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How Contact with Environmental Pollution Affects Economic Productivity in Adamawa State, Nigeria: An Ordered Logistic Regression Analysis

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Abstract: *The study examined how contact with environmental pollution affects economic productivity in Adamawa state, Nigeria. Primary data was collected across 10 Local Government Areas in Adamawa state by administering questionnaire to 440 respondents. The LGAs were chosen by Probability Proportional to Sampling technique (PPS) and the sampling size was determined by the Taro Yamane formular. In the study, males constitute 50.68% while females 49.32%. Ages 26-44 years constitute 65.68% representing the most productive categories of the population studied. In the survey, 52.27% were married, while 28.86% were single. 70.69% have acquired formal education ranging from basic level to tertiary level, only 12.73% have no formal education. In the months preceding the survey, 25.91% have earned between 21, 000 – 40, 000 naira, while 4.77% earned above 100, 000 naira. Only 37.95% have earned below 20, 000. To analyze the effect of pollution on productivity, Ordered Logistic Regression approach was used. Result of interaction between worker productivity per hour (Dependent Variable) and key independent variable (Environmental Pollution) has shown an inverse relationship with a negative coefficient of -0.429. Specifically, a one-unit increase in environmental pollution decreases the log odds of being in a higher productive category by 35% (OR: 1-0.651) at 5% level of significance. This means that an increase in environmental pollution significantly reduces worker productivity per hour. The study therefore calls on business owners, government institutions and citizens to initiate and implement concrete measures to stem the rising environmental pollution in the local environment, business places and government buildings by providing functional sanitation facilities and encourage citizens to make use of it in order to achieve a clean environment and reduce the effect of pollution on citizens' productivity.*

Keywords: *Adamawa state, Economic productivity, Environmental pollution, Nigeria, Ordered Logistic Regression.*

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1. Introduction

The increasing deterioration in environmental cleanliness points to the fact that economic activities have generated wastes that have not been managed well, thus resulting in inconveniences that have stalled higher productivities. Although this increase in environmental pollution itself is a sign of thriving economic activities, however it is responsible for the inconveniences being encountered daily by citizens. Since 1972, governments around the world have been concerned about growing environmental pollution and its effect on human health and economic growth. Specifically, the government of Sweden was concerned about growing environmental pollution in which the government recognized the interrelationship between pollution, health and economic growth, noting that human activities have negatively affected the environment which had become an emerging issue for economies around the world (WHO, 1973). One would be right therefore, to deem the efficiency and productivity of human being to be optimized in a clean environment with the support of materials and human expertise. Albeit, the environment has been contaminated and harmful substances have been introduced by unwholesome and unregulated economic activities that have made the physical environment a major concern for promoting productivity among the citizens.

In Nigeria, low productivity remains a major challenge to economic growth. It is among the weakests in the world as rightly reported on Global Competitiveness, 2019 where Nigeria ranked 116 out of 141 countries (World Economic Forum, 2019) . The major indicators used cited the country's low performance in key areas such as skills, innovation capability and labour market. The low performance of labour productivity has been responsible for poor wages that Nigerian citizens get when compared to other countries. For instance, Nigeria has one of the lowest labour productivity per hour in 2023 earning only $7 which is lower than labour productivity in other African countries whose wage per hour is higher such as Gabon, Botswana, South Africa, Egypt and Algeria (ILO, 2023).

According to International Labour Organization, productivity is an important economic indicator that is closely linked to economic growth, competitiveness and living standards within an economy (ILO, 2023). In Adamawa state, key productivity indicators are below average with high rates of unemployment (54.9%) and underemployment (24.7), (NBS, 2021). Poverty rate has reportedly been high with 3.44 million multi-dimensionally poor people in the State (Nigeria Multidimensional Poverty Index, 2022). In terms of human capital development, the State is classified within the low human development category with an index of

0.49 (Radboud University, 2021). These indicators are worrisome and a pointer that productivity in the State is low.

Increasing environmental pollution has become a serious problem to every human endeavour in Nigeria as observed by Chinedu, Ezeibe, Anijiofor-Ike and Daud (2018). They opined that solid waste management is a major environmental challenge in most Nigerian cities. Wolf et al. (2022) also observed that environmental pollution in Nigeria is among the worst in environmental performance index (EPI) in the world. The Clean Up Nigeria (CUN, 2021) reports that Cleanliness performance Index rating shows over 172.7 million Nigerians living in unclean environment in 2021, compared to 170 million in 2020. Also, Health Effect Institute (HEI, 2019) report indicates that the quality of air in Nigeria is bad and causes death of people more than any other country in Africa and 6th in the world.

