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Effects of agricultural carbon footprints and malnutrition on life expectancy in China

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Abstract

This study explored the impact of carbon footprints and malnutrition on life expectancy in China over the periods of 2000 and 2021. Data from the World Bank Indicators database was utilized, and Dynamic Ordinary Least Squares (DOLS) was employed to analyse the extracted data. The results show that over the periods of 2000 and 2021, agricultural carbon footprints in China experienced a first sharp decline in 2015. In contrast, per capita food production in China rose from 88.29% in 2011 to over 108% in 2021. Within a space of a decade, the undernourished population in China was reduced by 78.8%. Moreover, per capita food production had a positive impact on life expectancy in China. Conversely, malnutrition exerted a negative and significant influence on life expectancy. Agricultural carbon footprints contributed a positive but insignificant impact on life expectancy, and GDP per capita growth increased life expectancy significantly in the country. We conclude that policymakers in China are should ensure that all citizens have access to food necessary to improve life span of the country`s population. *(Afr J Reprod Health 2024; 28 [9]: 153-162).*

Keywords: Carbon, emissions, per capita food production, undernourishment

Résumé

Cette étude a exploré l'impact de l'empreinte carbone et de la malnutrition sur l'espérance de vie en Chine sur les périodes 2000 et 2021. Les données de la base de données des indicateurs de la Banque mondiale ont été utilisées et la méthode des moindres carrés ordinaires dynamiques (DOLS) a été utilisée pour analyser les données extraites. Les résultats montrent qu'au cours des périodes 2000 et 2021, l'empreinte carbone agricole en Chine a connu une première forte baisse en 2015. En revanche, la production alimentaire par habitant en Chine est passée de 88,29 % en 2011 à plus de 108 % en 2021. en une décennie, la population sous-alimentée en Chine a diminué de 78,8 %. De plus, la production alimentaire par habitant a eu un impact positif sur l'espérance de vie en Chine. À l'inverse, la malnutrition exerce une influence négative et significative sur l'espérance de vie. L'empreinte carbone agricole a eu un impact positif mais insignifiant sur l'espérance de vie, et la croissance du PIB par habitant a considérablement augmenté l'espérance de vie dans le pays. Nous concluons que les décideurs politiques chinois doivent veiller à ce que tous les citoyens aient accès à la nourriture nécessaire pour améliorer la durée de vie de la population du pays. *(Afr J Reprod Health 2024; 28 [9]: 153-162).*

Mots-clés: Carbone, émissions, production alimentaire par habitant, sous-alimentation

Introduction

The interplay between agricultural practices, carbon footprints, malnutrition, and life expectancy present a complex web of challenges and opportunities in China, a country that is both the world's largest producer and consumer of agricultural products. As the nation grapples with the dual pressures of ensuring food security for its vast population while mitigating environmental impacts, the relationship between agricultural carbon footprints and public health outcomes, such as malnutrition and life expectancy, has become increasingly significant. Agricultural activities are a major source of greenhouse gas emissions, contributing substantially to China's overall carbon footprints. According to the Food and Agriculture Organization (FAO), agriculture accounts for approximately 14% of global greenhouse gas emissions, with livestock production being a significant contributor[1-5]. In China, intensive farming practices, including the excessive use of fertilizers and pesticides, not only lead to increased emissions but also degrade soil quality and reduce biodiversity[6]. These environmental changes can have direct implications for food production, potentially exacerbating malnutrition among vulnerable populations. Malnutrition manifests in various forms, including undernutrition, micronutrient deficiencies, and obesity[7-9]. Despite significant progress having been made in reducing poverty and improving food access over the past few decades, challenges remain[10,11]. The World Health Organization (WHO) has reported that approximately 9% of children under five years old in China are stunted due to chronic malnutrition[12,13]. Furthermore, rapid urbanization and dietary shifts towards processed foods have led to rising obesity rates, which are now a significant public health concern[6,14]. This dual burden of malnutrition underscores the need for sustainable agricultural practices that not only reduce carbon emissions but also enhance nutritional outcomes. Life expectancy in China has seen remarkable improvements over the last few decades, rising from 67 years in 1981 to over 77 years in 2020[15,16]. However, this increase is unevenly distributed across different regions and socioeconomic groups[17,18]. Environmental factors, including air and water pollution linked to agricultural practices, have been shown to adversely affect health outcomes and life expectancy[19]. The challenge lies in balancing agricultural productivity with sustainability to ensure that future generations can maintain or improve their health outcomes.

