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Food security and wealth vs. environmental impact of agriculture as seen from a perspective of poor countries

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Abstract

Aim: The purpose of this article was to identify the determinants of low GDP per capita levels accompanied, and driven by, extreme food insecurity in the 25 countries with the lowest GFSI (Global Food Security Index).

Methodology: The countries were divided into five groups for descriptive purposes, while the determinants of GDP per capita were examined using a fixed effects panel regression model.

Results: The descriptive analysis showed a declining trend in agricultural land per capita and increasing methane emissions per hectare. The panel regression results indicated that electricity availability,

energy use per capita, and capital in agriculture were positive and statistically significant determinants of GDP per capita. Agricultural land per capita showed only weak significance at the 10% level, whereas CO_2 and CH_4 emissions were not statistically significant after controlling for country-specific effects.

Implications and recommendations: The conclusions drawn from the study provide grounds for seeking recommendations on how to make people less exposed to the risk of food insecurity, especially in Cluster 1 countries. Those five countries, also among the least developed ones, were not in a position to change the course of climate change. Therefore, in order to solve this problem, it is necessary to focus on their economic development. First, greater emphasis must be put on agricultural subsidies in the least developed countries. Second, their governments should focus on how to efficiently absorb technological progress in agriculture. Based on these efforts it would be possible to develop solutions which ensure food security, whilst enabling a reduction in negative environmental impacts.

Originality/value: Seeking the determinants of GDP per capita in the context of ensuring food security is an important aspect in view of the forecasted population growth, which in turn implies growing demand for food. The need to ensure food security is a global commitment with both an economic and an ethical dimension. It is therefore reasonable to address that issue, having in mind the progressing globalization and the persisting famine and poverty.

Keywords: food security, environment, agriculture, least developed countries, GFSI

1. Introduction

According to a FAO report published in July 2023, the number of people affected by famine grew by 122 million compared to 2019 (FAO 2023). The main reasons behind it are the COVID-19 pandemic (Balgah et al., 2023; Bilan et al., 2023; Saboori et al., 2022; Suh et al., 2023), climate change (Wheeler & Von Braun, 2013; De Pinto et al., 2019; Antwi-Agyei & Stringer, 2021; Oyelami et al., 2023) and conflicts, including the war in Ukraine (Abay et al., 2023, Zhou et al., 2023). The increasingly volatile weather conditions, floods and draughts have an effect on the growing season (Trenberth, 2005), reduce the availability of water (Frederick & Major, 1997), encourage growth of weeds and pests, and may diminish yields (Manida, 2022). Although the less developed countries are particularly vulnerable to each of these factors, climate change remains the biggest threat (Dube & Sivakumar, 2015). Greenhouse gas emissions have doubled over the last five decades (Das et al., 2022). While the least developed countries are the smallest contributors to greenhouse gas emissions, they are the most exposed to the impacts of climate change and are the least capable of adapting to it (Huq et al., 2004). The goal set in the 2030 Agenda for Sustainable Development is to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations General Assembly, 2015). The demand for food will rise by 50% by mid-century due to an extremely large numbers of undernourished people (Searchinger et al., 2018).

2. Literature review

2.1. Food security

A number of recent scientific studies (Thomas et al., 2017; Izraelov & Silber, 2019; Smith et al., 2017; Fujimori et al. 2019; Carney & Krause 2020, FAO, 2021) showed how important it is to ensure food security across the globe. The problem is extremely complicated and needs to be solved urgently – complicated because food security depends on many economic, social, political and other factors, and urgent since agriculture must deliver food to a population which is expected to grow beyond 9 billion by 2050 (Grafton et al., 2015).

Hence food security is a vital topic for today's world. The stability and security of the food system depends on human population. The occurrence of extreme events such as natural disasters, pests, diseases and trade disruptions have had a serious impact on the food system. Unfortunately, in 2020, the COVID-19 pandemic (Naja & Hamadeh 2020) considerably affected the food security of many countries.

