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Future Forecast and Economic Perspective of the Distribution of Greenhouse Gas Emissions by Sectors

(Sayfa 80-87)

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Abstract

Various policies aim to reduce greenhouse gas (GHG) emissions, placing specific limits on different sectors, and impacting the environment and the economy. However, fossil-based energy systems are continuously developing in rapidly industrializing regions. Balancing the immediate costs of transitioning with the long-term benefits of sustainability is key in addressing the distribution of GHG emissions across sectors in Turkey from an economic perspective. This study aims to provide a future forecast and economic perspective on the distribution of GHG emissions by sectors in Turkey. Depending on this purpose, Econometric Views (EViews) 12 software was used to analyze the collected data. The Autoregressive Integrated Moving Average (ARIMA) model has been used to predict future values. The study predicts that greenhouse gas emissions will increase by 5.5% in 2026 compared to 2022. The energy sector will continue to have the highest share of emissions, while the agricultural sector will experience the most significant increase. Additionally, emissions from industrial processes and product use are expected to rise, while emissions from waste are expected to decrease between 2022 and 2026.

Keywords: ARIMA, Economic Improvement, Future Forecast, GHG Emission, Reduce Carbon Emission.

JEL CODE: C13, C53, F64, S47, S56

1. Introduction

The concentration of atmospheric CO2 and its effects on the global climate has been debated for over a hundred years. GHGs are characterized by their radiative forcing, which alters the Earth's atmospheric energy balance, typically expressed in watts per square meter (Wm2) (IPCC, 1996). GHG emissions and land use from fossil fuels have increased continuously since the 19th century (Höhne et al, 2020). Each sector faces challenges in terms of climate change mitigation (Jakob et al, 2020). The effect of anthropogenic activity on the increasing atmospheric CO2 concentration is growing day by day. Studies have led to a better understanding of the relationship between atmospheric CO2 concentration and global temperature (Arrhenius, 1896; Bolin and Eriksson, 1959; Callendar, 1938; Pales and Keeling, 1965; Revelle and Suess, 1957). Countries globally have adopted strategies to address emissions. The Paris Agreement, signed by 196 parties, aims to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial levels. Nationally Determined Contributions (NDCs) outline countries' plans to reduce emissions (Meinshause et al, 2022).

GHG emissions have been on the rise worldwide. However, recent data suggests that in some regions, efforts to address climate change have led to a stabilization or even slight reductions in emissions. According to the Global Carbon Project, global carbon dioxide emissions from fossil fuels and industry totaled around 36.4 billion tonnes in 2021. The energy sector is the largest contributor to global emissions, accounting for approximately 73% of the total. The countries with the highest emissions are China (28%), the United States (15%), the European Union (9%), and India (7%) (Olivier et al, 2017). In recent decades, Turkey has seen a consistent rise in GHG emissions. According to the Turkish Statistical Institute (TurkStat), Turkey's total GHG emissions were about 506 million tons of carbon dioxide equivalent ($MtCO_2e$) in 2019. The primary source of emissions is the energy sector, contributing approximately 72% of the total, followed by industrial processes and product use (13%), agriculture (12%), and waste (3%). The continuous increase in energy demand, industrial activities, and urbanization are the main driving factors behind this rise (Dino and Akgül, 2019).

GHG emissions refer to the release of gases into the atmosphere that contribute to the greenhouse effect, trapping heat and leading to global warming and climate change. Evaluating the distribution of GHG emissions by sectors in Turkey from an economic perspective involves understanding the interplay between economic activities and their environmental impacts. The majority of GHG emissions in Turkey originate from the energy, industry, agriculture, and waste sectors. The energy sector in Turkey is the main source of GHG emissions, largely due to the use of fossil fuels for electricity and heating. The main reason for this is the dependence on fossil fuels such as coal, oil, and natural gas for energy production and transportation. The future of GHG emissions in the energy

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sector depends on Turkey's transition to cleaner energy sources such as renewable energy. Policies that encourage renewable energy investments, energy efficiency measures, and moving away from fossil fuels can reduce emissions in this sector (Kaygusuz, 2009). Industries such as cement, iron steel, and chemicals are significant emitters of GHG due to their energy-intensive processes and dependence on fossil fuels. Technological advances, the adoption of cleaner production processes, and stricter environmental regulations can help reduce emissions from these industries. Investments in green technologies and circular economy practices can also play a role in reducing GHG emissions (Durán-Romero et al, 2020). Agricultural activities such as animal husbandry and cultivation contribute to GHG emissions through the release of methane and nitrous oxide. Implementing sustainable farming practices, improving livestock management techniques, and promoting climate-smart agriculture can help reduce emissions from this sector. Additionally, carbon sequestration through afforestation can offset agricultural emissions (Monteny, et al, 2001). Waste management practices such as landfilling and incineration release methane and other GHG. Adopting waste-to-energy technologies, increasing recycling rates, and implementing methane capture systems in landfills can reduce emissions from the waste sector (Gautam and Agrawal, 2021).