Addressing the interconnections between agricultural carbon footprints, malnutrition, and life expectancy requires a multifaceted approach. Policies aimed at promoting sustainable farming techniques—such as agroecology and organic farming can help mitigate environmental impacts while improving food quality[20]. Additionally, enhancing education around nutrition and food choices can empower communities to make healthier dietary decisions. Research indicates that integrating climate-smart agriculture with nutrition-sensitive policies can lead to improved food security and health outcomes. In contributing to the literature, this study developed hypotheses, which include:

Hypothesis One: Higher agricultural carbon footprints are associated with increased mortality

The hypothesis that higher agricultural carbon footprints are associated with increased mortality posits that the environmental impact of agricultural practices—particularly their contribution to greenhouse gas emissions—can have detrimental effects on public health. Agricultural activities, including livestock production, fertilizer use, and land conversion, contribute significantly to carbon emissions. These emissions can lead to climate change, which is linked to extreme weather events, reduced air quality, and altered ecosystems. As climate change progresses, populations may face increased risks of heat-related illnesses, respiratory diseases from poor air quality, and food insecurity due to crop failures. Vulnerable groups, such as the elderly and low-income communities, may experience heightened mortality rates as they struggle to adapt to these changes. Furthermore, the stress on natural resources can lead to malnutrition and associated health issues, further compounding mortality risks. This hypothesis encourages exploration of the connections between agricultural practices, environmental sustainability, and public health outcomes. By addressing the carbon footprint of agriculture through sustainable practices, it may be possible to mitigate climate change impacts and improve overall community health, potentially reducing mortality rates associated with these environmental challenges.

Hypothesis Two: Higher rates of malnutrition are associated with lower life expectancy

This hypothesis posits that higher rates of malnutrition are linked to lower life expectancy suggesting that inadequate nutrition significantly impacts health and longevity. Malnutrition includes both undernutrition, characterized by insufficient intake of calories and essential nutrients, and over nutrition, leading to obesity and related health issues. These conditions can result in weakened immune function, increased susceptibility to diseases, and chronic health problems, all of which can reduce the quality of life and increase mortality risk. Vulnerable populations, such as children and low-income individuals, are particularly affected, as malnutrition can hinder growth and development and lead to higher illness rates. The cycle of poverty often exacerbates this issue, as limited access to nutritious food can perpetuate poor health outcomes. Additionally, high malnutrition rates can strain healthcare systems, increasing costs and limiting access to care for other health issues. Socioeconomic factors like education and income play crucial roles in nutritional status, with disadvantaged groups facing greater challenges. Overall, addressing malnutrition through improved access to nutritious food and healthcare is essential for enhancing public health outcomes and increasing life expectancy in affected populations.

Conceptual framework

In Figure 1, the nexus between the dependent variable and various explanatory variables have been demonstrated pictorially with the following explanation. Life expectancy, which is the dependent variable is driven by malnutrition, agricultural carbon footprints, per capita food production variability and GDP per capita. It is important to stress that malnutrition and agricultural carbon footprints are inhibitors to human welfare. That is the reason these two variables are expected to contribute negative impact to life expectancy. However, per capita food production variability and GDP per capita are catalysts that promote human wellbeing. Therefore, these two variables are expected to contribute a positive impact to life expectancy.