The term 'food security' itself can be analysed from different angles. As Kraciuk (2015) indicated, it belongs to economic sciences dealing with agriculture, political doctrines and sociology. Out of the broad range of its definitions, particular emphasis should be placed on that presented by two American sociologists, Bush and Lacey (1984), according to whom food security has at least three dimensions: free disposal, availability and adequacy (defined in terms of a balanced food ration). The first dimension refers to having an adequate amount of food available to the population at any time. The second indicates that no restrictions should be imposed on food supply. The official definition of food security was formulated in 1974 at the World Food Conference held in Rome. Accordingly, food security means "the availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (World Food Conference, 1975). The definition of food security has evolved; in the 1990s, it was enhanced with such aspects as food safety, food preferences, as well as social and cultural determinants and factors (Food and Agricultural Organization of the United Nations, 1996). As stated at the 1996 World Food Summit, "food security at the household, national, regional and global levels is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs" (Food and Agricultural Organization of the United Nations, 1996, p. 1). Another definition, formulated in The State of Food Insecurity, a 2001 FAO report, was additionally expanded with social access to adequate food.

At global level, ensuring food security could be part of the globalisation processes, provided that the adequate redistribution of goods is the political goal followed by governments (Sapa, 2010). In that scenario, any disruption in the globalisation processes could lead to food insecurity (Leśkiewicz, 2012).

According to Fujimori et al. (2019), food security covers four key elements: food availability, stability, access and use. In turn, Lu et al. (2020) proposed the Self-Adapting Statistics Allocation Model (SASAM) established with a view to develop a global map of arable land distribution, believing it is important to create more precise global maps of growing areas for research purposes and food security uses. Carney & Krause (2020) found that climate change and the continuous neoliberalisation process have exacerbated food insecurity and famine issues, resulting in a growing population of displaced persons incapable of feeding themselves.

Recent global problems, including hunger and the difficulties and disruptions faced in the process of ensuring food security, can be analysed from the perspective of different economic theories. It needs to be emphasised that the ever-faster economic and demographic development resulted in exceeding the capacity of the global ecosystem. The biosphere has certain threshold values which cannot be transgressed if people want to preserve their habitat. As noted by Kraciuk (2015), globalisation presents an intrinsic contradiction between the commitment to microeconomic efficiency and the socio-environmental costs of it, which are not taken into account at the microeconomic level by the businesses concerned. Thus "when these costs grow at a rate similar to that of globalisation processes, they give rise to an accumulation of potential social conflicts" (Grzelak, 2010). Therefore, the relevant authorities should regulate and drive rational behaviour not only at the microeconomic level rationality but also in the macroeconomic and environmental dimension. Mainstream economics needs to be realigned in order to take account of the broad range of changes to all areas of rationality (Kraciuk, 2015), hence the solution should consist in developing new agrarian economics, consistent with sustainable development economics.

Subsidising the underinvested agricultural sector in the least developed countries would be a significant effort in developing a system for ensuring food security (Pawlak & Kołodziejczak, 2020;

Modi & Cheru, 2013; Flora, 2010). Next to land and labour, capital is an essential input in ensuring food production (Giller et al., 2021; Irz et al., 2001; Cornia, 1985), moreover technological progress also makes agriculture increasingly efficient (de Souza et al., 2020). However, the problematic issue is the situation of the least developed countries which are exposed to a series of the adverse impacts of climate change (Sadowski et al., 2024; Chambwera and Stage, 2010; Campbell-Lendrum & Corvalán, 2007). As a consequence they not only become deprived of capital inflows but also have no development opportunities, making them truly vulnerable to deepening food insecurity.

2.2. The Global Food Security Index

The Global Food Security Index (GFSI) is an important instrument designed to measure food security across the world. Its main purpose is to precisely determine which countries are the most and the least exposed to food insecurity (FAO 2020). It was developed by the Economist Intelligence Unit (EIU) based on 28 indicators of different aspects of food security in more than 100 countries (FAO, 2020) as an interactive model which relies on a number of analytical tools used in benchmarking countries and regions based on unified ratios and methods (Kraciuk, 2015. The opinions of EIU experts and of a large group of EU food security specialists were the basis for defining three distinct categories which take account of three different aspects of food security, namely:

- affordability,
- availability,
- quality and safety (Carney & Krause 2020).