In terms of environmental cleanliness, Adamawa state has been ranked low. According to the Clean Up Nigeria report on environmental performance that covers refuse dump in open places, streets and roads cleanliness, personal hygiene and sanitation and open defecation, Adamawa state ranks the 12th dirtiest State in Nigeria (CUN, 2022). Environmental pollution is therefore a common phenomenon and can be regarded as a major factor for healthy and productive living in the State. The problem of pollution can majorly be attributed to bad sanitary habits and poor management of waste by the citizens. It is common to see people dumb refuse indiscriminately and this has caused serious environmental pollution problems. Open defecation is prevalent and adds to the problem of environmental pollution that is a major problem to human endeavours within the State.

The persistence of environmental pollution in Adamawa state is likely to bear adverse effect on labour force productivity. Specifically, Adamawa state's economic progress is potentially being undermined by environmental pollution given the persistence of unregulated economic activities in the State. Therefore, the study examined how persistence in environmental pollution undermines economic productivity in Adamawa state. Understanding this interplay is necessary to guide policy interventions and practical measures in addressing the problems of environmental pollution and low level of economic productivity of citizens in the State.

2. Empirical literature

Researches are replete with scholarly effort to understand factors that affect labour productivity amids divergent views by authors on which factors have the best or

worst effect on productivity. Dechezleprêtre and Vienne (2025) investigated the effect of air pollution on labour productivity using extensive firm-level data from over 2.5 million European companies between 2000 and 2022. Their causal analysis revealed that a 1 μg/m³ increase in $PM_{2.5}$ concentration leads to a 0.55% decline in labour productivity within the same year, with the strongest effects observed on days when pollution levels exceed 25 μg/m³. The adverse impact was more pronounced among construction firms, sectors with a higher proportion of skilled workers, medium-sized enterprises, and firms with low capital intensity.

Oniore and Irikefe (2025) observed that Nigeria's carbon emissions have reached approximately 127.942 megatons and a declining GDP per capita of $1,621 in 2023. To address these challenges, they examined the impact of environmental degradation on Nigerian economic growth between the periods 1990 and 2023 using the Fully Modified Ordinary Least Squares method to test the hypothesis of the Environmental Kuznets Curve (EKC). The results showed a marginally significant positive correlation between economic growth and carbon dioxide emissions suggesting that Nigeria is still in the early stage of EKC, where economic expansion is still having a negative environmental impact. While Mgbomene (2024) analyzed the effect of environmental degradation on food productivity in Nigeria (1990-2023), result shows that air pollution decreases food productivity in Nigeria. The study concludes that decrease in environmental quality erodes food production and this should be stopped to guarantee food security. Major result although positive but lacks statistical significance which shows that air pollution might not be a threat to food production in Nigeria. However, Nchege and Okpalaoka (2022) used ARDL to show that air pollution negatively impacts economic growth in Nigeria.

Thompson et al. (2023) found that $PM_{2.5}$ is significantly associated with reduced general cognition, verbal fluency and executive function indicators, particularly in the over 40s population. Dechezleprêtre and Vienne (2025) observed that these "subclinical" effects are less easy to detect than more severe health effects, but they are also more widespread and can affect behaviour, decision-making, performance and productivity.

Manotas-Hidalgo (2021) examined how pollution generated by oil operations in Nigeria can affect agricultural total factor productivity by analyzing oil spills, which are the main ecological disaster in Nigeria and lead to major environmental, economic and social problems. Following a consumer-producer household framework and applying a difference-and-difference approach, the study found that farmers located

less than 10 kilometers from oil spills suffer a relative reduction in agricultural output of around 2.73%. Also, the results show that oil-spill pollution causes less owner-occupied land and a drop in labour income in urban areas close to oil spills, which could also be explained by a decrease in the labour productivity component.