Literature review

Chen and Li[21] examined the relationship between lifespans and the Chinese countrywide emission-trading scheme (CNETS). A Computable General Equilibrium (CGE) framework was used to evaluate the study. According to the CGE findings, lifespan was increased by GDP but decreased by greenhouse gases. The influence of GDP on lifespan was greater than that of carbon. The research also showed that environmental regulation reduces both the GDP implications for life cycle and the adverse carbon consequences on lifespan, which had a double effect on a person's lifespan. The introduction of environmental regulations had limited effects on greenhouse gases throughout the course of life, suggesting that a person's lifespan has little effect on carbon reduction. The results suggested that lifespan and environmental policies go hand in hand. Khan *et al.*[22] studied the direct and indirect greenhouse gases produced from China's dietary intake in towns and villages between 2000 and 2021, using a life cycle approach. The research findings, as obtained by applying the LMDI (Logarithmic Mean Divisia Index) decomposition approach, showed that, overall, per capita direct greenhouse gases were declining but per capita greenhouse gas emissions from indirect sources were increasing. In another study, Li *et al.*[23] investigated the impact of the amount of land used on greenhouse gas emissions, and assessed the greenhouse gasses from farming with the aid of life cycle assessment, utilizing a fixed-effects approach. In addition, scenario modeling was used to forecast how farming might vary in terms of greenhouse gases in subsequent years due to adjustments to the amount of land used. The overall carbon output from farming showed an inverted U-shaped shift as the scale of farms increased, with variations in fertilizer-related greenhouse gases predominating. Song *et al.*[24] examined the evolving features and influencing components of agrarian greenhouse gases. The research employed an empirical framework to estimate greenhouse gases from farming supplies from 1991 to 2019 and utilized ridge regression to examine the contributing elements. According to the research, China's agrarian greenhouse gases have increased during the previous 30 years, although at a noticeably reduced rate. Between 1991 and 2007, there was a notable decrease in the average yearly expansion of farming-related greenhouse gases from 2008 to 2019. Whereas the amount of greenhouse gases per unit of crop production primarily demonstrated a declining pattern, the greenhouse gases per unit of cropping land indicated a broad rising pattern. Xiong *et al.*[25] examined Beijing's urban nutrition and associated greenhouse gas emissions between 1980 and 2017. The deviation index was developed as a benchmark utilizing the Chinese Nutrition Society's (CNS) suggested food intake to investigate the relationship between diet related greenhouse gas emissions and eating habits. The findings demonstrated the significant nutritional adjustment that urban Beijing has undergone, moving away from the conventional grain-based nutrition and toward eating habits richer in non-staple and animal-sourced items.

Methods

Research design

The use of *an ex-post facto* research design was considered as an appropriate research design in this study due to the fact this design is a quasi-experimental in nature in which investigation commences after the occurrence of the fact without the interference of the researcher. In the same vein, the goal of this study is the exploration of how variation in industrial performances is predicted by the set of explanatory variables.

Model specification

From the conceptual framework of the study, a robust model to assess nexus among agricultural carbon footprints, malnutrition and life expectancy in China was developed as follows by adapting model from these related studies Afolayan and Aderemi[26], Osabohien *et al*.[27], Zhou *et al*.[28] and Olayemi *et al*.[29]. The model is stated thus;

Life Expectancy (LE) = f (Agricultural Carbon Footprints) (1)

From equation (1), life expectancy is the dependent variable and the independent variables are agricultural carbon footprints and malnutrition. To enhance the robustness of the model, GDP per capita and per capita food production variability were included in the model. This is because these variables have both direct and indirect influence on health outcomes, especially life expectancy[30, 31].

In transforming equation (1) into an econometrics model, equation (2) is emerged as follows:

$LE_t = \alpha_0 + \beta_1 ACF_t + \beta_2 MAL_t + \beta_3 GDPCA_t + \beta_3 PFD_t + \mu_t$ (2)

In table 1, the operational definitions of various variables in the study are discussed as follows.