An important category of the index is the consumers' capacity to purchase food, i.e. affordability, and the costs they are able to incur in both normal circumstances and during food shocks (Izraelov & Silber, 2019). The calculations take account of such factors as GDP per capita, percentage of the population below the global poverty line, share of food consumption in household expenditure, and access to financing for farmers (EIU, 2015). The next category, food availability, is intended to assess the factors affecting food supply and the ease of accessing it. The calculations include the level of political stability and agricultural production stability, sufficiency of supply, food distribution, and food loss levels (EIU, 2015). Another important category, food quality and safety, is structured so as to take account of aspects such as nutrition standards, use of diets, availability of microelements, and protein quality. The difference in these ratios suggests there is a strong disparity between highly and poorly developed countries (Thomas et al., 2017; Izraelov & Silber, 2019). Smith et al. (2017) saw the GFSI as a model focused on factors contributing to food security rather than on results such as nutritional status or food consumption levels in the population concerned. In calculating the GFSI, EIU experts use data originating from different sources, e.g. databases provided by the World Bank, FAO and the World Trade Organization (WTO). In their analyses, Gou et al. (2021), Lam et al. (2020), Grafius et al. (2020) and Friel et al. (2020) indicated that an appropriate and adequate assessment of food security is of great help to governments (and other organizations) as it can support them in implementing a well--suited policy for food security.

Numerous scientific studies (Odhiambo et al., 2021; Friel et al., 2020; Grebmer et al., 2012; Nigam, 2019; Lv et al. 2022; Guo et al., 2021) structured their indexes used in assessing food security at different scales and from different angles. However, at global level, the Economist Intelligence Unit's GFSI provides a common framework which enables understanding the reasons behind food insecurity by analysing the evolution of food systems (Guo et al., 2021), which is not only a valuable benchmarking tool but also a way of identifying the countries with the most urgent needs in that area.

2.3. GDP per capita

GDP is a metric of the value of all goods and services produced in a country within a defined time interval, usually a year or a quarter (OECD, 2024; Callen, 2012). It is one of the key indicators used in

assessing the economic condition of a country (Dynan & Sheiner, 2018; Grishin et al., 2019). GDP reflects the general economic activity, and can be calculated in a number of different ways (Landefeld et al., 2008). It is used by governments, analysts and economists in analysing economic health, planning their economic policies, and benchmarking the countries. As a basic metric of economic development, it can be seen as related to what is the essence of ensuring food security. Indeed, the development of agriculture is strictly related to that of non-agricultural sectors of the economy (Timmer, 1995). The literature review provides a basis for identifying the basic links between GDP and food security (Fernandes & Samputra, 2022).

These links include expenditure on agriculture and food production, as a higher GDP often enables greater investment in agriculture and food production infrastructure (Pinstrup-Andersen & Shimokawa, 2006; Pawlak & Kołodziejczak, 2020). This can lead to an increase in agricultural efficiency (Czubak et al., 2014), enhanced product quality, and a greater availability of food (Hallam, 2011). Another relationship between GDP and food security is food availability. Usually, growth in GDP entails greater incomes for the population, thus increasing their capacity to purchase food (Gandhi & Zhou 2014). Countries at higher GDP levels usually enjoy better access to diverse sources of food. Government policies represent another link between GDP and ensuring food security. High GDP levels provide governments with more financial resources to implement policies that support food security, such as farmer subsidies, support programmes for the poorest, and food quality regulations. The public sector has a key role to play in countries at risk of food insecurity (Kuiper & Cui, 2021; Ströh de Martínez et al., 2016).

Moreover, GDP growth should go hand in hand with sustainable development aspects in order to ensure both the availability and the good quality of food, and minimise the environmental impacts of food production processes.

Although a higher GDP is beneficial for improvements in food security, it is not the sole factor, while other important factors are government policies, social structures, climate conditions, and many other aspects which may affect food availability and quality at country level. This is key to support economic growth and sustainable development in order to ensure food security.

Moreover, countries can guarantee their food security as they become wealthier. Self-sufficiency in food, in itself, does not entail growth in GDP. However, it can indisputably provide favourable development conditions across the economy, hence it was reasonable to analyse a situation where GDP can be determined to a certain (considerably limited) degree by food security. The feedback loop between the capacity to generate an increasingly greater GDP and ensuring food security in all of its dimensions is a pivotal part in analysing the determinants of this process in countries at greatest risk of food insecurity.