By examining the causal relationship between air pollution and labour productivity, Chen and Zhang (2021) adopted prison factory data for a perfect measure of labor productivity. The results showed that a 10-unit increase in air pollution index led to a significant decrease in labour productivity by 4%. A nonlinear relationship between air pollution and labour productivity was also suggested, which implied that the extreme air pollution reduced labour productivity heavily. Similarly, Sui et al (2021) explored the short-term impacts of Particulate Matter and Ozone ($PM_{2.5}/O_3$) on daily death in Hefei from 2013-2018 using time-series data on daily death of the residents. Meteorological factors and air pollutants collected from January 1, 2013, to December 31, 2018. The study found that an increase in the amount of air pollution increased non-accidental deaths. In cold seasons, air pollution had a stronger effect on the deaths resulting from non-accidental, cardiovascular and respiratory diseases.

By examining the impact of urbanization on Particulate Matter ($PM_{2.5}$) related health and economic loss in China's 338 Cities, Diao, Ding, Zhang, Na and Cheng (2020) estimated the negative health effects caused by exposure to $PM_{2.5}$. The results showed that $PM_{2.5}$ pollution remains serious in 2015, which brings about many people suffering from all kinds of fearful health problems especially premature death and related diseases. The mortality and morbidity increase dramatically and the total direct economic loss related to $PM_{2.5}$ pollution in 2015 was 1.846 trillion yuan, accounting for 2.73% of total annual GDP. In addition, there was a strong correlation between urbanization level and health risks as well as economic loss, which implies that people who live in highly urbanized cities may face more severe health and economic losses.

By asking if there is a Kuznets Curve for air pollution in Nigeria, Adelegan and Emmanuel (2020) examined environmental quality and economic development by using annual secondary data from the World Bank indicators and the Central Bank of Nigeria for the period 1980-2018. Findings from the study support the validity of the EKC hypothesis for CO_2 emissions. In a related study, Olatayo, Mayor and Moses (2019) also examined the dynamics of economic growth and environmental degradation in Nigeria. The study verified the Environmental Kuznet

Curve Hypothesis in Nigeria using the Vector Error Correction Model (VECM) to investigate linear and interrelationship mainly on life expectancy at birth, economic growth and environmental pollution in Nigeria from 1970-2015. The results indicate that economic growth increased environmental degradation in the long run and environmental degradation on the other way round reduced economic growth in most period of the study. The study also showed that reduction in environmental pollution led to a consistent increased in economic growth and life expectancy at birth in the country.

Ebenstein et al. (2016) provided evidence that pollution affects productivity in high-skill tasks, such as student performance in standardized high-school examinations and in high-stakes university exams (Roth, 2021) or investors' performance at the New York Stock Exchange (Heyes, Neidell and Saberian, 2016)

3. Methodology

The study was conducted in ten (10) Local Government Areas (LGAs) of Adamawa state: Girei, Hong, Yola North, Madagali, Michika, Mubi South, Ganye, Jada, Mayo-Belwa, and Shelleng. These LGAs were selected by Probability Proportional to Sampling Technique (PPS). The respondents were those working for government as civil or public servants, private sector workers, business owners, daily or casual workers and workers in consultancy or contract employment and farmers. A total of 440 respondents were chosen as population sample size which was determined by the Taro Yamane method.

Adamawa State has a population of 4,902,100 (NBS, 2022). It is located in the North-east and has a total land area of 36, 917 square kilometers making it one of the largest States in Nigeria. The vast arable land in Adamawa state and distinct climatic conditions support extensive agricultural activities, a key driver of economic productivity. However, these activities can also contribute to environmental pollution through practices such as improper waste disposal, chemical runoff and deforestation. A significant population of the State is heavily reliant on agriculture, livestock production and trade. These sectors are highly sensitive to environmental conditions and health outcomes. Any disruptions caused by pollution can cascade into reduced productivity and economic losses. The prominence of smallholder farming and other informal economic activities amplifies the potential impact of environmental challenges, making the study highly relevant for policy and development planning.

By its geographical location, Adamawa state is suitable for both local and international trade, facilitating movement of goods and services in commerce thus exposing the State to cross-border environmental challenges, such as pollution from trade-related transportation and industrial activities. The geographic linkages highlight the need to balance economic growth with sustainable environmental practices to protect economic productivity.

Adamawa State dual seasons (dry and rainy), expose the citizens to extreme weather conditions, including extreme cold, dusty winds and intense heat. These conditions increase the risk of environmental pollution, particularly air and water pollution, which directly impacts health status. Harsh weather conditions, particularly during harmattan, exacerbate the spread of respiratory and waterborne diseases consequently reducing labour productivity. Studying this relationship can provide critical insights into the seasonal effects of environmental pollution on economic outcomes.

