe (2020) who found that engaging in livelihood diversification activities is more likely in those with larger farmland sizes. Contrary to this, a study by Bereket *et al.*, (2018) found that instead of depending solely on agriculture, farmers are looking to other off-farm and/or non-farm activities to supplement their income as farm sizes decrease. This suggests that farmers with sizable farms have the chance to diversify their sources of income by engaging in various off-farm and/or non-farm pursuits.

Livestock holding: As it was expected, livestock holding by a household has negatively affected the probability of livelihood diversification into non-farm and/or off-farm activities and was significant at 10% level of significance. As shown from table 4 below, the marginal effect result of logistic regression revealed that keeping other factors constant, one unit increases in tropical livestock unit in livestock holding for household decreases the probability of diversification of livelihood in to non-farm and/off-farm activities by 18.7%. This finding is in line with the study conducted by Abera *et al.*, (2021) reported that an increase in tropical livestock units decreases the probability of diversifying the livelihood in to off-farm and/non-farm activities. But it is in contrast with a study by Dinku (2018) reported that an increase in tropical livestock units increases the probability of participating on livelihood diversification activities.

Frequency of extension contact: Extension contact, as anticipated, was significant at 10% level of significance and had a positive relationship with the likelihood of livelihood diversification into non-farm and/or off-farm activities. The marginal effect result, as displayed in table 4 below, indicated that, while holding other variables constant, a household's probability of engaging in off-farm and/or non-farm activities increases by 1.37% for every additional unit that the number of extensions contacts increases. This finding is consistent with a study by Adugna (2008), who found that diversifying one's livelihood into agriculture plus off-farm activities has a positive and

significant relationship with extension contact. In contrast, a study by Asfir (2016) found that rather than diversifying their income sources into non-farm and off-farm sources, farmers can produce alternative crops and achieve higher production and income by having access to better agricultural information and technical assistance on agricultural activities.

Access to credit service: As it was anticipated access to credit service was positively affected the livelihood diversification and was significant at less than 1% level of significance. As shown from table 4 below, the marginal effect result revealed that keeping other factors constant as access to credit service increase by 1% then the probability of participating in to non-farm and/ off-farm livelihood diversification activities increases by 45.1%. This finding is consistent with a study by Dessalegn and Ashagrie (2016), who found that as credit use or access rises, so does the likelihood that rural households will participate in livelihood diversification strategies.

Table 4: Logistic regression result

Variables	Marginal effect	P-Value
SeHH	-0.0508976	0.509
AgHH	0.0031543	0.485
EduLeHH	0.018141**	0.012
FamSize	-0.0101636	0.424
LaSize	0.1485129**	0.022
DistMkt	0.0058306	0.489
FreExtCon	0.0137301*	0.074
CrRisk	0.1752378	0.135
TLU	-0.018695*	0.051
AcCreSe	0.4510145***	0.000
_cons		0.045

Source: Own survey, 2024

Logistic regression

Number of obs = 364

LR chi2 (10) = 137.36

Prob > chi2 = 0.0000

Log likelihood = -152.64618

Pseudo R² = 0.3103

***, **, * indicates significant at 1%, 5% and 10% probability levels respectively.

4.4. Impact of non-farm and/off-farm activities on income of smallholder farmers

This section evaluates the impact of non-farm and/off-farm activities diversification on the outcome variable for their significant impact on participant households, after the pre-intervention difference was controlled for, in order to achieve the study's stated goal. Table 5 below shows the ATT result which depicts a positive relationship between non-farm and/off-farm activities and the total annual income of smallholder farmers. This implies the total annual income of smallholder farmers increases with increased engagement in non-farm and/or off-farm activities. The household income increases by birr 92004.41 when members of the household engage in remunerative non-farm and/off-farm activities, according to the causal effects result at 1% significant level. This outcome is consistent with a study by Astatike and Gazuma (2019) who found that farmers that participate in off-farm activities make more money than those who do not. This finding suggests that, in comparison to households that do not engage in

remunerative off-farm activities, those with a higher probability of participating in such activities are less vulnerable to poverty.