3. Methodology

3.1. Data

The Global Food Security Index (Economist Impact, 2022 report) was calculated through a food security analysis of 113 countries around the globe. The index was structured so that the closer the score to 100, the more food secure a country is, whereas a score close to zero represents the greatest food insecurity. The study found that countries falling below 50 demonstrated the lowest levels of socioeconomic development. Therefore the 25 lowest-ranked countries were retained for the analysis in this article, and were split into five groups by rank in order to compare their area of agricultural land and methane emissions (Table 1). Cluster 2 included Sudan, which was not retained for further analysis due to lack of pre-2012 data.

Table 1. Country groups covered by the analysis

Rank	Cluster	Countries
108–113	Cluster 1	Syria, Haiti, Yemen, Sierra Leone, Madagascar
103–107	Cluster 2	Burundi, Nigeria, Venezuela, Congo
99–103	Cluster 3	Chad, Zambia, Angola, Ethiopia, Guinea
94–98	Cluster 4	Togo, Niger, Cameroon, Côte d'Ivoire, Mozambique
89–93	Cluster 5	Uganda, Malawi, Benin, Tanzania, Burkina Faso

Source: own compilation based on the Global Food Security Index 2022 report.

The next step was a panel regression procedure carried out without splitting the countries into groups, with GDP_per capita as the explained variable, and the following as explanatory variables: agricultural_area_per capita; electricity, energy_use_per capita; emissions_from CO_2; emissions_from CH_4; capital_in_agriculture; consumption_of_fixed_capital. The variables were selected based on the analysis of the most frequently cited literature which included the following keyword tags: food security, hunger, Global Food Security Index, food insecurity, food sufficient, food self-sufficient, food consumption. The grouping of countries based on the Global Food Security Index ranking was used exclusively for descriptive analysis. In the econometric part of the study, all the countries were jointly analysed using a panel data approach.

3.2. Panel regression

The impact of selected factors on GDP per capita was examined using a panel data regression framework, which allows controlling for unobserved, time-invariant country-specific characteristics.

The general form of the regression model can be expressed as:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon, \quad (1)$$

where: y – dependent variable explained by the model; x_1, x_2, ..., x_k – independent (explanatory) variables; β_0 , β_1, β_2 … β_k – parameters; ε – error term.

In order to account for unobserved heterogeneity across countries, a fixed effects specification was applied (Allison, 2009). The model took the following form:

$$y_{it} = x_{it}\beta' + \alpha_i + \varepsilon_{it}, \quad (2)$$

where: α_i(i = 1 … n) – unknown intercept for each entity (n entity-specific intercepts), y_{it} – dependent variable, where i = entity and t = time, x_{it} is the independent variable, β' is the coefficient for the independent variable, and ε_{it} is the error term.

The fixed effects specification was selected due to the presence of significant country-specific effects and the correlation between unobserved heterogeneity and the explanatory variables. This choice was formally supported by the Hausman test, which strongly rejected the null hypothesis of no systematic differences between the fixed and random effects estimators ($p < 0.01$). Multicollinearity among explanatory variables was assessed using variance inflation factors (VIF). The initial specification revealed severe multicollinearity between capital in agriculture and consumption of fixed capital, with VIF values exceeding conventional thresholds. To address this issue, consumption of fixed capital was excluded from the regression model. After this adjustment, VIF values for all remaining variables dropped to acceptable levels, with all VIFs close to 1 and a mean VIF of 1.15, confirming the absence of multicollinearity in the final specification.