The study conducted a survey with the aid of a designed questionnaire to generate primary data. The questionnaire asked simple questions around how environmental pollution affects citizens productivity in Adamawa state. The study considered personal experiences of the respondents such as where they reside, level of exposure to pollution and the severity of the effect of pollution on their health and productivity. The use of questionnaire provided an opportunity for face-to-face interaction with the respondents who are considered relevant to the study. The total of 440 questionnaires were administered to the respondents and were all returned.

To evaluate the effect of environmental pollution on economic productivity, ordered logistic regression was used. The model was adapted from the empirical work by Rongxing (2018) and underpinned by the Environmental Kuznets Curve Hypothesis propounded by Simon Kuznets. Economic productivity is denoted by worker productivity per hour and is expressed as; $WPHour_i = f(EnvPol_i, EnvHyg_i, FCEnvPol_i, ConEnv_i, Facilities_i, Wen_i, WasteDM_i)$. The ordered logistic regression equation models the log-odds of being in or below a specific category of an ordinal dependent variable (in this case, economic productivity (WPHour) based on the independent variables. The ordered logistic regression model is specified as: $Log(Pr(WPHour_i \leq k) / Pr(WHour_i > k)) = \lambda_0 + \lambda_1 EnvPol_i + \lambda_2 EnvHyg_i + \lambda_3 FCEnvPol_i + \lambda_4 ConEnv_i + \lambda_5 Facilities_i + \lambda_6 Wen_i + \lambda_7 WasteDM_i$.....1, where; $Pr(WHour_i \leq k)$ is the probability that worker productivity by hours of the i-th individual is at or below

category k. Pr ($WPHour_i > k$) is the probability that worker productivity by hours of the i-th individual is above category k.

Thus;

$WPHour_i$ = Worker productivity by hours of work done

$EnvPol_i$ = Environmental pollution

$EnvHyg_i$ = Environmental Hygiene

$FCEnvPol_i$ = Frequency of Contact with Environmental Pollution

$ConEnv_i$ = Conducive environment

$Facilities_i$ = Availability of facilities like toilets, waste bins and waterpoints

Wen_i = Working environment

$WasteDM_i$ = method of disposing waste.

λ_0 is the Cut-points (thresholds) separating the worker productivity categories.

λ_1, λ_2, λ_3, λ_4, λ_5, λ_6 and λ_7 are the coefficients for the predictors ($EnvPol_i$, $EnvHyg_i$, $FCEnvPol_i$, $ConEnv_i$, $Facilities_i$, Wen, $WasteDM_i$) for outcome category k.

Table 1: Ordered logistic regression output for the effect of environmental pollution on economic productivity

Dependent variable: WPHour (Worker productivity per Hour)					
	Coef. OR	*St.Err.*	*t-value*	*p-value*	*Sig*
EnvPol	-0.429 (0.651)	0.213	-2.02	0.043	**
EnvHyg	0.115 (1.122)	0.228	0.51	0.613	
FCEnvPol	-0.184 (0.832)	0.169	-1.09	0.275	
ConEnv	-0.388 (0.679)	0.199	-1.95	0.052	*
Facilities	-0.244 (0.783)	0.143	-1.70	0.088	*
Wen	0.17 (1.185)	0.2	0.85	0.398	
WasteDM	-0.068 (0.934)	0.088	-0.77	0.44	
*** p<.01, ** p<.05, * p<.1 Odds Ratios in Brackets					

Source: Authors' computation using Stata 15

In Table 1, result shows an inverse relationship between environmental pollution and worker productivity. A negative coefficient of -0.429 indicates that an increase in environmental pollution significantly reduces worker productivity per hour. Specifically, a one-unit increase in environmental pollution decreases the log

odds of being in higher productive category by 35% (OR: 1-0.651) and significant at the 5% level. This aligns with the understanding that exposure to pollutants such as poor air or water quality can reduce physical and cognitive functioning, thus impairing productivity by the discomfort being experienced at work. In an environment where there is high prevalence of pollution such as land pollution, air pollution or even noise pollution, it becomes increasingly difficult for citizens to achieve optimum efficiency in their work. Although, this depends on the nature of job an individual worker is actively engaged in. Therefore, the effect of severe pollution on citizens' productivity is a relative one that depends on the nature of job and the type of environmental pollution that is persistent in an area. Thus, while others might not be affected by the pollution they produce from their work, pollution in most cases has a negetaive effect on human endeavours that produce it.