Data analysis

After sourcing data from the World Bank Development Indicator (2023), the preferred method of estimation and analysis of the data was Dynamic Ordinary Least Squares (DOLS). This is a regression that includes deterministic variables, integrated processes and their powers as regressors. The errors are allowed to be correlated across equations, over time and with the regressors. Also, the regression is constructed in such a way that the usual least squares procedure yields asymptotically efficient estimators. Moreover, Eviews 10 econometrics software was used to run the analysis. Meanwhile, the study further utilized graphs and descriptive statistics. This is because the use of graph provided a historical perspective in assessing and identifying patterns, trends, or changes in data over the years in one hand. And on the other hand, the descriptive statistics explains distribution and patterns of the variables under consideration by the mean value which was calculated by adding all the observations from 2000 to 2021 and divided by the number of the years, which is 22.

Ethical consideration

There was no involvement of human or animal subjects in this study. The data utilized in this study is available on World Bank. World Development Indicators 16 (2023) website. Hence, further ethical clearance was not needed for this study.

Results

In showing the trend of agricultural carbon footprints in China within the periods of 2010 and 2021, Figure 1 provides that, China had the biggest emission of agricultural carbon footprints in 2013 after which it was reduced significantly in 2014, and continued in that trajectory until 2020.

Figure 2 shows China`s capability to produce food based on current production technology. As demonstrated in the figure, in 2010, per capita food production in China was 88.29%, after which it rose sharply in 2011 and remained steadily to reach over 100% in 2015. It is important to stress that in 2017, per capita food production in China continued to rise in a sustainable manner to over 108% in 2021.

Figure 3 shows how life expectancy in China has improved over the periods of 2010 and 2021. In 2010, China had a life expectancy of 75 years, which has been consistently improving to reach 78 years in 2021. This shows that within a period of a decade, life expectancy improved by 4% in China.

In Figure 4, the percentage of the Chinese population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life is shown. In 2010, China had 11.8% of undernourished population. Meanwhile, from 2012, the percentage of the undernourished population continued to decline consistently to 2.5% in 2021. This implies that within the space of a decade, the undernourished population in China was reduced by 78.8%. In order to account for the normal distribution of all the relevant variables in this study, descriptive statistics were computed as shown in. Consequently, starting from the dependent variable, life expectancy (LE) had a minimum value of 71.8 years and maximum value of 78.2 years alongside a

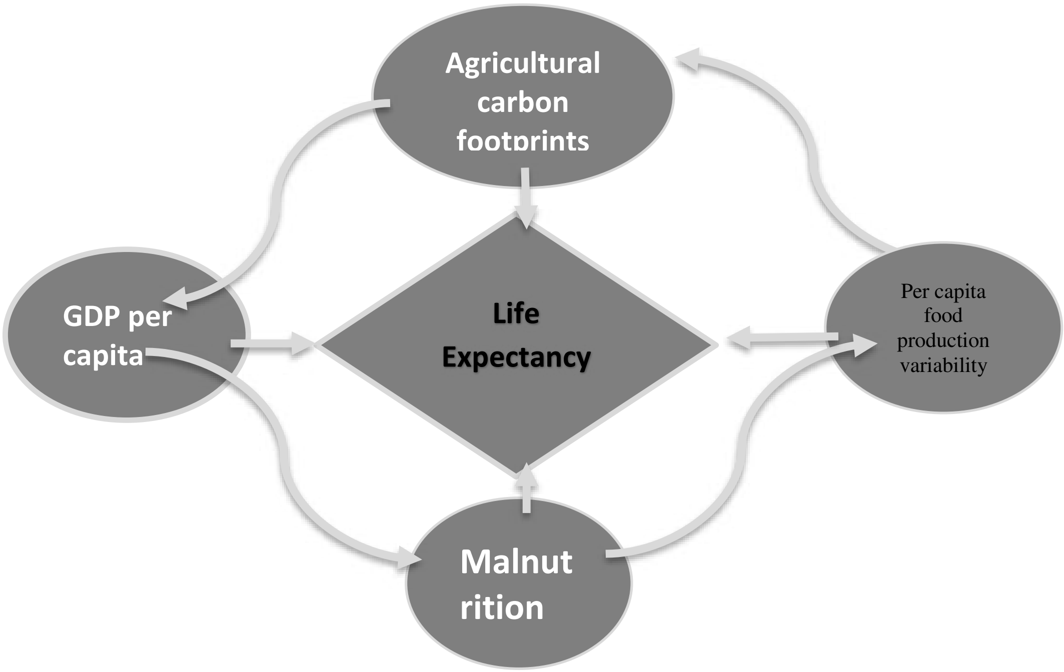

Figure 1: Conceptual framework of nexus among agricultural carbon footprints, malnutrition and life expectancy in China