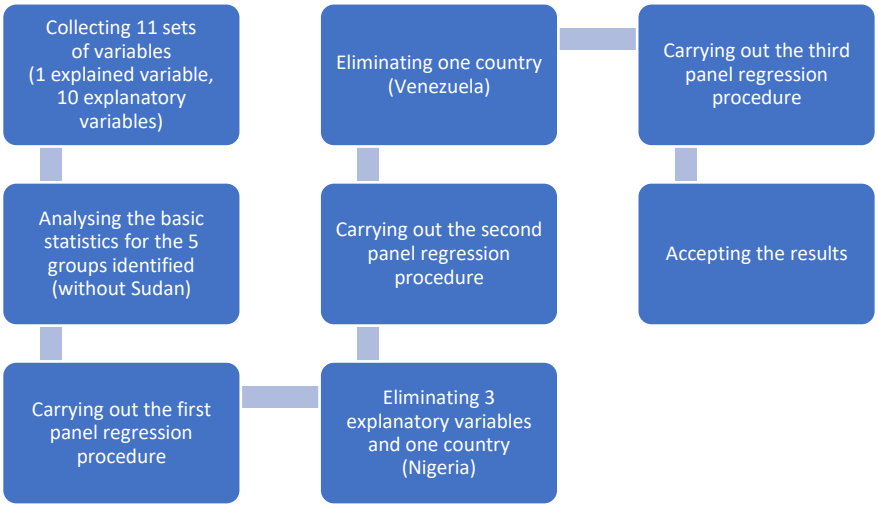


Fig. 1. Research procedure diagram

Source: own study.

The study initially collected 11 variables, including one dependent variable and 10 explanatory variables, for 25 countries. Sudan was excluded from further analysis due to the lack of pre-2012 data, resulting in 24 countries for the descriptive analysis. The first panel regression was then conducted, after which three explanatory variables and Nigeria were excluded. A second panel regression was performed, followed by the exclusion of Venezuela. The final estimation was therefore based on a balanced panel of 22 countries observed over 20 years. During the final model specification, consumption of fixed capital was additionally excluded due to severe multicollinearity with capital in agriculture, resulting in six explanatory variables in the final model.

4. Results and discussion

The basic statistics for the five groups identified were analysed in accordance with the research procedure diagram. One of the most important was the area of agricultural land per capita which largely determines the physical availability of food (Smolenaars et al., 2024; Long et al., 2018; Funk & Brown, 2009).

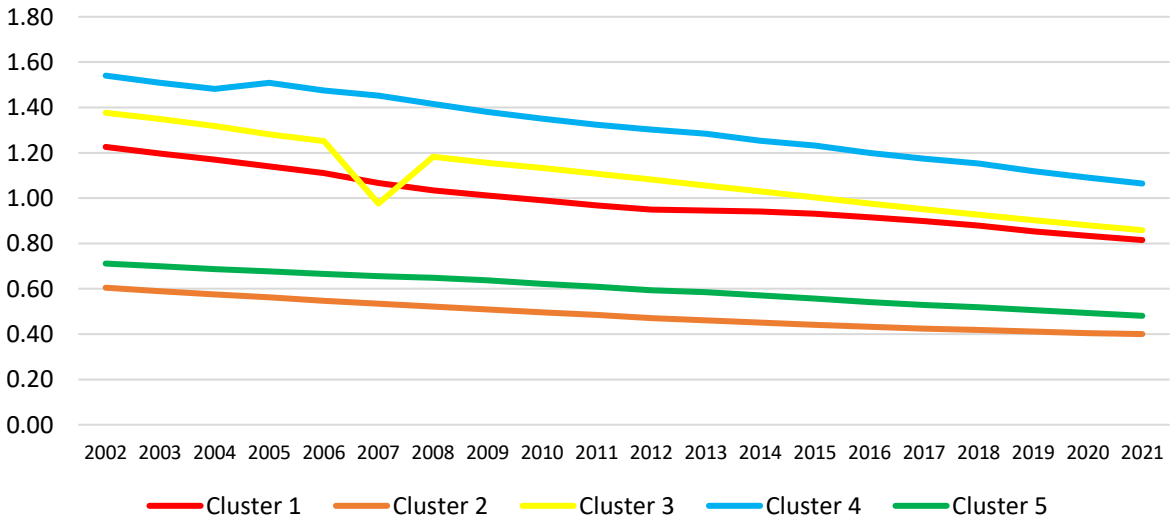


Fig. 2. Area of agricultural land per capita

Source: own study based on data FAOSTAT.