Table 5: Average treatment effect on treated (ATT) on income

Outcome						
variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Income	Unmatched	156206.75	56664.5938	99542.1563	11051.7435	9.01
(in birr)	ATT	153378.611	61374.2	92004.4111	20254.2407	4.54***

Source: Own computation using survey data (2024)

Note: *** indicates significant at 1% level of significance.

5. CONCLUSION AND RECOMMENDATION

It is crucial to investigate how the diversification of non-farm and/off-farm activities influences total annual income in the study area because it improves the living standard of smallholder farmers. Diversifying source of income in to non-farm and/or off-farm activities enables farm households to use their labor force all year long, especially during the slow seasons of agricultural activity. No idle or wasted labor hour is allowed. This will support farm households in seizing the chance to replace the breakdown in the rural financial system. Because of this, farm households are able to purchase new farming technologies, which will raise agricultural productivity and consequently increase household income.

Based on the result of this study, it is possible to draw the conclusion that intersectional issues of income sources linkage need to be addressed in addition to focusing on the agricultural sector in order to address the issue of smallholder farmers earning lower income. Furthermore, smallholder farmers benefit greatly from non-farm and off-farm activities.

Based on the findings of this study the following recommendations are forwarded:

The positive effect of education on non-farm and/off-farm activities diversification support the relevance of education for diversifying one's sources of income by demonstrating that higher levels of education are associated with greater levels of diversification in both non-farm and off-farm pursuits. Therefore, in order to increase the participation of smallholder farmers on non-farm and off-farm activities, government bodies and other stakeholders should support innovative on-job training programs and post-secondary technical training.

The likelihood of diversifying the source of income increases with the frequency of extension services provided on livelihood diversification into non-farm and off-farm activities. Therefore, the extension agents and concerned bodies should offer skill trainings regarding various non-farm and off-farm activities, encourage and give incentives for new non-farm and off-farm sector entrants, and establish formal and non-formal training centers in each kebele in order to improve the contribution of non-farm and off-farm activities to the total annual income of smallholder farmers in the study area.

The diversification of smallholder farmers' livelihoods into non-farm and off-farm activities has been positively affected by their access to credit service. This suggests that credit availability is essential for encouraging smallholder farmers to engage in non-farm and off-farm activities. However, because of the nature of the agricultural product, it is challenging for them to have collateral when credit is requested from financial institutions. Thus, it should be mandatory for banks, lending agencies, and microfinance institutions to develop a specific lending policy in order to overcome financial problem of smallholder farmers and encourage them to engage in various off-farm and non-farm activities.

It is evident from the detrimental impact of livestock ownership on the diversification of livelihoods into non-farm and off-farm pursuits that smallholder farmers who own a lot of livestock are less likely to do so. As a result, the relevant organizations and concerned bodies should work to increase livestock productivity and open up markets by offering technologies such as better breeds, improved management techniques, and forage seeds. They should also

support market-oriented production systems, which have the dual benefits of increasing livelihood diversification and helping households escape poverty in a sustainable manner.

As indicated in the above land size was positively and significantly related with livelihood diversification into non-farm and off-farm pursuits. While, it is impossible to expand the land size in order to increase the probability of participating in different non-farm and off-farm activities. Therefore, the farmers should intensively use their land holding to generate more income and to use it for expanding the livelihood in to non-farm and/off-farm activities by using it as initial capital.

According to the result of the study, livelihood diversification was found to have a positive and significant impact on income of smallholder farmers. As a result, further scaling up of livelihood diversification through awareness creation and training for farmers by extension agents and concerned other government officials will help to sustainably improve the wellbeing of smallholder farmers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

The author hereby declares that generative AI technologies such as Large Language Models have been used during the editing of the manuscript. The details of the AI usage are provided below:

1. Name and Source of Generative AI Technology: ChatGPT, developed by OpenAI
2. Version and Model: GPT-4-turbo, April, 2025 release
3. Input Prompts Provided to the AI:
 - ✓ Language editing of this manuscript.
 - ✓ Please improve grammar, coherence, and flow in the attached academic paper
 - ✓ Polish the language while preserving the original structure and meaning.The AI was used solely for language enhancement, including grammar correction, clarity improvement, and academic tone refinement.

DECLARATION OF CONFLICTS OF INTEREST

The author(s) declare that there is no conflict of interest regarding the publication of this paper.

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