Table 1: Measurement of variables

Abbreviation	Variable	Operational Definition	Expected sign
	Life expectancy.	Life expectancy at birth (years)	
CE	Agricultural carbon footprints.	Emissions from energy use in agriculture (total, CO2, CH4, H2O)	-
MAL	Malnutrition	This is measured as prevalence of undernourishment as percentage of population. This is the percentage of the population whose habitual food consumption is insufficient to provide the dietary energy levels that are required to maintain a normal active and healthy life.	-
GDPCA	Gross domestic product	GDP per capital growth.	+
PFD	Per capita food production variability	The variability of the net food production value in constant 2004-2006 prices divided by the population number.	+
μ	Error term	Other variables that affect the study but not captured in the study.	
t	Scope of the study	2000 -2021	

mean value of 75.5 years. In the same vein, per capita food production had a minimum and maximum values of 64.2% and 108.7% respectively. In contrast, the mean value of this variable within the period of the analysis was 87.8%. Agricultural carbon footprints, ACF possessed a minimum value of 118088.2 metric ton and 265228.4 metric ton as its maximum value respectively. The average value of ACF within the periods of 2000 to 2021 was 205203.2 metric ton. Furthermore, GDP per capita growth rate had 13.63% as its highest value and 1.99% as its lowest value simultaneously. And the

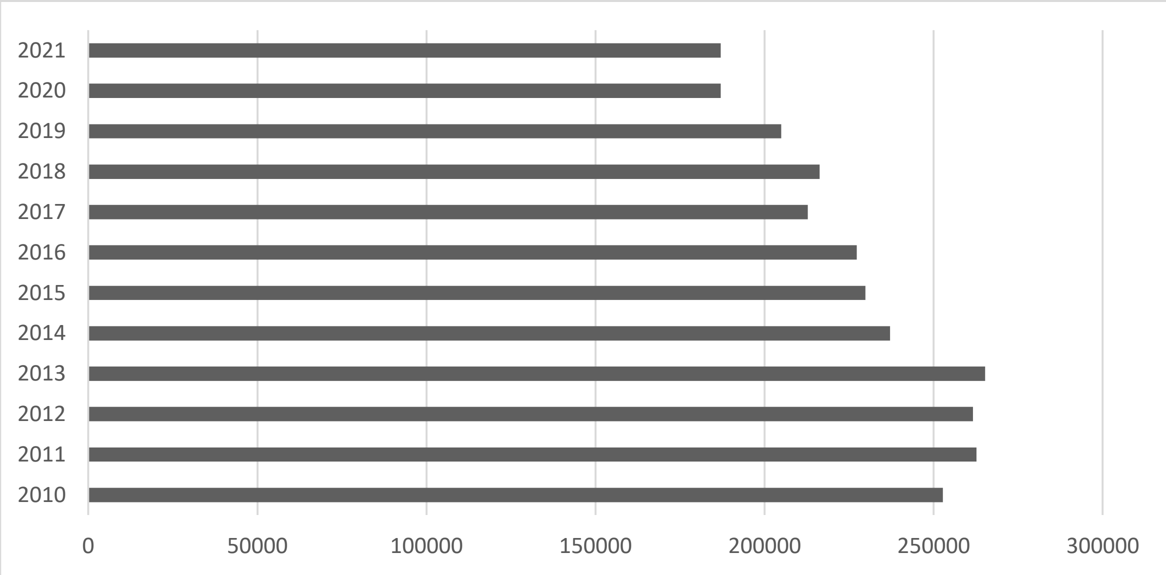

Figure 1: Agricultural carbon footprints (emissions from energy use in agriculture in metric tons) in China