The area of agricultural land per capita followed a declining trend in all groups covered by the analysis, which was mainly caused by the growing population (Bryant et al., 2009; Azadi et al., 2011; Miyan, 2015) and the inability to expand that area. This is all the more worrying since all the groups included countries at the lowest levels of the food security index. It may come as a surprise that the smallest area of agricultural land per capita was recorded in countries with a higher food security ranking. Thus, it is also important to analyse the successive indexes for the groups identified. Changes in methane emissions were examined to address the issue of climate change and the way agriculture affects it (Rehman et al., 2020; Pant, 2009; Lynch et al., 2021). In the context of GDP, it was essential to analyse this aspect since the wealthier countries usually demonstrate greater production as well as greater consumption levels (in particular animal products), and therefore report higher methane emissions. However, as the countries develop, they absorb more modern technologies. As a consequence the decline in emissions in successive years may result from the implementation of state-of-the-art solutions rather than from a reduction in production volumes.

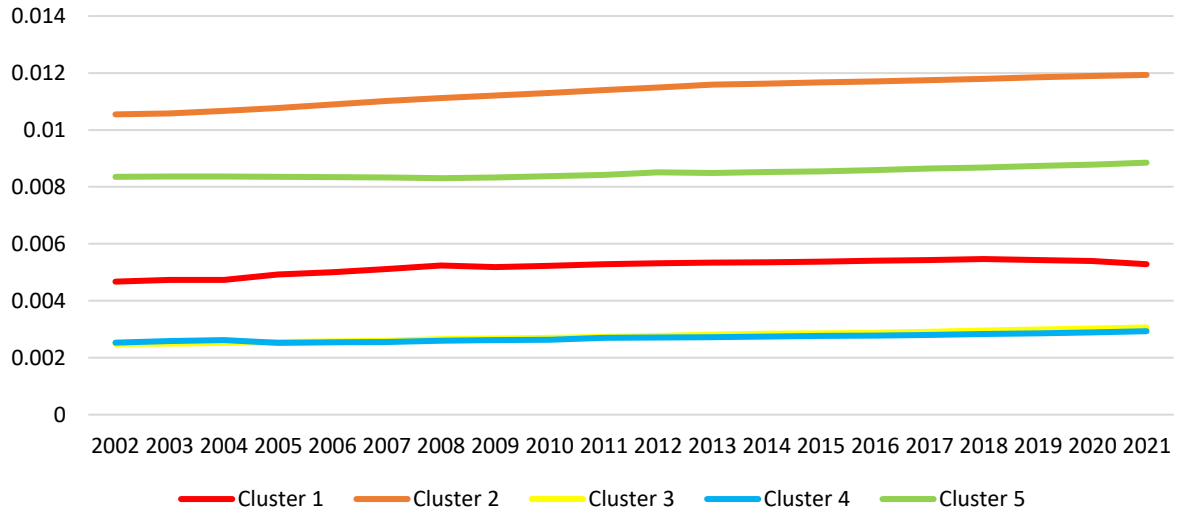


Fig. 3. CH4 emissions per hectare

Source: own study based on data FAOSTAT.

Countries at the greatest risk of food insecurity appear to demonstrate a certain trend of changes in CH4 emissions per hectare of utilised agricultural area (UAA), namely most experienced a slight growth between 2002 and 2021. Higher emissions were witnessed in Cluster 5 countries, i.e. those ranked at the top of the list of 25 countries at the lowest risk of food insecurity. The above confirms that countries at faster development rates are likely to report greater emission volumes. The increase in methane concentration around the globe is especially worrying because of its effect on the climate (Karakurt et al., 2012; Reay et al., 2018). Anthropogenic sources of methane emissions are generally grouped in three sectors: agriculture, energy, and waste management (Yusuf et al., 2012). In the least developed countries at risk of food insecurity, methane emissions originate from the agricultural sector, and therefore it was necessary to analyse their level per hectare of UAA. Another variable of importance to the food production process is capital. The relevance of estimating capital inputs in agriculture was already indicated by Fabricant (1938).

As found in the analysis, the second group (Cluster 2) witnessed considerable improvements in fixed capital consumption per capita, which was due to high levels of fixed capital inputs recorded in Nigeria. Although all the groups experienced a growth trend, the changes were negligible. Furthermore, Cluster 1 (bottom-ranked countries) reported no changes at all, which gives rise to serious concern. The decline in fixed capital consumption per capita since 2015 testifies to a drop in investments which are an essential driver of farming development (Shukla, 1968) and economic development.