Balancing the immediate costs of transitioning with the long-term benefits of sustainability is key in addressing the distribution of GHG emissions across sectors in Turkey from an economic perspective. This study aims to provide a future forecast and economic perspective on the distribution of GHG emissions by sectors in Turkey.

2. Materials and Methods

EViews 12 software was used to analyze the collected data. Based on data from 1990-2021, the ARIMA forecast method was employed for a 5-year forecast covering 2022-2026. The ARIMA model is a class of linear models that use past values to predict future values. ARIMA stands for Autoregressive Integrated Moving Average, where each technique contributes to the final forecast. ARIMA models are applied in cases where data show evidence of non-stationarity (autocorrelation) in the mean sense. An initial differencing (I) step can be applied one or more times to eliminate the non-stationarity (autocorrelation) of the mean function (Hyndman & Athanasopoulos, 2018). If there is seasonality in the time series, the seasonal difference (MA) can be integrated (I) to eliminate the seasonal component. The autoregressive (AR) part in the ARIMA term indicates that the variable of interest regresses on its own lagged values. The moving average (MA) part shows that the regression error is a linear combination of error terms whose values occur simultaneously and at various times in the past. I (for "integrated") indicates that the data values are modified by the difference between their value and the previous values (and this differencing process may have been performed more than once). The purpose of each of these features is to make the model fit the data as closely as possible (Box et al, 2015).

Non-seasonal ARIMA models, as in this study (since the data are on an annual basis), are often denoted as ARIMA (p, d, q), where the parameters p, d, and q are non-negative integers. p is the order of the autoregressive model (number of time lags), d is the degree of differencing (the number of times past values of the data are subtracted), and q is the order of the moving average model (SAS, 2015).

EViews offers an automatic ARIMA forecast series procedure that allows a suitable ARIMA specification to be quickly determined and used to forecast the series into the future. In the five-stage procedure, four stages are automatically determined by the algorithms in the software: transforming the variable (log, Box-Cox, etc.), determining the level of differencing (none, first difference, second difference), and selecting the order of ARIMA terms. Therefore, automatic ARIMA forecasting is a method of predicting future values for a single series based on an ARIMA model (EViews, 2020).

3. Findings

Table 1 includes descriptive statistics of CO2 emission data between 1990-2021.

Table 1. CO2 Emission Values Between 1990-2021

Year	GHG Emission (CO2)	GHG Emission (Log)
1990	219.5262	5.3915
1991	226.7947	5.4240
1992	233.1325	5.4516
1993	240.7717	5.4838

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1994	234.3878	5.4570
1995	248.2489	5.5144
1996	267.5814	5.5894
1997	278.8138	5.6305
1998	280.3190	5.6359
1999	277.7768	5.6268
2000	298.9168	5.7002
2001	279.7401	5.6339
2002	285.6234	5.6547
2003	304.7948	5.7196
2004	314.4236	5.7507
2005	337.5750	5.8218
2006	358.0025	5.8805
2007	391.6970	5.9705
2008	388.4946	5.9623
2009	395.1771	5.9793
2010	398.7932	5.9884
2011	428.6176	6.0606
2012	448.1845	6.1052
2013	440.1953	6.0872
2014	459.4895	6.1301
2015	474.9675	6.1632
2016	501.1079	6.2168
2017	528.5659	6.2702
2018	523.1080	6.2598
2019	508.7259	6.2319
2020	523.9908	6.2615
2021	564.3897	6.3357
J-B(p)	2.653 (0.265)	2.502 (0.281)
ADF (Level)	0.8490	-0.2210
ADF (1st Difference)	-4.740**	-5.519**

ADF: Augmented Dickey-Fuller unit root test **p<0.01 J-B: Jarque-Bera

According to Table 1, it has been determined that the 1990-2021 data to be used as a reference for estimation has a normal distribution. However, the series is not stationary at its level, meaning it has an autocorrelation feature. Differencing eliminates changes in the level of a time series, removing trend and seasonality, and ultimately