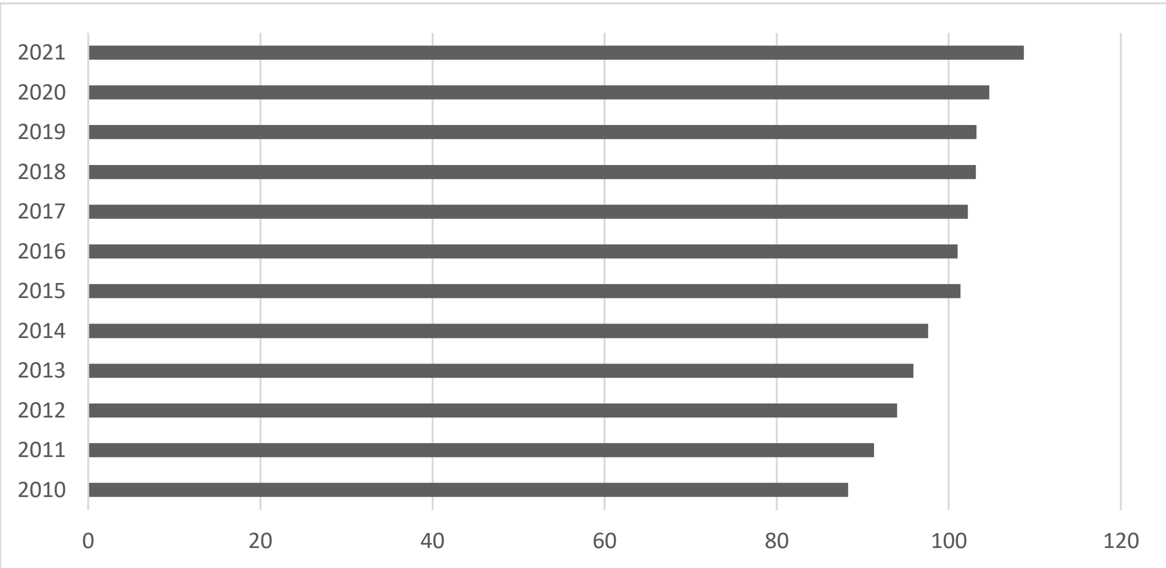

Figure 2: Per capita food production variability

mean value of this variable was 8.1%. The prevalence of malnutrition recorded 2.5% as its least value and 16.2% respectively. But the average value of this data within the period of the analysis was 9.5%.

Table 3 shows the computed results of impact of agricultural carbon footprints and malnutrition on life expectancy in China using Dynamic Ordinary Least Squares. The following were deduced from the table; it was only agricultural carbon footprints that did not follow the aprori expectation, whereas the rest of the variables followed the aprori expectation. Similarly, R-squared of the estimated model was 0.99, this is an indication that about 99% of the variation in the dependent variable, life expectancy was explained by all the explanatory variables. Therefore, the adopted model was highly efficient in running the analysis. Consequently, per capita food production had a significant positive impact on life expectancy in China. Meanwhile, agricultural carbon footprints contributed a positive but insufficient impact on life expectancy. Also, GDP per capita caused a significant positive impact on life expectancy.