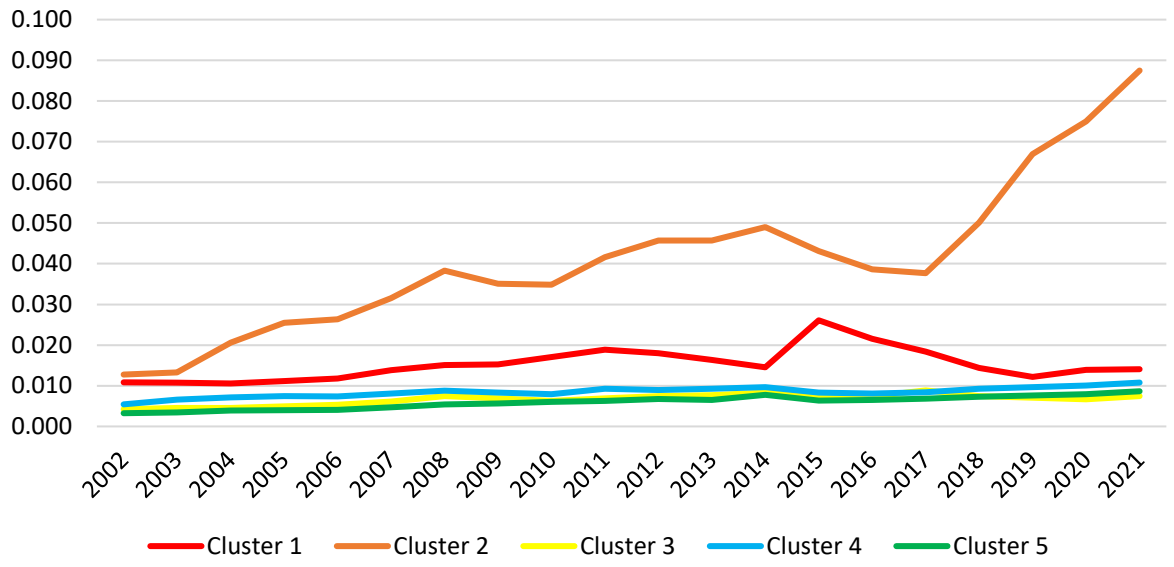


Fig. 4. Fixed capital consumption (USD per capita)

Source: own study based on data FAOSTAT.

The multiple regression procedure was carried out for 22 countries as the next step, with three countries eliminated because of incomplete data or strong fluctuations which caused a disruption to the model. The final panel regression was estimated for 22 countries observed over a 20-year period. The countries covered by this study were exposed to the real risk of food insecurity. The within R-squared value of the fixed effects model was 0.40, indicating that approximately 40% of the within--country variation in GDP per capita was explained by the included explanatory variables. The existence of such a correlation in an econometric model confirms that it provided an adequate description of the problem.

Table 2. Estimation results of the panel regression model used in explaining the evolution of GDP_per capita in 22 countries at risk of food insecurity

Variable	Coefficient	Standard error	*t*-Stat	*p*-value
agricultural_area_per capita	-117.483	69.921	-1.68	0.094
energy_use_per capita	569.437	104.720	5.44	0.000
electricity	3174.378	472.562	6.72	0.000
emissions_from CO_2	0.0028	0.0023	1.21	0.226
emissions_from CH_4	0.0289	0.1244	0.23	0.816
capital_in_agriculture	0.1097	0.0102	10.75	0.000
Constant	202.313	86.509	2.34	0.020

Model specification: Fixed effects (within) estimator
Number of observations: 440
Number of countries: 22
Time period: 20 years
Within R-squared: 0.401
F-statistic: F(6, 412) = 45.97 (p = 0.000)

Source: own study based on data FAOSTAT.