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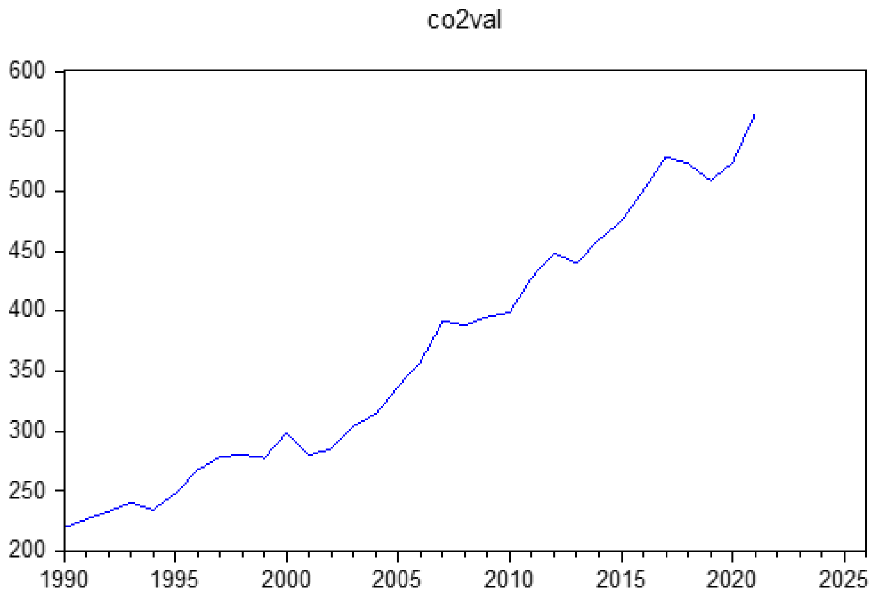
stabilizing the mean of the time series (Hyndman & Athanasopoulos, 2018). According to the ADF test results, it was determined that the mean of the series, which was found to be non-stationary (containing autocorrelation), was stabilized when the first difference was taken, and the trend disappeared.

According to the data in Table 1, GHG emissions have increased continuously between 1990 and 2021. When the previous five-year periods are examined, GHG emissions in 2011 were 19.7% higher than in 2006; it is seen that GHG emissions in 2016 were 16.9% higher than in 2011, and GHG emissions in 2021 were 12.6% higher than in 2016. These results indicate that although GHG emissions have increased continuously over the last twenty years, the rate of increase in GHG emissions has decreased.

Figure 1. The Course of CO2 Emission (1990-2021)



Automatic ARIMA Forecasting was utilized because both GHG emission values and their logarithms were found to be non-stationary, indicating the presence of autocorrelation in both series. In model selection, a Box-Cox transformation (second power) was applied, and after selecting the constant C as the external regressor, the algorithms of the EViews software were allowed to choose the appropriate model to determine the order of the ARIMA terms. In this process, the information criterion with the lowest value among the Akaike, Schwarz, and Hannan-Quinn information criteria was preferred. The maximum value for the autoregressive degree (AR) and moving average was set as 4 (4, 4). Since the data is annual and no seasonality was sought, seasonality was determined as 0 (0, 0) for both cases. Table 2 displays the results of the model selection tests to determine the order of ARIMA terms.

Table 2. ARIMA Model Selection Results

DLOG(LOGCO2)	**GHG emission (CO2)**
Sample	1990-2021
Number of observations included	31
Prediction length	5
The estimated number of ARIMA models	25
Number of non-convergent predictions	0
Selected ARIMA model	(2.0)(0.0)
AIC	19.759

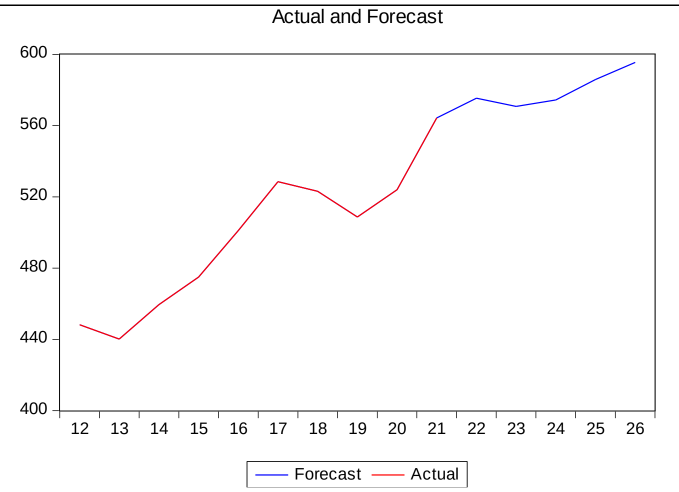
According to the results in Table 2, the selected model was determined as (2.0)(0.0). Table 3 shows the GHG emission ARIMA (2.0)(0.0) prediction results between 2022 and 2026.