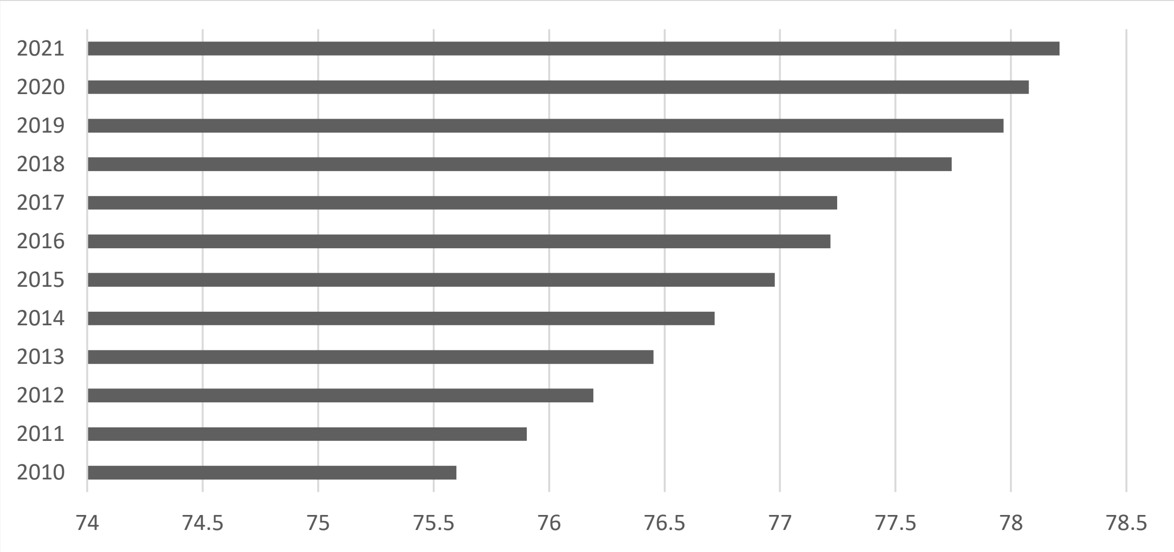

Figure 3: Life Expectancy at birth, total (years)

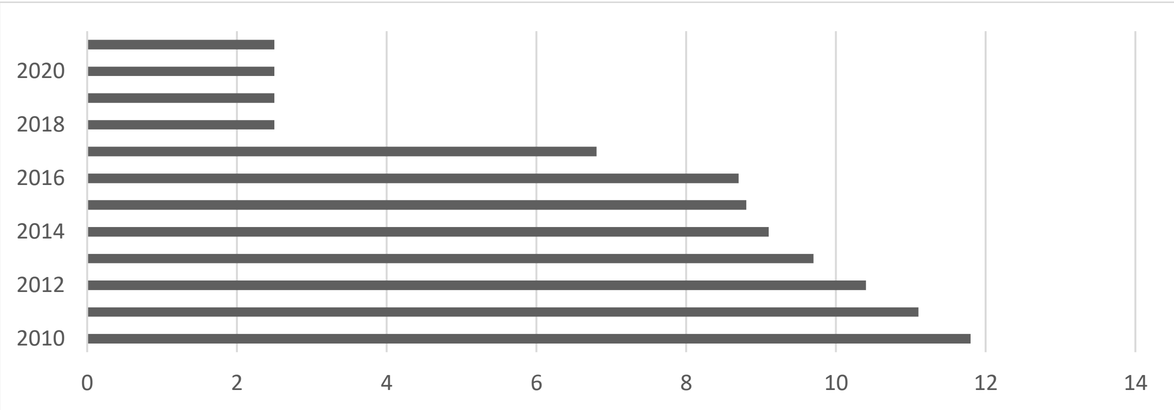

Figure 4: Prevalence of undernourishment as percentage of population

Table 2: Descriptive statistics of the variables of the study

Statistics	LE (Years)	PFD (%)	ACF (Ton)	GDPCA (%)	MAL (%)
Mean	75.56768	87.75455	205203.2	8.088908	9.463636
Median	75.75100	89.81000	214560.4	7.995159	9.600000
Maximum	78.21100	108.7400	265228.4	13.63582	16.20000
Minimum	71.88100	64.20000	118088.2	1.995558	2.500000
Std. Dev.	1.896463	14.47734	47419.93	2.433732	4.204934
Skewness	-0.301327	-0.243765	-0.636678	-0.003935	-0.345976
Kurtosis	1.977697	1.650269	2.265877	3.900019	2.278328
Jarque-Bera	1.290937	1.887837	1.980341	0.742587	0.916308
Probability	0.524417	0.389100	0.371513	0.689841	0.632450
Sum	1662.489	1930.600	4514471.	177.9560	208.2000
Sum Sq. Dev.	75.52804	4401.462	4.72E+10	124.3841	371.3109
Observations	22	22	22	22	22

Table 3: Dynamic Ordinary Least Squares (DOLS) of agricultural carbon footprints, malnutrition and life expectancy in China