For the effect of environmental hygiene on worker productivity, the result has shown 0.115 coefficient which suggests a weak positive relationship, however this relationship is not statistically significant ($p = 0.613$). While maintaining environmental hygiene is expected to positively influence productivity, its insignificant effect here might indicate its limited influence in the presence of other strong predictors such as level of education and years of working experience. Similarly, result for frequency of contact with environmental pollution indicates a negative coefficient (-0.184) which suggests that frequent contact with pollution likely reduces productivity, however the result is not statistically significant ($p = 0.275$). This might suggest that the frequency of exposure is less impactful than the severity or type of environmental pollution susbsistent in a specific environment or strong preventive measures put in place to mitigate the possible negative effect pollution can have on individual workers. Here, the use of personal protective equipment (PPE) such as face mask and high level hygiene practices at work place can render pollution ineffective towards hampering productivity. However, if frequent contact with environmental pollution is allowed to continue, cummulative effect can produce results that are counter productive to labour efficiency in all human endeavours. Therefore, when individuals continue to be exposed to pollution without any protection, the long term effect might result in sickness of labour force that is a critical factor for increasing economic productivity.

Result for the effect of conducive environment on productivity shows a negative coefficient (-0.388) which suggests that any deteriorating conducive environment decreases productivity. Specifically, a one-unit deterioration in a conducive

environment reduces the log odds of being in a higher productive category by 32.1% and significant at the 10% level. This result highlights the importance of favourable environmental conditions such as clean, organized and hazard-free workspaces in enhancing worker productivity. For facilities, result shows a coefficient of -0.244 which indicates that lack of facilities reduces productivity. Precisely, a one-unit increase in the unavailability of facilities decreases the log odds of higher productivity by 22%, at 10% level of significance. Functional facilities, such as availability of clean water, efficient sanitation and infrastructure are critical for ensuring worker efficiency and health. Albeit, most of the citizens who were administered questionnaire are faced with numerious challenges at work or business places that hampers their efficiency in their area of endeavour. There are numerous challenges such as having to work or do business in a noisy and dirty environment, or in an environment where infrastructure llike toilets or water source is lacking. These factors make it very difficult for individuals to stay long at work, concentrate or live without some sorts of discomfort from environmental pollution.

For working environment, a positive coefficient (0.17) suggests that a better working environment could improve productivity, but the relationship is not statistically significant ($p = 0.398$). Also, a negative coefficient of -0.068 implies a weak inverse relationship between waste disposal methods and productivity, however the result is not statistically significant ($p = 0.44$). The weak relationship might reflect variability in how waste management affects workers depending on their proximity to improper waste disposal. Although, the effects of working environment and waste disposl methods on productivity are statistically insignificant, however the relationship provide useful clue for the direction of relationship between a clean working environment and methods of waste disposal. For working environment, key elements such as conduciveness of work or business places with functional facilities such as toilets, water and adequate ventilation are necessary factors that would be useful for aiding workplace productivity. Sadly, most working environments are devoid of these necessities that make citizens abit uncomfortable as they work. For waste disposal, the lack of facilities make it difficult for controlled and organized waste disposal to be attained. Because of lack of these facilities, citizens find it difficult to properly disposed off their waste hence the increase in environmental pollution. The consequences associated with increasing environmental pollution is the direct discomfort on citizens in their work or business places leading to decline in their productivities.

4. Conclusion

Seven (7) independent but interrelated variables show different outcomes when environmental pollution interacts with citizens' economic productivity. The effect of environmental pollution on workers' productivity underscores an important fact that when the environment is clean and not harmful, labour efficiency would be optimized in addition to the role of technology, human expertise and availability of functional facilities. However, the results of this study leads to a concrete conclusion that environmental pollution significantly affects citizens' economic productivity. The analyses provide strong evidence to agree that increase in environmental pollution significantly reduces worker productivity per hour in addition to deteriorating conducive environment and lack of functional facilities. Athough effects of pollution on citizens' productivity vary, it calls for concrete measures against the rising tide of environmental pollution prevalent in local environment, business places and government buildings by providing functional sanitation facilities and promoting citizens' active participation in keeping clean environment.

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