Table 3. GHG Emission ARIMA Estimation Results

	Estimated Values for GHG				
Forecast Year	**Total**	**Energy**	**Industry**	**Agriculture**	**Wastes**
2022	575.445	408.152	75.153	70.362	14.567
2023	570.832	413.746	68.352	70.997	14.385
2024	574.413	419.265	72.846	71.625	14.171
2025	585.922	424.712	81.031	72.249	13.939
2026	595.505	430.09	79.767	72.767	13.703
2021-2026 Change	5.51%	6.86%	6.14%	9.59%	-6.77%
Dependent variable: DLOG(CO2VAL)					
Weighting method: Smoothed AIC					

When examining the prediction results in Table 3, it is observed that GHG emissions will reach 595.5047 in 2026, indicating an increase of approximately 5.5% compared to 2022. It has been determined that the energy sector will continue to have the highest share of GHG emissions between 2022 and 2026, while the agricultural sector will experience the highest increase in GHG emissions. Additionally, GHG emissions from industrial processes and product use are expected to continue increasing, while there will be a decreasing trend in GHG emissions resulting from waste between 2022 and 2026.

Figure 2. The Course of CO2 Emission According to Observation and Forecast Results



Total

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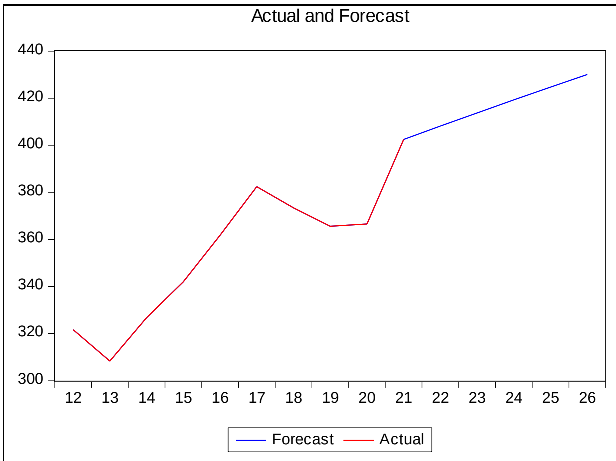
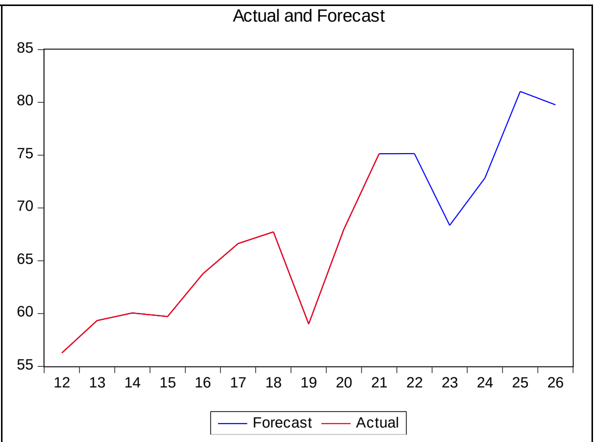
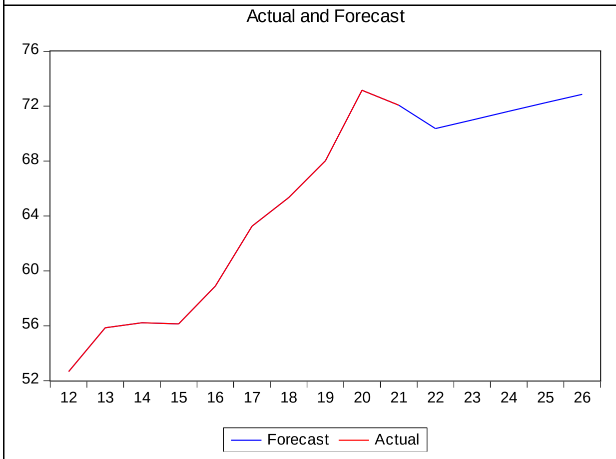