Dependent Variable: LE				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
PFD	0.100273*	0.018384	5.454347	0.0320
ACF	8.05E-06	5.50E-06	1.462237	0.2812
GDPCA	0.501615*	0.103092	4.865694	0.0397
MAL	-0.194007*	0.036014	5.387028	0.0328
R-squared	0.999749	Mean dependent var		75.77847
Adjusted R-squared	0.997741	S.D. dependent var		1.586987
S.E. of regression	0.075435	Sum squared resid		0.011381
Long-run variance	0.003756			

However, malnutrition exerted a negative and significant influence on life expectancy in China.

Discussion

Over the periods of 2000 and 2021, agricultural carbon footprints in China experienced a sharp decline in 2015, which continued to decline in a consistent manner until 2021. This drastic reduction in agricultural carbon footprints in China is likely to be attributable to the country`s efforts to ensure environmental sustainability, which is the major goal of the SDG 13 target. In the same vein, per capita food production in China rose from 88.29% in 2011 to over 108% in 2021. This implies that China does not only possess excellent capacity and technology to produce sufficient food for its teeming population but also has excess food for exports. It is important to stress that the finding confirms that within a space of a decade, the undernourished population in China was reduced by 78.8%. The above factors could be the reason why life expectancy improved from 75 years in 2010 to 78 years in 2021 in the country.

The results of the study indicate that per capita food production had a significant positive impact on life expectancy in China. As such, a unit change in per capita food production led to a rise in life expectancy by 0.1%. This suggests that sufficient food production may be one of the major factors that drives improvement in life span in China. However, malnutrition exerted a negative and significant influence on life expectancy in China. Based on this finding, a unit change in malnutrition reduces life expectancy by 0.19%. This shows that habitual food consumption is a crucial nutrient that provides the dietary energy levels that are required to maintain a normal active and healthy life. Therefore, it is incumbent upon the policymakers in China to ensure that all citizens have access to food that are required to maintain a normal active and healthy life in order to improve life span of the country`s population.

Contrary to the findings of Chen and Li[21], the results of this study indicate that agricultural carbon footprints contributed a positive but insufficient impact on life expectancy. The reason for this result in China might be attributed to the continuous efforts of the country`s policymakers to build a resilient health system in the face of challenges posed by climate change. On the hand, this result could also be a reflection of the aggressive commitment of China towards mitigating climate change while employing clean energy that emits zero carbon footprints in agricultural sector. In addition, the GDP per capita growth increased life expectancy significantly in China. Our results show that a unit change in GDP per capita leads to a rise in life expectancy by 0.5%. This attests to the important role played by household economic factors in elongating life span. This proposition is in tandem with Hao *et al.*[30] and Chen and Li[21] which emphasized that household with decent income usually possesses financial strength to cater for the basic necessities of life required for living a long life. Therefore, the policymakers in China in particular and other low and middle income countries in general should give more attention to the programmes and policies that can snowball into a rise in living standard of the citizens, this will invariably catalyze a significant improvement in life expectancy of all their citizens.

Strengths and limitations

Both the statement of the problem and the research question of this study were well stated. Also, this study utilized credible data alongside comprehensive techniques of data analysis, which led to the emergence of new empirical evidence. These serve as the strengths of this study. Meanwhile, this study is limited based on its scope, as the study focuses on China. The results might not be strong enough for generalization of the situation reports of the entire Asia. Further researches might be needed to explore the entire Asian countries for a wider policy implication.

Conclusion

The following are the conclusions drawing from this study; over the periods of 2000 and 2021, agricultural carbon footprints in China experienced a first sharp decline in 2015. In the same vein, per capita food production in China rose from 88.29% in 2011 to over 108% in 2021. Within a space of a decade, the undernourished population in China was reduced by 78.8%. Moreover, per capita food production had a positive impact on life expectancy in China. However, malnutrition exerted a negative and significant influence on life expectancy. Agricultural carbon footprints contributed a positive but insufficient impact on life expectancy and GDP per capita growth increased life expectancy significantly in the country.

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