The econometric analysis was conducted using a fixed effects panel regression model for 22 countries observed over a 20-year period. The fixed effects specification allows controlling for unobserved, time-

-invariant country-specific characteristics that may affect GDP per capita, such as institutional quality, geographical conditions, or historical development paths. The Hausman test strongly rejected the random effects specification, confirming the appropriateness of the fixed effects approach. The results of the estimation are presented in Table 2. The within R-squared value of 0.40 indicated that approximately 40% of the variation in GDP per capita within countries over time was explained by the included explanatory variables. The overall significance of the model was confirmed by the F-statistic ($p < 0.001$). Among the explanatory variables, electricity was positively and statistically significantly associated with GDP per capita. The estimated coefficient was positive and statistically significant at the 1% level. This result indicates that increases in electricity availability or consumption are strongly associated with higher income levels within countries. Electricity constitutes a fundamental component of economic infrastructure, enabling technological adoption, industrial activity and service sector development. In countries facing a high risk of food insecurity, access to electricity appears to play a crucial role in supporting broader economic development processes. A similarly strong and statistically significant effect was observed for energy use per capita. The positive coefficient suggests that rising energy consumption accompanies increases in GDP per capita. Energy use reflects the scale and intensity of economic activity and is commonly treated as a proxy for structural transformation and modernisation. The significance of both electricity and energy use variables implies that access to energy constitutes an important development constraint in countries characterised by low food security. In contrast, agricultural area per capita did not exhibit a robust statistically significant effect on GDP per capita, once country-specific effects were controlled for. Although agricultural land availability is a fundamental factor for food production, changes in land endowment alone do not translate directly into income growth. This finding reveals that productivity, technology and capital inputs may be more important than land expansion in shaping economic outcomes in the analyzed countries. The estimated coefficients for carbon dioxide (CO_2) emissions and methane (CH_4) emissions were statistically insignificant. After controlling for energy use and electricity, greenhouse gas emissions did not exert an independent effect on GDP per capita. This result implies that emissions were more likely to be a by-product of economic activity rather than a direct driver of income growth. In the case of methane emissions, largely associated with agricultural activities, the lack of significance may reflect the relatively low productivity and limited industrial integration of agriculture in the least developed countries. The coefficient for capital in agriculture was positive and highly statistically significant. This result shows that increased capital availability in the agricultural sector contributed positively to GDP per capita.. Investment in agricultural capital may support income growth by enhancing productivity, improving resilience to climate shocks and facilitating the adoption of modern technologies. While agricultural capital contributed positively to income levels, its role remained complementary to broader infrastructure and energy-related factors. Overall, the results indicate that electricity, energy use per capita and capital in agriculture were positively and statistically significantly associated with GDP per capita, while agricultural area per capita showed weaker statistical significance. The findings highlight the importance of infrastructure development and access to modern energy systems as prerequisites for economic growth. At the same time, agricultural capital remains relevant, though insufficient on its own to drive substantial income improvements. These results underline the need for integrated development strategies combining agricultural support with investments in energy and infrastructure in order to improve both economic performance and food security outcomes.

5. Conclusion

In accordance with the Sustainable Development Agenda signed by UN member countries, the second Sustainable Development Goal is “zero hunger,” while the forecasted population growth is accompanied by adverse climate change which poses a particular threat to agricultural production in the least developed countries. Therefore, it was reasonable to examine the determinants of economic growth (e.g. based on GDP per capita) in the context of ensuring food security to learn how different

aspects of agriculture may contribute to GDP. The key conclusions derived from this study are as follows:

- there is a decline in the area of agricultural land per capita due to population growth;
- despite the drop in the area of agricultural land per capita, there was a slight growth in CH_4 emissions per hectare of UAA;
- the analysis revealed differences in the levels of fixed capital consumption per capita across countries, reflecting varying degrees of investment and capital in agriculture;
- the panel regression results indicated that GDP per capita is positively associated with electricity availability, energy use per capita and capital in agriculture, while agricultural land per capita showed weaker statistical significance and greenhouse gas emissions were not statistically significant.

This study and the conclusions drawn by the author provide grounds for seeking recommendations on how to decrease the risk of food insecurity, especially in Cluster 1 countries. Those five countries, which are also among the least developed ones, are unable to change the course of climate change, therefore the focus needs to be placed on their economic development. First, greater emphasis must be placed on agricultural subsidies in the least developed countries. At the same time, the results highlight the critical role of energy infrastructure as a prerequisite for both economic development and the effective modernisation of agriculture. Second, their governments should consider how to efficiently absorb technological progress in agriculture. Based on these efforts, it will be possible to develop solutions which ensure food security, whilst enabling a reduction in negative environmental impacts.

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