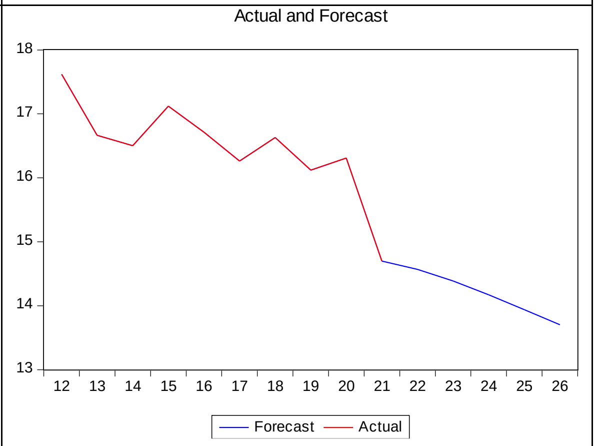
Energy



Industry



Agriculture



Wastes

4. Conclusions

The results of this study, which provides a future forecast and economic perspective regarding the distribution of GHG emissions by sectors in Turkey, are also compatible with the relevant literature. As a result of this study, GHG emissions have increased continuously between 1990 and 2021. It is observed that GHG emissions will reach 595.5047 in 2026, indicating an increase of approximately 5.5% compared to 2022. It has been determined that the energy sector will continue to have the highest share of GHG emissions between 2022 and 2026, while the agricultural sector will experience the highest increase in GHG emissions. Additionally, GHG emissions from industrial processes and product use are expected to continue increasing, while there will be a decreasing trend in GHG emissions resulting from waste between 2022 and 2026. It is estimated that GHG emissions, which are considered a major threat to the future, are increasing day by day due to different sectors. Measures that can be taken to reduce GHG emissions can be listed as follows: (a) Transitioning to renewable energy sources such as solar, wind, and hydropower, increasing energy efficiency in buildings and industries, promoting electric vehicles, and implementing carbon capture and storage (CCS) technologies can help reduce emissions; (b) Promoting public transportation, promoting electric and hybrid vehicles, improving fuel efficiency standards, and investing in alternative fuels such as biofuel and hydrogen can reduce emissions; (c) Adopting cleaner production technologies, improving process efficiency, implementing waste heat recovery, using sustainable materials and recycling can reduce industrial emissions; (d) Implementing sustainable farming practices such as precision agriculture, reducing animal methane emissions through dietary regulations or manure management, and promoting agroforestry can reduce emissions; (e) Improving building energy efficiency, using sustainable materials in construction, promoting green building standards, and adopting renewable energy for heating and electricity can reduce emissions.

Moving to a more diversified and sustainable economy often involves reducing GHG emissions. This requires strong environmental regulations and incentives to drive the transition. Policies should support innovation, investment in green technologies, and sustainable business practices. Access to green financing options, such as green bonds and climate funds, can help the transition to a low-carbon economy by mobilizing private capital for sustainable projects. Additionally, investing in green jobs and training workers to shift from high-emission industries to greener sectors is crucial for maintaining social and economic stability. Economically, investing in renewable energy sources like solar, wind, and hydro can reduce reliance on fossil fuels, create new industries and jobs, and attract investments, driving innovation and increasing global competitiveness. Improving energy efficiency in industrial processes lowers costs and emissions, making industries more competitive and sustainable. Promoting sustainable agricultural practices and utilizing agricultural and organic waste for biogas production can reduce emissions and create new income streams for farmers. Implementing circular economy principles in waste management can create economic value from recycling and waste-to-energy projects, reducing landfill use and associated emissions.

Future studies should prioritize sector-specific analyses of GHG emissions to uncover detailed insights within the energy, agriculture, industrial processes, and waste management sectors. Regional emission variations in Turkey need exploration for customizing localized policies and interventions. Future research may suggest extending projections beyond 2026 to analyze long-term trends and policy impacts and evaluate the effectiveness of current GHG reduction policies. Technological innovations, especially in renewable energy and carbon capture, should be assessed for their potential to reduce emissions.

This study contributes valuable academic insights by providing a comprehensive forecast and economic perspective on the distribution of GHG emissions across various sectors in Turkey. It analyzes data from 1990 to 2021 and projects future emissions up to 2026, offering insights into the trends and causes of GHG emissions in the country. The energy sector has been identified as the largest emitter, while the agricultural sector is the fastest-growing source of emissions. This provides a clear focus for future efforts in mitigation. Additionally, the study's findings on the expected increase in emissions from industrial processes and the decreasing trend in waste-related emissions contribute to a nuanced understanding of sectoral dynamics. Overall, this study enhances the academic discourse on climate change by integrating environmental, economic, and policy perspectives. It establishes a robust framework for future research and policy formulation concerning the reduction of GHG emissions in Turkey.

References

Arrhenius, S. (1896). On the influence of carbonic acid in the air upon the temperature of the ground. London, Edinburgh, Dublin Philos. Mag. J. Sci., Ser. 5, 41, 237-276.

Bolin, B. & Eriksson, E. (1959): Changes in the carbon dioxide content of the atmosphere and sea due to fossil fuel combustion. In: Bolin, B. (Ed.): The atmosphere and the sea in motion. Scientific contributions to the Rossby Memorial Volume. The Rockefeller Institute Press, New York, 130-142.

Box, G.E.P., Jenkins, G. M., Reinsel, G. C., Ljung, G. M. (2015). Time series analysis: Forecasting and control, Wiley.

Callendar, G.S. (1938): The artificial production of carbon dioxide and its influence on temperature. *Quarterly Journal of the Royal Meteorological Society* 64, 223-240.

Dino, I. G., & Akgül, C. M. (2019). Impact of climate change on the existing residential building stock in Turkey: An analysis on energy use, greenhouse gas emissions and occupant comfort. *Renewable Energy*, 141, 828-846.

Durán-Romero, G., López, A. M., Beliaeva, T., Ferasso, M., Garonne, C., & Jones, P. (2020). Bridging the gap between circular economy and climate change mitigation policies through eco-innovations and Quintuple Helix Model. *Technological Forecasting and Social Change*, *160*, 120246.

Eviews (2020). Eviews User's Guide I. https://cdn1.eviews.com/EViews%2012%20Users%20Guide%20I.pdf. (access 18.04.2024).

IJOSSAR ULUSLARARASI SOSYAL BİLİMLER AKADEMİK ARAŞTIRMALAR DERGİSİ
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Gautam, M., & Agrawal, M. (2021). Greenhouse gas emissions from municipal solid waste management: A review of global scenario. *Carbon footprint case studies: municipal solid waste management, sustainable road transport and carbon sequestration*, 123-160.

Höhne, N., den Elzen, M., Rogelj, J., Metz, B., Fransen, T., Kuramochi, T., & Dubash, N. K. (2020). Emissions: world has four times the work or one-third of the time. *Nature*, 579(7797), 25-28.

Hyndman, R. J., Athanasopoulos, G. (2018). Stationarity and differencing. Forecasting: Principles and Practice. https://otexts.com/fpp2/stationarity.html (access 12.04.2024)

IPCC (2019). Summary for Policymakers Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and GHG Fluxes in Terrestrial Ecosystems ed P R Shukla et al accepted. https://www.ipcc.ch/2019/ (access 12.04.2024)

Jakob, M., Flachsland, C., Steckel, J. C., & Urpelainen, J. (2020). Actors, objectives, context: A framework of the political economy of energy and climate policy applied to India, Indonesia, and Vietnam. *Energy Research & Social Science*, 70, 101775.

Kaygusuz, K. (2009). Energy and environmental issues relating to greenhouse gas emissions for sustainable development in Turkey. *Renewable and Sustainable Energy Reviews*, *13*(1), 253-270.

Meinshausen, M., Lewis, J., McGlade, C., Gütschow, J., Nicholls, Z., Burdon, R., ... & Hackmann, B. (2022). Realization of Paris Agreement pledges may limit warming just below 2 C. *Nature*, 604(7905), 304-309.

Monteny, G. J., Groenestein, C. M., & Hilhorst, M. A. (2001). Interactions and coupling between emissions of methane and nitrous oxide from animal husbandry. *Nutrient Cycling in Agroecosystems*, *60*(1), 123-132.

Olivier, J. G., Schure, K. M., & Peters, J. A. H. W. (2017). Trends in global CO2 and total greenhouse gas emissions. *PBL Netherlands Environmental Assessment Agency*, 5, 1-11.

Pales, J.C. & Keeling, C.D. (1965). The concentration of atmospheric carbon dioxide in Hawaii. *Journal of Geophysical Research* 70, 6053-6076.

Revelle, R. & Suess, H. (1957). Carbon dioxide exchange between atmosphere and ocean and the question of an increase of atmospheric CO2 during past decades. *Tellus* 9, 18-27.

SAS (2015). SAS / ETS 1.4 User's Guide The ARIMA Procedure. https://support.sas.com/documentation/onlinedoc/ets/141/arima.pdf (access 18.04.2024)